

Reconciling scientific approaches for organic farming research



Part I

Reflection on research methods
in organic grassland
and animal production at the
Louis Bolk Institute, The Netherlands

Ton Baars



LOUIS BOLK INSTITUUT

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**Reflection on research methods in organic grassland
and animal production at the Louis Bolk Institute, The Netherlands**

Part II:

**Effects of manure types and white clover (*Trifolium repens*) cultivars on the
productivity of grass-clover mixtures grown on a humid sandy soil**

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Part I:

**Reflection on research methods in organic grassland
and animal production at the Louis Bolk Institute, The Netherlands**

Ton Baars

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Abstract Part 1

This dissertation focuses on the research question: what is peculiar to agricultural research when its purpose is to support the conscious development of organic agriculture? What approaches, designs and methods are used for such research? Since the 1990s the Louis Bolk Institute has become one of the important actors in the field of organic research and development. The author analysed the methodological aspects of seven case studies, each following the same format: background of the project, methods used, a reflection on the methods and, to a limited extent, agronomic results. Each of these sheds light on an aspect of the Louis Bolk Institute's approach to research. Organic farming is experienced as a new paradigm and its research methods need to do justice to it. Three criteria were formulated for this purpose: the self regulation of farming systems, the involvement of farmers and the respect for the integrity of life. Two conceptual frameworks are used to analyse the research methods: (1) a four-quadrant matrix. Epistemological, ontological and methodological changes in the way of thinking are relevant in discussions about holism versus reductionism and positivism versus constructivism. The second framework is (2) a triangle which can show the relationship between the underlying values, the involvement of the actors and the nature of the scientific process. The scientific position which is defended in this dissertation can ultimately best be described as a *'radical holistic research strategy'*.

Research approaches applied in the case studies are: interdisciplinary research, experiential science and mutual learning, farmer-to-farmer learning, exploring tacit knowledge, bio-ethical evaluation, Goethean science and systemic development. In the four quadrant matrix two new additional research methods are positioned: (1) Goethean science is included as a holistic counterpart to multidisciplinary system ecology; (2) experiential science is included for comparison with mono-disciplinary experimental research. The constructivist character of both Goethean science and experiential science particularly distinguishes these methods from mainstream science. The meta-reflection on the research showed some important new elements of research. There was a systemic orientation in terms of a cohesive set of management measures and actions. This systemic orientation also encompasses holism in terms of Goethean science. In addition there is the experiential science based on intuitive action and pattern recognition. The reflection on the methods made it clear that their acceptance was influenced by the underlying scientific philosophy. The entire research strategy is thus based on two different interpretations of knowledge. Experiential science focuses on the actions of the farmer and is based on the epistemology of action. In addition there is an epistemology of knowledge, where it relates to interdisciplinary research and Goethean science. There are barriers to the acceptance of these scientific methods in the current lack of suitable statistical evaluation methods, and also in the absence of accepted methods for explicitly exploring reality as constructed by people.

Key words: organic agriculture, anthroposophy, methodology, research strategy, experiential science, multidisciplinary research, Goethean science

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Frens Schuring, animal nutrition (1993)

Liesbeth Brands, technical assistance in all fields of research (1993-1997; 2001 onwards)

Erik Prins, grassland agronomy (1994-1998)

Monique Hospers, arable cropping and statistics (since 1996)

Geert-Jan van der Burgt, soil science and farming systems (since 1996)

Nick van Eekeren, grassland and fodder crops, nutrients and farming systems (since 1997)

Jolanda Bleumink, grassland agronomy and farming systems (1997-2000)

Klarita Varenkamp, animal welfare and old organic pastures (1997-1998)

Wytze Nauta, animal breeding and farming systems (since 1998)

Monique Bestman, animal welfare (pigs and poultry) (since 1999)

Marlies Beukenkamp, animal welfare (poultry) (1999)

Liesbeth Ellinger, homeopathic veterinary science (since 1999)

Henk Verhoog, ethics and biotechnology (since 1999)

Jan-Paul Wagenaar, grassland agronomy, animal welfare and farming systems (since 1999)

Jan de Wit, grassland agronomy and farming systems (since 2001)

Udo Prins, arable cropping and farming systems (since 2001)

Ellen Heeres, soil science (since 2001)

Goaitske Iepema, animal science (since 2002)

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¹ Farmers in this dissertation are meant both as males and females.

together express the different views on life sciences. The original German title *Lebenszusammenhänge* (translated by me as 'connections in life') expresses for me the feeling of wholeness. The Dutch title *Levensprocessen in de natuur* (translated by me as 'life-processes in nature') focuses much more on interest in the developing process as the core of life, instead of the measurable, dead values, whereas the English title *In partnership with Nature* focuses on the need for another attitude; for people to widen their understanding of nature and life.

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I met the co-promoter Dr. Anjo Elgersma in her function of scientist at the Grassland Department of the Wageningen University. Together we have attended several scientific conferences in Europe and we are both members of the FAO-lowland pasture white clover group. In The Netherlands, we are members of a scientist group on forage legumes, Anjo as the president and myself, at the start of the group, as the secretary. Anjo has critically reviewed the two grassland research topics in this thesis with me. I am very thankful for her clear comments about the rules for writing a scientific journal paper.

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Last, but not least, I want to thank my family; at first my father Wim and his wife Gery. I am especially grateful for my father's open mind, which allowed me to experience as much as possible in my life as a young adult student in biology. That was the basis for me to get to where I am now. I met my wife, Gerda, in 1981 at the Institute when I did a phenomenological study of milk quality. Our love was formed above the smell of rotting or sour milk. We were the first 'Bolk-marriage' in 1985. We had the same spiritual feelings about life, based on anthroposophical insights into the world. Having such a partner is a very strong basis for doing all kinds of pioneering work. Although she has her own job as a graphic designer, Gerda never was angry when I spent a lot time during the weekends working on this book. Our two children, Brechtje and Jelle, did not experience me much as their father during this last two years. But I have promised to slow down after the completion of this thesis and to be with them in their next years of puberty.

Final motto

A motto from Rudolf Steiner, which have moved me since the first time I heard it and which very much covers the intention behind this doctoral thesis, is as follows:

Seek the really practical material life,

But seek it in a way that will not make you insensitive to the Spirit working in it.

Seek the Spirit,

But do not seek it as supersensible ecstasy through supersensible egoism,

But seek it, because you want to work with it selflessly in practical life and in the material world.

Use the old adage:

'The Spirit is never without matter, matter never without spirit' in this way, that you say:

We want to achieve everything material in the light of the Spirit,

And we would seek the light of the Spirit,

That warmth may be created for our practical activity.

Financial support

This thesis is based on 15 years of experiments and experience. In the thesis, all kind of projects are reported. All projects had different types of financing, because our Institute is still only project-based. Financial support in these past years came from:

- 'De Natuurweide', organic dairy farmers' association
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1. Introduction

The present chapter introduces all elements of the doctoral thesis that lies before you. The reflection on my experiences as a researcher, trainer and teacher in organic farming that accompanied its writing made me aware of the transformation of my thinking since I became involved in organic farming. This change is reflected in the discussion, later in the thesis, of objectivism versus positivism and holism versus reductionism in the philosophy of science. To grasp this change, it is relevant to understand what motivates organic farmers and how they think, the background and intentions of organic farming, and to define organic farming as a holistic principle for guiding action. Organic farming is not a static method of farming based on certain recipes. Not only do legal standards and regulations change but also the market and the players in it are constantly changing. Since organic farming has become part of official EU policy, the interest in organic farming is growing. This has led to a rapid change in market development, trading policy and to a more anonymous market. As its volume increases, also the pressure on organic farming increases to become incorporated into markets and institutions that serve conventional farming. At the same time, public research agencies, that have so far served conventional farming, are now entering the field of organic farming. Together these developments imply that both organic farming and the agricultural research organisations that seek to serve it have entered a period of dynamic change. It is appropriate at such a moment to ask which research structure and what kind of research methods best fit the character of organic farming.

This dissertation tries to address these questions. It is based on the author's 20 years of experience as a grassland researcher in a private research institute, the Louis Bolk Institute. The Institute is based on anthroposophical ² principles. These principles are quite different from those underlying conventional science. To make these principles explicit, I thought it helpful for the reader to briefly describe the transformation I experienced since my graduation as an ecologist. Firstly I shall deal with this personal transformation, followed by a definition of organic farming. There are many different and related practices. I will also describe the pressures on organic farming in the Netherlands in this period of change. These provide an important context and reason for undertaking the research presented in this part of the dissertation (the other part reports on experiments with manure and white clover in grassland). To complete the initial part of the study, I will also give some background on current research in organic agriculture.

² Anthroposophy is the spiritual worldview based in the insights of Rudolf Steiner (1865 – 1925). See also Chapter 1.1.1.

1.1. Personal reflections on organic farming research

My 20 years of working with organic farming, were not only as a scientist, but also as an involved partner in research and development (R&D). My personal attitudes and choices were as important as the technical outcomes of studies. Therefore, this thesis will not only reflect on research outcomes in terms of technical findings, but also be a discussion on the role as a partner in transformation processes. In a self-reflective circle of learning, I am an involved '*actor*' in terms of being part of research systems in which subjective choices are made. At the same time I am expected to be an objective '*observer*' of the on-going interactions as a result of this involvement (Figure 1.1) (Alrøe and Kristensen, 2002).

The relationship to the observed object, therefore, has two faces: involved partnership and objective onlookership (Van der Wal, 1997). As I change face, the reality of the observed world also changes due to the change in my position. This realisation leads to the discussion on the difference between a constructed³ worldview ('a world') versus a positivistic worldview in science ('the world') (Pretty, 1995; Pearson and Ison, 1997; Bawden *et al.*, 2000) later on in the thesis. I will, at first, describe in general terms my own shift in perspective as I became involved as an '*actor*' in the organic farming research projects described in this thesis. These biographical elements hopefully help the reader understand the choices made in this thesis and its

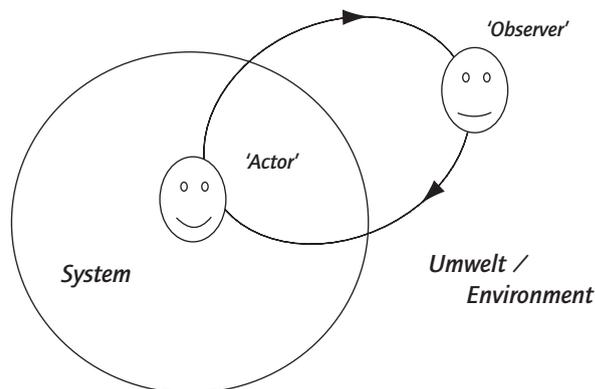


Figure 1.1. The self-reflective circle of learning in systemic research, moving from an inside actor viewpoint, or stance, to an outside observer viewpoint, and back (taken from Alrøe and Kristensen, 2002).

³ According to Pearson and Ison (1997), a 'construct' is the particular viewpoint or perspective of 'reality' unique to an individual and specific to time and place. A constructivistic perspective is one in which the observer is part of the system rather than independent of, or external to, it.

exploration of the additional research methodologies that are required to support organic agriculture.

1.1.1. Paradigm change

My experiences are based on basic and applied research, demonstration and extension projects in the field of grassland and animal production at one of the pioneering research institutes in organic farming in Europe, the Louis Bolk Institute in The Netherlands. As a research organisation in a new area of farming, the Louis Bolk Institute has accompanied, investigated and answered all kinds of questions raised by organic farmers and traders (Chapter 1.1.4). The Institute has made the choice to carry out its research on farms together with the farm managers who feel responsible for personally realising new approaches in farming. In our exploration of unknown areas of organic farming, we work mainly with farmers who are ahead of the group. Choices for co-operation are based on 'relevance of discovery' and not on the representativeness of the pioneers for the entire population of organic farmers. We work with pioneers who choose their own style of farming, and who have a strong inner drive to explore new, often high risk areas and to develop and fine-tune their management. In the research projects reported in this dissertation, I have respected this co-search process together with farmers as much as possible. Therefore, my relationship with the farmers involved was co-operative and egalitarian rather than a teacher – pupil relationship. Farmers have another kind of knowledge and make other types of observations, which could be described as broad, coherent, connected and holistic⁴. During my experiences, it became clear to me, that farmer and researcher each have a different role in the process of learning and innovation. This allows a co-operation that can be the basis for interactive learning, which we later called experiential⁵ science (Baars and De Vries, 1999; Baars, 2001-c; Baars and Wagenaar, 2002; see Chapter 5.2 and 5.3).

Although my responsibility was in the field of grassland and animal production, the interdisciplinary character of Louis Bolk Institute was an important support for a holistic approach to organic farming and nutrition. The anthroposophical background of the Institute made me aware how one's personal attitude and philosophy affect one's choices, action,

⁴ Holism is the perspective that makes the existence of 'wholes' a fundamental feature of the world. It regards natural objects, both animate and inanimate, as wholes and not merely as assemblages of elements or parts. Organisms as biological wholes are not isolated units and they do not exist apart from their surroundings (Smuts, 1929 in Woodward, 2002).

⁵ Experiential learning is based on reflection of experiences during action and can be seen as part of an epistemology of action. In that sense it can be distinguished from experimental learning based on experimental design that is part of an epistemology of knowledge. Of course, experiments also lead to (contrived) experience. Experiential learning, as I use it in this dissertation, refers to the learning that occurs in a complex field situation and that focuses on developing 'systems that work' instead of on establishing causal relationships. Experimental science can provide important inputs into experiential learning.

observations, learning processes and judgements. Exposure to the spirituality and worldviews or cosmovisions that underpin agricultural and health practices in many non-western countries made me aware of cultural diversity and affected my own convictions (Haverkort and Hiemstra, 1999). Anthroposophy introduced me to new concepts that were necessary to create scope for solutions of problems organic farmers mentioned. The strong side of anthroposophy for me is that it is a comprehensive and inclusive philosophy that gives one an additional perspective on all areas of life and living. Personally I was highly affected by new insights into evolution, the relation of spirit and matter, and the role of man in nature as more than a mere coincidence in evolution (Mees, 1984; Verhulst, 1994; 1999). Anthroposophy is practised in architecture (Alberts, 1990), medicine, science (Bockemühl, 1985; Seamon and Zajonc, 1998), education, religion, agriculture (Steiner, 1924; Klett, 1985; 1992; Beekman and De Jonge, 1999), the arts, economics and social life (Brüll, 1984).

I received my research training as an ecologist in grassland biology and landscape ecology at Utrecht University⁶. The tensions between objectivity versus subjectivity and reductionism versus holism were personally brought home to me during a two-year training course in bio-dynamic⁷ farming in 1979-1980. This course was additional to my training as a scientist/ecologist. During these two years, I was most affected by the training in the philosophy of science and by the biology curriculum. This new biology was taught as phenomenology⁸ and not discussed in terms of physics and chemistry, based on mechanistic and reductionistic explanations. I became aware of holistic levels of integration of life and of the entelechie (see below) of life. In the area of holistic life sciences, researchers were exploring new methods to directly visualise these life forces. These methods included picto-morphological methods, such as the use of crystallisation and chroma pictures (Anderson *et al.*, 1998; Ballivet *et al.*, 1999), and later delayed luminescence (Van Wijk and Van Aken, 1992; Bloksma *et al.*, 2001; Köhler *et al.*, 2002). During the two-year course, I learned to observe plants and animals in terms of life processes, meaningfulness and as an expression of a vital force (Bockemühl, 1980; 1985; Schad, 1977;

⁶ Dr. Jacques de Smidt was an important inspirator of my ecological thinking. He was a pioneer in the analysis of the relationship between ecology and farming (De Smidt, 1973), which inspired me to think in terms of processes and development (Baars, 1990 b). Due to his specialisation in heather ecology he was interested in mineral cycling of agro-ecological systems (De Smidt, 1978), which I have used later for my own research in farm mineral balancing (Baars, 1991; 2002 c).

⁷ Bio-dynamic farming is a practical translation of anthroposophic principles into agricultural practices. Bio-dynamic farming is one of the 'blood groups' in organic farming.

⁸ Phenomenology can be understood in two ways (1) The first interpretation stresses on the holistic observations: direct observation of the life cycle of the observed by using all senses and without use of instruments and (2) Mentioned as Goethean phenomenology or Goethean science, which in connection with the first point reflects the understanding and interpretation of phenomena as an holistic entity.

1985). All these aspects could directly be observed or taken from the living creature as a whole. Due to this new worldview, I explored new terms such as coherence, interaction and development over time, but also intrinsic value⁹ and the living creature as a being. This transformation of my thinking affected the rest of my scientific life.

It can be summarised by saying that I became aware and accepted the premises of Goethean science¹⁰, and the implicit relationship between spirit and matter and the need to integrate the philosophy of science and ethical questions.



... action based on animal integrity: in an attractive chicken run there are plenty of places for a hen to hide ...

The transformation that resulted from participating in the course described above was confirmed by insights gained into the process of conversion that farmers experience when they embrace organic farming. It became clear that farmers experienced this conversion as a complex inner change that can justly be called a paradigm shift (see also: Briones *et al.*, 1996; Wijnen, 1997; Østergaard, 1998). During conversion, the farmer not only experiences an adaptation of concepts, mentalities and actions, but also a change in his social environment. These changes often require a process of between four to seven years to structure a new and integrated way of anticipating and acting that arises out of the new holistic thinking. Comprehensive management at the right time and the right place turns out to be an important quality of this new skill. A good example is a study of the behaviour of beaked chickens (Bestman, 2000; 2002). Although the study looked at chickens, it became clear that farmers could not manage large numbers of chickens whose beaks had not been blunted without an inner transformation. Farmers who had not experienced this transformation kept asking for symptomatic and technical, instead of systemic solutions, and could not follow the organic principles of animal welfare and integrity¹¹. Such farmers only reacted on the symptoms of cannibalism and feather pecking without

⁹ Intrinsic value is the value of the object or organism of itself and is used in contrast to instrumental value, which is the value an object or organism has for people's purposes.

¹⁰ Goethean science is the study and comparison of morphological and biological phenomena in order to establish the characteristics of their relationships, what they have in common and in what ways they are different (Van der Bie, 2001).

¹¹ integrity is the inalienable intrinsic value of the being, based on its needs. Integrity can be seen as uprightness, as the state of being, whole, entire or undiminished.



... norm versus reality: sufficient surface area in the run complies with the standard, but unfortunately it is not used ...

considering their own role as a manager of man-animal relationship and without considering the specific needs of chickens, their housing and rearing.

Although I have experienced the power of a positivistic research strategy (see the case described in Chapter 5.1), I have come to accept that there is also a subjective aspect of a research project that has its impact before and after the measurements are made. As Pretty (1995) put it, *'the problem with the positivistic paradigm* ¹² *is that its*

absolutist position appears to exclude other possibilities'. One's perception of truth very much depends on one's point of view and on the context in which one is working and these elements are not paid attention to in the positivistic paradigm.

1.1.2. Philosophical reflections

The scientific methods in which I was trained during my university education were based on a philosophical choice. For four centuries, Western science has been based on philosophies of Descartes and Kant whose approach to biology reflects the ideas of Bacon and Newton and a mechanistic and mathematical interpretation of nature. The Cartesian paradigm commonly is called positivism or rationalism. In Pretty's words (1995): *'this posits an objective external reality driven by immutable laws. Science seeks to discover the true nature of this reality, the ultimate aim being to discover, predict and control natural phenomena. Knowledge about the world is summarised in the form of universal, or time-free and context-free generalisations or laws. The consequence is that investigation with a high degree of control over the system being studied has become equated with good science. And such science is equated with 'true' knowledge'*.

The discussion on positivism and objectivism is closely related to the discussion on holism and reductionism. In his dissertation on philosophy about holism and reductionism in biology and

¹² Paradigm is the set of principles, assumptions or the framework underlying theories and models, comprising epistemology, methodology and ontology.

ecology, Looijen (1998) distinguished between epistemological ¹³, ontological ¹⁴ and methodological ¹⁵ aspects. Distinguishing these three aspects is helpful for positioning worldviews in science and for becoming aware of the self-imposed limits of science due to agreements within the scientific community.

Looijen (1998) said that *'in the epistemological discussion, reductionism in its extreme reduces biology as a whole to chemistry, and chemistry to physics as the unity in science. Laws in nature can be reduced to fundamental theories of physics. Holists deny this possibility to reduce biological wholes to physico-chemistry. They defend the autonomy of biology with respect to chemistry and physics'*. The claims of both reductionists and holists appear to be based partly on ontological and partly on methodological arguments. However, Looijen (1998) considered the ontological differences less relevant. *'In relation to ontological aspects most biologists, reductionists and holists alike, are in the first place 'materialists'. That is, they assume that nature is entirely and exclusively made up of 'material' substances and forces, where 'material' is meant in the sense of modern physics. Both holists and reductionists are 'causal determinists'. Disagreement in biology appears with respect to the role of functional explanations (holism) versus causal explanations (reductionism). Another disagreement is the way in which the principle works.* However, Looijen (1998) also mentioned a minority of scientists who claimed that animate nature was different from inanimate nature: *'Most scientists developed a resistance to any idea of a non-material force, entelechie or 'soul', which would distinguish animate from inanimate nature'* ¹⁶. Ontological reductionism finally becomes atomism that assumes that biological structures are composed of, and have developed from, physico-chemical structures, and that therefore the former must be causally determined by the latter. Both holists and reductionists agree on the principles of evolution. Holists, however, point to the emergent aspects of the evolutionary process: new structures and forms having new, 'emergent' properties. Emergent properties are generally considered to be 'irreducible' and can be applied to all levels of organisation. Organicism is the view that living organisms are complex, hierarchically structured wholes, whose parts are functionally integrated in and co-ordinated by the whole. The causal influences from the whole are thought of as integrated and co-ordinating actions on its

¹³ Epistemology: the branch of philosophy that deals with the varieties, grounds, and validity of knowledge (Oxford Interactive Encyclopaedia); the way the knowledge is embodied in theories, and to logical relations between theories (Looijen, 1998).

¹⁴ Ontology: The science or study of pure being; that part of metaphysics which relates to the nature or essence of being or existence (Oxford Interactive Encyclopaedia); the relation to the entities, things or substances that are assumed to constitute nature (Looijen, 1998).

¹⁵ Methodology: the way of acquiring knowledge related to the principles, rules and strategies used in acquiring it (Looijen, 1998). Looijen distinguishes between methodology as method of research (scientific method) and methodology as strategy of research.

¹⁶ A description of how plant growth is accompanied by immanent forces is found in: Van Romunde (1998).

component parts. The whole itself is part of an environment present or a larger whole. In methodological respect, reductionism is a very common effort both in science and in everyday life to reduce complexity. *'Reductionists are mechanists, when they try to understand phenomena at the level of the whole to study causal mechanisms at lower levels of its constituent parts. Holists say that in order to understand the whole, one must not (only) study its component parts, but (also) the whole itself as well as the larger whole of which it is itself a part. Reductionism is directed downwards and associated with analysis, holism is directed upwards and associated with synthesis.'* Looijen (1998) described how scientists chose different research strategies. Holism and reductionism can become intertwined, depending on the way positions are decomposed into their epistemological, ontological and methodological dimensions.

Following Looijen's (1998) arguments, I will, in this thesis, take a specific position with respect to agricultural science. I assume holism with respect to all three elements of the scientific paradigm: ontology, methodology and epistemology. All levels of organisation in life are interesting and the explanations of research findings and the correlation between observations should be considered from a holistic point of view, because of the emergent properties at higher levels of integration. Life is too complex to ultimately be reduced to physico-chemistry. In the methodologies applied reductionistic measurements have to be an integrated part of a holistic approach.

1.2. Organic farming: its character

In the present Chapter, I will try to define organic farming and its different blood groups. Chapter 3 will present additional information on the history and development of organic farming.

In the Netherlands, organic farming is the umbrella term for both ecological  and bio-dynamic  agriculture. In the EU, organic agriculture is the legally protected term for a specific method of production. Organic farming must be seen as a second-generation development. It is not the same as the traditional farming systems that have evolved over often thousands of years before the advent of chemical industry, mechanisation and global marketing. Organic farming is a reaction to the modern developments in mainstream farming, especially in industrial countries. Hence organic farming emerged as a kind of protest movement around the 1920s. In recent history, several basic innovations have been introduced into farming, such as chemical fertilisers, large-scale mechanisation, the co-operative movement and, after the 1950s, chemical protection against pests and diseases (Bieleman, 1992). These innovations completely changed the nature of agriculture because of the possibilities they offered to standardise all kinds of agro-ecological farming situations.

The invention of organic farming was not the only reaction to industrial agriculture. For example, as a reaction to the use of pesticides that accumulate in the food chain, for ever associated with Rachel Carson's 'Silent Spring' (1963), ecological approaches to pest management were introduced as a first step in integrated production (Gruys, 1970; Van der Fliert, 1993). This gradual 'ecologisation' of conventional farming led to so-called 'integrated production' as a 'modern way of conventional farming' that is based on the economic integration of ecological and technological knowledge (Van der Weijden *et al.*, 1984). As all agriculture, integrated production does not constitute a fixed set of techniques. Newly developed methods and techniques are used to find a balance between conflicting goals in agriculture, economics, environment, health, nature and landscape. Examples of integrated farming are the production systems for dairy and mixed farming respectively that have been developed on the experimental farms De Marke and Minderhoudhoeve (Aarts, 2000; Lantinga and Van Laar, 1997). As a matter of principle, integrated farming does not reject technical or artificial solutions.

Although many aspects of integrated farming are also applicable to organic farming, the latter adheres to the complete rejection or prohibition of a number of practices. For instance, artificial fertilisers, chemical pesticides, embryo transfer and genetic modification are not allowed in organic farming (Schmidt and Haccius, 1998). Therefore, at the farm level, there will sometimes be a gradual, but more often a fundamental difference between integrated and organic farming. Although both methods use ecological principles, organic farming involves a complete change of thinking and acting. The focus in organic farming is principally oriented to preventive management, adapted and resistant breeds and races and long-term investments. In comparison to many developing countries, agriculture in industrial countries does not retain many elements of traditional farming. Organic farming can definitely not be seen as the continuation of traditional farming, based on the conservative refusal of farmers to modernise. Of course, many traditional practices can be very relevant to organic farming because traditional farming represents thousands of years of experimentation and learning in the absence of chemical solutions by people who had to live by the results. Organic farming is 'modern' in that it can be strongly supported by modern science, although its principles voluntarily restrict the implementation of certain methods and materials. Knowledge about the functioning of ecosystems, pest ecology, soil-plant-animal-relationships are very relevant for organic farming. In addition, standards in organic farming will be expanded, refined and renewed on the basis of the emergence of ethical principles from public debates on food safety, food security, the sustainability of food production, and other issues, that regularly arise in industrial society as it tries to cope with the threats to essential ecological services.

Due to their ethical convictions, organic farmers voluntarily restrict their management options (Lampkin, 1990; Gerber *et al.*, 1996), and the extent of the intensification and specialisation of their farming. Organic farmers deal with complex issues (different integration levels), multi-factorial problems (depending on the context), sub-optimal solutions (depending on their self-chosen objectives), site-related adaptations and with issues that are beyond the immediate control of the farmer. Many site-adapted options appear to exist for solving problems that seemed unambiguous at first, depending on the farm situation and social context (Baars and De Vries, 1999; Van der Burgt and De Vries, 1998). It can even mean, that agricultural or economic problems are solved by sociological approaches instead of by finding technical agronomic answers¹⁷. A shift to organic farming makes increased demands on farm management, farmer involvement and farming skills.

1.2.1. Definition, principles and standards of organic farming

The Nordic Platform (= umbrella of the Nordic organic associations) states the following definition of organic farming (Alrøe *et al.*, 2001). This definition is formulated in terms of idealistic principles, and reflects the international IFOAM (International Federation of Organic Agricultural Movements) standards (2002): *'Organic farming is conceived as a self-sufficient and sustainable agro-ecosystem in equilibrium. The system is based as far as possible on local, renewable resources. Organic agriculture is based on a holistic view that encompasses the ecological, environmental, economic and social aspects of agricultural production, both in a local and global perspective. Thus, organic agriculture perceives nature as an entity which has value in its own right; human beings have a moral responsibility to steer the course of agriculture such that the cultivated landscape makes a positive contribution to the countryside.'*

Woodward (2002) mentioned three schools of thought, the bio-dynamic or anthroposophical school of Steiner, the Organic-Biological School of Muller and Rusch and the Organic School of Howard and Balfour. World-wide, the practice and philosophy of modern organic farming are based on at least 50 pioneers, people who were dealing with special aspects of agriculture, health, food quality, nature and socio-economics (Lünzer, 2000; Vogt, 2000). The first pioneers in organic farming (1920s-1940s) were largely motivated by idealistic goals, based on holistic principles, spiritual and intrinsic values and concern about food quality (Pfeiffer, 1970; Vogt,

¹⁷ For example, the incredible increase of land prices in the last decade strongly has restricted the application of the principles of closed mineral cycles. On purely financial grounds, it is not economically sustainable to grow concentrates on such expensive land so that farmers buy cheaper concentrates produced elsewhere. Current land prices frustrate the development of organic farming in all sectors.

2000). In the 1960s and 1970s, the ecological concerns and fears about environmental problems, nature degradation and future energy supply, led to an increasing interest in organic farming and to the first impulse for the growth of the sector (Gerber *et al.*, 1996). In the 1990s, organic farming approached adulthood, when governments supported price premiums for organic produce and conventional retailers became interested. These developments led to a new and exponential growth of the organic market ¹⁸ (Gerber *et al.*, 1996).

Although there are some highly significant differences between the three schools of thought (Woodward, 2002), from the work of these pioneers in organic farming, a set of objectives can be described that cover the main aspects of organic farming in general. Lund and Röcklingsberg (2001) confirmed that the values adhered to in organic farming today were established by people in the early organic movement. These authors derived the following core values of organic farming from the IFOAM standards (IFOAM, 2002): (1) Aim for a holistic approach; (2) Aim for sustainability; and (3) Respect for nature. These general values have been implemented in objectives and have found their expression in restrictive standards defined in terms of allowed levels and prohibitions (IFOAM, 2002, EU-regulations 2092/91 and SKAL-regulations, 2002). The objectives of organic farming were summarised by Gerber *et al.* (1996), Niggli (2000), Woodward (2002) and reflect the international IFOAM-standards (2002). Organic farming:

- minimises the use of non renewable resources, including fossil energy; and uses strictly naturally derived compounds, resources and physical methods for direct interventions and control (with only few and listed exceptions);
- maintains and improves soil fertility through a 'living soil ¹⁹', which is the starting point for a healthy system;
- respects and enhances production processes as far as possible in closed cycles ²⁰ to be responsive and adaptive to its own environment; avoids environmental pollution as much as possible, and develops a land and landscape-related farming system;
- establishes links between soil, plant and animals to constitute a whole system with a dynamic

¹⁸ At the time of writing both the UK and Denmark experienced a surplus in the market for organic milk. This strongly affected price premiums. Given the international nature of the market, this in turn affected the rate of conversion to organic agriculture in the Netherlands (personal communication P.Boons, president of the Natuurweide association of dairy producers).

¹⁹ Eve Balfour created widespread awareness of these issues through her book 'The living soil' (Balfour, 1946). Together with Albert Howard she was one of the philosophers behind the organic movement in Anglo-Saxon countries (Lampkin, 1990). Their approach to soil fertility was based on the improvement of soil structure by means of plant composts. The notion of a living soil leads to the practice of 'feeding the soil' instead of mineral fertilisers that can be directly taken up by plants.

²⁰ Closed cycles refer to the flows of minerals through soil, plant, animal and manure within a mixed farming system. The term 'closed' is not entirely accurate. Cycles are open for N fixation by legumes and release of nutrients by export of products from the farm, erosion and weathering of the soil. In organic farming some well described rock minerals are allowed as external farm inputs.

that is yet to be understood;

- develops a diverse landscape based on cultural diversity, and local agro-ecosystems;
- stimulates and enhances self-regulatory processes through system, habitat, and species diversity and through locally adapted breeds and cultivars;
- improves animal husbandry based on the natural behaviour and the needs of the domesticated animal (derived from the concept of 'animal integrity');
- produces healthy food with a high qualitative value. The discussion of what constitutes a high qualitative value is accompanied by a search for more abstract concepts and principles (for instance 'vital quality') and new methodologies (Meier-Ploeger and Vogtman, 1988; Bloksma *et al.*, 2001);
- considers the wider social, ethical and ecological impacts of farming (linked, for example, to the ideal of a fair-trade economy (Roozen and Van der Hoff, 2002; Klein, 2000)).

Such objectives can be given different accents in different EU countries and by the different organic movements (Schmid, 1999). The harmonisation of EU standards (EU 2092/91; Schmid and Haccius, 1998) led to a list of minimum restrictions for the organic farming practice. In The Netherlands these standards are controlled by SKAL, the organisation that seeks to maintain organic standards. Due to the need for harmonisation within the EU, regional differences between systems are hardly allowed.

As can be gleaned from the discussion in the above section, wide consensus exists with respect to what constitutes organic farming. Bio-dynamic farming which seeks to implement anthroposophic principles in farming practice distinguishes itself from other blood groups by its emphasis on life forces which are believed to play a key role in agriculture, i.e., agriculture is not just a matter of physical, chemical and even biological (in the sense of genetic and evolutionary) processes. This emphasis on life forces adds relatively minor additional considerations with respect to the objectives and especially the practices followed in organic farming. The key differences are:

- the emphasis on the farm- and site-specific nature of farming. The farm is seen as a living entity on its own;
- the use of methods to identify and manage life forces (e.g., the use of certain compounds in compost making);
- the emphasis on the intrinsic nature of beings and their integrity, and the effort to understand these through e.g. Goetheanistic approaches.

These relatively small differences are additional to the bulk of the standards that define organic agriculture in general. Throughout this dissertation I will use the term organic farming to refer to the broad set of widely shared standards, and not specifically to those used in bio-dynamic farming. When I come to analyse my own research projects to tease out the specific nature of the research approaches and methods that can support organic farming (Chapter 5), I shall try to make clear where and how anthroposophic principles affected my practice.

1.3. Organic farming: threats, obstacles and uncertainties

Verhoog *et al.* (2002 a and b) contended that although organic farming is diverse, there is a tendency in society and politics to push organic farming towards uniformity. The main focus is on general public concerns about environmental pollution, food safety and the natural origin of food additives (see Chapter 3.4). Consumers have a strong belief that organic food is healthier, less polluted and more natural, than conventionally produced foods. This motivates the rapid industrialisation and commercialisation of organic food production (the 'Organic-Industrial Complex'), especially in the USA (Pollan, 2001). Pollan claimed that the way of thinking behind the industrialisation process is very conventional. The aim is to produce uniform organic products that have to be substantially processed to be able to transport them over long distances. The organic produce can be processed, except for the fact that natural additives are used instead of artificial flavours and substitutes. This leads traders and processors to alter the standards to allow all kinds of 'natural additives'. To the consumer, organic farming is presented as a small, but healthy change. Organic produce is very similar to conventional produce, except for the fact that the (many) ingredients should not be artificial. Retaining organic farming as a truly alternative approach to integrated and environmentally friendly production requires political support based on the improvement of farming system ecology and life integrity. These notions would also have to be incorporated in research to support the development of organic farming (Chapter 3.4).

Organic farming is now at a very critical point in its development. The Dutch Government is stimulating organic farming to grow to a level of 10% of total agricultural area in 2010 (LNV, 2000), a large increase compared to the 1.5% in the year 2001. This stimulation takes the form of a new market infrastructure, support for advice and training, subsidies for covering the first two years of conversion, and support for R&D. This rapid expansion and the presumably large numbers of converting farmers raise questions with respect to the nature of the conversion that the converters experience and the nature of the organic principles that they will follow. There is the not imaginary threat that organic farming will be reduced to an improved system of integrated farming that is among others caused by:

- insufficient holistic regulation to support organic principles. This leads to contradictions between the reality of the farm economy and the identity of organic farming. Adequate economic alternatives are absent and economic incentives are too oriented on the short term;
- the innovations in organic farming promoted by the new generation of traders and processors is based on too low standards and does not reflect its holistic principles;
- regulations and state legislation covering conventional farming are oriented on symptoms and therefore come into conflict with holistic solutions;
- the nature of scientific support and advice given is not based on an inner conversion of the scientific community.

I expand on some of these issues because they are important for understanding the new context within which research in support of organic agriculture is expected to work.

Scaling up of its share of the consumer market is a necessary next step in the development of the organic sector. The question can be raised how the innovative elements and holistic views of organic farming can be retained by the new generation of farmers, scientists, traders, politicians and extensionists. The inner conversion to organic ideas is a time consuming process. For instance, the effort to create a new type of agricultural professional for Australian agriculture in the so-called Hawkesbury experiment took almost 20 years. (Bawden *et al.*, 2000). *'Clearly a praxis that is truly systemic, has to embrace learning competencies that accommodate the ethical along the technical, the aesthetic along the practical, the spiritual along with the rational'*. Exactly these aspects are also part of the conversion to organic agriculture.

In our economy, the distance between consumers and producers has become larger and the anonymity of products has increased. Players in the organic market are rapidly changing from involved pioneers to companies with multinational activities (Chapter 3.2). The same price squeeze that threatens the survival of conventional farms is felt in organic agriculture. Each year brings new pressures to reduce costs, to increase efficiency and to scale up farm size. To maintain farm income, the farm structure also in organic farming has changed from farms with closed mineral cycles to more specialised, simple structured farms with a high production per animal and per land area, still within, but challenging the constraints of EU 2092/91²¹ (Baars and Van Ham, 1996). The economic room for making the conversion to organic farming or for maintaining a certain standard quality of farming system is becoming smaller (Chapter 3.3).

²¹ Schlüter (2001) showed the differences between the bio-dynamic principles and the EU-standards. For instance in the EU-standards there are no restriction on inputs of organic fodder; 10% of the fodder purchase can be conventional; and cattle can be fed with 40-50% of concentrates.

An adequate regulation that reflects the identity of organic systems in a growing market is very important (Vogt, 2001). In several areas, regulatory development still does not support the principles of organic farming. In the past, at first restrictive guidelines were established for manure use and plant production. Later on, regulations were developed for animal production (EU regulation 2092/91). At present, a discussion has been started about standards for animal welfare (Alrøe *et al.*, 2001; Lund and Röcklingsberg, 2001; Spranger and Walkenhorst, 2001), about the origin and type of breeds (Nauta *et al.*, 2002) and about seed production techniques (Lammerts van Bueren *et al.*, 1999; Lammerts van Bueren, 2002 in prep.). But it is not only the lack of suitable guidelines for specialised issues, such as animal health and welfare that is frustrating the intentions of organic farming (Keppler, 2001). Adequate standards are necessary also with respect to more holistic issues such as the nature of mixed farming systems (Schlüter, 2001), bio-diversity and landscape (Bosshard, 2001), socio-economic conditions (e.g., labour quality, fair trade and ownership and price of land) and 'values of scarce commodities' (e.g. wildlife, fresh air, clean water). Since market prices are determined by supply and demand, issues such as produce quality, regional production or closed mineral cycling are not accounted for in the prices of organic produce.

Taking organic farming as an integrated solution to agricultural problems would not only imply a change in technology, but also a change in the socio-economic network in which agriculture is embedded. From the point of view of organic farming, the new mid-term review of the EU's Common Agricultural Policy (CAP) only provides an opportunity to give political support for another view of the market that will cut the link between production and direct payments. In addition to supporting farm incomes, CAP will also reward farmers for food quality, animal welfare, the preservation of the environment, landscapes, cultural heritage, and the enhancement of social balance and equity²².

1.4. Changes in R&D of agriculture

Sustainable agriculture is knowledge-intensive. Organic farming has expanded the horizons of agricultural practice. It is questionable, therefore, whether the methods, techniques, social approaches and organisation that have been used in agricultural research and extension to intensify conventional agriculture are suitable to support organic farming (Röling and Jiggins, 1998). It is clear that organic farming calls not only for new knowledge and techniques, but also for new attitudes, socio-economic behaviour and mentality in farm practice and in science and advice. With regard to systemic development, Bawden *et al.* (2000) described the reform of the

²² EU press release July 10, 2002: Towards sustainable farming - Commission presents EU farm policy mid-term review.

agricultural curriculum at the University of Western Sydney. The evolution of methods of research and extension has been described for the developing countries (Chambers, 1992) and also for integrated farming (Vereijken, 1992; Somers and Röling, 1993; Proost and Röling, 2000). Table 1.1 summarises the development of research and extension.

Table 1.1 Research and extension: some dominant beliefs and approaches 1950-2000 (after Chambers, 1992)

	Explanation of non-adoption	Prescription	Key activities	Focus of socio-economic research	Methods	Label
1950s 1960s	Farmers' ignorance	Extension education	Teaching, transfer of technology	Diffusion of innovations, determinants of adoption	Questionnaire surveys	Diffusion research
1970s 1980s	Farm-level constraints	Removal of constraints	Input supply, adapted approaches	Constraints; farming systems	Questionnaire surveys, on-farm research	Farming system research
1990s	Inappropriate technology	Farmer participation	Facilitation of participatory processes	Participatory approaches and methods	Discussion observation, diagramming by and with farmers	Farmers participatory research, Participatory Technology Development, farmer-first, PRA ²³ , etc.
>2000	Inappropriate policies, failure of market forces and technological fixes	Multi-stakeholder learning	Facilitation of discovery and learning	Multi-stakeholder situations, Interactive learning	RAAKS ²⁴ , stakeholder meetings, platforms	Social Learning

Röling (2000) mentioned three driving forces behind the development of industrial agriculture and the role of science in it: (1) Science is the source of agricultural innovations. These innovations address component technologies and have been developed on the basis of positivistic and reductionist practices aiming at gaining control over nature. (2) The 'Agricultural Treadmill' (Cochrane, 1958; Röling *et al.*, 1998), which creates a constant price squeeze. Each technical innovation gives its early adopters an economic advantage and creates pressure on

²³ PRA = Participatory Rural Appraisal (Röling and Wagemakers, 1998)

²⁴ RAAKS = Rapid Appraisal of Agricultural Knowledge Systems (Engel, 1997)

others to follow suit to stay in the income race. (3) A continuum of organisations is required which covers the whole field from basic research to application, which delivers science-based technology to 'ultimate users'. Kline and Rosenberg (1986) called this approach the 'linear model'. Of course, the practice of research and extension often differed from this model, but policy, public investment, and development assistance were based on it (Hubert *et al.*, 2000).



... farmer participation in the Farmer Field School approach ...

It is fair to say that the explicit resistance against this model started in developing countries. It soon became clear that Western technologies and farm management approaches could not be used as blueprints in the sometimes very complex farming systems in those countries. Therefore, other ways of developing technology and of learning to improve farm situations had to be invented. A typical example is the Farmer Field School which was developed for Integrated Pest Management (IPM) in rice in Asia, after it became evident that so-called Green Revolution rice production technologies and especially pesticide use induced pest problems that threatened food security in countries such as Indonesia. The Farmer Field School approach is now used for a wide variety of farm situations, crops and problems. An unexpected side effect of the Field Schools, based on farmer experimentation, discovery learning, discussion in farmer groups, etc., is that farmers gain pride, no longer consider themselves as helpless peasants and begin to develop their own organisations to solve their own problems (Röling and Van de Fliert, 1998). This human factor has been an important starting point for sustainable bottom-up development (Hagmann *et al.*, 1995).

Another example of the adaptation of the linear model in developing countries as the 'discovery' indigenous knowledge. One of the first times this happened was when Norman (1980) and his colleagues in Northern Nigeria started to ask themselves why farmers adjacent to the experiment station refused to adopt mono-cropping. A study of multiple cropping as practised by local farmers revealed that the local practice provided better protection against the risks emanating from unpredictable rainfall, provide better pest control, used the scarce production factor of labour at peak times more efficiently, gave a higher yield per hectare and brought more profit

both per person-day and hectare. Such discoveries led to the development of approaches that involved farmers in technology development (e.g., Pretty, 1995; Waters-Bayer and Bayer, 2000). Also in the 1970s, it became clear that the extent to which project impact proved sustainable was directly related to the extent to which the beneficiaries participated in and felt committed to the project.

Several guides for participatory approaches and for participatory technology development have now been published (see for instance: Mutsaers *et al.*, 1997; Selener, 1998; Van Veldhuizen *et al.*, 1997). Sumberg and Okali (1997) remarked in their overview of the literature dealing with indigenous agricultural experimentation and innovation: *'...both farmers' experiments and much formal experimentation aim to develop practical solutions to immediate problems or to seek gains within the context of proven production methods and systems. Both are largely experiential and iterative, combining experience, observation (both methodological and opportunistic), intuition, persistence, skill and luck...'*

Facilitating sustainable farming systems means active creation of local knowledge through discovery learning and inter-subject social learning (Röling and Brouwers, 1999). The focus changes from techniques to the management of ecosystems and insight into processes. In a focus on learning, it is not so much the end result and the exact answer that matter, but the process of the search for your own solutions and development (Bawden *et al.*, 2000). The process of co-learning combines academics, teachers, facilitators and farmers within a team. Østergaard (1997) mentioned two basic expansions of the traditional role of the agricultural researcher as the producer of knowledge. *'There will be a need for methods and structures which enable farmers to become co-researchers and learners. Secondly there is a need for developing 'flexible tools' – methodologies adaptable to the individual situations on farms with regard to human, climatic and economic conditions. The farm can become a place of mutual learning where concrete problems and challenges in concrete situations form the common task for the learning among farmer, advisor and researcher.'*

Approaches using such principles are rapidly becoming mainstream, also in industrial countries (e.g., the Landcare movement in Australia). In the Netherlands typical examples are the introduction of integrated farming (Somers and Röling, 1993; Proost and Röling, 2000) and the VEL-VANLA project (Verhoeven and Van der Ploeg, 2001). In terms of the philosophy of science, the development described means that R&D is incorporating a greater attention to systems (i.e., moving from reductionism towards holism) and accepting that 'realities' other than the scientific reality matter (i.e., changing from positivism towards constructivism) (LEARN group, 2000). In The Netherlands on-farm research with farmers has only emerged in

an approach that seeks to prototype farming systems (Vereijken, 1992; 1995; 1997; Wijnands, 2000). There also is a much greater interest in interdisciplinary research approaches to farming systems (Aarts, 2000).

Organic farming with its emphasis on farm- and site-specific development, on holism and on interaction with pioneering farmers and problem owners has, from the start, experimented with approaches that reflect a recognition of the farming system and that are what one would now call 'participatory' (see Lockeretz, 1991).

1.4.1. R&D discussion in organic agriculture

The current mainstreaming of organic farming is now supported by governmental policy. Where research in support of organic farming was once only carried out by private research institutes and initiatives, now, all over Europe, research in organic farming is being taken up by existing public institutions and universities, and supported by national governments (Niggli, 2002). The research approaches and methods that are used in the new situation have remained implicit. The point of departure of this thesis is, therefore, to explore whether organic farming, by its very nature, requires different R&D approaches and methods.

I am not the only one concerned with this issue. At the IFOAM meeting in Canada, Köpke *et al.* (2002) launched an International Society of Organic Farming Research out of concern that the principles of organic concept might be diluted if many disciplinary research activities are undertaken that have not been properly grounded on these principles. However, older networks also dealt with these issues. A European network of bio-dynamic researchers, who annually met in the period 1980-1990 (among others Bockemühl *et al.*, 1992), discussed principles and differences of research methodologies and strategies between conventional and organic farming research. Recently a group of researchers in organic farming initiated a discussion on the need for new or additional methods of research and extension in organic farming (Krell and Zanoli, 1999; Zanoli, 1998). Key words with regard to methodologies used in R&D in organic farming identified in this group are (Krell and Zanoli, 1999): on-farm research, participatory research, tailor-made decision support, case studies, pilot farms, prototyping, decision-support tools, farming systems, whole-farm studies, demonstration farms. All these terms show an interest in additional research methodologies and ask for strategies that integrate basic and applied research and extension.

One can suggest several reasons why on-farm research is still not generally applied in organic farming. Lockeretz and Stopes (1999) discussed the problems of on-farm research on organic farms. Reasons why such research seems very dissimilar to conventional agricultural research

from a methodological point of view are: *'realistic (complex and integrative) management of the experimental area conflicts with traditional criteria for good experimental design, because many more variables come into play. In traditional research, only a few variables are considered relevant and all others are carefully controlled at their ideal values. Otherwise, analysis of the data becomes difficult and it may become difficult to pin down the phenomenon of interest. On-farm research is difficult to analyse because it allows more complexity, but is more complex because it is more realistic'*. Earlier I have remarked that such farm research is probably more appropriate for developing 'systems that work' than for establishing causal relationships.

Evaluations of research programs in organic farming (Lund, 1998) or abstracts and papers presented at scientific conferences in organic farming (Lockeretz, 2000), showed that over 90% of organic farming research hardly differs from conventional research. The majority of projects discuss only one component of a farming system and only a few outcome variables are included. There was little evidence of interdisciplinary approaches or of participation by farmers. The main difference is the *topic* of study, not *how* it was studied (Lockeretz, 2000). Although Lockeretz did not explain the reasons for his findings, he suggested a moratorium on the use of the words 'holistic' and 'system-approach' in discussions about research methodologies in organic farming. I believe that such a moratorium would be a mistake. In the first place, organic farming research, as practised, especially now that so many conventional researchers are entering the field of organic farming research, might not be the best guide for what such research could or should be, given the intrinsic character of organic farming. I shall, of course, discuss this issue in greater detail during the rest of this thesis. In the second place, Lockeretz' findings can give a biased picture for a number of reasons:

- In order to have their papers accepted by mainstream peer-reviewed journals researchers choose to communicate their findings in terms of accepted research methods. Journals ask for a traditional evaluation of findings, based on statistics and quantification of measurement. Integrated studies of systems are classified as 'case studies', the lowest category of studies in terms of scientific rigour and predictive power (Vandenbroucke, 1999);
- Researchers in organic farming are likely to communicate their more holistic and participatory work in other journals, mentioned as grey literature (Dororszenko, 2000) and farmer-oriented magazines (e.g., 'Ekoland' (NL) and 'Ecology and Farming' (IFOAM)). Even then, results based on participatory approaches often are only reported in terms of their 'hard science' results and neglect the 'soft' dimensions, such as the critical learning involved, and the roles of attitudes, ethics and reflection. Holistic methods in biological research, such as picto-morphological methods and Goethean science are considered non-scientific by mainstream science. Results from such studies tend to be published in 'alternative' journals (e.g., 'Elemente der

Naturwissenschaft' (CH)).

- Holistic systems that seek to integrate the contributions of different disciplines are hard to investigate, time consuming and depend, naturally, on the input of researchers working in different disciplines (see for instance Aarts, 2000 and Chapter 7). Little money is available to carry out such projects.

1.5. Purposes of this dissertation

Conventional research strategies are also incorporating system approaches and interactive agricultural science and research institutes that used to support only conventional industrial agriculture are now also moving into organic farming. But organic farming has its own set of values. Its holistic character means that the embrace of, or transition to, organic farming implies a shift of paradigm. The organic research community explicitly asks for and experiments with, new research methods and approaches, although the outcomes do not find an outlet in established scientific journals. It is time to make these issues explicit and to systematically explore the nature of methods and approaches that are required for the development of organic agriculture. Together these elements form the point of departure of this thesis.

Based on the experience of the Louis Bolk Institute, one of the pioneering institutes in R&D in organic farming in Europe, I will investigate the research strategies, approaches and methods that support and operationalise the values and principles of organic farming as they have been established by its pioneers in their protest against the advent of industrial agriculture. As a private research organisation, the Louis Bolk Institute was in a position to develop its own R&D strategy based on additional methods of value explanation and investigation, Goethean life science, and experiential research approaches. Out of its experiences the following elements are important to support the intentions of organic farming:

- Acceptance of the self-regulation of the farming system as a complex agro-ecosystem based on site-related farming solutions, while maintaining diversity and respecting the integrity of life and its manifestations.
- Acceptance of the independence and autonomy of farmers' judgements so that they can trust their own observation, intuition, experience and insight and are supported in their learning. In that sense, the farmer is considered to be an expert (this is also one of the principles of IPM Farmer Field Schools).

The purpose of this thesis is to explore whether, and to what extent, organic farming is fundamentally different in character from integrated production or conventional farming and how R&D does and can support this character of organic farming. This exploration is based on

an analysis of research projects carried out at the Louis Bolk Institute. This analysis will hopefully identify the fundamentals, if any, that exist with regard to R&D in organic farming. If successful, as a final step, the exploration will suggest a coherent approach to the design, strategy, approach and methods of R&D that supports organic farming.

In my analysis of research practices in organic farming, anthroposophy will emerge as an important background. It provides the spiritual basis of this dissertation as well as the holistic philosophy of nature and life that underpins the research approach used in the case studies that I have analysed. The question is whether this anthroposophical point of departure nullifies any claims I might make with respect to the generalisability of my findings across all 'blood groups' in organic farming. As I will explain in Chapter 3, when more information is available, I believe it is fair to say that the central spiritual tenets of bio-dynamic farming, especially where the holistic philosophy is concerned, are widely shared among the different blood groups in organic farming. It is true that many organic farmers reject some of the fixed prescriptions that are used in bio-dynamics²⁵ to mobilise cosmic forces for farm practice. But the blood groups in organic farming share its holistic approach²⁶ and try to translate it into daily farm practice (Cf. Chapter 1.2). Later in this dissertation, I will discuss in more detail the implications of adhering to anthroposophy for the generalisability of the outcomes of the thesis to research for organic farming in general.

1.6. Structure of the dissertation

This dissertation has two parts. Part I reflects on learning processes, research methodologies, and approaches in science in the field of organic farming as explained above. Seven research projects carried out by the Department of Grassland and Animal Production of the Louis Bolk Institute are used as case studies to highlight lessons in this respect. Part II is a scientific report on a large multidisciplinary research project on the use of manure and the choice of varieties in grass-clover swards. Part II reflects on the scientific *results*, whereas Part I, is a reflection on *methodology*. Below, I only provide the outline of Part I.

²⁵ These are specific actions designed to 'vitalise the earth', and to affect the growth of plants and animals as much as possible by using forces that emanate from cosmic constellations. Examples are ash-peppers to reduce pest, weeds and diseases, herbal and animal preparations to vitalise compost and soil, and a cosmic calendar for sowing and cultivating crops (Boeringa, 1977; Klett, 1985; Schilthuis, 1999; De Jonge and Beekman, 1999).

²⁶ I am aware that other philosophies are underpinned by similar principles. For instance, Alrøe and Kristensen (2002) discussed the ethics of organic farming in general terms, whereas Alrøe *et al.* (2001) and Lund and Röcklinsberg (2001) discussed the principles of animal welfare. The authors developed very similar concepts of animal integrity to those used in bio-dynamics (Verhoog, 2000). Similar holistic interpretations are found in Boehncke (1991) who discussed the principles of ecological animal husbandry. More recently the German organic research community discussed the guiding models (German: Leitbilder), which inspire organic farmers (Reents, 2001).

Chapter 1 presents the introduction to the dissertation Chapter 2 outlines the conceptual framework and methodology used to analyse the different case study projects that form the empirical base of the dissertation. Chapter 3 provides necessary context by describing the organic dairy sector in The Netherlands over the last 15 years. Also by way of context, Chapter 4 summarises some of the history of R&D at the Louis Bolk Institute. Chapters 5 and 6 contain the descriptions of six case studies and the research methods used. Smaller case projects focusing on specific main aspects of the research approaches used are presented in Chapter 5, whereas Chapter 6 presents an integrated research strategy of a large interdisciplinary project. The analysis of each project outlines the background of the question, the methods used, reflects on the method used in terms of a framework established in Chapter 2, and summarises the research findings. Chapter 7 provides an overall analysis of and reflection on the methodologies presented in the previous Chapters. Where the case studies presentations could not avoid presenting a fragmented picture, Chapter 7 seeks to establish that the consistent elements of R&D can be seen as a coherent research strategy. The final Chapter 8 draws together the main conclusions about R&D in organic farming, and identifies the implications for improvement and future research.



2. Conceptual framework and methodology

This Chapter will outline the framework for analysing the different research methods used in organic grassland and animal production by the Agricultural Department of the Louis Bolk Institute. It is a reflection on the nature of science and on methods used according to the Institute's research philosophy as it was outlined in Chapter 1.1.2. A complication for this reflection is my personal involvement as an actor in all research projects (see Figure 1.1). There are three levels of involvement and therefore three levels of reflection are needed. I was an involved actor in a R&D project (*process actor*). But I was also an observer of the outcomes of each case study project (*observer*). Thirdly, I am an analyst of methodologies used in the projects (*meta-observer*).

My analysis of the research process in this dissertation was greatly supported by three sets of experience. In the first place, the double position of the researcher in experiential science as both a researcher-observer and as an actor in a process of mutual learning (Baars and De Vries, 1999). In this project, an external process counsellor, De Vries, supervised the researchers involved with regard to the research approach and the interactive learning process with farmers. BOX 7.1 (Chapter 7) will further elaborate on the position of 'process-actor'.

In the second place, I have been a member of two international networks of researchers in bio-dynamic farming and organic farming for several years (Krell and Zanoli, 1999). These networks have been set up to discuss research strategies and methods. That is, the focus of these networks was on research methods and not on the outcomes of research. One of the networks also pays explicit attention to the philosophy of science.

In the third place, research methods and ethics relating to organic farming are regularly discussed within the Institute itself. A circle of colleagues meets for 1½ hours every week to assess the results of research projects, and discuss the methods used and the underlying research philosophy.

Two complementing frameworks will be used for the analysis of the observer's role in the different case studies and for the meta-analysis of the methods applied in the projects. The frameworks were adapted so as to allow a holistic approach, position the research methods applied and reflect on the steps undertaken in each project. The two frameworks are a four quadrant framework, representing some basic choices of the philosophy of science (Chapter 2.1) and a triangle of research methods applied in agricultural R&D (Chapter 2.2). The adaptation of the frameworks is based on the earlier discussion on holism-reductionism. One could say that the

use of the adapted frameworks allowed me to follow what Looijen (1998) calls a '*radical holistic research strategy*' (see 1.1.1).

2.1. The four-quadrant framework

The first framework is a four-quadrant matrix, developed by Miller (1985) and adapted by Bawden (1997) and Röling (2000) (Figure 2.1). The matrix reflects two polarities derived from the philosophy of science:

- The objectivist, positivistic approach to knowledge, versus the subjectivistic, constructivistic one. This contrast reflects different epistemologies in the way we try to understand the world;
- The holistic versus the reductionistic approach to observation, thinking and explanation. This distinction reflects two discussions. In the first place, the discussion about mono-, multi- and interdisciplinary approaches in which holism stands for recognition of higher levels of organisation in nature and of emergent properties (Looijen, 1998). Holism in this sense refers to the move from purely reductionistic science to the embrace by scientists of hard systems thinking and to the recognition of emergence and complexity. In Figure 2.1 this move is represented by the move from quadrant 1 to quadrant 2. In the second place, holism is used to reflect the acceptance of 'soft' systems, i.e., acceptance of the distinction between hard goal seeking systems with given goals, and soft systems with contested human goals (Checkland, 1999). The third quadrant in Figure 2.1 represents the recognition that most hard systems are sub-systems of soft systems (Pearson and Ison, 1997). Often the distinction between holism and reductionism in science is discussed without paying explicit attention to constructivism.

	Constructivism (subjectivism)	Positivism (objectivism)
Holism	3. HOLO-CENTRIC	2. ECO-CENTRIC
Reductionism	4. EGO-CENTRIC	1. TECHNO-CENTRIC

Figure 2.1. Matrix to distinguish between different scientific paradigms (after Miller, 1985; Bawden, 1997 and Röling, 2000).

These basic distinctions in the philosophy of science have also been used to describe the evolution of R&D strategies (LEARN Group, 2000). Figure 2.2, illustrates this evolution as the move from mono-disciplinary research (quadrant 1), via the (multi-disciplinary) attention to (farming) systems (quadrant 2), to (trans-disciplinary) research projects based on interactive and

critical learning (quadrant 3). This development represents an integration of hard agro-ecological approaches and soft system thinking which sees agro-ecological outcomes as emergent from human interaction (Jiggins and Röling, 1998). The ecologist Holling (1995) referred to this integration as 'adaptive management', i.e., the need to take into account the ecological imperatives through learning. According to Kersten (1995), the researcher is not external to the system but part of it. The system is socially constructed and therefore involved responsibility replaces outsider objectivity. In soft systems thinking, human reasons become causes, and 'institutions' matter more than experimental proof (Röling, 1998). A good example is the way in which Pearson and Ison (1997) discussed the evolution of grassland agronomy strategies: *'No longer can a grassland agronomist be concerned with only technical issues that have preoccupied grassland agronomy for most of the last 50 years. The complex, messy problems that the next generation of agronomists will attempt to address will require skills and understanding that are not found within conventional agronomy texts' 'Thinking of grassland systems is necessary as social constructs and system concepts are used to think about, describe, and inform action in the design of future grasslands.'*

2.1.1. Expansion of the four quadrant matrix

A regular and recurrent point of discussion in organic farming research concerns the definition and contents of holistic research methods (Lund, 1998, Niggli, 1998, Alrøe *et al.*, 1998; Lockeretz, 2000). In Chapter 1.1.2, the discussion of holism versus reductionism in biology and ecology was introduced and attention was paid to epistemological, ontological and methodological aspects (Looijen, 1998). In view of that discussion, the four-quadrant matrix can be elaborated as follows.

- A reductionistic research approach looks for explanations at lower levels of complexity. Explanations are thought of in terms of causal relationships, and the lowest level of life is thought to be DNA. The communication of scientific findings is based on measurable quantities. Holling (1995) called this approach a science of parts. In this thesis I will also use the word reductionism to refer to a limitation of attention and a narrowing of focus of an



... the complex messy problem of oversowing of white clover solved in a social context ...

observer without the use of the reductionistic explanation.

- A holistic research approach looks for understanding at higher levels of integration, focusing on the context of the object of research, on the relationships between the elements making up the whole, and on the emergent properties of each level. According to Holling (1995) this approach is a science of the integration of parts. In anthroposophist thinking, holism is search for unity, entity and/or integrity, and the highest level of unity is the level of spirit. That is, systems are not just assemblies of a chemico-physical nature. Unity is thought of as a spiritual and leading principle that can be recognised at all levels of integration.
- An objective, positivistic approach tries to eliminate the viewpoint of the observer (Pretty, 1995) by means of methods that prevent bias and by using instruments that eliminate subjective interpretations. Unbiased values have to be discussed as measured, counted or weighed relationships. A statistical analysis is used to discriminate between observations (Looijen, 1998).
- In a subjectivist, constructivistic perspective multiple realities exist that are socially constructed. As part of a community, people collectively bring forth *a world*, which is realised through involvement and personal commitment. The constructed world is value-bound, instead of value-free and has emergent properties due to human action (Pretty, 1995). The choices of themes in research and the interpretation of its findings depend on personal attitudes, experiences, beliefs, personal worldviews, religion, etc. Röling (1997; 2000) spoke of 'the soft side of land use' and called for research on the way in which people construct their land use. From my own anthroposophic perspective, the reality of hard natural science also is a constructed world. Science is a human method of knowing and subjectivity is part of the observation method itself, and cannot be divorced from the personal skills, belief and experience of the observer. This is particularly the case in Goethean science, which can be interpreted from the point of view of natural science as a 'double constructivistic scientific approach'²⁷. Only direct observations are made without interposing instruments between the perceiver and the phenomena and all senses are used for observation²⁸. The human being is the measuring instrument itself. Goethean science is also holistic, because it focuses on different system levels. However, in order to prevent a chaos of arbitrariness, people can be trained to use their personal skills in an objective way and the personal findings have to be

²⁷ In science the bias of the scientist is reduced in two ways: instruments objectify the observation and measurement objectifies the observed. Therefore Goethean science has two elements of construction, namely the observer himself, his/her skills, involvement and attitudes, and the observed, whose characteristics cannot be reduced to only measurable values.

²⁸ Goethe was deeply convinced of the primacy and immediacy of sensory phenomena. For him, sensory qualities were substantial irreducibles that are explicable only in terms of themselves (Hensel, 1998). This conviction is, of course, disputable from the point of view of objectivity.

reflected upon.

- Experiential science too has the same constructivistic element. However, the reflection now focuses on personal action based on skills. As in experimental science, experiential science is reductionistic because it always reflects on a part of the world.

Using the above elaboration of the dimensions used in the four quadrant matrix, I have relabelled the four quadrants below in a manner that provides a framework for analysing concrete case studies of research in organic agriculture. I have already made clear what specific anthroposophic elements are being introduced.

- *Eco-science-holism (2nd quadrant)*: research is expanded from component, reductionistic science (1st quadrant) towards multi- and interdisciplinary system science, based on the ecosystem approach of Odum (quoted by Lund, 1998), who looked at relations within the ecosystem based on energy flows. In agriculture, the agro-ecosystem was formulated as a new level of analysis and as context of detailed research questions. Instead of the farm's components, the total farming system became the focus of attention, even if the same scientific methods often are used as in compartmentalised science (Aarts, 2000). Farm models can be used as blueprints based on complex constructions based on the integration or synthesis of reductionistic research findings. An expansion of a hard farming system approach to incorporate the needs of society is often accomplished by focusing on agricultural marketing chains.

The additional elements that play a role in the third quadrant are (1) human values, beliefs and behaviour, including learning and education processes, and (2) ethics. I include a third dimension for this quadrant, the *constructive elements within science itself*. Therefore, three elaborations are made for the 3rd quadrant:

- *Socio-holism*: focus on farming styles and human attitudes, i.e. the connection between beta and gamma sciences with an emphasis on learning processes (Jiggins and Röling, 2000). This includes the economic studies of farming systems. Röling and Brouwers (1999) discussed the human side of indigenous knowledge in plant breeding. In their view, indigenous knowledge is not only a physical relic of the past in terms of old tools and machinery or old cultivars within a seed bank, but also a living and adaptive resource of human skill and local knowledge needed to manage ever-changing local situations.
- *Value-holism*: focus on ethical values. The relationship to life styles or business styles is part of this aspect. One's personal ethical values affect one's view on life. Verhoog (2000) distinguished five bio-ethical theories: anthro-centric, patho-centric, zoo-centric, bio-centric and eco-centric. A bio-ethical theory is normative in that it defines what is to be considered

morally relevant and what is not. For example animal breeding strategies should include awareness of these different bio-ethical theories. One should realise, for instance, that the concept of animal integrity cannot be found within anthropo-centric and zoo-centric approaches, the most prevalent bio-ethical theories at present (Visser and Verhoog, 1999). Therefore, a discussion of values is only relevant if one is prepared to become involved in other points of view.

- *Goethean science as life science holism*: as a phenomenological approach, this orientation is holistic because all elements of a life cycle are a part of research. Its context is inclusive. At the same time, the approach is constructivistic because the method is based on direct observation that depends on human skills, etc. The observer directly experiences the phenomenon being studied without the use of instruments. Therefore the skills of observation have to be trained to reach a level of inter-subjectivity and to prevent subjective statements (see Chapter 5.5).

The interpretation of science in the 4th quadrant is called 'experiential science', the epistemology

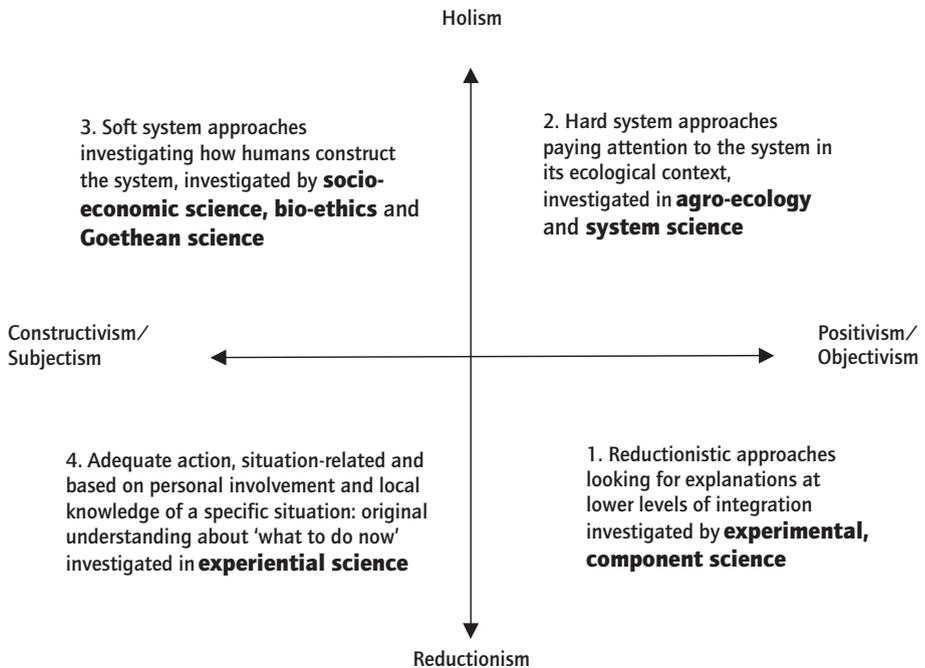


Figure 2.2. Adaptation of the Four-Quadrant matrix to provide a framework for the analysis of case studies of research projects in organic agriculture. The adaptation makes clear where anthroposophic principles come into play in the analysis.

of action research. A key element of experiential science is '*adequate action*' in terms of relevance, effectiveness, timing and vision. Such an action is always related to a part of the world, which gives the quadrant a reductionistic element. At the same time, adequate, situation-based solutions are found only after personal involvement, which provides a constructivistic element. Maturana and Varela (in Kersten, 1995) said, that '*to know is to be able to operate adequately in a situation*'. In their emerging view of professionalisation of agricultural R&D workers, Bawden *et al.* (2000) used a similar term to describe adequate action: '*responsible action*'; '*the idea of responsibility of action is very firmly linked to notions of ethics and of moral dimensions in decision making*'. In all, I suggest a new epistemology of action in terms of experiential science:

- *Experiential science based on adequate, situation-based action (4th quadrant)*: the final goal is to look for adequate answers ('systems that work') and site-adapted solutions. Its final methodology as elaborated in this thesis, includes intuitive learning of farmers, mutual learning of on-farm experiments and a reflection on farmers' action. Together these are the elements of experiential science (Baars and De Vries, 1999).



... experiential science: concrete issues facing individual farmers ...

2.2. The triangle of research methods

The second framework is a tool to describe the relative position of various methods in strategic and applied agricultural sciences (Alrøe *et al.*, 1998). The three corners of the triangle are used to discriminate scientific methods:

- *Laws of nature*: knowledge about the world explained as causal relationships of materialistic findings;
- *Images*: models to construct the knowledge of a complex world;
- *Actions*: action to test and apply knowledge and models of the world.

The two frameworks do have a relationship. The polarity of holism – reductionism in terms of more or less integration of research disciplines in relation to the emergent properties can also be recognised in the triangle in Figure 2.3. In the upper half of the triangle, research methods are

CHAPTER 2

more holistic, which in this case means being more systemic, covering a higher integration of farm segments and using more interdisciplinary approaches to research. At the bottom end of the triangle, basic research approaches are emphasised, focusing on details mainly through mono-disciplinary research and small-scale and detailed experiments. The distinction between constructivism and objectivism is not present within this triangle because all research methods mentioned in Figure 2.3 are assumed in the original to emanate from a positivistic approach.

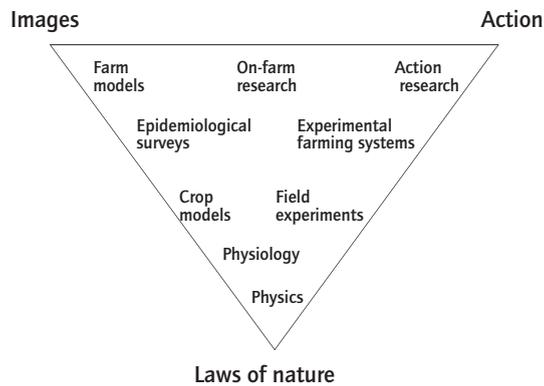


Figure 2.3. A triangular view of research methods (based on Alrøe et al., 1998)

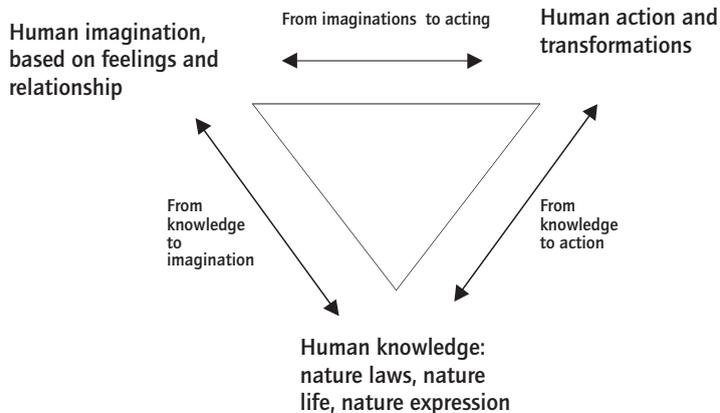


Figure 2.4. The triangle adapted to allow its use as a framework for analysing case studies of research projects in organic agriculture (adapted from Alrøe et al., 1998)

2.2.1. The adaptation of the triangle for purposes of the present research

As mentioned above, the triangle sorts conventional science approaches in agriculture. Before I can use it as a framework for the analysis of the case studies, the triangle needs to be adapted. I made adaptation on the basis of the work by Maturana and Varela (1992) on the elements of the cognitive system, and on the basis of Steiner's (1904) work on the domains of the human soul, thinking, feeling and willing. These three elements of cognition are connected in such a way that subject oriented feelings or emotions finally decide about the type of our action and perception (see 1.1). Table 2.1 suggests that the elements of cognition, the domains of the soul, and three areas of human interest suggested by the triangle can be considered as basic dimensions underlying the approaches used in the holistic research methods applied by the Louis Bolk Institute.

These parallels allow the adaptation of the triangle so that it can be used as a framework to analyse the activities undertaken in the different case study projects, as shown in Figure 2.4. Projects can start in any corner of the triangle. Some start in actions with farmers (upper right hand corner of the triangle), they can start from an exploration of ethics (upper left hand corner) or they can start because of a lack of knowledge about natural processes (lower corner). During the project, connections with one or both other corners of the triangle are established. The triangle can be used to make a first classification reflecting the main focus of each project.

Table 2.1. Parallels between the elements of cognition, the domains of the soul, the dimensions of human interest and their relationship to scientific approaches used by the Louis Bolk Institute

Elements of the cognitive system (Maturana and Varela, 1992)	Domains of the soul (Steiner, 1904)	Area of human interest (Alrøe's 1998 triangle, Figure 2.4)	Louis Bolk Institute's approaches in holistic research
Perception	Thinking	Knowing and understanding	Goethean life science, picto-morphological methods and inter-/multi-disciplinary science
Emotion	Feeling	Judging, images, values	Bio-ethics, visioning and communication of concepts
Action	Willing	Acting and transformation	Participatory research and experiential learning with pioneering farmers

2.3. Case studies to develop new concepts

The evaluation is based on an analysis of seven case-studies (Chapters 5 and 6) chosen by myself to illustrate the full range of specific methods, findings and statements used in the past 20 years by the Louis Bolk Institute's grassland and animal systems research. No attempt has been made to select representative case studies or to select all projects. According to Vandenbroucke (1999) case studies are important because a case-report can tell us what is 'unknown' or 'unrecognised'. It can present a general truth that can be stated in abstract scientific terms even though it was based on a single observation. According to conventional science criteria, case study reports and case series are regarded as the least rigorous approaches. Yet they have a considerable potential to stimulate new learning and formulate new ideas. Case studies are highly sensitive to novelties that are identified in a qualitative way (Vandenbroucke, 1999). Yin (1993) defined the case study method as a form of empirical inquiry that investigates a contemporary phenomenon within its real-life context, addresses a situation in which the boundaries between phenomenon and context are not clearly evident, and uses multiple sources of evidence. Case studies can be exploratory, descriptive or explanatory. In this dissertation, case studies are used to explore, identify, describe, analyse and illustrate the range of research methods used in organic agricultural research.

Each of the chosen case studies analyses a specific research method, describes the research findings (briefly in most cases) and reflects on the results. Since the purpose of this dissertation is to position, analyse and reflect on scientific strategies that support the characteristics of organic farming, the focus is mainly on the research process in terms of steps undertaken and less on the research findings and technical outcomes. The seven case studies each had a focus in one of the corners of the triangle presented in Figure 2.4. In selecting the cases in relation to action research we relied on the questions and challenges of pioneering farmers or traders.

In almost all cases, the actions of farmers in their own daily practice were an important source of new questions. Dialogue groups (Kersten, 2000) were used to discover new areas of interest and to maintain contact with farming practice, the key to our awareness of farmers' needs²⁹. Due to our on-farm trials and demonstration projects, we were conversant with farming practice on different soil types, and with different farming styles and farm intensity levels. New questions and new areas for development were obtained directly from practice. Thus at each of the three

²⁹ An important dialogue group that reflects on research topics is the 'Natuurweide' Farmers' Association. It carries out research financially supported by the Louis Bolk Institute. At least once a year, members of the Institute meet with a delegation of farmers to discuss research outcomes, problem areas and new research topics.

corners of the triangle, whether it reflects farmers' actions, ethics or knowledge, farming practice was the entry point for raising issues.

In conclusion

The case studies in Chapters 5 and 6 will be analysed according to the two adapted frameworks. One of the key characteristics of organic farming is the rejection of the use of artificial fertilisers and chemicals. Compounds have to be replaced by agro-ecological measures to support *the self-regulation of systems*, to allow *site-related solutions*, to maintain *a diversity of farming systems* and to respect *the integrity of life*. The statements in italics represent 'the spectacles' for examining research methods at the meta-level (Chapter 7).



3. Organic farming in The Netherlands

In this chapter, the history and development of the two mainstream organic farming associations will be presented to provide some context for the research presented in this dissertation³⁰. In order to understand the approach and background of research for organic farming, it is relevant to provide some historical background on organic farming and to show how differences emerge in modern organic agriculture.

I will start the chapter by describing the two main labels used in organic farming in the Netherlands. I then explain the structure of the organic dairy farming in the year 2000 with the use of economic statistics. All organic dairy farmers have to deal with the same market characteristics. Also organic farming is based on principles and standards that are reflected in the worldwide IFOAM standards and in national legislation. However, it is clear that organic farming even in one country does not reflect only one style of farming and the milk market is changing rapidly. In the last part of the Chapter, I will present an additional set of concepts with which it is possible to classify organic farming according to the ways farmers interpret nature and natural processes in farming.

3.1. EKO and Demeter as the two mainstreams in organic farming

The two mainstreams in organic farming in the Netherlands are called ecological (EKO-label) and bio-dynamic (Demeter-label) farming. In terms of the EU regulation 2092/91, the overall term for organic farming in The Netherlands is 'biologisch' and the overall label is EKO. As in other European countries, labels such as Demeter are additional to the mainstream label.

3.1.1. EKO

The ecological movement started as an initiative that had nothing to do with bio-dynamic farming, even though bio-dynamic farming in the Netherlands had been going on for many years at the time. The ecological movement was born in the city of Amsterdam in the early 1970s. It was based on the revolt of the student movement against established politics. An important issue was the ownership of property. For example, the so-called 'Provo-movement' developed various plans for the shared and free use of bicycles in the city. Around 1970, the report of the

³⁰ Important sources for Chapters 3.1 and 3.2 were: 'Ekoland', the farmers' journal for organic farming; 'Vruchtbare Aarde', the journal of the bio-dynamic society until 1990; 'Verenigingsnieuws', the journal of the bio-dynamic society since 1990; Schilthuis, (1999); Boeringa (1977), and personal communication with Rob Boeringa (formerly of the NRLO (Nationale Raad voor Landbouwkundig Onderzoek)).

Club of Rome raised widespread awareness about the natural limits to the exploitation of non-renewable resources. In the same period, various environmental organisations were established, partly related to environment (e.g., Stichting Natuur en Milieu, Milieudefensie), and partly based on agriculture (e.g., De Kleine Aarde). Members of the movement who were interested in agriculture started their own small market gardens. The first 'organic shops' to sell their produce appeared in the major cities.

Nowadays, the 'Green' political parties reflect the intentions of the erstwhile ecological movement. These intentions were based on personal responsibility and environmental concern. The main issues of the ecological movement were:

- work should be friendly to people as well as to the environment;
- enterprises should be small-scale;
- trading should be regionally based with short transport lines;
- agricultural prices should not be based on an anonymous market;
- the earth should not be exploited, recycling should be stimulated;
- over-consumption of food should be discouraged; and
- the third world should not be exploited.

The ecological movement was the first organisation to develop official guidelines and standards for farm practice (March 1982). The Dutch Society for Ecological Farmers (NVEL) was founded in 1982.

People within the ecological movement were not primarily attracted to the anthroposophic and spiritual character of bio-dynamic farming. Their interest was much more based on the overall concern for the environment and pollution. Ecological farming started in 1978 as a separate body of practice. Its development was based on private consulting ('Ekologisch Landbouw Consulentschap'), a control body ('Stichting Alternatief Warenonderzoek') and an information service for consumers ('Alternatieve Konsumentenbond'). Initiatives for an ecological school similar to the bio-dynamic school at Warmonderhof began in 1982. However, the Ecological Movement did not succeed in establishing private education of this nature. Later, courses in organic agriculture were integrated into several 'conventional' tertiary level schools of agriculture.

3.1.2. Demeter

The first bio-dynamic farm in the Netherlands started in 1926 (Heinze *et al.*, 1986). In 1937, the 'Foundation for Bio-dynamic Farming' was established. Information about bio-dynamics was published in a journal called 'Vruchtbare Aarde', later 'Dynamisch Perspectief'. In 1964, a private advisor was employed, although only 20 bio-dynamic farms existed at the time. Bio-dynamic

farming in those years was and still is connected with the anthroposophic movement. Anthroposophy, as a spiritual way of life, is active in different parts of society. In the Netherlands, education for bio-dynamic farming was already established in 1947 at the 'Warmonderhof' (Meijer *et al.*, 1980). In addition, Waldorf school pupils stayed on bio-dynamic farms for one or two weeks during the course of their education.



... the first bio-dynamic farm started in 1926: Ter Linde at Walcheren ...

Consumer circles based on ideals with respect to the design of the economy where consumers and producers were directly connected, were already active in the cities in the 1960s. A consumer group, the so-called 'Landelijk Consumenten Contact', entered into agreements with farmers about the amount, quality and price of bio-dynamic produce. The first regular supply of bio-dynamic vegetables by subscription was in that period. In the 1990s, the idea of subscriptions was replaced by Consumer Supported Agriculture (CSA) (Lamb, 1994; Getz and Morse, 1995; Fieldhouse, 1996; Lind, 1999;). In the Netherlands, this CSA was established through the 'Pergola Association'. Bio-dynamic traders followed the CSA vision about the relation between consumer and producer. A large consumer circle in the region of The Hague and Leyden was transformed into the first trading centre for bio-dynamic produce, Proserpina, established in 1966. The basis for trade was a co-operative union of the farmers. The Dutch variety of the CSA was the weekly vegetable, fruit or even meat subscription. This initiative started on private organic farms, which distributed their own vegetables to consumers in their direct surroundings. The content of the bag depended on the season. That initiative was commercialised in 1994 by 'Odin', a trader of organic produce. Ecological traders also followed this initiative. Each week consumers received their bag of organic produce and the trader informed them about the different farms the produce came from. In this way the distance between consumer and producer was diminished and consumers could buy a more personal organic product. By 1999, there were 30,000 subscriptions per week for fruit and vegetables. Nickerson (1997) called the CSA 'a risk-reducing strategy' for organic farmers.

Since 1978, the foundation 'BD Grondbeheer' is active with the goal of buying and managing land for bio-dynamic purposes. The people involved were motivated by the idea that land should not be part of trading. Land was no merchandise, a view that is comparable to the vision of Native Americans in the 19th century who were astonished that white people could own the land. Even today, the staff of the oldest bio-dynamic farm in the Netherlands is not the owner of the farm. The workers only bring their personal skill and labour to manage the farm. Land, buildings, animals and machinery are owned by a foundation. This complete separation of ownership and labour is much more popular in the German bio-dynamic movement.

A specific form of multifunctional agriculture within bio-dynamic farming is the care for mentally or socially disabled people. Within so called Camphill communities, farms, family life, housekeeping and specific workshops are integrated.

3.2. Changes in the organic milk market

In The Netherlands, the market for processed organic dairy products has developed since 1976 (Island of Terschelling) and 1980 (Limmen) based on private initiatives. In the development of this market, several different economic approaches can be recognised. At first, the market was

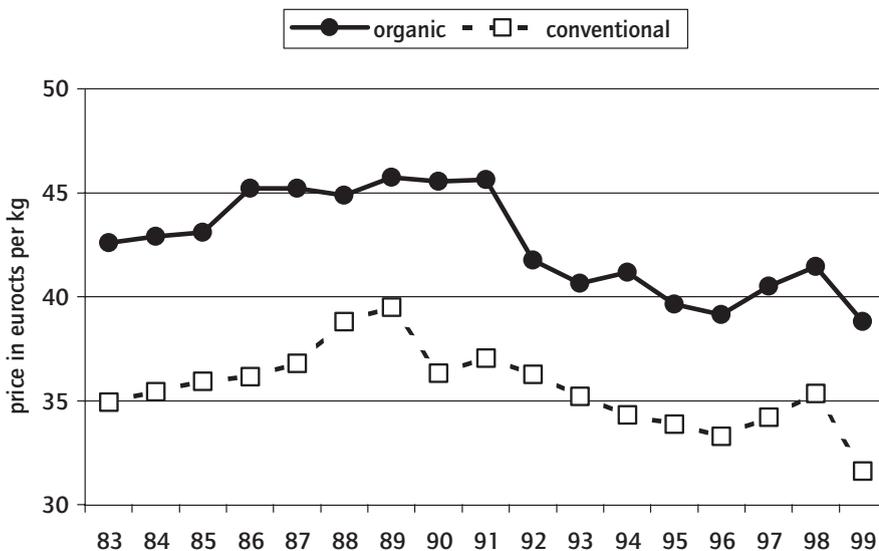


Figure 3.1. Annual average price of organic and conventional milk (Dairy factory 'De Vereeniging'; Hoogland, 1995)

protected and was controlled by only one of the processors. In 1990, the first sale of organic milk through a supermarket chain failed because conventional processors did not advertise the added intrinsic value of organic milk. In the 1990s, the growth of the sector attracted new processors who tried to decrease the consumer price. The first competition between processors of organic milk led to a price decline for the farmers (Figure 3.1). To prevent prices from decreasing to the lowest level possible, the organic dairy farmers united in a farmers' union called 'Natuurweide'. The decision in 1996 by the supermarket leader Albert Heijn to develop a new organic market was an important support for the growth of the sector. Parallel to this, conventional processors took over the most important pioneering private organic milk processors in the middle of the 1990s.

In 2001, nine factories processed almost 81 million kg of organic milk (personal communication P.Boons, President of 'Natuurweide'). This large number of processors was a reaction to the earlier take-over of the two main organic milk processors by a conventional processor (Campina-Melkunie). As a result of this take-over, several new and often small-scale initiatives to process organic milk emerged. One of the main reasons for farmers to look for new private processors and traders was the loss of control over milk market politics. Since 1996, the majority of organic dairy milk suppliers joined forces in a union of organic milk suppliers. The main reason for the co-operation was that farmers wanted to prevent competition among themselves. Together they tried to control the flood of converting farmers. Lessons from the past had shown that within the small market any surplus of milk supply immediately affected the price. The policy of the union is to achieve a fixed premium price for all organic farmers without being affected by the competition between the different factories. Since 1999, the united organic dairy farmers even meet internationally. The change of ownership of processors, from private companies to multinational processors, led to an international union of organic dairy farmers. Organic dairy farmers are now informed about surpluses and shortages in several European countries to have a better position for negotiation with the processors. Recently similar changes in processing and trading were realised in the organic butchery sector. The private company 'De Groene Weg' had a central slaughterhouse for organic meat and franchised organic butcher shops all over the country. At the end of 2000, the slaughterhouse was sold to Dumeco. The take-over was accepted because the 'Groene Weg' was not able to make the step to supply supermarkets. Its level of organisation, financing, control and automation could not handle the increase in demand.

³¹ In: Zuivelzicht, 22 March 2000.

CHAPTER 3

According to the Dutch Central Bureau of Statistics (CBS), in 1999, sales of organic dairy produce reached € 20 million, 7,7 million higher than the previous year and about 1.1 % of total dairy consumption³¹. In total, € 227 million of organic produce was sold in 1999, 75% in health food shops, farmers' markets and by produce subscriptions, the other 25% by supermarket chains, mainly Albert Heijn (Motivaction, 2000). However, since 2002, the sales by supermarket chains are higher than in the other markets (Press release Platform Biologica, 2002).

Key players in the organic milk and meat markets have changed in the last five years. This means that processing and trading of organic produce is now in a phase of conversion, from health food shops and private pioneering processors to supermarkets and multinational traders and processors (such as Wessanen, Campina and Dumeco). The development in the organic milk market fits very well in Dutch Government policy on organic farming that emphasises an increase in the area of organic farming. The aim of the government is that 10% of land area should be under organic farming in 2010 (LNV, 2000).

Table 3.1. Characteristics of specialised dairy farms in 1998/99: figures for 'organic' are an average of nine farms in the project BIOVEEM (see chapter 7) (Zaalmink, 2000)

	Organic	Conventional
Hectares: No	42	34
Cows: No per ha	1.3	1.6
Milk: kg per cow	6,200	7,300
Milk: kg per ha	8,300	12,000
Income in € per 100 kg milk:		
Milk	38.66	34.35
Beef	4.27	3.90
Other	4.99	1.59
Total	47.92	39.84
Costs in € per 100 kg milk:		
Fodder	6.76	5.90
Labour	19.88	15.66
Machinery and hired labour	8.89	7.71
Land and buildings:		
Other	9.62	11.53
Total: € per 100 kg	55.81	47.92
Net farm result: € per 100 kg ³²	-7.90	-8.08
Family income: € per 100 kg ³³	11.98	7.56

³² Net farm result is based on a fixed rate per hour of labour.

³³ Family income = Net farm result plus labour income.

3.3. Structure and economy of the Dutch organic dairy farms

WUR-LEI recently evaluated the economics of organic farming (Zaalmink, 2000). Table 3.1. shows that organic dairy farms on average are about 8.0 ha larger than conventional farms; that the number of cows is roughly the same, but that the total milk production is 80,000 kg lower. The average milk production per ha is 8,300 kg, which is far below the conventional specialised dairy farms (12,000 kg per ha), but it has increased by 70% compared to 1980. The production per cow (6,200 kg) is about 1,100 kg below the conventional cow productivity. Compared with 1980 figures, the production per cow on organic farms has increased by 45%. The most extensive of the organic dairy farms produced 5,000 kg ha⁻¹. Such farms are self-supporting for all fodder. The most intensive farms produced 11,000 kg ha⁻¹. The amount of concentrates per cow varied between 1,100 and 1,600 kg per cow. The most extensive farms used 160 kg per cow.

The average milk price per 100 kg in 1998/99 was only € 4.31 above the conventional price. Organic dairy farms had a higher total income per 100 kg of milk (€ 8.08) compared to conventional farmers, mainly because of subsidies (included in other incomes: € 3.49). The total costs per 100 kg were higher for the organic farmers (€ 7.90). The main source of these extra costs were labour (€ 4.22), plus higher costs for land and buildings (€ 3.54). Costs for land and buildings are relatively higher when farms are more extensive. Zaalmink concluded, that the overall net farm income was the same for conventional and organic specialised dairy farms. However, the differences in farm structure between the two types of farms were large.

The price of milk paid to bio-dynamic suppliers³⁴ has declined since 1991 (Figure 3.1). After 1991, the price differential with conventional milk decreased as well. Milk prices for ecological farms were even lower (€ 1.36). The loss of income from milk has been partly compensated by subsidies paid for conversion as well as income for nature conservation activities. The government subsidy was for a five-year period only, and payments by nature conservation bodies depend very much on regional factors. For instance, the Friesian subsidy for delaying the 1st spring cut of silage (to improve the survival of nests and young meadow birds) is only operating in small parts of the Province. A maximum of 10 ha per farm can be part of this nature conservation scheme.

Parallel to the price development and related to their year of conversion, the production intensity of organic dairy farms is increasing. From a study of breeding strategies in organic dairy farming

³⁴ Data were derived from the processor 'Zuiver Zuivel' in Limmen, North-Holland, which is the largest processor of organic milk.

CHAPTER 3

Table 3.2. Organic dairy farm characteristics in 2000, related to the year of conversion of the farm (N = 149) (Nauta and Elbers, 2000)³⁵.

Year of conversion	<1987	87-90	91-96	97-98	99-00	Mean
No of cows	37	50	51	51	49	49
Farm size (ha)	39	46	43	39	35	39
Milk quorum: kg x 100,000	2.14	3.31	3.42	3.34	3.41	3.26
Milk yield per cow: kg	6,746	6,790	7,034	7,148	7,885	7,242
Milk quorum: kg/ha	6,359	7,421	8,614	8,928	9,747	8,683
% EKO-farm	31	56	88	100	97	86

(Nauta and Elbers, 2000), we can see a clear trend towards increasing intensification of more recently converted dairy farms (Table 3.2). On average there is no increase in cow numbers since 1987, the overall farm-area has decreased and the milk yield per cow increased. Therefore the increase in farm intensity showed up most clearly in terms of milk per ha. Since 1991 the growth of the organic dairy sector as a whole is mainly based on the growth of the numbers of ecological, and not those of bio-dynamic dairy farmers. This was caused by the demand for EKO-milk, the support for EKO-advertising, the more restrictive rules for bio-dynamic production and the lack of appreciation of additional values in bio-dynamics.

The overall intensification and specialisation of dairy production was considered a progressive evolution within the organic dairy sector, leading to comparable organic and conventional farming systems depending on large inputs of concentrates and purchased fodder and straw (Baars and Prins, 1996). The background of intensification in organic dairy farming lies in the price squeeze to lower production costs. Based on the area outside the home farm required to produce imported manure and fodder, organic dairy farms with a milk production of 10-11,000 kg per ha or more used an '*external farm area*' (Baars and Van Ham, 1996) of more than 35% of the home farm area. There is a structural dependency on external fodder, concentrates and even manure, leading to a constant import of minerals. At the same time, more intensive farming guarantees a higher farm income. According to EU standards, organic dairy farming is no longer bound to the land actually farmed. A recent study of the use and origin of manure, straw and

³⁵ Differences in yield per cow between Table 3.1 and 3.2 were caused by the sample. In Table 3.1 9 farms with a longer conversion history were included.

fodder in the west and centre of the Netherlands (Hendriks and Oomen, 2000) showed that organic arable, vegetable and fruit producers rely for 70-100% of their manure on conventional sources. Most dairy producers are using all their own manure on their own fields and even then 50% of the dairy farmers still import conventional manure. Eighty percent of the straw used for bedding is conventionally produced. Nowadays most of the dairy herds are housed in cubicles, which hardly need any straw. The need for straw only increases when animals are kept in different housing systems. The study also showed that 30-40% of concentrates is still based on conventional ingredients. Figures for the landless organic poultry and pig sector showed that concentrates for egg and meat production are mainly produced outside the Netherlands. This development leads to problems of traceability of produce (see for instance the organic food scandal in Germany May 2002) and there is no longer a connection between land, manure and the level of production.

One of the threats the development of organic farming mentioned in Chapter 1.3 was the lack of 'holistically-oriented regulations'. The regulation on manure is an example of this. Produce is certified as organic if farmers did not use fertilisers and chemical plant protection. This type of regulation only takes into account the natural origin of the materials used in production but does not reflect on the farm as a coherent agro-ecosystem. Such an open regulation allowed organic farms to become strongly dependent on conventional manure inputs. Since 2001, however, according to SKAL regulations, at least 20% of the animal manure applied in the fields must be of organic origin. This small change in regulation (from 0 to 20% organic manure) has an impact on the use of legumes in arable and grassland farms, on crop rotation and on the efficiency of manure use. Instead of manure-N inputs in limited crop rotations, systems will increasingly have to depend on N-fixation by legumes, which will widen the crop rotations. Both in organic grassland and in arable crop rotations, manure will be replaced by greater use of legumes (see Part 2 of this thesis; Baars, 2001-a). A full rejection of conventional manure inputs has been developed in the new concept of '*partner farms*' or '*mixed farming at a distance*' (Chapter 5.3; Baars, 1998; Nauta *et al.*, 1999). Such collaboration between specialised systems will allow closed mineral cycling and should lead to a 100% organic origin of manure, fodder and food. In future, all organic crops should be grown on manure of 100% organic origin. This will not only affect the production level per hectare, but also will increase the cost price of milk, meat, arable produce and vegetables.

Another, although negative, example of the importance of adequate regulation with regard to the identity of organic farming, is the discussion on the amount of concentrates fed to ruminants. From the organic point of view, which is based on a vision of the integrity of the animal,

ruminants by nature consume fibrous material that cannot be eaten by most monogastrics. In the wild they hardly eat any seeds. In the holistic concept of a mixed and closed farming systems, cows are kept to produce manure to maintain and improve soil fertility. However, after the acceptance of the new EU standards for organic animal production in August 2001 (EU 2092/91), the amount of concentrate per dairy cow has increased to such a level that, after conversion, dairy farmers in The Netherlands hardly needed to reduce their concentrate level and organic dairy cows are not really fed according the nature of ruminants.

Supported by the (too open) EU standards, the price of organic milk has now dropped to a level that is too low for a true land-related production, but is still higher than the world price for milk and does not give room to organic farmers to follow high animal welfare standards. Farm costs have increased in organic systems. For instance, land prices in The Netherlands have tripled in the last 15 years. To speculate about a more realistic milk price, we indexed the producers' price of 1989 (€ 46.30 per 100 kg milk) with a fixed inflation of 2.5% per year. After 10 years the indexed price would have been € 59.27. However, the main group of EKO-farmers only received € 37.89 per 100 kg milk, which is 36% lower. From this calculation it becomes clear, that political choices, economical forces and the choices of the consumer force organic dairy farms to increase production per cow and per ha and to look for the lowest possible standards. This gap between market and realistic or fair trade price partly explains the ongoing need for intensification of organic farming and the scaling up of farm size. Instead of the domination of market principles in defining the future possibilities of organic farming, standards should much more reflect the ideals of organic farming. As a consequence, farmers might receive a direct payment for their extra efforts with respect to the production of welfare, environment, land related production and food safety. Such direct payments would be supported by green taxes and by a direct relationship between farmers and consumers. However, as long as milk is only treated as a bulk component, organic farmers will be fixed in the treadmill of intensification and the scaling up of size.

3.4. Farming styles in organic farming

Van der Ploeg (1991; 1994) introduced a classification of modern farming styles. Farmers were grouped on a personal scale, reflecting their aims in terms of interest, attitude and strong sides of farming skills. Styles were defined as a set of strategic and practical considerations of how they farm (Van der Ploeg, 1999). Farmers were classified in groups such as 'cow farmers, economical farmers, optimal farmers, double-purpose farmers or machine farmers'. Unfortunately Van der Ploeg did not provide a class for organic farmers. Therefore, additional typification is needed for the organic sector.

Verhoog *et al.* (2002 a, b) interviewed organic farmers and traders about their understanding of the concepts of nature and naturalness, three main approaches to action could be distinguished. It became clear that these approaches could also be recognised as steps in the inner conversion process of some farmers from conventional to organic agriculture. In relation to each other the three approaches are not meant as morally higher or lower. Only when farmers or traders claim 'naturalness' the authors suggest including all three approaches. However, farmers can choose for a certain style, because of market pressure or personal philosophy towards organic farming. More relevant is that farmers do not act consistently in all areas of their farm, because a particular farmer can be more involved in a certain aspect of his farming, comparable with the styles of Van der Ploeg.

Three main approaches within organic farming were:

- **the no-chemicals approach.** The holistic approach taken in organic farming leads to a rejection of component technologies dealing with symptoms without taking the whole into consideration. This is one reason for rejecting chemicals. The distinction between living (organic) nature and dead (inorganic) nature is associated with the distinction between healthy and unhealthy (related to death). The no-chemicals approach is a negative expression in the sense that organic agriculture is said to distinguish itself from conventional farming because *no chemical pesticides, no synthetic fertiliser, no GMO's, etc.* are permitted. Farmers have to replace (bio)chemical-synthetic substances by more natural substances. Instead of chemical sprays against diseases, farmers use 'natural' sprays or biological controls, synthetic fertiliser has to be replaced by organic manure, and instead of herbicides mechanical weed control is used. Even the use of homeopathic remedies in animal husbandry can be seen from this point of view. Homeopathic medicine is believed to be more natural because it is derived from natural substances and not from chemical substances synthesised in the laboratory. This approach is linked to a rather limited view of human and environmental health. Using natural pesticides and herbicides (etc.) is believed to be healthier not only for the environment, but also for humans.
- **the agro-ecology approach.** The farmer learns from nature and *reflects on process in nature*. In practice this means that the ecological farmer wants to model his agricultural practice on nature as an agro-ecosystem. Farmers might experience that during their conversion period they cannot ignore the ecological context of emerging problems. They notice that under organic circumstances it is not sufficient to only stop using chemical pesticides and artificial fertilisers. A new attitude and another way of acting is needed, based on prevention through knowledge of ecological processes. Diseases are seen as symptoms of an unbalanced system expressed in the lack of balance between plant or animal and farm



... the agro-ecology approach: self-regulation of systems ...

environment. Rather than fighting pests and diseases with chemicals, the emphasis shifts to control of the environment. A more diverse environment is necessary in which wild plants in hedges, borders or ditches are grown to maintain natural enemies within the farm system. Plant strength can also be increased through the right choice of manure, or by sound crop rotation. All this means that farmers start to think in a more ecological way, looking for the broader context of a problem and realising that the farm should be transformed into a complex, sustainable and balanced agro-

ecosystem. Terms such as closed system, mineral cycle, self-regulation and bio-diversity are important keywords to characterise naturalness in this approach of organic agriculture. One needs to work together *with* nature instead of fighting against it. Solutions are based on rational, experiential and experimental ecological knowledge.

- **the integrity approach.** The recognition of integrity reflects an attitude of respect that inspires the farmer to find the right course of action at the right moment in the specific farm context. This respect for integrity first emerged in animal husbandry. The animal's needs (Rist, 1987; Bartussek, 1991) have to be understood by farmers in the context of the farming system. Cattle should be fed as ruminants instead of monogastrics (Bakels and Postler, 1986; Haiger, 1989).



... the integrity approach: horned dairy cattle grazing outside as real ruminants ...

They should be kept as horned animals in a well-balanced herd. De-horning can only be avoided if the farmers are prepared to develop a new way of herd management, housing and feeding based on the cow's needs (Baars en Brands, 2000; Waiblinger *et al.*, 2000). Also the cows' right for outdoor grazing is derived from respect for the cow's 'nature'. Outdoor grazing can not be replaced by an outdoor run only. This approach manifests itself among others as respect for the integrity of life, for the agro-ecosystem, and for human needs (including social and economic integrity). The term 'natural' here refers to taking into account the *characteristic nature* of plants, animals, man and ecosystem because nature has an intrinsic value. Respect for the integrity of the farm ecological system, the living soil, the plant and animal species used is the result of an inner process of involvement with the way of being of natural entities. Farmers begin to experience that their focus on problems and solutions is connected with their personal attitude and their personal relationship with either the soil or the cultivated plants or animals. They experience that organic farming is more than a complex ecological mechanism and more than the sum of the parts. This feeling is also present in relation to the plants or animals they take care of. They develop a respect for the wholeness, harmony or identity of a living entity based on a personal involvement with the life of plants or animals.

Given that organic farming is likely to distinguish itself from conventional farming in terms of combining the three approaches described above, i.e., in terms of its 'naturalness' as defined by these three approaches, the question raised in this dissertation becomes more pertinent. Which research methods are the most adequate within these three meanings of naturalness? This question assumes that the different approaches are integrated and lead to one shared set of criteria for organic farming.

If such an integration of interpretations were impossible, a next step would be to distinguish the three styles of organic farming and introduce regulatory differences. In Germany, the AGÖL umbrella organisation has recently split up into three different regulation schemes. Farmers can be controlled at the level of the EU standards that represent the most open and simple form of regulation in that it mainly limits the system in terms of chemical use. On the other hand, both the Demeter and Bioland associations have chosen for higher ethical standards compared to the AGÖL standards, mainly in terms of animal welfare and the overall farming system. The rest of the organic organisations kept an intermediate position, in comparison to Demeter and Bioland, accepting the less restrictive AGÖL standards. A similar change has occurred in Switzerland where three levels of organic farming are certified nowadays.

In conclusion

This chapter described the evolution of the organic dairy sector in The Netherlands. Market forces rapidly push organic farming in the direction of the anonymity of the supermarket. Its increasingly conventional partners in trading and processing leads organic farming to fall into the same trap as conventional farming, exposing them to the price squeeze of the global market and pressures to reduce costs, and scale up farm size. The review of the history of organic farming shows that, after 1980, the size of EKO farm area became about 10 times bigger than the Demeter label. Since the Demeter label is the most restrictive label in terms of limitations and the most difficult in terms of philosophy, it is obvious that converters oriented mainly on the EKO label. This has important implications for the criteria used to establish the nature of appropriate research in support of organic farming. Organic farming in future might split up into three styles. Based on research findings of the Louis Bolk Institute on how organic farmers interpret naturalness, each 'blood group' would be supported by different sets of regulations and intentions.

Another solution would be to accept naturalness as one of the basic values for organic farming as a whole. In that case, all three basic meanings of the word 'natural' as expressed in the three approaches I have described above should be included in the principles of all types of organic farming. That would mean that the different methods of research that I have distinguished before should all be developed and applied in organic agriculture research. In this dissertation I have chosen to look at organic farming as a practice that adheres to, and integrates, the three approaches to naturalness. That choice means I will look at the 'most difficult' and least developed case. It allows me to describe the widest range of research practices in organic farming. This will hopefully help other organic researchers to be aware of the implications of the choices they make when designing their research projects.



4. Changes in research and development

The case studies presented in Chapters 5 and 6 are based on research projects selected from all the projects carried out by the Louis Bolk Institute in the past few years. Since the Institute is a private research institution that does not form part of the official public agricultural research infrastructure in the Netherlands, I believe it is useful to briefly describe the work of the Institute's Agronomic Department. The chapter will conclude with a brief overview of organic agriculture research carried out by other organisations in the Netherlands, mainly to demonstrate that the Institute is by no means the only player in this field. In fact, since the 1970s, a state-supported R&D programme for organic agriculture has been developed.

4.1. Agricultural Research at the Louis Bolk Institute 1980-2000

The Institute was founded in 1976 after the University of Amsterdam had prohibited continuation of a homeopathic *in vitro* experiment on cell tissues (Amons and Van Mansvelt, 1972; Van Mansvelt and Amons, 1975). This prohibition led to the initiative to establish an institution where researchers could not be stopped from pursuing research topics that were not in accordance with accepted science. The Institute was named after Louis Bolk (1866-1930) who was professor in human anatomy at the University of Amsterdam. He presented himself as a scientist with a broad and encompassing view which is best expressed in the following statement *'How much broader would our view of life be if we could study it looking through reducing glasses. This would widen our range of vision, thus allowing the coherence of phenomena to become visible to the naked eye'*. The Louis Bolk Institute tries explicitly to take into account this coherence in its research. When conventional research methods are considered not to suffice, new ones are developed or adopted, such as phenomenology, picto-morphological investigations and methods that use enhanced consciousness and intuition (Anonymous, 1999).

In the Agricultural Department of the Institute all fields of agronomy are represented. In the year 2001, a total of 25 researchers were working in five sub-departments: soil and manure, horticulture and glass houses, plant breeding, fruit growing, grassland and animal production. The income of the Institute is mainly based on contract research. The number of projects and their share of the total work of the Institute increased rapidly in the 1990s.

The research topics and methodologies of the Grassland and Animal Department cover four types of activity:

- *'farmer supporting research'* was initially based on farmers' questions, later transformed into

participatory research and eventually into experiential science (Baars and De Vries, 1999);

- *'basic research'* focused initially on questions about research methodology and later on understanding basic agricultural processes. The activity is science-driven, although it could be initiated by farmers' questions. Within this framework more attention has been paid to phenomenology of life processes and new researchers could freely explore intuition and imagination in developing scientific knowledge;
- *'concepts of organic farming'* were developed, explained and renewed and later mathematical modelling was also undertaken;
- *'sharing our own research findings'* directly with farmers by means of farmer discussion groups, demonstration projects and by means of articles and leaflets targeted directly at farmers.

4.1.1. Farmer supporting research

The Institute made the fundamental choice to engage in R&D together with organic farmers. The 1985 annual report of the Institute (Anonymous, 1985) presented a policy for organic agricultural research: *'A core idea of bio-dynamic farming is the perspective on the individuality of the farm (Steiner, 1924). This means that every farm has its own identity, depending on the farm's position, soil quality, natural, social and economic environment and the farm's managers. The specific farm identity can be developed more intensively when the import of inputs such as manure, fodder and seeds is reduced. Research will be undertaken to strengthen organic farms in such a way that farms become less dependent on conventional inputs.'* Of course, organic farmers undertook many small trials themselves. They were very keen to develop new insights to improve their farming situation. Such 'research' activities took place without any formal connection between farmers and researchers. Recently, Swagemakers (2002) defined the results of such small trials as novelties (see also Nielsen, 2001): *'a change in the farming system and / or the relation between the farm and its environment, which is developed by the farmer himself, although not yet recognised or valued by others. Novelties are meant to reach a new, desired farming situation....Farmers improve their situation in a certain direction and bring it to perfection by means of one or a set of novelties.'* From our own experience we knew that, depending on their interest, farmers tried to develop their system by trial and error. However, in the choice of our on-farm research projects we focused on the farmers' actions and activities and not on their oral description of their problems. Their activities better express the personal involvement of the farmers with the problem or new challenge. It is important that the farmers were really the owners of a question.

This research approach was initially called farmer-supporting research. Researchers would assist the farmer in his development activities. The farm manager was the owner of the problem. It was the task of the researcher to assist him with literature review, layout of experiments, specific

analytical measurements (if necessary), and the publication of results. The selection of research topics was discussed in an annual meeting with a delegation of four organic dairy farmers plus a farm adviser. The delegates were responsible for the choice of research topics and decided how to divide up the available money. This approach led to a large number of small on-farm projects. Questions were farm-specific and therefore very diverse. Questions covered all areas of organic dairy farming. The criterium for



... farmer supporting research: experimenting on commercial farms ...

deciding to work on a farmer's question was whether the specific question was innovative for the farmer (personal innovation) and whether the question opened new horizons for the improvement of organic systems (sector innovation). The farmer had a large responsibility in looking after the on-farm trials. This responsibility consisted of technical assistance to care for the plots and the treatments, and an interpretation of the effects. In most cases, trials were set up without replication. In specific questions, a specialised scientist, such as a nutritionist or a housing specialist, assisted in the research process. BOX 4.1 provides some examples of research undertaken in the field of grassland and animal production.

In addition to these farmer-directed research questions, there were topics that were hard to investigate in farm practice, because of time, risk or cost. In that case the researcher had another role as dialogue facilitator in group meetings of farmers. Examples are the introduction of dairy cows from a specific breeding program based on life-time production; prevention strategies for mastitis from an organic point of view; discussion groups about the role of the farmer's biography in relation to choices and farm results.

An important conclusion was that these farmer-directed experimental studies could be seen as pilot projects for exploring new problem areas. They could be transformed into more detailed and larger experimental trials, if necessary and supported by basic scientific studies. Another possibility was to deepen the participatory work on individual farms in projects of a longer duration and with a longer co-operation between the farmer and a group of scientists of different disciplines. In that case commercial farms were treated as experimental farms.

BOX 4.1. Examples of research topics in grassland and animal production research

- Comparison of dairy breeds in terms of their suitability for a mixed farm;
- The feasibility of replacing composite concentrates by individual ingredients;
- Optimal timing of manure application on grassland;
- The effects of bio-dynamic preparations 500 and 501 on the yield and quality of natural grasslands;
- The effects of extra potassium on yields of permanent pastures;
- The control of docks (*Rumex obtusifolius*) by bio-dynamic ash preparations;
- Alternative strategies to reduce phosphate shortages and increase the availability in crop rotations;
- The quality of the intake of roughage from nature reserves;
- The extent of leaching of nutrients from compost stored in the field;
- The feasibility of over-sowing with clover;
- Comparison of the quality of calves from different breeding programs;
- Comparison of red clover varieties on their suitability for ley farming;
- The effectiveness of using homeopathic nosodes to improve dairy cow disease resistance;
- Fly ecology and control of flies in barns;
- The effectiveness of grass-white clover mixtures in leys or in permanent pastures;
- Minimum P and K levels required for effective grass-clover mixtures;
- Methods to control bird damage in germinated maize and cereals.

4.1.2. Basic science

The focus in basic research at the Louis Bolk Institute was on 'life science'. At the Institute, the term has the meaning of a science concerned with life processes in general. Three types of life science research can be distinguished and two of these are discussed in this thesis, Goethean science (see BOX 4.2 ³⁶; Seamon and Zajonc, 1998) and multidisciplinary system research. The third one, the so-called picto-morphological method of crystallisation, that is thought to reveal complex life processes, and used in research of produce quality, is left out of the discussion. Picto-morphological methods are practised especially at the Department of Human Health and Nutrition of the Institute.

³⁶ Miller (1994) describes Goethe's scientific studies on plants, light and animals.

BOX 4.2. Johan Wolfgang von Goethe (1749 – 1832).

Goethe made observations on plants as well as on animals, but he is also famous for his theory of colour. His most popular book is 'The metamorphosis of the plant' (Von Goethe, 1978). Goethe was looking for the unity in the world of plants, a holistic point of view. He was interested in the 'archetypal plant', an idealistic or spiritual phenomenon or proto-plant from which all plant types can be developed. This plant is not physically present, but is present as an idea in the cosmos. Such a view can be compared with a 'model', although Goethe's imagination of this proto-plant was not fixed, but very lively. Within anthroposophy, the work of Goethe has been developed into phenomenology, called Goethean science. As a holistic method of research, Goethean science looks for the 'expression of an organism' or in other words the 'inner language of an organism'. In discussing Goethe's scientific work, Brady (1998) calls this 'the idea in nature'.

The initiatives in Goethean science were mainly undertaken by scientists interested in a better understanding of complex research issues. As a qualitative and descriptive research method, Goethean Science tries to understand and reveal the quality of life. In addition to traditional quality criteria, such as nutrient content, taste and absence of negative values (mainly of end products), attention was also paid to the growth and development of plants and the expression of life in growth patterns. Based on this attention to process and development, the physiognomy of the object of study (the 'Gestalt') is used to answer questions about its inner quality. The approach is used for topics such as improvement of the landscape quality on farms, grassland quality in relation to the use of bio-dynamic preparations, produce quality in relation to specific plant shapes, soil fertility and landscape, and the quality of organic products. In the multidisciplinary research approach we emphasised measurable, quantitative and technical results of organic farming, based on reductionistic science.

4.1.3. Development of concepts

The development of concepts relating to organic farming was based on three approaches. In the first two indigenous knowledge was used, at first from more spiritual sources and secondly from experiences of farmers who had worked out complete farming systems, or parts of farming systems. The third approach to concept development was very similar to conventional mathematical modelling used as the final step in a reductionistic approach. In bio-dynamic farming, concept development is based on the spiritual insights of the anthroposophist Steiner (1856-1925). His insights were used for concept building of mixed

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farming, landscape building, composting of manure, closed nutritional farm cycles, etc. Steiner's tacit knowledge were transformed into terminology that could inspire organic farmers in their farm development. Important issues were 'the individuality of the farm' and 'the farm as an organism' (Steiner, 1924). Examples of the use of these insights as concepts for farmers are:

- Using the wholeness and the growing process of the forest ecosystem as a metaphor for organic farming systems (Baars, 1990-b);
- the concept of naturalness as a basic principle of organic farming (Verhoog *et al.*, 2002 a; b);
- the concept of partner farms as an alternative to mixed systems (Baars, 1998; Nauta *et al.*, 1999, see also Chapter 5.3);
- the concept of family breeding as a breeding method reflecting the interaction of genome and environment (Baars, 1990-a; Endendijk *et al.*, 2001, see also Chapter 5.4).



... the forest ecosystem as a metaphor ...

4.1.4. Consulting and dissemination

The dissemination of research findings is a follow-up to research. In communication with organic farmers we have used different tools to share information. Although knowledge was also disseminated to the extension service (DLV), we have chosen to stay in direct contact with the organic farmer community for purposes of sharing our own research findings. Tools for sharing research findings were: training courses for farmers and advisors; one or two page pamphlets and newspaper articles; translations of available foreign knowledge; farmers' guides; loose leaf intermediate reports, final scientific reports, posters and scientific conferences; national and international scientific discussion groups; books.

4.1.5. Mission statement of the Agronomic Department of the Louis Bolk Institute

After more than 20 years of R&D experience, the mission statement of the Agronomic Department was adapted in 1999 to express the objectives of our scientific approach as follows:

The research will build bridges between

- *science and pioneering farmers*
- *science and ethics of organic agriculture*
- *science and ecology.....*

.....to serve the quality of life and life processes.

The development of the budget of the Louis Bolk Institute is presented in Figure 4.1

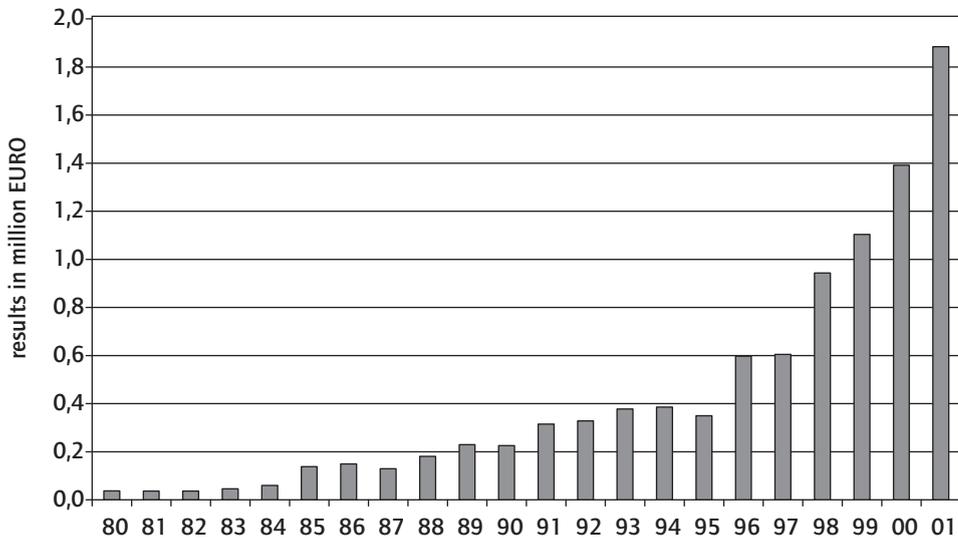


Figure 4.1. Annual financial turnover of the Agricultural Department of the Louis Bolk Institute in million Euro

4.2. Research in organic farming by public institutions

In the Netherlands, the growth of the organic sector in the last 25 years has led to a gradual change of policy and support. In 1976, the Commission on Research into Biological Methods of Agriculture (COBL) published a description of existing types of alternative agriculture (Boeringa, 1977). The commission's report advised to give high priority to research into new forms of agriculture with specific targets such as the relationship of agriculture and nature and alternative forms of agriculture. Thirteen themes were distinguished in alternative agriculture that needed research attention. The report suggested that specific attention be paid to the quality of organic produce. As a result of the report, two private advisors of the Bio-dynamic Association were employed in the governmental advisory service (1979). Furthermore, a farming system

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experiment started in 1978 to compare the outcomes of conventional, integrated and bio-dynamic farming in terms of yields, N-emissions, etc. (OBS at Nagele, Flevoland), and a study was launched to compare quality of produce (carrots, wheat and milk) of organic and conventional origin (1981/82). The comparison not only took into account the origin of the produce, but also the different research methodologies employed (Baars, 1982). In 1981, a special chair for alternative agriculture was established at Wageningen University using external funds.

In those early years, official research in organic farming was mainly based on the personal interest of individuals. The Institute for Agricultural Economy (WUR-LEI) started in 1972 with a case study of an organic dairy farm (Cleveringa, 1978). Cleveringa was already involved in the bio-dynamic movement. Later years the Government gave WUR-LEI the task of regularly collecting information on economic results of a group of organic farms as part of WUR-LEI's official task of collecting farm economic data. Another research initiative came from the erstwhile Institute for Agro-biological Research (CABO). Its interest in nutrient losses and nutrient cycling in farming systems and the role of red and white clover in grasslands led to two research projects on the contribution of legumes to grassland systems (Van der Meer and Baan Hofman, 1989). Ennik *et al.* (1982) also measured the productivity of old pastures in Friesland that did not receive mineral fertilisers. These projects were undertaken mainly because of the interest in forage legumes in low input systems. Due to high fertiliser nitrogen levels, legumes had almost disappeared from conventional farming systems.

In October 1992, a full professorship in organic farming commenced at Wageningen University. The title of the professorship was changed in 1999 from *alternative agriculture* to *organic farming systems*. A weak point was the poor contact among researchers of several disciplines within the university and between researchers and farmers. It was decided that more attention should be paid to complete systems and less attention to partial solutions.

New government policy on research into organic farming led to an increase in the conversion of official research farms in the late 1990s. WUR-PRI and WUR-PPO converted several locations for arable and vegetable production. In May 1997, the official research farm of Wageningen University, the AP-Minderhoudhoeve (Swifterbant), started a research project on different farming systems, one based on ecological farming and another on 'best agronomic methods'. The aim was to reduce harmful emissions while meeting the profitability needs of a farm³⁷.

³⁷ The Minderhoudshoeve will be closed in 2003. A new organic testing and learning facility will be created in Wageningen.

In 1997, applied research farms also converted to organic fruit growing, organic bulb-flower production and production of organic nursery trees. The Ministry of Agriculture invested in the stimulation of the exchange of knowledge and information between researchers of the Louis Bolk Institute, which was regarded as a pioneer institute, and scientists of the different research stations for applied research. In dairy production, the conversion of a research farm to an organic experimental facility was made in 1998 (at Heino), for pigs in 1999 (at Raalte) and for poultry in 2001 (at Lelystad). In August 1998, a program was formulated for multifunctional agriculture (WUR-PRI). Keywords in this program were 'sustainable agriculture' and 'ecologisation of agriculture'. In addition to attention to labour, income and production, organic agriculture was expected to also pay attention to environment, animal health and welfare.

The amalgamation of Wageningen University and the public agricultural research institutes (DLO) and Applied Research Institutes led to the formation of Wageningen University and Research Centre (Wageningen-UR, WUR). It has established a central, organisation-wide co-ordination centre for organic agriculture called the Innovation Centre for Organic Farming (IBL). It advises in the formulation of the research agenda for organic farming, together with the Platform Biologica³⁸ and the Louis Bolk Institute. In February 2000, a research agenda was presented (Kloen and Daniels, 2000). The information was based on an inventory of ongoing research in 1999 and demands for research formulated by the organic sector. Twelve themes were defined and a plan was made to increase the yearly budget for organic farming from 4% in 2000 to 10% in the next years³⁹.

In conclusion

The share of public R&D in organic farming is increasing rapidly in The Netherlands. The research agenda is based on the needs of the organic sector. The early start of the Louis Bolk Institute in R&D for organic farming has allowed it to formulate a clear mission statement with regard to research methodology. In co-operative projects with other organisations increasingly engaged in R&D for organic agriculture, shared experience can be used to develop an approach research that reflects the principles of organic farming. In this dissertation, an attempt is made to identify such an approach.

³⁸ This is an umbrella organisation of organic farming, connecting farmers and traders. Since 2000 there are two joint staff positions between Wageningen-UR and the Platform Biologica dealing with R&D in organic farming.

³⁹ The budget for organic farming research at Wageningen UR was € 8.5 Million in 2002, 7.7% of their total agricultural research budget (personal communication J.Meijjs, director IBL).



5. Case studies

Six research projects are presented in this chapter. A sixth, more integrated case project has been worked out in Chapter 6. To describe the process of research the triangular matrix developed in Figure 2.4 has been used in two ways:

- At the start of the project, what is the main focus of R&D?
- Which steps are undertaken to integrate the other corners of the triangle in the approach?

In Figure 5.1 the three main points are summarised.

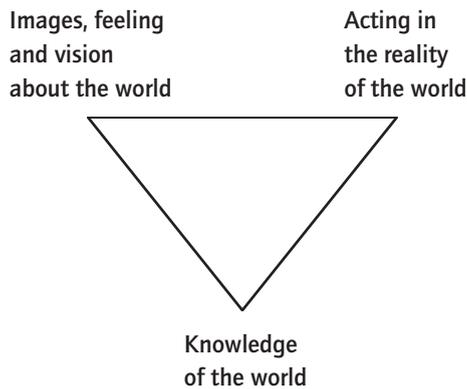


Figure 5.1. Research attentions as main entrances of projects of the Louis Bolk Institute

5.1. Multidisciplinary research of a soil-grass/clover system

The first case is a conventional research approach. The project has been carried out over a six year period on the research farm for organic dairying 'Aver Heino' ⁴⁰.

5.1.1. Background: development of a research question

In the early 1990s, in international research project financed by the European Union was formulated about the problem of the early spring growth of grass-clover swards. On conventional

⁴⁰ Agronomic results about this project have been published in: Baars T. (2000 c); Baars T. (2001 a and b) and Van der Burgt and Baars (2001), and comprehensively as Part 2 of this thesis.

grass-clover pastures, mineral N is being used to improve spring growth (Frame, 1987; Frame and Boyd, 1987), but it was not clear whether this N could be replaced by animal manure. From the plant breeders' point of view other options were suggested to solve the problem of early spring growth (Collins *et al.*, 1991; Rhodes and Ortega, 1996). New white clover varieties bred for improved winter survival of clover stolons were introduced as other solutions to increase spring growth. In three countries a similar, more or less parallel field trial in small plots was laid down based on the measurements of effects of white clover varieties and animal manure on spring yield, total yield and clover growth. Only yield measurements and parameters for chemical soil fertility were part of the original workplan. Observations during the term of the trial led to a more multidisciplinary approach.

Due to its complex structure, the project in The Netherlands was situated on the regional research station, not on farms. Plots were sown in September 1992. The design was based on two similar plot structures. The first trial was fully controlled and cut 5 times per year. The second trial was carried out under practical farm conditions and was cut twice and grazed 3 times per year. An extra trial to look into effects of timing manure application was laid out on an organic farm, which had been converting over a three year period. The goal of this third trial was much more related to the desires and practice of the farmer.

**BOX 5.1 Research management: a division of tasks or not?
(protocols at the Louis Bolk Institute)**

Based on the Goethean interests of the Institute, we are keen to make a detailed description of all kinds of observations related to our topic of research. In our grassland trials we used a check list just before every harvest with the following items concerning the sward

- What is your first impression?
- What are your expectations with regard to your previous visit?
- What kind of colours and smells do you encounter?
- What is the composition and structure of the sward?
- How is the soil condition?
- What were the weather conditions during the previous week?
- What are the farmer's comments?

All this information was used to obtain a general idea about the plot, its development and its environment. The list was used to develop an involvement with the object of research and the additional contact with the farmer is relevant for the interpretation of measurable findings (see also Chapter 5.2).

5.1.2. Methodology

In contrast with other trials at the Louis Bolk Institute, the principle of the co-operation with the official research station was based on a division of responsibilities. As one of the first steps of the project a detailed protocol of all tasks and work involved in the trial was made. The work of the researcher was mainly before and after measurements in the field. The co-workers at the research station had the responsibility to deliver results of measurements to the researcher. In this case the technical staff measured the herbage dry matter yield and in later years a botanical specialist estimated the botanical composition. It depends on the researcher whether he decides to gather his own information based on the visual assessment of his plots or whether he completely relies on the quantitative information provided by his technical staff (BOX 5.1).

In the first three years the researcher spent much effort to observe the plots at the experimental station. There was not a strict division of tasks between researcher and technician. At every cutting date he was present to observe the stage of growth. All herbage samples for the separation of herbage into grass, clover and herbs were observed by him to create the possibility of additional visual information such as plant colour and presence of pests. Slides of the cross section of each cut sward were made to keep an image of every cut. Visual score cards were developed on which to record specific characteristics regarding manure and clover cultivar effects. Due to these additional observations we had early warning of slug damage and potassium deficiency and we decided to take extra measurements in an additional trial to look at three increasing levels of manure application. The original project plan was simple and looked only at yields, clover and chemical soil fertility parameters. However, the project was adapted in several ways and it was planned for six instead of three years. Therefore, the design became much more interesting for other disciplines. In the first year other specialists (for nematodes, slugs, soil science and earthworms) were informed about the project, which led to a multidisciplinary research plan.



... strictly controlled circumstances ...

5.1.3. Reflection on methodology

The main point in this trial was to gain knowledge. Components of this trial are presented in Figure 5.2. The innovative part in this project was small, although there was a multi-disciplinary approach with specialist researchers. The aim was to incorporate the following aspects:

- holistic system awareness in terms of a soil-crop model;
- integration of tasks as technician (additional observations) and researcher (analysis of results);
- additional observations of the sward, which were not in the protocol.

In terms of the four quadrant matrix (Figure 2.2) the workplan reflects mainly quadrants 1 and 2, although the field trial did not integrate any aspects at the farming system level. There was attention for the agro-ecological understanding of the soil-manure-crop interaction, which is expressed in a quantitative modelling of the research findings and a qualitative description of how timing of manure application and quality, clover growth and soil fertility development were interacting in terms of growth processes.

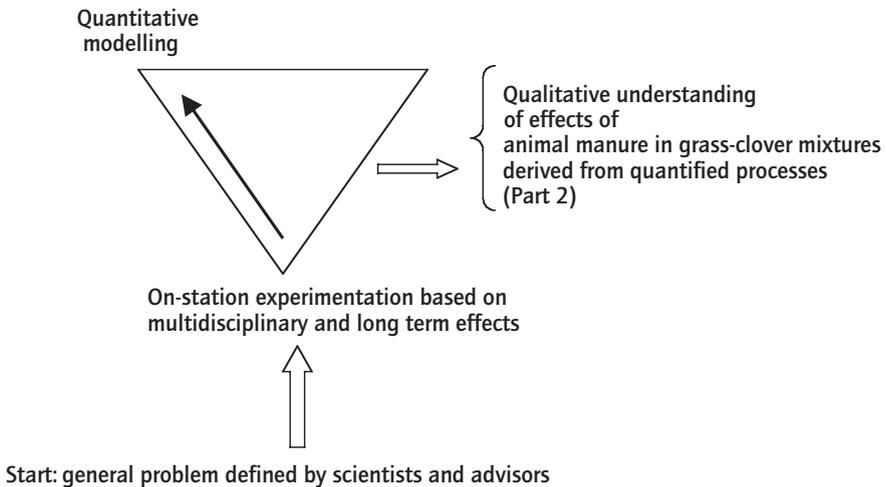


Figure 5.2. Components of on-station research and modelling in grass-clover mixtures.

5.1.4. Agronomic results

There was a large set of data, which was statistically analysed according to a split-plot design. To describe effects of manure on grass-clover growth, there was confounding of effects. Effects were confounded, because the trials were only standardised at a N-input level without correction of

P and K levels so that it was impossible to distinguish effects of separate elements. So plots received different levels of a.o. P and K, and soil samples showed different lines of change in organic matter, P and K-levels, which were related to the type of manure. The choice not to compensate for extra P or K per manure type was made for reasons to simulate as much as possible organic farm practice, although it was realised that effects of nutrients could not be measured.

The data were also used for linear regression, which led to a basic understanding about manure. The highest level of integration was a soil-crop model (see Part 2). The transfer of knowledge to farmers about this project was quantitative in terms of crop yields (Baars, 2000-c), relation between clover yield and herbage yield (Baars, 2002 a), effects of manure type on long term soil fertility and soil fauna (Van der Burgt and Baars, 2001), but also qualitative. Backed up by statistics and supported by our additional sward observations and descriptions, in the end a descriptive concept was made about how the main factors in manure, application time in spring and sward yield affected the growth dynamics of an organic grass-white clover sward within the year and over years. Knowledge transfer was much more descriptive in terms of growth patterns and developments over time.

The descriptive concept was used as a qualitative model which showed the processes of growth: *'On a sandy soil the amount of inorganic and organic N, the N release and K level of the different manure types are the main factors to explain fluctuations in total yields, white clover development and differences in N yields. If P and K are adequate, the level of (inorganic) N shows a high, positive correlation with herbage yield and N yield, but a negative correlation with the white clover yield. N yields are not affected by manure type, because of compensating effects of white clover N and manure N. K yields ha⁻¹ and K concentrations in herbage DM are related to the amount of available K, irrespective of the manure type. P yields are related to herbage yield and N yield. After the phase of establishment, the level of applied N is the main effect of slurry application in spring. FYM should be applied on sandy soils as early as possible within legal regulations. FYM increased the earthworm population, reduced the number of nematodes and maintained the highest level of soil pH, all factors that might positively affect white clover growth in the long term. FYM applied in spring resulted in the typically extended growing period in the second part of the growing season. On a sandy soil the high concentration of K in the FYM positively affects the potential white clover growth.'*



... integration in the farm: the farmer opts for integration of the trials with the management of the whole field ...

5.2. Mutual learning based on farmers' actions and on-farm experimentation ⁴¹

Since 1986, a research co-operation has existed between the Louis Bolk Institute and organic farmers. The ongoing co-operation with Warmonderhofstede ⁴² farm is the longest in existence of the Louis Bolk Institute. Several questions on and challenges relating to grassland production, crop rotation, weed control and animal breeding have been investigated in a direct co-operation with the farm manager, in trials at the

farm (Baars *et al.*, 1998 a). This chapter describes the process of mutual learning of the farm manager and the grassland scientist.

5.2.1. Background: characterising challenges raised by a pioneer farmer

The farm manager of Warmonderhofstede was a pioneer, because he adapted new ley mixtures for organic crop rotations. His specific farm situation was the reason for the question and the problem was also solved on his farm. The goal of the study was to develop ley mixtures which best suited the farm objectives. Leys should produce a high amount of fodder with enough protein. The growth and yield of the leys was also very important for the recycling of legume fixed nitrogen through the rest of the crops in the rotation as well as for controlling perennial weeds. In this research, considerable attention was paid to the grass component of the mixtures, whereas until then the main attention was on the effects of the legumes.

From my viewpoint as a researcher, the question at Warmonderhofstede was interesting for the entire organic sector, because:

- the farm context was very strict in terms of manure use; there were no opportunities for symptomatic corrections, which meant that solutions had to be found within the agro-

⁴¹ The agronomic results were published in Baars and Veltman, 2000.

⁴² Leon Veltman was dairy farmer at Warmonderhofstede, farm of the college of Education for Bio-dynamic Farming, Wisentweg 16, 8251 PC Dronten, The Netherlands.

- ecological side of the farm management; the findings were system solutions and such an approach leads to a basic understanding of the possibilities and impossibilities of ley farming;
- the specific questions of the farmer about potential organic grassland production were based on one of the principles of organic farming, which is to produce milk, meat and manure using home grown fodder; in the experience of many organic farmers the amount of roughage, and especially the amount of protein in the ration are key issues for the system result;
 - the particular constraint on future organic farming development at Warmonderhofstede was in leys, in particular the central role of legumes in a mixed system, in complete dependence of the animal's diet on grass-clover and in the very low input of manure; the interesting and progressive aspect was that the system relied completely on soil mineralisation, legumes and atmospheric deposition for its N supply; no corrections were possible through other external sources.

5.2.2. Methodology

In contrast with a pure scientific approach, the researcher was dealing with different roles. As a specialist he was involved in a specific area of research; as a generalist he was aware of other areas of research in terms of farming system research, but also social sciences; as an extensionist he was a discussion partner for the farmer to deliver information in specific areas.

In the process of mutual learning several steps can be distinguished, which are worked out below.

5.2.2.1. Context description: understanding the farm from your own frame of reference

To start a project on a commercial farm in a process of mutual learning, it is necessary to be aware of the specific farm circumstances, both agronomic (i.e. soil conditions, farm structure) and socio-economic (i.e. farming style, financial situation). To enable co-operation with a pioneering farmer it is important to be clear about his goals in life, his ethical background and the constraints that he imposes on himself. These farm backgrounds and principles are described first.

Warmonderhofstede is a 85 ha mixed bio-dynamic farm located in the province of Flevoland. The farm and the college moved to Dronten in 1994 where previous owners were three different conventional arable farmers. The college farm has a responsibility to educate pupils in bio-dynamic farming while being financially self supporting. From an agronomic point of view the soil is one of the most fertile in the Netherlands. The polder structure is simple, with large rectangular fields. For Dutch circumstances the farm area is large.

Four farmers are each responsible for a specific farm enterprise and college students are involved in the daily farm practice. It has separate areas for fruit (apple, pear, 5.5 ha) and garden

vegetables (7.0 ha), which have their own crop rotation. The rest of the farm has a 6 or 12 year crop rotation, but because of market requirements and problems with perennial weed control and pests in crops, the crop sequence is flexible. Important crops in the rotation are: potatoes, seed potatoes, carrots, onions, peas and the two-year grass-clover leys. Wheat or barley is minimised in the rotation because of low prices. The total area of grass-clover is 28 ha per year, either 1st or 2nd year ley. The grass-clover leys are important for the crop rotation as they are used to build up soil fertility (C and N), to increase the amount of N circulating in the system and to control perennial and annual weeds. Important weeds at this location are: creeping thistle (*Cirsium arvense*) and other thistles (*Sonchus arvense* and *Sonchus asper*) and a minor amount of *Tussilago farfara*.

The main farm income is from the arable crops followed by dairying. The mixed system is chosen instead of a pure arable system as the best solution for organic farming, because of the production of farm yard manure and the advantages of grass-clover leys in the crop rotation. All manure used is produced at the farm, although all the straw for bedding (150 t year⁻¹) is purchased. The yearly dung production is collected from a deep litter barn (1000 m³ FYM) and a walking and eating area with a slatted floor (700 m³ slurry). The slurry is used on the leys, and there are three possibilities for its application. Slurry collected over the winter is applied in spring before the 1st cut of the 2nd year ley and after the 2nd cut of the 1st year ley (about 27 m³ ha⁻¹). Slurry collected during the summer is used before ploughing and reseeded of the new leys in August or September. FYM is composted during summer and ploughed into the soil in late autumn before several arable crops are established. During the summer animals are kept indoors during the night and the main reasons for this choice were bloat problems in 1994 and 1995 and the extra collection of manure.

In total about 66 livestock units (LU⁴³) are present, which is 0.8 LU per ha and 2.4 LU per ha grass-clover. The milk quorum is 216 400 kg (4.22 % fat). The milk production is realised on a ration of grass-clover (fresh or silage). In some years whole plant silage from barley or wheat undersown grass-clover ley is available, and in some years organic maize silage is purchased as a second fodder crop in late summer and winter. The milking cows do not receive any concentrates, although small amounts of concentrates are used for rearing calves. The young stock graze an area owned by a nature conservation body during summer. The ration of the dairy cows is simple. In winter, it is only grass-clover silage or some silage maize (3 kg DM cow⁻¹ day⁻¹, till 1998) plus small amounts of carrots and potatoes (if available). The summer grazing till 1 July, consists only

⁴³ It expresses the annual phosphate production, equivalent to one dairy cow producing 41 kg per year.

of grass-clover. After 1 July, the ration is grass-clover plus 3 kg DM cow⁻¹ day⁻¹ fodder maize, if available.

Besides the farmer's context, it is necessary that the research worker makes his own scientific reference of the farm situation. Depending on the personal background and scientific training many references can be used to distinguish a specific farm situation, in this case that of Warmonderhofstede. As a grassland researcher different observations were made to get a better understanding of the specific grassland situation (data monitoring). In the first year the following data were used to build up a frame of reference:

- The soil from all farm fields was analysed;
- The production of a ley was measured and specific attention was paid to the development of red and white clover and of the N content of the herbage;
- Every two weeks, urea levels in milk were measured to provide information for managing protein supplementation;
- Fresh herbage samples of different leys were taken to measure the ratio of energy to protein in grazed herbage;
- A farm fodder balance was made.

The analysis of these findings led to some insight into the soil's productive capacity: the level of Ca (and therefore pH) was very high, because of the marine history of the land and its surroundings and the level of soil N was low. Because of the high pH and because of previous conventional arable farming, which had reduced the amount of soil organic matter, the delivery of N during the growing season was poor. This combination of effects gave rise to a very high potential for legume growth. Measurements in the first year grass-red/white clover ley in 1996 showed an extremely high yield, including a very high clover and protein production. Measurements of the clover content and the fodder value of fresh grass of other leys, however, showed a very low protein yield until the 3rd or even 4th cut. The establishment of white clover took a long time and therefore the protein levels were too low. Urea levels in bulk-tank milk were compared with those of another mixed farm in the polder area with more or less the same philosophy and with two specialised dairy farms in Friesland. The bulk-tank milk urea levels for Warmonderhofstede were below the recommended levels and were a sign of a shortage of digestible protein.

5.2.2.2. Taking care of mutual learning

From the first year onwards, there were monthly farm visits during the growing season. Researcher and farmer together crossed and evaluated all grassland fields. The main focus was



... taking care of mutual learning ...

on the growth of red and white clover in all fields. The farmer's contribution was to describe pasture management between two successive visits and to relate specific observations of growth since the previous visit. The researcher contributed general knowledge and information on clover from other experiments and from the literature, plus measurements and analysis from several farm fields. Thus, in these talks general information plus qualitative information from the farmer's side

were brought together with the analytical data from the researcher's side. The experiences of the farm manager were always related to specific previous action in specific fields. For instance, due to circumstances during the harvest of the previous flax crop, half of one field was sown in August, but the other half was not sown until the middle of October 1995. Red clover was established, but white clover was hardly present. We decided to make single measurements during the growing season of the development of the fodder value in fresh herbage on both sides of the field, to investigate the effects of presence and absence of white clover. Later on, these unintended and unreplicated experimental situations became very important for the further interpretation of results. They were case studies in a farm context.

Contacts were made with specialists in animal nutrition and with plant breeders (May 1996). The nutritionist was asked to judge the farm feeding programme and to suggest improvements within farm limitations. His advice led to a change in silage making. The farmer accepted the advice because it suited his policy to increase the efficiency of home grown fodder.

Together with the grass breeders of Barenbrug Research we explored the positive results of certain New Zealand mixtures. Those results were explained in relation to winter growth and resistance to drought in summer. We also looked for alternative mixtures from Western Europe.

After the build up of this reference, at the end of the first year the farm manager and the researcher formulated a ley production goal. We could consider a grass-white clover mixture on this farm to be successful if:

- the clover survived the first winter after sowing;
- the growing season was increased by earlier production in spring, resulting in a higher first cut yield and total yield for the first year;

- on an average year base the clover content should be adequate (> 50% on average); in every cut the surplus of available N as OEB-value (= protein surplus in the rumen) should be positive for grass and animal production, although this conflicts with a low N emission.; grass-clover mixtures were tested in successive on-farm trials.

5.2.2.3. Experiential and experimental learning combined

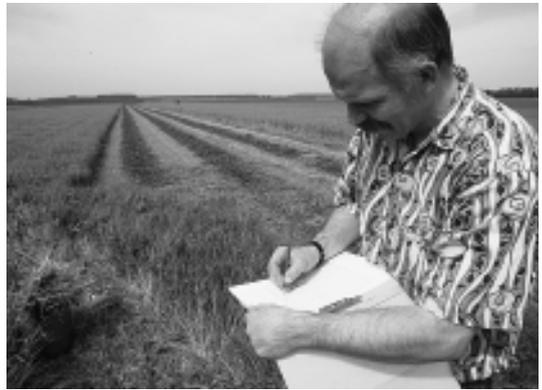
The on-farm experimentation in large-scale field trials started in August 1996. Until March 1999 measurements were made in replicated field trials. Open planning was characteristic of the research approach. The annual reflection on the scientific on-farm results and the personal experiences of the farmer inside and outside the experimental fields led to regular adjustment of the question. The development of the experimentation was gradual, with a yearly change of mixtures.

Due to pest problems in the potato crop, the crop sequence changed after 1996. From 1997, leys were sown after consumption potatoes and therefore their sowing dates were delayed until the 2nd or 3rd week of September. Only after a crop of seed potatoes, the sowing date could be earlier, between the middle and end of August. The amount of manure available was low, and this, in addition to the restrictions on date of sowing, restricted optimal ley production and herbage quality. All FYM was used for arable production and only some slurry was used on leys, mainly in the 2nd year of the ley production or before reseeding them.

By coincidence new ideas were developed and new insights were reached. In 1997, a trial was established to investigate the effects of Italian ryegrass in the mixtures of perennial ryegrass with red and white clover. Due to the extremely mild weather after the August sowing, there was too much herbage left in the field before winter. The farmer decided to cut the trial areas in the first frost period of November. The frost, present in the first centimetres of the soil, protected the soil structure and the herbage was harvested without any further soil damage. However, a part of the field was not cut and so an unplanned experiment was created. In the next year we measured the herbage yield and clover growth in this uncut part of the field as well as in the other, although this part was not replicated like the other treatments. From the November cut area, a well-balanced sward was harvested in the next spring. Annual weeds had disappeared. Although this specific autumn management had a positive outcome, it was clear that there would not be these coincidences every year and a better adaptation of the management was necessary. In relation to sowing date, the farmer observed that white clover germinated very well before winter. However, at the end of winter, he observed that white clover had almost completely died out. Experiments with grass mixtures containing hybrid ryegrass, Italian ryegrass or perennial ryegrass, all cultivars with lower winter dormancy even increased the negative effects of late sowing on clover survival. Following negative results in 1998, the farmer never included Italian



... research in action: each strip is sampled separately ...



... and the differences described ...

ryegrass in his mixtures. It was clear that its low winter dormancy did not suit his September sowing system. Additional negative results appeared in spring 1999, when perennial ryegrass cultivars of New Zealand origin were used in mixtures. Even perennial ryegrass cultivars with a high winter growth rate were not suitable in these circumstances.

In this participatory process, the farmer did not experience the mathematical and statistical results as the most important tools for understanding his farm. However, mathematical results strengthened his personal visual findings and were used to communicate the findings to other farmers. The analytical measurements helped him to see the whole range of ley growth at his farm. An important learning process of the farmer is 'pattern recognition'. The farmer experiences a clear relationship between differences in the field and earlier actions. Even if these findings are not replicated and are in fact coincidences, the farmer trusts them (see further Chapter 8.1).

5.2.2.4. The completion of a research question

The search process stops once the farmer has developed a comprehensive, new way of management. This point was not reached in the above example, although parts of the puzzle were solved. A previous participatory arrangement, undertaken before the college moved to Dronten, involved co-operation on management of permanent pastures (Baars *et al.*, 1998 a). These experiments were concluded when a complete new grassland management system had been developed. Both farmer and researcher could communicate the results as a system in which spring grazing, manure application, increased cutting frequency and summer grazing of external red clover leys all fitted into grassland management (BOX 5.2).

BOX 5.2. The end of the search: site adapted grassland management as a new system (Baars *et al.*, 1998 a)

Between 1987 and 1991 there were several unreplicated on-farm trials on several farms. Measurements were made of herbage yield and quality. The question was how to improve the overall fodder production of the permanent pastures. The trials led to a better understanding of the conditions for growing pastures.

During the period changes were made in: the time of manure application, the grazing rotation in spring, the alternation of cutting and grazing and the start of grazing of the leys in autumn. The farmer discovered the limits of the growing possibilities and how to react to differences in weather from year to year. At the end the new grassland management could be described as a system.

5.2.3. Reflection on methodology

The main point is these trials was action. Steps undertaken are presented in Figure 5.3.

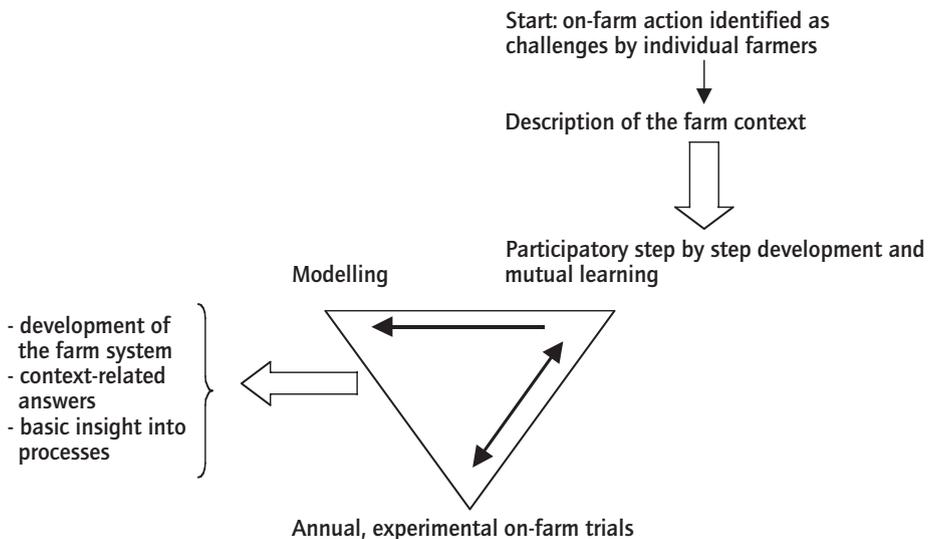


Figure 5.3. The participatory approach at Warmonderhofstede: the main actions were a mixture of participatory action research (right upper corner) and experimentation within the farm context (corner below).

In comparison with the standard in science, which was defined as mono-disciplinary compartment science, the innovations in this project are several:

- The awareness of on-farm actions, which are likely to be successful and which are the guide for the development of new knowledge.
- The experiences and observations of the farmer were as important as the on-farm experiments. Experiences reflect non-replicated casuistic observations, whereas experiments were based on replicated on-farm measurements. The confidence on the farmer's experiences was based on pattern recognition, which reflects the relation of his specific action and later on the patterns in the fields.
- The on-farm experimentation was open to adaptation by intuitions of the farmer. Due to his own search process, the personal involvement of the farmer led to new and intuitive acting. This acting was integrated in new steps of investigations.
- Replicated field trials and modelling were used as scientific methods. However, there is a difference of principle about the place and timing of these experiments. Experimental trials were not carried out on an experimental farm, as was done in Chapter 5.1. Trials were still embedded in the context of a specific farming system ecology and a farmer's style and biography, which were clear limitations for appropriate answers and were steering the search process.
- The on-going process of experimenting and experiencing went on until a new adequate set of action was reached, which was described in terms of management. For the farmer this management was relevant to understand the system in terms of processes and extremities. For the researcher the process stops, once new action becomes part of the system.

In terms of the four quadrant matrix (Figure 2.2) the workplan started in quadrant 4. The action of the farmer was exploited in terms of socio-economic limitations (quadrant 3) and in terms of agro-ecological context of the farming system (quadrant 2). These descriptions limited the process of search within the on-farm experimentation (quadrant 1). Over time this process was repeated and affected by intuitions, other on-farm experiences and knowledge gained from the literature and other specialists. The process ended when the farmer and researcher could describe a new management, which was adequate for the new circumstances.

In conclusion

The way of learning of the pioneering farmer is not just a process of random trial and error. Personal interest and involvement in a certain part of the farm reduces the farmer's focus. Although the whole farm is present as a system and acts as the context for his explorations, this personal focus limits his fields of interest. Reflection on positive and negative experiences,

sometimes the result of coincidence, is an important element of this process. New ideas about factors affecting the outcome of the problem in which the farmer is currently involved, are integrated into the next step of research and development. From that point of view the farmer can be regarded as an 'experiential researcher'. In this co-operation between researcher and pioneering farmer, it is necessary to maintain an open mind and to adapt the on-farm experiments if possible. It is also important to make these additional on-farm measurements, in order to support newly emerging insights. Characteristically this approach leads to a yearly development and adaptation of experiments instead of a repetition of the same trial over a longer period. It does, however, often conflict with the demand for statistics. The difference became particularly clear in 1998, when the farmer created an 'experimental design' by not cutting a part of his field. Later a similar situation appeared again by coincidence, when a part of the field received less manure, which led to a lower grass yield in the first cut, but a much higher clover establishment in the second cut.

5.2.4. Agronomic results

All observations were accompanied by herbage measurements. Each cut was sampled for dry matter yield, botanical composition and N yield. At the end of the project a regression analysis was used to present the effects of sowing date and ryegrass type (Baars and Veltman, 2000). A limitation was the absence of statistical analysis of the non-replicated trials. The non-replicated experimental situations, which arose by coincidence, especially could not be analysed. However, many of the unreplicated differences were often very clear to the farmer, who integrated these experiences into insights about farm management.

The overall evaluation showed that total herbage yields were not affected by ryegrass choice or by time of sowing. Total N yields, however, were affected by sowing time and tended also to be affected by ryegrass type. The total percentage of clover was negatively affected by a delay of sowing time and the inclusion of Italian ryegrass in the mixture. The protein quality (DVE) tended to be lower if Italian ryegrass was included in the mixture. Similarly the N concentration in herbage DM, tended to be lower if Italian ryegrass was included in the mixture and if the mixture was sown in September.

It was concluded that grass-clover mixtures sown in late summer should not contain Italian or hybrid ryegrass. The inclusion of these species at this time of the year only increased grass growth to the first cut, but reduced the development of red and white clover. The lack of clover led to low protein yields. N yield, energy yield (kVEM) and digestible protein yield (DVE) were positively correlated with clover yield. The relationship of the total clover yield to the total herbage DM yield was less clear, although P values for the regression and the correlation coefficients were significant. The calculated relationships between total clover yield (X as tonnes

DM ha⁻¹) and N yield (Y as kg of N ha⁻¹) or energy yield (W as kVEM ha⁻¹) were: $Y = 131.0 + 40.0X$ ($R^2 = 0.87$; $N = 9$); $W = 8.72 + 0.38X$ ($R^2 = 0.81$; $N = 9$); such a relationship was not found for clover and protein yield (as kg DVE ha⁻¹).

The correlation of herbage quality (gr N, VEM and DVE per kg DM) and average annual total clover content in herbage DM were significant as well. When there was 0-28% of clover in herbage DM, the OEB value was negative. On average, a level of 40% of clover was necessary to realise an average DVE value of 80 and even 50% of clover to reach a VEM level of 900 (Baars and Veltman, 2000). These results show that in the optimisation of grass clover growth conflicting goals exist.

5.3. Co-operation with a farmers' group: partner farms ⁴⁴

Wytze Nauta, Geert-Jan van der Burgt and Ton Baars ⁴⁵

The project described here was a co-operative venture with a group of pioneering farmers. The interaction with individual group members was as in the previous project. However, in addition, regular project meetings were used for dialogue within the group and for sharing results and experiences among the participating farmers. New elements in this case project were, therefore, the possibilities of farmer-to-farmer learning and on-farm experimentation in parallel trials within the same theme of research. The farmers acted as a group, which in turn interacted with a network of feed suppliers, because a new demand arose for the processing of concentrate feedstuffs for dairy cattle.

The start of the idea of 'partner farms' came up in 1992. Some pioneering organic arable farmers who did not feel happy with their dependence on conventional manure raised the initial question that led to this project, which aims at partnering arable and animal producers. Bio-dynamic farmers asked the Louis Bolk Institute to be an intermediary for the exchange of fodder and manure. Farmers were looking for 'modern concepts of mixed farming'.

This concept is being developed in practice with nine specialised farms. Financial support was available to the farmers during the first three years of the project to compensate for any risks or additional costs resulting from the collaboration and to support some investment.

⁴⁴ The description of the technical results is based on a conference paper, entitled: 'Partner-farms: a participatory approach to collaboration between specialised organic farms' (Nauta *et al.*, 1999).

⁴⁵ All: Louis Bolk Institute.

5.3.1. Background: the needs for a mixed farming system

In the Netherlands, mixed systems based on the integration of arable, vegetable and animal production have hardly been developed. Reasons are:

- Specific peat and clay soil conditions and the high water table in several parts of the coastal area restrict the growth of arable crops and cause them to be suitable only for permanent grassland;
- The intensification and specialisation of the conventional sector since 1950s has led to specialised farming systems. Even in situations where the farm had a mixed origin, price pressures led to complete separation into arable, dairy, pigs or poultry;
- The average farm size is relatively small and therefore the highest farm income is realised by specialisation;
- Farmers today must participate in quality assurance systems and satisfy environmental regulations, and this demands a high level of specific expertise.

However, mixed farming systems would be the ideal choice in organic agriculture for several reasons (Goewie, 1998). Firstly, a mixed production cycle is better at retaining mineral inputs (N, P, K) and organic matter. Secondly, nutrient uptake is more efficient, reducing the need for external inputs such as concentrates, chemical fertilisers and biocides. Thirdly, farmers rely on the control of weeds by grass/clover leys. Finally, the manpower available on a farm is employed more effectively in mixed farming systems (Bos, 1998). This leads to a more sustainable production system that is less dependent on external circumstances.

Specialisation has its price. Specialised dairy farms need to purchase concentrate feed. Stockless arable or horticultural farms have no choice but to buy farmyard manure and include cereals and leguminous cover crops in their crop rotation to maintain soil health and fertility. We cannot simply turn back the clock on specialised farms. The Partner Farm concept is aimed at establishing intensive collaborations between specialised arable or horticulture farms and farms with only animals. This co-operation may realise several benefits of a mixed system while retaining the farmer's autonomy (Baars, 1998).

Goal of the project was to achieve a sustainable collaboration between the specialised farms such that they form a 'mixed system at a distance'. The desired degree of synergy is achieved by means of intensive consultation, group meetings and on-farm experimentation.

5.3.2. Methodology: action research and group learning

Within a project aimed at over-sowing white clover in permanent pasture, we discussed the topic of 'mixed farming at a distance' with the farmers. Existing contacts with organic arable farmers



... group learning: bring several farmers together on a particular topic ...

about selling straw for bedding were used to form a group of 10 farmers. A project called 'partner-farms' was formulated in 1996 with financial support from the province of North-Holland and RABO Bank. Two scientists within the institute, one for arable and one for animal production, managed the project. The project comprised five dairy farms with a total of 260 ha of grassland and 1.7×10^6 kg milk and four arable farms with a total of 130 ha. The dairy farms participating in the project did not really have suitable soil for growing fodder crops or improving the sward (peat soils and clay on peat), while the four arable farms had ideal soils for a variety of crops. The greatest distance between the dairy and arable farms was 35 km.

The present project will be described using the same outline as the previous one (Chapter 5.2): context description, taking care of mutual learning, combining experiential and experimental learning. New elements in this project were the group meetings and the modelling of whole farm systems. The meetings were used to discuss individual progress and the ethics of mixed systems to support the individual farmer's decisions. Group meetings were combined with farm visits so that each participant could observe other farmers' results. The project was principally oriented on the farming system. Therefore, computer models such as FARM (Oomen and Habets, 1998) and NDCEA were used to extrapolate data derived from the farms and to accompany individual decision making about the future.

A mix of methodologies and techniques within R&D were used to support the choice of the farmers:

- 'Understanding of the farm context': individual measurements at farm level to gather

information to understand the structure of each individual farm. Before the exchange of produce between 'partner farms' was started, the efficiency of manure use and fodder production within each farm was improved. The dairy farms were thoroughly analysed. An external animal feeding specialist analysed the farms' feed balance. Farm structure, grassland management and grassland quality have also been assessed. The first priority for these farms was to realise improvements in farm management and to optimise the utilisation of inputs. Our analyses of the dairy farms focused on fodder production and fodder intake, but also extended to related matters such as fertiliser regime, milk production, and soil mineral and organic matter content. On the arable farms external advice in organic arable farming accompanied the process. Measurements were made of the dynamics of N mineralisation in the soil (Bokhorst and Oomen, 1998; Koopmans and Bokhorst, 2000), which was regarded as a key issue in an efficient use of manure. Another important measurement tool was the farm's mineral balance.

- 'Exploring the literature': from existing knowledge we knew that legumes were a key issue in partnership. On the dairy farms, legumes in pastures were necessary for herbage growth and quality and to reduce the need for external protein concentrates. Parallel to this project, we ran an experiment to investigate the effects of manure type on the growth of grass-clover mixtures (see Chapter 5.1). As a control plot of this trial, we looked at effects of only P and K fertiliser. Results of these trials were important to convince the dairy farmers to 'sell' their animal manure. Also on the arable farms, legumes in the crop rotation would reduce the import level of farmyard manure. We were aware that a new balance had to be found between the use of manure-N and legume-N. We discussed a policy of change with each farmer. Several areas of interest were mentioned and farmers were invited to carry out on-farm trials.
- 'Investigating the reality of real mixed farming systems': we analysed the structure of several mixed organic farms. In the discussion with those farmers we looked how management choices were made in mixed systems. It was necessary to be aware of differences between an ideally mixed system on one farm compared to a mixed system between farms at a distance.
- 'Multidisciplinary co-operation': external institutions were invited to join the project. Technical knowledge on dairy nutrition was necessary to develop a new concentrate based on 100% produce of the arable farmers. The arable farmers produced lucerne that was cut three times a year by a regional company for artificially dried hay and pellet production. It was known that the quality of lucerne could be increased if the first herbage was cut at a lower yield (Van der Schans, 1997 and 1998). The new concentrate consisted of 50% dried lucerne and 50% wheat or barley grain. When this concentrate was available, a new market developed a variety of concentrates consisting of between 30 and 100% lucerne. The ratio of grain to lucerne in the mix was based on the type of animal. It was clear that choices had to be accompanied by

economic considerations. Researchers from WUR-LEI (the Dutch agricultural economics research institute) were invited to join the project.

- 'On-farm trials to develop a self-chosen prototype': on-farm projects were initiated for future co-operation including testing the feeding value of the newly developed concentrate; effects of an earlier 1st cut of lucerne on the quality of herbage and the persistence of the crop; effects of reduced manure use in grassland. In addition to on-farm experiments, some additional monitoring was done to support the farmers' choices and final decisions. Examples are the development of the inorganic soil N in the arable crop rotation as a basis for discussing the question about the efficient use of manure in arable crop rotations and the development of the protein quality in grasslands when the amount of animal manure in the sward was reduced.
- 'Group meetings': see Chapter 5.3.2.1.

5.3.2.1. Group meetings and the exchange of experience and ethics

Incorporating the mixed farm principle in daily farming practice required major changes in farm management on each farm. The farmers had to recover or develop the principles of 'being part of a mixed system' and to see the different perspectives of arable and dairy production, such that they automatically considered the other specialisation when making their annual management plans. We organised regular group meetings to support the process of change. The topics discussed at the group meetings were based on the actual interest of the farmers. The researchers prepared topics and specialists were invited for the group discussions. Information gathered on the farms as well as available scientific knowledge was circulated for discussion. The farmers were able to compare their farm situations. During these meetings several areas of interest were discussed and a vivid exchange of experience took place: why mixed farming; the role of legumes; how far could one reduce the manure inputs in both arable rotations and grassland; what should be the price of products in the exchange? The discussions were a mix of more idealistic and philosophical topics and very practical topics about mutual needs and suggestions for adaptation. New techniques had to be developed, such as the concentrate based on lucerne and grain. Traders and processors were asked to join the project and to support this development. An important ongoing point of discussion during the group meetings was how to value the exchanged produce from a point of view of mixed systems. For the farmers it was a big question how to develop new criteria for exchange, which were not purely based on prices in the conventional market. These answers were formulated in agronomic studies on the economic value of produce in the context of self-supporting mixed systems and closed mineral cycling⁴⁶ (Van Rijs, 1996).

5.3.3. Reflection on methodology

The main point in this trial was action. Steps undertaken are presented in Figure 5.4.

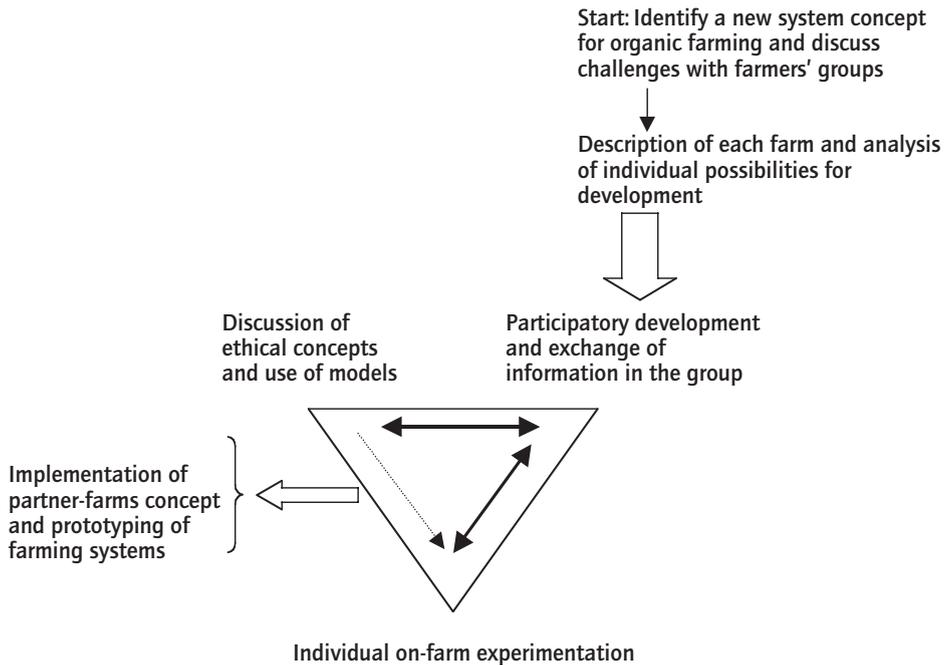


Figure 5.4. Steps undertaken in participatory learning in the project 'partner-farms'.

In comparison with the standards of mono-disciplinary science, and in addition to the findings mentioned in the previous chapter, the innovations in this project were:

- Group meetings deepen the possibilities of interactive learning and the discussions of ethical concepts. The possibilities of farmer-to-farmer learning are present in a group setting;

⁴⁶ For instance there were discussions on the value and price of farm yard manure. In the present practice dairy farmers were obliged to buy straw of organic origin, whereas the arable farmers still could buy conventional manure for a very low price or even receive it for free. However, in a closed system of partner farms, both arable as well as dairy farmers were convinced that a maximum profit of carbon rich manure was in an arable crop rotation instead of grassland with a large built up of soil-C by roots. However, if dairy farmers were selling their manure, what should than be a fair price if manure was more than only a mineral source, but also helpful to reduce pest and diseases and how could grassland farmers develop a 'living soil'?

- Group sessions were used to develop a policy to change the attitude of processors and traders of organic concentrates.

In terms of the four-quadrant matrix, similar steps were undertaken as described in Chapter 5.2.

In conclusion

Specialised organic farmers voluntarily reduced their manure use and concentrate input in comparison with the minimum EU organic standards. As a group of pioneering farmers, they were ahead of future regulations due to their own idealistic goals. They developed and improved their self-chosen prototypes by means of on-farm experimentation to explore new elements of the system, group discussions about the ethical principles of organic farming, and group meetings to make changes in their social environment. The participatory research approach within the farmers' group was not much different from the experience gained with individual farmers in Chapter 5.2. All farmers in the project were asked to make a real experimental design with regard to a part of the project and related to their own farm situation. As much as possible, these experiments were replicated with the proviso that a comparison among farms could be made. It was clear that such a group approach depended to a great extent on the commitment of the individual farmers. At the start of the project, farmers were identified and asked to join the research project. However, the personal interest and involvement in the question differed between farmers. Therefore, the best results were found on farms where the farmer was really committed to the future challenge.

On the other hand, a positive aspect of the group was the interrelationship among the farmers. The exchange of experience, excursions to farms and the discussion of results were positive aspects of the group meetings. Especially, the reality and feasibility of future solutions could be discussed in the farmers' meetings.

5.3.4. Agronomic and social results

Results were divided into 'hard, technical knowledge' and 'soft knowledge', based on the social side of such a development. Examples of these changes in personal motivation were:

- Farmers have to learn to think mixed farming.

⁴⁷ This Chapter is based on a Dutch booklet about the breeder Dirk Endendijk (Baars, 1990-a), which has also been published in German. This work was presented at the 4th meeting of the Network for Animal Health and Welfare in Organic Agriculture (Endendijk *et al.* 2001). Many thanks to Dirk Endendijk, Dutch Friesian breeder at the Rivelinohoeve and president of the Dutch Friesian Breeders Association.

⁴⁸ Family breeding. In this method, the breeding animals are related to each other to some degree. They have one or more fairly closely related predecessors (Anema, 1950).

- Once evolved, a partnership is the best way to experience the mutual dependence of specialised areas.
- Legumes are a key issue in mixed systems.
- Mixtures in different proportions of dried lucerne and grain will cover the concentrate requirements for dairy cows, dry cows and young stock.

Further technical results were described in more detail in Nauta *et al.*, (1999) and in an internal report of the Louis Bolk Institute.

5.4. Exploring tacit knowledge generated by farm practice: family breeding ⁴⁷ ⁴⁸

Often pioneering farmers, whether they are organic or not, develop new management practices even before the research society becomes interested in the issue. Following their personal interests, farmers can develop completely new areas of adapted management. Their experience can remain hidden as 'tacit knowledge' and the lack of a conscious reflection might lead to personal skill or farming skills, or to verbal expression in farmers' own language.

This case study describes an independently developed insight of a farmer. A retrospective study was done, based on discussions with the farmer and on an analysis of his animal breeding system. At the start of the process, one misses the appropriate vocabulary and even the right focus to understand the system of family breeding. One only becomes aware of the coherent set of actions that underlay this novel system due to a shift in one's own breeding paradigm.

5.4.1. Background: family breeding as a challenge for organic farming

Organic farmers are interested in breeding programs, which are better adapted to the main principles of organic farming, such as animal feeding with a reduced concentrate use, life time production and natural mating. Organic farmers who use natural mating are often anxious about inbreeding when a male animal is used for too long. On the other hand, most organic farmers still buy breeding stock from conventional AI organisations, simply because they lack a clear vision on an alternative breeding system. In the German practice, organic dairy farmers use artificial insemination in 65% of the cases (Krutzinna *et al.*, 1996). As a matter of principle, in the organic standards artificial techniques, such as deep freezing of sperm and embryos or the use of hormones for synchronised ovulation are not allowed ⁴⁹.

Endendijk is a famous breeder with a specific personal opinion about breeding goals and breeding strategies. In the 1970s and 1980s Endendijk did not follow the system of population

⁴⁹ For practical reasons the standards permit artificial insemination, whereas embryo transfer is prohibited. A discussion is on-going whether organic farmers could use breeding sires born from artificial embryo transfers.



... Rivella 160 as the champion of the Dutch Friesian herd book ...

breeding on a world scale after the introduction of the American and Canadian Holstein breed, which was used by most farmers. He managed his farm with the smaller, dual-purpose Dutch Friesian cattle, a breed that was almost wiped out by the introduction of the Holsteins. Endendijk's breeding system is centred on the unique characteristics of the individual farm. His method of observing and breeding may therefore be particularly interesting for organic

farmers who ideally formulate their own breeding goals. The advantage of this system is that the animals are selected for outstanding performance in this farming system. The qualities of these animals are reinforced by the system. The type of family breeding Endendijk is using is moderate family breeding or kin breeding, in which the paired animals are distantly related.

5.4.2. Methodology: analysis of tacit knowledge and action

To undertake research of the outcomes of breeding practices was impossible because of the time involved. It was decided to analyse and describe the system of family breeding system practised by Endendijk. The breeder agreed to share his insights about his breeding system.

We recognised a consistent breeding system although we did not understand the way it worked. The farmer's breeding concept had not been developed in a positivistic and reductionistic manner through experiments. Instead, it had been developed in an experiential way by action, reflection and understanding, a first hand learning process. After several interviews, the core issues and the results obtained by the farmer could be described in terms of a novel breeding system, which could be made explicit and adopted by other farmers.

5.4.2.1. Finding an entry point into hidden experience

For the farmer the breeding method had become a consistent system of acting that was integrated into his daily life. For us the system was unclear because we did not understand his daily choices and were not aware of the relative importance of all management measures. We analysed the breeding strategy of the farmer in a retrospective way by means of a series of in-depth interviews and the analysis of several cow and bull pedigrees (Baars, 1990-a). The

interviews were recorded on tape. During the analysis of pedigrees, new questions about choices, breeding goals, motives, etc. were raised and in the next interview we asked the farmer again. Facts were written down from the memory of the farmer, who was treated as an authority. Endendijk had carried out several experiments on his farm. He compared different forms of housing to see which the cows like best. He was fortunate to do business with a small feed company that makes concentrate feed exactly following his specifications. Endendijk has also travelled widely. In his youth, he was a hoof trimmer. In this profession he visited many farms and experienced the relationship between breed, housing and hoof quality. He had also been to California (1980) and Israel (1985). Over time, various changes have been realised in Endendijk's farm management. These changes were in the cows' best interests, as Endendijk firmly believes that happy cows perform best. The farmer's experience was analysed first; literature about family breeding was used as a reference.

5.4.2.2. Understanding the management as a coherent system of action

The pedigrees of all animals were described and after an analysis of the mating choices made in several pedigrees I tried to understand the perspective and thinking of the breeder. However, my knowledge on breeding was based on regular breeding practice and the role of mainly bulls (Sires indices). In the beginning this led to a misunderstanding of the crux of the family breeding system. After several interviews the farmer told me that I should change my view on breeding. In family breeding, it is not the single animal that is important, but the composition of the herd. New thinking was necessary to understand this way of breeding based on the interaction of genome and environment and the importance of a homogeneous cow family. As in Chapter 5.2, the end of my search was reached when I could communicate the new breeding system in terms of an explicit and consistent framework of actions that could be applied by other farmers. The other part of the system was related to the competence of Endendijk as an elite ⁵⁰ breeder who must have an idea, a conviction, of what the ideal cow should look like. Endendijk's ideal dairy cow belongs to the Kate family bred by Meekma Jr. (Anonymous, 1967). His breeding system is ultimately about perfecting the Kate cow. In our meetings, we became aware that Endendijk visualised this ideal cow and used this flexible cow-prototype to judge newly bred

⁵⁰ The term 'elite breeder' comes from Hagedoorn (1927). He distinguishes three categories of breeders: elite breeders, herd book breeders and users of the breed. The first category is a fairly small group of breeders who know the breed through and through and who constantly work to maintain or improve the quality of the breed through continuing breeding selections and family breeding. The quality and continuance of the breed depends on these elite breeders. They are breeders in the true sense of the word. They have an ongoing but exclusive supply of top-grade male breeding stock, and so their influence on the quality of the breed is much greater than one would expect solely on the basis of the number of animals bred by them. In other words, their influence bears no relation to the number of animals which they provide for the breeding programme.

animals. This inner eye was not a fixed picture, such as the statue or picture of so-called true-types in the herd books. He was dealing with the whole life cycle of the cow.

5.4.3. Reflection on methodology

The steps undertaken in this project are summarised in Figure 5.5. The main point in this case study was reflective action based on retrospective inquiry of the farmer’s actions.

In comparison with standard mono-disciplinary science, the innovations in this project were:

- Learning from experience is based on reflection on personal action and on comparison with other farmers. This last activity is very similar to the process of a literature review or a scientific conference of scientists.
- ‘Pattern recognition’ in this case consisted of visualising a vivid ‘cow-prototype’. Patterns of growth and development and an ideal type, all in the mind of the farmer, are used as a reference to judge new-born calves.
- A shift of focus is necessary to become involved in the vision of another person, i.e. a cattle breeder.

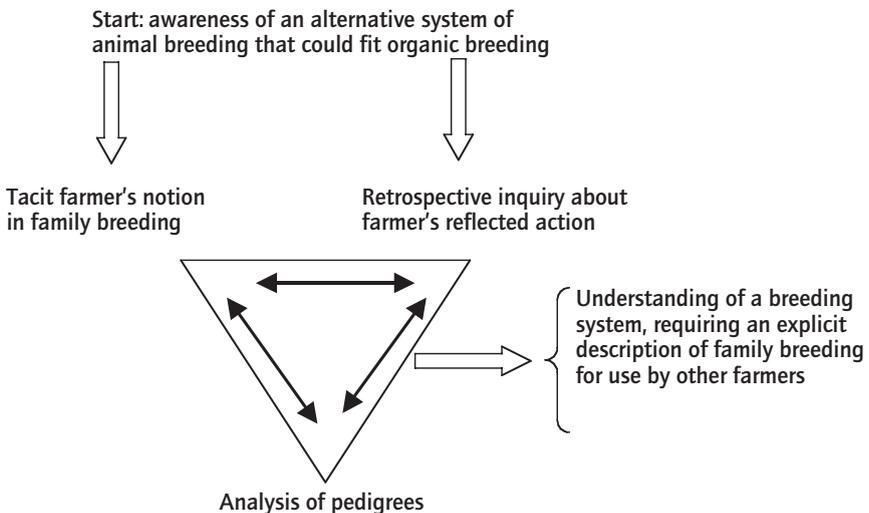


Figure 5.5. Steps undertaken in exploring the tacit knowledge in the project 'Rivelinohoeve'.

In terms of the four-quadrant matrix, this project is a modification of the one described in Chapter 5.2. In this case, the farmer's past action is the entry point (4th quadrant). We focused on his action to be aware of his breeding system (2nd quadrant), which was related to his specific values and networks (3rd quadrant). In a repeated cycle of discussions, we tested his action (4th quadrant) with his breeding results (1st quadrant). Finally, the new concept of family breeding could be described as a system of coherent action that other farmers could apply (2nd quadrant).

In conclusion

In the reality of life, farmers are often ahead of scientific research in terms of knowledge and experience. In the practice of these pioneers, knowledge is implicit in their coherent set of actions. In a process of reflection and pattern recognition, farmers develop new insights about their world. In this case project, in a process of in-depth interviewing and analysis of action, a reflection is made on the systemic nature of the action. However, it is necessary to become aware of the other's point of view on the farm's reality, i.e. family breeding instead of breeding using a global system for sperm and embryo exchange based on quantitative population genetics.

5.4.4. Agronomic results: understanding the system of family breeding

Results are presented as a breeding system not as technical results of improved milk production, etc. This has been described by Baars (1990-a). Endendijk's system of breeding is one that Dutch farmers have practised for centuries. In the 19th century, family breeding (line breeding with some inbreeding) helped make the Dutch cow renowned world-wide. The origin of many American and Canadian Holsteins can be traced back to Dutch farms in the late 19th and early 20th centuries (Wiersma, 1989). Endendijk practises a specific form of family breeding, which was described by Anema (1950) as 'extended family-breeding'. Endendijk's breeding goals do not differ much from the goals of other farmers. The difference with other farmers is that Endendijk knows exactly what the characteristics of his breeding bulls are. These characteristics have not been reduced to an abstract score of estimated breeding value, as in most sire catalogues, but are described qualitatively. Endendijk sets clear priorities in his breeding programme: milk yield, and persistence and feed intake capacity, which all fall under the broader concept of vitality. Bulls are taken from several cow families from herds of about 60-70 cows. The animals are related because of pairings between the different lines.

Endendijk's breeding system ⁵¹ can be characterised as follows:

- Five to ten bulls are used per year; these are selected from the top performers in the herd. The animals are selected on the basis of their suitability for Endendijk's own farm management system. A bull's parentage is important: both mother and father should belong to a certain cow family, in this case the Kate family.
- Not only the best bull is used; second-best bulls (sub-top) are also used to prevent excessive inbreeding.
- In principle, new blood is only introduced in the female line. Cows with elements of the own type are bought. These cows usually belong to closely related families.
- Own bulls (Rivelino) used in breeding must at least have double Kate blood ⁵².
- Several bloodlines are maintained (10-15). Buying in female breeding stock (see above) creates new lines.
- Compensation crosses are made to improve the weaker characteristics in a line.

In this system, it is important to find a satisfactory balance between the degree of inbreeding among top animals and the maintenance of good qualities. Good characteristics can also be introduced into a line by second-best animals. Endendijk stresses that the success of family

breeding does not depend on an individual bull but on a well-bred cow family. Adherence to this system implies that bulls used for breeding are at least double-blooded, that is, are progeny of earlier generations of own bulls.



... the power of one's one system: descendants of Rivelino 279 ...

⁵¹ At the time that I completed the booklet about family breeding, De Roo (1988) completed his doctoral thesis on breeding in small pig populations. His recommendations about breeding strategies were similar to the system developed by Endendijk.

⁵² Double Kate blood means that in the pedigree of both mother and father at least two generations out of the Kate family should be present.

5.4.4.1. Choice for the right system: the power of one's own system

When studying different pedigrees, one always wonders why a particular cow was mated with a particular bull. The answer is rarely profound. The match usually concerns a yearling bull that had just come of age to serve a cow. It is rarely a match based on careful selection. Endendijk: *'The system is of primary importance. The bulls are only part of the system. Many farmers think that breeding is all about finding that one special bull. It's not.'* To show the paradigm shift, Endendijk criticised our focus on breeding: *'In every day practice, you don't study pedigrees retrospectively. It's important to figure out which are good families on your own farm and then you go and breed with them. Success is created by the system, a system that is hundreds of years old. Individual bulls aren't successful, their families are. People have forgotten that. Everyone is focused on that one bull now: that unique, excellent special bull. But if you choose a good family, good progeny follows automatically. Breeding is really so simple, but it's been made into a science. You just have to stick with good families, use the bulls from those families.'*

5.5. Vision formulation: breeding for local genetic diversity, herd adaptation and harmony ⁵³

Ton Baars and Wytze Nauta ⁵⁴

It is clear that organic farming generates concepts that are completely new or that can adapt or enlarge existing concepts. In Chapter 1.3 is mentioned, as one of the challenges for R&D in organic farming, that conventional science is now prepared to support the development of organic farming. The same Chapter stated that a conversion of scientific values is needed that reflects the conversion from conventional to organic farm practice. Recently the interpretation of the concept of 'naturalness' was investigated (Verhoog *et al.*, 2002 a and b) in a search for better ways to distinguish organic farming from integrated and conventional systems. In the end, the concept was very helpful to describe the socio-economic forces that are now present in and outside organic society (Cf. Chapter 3.4).

The present case shows how a breeding concept was adapted to organic farming.

5.5.1. Background: request for a vision

One of the on-going discussions in organic farming concerns the domestication process of farm animals. This concern is not only raised in terms of appropriate breeding techniques, but also in

⁵³ This Chapter has been published by Baars and Nauta, 2001. As part of Nauta's doctoral thesis (in prep.), Nauta has elaborated the discussion about suitable breeding strategies (Nauta *et al.*, 2002).

⁵⁴ Animal breeding scientist, Louis Bolk Institute.

terms of breeding goals. To assist the choices in breeding it is necessary that the organic movement is clear about its own views on animal breeding.

In addition to the description of family breeding (Cf. Chapter 5.4), we were asked to develop a point of view about the use of genetic modification of farm animals. Within a group of scientists, the concept of genetic modification was discussed from a spiritual point of view (Van der Wal and Lammerts van Bueren, 1993). However, genetic modification is not a big issue in farm animals. Therefore we focused on a vision on animal breeding from the point of view of organic farming.

5.5.2. Methodology: reflection on bio-ethical concepts

As a more general approach, several phases can be distinguished in such a project of concept discussion (Verhoog *et al.* 2001):

- Interviews with key figures with regard to the topic of interest (farm practice, regulation, policy, trading, etc.);
- reflection on existing concepts and normative (ethical) research aiming at a reconstruction of the system of values and norms of organic agriculture, followed by an internal group discussion of the findings; and
- implementation.

The vision for breeding was based on several sources. The idea was developed by combining personal feelings, philosophical consciousness based on holism and observations in life, and scientific insight. Meetings with specific farmers and scientists were important tools to develop and sharpen the concept. Beforehand, a report was written about the practice of family breeding (Cf. Chapter 5.4; Baars, 1990-a). Perhaps not unexpected, given the ecological background of the scientists present, the feeling immediately established that family breeding was the key to site-related adaptation. Secondly a farmers' group was formed to discuss dairy cattle breeding in organic farming. This group contacted Professor Bakels, an emeritus professor of Munich University and founder of the program for life-time breeding for the Holstein breed. Professor Bakels visited the Netherlands several times (1989-1991). Thirdly, because of this background, we were asked to become a member of the Dutch network on genetic engineering. Anthroposophists who were concerned about the impact of genetic modification on life started this network⁵⁵. Finally, two new findings were important to finalise the vision: the meeting with the breeder of Dutch Friesian cows, Cees Dekker, who formulated the sense of beauty as a viewpoint within

⁵⁵ International Forum for Genetic Engineering: www.anth.org/ifgene/

breeding. This farmer had developed a completely harmonious animal with proportions that fitted very well with the so-called Divine Proportion (Huntley, 1970; Kleijne and Koning, 2000). This attention to harmony for us was an indication that such empathic breeders had a feeling for the animal as a whole and based on their own observations. In addition to this, we found inspiration in the work of the biologist Schad (1977). He focused on the holistic entity of all mammal species together and the inner interrelationship between species and animal build, based on the anthroposophic principle of the three-folded human spirit: thinking, feeling and willing (Cf. Chapter 2.3). Schad mentioned a sense of the cow's integrity, based on the spiritual interrelationships within the world of mammals.

Verhoog (2000) distinguished several bio-ethical theories: anthropo-centric, patho-centric, zoo-centric, bio-centric and eco-centric. A discussion of values is only relevant if one is aware of one's own points of view. Our point of view with regard to organic breeding will be described below.

5.5.3. Reflection on methodology

The approach to science and ethics was based on communication within groups that discussed the philosophy of science, the relation to the worldview and the implications for action. The interaction of practitioners and philosophers in brainstorming groups was very fruitful for the

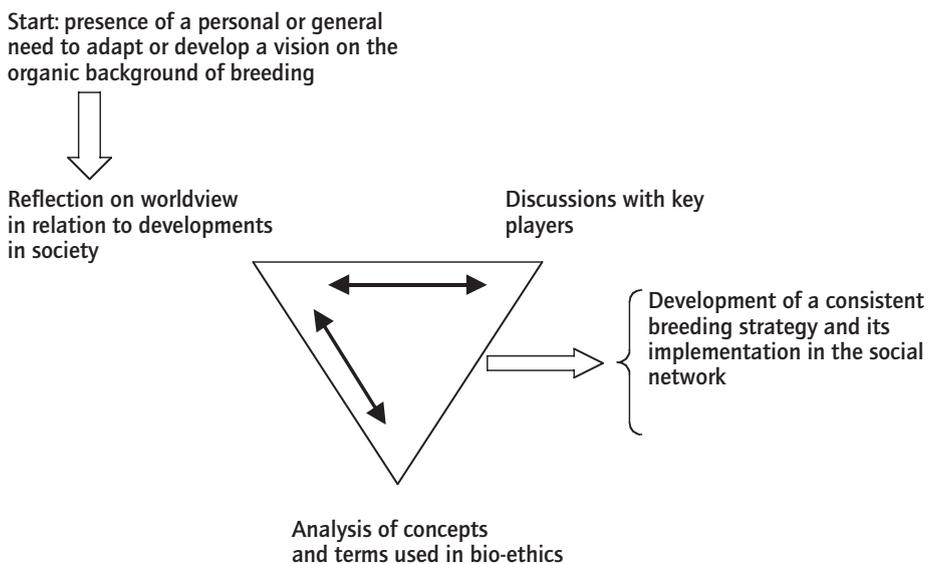


Figure 5.6. Steps undertaken in the bio-ethical discussions and adaptations of a concept.

discussion on concepts. In case of organic farming, it is important to discuss the implications of the holistic principles of life sciences, the views of the spiritual pioneers and the consequences for action on the farm. New concepts can be integrated and practised in organic farming, based on an interpretation of spiritual ideas.

The main point in this case study was concept building based on more holistic principles of organic farming (Figure 5.6). This method is in no way comparable to the standard of mono-disciplinary science. The innovations in this project were:

- In ethical discussions, the boundaries of the positivistic science were crossed. Such a basic discussion is a strong support for the implementation of on-going developments in the historical concepts of organic farming

Based on the four-quadrant framework, this project is strongly related to the 3rd quadrant. As shown in the discussion on holism and reductionism, this quadrant represents the category of 'value-holism', i.e. a discussion on backgrounds and concepts.

In conclusion

Several approaches have been suggested to novel ways of breeding. Family breeding has been suggested as a practical method to increase the genetic diversity between regions. This way of breeding is locally oriented instead of the use of semen of world sires. It is a small scale breeding method that can strengthen the specific environmental characteristics in the farm animals by mating and selection. Breeding choices have also to do with ethics in the way that a holistic view on farm animals will be a guide for choices and boundaries. Several breeders have developed a holistic view on dairy cows, which reflects their character and their harmonious build. Finally, it is striking how often three lines of breeding are used in several breeding programs, which probably reflect on the spiritual relationship with the trinity of man.

5.5.4. Social results

Results are presented in terms of an 'adapted or elaborate vision', which reflects the intentions of organic farming (Cf. Chapter 1.2). These are presented in terms of recommendations and were used in a later discussion with organic farmers, breeding companies and traders about breeding goals and acceptance of breeding techniques in organic farming (Nauta *et al.*, 2002):

- Local genetic diversity. Regional family breeding, which incorporates the genotype x environmental interaction, and which act on a local scale will increase the genetic diversity between regions by means of site-adapted landraces;
- Self-regulation and prevention. One-sided production goals might lead to disharmony of

individual animals, dysfunction and too short a life expectancy. Therefore a harmonious body build of animals should be part of the breeding goal;

- Holistic breeding concept (general). In relation to the discussion of animal integrity, breeding should respect ethical and ecological animal-specific criteria;
- Holistic breeding concept (practical). The basics of breeding should reflect three qualities in animals. This is reflected in several breeding practices, as well as in a holistic view on humans in relation to the other mammals.

Below these visions will be further explained.

5.5.4.1. The answer to the decline in genetic diversity: site adapted landraces

In organic farming, breeding should be used to reinforce the relationship between the animal breed and the environment in which it has to live. Plants and animals are expressions of a certain (semi-) natural environment. Differences between farms spring from differences in soil quality, their situation in climatic zones, etc. Therefore, breeding and improvement should, from an organic point of view, follow on from the improvement of the original native breeds. That is to say, one aims for small-scale improvements that consciously seek to reinforce those qualities that suit a particular environment. It is not so much a question of adapting as of fitting in.

The family breeding method as currently practised by a handful of individual breeders ensures that a farm-specific cow will emerge within a current farm environment (Baars, 1990-a). Family breeding offers ideal opportunities to achieve versatility. Regionally oriented breeding of this nature makes it possible to reflect the diversity present in the different landscapes in the physiology and behaviour of a domesticated animal such as the old landraces. Animals and surroundings can thus be brought into balance and be further improved together.

5.5.4.2. A sense of beauty and proportion: harmony in build

In addition to biased production characteristics, some breeders also consciously take account of the 'harmonious proportions' of the animal. An animal's build and bone structure are considered important determinants of whether an animal will be a good milking cow. The American Bill Weeks developed the 'aAa' (triple A) system, in which he supplements production-based criteria with the strong and weak points of an animal's build. In pairing a dam and a sire he tries to select animals in such a way that their offspring will be a more harmoniously built dairy cow. Weeks posed that the better a farm succeeded in 'harmonious' pairings, the longer the mean life expectancy of the herd, in comparison with farms that did not practice compensation pairing. Weeks originally distinguished two types of animal: a more flat-ribbed type and a more round-ribbed type. Later he made further distinctions within these types, dividing each of the main

CHAPTER 5



... site adapted landraces ...
... a rare red and white Dutch Friesian in the province Friesland ...



... a black and white Dutch Friesian bull
from North-Holland ...



... Blaarkop bulls from the peat area in South-Holland ...



... a black and white Dutch Friesian bull in the province
Drenthe ...

types into three sub-types. The ideal cow averages out all the extreme types in its build and stands at the centre of a circle (Figure 5.7). The extreme types make up the circumference of the circle.

Another view of the harmony concept can be traced back to Dutch Friesian breeder, Dirk Endendijk (Baars, 1990-a). As a breeder he values a harmoniously built cow. Harmony in build makes a milk cow into a good breeding cow. Endendijk judges this by eye from his own sense of harmonious proportions. In the 1970s, the Dutch Friesian breeder Cees Dekker from Vierpolders defined 'the ideal Dutch Friesian cow'. Dekker goes so far as to indicate the ideal cow in

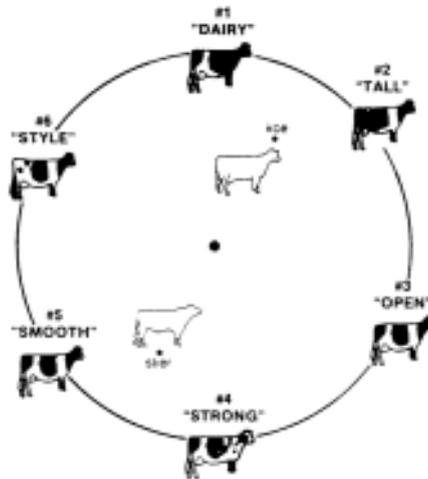


Figure 5.7. Sketch of an aAa pairing: extreme builds of animals are categorised in six main types. Each cow receives a visual score for the three strong and three weak points in her build. In the mating, the weak points in build are compensated by the selection of a bull with as many compensating characteristics as possible.

numerical proportions of all body elements. What is striking about Dekker's definition is that it essentially comes down to the numeric ratios of 1:2 and sometimes 1:3⁵⁶. The type of focus on ratios by Dekker show much similarity to the ratio in the Divine Proportion⁵⁷ that was used in the design of paintings and building and that led to a harmonious composition. It should be noted that Endendijk, Dekker and Weeks are all concerned with the relationships between body measurements, and not with the absolute value of the different variables. Consciously or unconsciously, all three breeders have an instinctive sense of beauty that is normally only discussed within arts instead of science.

A third way of incorporating a feeling for interrelationships and proportions is to consciously consider the effect that, say, breeding for milk production may have on the rest of the animal. Genetic progress (in terms of milk production) appears to proceed fastest when breeding goals focus on only one or a few characteristics. However, in that case one must also consider the characteristics that are changed unintentionally and simultaneously. Conventional breeders as

⁵⁶ Dekker developed standard measures for the Dutch Friesian defined on an age of 4-5 years. In total he used 33 points for his score of an ideal body build (see Baars, 1993). As an example the proportions from the udder: the udder length should be 45 cm; udder depth measured from the belly 22.5 cm; distance between the teets 11.5 cm and teet length 5.5-6 cm.

⁵⁷ The divine proportion or golden section ratio is 1:1.6180 (Huntley, 1970)

Endendijk, Dekker and Weeks looked at the interrelationships between the different characteristics. In this way they can prevent breeding focusing too singularly for a specific characteristic such as height or INET ⁵⁸ (Hansen *et al.*, 1999). The danger in reducing breeding to milk yield is that the context in which the data were collected can no longer be assessed. Increased milk yield may lead to fertility problems (Ostergaard *et al.*, 1990) and reduced efficiency of fodder utilisation (Yerex *et al.*, 1988), mainly because of reduced attention to cow height and cow weight. For this reason it is essential to test data continuously in real life, looking at the animal as a whole (Endendijk, 2000). This also prevents certain characteristics, such as fertility and life expectancy, to be forgotten or overlooked.

5.5.4.3. Action based on animal's integrity: animal-specific criteria

Another alternative to prevent reducing the cow to its component parts was formulated by Professor F. Bakels (Haiger *et al.*, 1988; Haiger, 1989; Postler, 1990). As a geneticist and veterinarian, Bakels developed a breeding programme that centres on 'lifetime production'. Bakels' basic premise is to carry out selection based on characteristics that include all the sub-aspects of the cow (this method can also be applied to pigs and poultry). Here we are concerned with finding criteria which are not inspired by economic considerations (for example protein and fat content and now lactoglobulin content) but which are taken from the totality of the cow as a living organism. The primary selection characteristic is vitality (or fitness), the capacity of an animal to remain productive throughout its life without any serious problems. This is translated into life expectancy and energy production during life (in offspring and/or milk and meat) (Zeddies, 1972; Essl, 1989; Postler, 1990).

To assess Bakels' viewpoint properly, it is important to understand that he attaches value to, among other things, the process of domestication of the cow and the regular behavioural patterns which the animal itself displays in this process. In this sense, Bakels, unlike Weeks, Endendijk and Dekker, has more consideration for the intrinsic characteristics of the cow. He allows the animal itself, as it were, to indicate the limits which should be observed in breeding in order to evaluate the cow as a cow. Bakels shows in his 'nature-like breeding method' how the domestication process has proceeded from prehistoric cattle to our domesticated cow. From this domestication process he traces all kinds of functional characteristics which are now a proper part of the cow. The following characteristics should be considered in the breeding process of dairy cows (Postler, 1990; 1991):

⁵⁸ The Dutch calculation of improved milk yield through breeding expressed as additional income.

- sexual dimorphism: bulls should be male-like in their expression and body figures and kept for meat production, whereas cows should be feminine and kept for milk production
- cows are long distance walkers
- cows are ruminants
- cows have a functional build (pelvic shape, flexible back)
- physiological traits which are sex-linked.

With this system Bakels developed practical and practicable breeding and selection characteristics which leave the domesticated animal as 'whole' as possible, and which are in keeping with the 'nature' and behavioural preferences of it (Haiger *et al.*, 1988; Haiger, 1991). Schad (1977) chooses yet another entry point to identify the typical characteristics of the 'cow being'. Based on the morphology and build of the animal species, its behavioural traits, and vital functions Schad classifies mammals into three main groups: rodents, predators and ungulates. Schad states that this trinity is a reflection of the threefold structure of man's spirit: thinking, feeling and willing (see also Table 2.1). Baars E. and Nierop (in prep.) prepared a statistical analysis of these morphological principles. They showed, that the basics of these three main mammal groups were found in e.g. morphology, growth rate, teeth and birth. All the different types of animals show a certain bias. By becoming aware of these biases, we can ask ourselves what function each animal will serve for nature, agriculture and man. According to these correlations, Schad's work illustrated that a cow, for instance, is in the first instance the perfect example of a roughage converter. The animal metabolises and transforms plant substances into milk, meat and manure, heat, work etc.

Such an elaboration makes one aware of the typical characteristics of, say, cows. Just as Bakels' approach, Schad's can clarify what kind of being we are dealing with. Human action could now be aimed at housing and feeding all domesticated animals in accordance with their nature. Breeding and selection must allow the essential characteristics of each domesticated animal to come into their own.

Bartussek (1991) indicated gradations of 'naturalness' in the agricultural production system. For this purpose he designed an 'animal need index' for feeding, welfare and breeding. Criteria for the index are drawn from animal-specific needs. Rist (1987) also started from the level of animal-specific needs with regard to animal welfare and housing. Rist pointed out that the psyche and its expressions, both in terms of well being and suffering, are examples of immanent forces. Herein lies the problem with the positivistic scientist, whose numerically based approach overlooks this immaterial level (see also Rist and Rist, 2000).

5.6. Goethean science: landscape planning at the Noorderhoeve farm ⁵⁹

Hans Vereijken ⁶⁰, Tom van Gelder ⁶¹, Ton Baars

Research practised at the Louis Bolk Institute, is not only based on a positivistic approach of science. Renewal of science is therefore more than an expansion in terms of system attention or the integration of beta and gamma approaches. This case project shows how positivistic aspects of knowledge are integrated into Goethean science. It is another type of science expansion in terms of involvement, direct observation and the qualification of the observed. As a holistic approach, terms are developed to express the entity instead the quantification of details. The start of the project was based on a request by the farmers' group of the bio-dynamic farm Noorderhoeve to support them in their landscape-planning. The farmers wanted to elaborate this question in a Goethean-phenomenological approach. With help of that approach we wanted to get a grip on the identity of the farm in its surrounding landscape. Bockemühl (1985; 1992; 1993; 1994) has worked out this phenomenological approach, Colquhoun (1993) described the main steps.

5.6.1. Background: Goethean science as an integration approach

5.6.1.1. The theory of a healthy landscape

For an organic farmer who looks at the 'farm as an organism', a closed, self-supporting mixed farm is the ideal farming-system. Natural conditions form its foundation. It is therefore not surprising that (well-established) organic farms are characterised by a high diversity in production and nature elements (Hendriks and Stroeken, 1992; Braat and Vereijken, 1993). The farm itself can be seen as an organ within the greater organism of the landscape. From this point of view, an organic farmer is interested to fit his farm into the surrounding landscape. He is looking for a healthy landscape with a strong identity and with an optimal balance between agricultural, ecological and economic qualities in which it is humanly rewarding to work. In this project, the approach is to take the actual situation on a specific farm as starting point and to optimise the present situation, solving at least a few of the agricultural and landscape problems on the farm. The aim is then to design a landscape, which precisely fits this farm and

⁵⁹ The scientific results of this project were published in Vereijken *et al.*, (1997-b) and were based on the study of Baars and Van Gelder (1994). The approach was further developed in a second project on another bio-dynamic farm, Warmonderhofstede (Vereijken and Van Gelder, 1995; Vereijken *et al.*, 1997-b).

⁶⁰ Louis Bolk Institute, Driebergen. The Netherlands (until 1997).

⁶¹ Groenhorst College, Department of Bio-dynamic Agriculture, Warmonderhofstede, Dronten, The Netherlands.

the people who work there. The question was raised how the concept of farm identity can be used in landscape planning. We have to solve at least three problems. Firstly, we must have a method to describe the farm identity. Secondly, the people who live and work on the farm are part of the farm identity so we have to co-operate with them (Vereijken, 1995-a). The concept of identity has to do *'with appreciation by the people who live there. Historically they gave the landscape its present identity and they have to accept the new identity'* (Boerwinkel, 1994). Thirdly, a landscape is not a static object like a house, but a dynamic system, which develops constantly (a tree grows, soil changes, vegetation is in succession). So a dynamic or evolutionary approach with regard to identity is called for (Bockemühl, 1993). Our approach, the development of the farm's identity, and the method we developed, try to take these three problems into account.

5.6.2. Methodology: bridging positivistic and constructivistic approaches

In co-operation with the farmers, we tried to describe the farm's identity, which, in bio-dynamic farming, is termed 'farm-individuality'. An important and crucial point of the method is that we tried to find the trends of development or the directions for future development present in this present-day farming situation⁶². Suggested changes in farm management and landscape should logically arise from the actual farm situation, taking into account the history or biography of the individual farm including its ecological and agricultural problems at this moment. If we are able to find these developmental trends and appreciate their benefits and flaws, we have gained a set of criteria for developing appropriate proposals for improving the landscape on the farm. If we then study the landscape around the farm in the same way as we studied the farm - in search of the *genius loci* -, we are able to add another set of criteria. Together they enable us to formulate concrete proposals.

The methodology to find the directions for future development comprises three steps, which are taken in close co-operation with the farmer or farmers working on the farm:

- The first impression of the farm as a whole is described. It is a simple and, at first, a personal impression of what one sees, smells, hears and experiences when one visits the farm. This description of 'the farm as a whole' gives the necessary background to go into further detail in the following steps.
- All kinds of data are collected and divided into several categories:

⁶² Bockemühl (1985) used the German expression: *'Impuls zum Keimen'*. This means, that a future impulse is present, which is still hidden in the present situation and waiting for germination.

- the present: soil, water(quality), geology, vegetation, fauna, data about the farm, production, agricultural problems, people who work on the farm, etc.;
 - the past: history of the farm, soil, vegetation, etc. is described in such a way that 'lines of development' become visible; and is what interests us most;
 - the characteristics of the farm that emerge from the description of the farm in facts and lines of development.
- In special group meetings all this information is put together in symbolic pictures or holistic images⁶³ of the farm that characterise it and can show aspects of the farm-entity. We often found that fairy-tale personalities, plants or animals were used as symbolic images to express a farm's characteristics. The meaning and importance of the symbolic images are discussed, so that directions for future development that can solve current problems become clear. In this part of the method, co-operation with the farmers and people involved is of essential importance. They are the ones who know the farm and are therefore the most familiar with the farm-entity. But they need, so to say, a mirror that is held up by the researchers, to look at the farm-entity and to see what this entity 'wants', which is not necessarily the same as what the farmers want⁶⁴. A second method to find directions for future development lies in the biography of the farm. The biography shows long-term changes in motives and intentions of the farmers and the farm. In this context the present work of the farmers is also studied as this expresses most clearly their present intentions.

The meetings with the farmers are central in our methodology; therefore we will describe them in more detail. The meetings start with a farm walk. Then we go inside and ask the people to describe what they have seen and experienced, so as to collect all kinds of observations from different angles. As a kind of meditation, we ask everyone to draw a picture of the farm in which one's understanding of the farm is presented. Afterwards, or even better at the next meeting, everyone describes what he/she has visualised. These sessions of observation and visualisation are repeated in three or four seasons to obtain impressions of the farm and the landscape at different times of the year. The meetings are instrumental in enabling the participants to characterise the present situation of the farm in or through a symbolic image. In one of the sessions, the farmer describes the history of the farm, which led to the present situation.

⁶³ These imaginations are very much comparable with metaphors. Metaphors are based on an internal language of a group of people to describe their own situation (McClintock *et al.*, 1997; McClintock, 2000).

⁶⁴ We understand the farm-entity (or individuality) as a spiritual being, which is behind what we can observe. The farm-entity should not be mixed up with the individuality of the farmer, which is undoubtedly also clearly visible in all aspects of his farm.

The more successful the participants are in observing and describing the farm, the more reliably the symbolic images reflect crucial aspects of the farm's agricultural entity, although each image does have much of the participant's personal colour as well. Each of the images describes a part or the whole of the farm's situation from different points of view. Often the images give indications for some problems and, if we scrutinise them carefully, also some directions for solutions. Examples of these images will be given below.

From the directions for development derived from the successive sessions, we want to reach concrete proposals for measures. Therefore, we study in co-operation with the farmers, the landscape of the farm and the landscape around it. We use three levels of description of the landscape:

- the present landscape (facts and figures);
- the processes in terms of past development that are visible in the present landscape (changes and developments); and
- the history or biography of the landscape (identity).

The present landscape we describe in polar qualities. This gives us a first possibility to formulate the directions more clearly. For example: *The landscape is too wet and too cold, (the qualities of a polder) and has too little light and warmth (the qualities of dunes)*. Here we can try to see if elements inherent in the dunes can be used to improve the quality of the farm as a whole.

Describing and characterising the processes in the landscape within its biography (the agricultural, cultural and geo-morphological development) enable us to describe the way in which processes will possibly go or develop and how they can be stimulated, changed or inhibited. Thus a new set of criteria and possibilities is created to implement the directions.

In this way the directions for development are translated into concrete proposals step by step. These proposals follow logically from both the farm-entity and the landscape and support the identity of the farm and that of the landscape. The proposals for improvement are discussed with the farmers. If the job has been done well, the farmer accepts the proposals of the group or helps us to formulate better proposals since he knows the farm best.

5.6.3. Reflection on methodology

The main points of departure of this project are knowledge and action. New knowledge was developed in terms of Goethean science, as an extension of positivistic research. Qualitative descriptions or models in terms of holistic symbols were used as intermediate steps between knowledge and action. In this specific case, action could be taken due to the involvement of the farmers' community⁶⁵. The farmers were not only partners in the process of identification, but also in the stage of planning change.

Goethean science can also be used as a basic and isolated method applied by scientists to describe laws of life processes (Bockemühl, 1966; 1967) or to describe the quality of e.g. a cultivated crop (Bisterbosch, 2001) or a medicinal plant (Verhaagen, 1998). In this case project a connection is made with experiential science.

In comparison with mono-disciplinary science, the innovations in this project were:

- Goethean science always reflects on a whole, and therefore has the character of a systemic approach. This system can be a farm, but also a plant or an animal. Systemic attention is shown as attention to development and history or critical steps in the life cycle.
- As a model of understanding, Goethean science uses qualitative expressions to describe the entity of the observed object. Therefore, Goethean science is a descriptive rather than a statistical method of research.
- Goethean science is based on direct observation of the whole, therefore there is no risk of a reduced attention. Due to this observational method, there is an immediate link with the farmers' observations and experiences.
- As a holistic descriptive method, Goethean science is a step towards a qualitative judgement, which is used as a model for action.

The procedure followed in the research project is outlined in Figure 5.8.

In terms of the four-quadrant matrix, Goethean science is a method that reconciles the different quadrants. In the qualification of this method it is important to be aware of its constructivistic elements. Personal, first impressions and imaginations are used to express subjective as well as objective feelings about the situations. The characterisation of the farm situation is regarded as the expression of the holistic farm. Also, the specific agronomic problems are explained as an

⁶⁵ Farmers is used in the plural throughout this case study because the farm was managed by a group of farmers, each with his own speciality

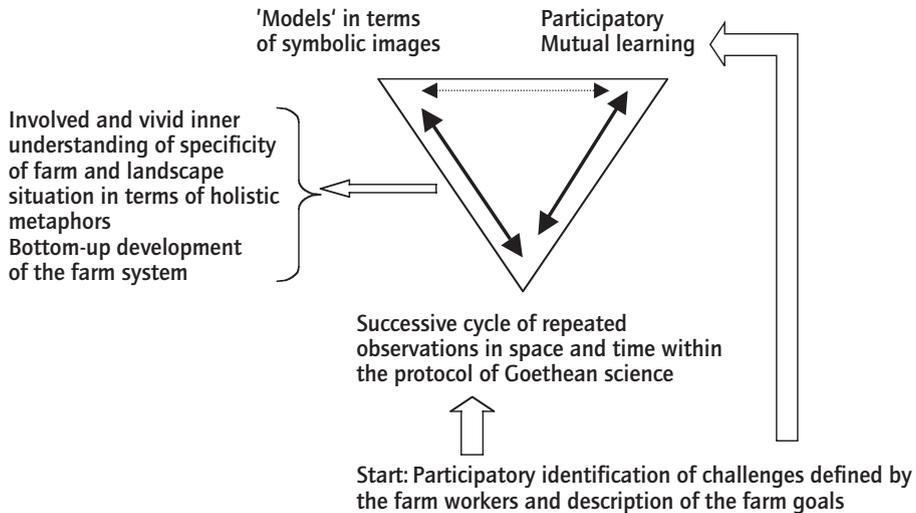


Figure 5.8. Integration of Goethean science and participatory development at Noorderhoeve farm.

expression of the particular circumstances. This approach can be judged on the basis of the 3rd quadrant (holistic impressions).

These holistic impressions and imaginations can only be generated after a deep involvement and engagement with the farm situation. Therefore quantitative measurements and exact descriptions are made at the level of the 1st quadrant (analysis of the situation). The particular circumstances of the farm situation improve when the farm context is taken into account. These activities are part of the approach in the 2nd quadrant (agro-ecology).

After this point of judgement has been reached, it is possible to find solutions for the agronomic problems in such a way that the specificity of the farm situation can be maintained. The proposed changes are regarded as solutions that have a connection with specific farm circumstances that are elicited from an inner understanding of the farm in its specific landscape. The proposed changes in the farm and the landscape are actions following on from the previous steps. These actions, therefore, are part of the 4th quadrant (adequate action).

In conclusion

The different steps in Goethean science were undertaken to develop an involved concept of the specific farm situation. In terms of approaches of 'naturalness' (Cf. Chapter 3.4), the method aims to act in accordance with the integrity or entity of the observed itself. In this case of system development in relation to landscape planning, an analysis and description were made of the farm situation and of the farm's problems. Biographical elements of the farm and the landscape were taken into account. The daily experiences of the farmer are used to gain a better understanding of the situation. The different observations and impressions were used to imagine the farm situation as a whole. This is expressed in metaphors. These holistic expressions are guides for future acting. To prevent a shortcut between problem analysis and the formulation of a general answer, the holistic expressions of the farm entity and its surrounding landscape were guides for situation-adapted action.

5.6.3. Results: planning based on inner understanding

5.6.3.1. Actual situation on the Noorderhoeve farm

Noorderhoeve is a mixed bio-dynamic farm of 18 ha on which five people work as a team. The farm is situated in the north-west of the Netherlands close to the North Sea where the dunes (which are elevated, dry and sandy) merge with the polders (which are low and wet on acid clay). Noorderhoeve is a rather extensively managed mixed organic farm, with very low inputs of nutrients and energy. Nitrogen is mainly supplied by the farm's own manure and nitrogen fixation by legumes, making the farm highly self-sufficient. A great variation throughout the year of farm- and non-farm activities characterises the farm (e.g. Waldorf-school classes, therapeutic work). At the start of the project, the farm had 12.5 ha grassland (mostly in the polder), 3.5 ha arable land and horticulture (near the farmyard on the sandy soil), an orchard and a tree-nursery (0.5 ha) and gardens for medicinal plants and flowers. In addition there are 2 ha of woodland and hedges. Some 12 dairy cows plus young stock, about 20 sheep and some chickens are present. Bulls are kept for breeding and nearly all calves are for meat production. Bees were kept earlier without success. The farmers care for the wildlife on the farm, which is shown by the fact that they bought 2 ha of woodland in 1988.

The landscape of Noorderhoeve contains very different, even opposite characteristics. The farmland shows a gradient from high, dry, poor sand (originally dune) in the west to low, wet and acid clay (originally sea) in the east. In between lie some characteristic elements of the transition zone, such as small woods, hedges, dune brooks ('duinrellen') and many ditches. The ecological speciality of this area is the so-called 'duinrel': small streams of clear seepage water from the

dunes. The transition zone was very wet until the last century. Extraction of drinking water in the dunes has lowered the groundwater table, which diminished the amount of seepage from the dunes. Nowadays most dune brooks have very little water or no water at all. The government has developed plans to renew the flow in some of the dune brooks. A small continuous flow from the dunes into the polder, through the farmland, still exists.

The inventory revealed problems with the soil (acid soil and structural problems, low infiltration of water), health problems with cattle (liver fluke, hoof problems) and the failure to keep bees. In the direct surrounding, the sources of the water problem were the wastewater from the conventional neighbouring farm, the riding school and the farms' own manure-storage.

5.6.3.2. First impression, present and past

When a short description of a farm has to be given, as above, it has to be a description of characteristics. We just want to give some impressions of the whole method and present some results as it would be much too long to give full descriptions of the first impression, the present situation, the lines of development from the past and the ideas of the farmers.

In the first impression, the observer is explicitly present, as we can see in the following example: *On a cold, but sunny day in spring, we make a stroll around the farm. While walking on the pasture we notice that the soil is hard and firm, it does not feel 'elastic'. All fields have different colours: shades of green, but not bluish-green. Further on: On the sandy horticultural blocks we notice that the atmosphere feels different, warmer. We notice that walking upon loose sand feels different from walking upon solid clay.*

In the description of the actual situation several facts are given: plant diversity, soil-types, the number of cows, low mineral contents of the soil, the water level etc. Maps of land use and soil types, profiles of the soil, etc. are provided. These facts are described objectively. The description of the past and the lines of development include the development of the farm, the soil, water and vegetation. The development of the farm started in 1978 as a therapeutic initiative, and was completed in 1981 with the purchase of additional land. Little is known of the earlier history. The biography of the farm shows a slow but steady growth, with increasing diversity, while keeping the farm self-supporting, and without surpassing the attention for the human connection with all farm areas. This shows that the farm-entity Noorderhoeve develops by small steps, which can be incorporated without losing control. This means that changes should not be too big or too fast.

5.6.3.3. Searching for direction for development: formulation of symbolic images

As a preparation for the working session, everyone is asked to visualise an image of the farm as completely as possible including everything that is important. In a next step, people are asked to erase the image and to wait for the spontaneous formation of a new one. These 'imagnations' or 'symbolic images' are then related to each other and reflected upon.

Some people described the farm as a little ship, a nutshell, in relation to the subterranean and surface water flows and the animals' health-problems caused by excess water, such as liver fluke and a prevalence of hoof diseases. One person described the farm as a sleeping giant with his head in the grassland and his belly on the house. The open outgrown hedge between grassland and horticulture makes the giant sleep. Head and stomach do not communicate with each other. This image indicates that the farm does not give a feeling of being complete, a unity, and a whole. The high hedge across the land divides the farm into two different, separate areas. The person felt that the giant should be woken up. This gives us a 'direction for change'. Something has to happen to the hedge to allow both parts of the farm to communicate.

Another image is that of a cow. Inside it, green matter is streaming too fast; the cow stands poorly on its feet. This image expresses the opinion that the ratio between growth and quality is out of balance, as growth dominates. The elements of light and warmth are subordinated to water and cold. This was interpreted as the prevalence of the polder character (wet, cold) and too few dune qualities (warm, dry) on the farm. This imbalance might also be reflected in the unsuccessful beekeeping. Bees like warmth. The direction for development, now clarified, is 'to strengthen the farm's dune-character'.

5.6.3.4. From the direction for development to concrete proposals - Problems as an opportunity to develop the farm-entity

In an agro-ecological view on organic farming (Verhoog *et al.*, 2002 a; b), agricultural problems are seen as dysfunctions of the farm organism. Dysfunctions represent challenges and opportunities for future development of the farm. If we find appropriate solutions to the problems, which fit into the landscape, we help the farm-entity to develop and strengthen the identity of the landscape. Farm and landscape are improved simultaneously. This is the opposite of many measures taken during the last decades, where farm improvement was often accompanied by landscape decline.

The agricultural problems that the farmers specified in greater detail included acid soil and poor soil structure on the clay; poor water quality; health problems with the cattle caused by excessive grassland moisture; problems with the cattle's access to the grassland in the shade of the hedgerow because of trampling; a too high, open outgrown hedgerow that disturbs the farm's unity; unsuccessful beekeeping. Although these problems were experienced in daily practice, the

farmers were not looking for short-term solutions only, but were asking for site-specific adaptations and more long-term changes in the farm structure and management.

As a result of the Goethean approach and based on a participatory communication with the farmers' group at Noorderhoeve, the following changes have been developed and most of them have been worked out in practice, although not tested on effectiveness (Figure 5.9):

I: The path from the farm into the fields will be improved with a mixture of seashells and clay.

This will solve the problem of trampling and, as the seashells will be spread by the cows over the land, improve the acidity of the soil. In this way, a gradient will also be formed from the path to the surrounding land. This is of ecological interest (increased biodiversity). An element inherent in the dunes is thus used to solve problems in the polder.

II: On certain spots the grazing paddocks will be raised a little by making small hillocks of about 3 meters height (Figure 5.10). This will be done by using the excavated earth that becomes available by deepening and broadening some of the ditches. Thus dryer places are created, where the sheep and cattle can lie down. This can solve the health problems of the animals caused by the wetness of the grassland. Digging out the ditches gives the water more of its own place on the farm, strengthening the groundwater gradient.

1. path of seashells
2. small hillocks in the grassland
3. pond, broadened ditch
4. lowered hedge
5. solitary tree
6. groves, extended hedge
7. dam
8. helophytenfilter (reed-bed)

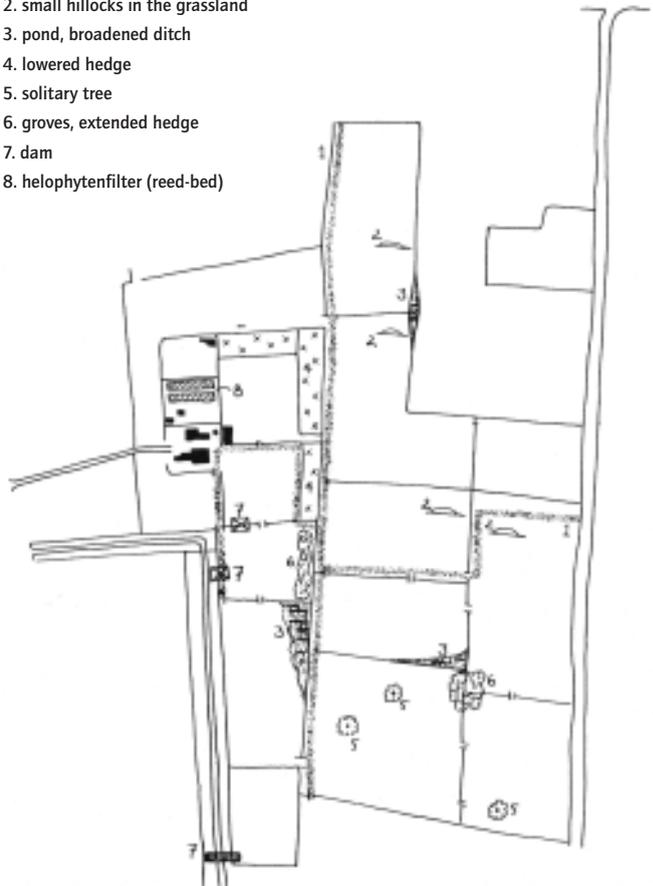


Figure 5.9. Summary of proposed changes.

CHAPTER 5

III: The high hedgerow growing across the farm will be cut back to a lower hedge with more flowering shrubs for the bees and a few higher trees. Some solitary trees will be planted in the meadows and on the outskirts of Bergen village. Groups of shrubs will be planted at the intersections of some fields. These measures will help to strengthen the farm's unity

IV: A new waterflow system and a water purification based on aquatic plants like reed (a so-called helophyte filter) will be constructed. By building new dams in some ditches and digging some culverts, the course of the water will be changed. Clean water from the dunes, poor in minerals, will no longer be mixed with polluted water on the farm. The latter will flow through the helophyte filter, whereas the clean water streams directly into the ditches on the farmland. The helophyte filter will be built to clean the polluted water coming from the neighbouring farm as well as the wastewater from the farm itself. The clean effluent will flow through the farmland.

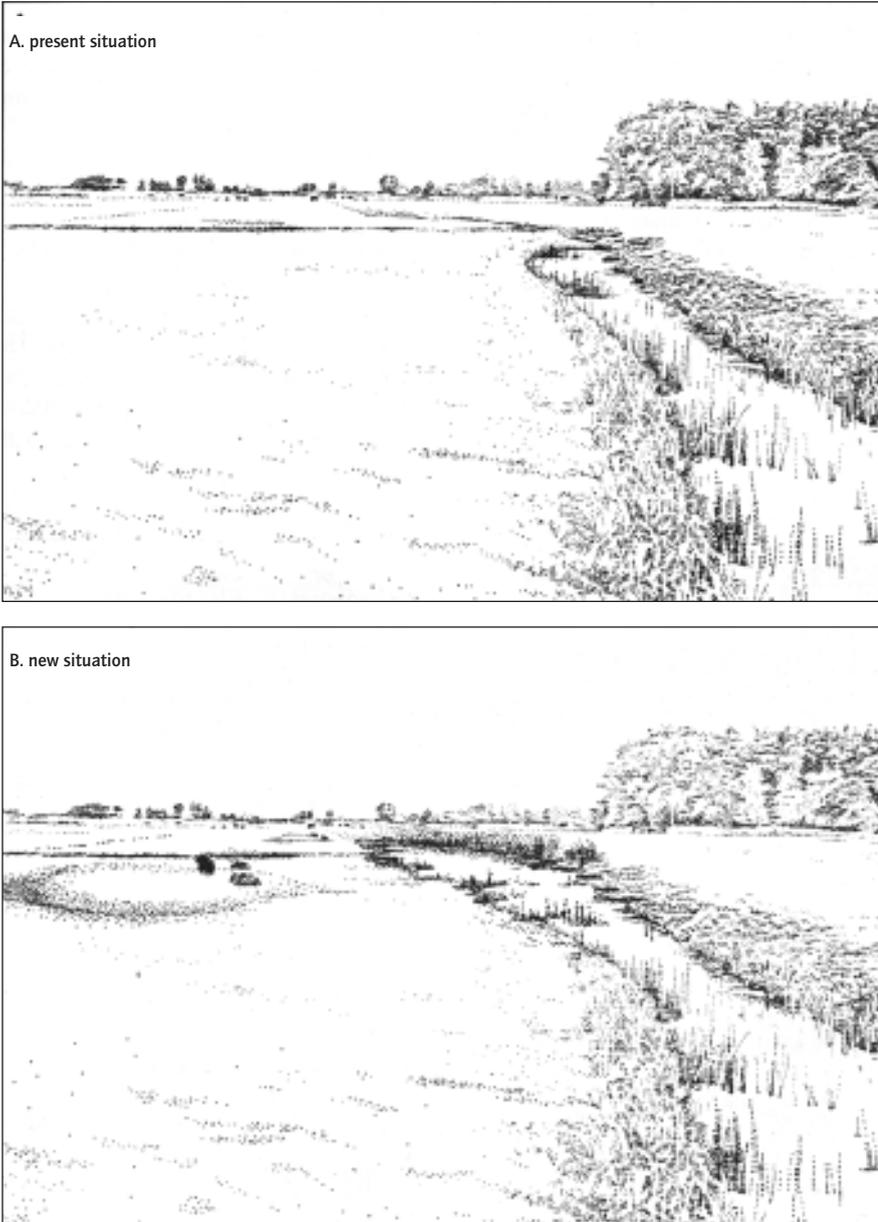


Figure 5.10. Small hillocks in some pastures and a broadened ditch.



6. The case BIOVEEM⁶⁶: seeking a holistic research design

Due to the history and circumstances of the cases presented in Chapter 5, the methods were fragmented. Each focused on different elements of an overall R&D strategy. Each case project had its limitation from a methodological point of view. Lessons can be learned, however from these research methods, because they were part of an overall research strategy. In a final case study, several methodological elements will be combined into one large R&D project 'BIOVEEM', which had a strong interdisciplinary design.

In Chapter 6.1 the first three years of the project will be presented and analysed, and in Chapter 6.2 the transformation of the project into a more holistic and bottom-up approach will be shown. The study is presented as an example of an approach that links experiential science, bottom-up learning, system-prototyping, farmer-to-farmer learning, multi- and trans-disciplinary research and on-farm research. Specific attention is paid to each farmer's worldview in biographical interviews. It investigates the position of conventional science in such an approach. In the ensuing design, the differences between extension and research became smaller (see also Schmid, 1996).

6.1. BIOVEEM. Phase 1: monitoring

Bioveem focuses on whole farm management. It represents a co-operation with the Research Station for Applied Animal Research (WUR-PV) and the Louis Bolk Institute as principal partners. An economic evaluation of the participating farms was made by WUR-LEI (Zaalmink, 2000). The initial approach was very much related to farming systems research and farm proto-typing. In this first phase of the project, several discussions took place, which, in hindsight, can be interpreted from the different perspectives of the research partners and their insights into organic farming. These discussions covered:

- Farm and farmer selection (converted or in conversion; scale and intensity; invited representative or self-chosen pioneer);



⁶⁶ *Bioveem* is a contraction of *BIO*logische *VEE*houderij en *Management* - Management of organic dairy farming. A management team is responsible for the decisions in this project and the content of R&D: Carel de Vries (projectleader) and Ina Pinxterhuis (both WUR-PV, Lelystad), Flip Lutteken (De Landbouwworlichting, Wageningen) and Ton Baars, Louis Bolk Institute.

- The use of data analysis (as a support for decision making on the specific farm, or as a reliable average of organic farming in general);
- Criteria for farm evaluation (an *ex ante* defined set of goals, or defined depending upon the farmer's purposes).

Eight out of 20 organic dairy farms were selected after discussion the selection criteria. There were two opposing points of view. One group felt that the farms should be 'a reflection of future organic dairy farming, which was thought in terms of potential survivors with a higher than a defined scale and intensity'. 'These criteria should select the professional farmers.' 'Recently converted farmers should be part of the project.' It was clear that only a limited number of farmers could be involved in the project and from the point of view of data evaluation, 'the farms should (therefore) be as similar as possible'. However, there was also another view on this project: 'Organic dairy systems are diverse and the project should reflect this practice'. 'New methods of integrated evaluation were necessary for an holistic evaluation.' 'To understand the farm practice, one should only focus on fully converted farms, otherwise one is measuring the doubts and uncertainties of a converter.' A decisive eye-opener in the discussion was the calculation of the external farm area used by each farm due to inputs of manure and fodder (Baars and Van Ham, 1996; see also Chapter 3.3). It was calculated that the land-based production of farms was much more similar than the actual production per hectare. At first, these highly productive farms were judged as very professional farmers, however, this professionalism contained a limited interpretation of organic standards.

Another discussion, which took place at the start of the project, was the number and type of data analyses. One focus was to achieve a reliable set of data about all kinds of variables that could be used for programme planning and advice. This implied a demand for a repetitive set of data over the season and across different years. A computer-based programme had been developed by WUR-PV, called BBPR, which is a planning programme for dairy farm management. Input data about organic systems were missing. On the other hand, the question was raised whether we needed these large sets of data for the further optimisation of farms.

6.1.1. On-farm measurements

Over a three-year period, the participating farmers were asked to monitor their animals' health and grassland management. Yearly analyses of data were made for economics (standard WUR-LEI procedures), standard soil fertility, manure quality, feeding value of herbage in grazed swards and of silage and hay, and for the quality of deeper ground water. Each year in spring a botanist investigated the botanical composition of each field. In late summer, an extra monitoring was carried out to assess at the maximum amount of clover in each field.

Each farm was visited twice a year by a selection of researchers to look back on the management

of the last period and discuss the plans for the next half-year. A key research co-ordinator visited each farm every six to eight weeks for two reasons: to give advice and to control the collection of data by the farmer. Farmers met once or twice a year as a group on one of the farms. The goal of this visit was to generate centralised discussion on specific topics.

One of the most impressive results was the enormous amount of data that was recorded. A booklet was published about all the findings (Projectteam Bioveem, 2000). Although the group of farms was small and the range of farms was very diverse, most specialists presented average values for the farms as a group. The project also tried to focus as well on the relationships between components of a single farm. However, suitable casuistic methods were not available to establish the unity within each farm and its expression in all farm components. Data could only be related to each other during the individual discussions made on each farm, with the help of to the background information given by the farmer. In these discussions, the data were provided within a context of values and specific circumstances. In the first year of the project, we made an effort to characterise each farm. A semi-structured interview was used to identify the farmer's goals in life and his personal attitudes were quantified by means of a scorecard.

At the end of the first phase seven farmers did not continue for the second phase. An interview about the project was held with several of these farmers (Oudendijk, 2002). Important points of evaluation of the first phase of the project were:

- Data were very helpful for understanding one's own farm and for the farm comparisons. However, from the farmer's point of view, too many of the same data were collected, which did not give him additional information. Too little attention was paid to additional and new quality measurements. The way data were assessed did not always express the farmer's specific organic farming style.
- The farm visits made together with the other farmers were a strong point of the project, due to the farmer-to-farmer discussions and because they allowed exploring other styles of farming. The role of the researchers was important because of their critical questioning of the farmer's position and results.
- On the other hand farmers felt a need for some of the researchers to be better trained so to allow them to change their position towards their specific farming situation.
- Farmers mentioned several new ideas for monitoring their specific farm management as an addition to the standard set of measurements developed for conventional farming. Examples of these personal views are the elasticity of a living soil, rooting patterns, speed of degradation of dung patches, elasticity of animal health, and liver functioning. Some of these parameters could not immediately be quantified and were expressed as a personal point of

view. Farmers also mentioned that other areas were important to evaluate in a next phase of the project. Examples were labour efficiency and workload, composition of soil fauna, produce quality, alternative remedies, prevention strategies, trace elements, animal welfare and horned cattle, co-operation with arable farmers to close mineral cycles, and the role of breeds. Farmers also expressed a need to change the focus of evaluation. For instance, the evaluation of grassland composition was too much oriented to production and fodder quality while a health focus was missing.

In conclusion

The first phase was an exploration of the multidisciplinary co-operation of institutes. Several disciplines and types of expertise were still missing. The research attention was too much oriented to monitoring while an overall analysis of figures was missing. Too little attention was paid to system development and too little attention was paid to the transition of knowledge. In such a complex project internal communication and co-ordination were crucial for success and a clearer vision about project goals was needed.

6.2. BIOVEEM. Phase 2: bottom-up development of individuals ⁶⁷

The second phase of the project started in 2001. The face-lift of the project was due to the developments in experiential science (Baars and De Vries, 1999) and due to a change in a parallel research project in conventional farming (project Cows and Challenges). The new project leader, Carel de Vries ⁶⁸, was also the project leader of this parallel project. The main attention on monitoring of a broad set of farm data was left and the bottom-up development of farmers, based on the chances they mentioned themselves was put in the centre of the project. Specific data measurement became supportive for on-farm development.

BIOVEEM was expanded in different ways in comparison with the first phase:

- Instead of a selected set of disciplines, in principle all disciplines should be collaborating in the project. The character of the project was improved in a more inter-disciplinary way with more specialised researchers taking part;
- The project became more farmer-oriented and three groups of farmers took part in the project;
- Innovative farmers who act as pioneering entrepreneurs in specific areas of organic farming. Their farms are treated as experimental stations (see BOX 6.1).

⁶⁷ The interpretation of the second phase is based on an internal document which describes mission, goals, methodologies and project partners and which was prepared by the management team (see previous footnote). Mainly the expectations of this interdisciplinary project will be described. An evaluation is not yet possible, because the project has not yet been running long enough.

⁶⁸ Project leader until June 2002; Bert Philipsen (WUR-PV) after June 2002.

- Optimising farmers whose farms are used as a testing ground for existing knowledge in organic dairy farming.
- Farmers in conversion.
- The first goal of the project was 'system development based on bottom-up choices of the farm manager'. It was decided to strongly reduce the budget for general monitoring. A second important choice was to increase the range of system differences;
- At the start of the second phase we only formulated themes of interest, and left blank the project's details. Only after a selection of the farms could research projects be implemented;
- A link was made with the extension service, 'Stichting Landbouvoorlichting (DLV)'. One of its tasks was to advise and support each farmer in specific data collection, if necessary.

The following mission was formulated: 'Dairy farmers, researchers and advisors combine their specific knowledge, visions and skills. Together they deliver a unique contribution to the strengthening, development and expansion of organic dairy farming in the Netherlands.' BIOVEEM was an extension of the idea of farm prototyping based on pilot farms (Vereijken, 1995; 1997; Kloen and Vereijken, 1999). In that project, a pilot group of 10-15 farmers is confronted with a set of development objectives. A hierarchy of objectives is developed on the a-biotic environment, basic income and profit, nature and landscape, employment and health and well-being. This approach of weighting goals within multi-functional agriculture is similar to the so-called 'life-cycle-assessment' of farming systems (Köpke *et al.*, 1999), based on goals other than just production. In the BIOVEEM project, the optimisation group of farmers is used for the purpose of prototyping desirable future organic farming systems. This group is used to demonstrate existing knowledge and farmers are assisted by researchers and extensionists to adapt existing knowledge to their specific situations. However, we have added an innovation group to the project, which is characterised by a voluntary search for future development of knowledge that does not yet exist. The basic requirement for joining the innovation group is personal involvement of an individual farmer with a specific type of organic farm. Action research and mutual learning are the methodologies to accompany this group. The whole innovative farmers group acts as an interactive 'research-group' at the same level as the research farms for applied research. New topics will be tested and developed within specific farming circumstances. In a bottom-up co-operation between farmers and scientists, these farmers explore the limits of the diversity of farming systems (see BOX 6.1).

BOX 6.1. Innovative farms/pioneers in the BIOVEEM project

In principle, 10-15 innovative farms with different farm and soil types, distributed across the country have been selected. This group comprises dairy farmers who are consciously committed to organic agriculture. They have been operating organically for some time, have overcome the teething problems and are now considering how to proceed. The direction of development varies between participants, depending on their personal management style. The farmer chooses the themes to be developed and the desired outcomes in consultation with the project team. Personal involvement provides an incentive to push back frontiers. The farmer is prepared to take risks. Each farmer in this group adds a unique element to the group as a whole in terms of operational style, challenges or objectives.

The objective is to open up and generate new knowledge and to make the individual's search for solutions a conscious process, which can then be communicated to others. Monitoring and analysis provide insight into the effects of the farmer's actions. The guidance provided is individual and characterised as a 'guided trial-and-error search process'. The farmer's knowledge and experience are an essential part of the operation. The researcher is detached and on equal terms with the farmer. The farmer is explicitly encouraged to develop methodologies by experimenting in the farm context. Exchange of experience among the participants in this group is important. The specific new insights obtained are developed within the context of a specific farm and should therefore be considered as hypotheses or principles rather than as transferable concepts. The next step is to further quantify and model the new insight (if necessary on experimental farms) and to test it on the optimisation farms.

In Figure 6.1 this group is positioned as the circle for experiential learning based on self-chosen prototypes.

6.2.1. Co-operating institutions and themes

The areas for consideration are shown in Table 6.1. The table indicates which institutions will be responsible for implementation. The first institution named is the institute responsible for the theme in question. The responsible institutes are Praktijkonderzoek Veehouderij (Applied Livestock Research Unit-WUR-PV), the Louis Bolk Institute (LBI), and DLV-Adviesgroep (Extension Service-DLV). Collaborative agreements have already been made with the Gezondheidsdienst

voor Dieren (Animal Health Service-GD), the Landbouw Economisch Instituut (Agricultural Economics Research Institute-WUR-LEI) and Wageningen Universiteit en Research Centre (WUR). Opportunities for further trans-disciplinary collaboration with other institutions are being investigated.

Table 6.1. Themes within the project BIOVEEM and institutes involved in trans-disciplinary co-operation

Theme	Implementation
Farm quality and business development	LBI, WUR-LEI, DLV
Farm economics, chain development	DLV, WUR-LEI
Milk product quality	LBI, WUR
Manure application, soil fertility and crop rotation	LBI, PV
Cultivation of grass and fodder crops	PV, LBI
Livestock feeding	PV
Inter-sectoral co-operation	LBI, DLV
Livestock breeding	LBI, PV, WUR
Animal health and fertility	PV, GD, LBI
Environment	PV, RIVM
Nature	PV

6.2.2. Methods applied

Participatory action research and experiential learning of pioneering farmers were integrated in a larger setting within the project. Each of the pioneering farms acts as an experimental station (Figure 6.1). The positive side of this approach is that we focus on a diversity of farming systems and other farmers can recognise their own style of farming in one of these pioneers. Therefore, the variety of chosen pioneering farming systems will be as large as possible. Each pioneering farming system has its own context, goals and restrictions, which will be described in the yearly monitoring of facts and figures about the farm. In this praxis, the pioneering group of farms together acts as a 'Garden' for the development of future organic farming. Each of these pioneering farms can be further improved, depending on the goals and possibilities of each individual farmer (bottom-up). This group of diverse farm practices can be used by researchers who are developing different farm-related themes together with an individual farmer or a farmers' group (Cf. Chapters 5.2 and 5.3).

BOX 6.2 In search of the farmers' biography (project of the Louis Bolk Institute)

A course was organised with a small farmers' group in the north of the Netherlands. All the dairy farmers knew each other and some of them had already visited another farm. We suggested a course on farm and farmers' biography. The main goal was to examine the reasons why people became farmers, what kinds of choices they had made in the past and what kind of challenges they were facing in the future. Therefore, each of the five farms was visited twice by the whole group. On the first visit the farmer was only asked to tell his or her life story. Questions could be raised only to explain, not to judge. We asked the farmer to show us his farm, but only in the sequence he chose, based on his specific interests. On the second visit we asked the other farmers to reflect on what they had seen and experienced during the previous visit. We used metaphors to express what kind of quality we had experienced. In a next step we asked the group whether they could help this particular farmer with the challenges he foresaw for the future. However, this was to be done not in the abstract, but only after involvement with the farmer's intentions, which we had derived from the farm visit and the farmer's personal story. WUR-LEI developed a comparable instrument to analyse strong and weak points of the farmer, challenges and threats of the farm in the so-called 'Strategic Management Report' (see Wagenaar *et al.*, 2002)



... in search of the farmer's biography ...

In this approach, the role of the WUR-PV experimental farm, Aver Heino, was not to act as a 'the model-farm for organic dairy farming'. In the discussion about the role of the experimental station we have suggested that the organic sector is not asking for only one blueprint farm. In most areas of organic farming, pioneering farmers are far ahead in their development compared to the experimental station. In addition, an experimental station also has its agro-ecological

restrictions and can only handle specific site-related problems. Most of the questions and challenges for research therefore should be solved in the context of one of the pioneering farms. The role of the experimental station is to act as an ecological environment for detailed research questions that are hard to solve in a commercial farm situation (Cf. Chapter 5.1). The open structure of the project is attractive for researchers to position and start strategic research. It is expected that during the course of the project several strategic research questions will be raised for mono-disciplinary reductionistic research that aims to clarify specific details (Cf. Chapters 5.2 and 5.3).

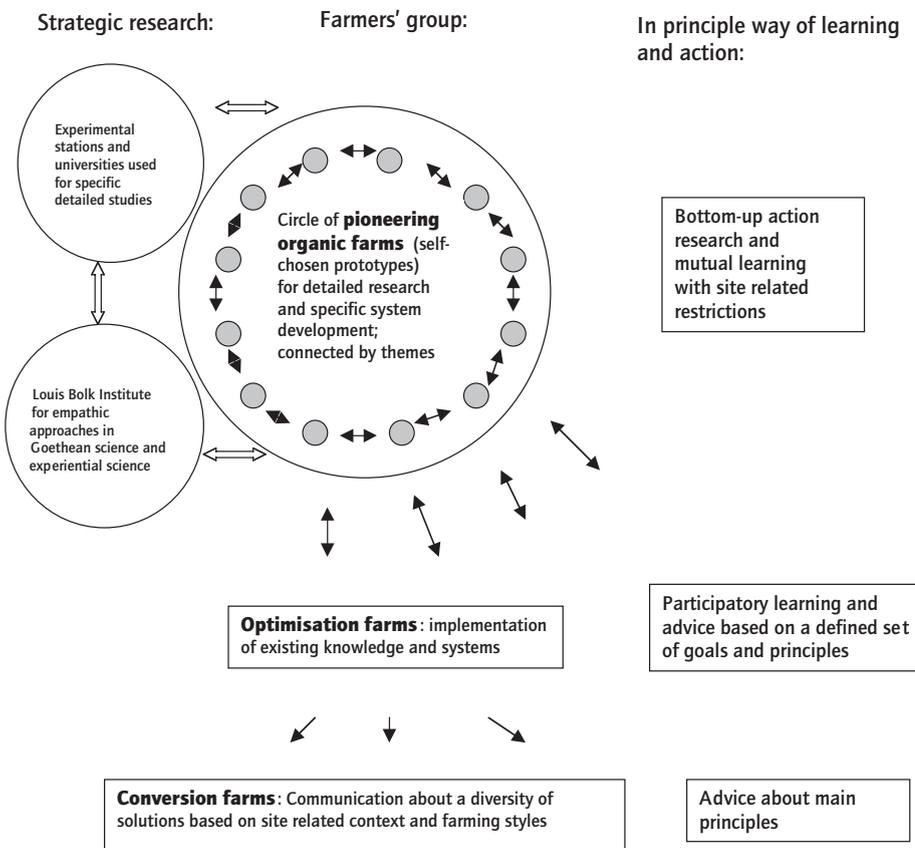


Figure 6.1. Initial R&D model including extension in the project BIOVEEM and the assumed relation to strategic research, which can be implemented by different research organisations; the pioneering farmers are considered as self-chosen prototypes exploring new areas of interest; the optimisation farms are considered as 'future good farm practice' based on existing knowledge and experience' showing the level of knowledge about organic dairying. The conversion farms are generally advised.

After the farm selections, the group of pioneering farms was visited for a biographical interview (BOX 6.2). A framework was used to discuss challenges and threats, weak and poor aspects of the farm as an agro-ecological entity, and of the farm manager as the person who sets the values and makes the choices (Cf. Chapters 5.4 and 5.6). At the end of the interviews, each farmer was asked for the development of which themes he felt responsible during the next three years? This was recorded and farmer dialogue groups were formed (Cf. Chapter 5.3). A result of these in-depth interviews a document was accessible to all involved researchers in which the values and limitations of each individual farmer were described as well as his direction of search for the future (Wagenaar *et al.*, 2002).

An important question raised in the project concerns the owner of the research agenda. In our approach of pioneering farmers, we were careful not to take over the role of problem-owner. The involvement of farmers meant in their case that they were supported and guided by scientists in their search to solve their own questions concerning future development. We support on-farm innovative ideas tested by pioneering farmers. The farmer himself makes the choice of innovations (Cf. Chapter 5.2). The characterisation of the farmer and his attitudes are still to be worked out in greater detail. Methods such as those developed in Goethean science (Cf. Chapter 5.5) will be used for this holistic characterisation of the entity.

New challenges arose after the start of the project. A one-day training was carried out for both advisors and researchers to be aware of the special aspects of experiential science. Group meetings with farmers and researchers proved to be very fruitful in stimulating on-farm research with farm pioneers and to adapt research protocols to questions raised by farmers. The hardest problem is to adapt the experiential scientific methodologies in such a way that they can be statistically evaluated. Statistical evaluation and the control of experimental plots remain important bottlenecks for researchers in adopting these novel methodologies. Additional non-linear statistics will be used for the following areas of interest:

- The personal framework of farmers and their personal vocabulary, so far used to deal with management solutions will be converted according to the methods on inter-subjectivity according to Wemelsfelder *et al.* (2000; 2001).
- The casuistic pattern recognition that farmers use for purposes of their own evaluation, need to be integrated into a scientific evaluation (Kiene, 1998; 2000).
- The expression of the farm in terms of a holistic metaphor of the farm's entity has to be related to other farm data to establish the coherence of this holistic expression in the farm details.

In conclusion

The project BIOVEEM integrates several styles of learning and investigation about a systemic farming system level. In the group of pioneers, the bottom up approach in experiential science and on-farm experimentation, farmers' reflections on experiences are combined in the development of a self chosen prototype. Within the regulations of organic farming, each farm has its own set of principles, restrictions and agro-ecological context, which are starting points in the exploration process. The unity of the farm will be described as a holistic metaphor, which connects all specific farm elements and farmer's choices. A key element of this exploration is the explanation of tacit farmers' experience, based on pattern recognition and intuitive action. Farmer-to-farmer learning is possible due to the interconnection of farmers in themes of interest. An interdisciplinary research team and a circle of farm advisers are co-operating together in this process. Existing specialist researchers will integrate their systemic knowledge on farming into the questions raised by organic farmers and these specialists can attend to weak areas within organic systems.



7. Discussion and conclusions

The present chapter aims to pull together the results of the case study analysis in Chapters 5 and 6. It seeks to develop coherent theoretical statements that reflect the lessons learned from the case study review (see Chapter 7.1). This chapter therefore answers the main research question with respect to the nature of the agricultural research that supports the development of organic farming.

In the second place, the special strategies and methods that were identified throughout the case studies reported in Chapters 5 and 6 must adhere to criteria of 'good science'. This chapter will also evaluate the strategies and methods identified through the case studies according to criteria of good science (see Chapter 7.2).

In the third place, the chapter will position the strategies and methods identified in terms of their position *vis-à-vis* other research approaches. Do the newly identified approaches replace or complement? In his discussion on revitalising agricultural research, Lockeretz (1991) said that the *'alternative agricultural movement has done an important service in reminding us there are alternatives in agriculture, that there is no best way. It also has driven home the importance of alternatives in agricultural research. However, there is some ambiguity in just what "alternative" means. An "alternative" can be something intended to replace the way we do things now. But instead, it can be an additional option, giving us more alternatives from which to choose.'* In accordance with the last sentence, the alternative strategies and methods presented in this dissertation are seen to complement rather than replace. The overall character of the emerging strategy and methods will be discussed in four main points (Chapters 7.3-7.6).

In the fourth place, this chapter will discuss the connection between spirituality and organic farming in relation to anthroposophy and bio-dynamics and its implications for research strategies and research methodologies. In Chapter 3, it has become abundantly clear that bio-dynamic agriculture (Demeter label) is a relatively small sector compared to ecological agriculture (the EKO label). Differences exist with respect to the principles that have to be followed to satisfy the respective labels. In many ways, bio-dynamic agriculture has a more restrictive farm practice, and due to its spiritual character bio-dynamics is 'more difficult' to follow.

Given that this dissertation is based on research projects carried out by a research organisation that adheres to anthroposophist principles, the question is justified whether the presented

research methodologies are only restricted to bio-dynamic agriculture or that they can be generalised for other blood groups in organic farming. In Chapter 7.7 a comparison is made with other approaches.

After a discussion of the weak elements of these novel methods (Chapter 7.8), final conclusions will be made at the end of the chapter. The epilogue suggests improvement and strengthening of the novel methods.

7.1. The elements of the R&D that emerge from the case study analysis

The following elements emerge from the analysis of the research methods applied in the different case study projects described in Chapters 5 and 6:

- 1 In all cases, attention is paid to a system-oriented approach, although there are two interpretations based on either a constructivistic or a positivistic perspective. In the former perspective, 'system' and 'systemic' include human values and reasons. Values expressed in the principles of organic farming or personally held by farmers are explicitly communicated. Related to the different farming styles discussed in Chapter 3, values act as a context for meaningful answers and as a guide for the search process. In the latter perspective, system often refers to the agro-ecological unit that contextualises a research question, i.e., the farm, the field, the crop or the soil. Emergent, defined as new and irreducible, properties, not present at lower levels, appear at each level of organisation (Looijen, 1998).
- 2 There is a clear involvement of and orientation to pioneers and individuals by means of interactive and bottom-up learning. However, the definition of a pioneer was based on my personal interpretations and on the scope for development of organic farming (see point 4). Interactive learning can occur between farmers, but also expresses itself as the co-learning between farmers and scientists based on experience and experimentation using participatory methods.
- 3 There is an orientation on an epistemology of action. This is evident from the focus on the practice of organic farmers, and reflected in the limited number of publications in peer reviewed journals. Especially novel methodologies such as Goethean science and experiential science conflict with conventional scientific practice. However, both these novel approaches do not conflict with conventional approaches, but integrate them.
- 4 Not all styles of organic farming are relevant for the R&D approach of the Louis Bolk Institute. Three styles or entry points in organic farming were briefly summarised as 'non-chemical', 'agro-ecology' and 'integrity' (Cf. Chapter 3.4; Verhoog, 2002 a and b). As a matter of choice, R&D is expected to lead to solutions within an agro-ecological context, and related to value discussions around questions of integrity. Therefore, there is an orientation to research

methods that asks for a high level of integration by the researcher involved. Both the holistic orientation and the experiential scientific approach ask for personal experience and a broad orientation to different aspects of farming.

Several weak points of the strategies and methods applied in the case studies have to do with the methodological aspects of the scientific approach:

- 5 The co-operation with specialised scientists in several smaller R&D projects is too limited in scope to be able to speak of a well-developed interdisciplinary approach. However, this was not a choice on principle but one due to historical developments and in the project BIOVEEM (Chapter 6) a more truly interdisciplinary approach was realised.
- 6 The absence of statistical analysis to support inter-subjectivity and credibility of constructivistic strategies in R&D in experiential science and Goethean science.

7.2. The character of science: value free or value bound?

Criteria for 'good science' depend, to a large extent, on the epistemological point of departure. For some, criteria must include objectivity, contribution to the body of knowledge, etc. Others, with a perhaps more constructivistic perspective, emphasise consensus within the scientific community, the nature of explanations and theory building, and e.g., the credibility of the study. This Chapter will focus on the criteria for 'good science' that have been used in the different case studies.

Alrøe, in his doctoral thesis about wholeness-oriented research in agriculture, posited that the quality of science was best approached by analysing science as the learning process of a community rather than a system of knowledge. If science was a learning process it had to be clear how intentions enter into the process and what the consequences were for objectivity (Alrøe and Kristensen, 2002). A conventional view is that science is a social, communicative system, which is based on the ideal of objectivity and the practice of peer criticism within a small expert community (Alrøe, 2000-b). Conventional peer criticism is directed towards the relation between the research results and the observational context. However, in systemic approaches, science is part of the world that it studies and the observational context is related to the intentional context. This context is, in turn, related to the assumption of only one or several possible constructed worlds (Pretty, 1995; Van der Wal, 1997). Values are implicit in every scientific communication (Alrøe *et al.*, 1998). These implicit values are expressed in terms of the dominance of knowledge in the process of learning and in the choice of a personal perspective on the world, which tells us what should be known and investigated. Such 'pre-scientific worldviews' and 'beliefs' do not allow science to be value free. Worldviews rely on ethical choices

that are grounded in a bio-ethical theory that underpins the values and beliefs behind thinking and acting (Verhoog, 2000). Visser and Verhoog (2000) showed that an immanent value such as integrity is excluded from several bio-ethical approaches that dominate research. An important factor affecting people's values in life or their worldviews (Weltanschauung or Leitmotiv) is their religion or spirituality and the extent to which and how these are integrated into their daily action. Röling (2000) suggested that spiritual experiences that transcend the self and create a sense of unity with a larger world could underpin ecological rationality and replaced the selfish economic optimisation or satisfaction of preferences that often seemed the only basis for dealing with our ecological environment. Such spiritual experiences led to respect for other beings, if we focused on their integrity instead of on our own profit.

There are several entry points into respectful contact with other beings. Basic elements of all approaches that try to meet the integrity of other beings are personal involvement and a notion of the wholeness of the other, leading to understanding of the other being's needs. In the end, it is our worldview that helps us to make judgements about good and bad, to contextualise and implement scientific results and to accept scientific interventions.

Therefore Alrøe suggested additional criteria to tackle the problems of objectivity and subjectivity within research protocols and to be aware of the choices made by the involved researcher (Alrøe *et al.*, 1998) and Alrøe (2000):

- Research should investigate and explicitly describe its own point of departure, its point of view and the values implicitly used in the research project.
- Research should engage in the problems to be investigated, working explicitly with the goals and values involved, and making explicit the client's needs.
- Research should describe the choices made, the limitations and constraints involved, and the areas of ignorance uncovered in the particular project, as a necessary context for the results produced.
- Research should position itself within a larger perspective, allowing different users to fit the results into a coherent overall picture.

These criteria can be recognised in the discussion about the integration of beta and gamma science in which attention is paid to an integration of values into science (Pretty, 1995; Jiggins and Röling, 1998; Pearson and Ison, 1998).

In line with Alrøe's statements, I have in this doctoral thesis been explicit about the choices we at Louis Bolk Institute tend to make. I have, furthermore, integrated these values into the two theoretical frameworks and methodologies that I have used in this dissertation to discuss R&D in organic farming. These two frameworks have been used as the main tool for analysing the

research approaches described in the case studies. The adapted triangle (Figure 2.4) showed the choices within each project and steps undertaken during each project. The explicit inclusion of constructivistic position allowed us to pay explicit attention to the reasons researchers and farmers have for making their choices during the course of a project.

The four-quadrant framework (Figure 2.2) was adapted to include the type of holism that is the basis for Goethean science. Furthermore, the quadrant was adapted to allow for the kind of experiential science that is a key element in organic agricultural research. In my analysis of the case studies, the four-quadrant framework was used to describe the stages of the development of a research project, not so much as changes in the consciousness of a scientific community, as for example Rölting (2000) has done, but as developments in a scientific approach (see below). It is now time to revisit these frameworks and draw some broad conclusions about the nature of research in support of organic farming.

Figure 7.1 revisits the triangle (Figure 2.4) to make clear one important result of our exploration with the use of the case studies: Research to support organic farming tries, as much as possible, to pay attention to all three points of the triangle and iterates through them, mutually adjusting these three aspects as the research project proceeds.

A project might start with an emphasis on one of the aspects but, in the end, each project either turned out to be a combination of all three, or turned out to be part of a larger enterprise which did address all three. Additionally, farmers are an essential ingredient of agricultural research. The work with farmers, and their actions and choices are the point of departure of the research. The farmers are not average farmers but deliberately chosen to be pioneer farmers who are explicitly working to improve their practice and understanding. In this, the projects described go further than 'participatory technology development'. The farmer is chosen for his ability to innovate and frame the research.

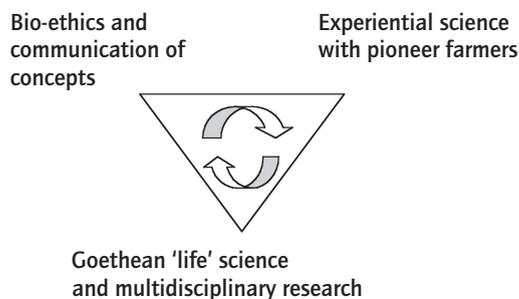


Figure 7.1. Interconnection of approaches.

7.3. Systemic approach and holism

Systemic or agro-ecological nature of the R&D projects revealed itself in different ways:

- *The farm* was always, albeit sometimes passively, present as the context for research. In contrast with experimental research on a research station, in our approach the research question is embedded in the context of the farming system of the farmer who raised the research question. In our cycle of experiential science, both the farm's ecology and farmers' values restricted the solutions and contextualised findings.
- In experiential science, research findings were discussed as *a coherent system of on-farm action* that describes the logic of situation-adjusted interventions and adapted management. The end of the search was reached when a new set of actions was adapted to the new needs of the farmer and could be communicated as systemic action to other farmers.
- In multi-disciplinary science, research findings were discussed as *a coherent set of interacting and underlying factors* that explain the findings. This way of thinking about systems fits science best. In that perspective, the system is present in terms of an integrated model of causal factors. Hard systems are expressed as complex levels of integration.
- In Goethean science, the systemic level was present in terms of *entity and metaphor* that were thought of as the non-materialistic expression of the whole. Systems were thought as expressions of beings, as entities with their own integrity interacting in networks of learning, co-evolution and inter-dependence.



... casuistry and context: here grass-clover, a deep litter barn and wind energy ...

7.3.1. Goethean life science as an empathic holistic method

Goethean science has a constructivistic orientation to holism. It focuses on wholeness, relationships and developments in time. It does not explain life in terms of reductionistic causal relationships, its understanding of phenomena is based on the idea of non-material forces, entelechie, 'soul or mind'. This idea goes beyond emergence of system properties which cannot be explained from the constituent parts (Looijen, 1998).

In agricultural research, Goethean science is used as an additional methodology based on a view on 'life' or 'consciousness' as an independent level of emergence that has its own identity and as imperative forces require its own research methodologies. If biology is to have another level of explanation than 'physics' and 'chemistry', life has to be more than machinery and mechanics. Life has its unique shapes, inner regulation, growth patterns and development (Augros and Stanciu, 1987). Based on this recognition, Goethean research with regard to plants was developed to examine patterns of growth and development (Grohmann, 1959; Schad, 1985; Bockemühl, 1985; 1998; Verhaagen, 1998 and Bisterbosch, 2001). As a result of his long term studies of plants, transformations of leaves and leaf sequences, Bockemühl (1964, 1998) discovered laws of life expressed as 'ideal activities' that fit with Goethe's 'archetypal' phenomena. The holism was recognised in a statement at the end of his article, where Bockemühl said: *'In the multiplicity of the movements of the leaves, we sense a wisdom-filled structure through which the archetype as a being first announces itself.'* Bockemühl (1998) explained errors in the relation between observation and interpretation and how these could be prevented: *'Goethe pursued these archetypal phenomena, also called essential patterns, in full awareness of the two possibilities of error: freezing oneself in abstraction or losing oneself in mystical reverie. To avoid these potential errors, observers must direct their gaze upon their own thinking activity as well as on the object observed itself.'*

As a holistic approach, Goethean science undertakes several steps to ensure awareness of the object itself, its surrounding and its development. In addition, the researcher seeks to understand the 'inner meaning' and 'expression' of the object or 'the essence embedded in the whole', which is very much comparable to the holistic concepts of integrity or intrinsic value in the animal welfare discussion (Verhoog, 2000), or the Genius Loci⁶⁹ in holistic landscape planning (Colquhoun, 1997).

A reduction is part of Goethean scientific method in its focus on detailed observations rather than on mechanistic and causal explanation. The concept of the 'considered whole itself' clearly points the way in which to look for details. According to Bosshard (1997), *'every analysis will therefore start from a superior or authoritative whole, which perhaps only has been grasped unconsciously. There is an inter-dependence between the parts and the whole as a double mirrored and complementary relation. The higher integration level or the entity of the whole clarifies the parts and gives them significance, and in turn, the parts clarify the whole and help to understand it. Every division into parts, but also every evaluation criterion derives its significance and its*

⁶⁹ The Genius Loci is the 'invisible, ever-transforming and yet decidedly obvious characteristic of a place, which has been transformed through the stream of a complex interplay of past and future events' (Colquhoun, 1997)

justification solely from the actual context. The figures and parts ('objects') obtained can only count as objective in connection with the situation from which they are derived, not in the sense of universal, but of feasible and factual'. Bockemühl (1992) used the paraphrase 'the whole can be observed into its parts' (Das Ganze im Teil) and used the imagination of a dewdrop that, lying on a leaf, reflects at the same time its complete environment.

In terms of the four-quadrant figure (Figure 2.4), Goethean science starts in quadrant 3 and integrates elements out of quadrant 1 and 2 in a nested lazy eight iteration before action is undertaken (quadrant 4) (Figure 7.2).

Another essential aspect of Goethean science is an empathic involvement of the observer with the topic of research, an attitude that is very similar to the organic farmers' normal daily practice. Empathy is needed to keep people involved in the full cycle of observation, interpretation and synthesis. The absence of technical instruments that are in between the observer and the observed ensures this empathy. An empathic research approach is easily recognised in animal

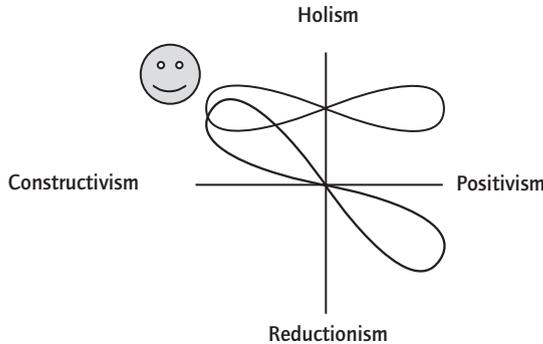


Figure 7.2. The steps undertaken in Goethean science in the framework of reductionistic versus holistic science approaches (vertical axis) and of the constructed world versus the objective world (horizontal axis).

⁷⁰ See for instance the empathic research work of neurologist Oliver Sacks in his books 'Awakenings' (1990) and 'The man who mistook his wife for a hat' (1985). Sacks is a splendid user of cases to tell his story and illustrate his findings; see also www.oliversacks.com. Another interesting case is the study of the behaviour of domesticated animals by Temple Grandin. Although born an autistic woman, Grandin has designed one third of all livestock handling facilities in the United States. In her book 'Thinking in pictures', she explained how her handicap allowed her to empathise with animals. Due to her autism, she lacked the ordinary way of abstract scientific thinking. Her understanding was based on patterns of visual thinking about the animal and on concrete visual metaphors. See also: www.grandin.com/inc/visual.thinking.html.

⁷¹ See for example her books 'The chimpanzees I love' and 'In the shadow of man' (www.janegoodall.org).

ethology and human psychology⁷⁰. In her work in studies of animal behaviour, Goodall (2001) showed much empathy with her chimpanzees⁷¹ (see also Van Putten, 1999). She was criticised for this by the scientific establishment because the loss of distance between the researcher and her object might lead to subjective science. Goodall said that her approach of ongoing observation of behaviour and living among the chimpanzees made it possible to understand their behaviour. In Goethean science, this empathic attitude is also practised in other areas than the study of humans and other mammals.

7.3.2. Holism in multi/interdisciplinary research

In contrast with Goethean science, multi- and interdisciplinary research is usually based on co-operation among disciplinary scientists. As the positivistic counterpart of Goethean science, an interdisciplinary approach will ultimately lead to the broad view on a specific situation in terms of quantified relationships. In general, a multidisciplinary design extends the analytical compartmentalised approach in the direction of ecology (Figure 2.2, 2nd quadrant) and hard system research. Holism in this sense is thought of as the *complex integration of disciplines* and is communicated in farm models⁷². Models of functioning systems can be developed at several levels of integration: soil, soil-crop, DNA-cell, animal, soil-crop-animal, farming system or chain. In Chapter 5.1 we have used this approach at the soil-crop level (compare Mäder *et al.*, 2002). An approach of a whole farming system has been worked out in the inter-disciplinary research design based on a team of compartmentalised oriented scientists (Aarts, 2000). Aarts (2000) defined the limitations and challenges for future integrated farming at the experimental farm 'De Marke'. When communicating the system level results of the 'De Marke' farm study it was found that the application of these results to new situations occurred in terms of the *process of research* (how to tackle problems), rather than in terms of replication of the physical outcomes of the experimental farm (personal communication De Vries, former project leader of De Marke). This means that not a 'farm blueprint' but an interconnected 'process blueprint' was used to communicate the outcomes. In the same way, in the communication of the scientific results of multi-disciplinary study reported in Chapter 5.1, we were presenting and discussing hard science results with farmers in terms of integrative processes within a soil-plant system, rather than in terms of statistical figures about differences in yield. Hard science was used for evidence to distinguish between variables. This is very similar to Paine (1995), who concluded in his doctoral

⁷² For instance it makes a difference whether one thinks of a body *divided into cells* or of one *built up out of cells*. The first focus is holistic from an emergent entity to its parts and the second focus is more reductionistic in that it looks at the emergence of the whole from the parts.

thesis about social change in the New Zealand dairy sector that '*living with complex problems requires a way of muddling through a labyrinth of uncertain outcomes that emerge from human activities*'. He admitted that in the learning and development process of an entrepreneur, it was not so much the end result and an exact answer which matter, but far more the process of looking for solutions and the method of development. People learned from inside out, and goals were adjusted in the light of experience (see also Paine *et al.*, 2000).

A strong point of the systems approach is the implicit and built-in boundary provided by a 'well defined whole farm context'. The danger of the approach is the communication about systems solutions as the only feasible 'farm blueprint'. Although the farm context is present, also the values or farm styles and the limitations of the suggested solutions chosen in this blueprint should be communicated. Farmers often consider their own personal situation different from that of the experimental farm. In the discussion of the BIOVEEM project in Chapter 6, we brought these elements together in one approach. The group of pioneer farmers could each develop their own farm blueprint based on his style of farming. This group of 'optimisation farms' is used for future farm prototyping (Vereijken, 1995-b and 1997; Wijnands, 2000; Kabourakis, 2000). A framework of optimisation sharply defined by researchers restricts the farmer's action and guides him to 'good organic farm practice'.

7.4. Orientation on pioneer farmers

Pioneers are involved in three different ways:

- As holistic experiential experts;
- In the farmer – to – farmer learning process; or
- As individuals who care for values in an on-farm project.

The focus on pioneers was financially embedded in a strong dialogue group of the dairy farmers' association and direct researcher-farmer contacts in several demonstration projects. Dialogue meetings were used to define priorities, whereas the direct contacts were used to focus on new farmer actions. This focus on pioneer-oriented action is part of our method of experiential science (see Chapter 7.5).

7.4.1. Pioneers as experiential experts

Pioneers in organic farming are defined as people who act according to concepts instead of react to (negative) regulations. These pioneers pay specific and personal attention to a certain farm area and deal with questions with regard to the specific constraints of their own farm's limitations. In our experience, their questions often have a long-term scope. Our participatory

research projects have often been criticised because farmers should mainly deal with short-term problems. Our involvement of pioneers concerned with the background and philosophy of organic farming has overcome the arguments on which these criticisms were based. This process is not always equally conscious and explicit but is evident in what the farmer does. Their personal commitment drives them to push back frontiers and even makes them willing to take risks. Most of the farmers' experimental initiatives are undertaken at the individual level. New knowledge and insight are developed in co-operation with individual farmers. The individual approach does not exclude co-operation within a farmer group. Within a well-defined theme it makes sense to explore a problem with more than one farmer. But if the bottom-up approach is taken seriously, one must deal with individual questions and strategies for development. A farmer never appeared as a pioneer in all fields of agriculture, which means that site-related and farming style-related limitations have to be set for each solution. Therefore, a pioneer farmer should also be treated as a follower with respect to his weak points or with respect to parts of the system which are not of his interest.

The presence of an involved, pioneering farmer guarantees a large range of additional direct observations and information. Instead of a limited number of measurable observations, mainly of the produce at harvest stage, the farmer also knows the process of growth and development and the relation to other farm elements. For the participating farmer, the presence of a research trial on his farm increases his interest in the topic. On-farm experimentation, irrespective of whether the trial is assisted by a researcher or not, will increase the self-reliance of the farmer. If plots are made on a field scale instead of small plot scale (Cf. Chapter 4.1), the farmer can immediately integrate the research findings into his system. No additional understanding is necessary with respect to effects on management, such as requirements for other machinery.

For reason of representation, a research project on a single farm is not considered to be scientific. As mentioned earlier, the case study approach was considered the lowest level in science (Vandenbrouke, 1999). Also in the literature of participatory research, farmer groups were preferred above individuals (see Chapter 7.4.2). Although this issue is relevant in terms of representation and hence for extension and education, it is not essential where the discovery of new areas or the invention of systems that work is concerned. Although it cannot be denied that farmers can mutually benefit from being engaged in the same topic of research, learning, exploration and discovery remain an individual struggle. Reij and Waters-Bayer (2001) showed how teams of African scientists and field agents identified almost 1000 innovators and described management systems highly adapted to extreme local conditions and developed by local farmers without the intervention of any scientist. We described the case of Endendijk to similar effect (Cf. Chapter 5.4).

This still leaves open the question of the style of the farmer on whom the researcher will focus. This remains a subjective choice and depends, for instance, on one's views on life and on the future of farming, but also on the policy of the institute one works for. Therefore, Alrøe *et al.* (1998) suggested that these orientations be made explicit (Cf. Chapter 7.1).

7.4.2. Farmer-to-farmer learning

The approach to on-farm experimentation is expanded if one works with a farmers' group (Cf. Chapter 4.2). Knowledge and experience are exchanged and therefore the farmers' trust in their own judgement will increase. Farmer-to-farmer learning can be passive and active. Learning is passive when farmers visit other farmers, pioneers or interesting field studies. From their personal point of view they observe the system and integrate elements in their own circumstances. Active learning starts when farmers work together on the same theme of discovery. In our demonstration projects we always 'forced' farmer into such an active learning process. At least we expected from them that they explored their own question by means of a simple trial on their own farms. From that moment on, they become experienced insiders and do not only discuss problems from an outsider point of view.

In their co-operation with two local farmers' initiatives, VEL and VANLA, Verhoeven and Van der Ploeg (2002) covered almost 80% of the dairy farmers in the area. The main reason for such a huge response was the presence of a clear context and a well described set of principles, which was fully explored and defined by the farmers themselves. The specific ecological circumstances of the area in the south of Friesland restricted the action of all farmers. The small-scale landscape set strong agro-ecological boundaries for farm development. Changes in values (environment orientation, reduction of N input) and the specificity of the landscape led to a set of self-chosen limitations by the farmers' co-operatives to reduce environmental impacts and to restore the landscape. The presence of such strong contextual limitations and the bottom-up approach (self-chosen limitations) proved very helpful tools in farmer-to-farmer learning. In the method of farm-prototyping (Vereijken, 1995-b and 1997) similar elements of learning were found. In a group of organic arable growers, Wijnands (2000) defined a clear set of goals to improve the on-farm results. These goals were based on an analysis of the main problem areas in organic arable production. Farmers were invited to subscribe to the goals at the start of the co-operation. In our own approach to mutual learning with individual farmers or in a farmers' group it was very important that farmers remained the owners of the challenge defined or recognised by themselves. This was felt to be a guarantee for a creative process of discovery learning. This was highlighted in the circle of 'farm pioneers' who set their own goals for development (Cf. Chapter 6.2).

Finally, experimenting jointly with a farmers' group can also be very cost effective, if the responsibility of scientist and farmer is really shared. Ruddel and Beingolea (1995) described their experience in the Andes, where they at first taught the basics of experimentation to a farmers' group (description, trials and results analysis). In their example, the farmers were responsible for all steps in the experiments, inclusive of the discussion among farmers. In a three year period, 101 farmers did 427 experiments on about eight different crops. Together the farmers' group developed the best potato varieties for their specific dry farming circumstances.

7.5. Experiential science

The development of methodologies to exploit indigenous knowledge has been reviewed by Prain *et al.* (1999). It is not a new idea that farmers actively solve their problems and do so based on locally developed knowledge. Examples of the explicit use of this recognition in agricultural research go back at least to 1911. Cultural ecologists (or 'ecological anthropologists') document farmers' practice and knowledge. Experiential science refers to participatory action research, Participatory Technology Development (Reij and Waters-Bayer, 2001-a), adaptive management (Gunderson *et al.*, 1995) and on-farm research approaches. Adaptive management deals with the unpredictable interactions between people (in this case farmers) and (agro-)ecosystems as they evolve together. The primary expectation of adaptive management is the surprise (Gunderson *et al.*, 1995). Experiential science in the way we have used it on pioneering farms (Cf. Chapters 5.2 and 5.3) integrates experiential learning in terms of intuitive learning and pattern recognition by farmers with experimental on-farm evaluation by scientific evidence (Baars and De Vries, 1998; 1999).

7.5.1. Characteristics

In action, the farmer is often ahead of his theoretical understanding (Cf. Chapter 5.2.1). In an ideal situation, the farmer invites a researcher to reflect and participate in his learning and experiential process. Otherwise the researcher has to look for farming situations that are different from 'normal and accepted' farm practice, that is look for farmers who move in other directions. In the third world these



... take the action as the starting point for research ...

farmers are referred to as 'local experimenters' (Van Veldhuizen *et al.* 1997). Our experiential science has several elements that call for attention:

- Based as it is in the action of the farmers, experiential science is a research approach that integrates both the farmer's values and the agro-ecology of his farming system as the context for the final experimental research design. There is no direct short-cut between experiment and action.
- Attention is paid to reflections on action and intuition during the process of search and research.
- As a new element of casuistic outcome research ⁷³, attention is paid to 'pattern recognition' as one of the key elements of experiential science.

Anderson (1992) mentioned three types of investigations that may be made on a commercial farm and all these three points are relevant to organic farming studies:

- (1) Specific management history or physical conditions and natural phenomena not available on experimental stations (ecological diversity);
- (2) Ecological effects of whole-farm changes and dynamics, complex people-dependent integration, preventive and comprehensive management; and
- (3) The farmers' management itself, especially of innovative systems related to human diversity or styles.

All three points are relevant as our entry points into experiential science. The main point, however, is the last one, which reflects our focus on two crucial elements: farmer pioneers and their skills to adapt management in a direction of prevention based on anticipation. Experiential science is used as a methodology to discover new areas of interest, to develop new scientific knowledge and insights, and thus to develop adaptive, preventive and comprehensive management in organic farming.

Lyon (1996) divided farmers' experimentation into original ideas, re-inventing the wheel, and adapting, or customising ideas from other farmers and scientists to the specific context. From the range of questions raised by farmers, we have chosen to look at questions or original ideas that deal with the identity of organic farming and that push back its frontiers. In experiential science, the specific farm is treated as an experimental research station. The farmer is not treated only as the owner of a specific set of a-biotic conditions needed for the research in question, but he is part of the answer, since he is the context of the question as well. We have focused on the

⁷³ Casuistic outcome research is based on a single case or a limited number of cases.

cohesion of experiential learning of agricultural pioneers and experimental testing of on-farm challenges by a researcher. Jacqueline Ashby (cited in Selener, 1997) summarised a number of principles associated with participatory research methods. The participatory method with pioneering farmers should be:

- Interactive, emphasising immediate two-way information flows both in the farmer-researcher-extensionist interface, and in the farmer-to-farmer information exchange;
- Flexible, tending to minimise researcher control and maximise farmer intervention in research design;
- Rapid, to maximise ability to respond to farmer initiatives or unanticipated areas of research; and
- Multiple, such that different techniques are applied simultaneously or overlapping in time, rather than sequentially

We strongly support her recommendations. The first three elements were already described in our case projects. In fact, it is becoming increasingly evident that the participatory research approaches we have developed at Louis Bolk Institute have parallels in international efforts to overcome some of the major short-comings of conventional research, especially with respect to producing results for highly diverse, risk prone types of agriculture in developing countries.

7.5.2. Reflection on innovative action

To emphasise the particular aspects of our approach to experiential science, the classification of Biggs (in Waters-Bayer and Bayer, 2000) of farmer-scientist interactions is very helpful.

- Contractual: scientists contract with farmers to provide land, animals or services; experiments are planned and evaluated by scientists.
- Consultative: scientists consult farmers about their problems, interpret the responses and then try to develop appropriate solutions.
- Collaborative: scientists and farmers collaborate as research partners in identifying research questions, planning experiments, and collecting and interpreting data jointly.
- Collegial: scientists work to strengthen farmers' informal research and development systems.

According to this classification, collaboration and collegial interactions have been inter-mixed in our experiential science. Farm manager and researcher collaborate to reflect on the learning process and carry out specific on-farm trials. The reason for co-operation is to clarify the learning process and to describe the farmer's findings. Instead of 'farmer's tales and hidden knowledge', the findings of farmer and researcher become exchangeable with other farmers. The black box of specific farm situations is opened and becomes accessible to other farmers.



... learning during action as part of the day-to-day practice ...

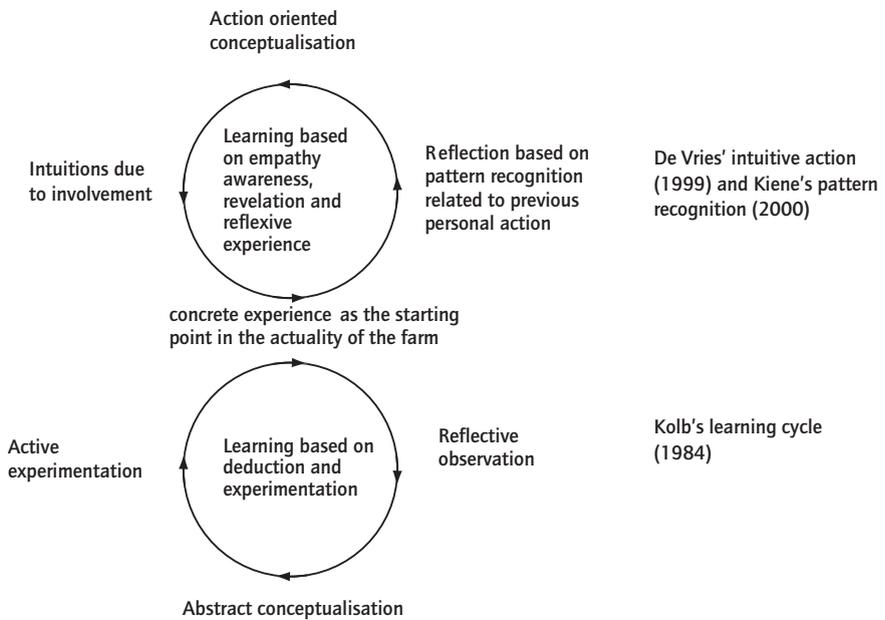


Figure 7.3. The concept of experiential science including both experimental (below) and experiential (above) learning.



Öhlmer (in Lunneryd, 1997) described decision-making as a cycle of problem detection, problem definition, analysis plus choice and implementation. This formal description does not reflect experiential learning. Maturana (in Ison *et al.*, 2000) said that 'all knowledge is action'. In other words 'knowing is in the doing'. The model of experiential learning developed by Kolb (1984) showed the daily experience as the start of a learning cycle (Figure 7.3). Learning during action may not be planned at the beginning of the season, but rather evolves as the agricultural season goes on. Learning during action lacks controls and details of the treatments, and this limits its power of analysis and validation compared to formal methods (see also Schön, 1987). The weakest links in the process often are the reflective and conceptualising steps. At work, people seldom have time for them and especially not to do them with others which is crucial for work place learning (Waldenström, 1997). In our concept of experiential learning, according to De Vries (1999), we integrated an intuitive learning cycle to this first deductive learning cycle. This intuitive learning cycle was based on intuitive action, which might be unexpected or unplanned beforehand and on reflection on this action (Figure 7.3). Lyon (1996) also used the term 'intuitive learning' and learning during action as a part of the day-to-day practice. Bawden *et al.* (2000) mentioned 'inspirational learning' in this context.

Waldenström (1997), looking at the process of individual learning, said that learning based on personal involvement and creative innovation is in fact based on reflective action and meta-cognitive knowledge. The meta-cognitive knowledge at the farm level can be revealed if experiments are designed in a specific farm-context. Box (1987) mentioned the historical and biographical approach within social science. A farmer's life story brings to light crucial phases of his developmental and essential life problems, instead of everyday problems.

7.5.3. Pattern recognition as a key element in experiential science

A key in experiential reflection is the immediate recognition of patterns, which are related to one's own action in the past or to the imagined model in mind (see Epilogue). There are three levels of pattern awareness (De Vries, 1999; Kiene, 2001): pattern recognition based on correspondence *in space* and *in time*, and pattern recognition based on the *inner expectations* that emerge through involving the farmer. For instance, breeder Dirk Endendijk (Cf. Chapter 5.3) had an inner picture of his ideal cow: '*the ideal shape and quality of a cow is always in my mind if I look at new-born animals*'. Such an expectation is the guide for his judgement and action. Compensatory crosses are made, and strong and weak points of an individual animal are identified with regard to this inner eye. The reality of the expectation functions as the control for the outcomes. Similarly in Goethean science, one assumes that the observations one makes of objects in the world are an expression of a non-material, living reality. The individual plants are an expression of a *single* manifestation of an entelechie, the 'archetypal plant' (Von Goethe, 1978; Cf. Chapter 4). This 'archetypal plant' must not be interpreted as a static entity or model, but as a plastic being, of which every plant and every plant species is a *single* manifestation. Also in non-replicated on-farm experimentation at Warmonderhofstede (Cf. Chapter 5.2), the

concrete imagination of the future outcomes functioned as a control to test the farmer's expectation. In that case there was not an idealistic situation but an expected situation, which acted as a control on the findings.

Pattern recognition has its equal in science as pattern analysis (Kelly and Basford, 2000). Statistical techniques are used for the exploratory analysis of complex multivariate data as they determine and display the underlying patterns in such data. Although there are parallels in terms of intention, we have focused on the relationship between farmers' actions and the patterns that emerge from this action (see Chapter 8.2).

7.5.4. The skills of experiential science

Based on our analysis of, and reflection on experiential science with pioneering organic farmers, several elements and points of interest in experiential science become clear (Baars and De Vries, 1999) (BOX



... pattern recognition: correspondence in space after spraying of diluted seed pepper (D8-potency) ...

7.1). The task of the researcher is to develop the experiential concept and to guide the quest of the pioneering entrepreneur. In experiential learning the emphasis is placed on developing a new way of thinking and conceptualising which ties in with the methodology and inspires the adoption of new set of coherent actions. Assisting the farmer in his quest requires both communication skills and skills in designing the research process itself (experimental and non-experimental research). Insight and understanding are developed from specific local and human knowledge, which is still partly implicit. In farming systems research, we talk about 'indigenous knowledge' (literally 'native knowledge', or 'knowledge from and about one's own environment') and 'tacit knowledge' ('unspoken knowledge', or 'knowledge that can not (yet) be put into words'). The aim of a researcher is to form an overall explicit understanding of this way of working (of the 'practical insight') that will make communication and transfer possible. This new professionalism therefore is based on a beta/gamma approach that facilitates learning instead of working on technical answers (Jiggins and Röling, 2000). Hatchuel (2000) mentioned 'intervention-research' as the renewal of the epistemology of action, a concept which is very similar to our experiential science.

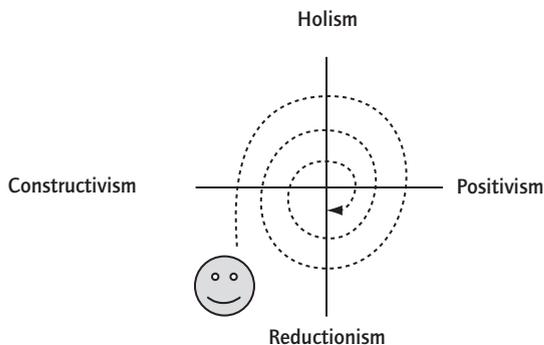


Figure 7.4. The steps undertaken in experiential science in the framework of reductionistic versus holistic science approaches (vertical axis) and of the constructed world versus the objective world (horizontal axis).

Experiential science as it has been elaborated in this doctoral thesis is not the same as the stepwise contextualisation of compartmentalised science that was described by Miller (1985), Bawden (1995; 1997), or Röling (2000). In Figure 7.4, we visualise the steps made in experiential science as a principle of the epistemology of action: the innovative concrete action is first (4th quadrant) and made before knowledge is present. In a research process, this action is taken according to a certain value in life, which has to be described (3rd quadrant), and within the context of a specific farm, which is also relevant for the range of solutions (2nd quadrant). In

BOX 7.1 The practice of experiential science

In a handbook on participatory action techniques of experiential science, Baars and De Vries (1999) described the points of attention for the researcher involved in participatory research projects:

- Identify yourself with the farm and the farmer's motives; respect his search.
- In your meeting with the farmer, realise that you each have a different assignment; and take account of the differences with respect to the knowledge, depth and overall view of the farm and the subject of research.
- Focus on whatever the farmer does, i.e., on his actions, both innovative and otherwise. It is these that reveal his underlying motives.
- Create opportunities for unexpected changes of course; keep the research process open.
- Ensure that experimentation is in keeping with the reality of the farm concerned.
- Involve the farmer in the experiment – its purpose, observation and evaluation. Make regular rounds of the trials.
- If possible, work with several farmers on the same theme, on the condition that they themselves do something with this theme (reference farms).
- Involve external experts in the research; stimulate an interdisciplinary approach.
- In the interaction with the farmer, focus first on his prognosis for action, and examine this later against a retrospective look at what he has done.
- Reflect on the actions that have had an unexpected success.
- Create an opportunity to compare different farm systems.

the context of these three elements, it is relevant to make an on-farm experiment (1st quadrant). Due to reflections on on-farm experiments, the cycle will start again. In fact we are dealing with a nested spiral ending in a new set of systemic actions fitting in the right context of the farm and the farmer's values. The final goal is to support the necessary action at the right moment, and in the right context. Bawden *et al.* (2000) mentioned 'a context of responsible action' (knowing when knowing what) and the 'innate sources of spiritual insight' (room for personal intuitions out of an involved experience), formulations which closely reflect our findings.

7.6. Comparison with other approaches

A project to transform an academic training program has been attempted at the University of Western Sydney in New South Wales (Bawden *et al.*, 2000). This reform aimed at a 'shift in systemicity' and at adoption of systemic inquiry for 'situation improving' based on the challenges

of 'real-world complexity'. The focus changed from problem-based to an experience-based (experiential) one. Attention was paid to the 'learning community' in networks of collaboration. This approach was supported by theories, philosophies and methodologies drawn from the 'systems movement'. Both practical experience and theoretical understanding were integrated into a systemic praxis. The essence of systemic praxis *'came to be understood as the facilitation of the development of systemic perspectives on the broad process of responsible development, through experiential learning.'* Interesting for all these endeavours was the presence of a dominant context, the emergent notion of ecologically sustainable development within Australian agriculture particularly expressed by the so-called Landcare and Catchment management movements.

The authors also reflected on the inner changes caused by this change of paradigm: *'it is one thing to learn various system theories and how to apply them in practice; it is quite another to learn how to become a systemic being.'* The old distinctions between researcher and extensionist as well as between agriculturist, professional and ecologist were becoming increasingly inappropriate. The emerging view is that *'agricultural professionals are essential facilitators of systemic development, helping farmers to learn about their own ways forward, within a context of responsible action.'*..... *'To become systemic, of particular significance is the attention for inspirational learning as a process that enables learners access what are regarded as innate sources of (spiritual) insight.'*

In comparison with our definition of experiential science, we oriented on an adequate, situation based action: adequate answers for site adapted solutions based on experiential science. This approach includes the intuitive learning of the farmers, which has been made conscious for communication to others by reflection'.

In their popular textbook on grassland management, Pearson and Ison (1997) presented a constructivistic perspective on grassland system design that integrates soft systems, hard systems, technology development and reductionistic science. Starting at the holistic level of a soft system and in the tension between the 'real world' and the 'conceptual world', they link cyclical research processes. Each cycle has its own way of learning, engaging in science and reflection. Also Humphreys (1997) looked for an integration of different methods in grassland science ⁷⁴, and Tekelenburg (2001) in his doctoral thesis about the development of a cross-

⁷⁴ Humphreys identified the shifting emphasis of key issues and research methodologies in grassland science over the past 60 years. His findings were based on the proceedings of the International Grassland Congresses. Comparable to Pearson and Ison (1997) he concluded that *'the balance of effort in grassland improvement will be found by maintaining a spiral of interconnected learning cycles (based on Kolb, 1984) covering the spectrum from reductionistic basic science, applied science and technology, and the application of hard systems through to the holistic study of soft systems. Each of these types of activity is only effective in grassland improvements if its interdependence with the others is recognised.'*

epistemological management toolkit for interactive design of farm innovation, developed a framework that integrates decision-making in a process of interactive learning at four levels of integration similar to what Pearson and Ison (1997) described.

Starting at the soft system level to ensure acceptance, as well as engaging in an iterative cycle of different types of research to find solutions and gain comprehension at a soft system level is very similar to our experiential science approach. Reductionistic scientific methods are not excluded, but they are used to support the search for acceptable solutions that work. The project BIOVEEM (Cf. Chapter 6) is designed in a similar way. Farmers' concepts of organic farming and the future challenges they perceived were the point of entry of the project. An interdisciplinary mix of research activities seeks to find answers to these challenges using both positivistic as well as constructivistic approaches. Stakeholders were invited to become co-investigators with scientists in a shared process of enquiry and experimentation (Jiggins, 2002).

Our novel methods have similar elements of the so-called 'empathic learning and action' cycle according to Millar (1999-a and 1999-b), which includes attention for the spiritual world as a driving force. Millar (1999-b, page 148) developed a scheme of steps, which is very similar to the steps undertaken in our experiential science (Cf. Chapter 5.2).



... spirituality in bio-dynamic farming ...

7.6.1. Spirituality and methodological holism

A spiritual view on life is a common tradition both outside and inside the organic farming community (Crossroads, 1995; Haverkort and Hiemstra, 1999). Bio-dynamic agriculture, therefore, should be judged as a specific expression of spirituality, with its own prescriptions and rituals. Explicit attention to spirituality is an aspect of many western and non-western cultures, whether it is expressed in terms of 'ecological spirituality' (Zweers, 1995), 'the spirituality of the Bible', Yin and Yang, Taoism, Buddhism, or in tribal rituals in non-western societies (Huizer, 1995; Witte, 1995; Haverkort and Hiemstra, 1999). The main differences in the organic movement with respect to dealing with spirituality can be found in the

concept of holism, and especially in the way this concept expresses itself in the relationship between spirit and matter and in the concept of emergent property. This difference also expresses itself in the extent and manner to which spirituality is translated into a research methodology. In anthroposophy, the expression of spirituality is most evident in Goethean science and in experiential science, which were described in this dissertation as scientific approaches with a constructivistic character (Cf. Chapter 2.2.1) and which are presented as methods to investigate and integrate values into a research practice. These values are explicitly expressed in two different ways: as the entity or integrity of the observed and as personal values and inspiration of farmers in action. Goethean science has been presented as a method to investigate the concept of integrity and experiential science has been elaborated as a method to integrate empathic involvement of farmers in concept development.

It is this acceptance of non-material or life forces which is behind the concept of 'integrity of life', and, in my case, has its basis in anthroposophy. Although integrity is explicitly present in biodynamic agriculture, it is expressed also in the IFOAM principles that have been accepted as the general standard for organic farming world wide. The concept of 'integrity of life', is discussed by different researchers and philosophers with different backgrounds in farming. In the animal welfare discussion, several people discussed the ethical side of the concept (Rutgers and Heeger, 1995; Grommers, 1995; Lund and Röcklinsberg, 2001), whereas Wemelsfelder *et al.* (2000; 2001) integrated the method of empathic observation to open the positivistic scientific approach of welfare. Verhoog *et al.* (2002) transformed the discussion on the integrity of farm animals to other elements of farming, such as the integrity of a landscape, the soil and plants. Lammerts van Bueren (2002) discussed the ethics and methodology of integrity in plant breeding.

7.7. Weak points

The often poor acceptance of constructivistic approaches is related to the domination of positivistic viewpoints (Pretty, 1995). Concepts about the world can only be derived according the method of logical verification, based on objective and repeated observation by quantitative measurements and statistical correlation (Kersten, 1995). From this positivistic definition of science several struggles emanate with respect to experiential science and Goethean science as described in this dissertation.

- New action-related concepts are necessarily related to the development of an experiential language and the discussion of inter-subjectivity. To remain objective in observations, inner expressions and feelings, researchers and farmers need to be taught to distinguish between object-related feelings and their own personal feelings. Another element is to develop a level of inter-subjectivity that reflects the constructed objectivity of the group and is the basis for a common language, and which pays attention to the bias of human observation and

interpretation.

- There is a need for adapted statistical approaches in experiential science and morphological approaches such as Goethean science.

7.7.1. Inter-subjectivity and language

"If every event that occurred could be given a name, we would not need stories. But the reality here is that life goes beyond our vocabulary. We do not have a word, and so we have to tell a story" (Berger, 1988)

Work in agriculture is characterised in part by the personal relationship between the farmer and his cattle, crops and land. There is a continual empathy of the farmer with the processes of growth and flowering, of development and decay, but also with changes in the weather. Daily activities are directed by these more or less conscious experiences, as well as by technical knowledge.

Experience is expressed among farmers in the form of narrative descriptions or 'stories'. In the narrative, the experience is still only semi-conscious. The role of the researcher is not to tell new or different stories, but to condense the story and the experiences into a concept. In this way the experience is made conscious and can be used in new situations as the user sees fit.

In practice, experience is not generally passed on by means of explicitly formulated experiential concepts. Also, when the farmer's own semi-conscious experience becomes apparent to him or can be recognised by others, that experience can be sufficient to inspire his actions. He relates experiences in other situations to his own new experience. Half a word is enough for an



... empathic observation and drawing the potato with the growers ...

experienced farmer. As part of an epistemology of action, in experiential science the new vocabulary and concepts should capture the farmer's action and at the same time be an inspiration for new initiatives (Van der Burgt and De Vries, 1998). The concept of experiential science both reflects the complexity of a holistic situation and generalises concrete experiences. It has the following characteristics:

- It addresses the way a person works (that is why it is formulated as an activity).
- It is positively formulated (to inspire others).
- It encompasses complex situations (because it must be a transcendental concept).
- It is drawn from one's own experience (involving one's own practical experience).

Apart from experiential concepts there are other ways to inspire farmers to new action and describe their experiences. The results can be regarded as the forerunners of experiential concepts and are often in the form of an artistic expression. Comic strips are visual representations, illustrations, and wordless stories. Instead of expressing the essence of a situation in concepts, one uses an expressive image. This draws on the imaginative power of the other person. Photographic images, series of pictures and stylised drawings are examples of this. Images appeal to the other person's capacity to recognise a symbol or gesture. In Africa, Hoffmann (2000) used pictorial communication to engage in an effective communication process with farmers in a rural development programme. Three major classes of signs are distinguished, 'namely *index, icon and symbol*. They differ in the relationship in which they stand to the real object they denote. *Index signs are indicative, iconic signs are similar (or analogous), and symbolic signs retain a link to their object by convention!*... *'Symbolic experiences cover verbal symbols (words) as well as visual symbols (signs, logos). Experience gained by means of verbal*



... seeking an understanding of the characteristics of the potato ...

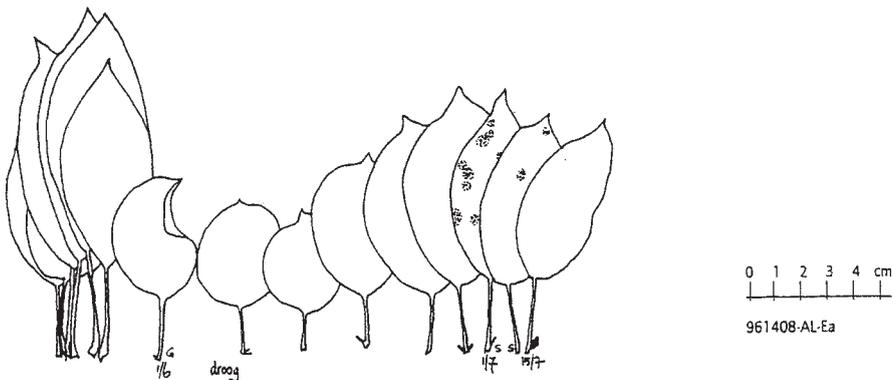


... seeking the expression of the plant in its dynamics ...

symbols would have to denote the peak of experience attained by humans.' As one of four essentials for goals in communication with rural people, Hoffmann (2000) formulated 'further stimulation' of the process of discovery, which is also an element in the experiential concept building of Van der Burgt and De Vries (1998) mentioned above. In Goethean science arts as painting and drawing are used to express the observed by means of visual symbols. In his scientific approach the Goetheanist Bockemühl connected Art and Science. He mentioned Goethean science 'as an enlargement of science by forces which are maintained in an artistic expression' (Bockemühl, 1992), and which can be used in the comprehension of the observed object. In the artistic expression our feelings are oriented to holistic principles of the composition, movement and gesture of the artistic idea (Templeton, 1992).

Derived from Goethean science, Bloksma and Jansonius (2000) used the exact leaf sequence of a characteristic twig of an apple tree to express the growth dynamic of the whole season (Figure 7.5). Another example to inspire farmers' action is a model farm or farmer (such as Endendijk in Chapter 5.4) as 'direct experience'. It represents a concrete, cohesive entity. A farmer can tell from many different details how the model farm fits together. When one visits such a farm, one always sees the outcomes in relation to the context.

A preliminary stage of development of such new concepts is the use of metaphors (compare verbal symbols) to facilitate the dialogue within a group (McClintock *et al.*, 1997; McClintock, 2000), or the usage of stories and examples (Baars and De Vries, 1999). Metaphors are based on



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Figure 7.5. Leaf sequence of a characteristic twig of an apple tree positioned at distances found on the twig itself.

an internal language of a group of people to describe their own situation and were explored as part of Goethean science (Cf. Chapter 5.3). Van der Ploeg (1986) described Andean farmers, who used their own language for potato growth in relation to climatic conditions, whereas Nielsen (1996) described the internal language of farmers in agro-forestry. Typical for a metaphor language is that it is a qualitative language based on relationships and holistic expressions. Metaphors are powerful means for defining boundaries (barriers) and spanning them (bridges). Metaphors reinforce entrenched views of what is real, true, important, or trivial (Michael, 1995).

A weakness of Goethean science is the additional training needed to be aware of the differences between objective and subjective involvement and feelings when the researcher is dealing with the question of how the object in question expresses itself. Another weakness of the method is the risk of remaining at a descriptive level instead of reaching an explanatory level. As Goethean science is mainly employed in holistic case study approaches, adequate statistical methods have not been developed. The Goethean science approach therefore should be integrated into a participatory approach as we have done (Cf. Chapter 5.2). The combination of on-farm action research and Goethean science will lead to a mix of solution-oriented answers based on the awareness of the farm context.

7.7.2. Statistical reflection

Weaknesses of the approach include the limited number of experimental variants when trials are made on a field scale. However, this is more than compensated for by the information about growth and development observed by the farmer himself. If plots are situated on a commercial farm, there is always a tension between the ability to control and farm reality. If the plot layout is more integrated into the daily farm routine, a smaller number of variables can be included. If the choice is an isolated, more complex plot design, there is less connection with the farm management reality. Another point regarding control in action research (Cf. Chapters 4.1 and 4.2) is the year by year evolution of research questions, which results from the immediate implementation of newly derived insights. Instead of a controlled replication of the same trial layout over years, the characteristic of this approach is a yearly evaluation of results and concomitant change of the trial. The year by year evolution was carried out for several reasons: the on-farm trial measurements were evaluated and the insights in the problem changed because of positive and negative coincidences, on-farm observations and experiences during the trial. Important for the mutual learning process of researcher and farmer is the personal involvement of the farmer with regard to the research topic. This involvement makes him conscious of the relationship of his management to the choices to be made. The farmer can interfere with the design of the experiment, based on his actual daily insight and his responsibility for the plots.

These extra farmer's variables can be analysed by means of pattern recognition and non-linear statistics (personal communication A.F.M. Nierop ⁷⁵). In grassland and animal production systems, pattern analysis has already been used as a very powerful technique in determining and displaying the underlying response patterns, for instance multivariate ecological data, especially in large data sets for which conventional statistical analysis is inappropriate. It involves multiple facets, each of which reveals different aspects of the data, and clustering techniques that can impose group boundaries (Kelly and Basford, 2000).

In Chapter 4.1.3 we described the difficulty of each year integrating the farmer's new insights into an existing plot layout. It is clear that the year by year development of the farmer's knowledge is in conflict with the scientific approach to plan a three-year repeated plot layout in advance. However, farmers learned from responses observed as growing patterns in their fields, which they could relate to their own previous management. The pressure from the farmer to look for a next step of development if he understands the facts he has observed is in conflict with the requirement of repeated measurement and statistical evaluation. Therefore additional methods for statistical methods for case study evaluation should be developed based on non-linear regression techniques (see Epilogue).

7.7.3. Additional skills and attitude

Both Goethean science and experiential science are additional approaches in R&D that show a high level of integration as in inter- and trans-disciplinary strategies. At the same time the researcher has to be a generalist, because:

- In experiential science, he integrates specific tasks of researcher, technician and advisor;
- He is involved in several disciplines of research;
- In Goethean science, there is a spiritual holistic orientation.

In Goethean science (Bockemühl, 1985; 1992; 1994), the interrelationship between the research object and its context are investigated in a stepwise manner according to a protocol (Cf. Chapter 5.2.2). A reductionistic view is part of the approach, when the object is analysed. However, the facts are always judged as an expression of a higher organised whole (Cf. Chapter 6.1.1). Although Goethean science can be worked out as an isolated basic science (Bockemühl, 1998; Verhaagen, 1998; Bisterbosch, 2001) and in several scientific disciplines (Bockemühl, 1992; Van Romunde, 2000; Van Tellingén, 2001; Van der Bie, 2001), in our case study project (Cf. Chapter

⁷⁵ This statistician used geometric techniques to analyse processes behind complex phenomena. Visual assessment was used to present interpretations of principal component analysis (see Van der Geer, 1986; Albertsson-Wikland *et al.*, 2000 and www.muvara.nl).

5.2) it was linked with on-farm questions and a participatory approach.

The regular and repeated observations of the object in its own surroundings during its growth and development, as is practised in Goethean science, very much reflect the normal farmers' daily observation and reflection. The approach is descriptive and holistic, because an overall vivid imagination is used to describe the object, and its shapes and colours as a whole both in space and in time. Attention is paid to deviations of forms. After training in this type of observation, Goethean science can become a tool to reduce the language barriers between positivistic scientists and constructivistic farmers.

However, the key of both approaches is that the methods are value bound (Cf. Chapter 7.1); they integrate values into a scientific approach. In Goethean science these values are object related, whilst in experiential science these values are person related, whatever these values are. In positivistic science these values are left out, and the discussion is only about the topic of research not about the method applied. Ethical discussions are held afterwards or beforehand or not at all.

7.8. Conclusions

In various locations throughout this doctoral thesis I have expressed my awareness of the specific impact of a holistic perspective on R&D approaches. It is now necessary to bring these elements together.

- The character of organic farming and its principles;
- The styles of organic farming in relation to the inner conversion process and the blood groups in the organic movement;
- The role of spirituality and anthroposophy in relation to holism; and
- The character of science in relation to the discussion of one's position.

At first, I will make conclusive statements about these points and secondly, I will show the impact of these findings on the attitude of a researcher, the co-operation of disciplines and foci in a research process.

Chapter 1.2 of this dissertation reported the widely shared and formal (IFOAM-supported) principles of organic farming. In summary, these principles stipulated that artificial compounds have to be replaced by agro-ecological measures to support *the self-regulation of systems*, that *solutions to problems must be site-specific*, that *a diversity of farming systems* must be maintained, and that *the integrity of life* must be respected. Research that supports organic farming must first and above all do justice to these principles.

I discussed the three approaches in organic farming based on our investigations on 'how the *concept of naturalness* was interpreted within the organic movement' (Cf. Chapter 3.4). Due to the rejection of artificial chemicals, two approaches to holism appeared important for the development of organic agriculture: an 'agro-ecological approach' and an 'integrity-approach'. At the same time, it was shown, that market forces push organic farming in the direction of the 'no-chemical approach', and that additional regulations were desired to develop organic farming into another direction. In positivistic terms, this 'no-chemical' approach implies a conversion process in terms of replacement of artificial chemicals to 'natural chemicals' without any adaptation of the farming system. Following this initial conversion, one can discern a succession of stages of inner development towards being a more 'holistic' organic farmer in terms a self-chosen style, the self-regulation of the system and the skills to act according to site-adapted solutions. Not all farmers complete all stages due to their personal view on organic principles and 'organic' farmers can become 'stuck' at all intermediate definitions of organic farming.

It was also discussed that organic farming is facing a serious dilemma. Each of the three approaches to or stages of organic agriculture can develop into an autonomous movement, accompanied by different legislation and labels. The other alternative is that all organic blood groups remain under one umbrella approach, defined according to the IFOAM standards and regulations. If the latter development prevails, and naturalness is chosen as one of the basic values for organic farming as a whole, then all three interpretations of 'naturalness' have to be accepted as an overall ethos of the organic movement. That would mean that research methodologies would also be developed and nourished according to this ethos.

I discussed the statement that science is not free of values, and in case of organic farming with its clear set of own principles, it is necessary to include one's position and one's beliefs into a scientific approach and if possible integrate them into the methods applied (Cf. Chapter 7.2). For the purpose of this thesis, two frameworks were adapted from the point of view of a radical holistic research strategy. I adapted existing frameworks to allow ethics, beliefs and life views to become an integral part of the scientific discussion instead of separated ones in science and ethics (Verhoog, 1999). In this thesis emphasis is laid on new and additional empathic research methods because they are the least developed in the field of organic farming. Goethean science and experiential science were demonstrated to methodologically overcome some of the implicit contradictions.

The adapted triangle (Figure 2.4) showed three points of entry for research projects: (1) the feeling about the world reflected in worldviews and judgements, (2) action and transformation of the world as a reflection of farmers' involvement with the world; and (3) knowing about the world. Research to support organic farming tries, as much as possible, to pay attention to all

three points of the triangle and iterates through them, mutually adjusting these three aspects as the research project proceeds.

The adapted four-quadrant matrix (Figure 2.2) opens a perspective on science which allows the use of constructivistic methods such as Goethean science and experiential science. With these methods new constructivistic and metaphysical concepts such as 'the farm as an organism, the 'organism earth' and 'integrity of life and the living soil', can be developed and investigated (Endlich *et al.*, 1985; Lovelock, 1979),

These summarised conclusive statements raise some issues which directly reflect on the extent to which this dissertation is relevant across the board, and especially on the extent to which conventional scientists who enter the field of organic agriculture feel addressed by this study. Can what I have identified by way of strategies and methods of agricultural research in support of organic agriculture be generalised to all forms of organic agricultural research, or must I strictly limit my knowledge claims to research in support of bio-dynamic agriculture? In connection with the three styles in organic farming, different research approaches can be distinguished, each supporting different elements of organic farming: empathic methods, systemic methods and reductionistic methods. I have chosen to focus on a type of organic farming that includes all three approaches of organic farming as suggested by the IFOAM principles. Research methods that do justice to these three cumulative approaches can be considered as the most difficult. I thought it my task to elaborate the full range of organic agriculture research methods as a truly alternative approach to agricultural research. It is up to researchers in the field of organic farming to pick and choose what they like.

In the R&D approach for organic farming, conventional interdisciplinary research and experimental science remain important tools (Cf. Chapter 5.1 and Part 2), especially if they are integrated into dialogue groups or into farm-prototyping. I presented an expansion of this approach by deliberately working with a network of farm pioneers, all dealing with specific interest in a specific theme in organic farming (Cf. Chapter 6).

I have elaborated *experiential science* as an empathic reductionistic approach that supports 'the right farmers' action, at the right time and in the right place'. Two new methods were introduced: (1) *pattern recognition* as a reflection on one's own previous action, even if this was only once, and (2) *intuitive action* was taken seriously as part of an empathic involvement and based on challenges chosen by the farmer. My interpretation of experiential science therefore reflects an integration of experiential learning, intuition and pattern recognition by the farmer, with reflection and interpretation of experimental on-farm research by the scientist.

In this dissertation, considerable attention is paid to *Goethean science* as an explicitly anthroposophic method. It not only asks for intense observational skill as practised in scientific ecology, but includes an understanding of the 'inner meaning or entity' of the observed, and, as such, introduces 'phenomenology' as a method of holistic observation. Another constructivistic element of Goethean science is its approach to communication in expressive pictures that can act as a tool in the communication between farmers and scientists based on metaphorical language and an artistic way of expression (Cf. Chapter 7.7.1).

At the same time, both Goethean science and experiential science are presented as nested methods, which means that they bridge holistic and reductionistic aspects into complementary and additive approaches. In agreement with Looijen (1998), holism and reductionism are mutually dependent and co-operating research programmes. However, the inner meaning of the observed (Goethean science) or the constructed world of the farmer and his action (experiential science) are holistic points for reflection. In Goethean science this relationship between holism and reductionism is explicit because 'entity' is thought to express itself at all levels of integration.

These new elements introduced through Goethean and experiential science are at the same time the weak points of the methodology I suggest for organic agriculture research. The inclusion of human skills in terms of process observation, reflection and intuition conflict with the scientific traditions and ask for an additional training of scientists as well as for new statistical techniques that integrate inter-subjective observations into science and allow judgement on the basis of single cases ('casuistics').

I do not have the illusion that this dissertation will become a 'handbook' for research in organic agriculture. What is more, I would not want it to be used as a handbook. My interest has been to raise issues, to stimulate discussion and to involve others in the excitement that I have felt throughout my years as an organic researcher when new frontiers opened and new questions emerged, especially throughout my close contact with pioneer farmers. Organic farming is a form of land use that tries to pay explicit attention to ecological rationality. Research to develop it is at the frontier of adaptive management.

DISCUSSION AND CONCLUSIONS



8. Epilogue: future implications

The acceptance of the methodological aspects I have explored in this dissertation will depend on the acceptability of their explicit reliance on the 'human construction of reality'. Casuistic methods are as yet scarcely developed as a scientific approach and stand in sharp contrast to orthogonal and interdisciplinary experimentation followed by modelling (Chapter 8.1). The new approaches have to be accompanied by new statistical methods that deal with both human observer bias through reliance on inter-subjectivity (Wemelsfelder *et al.*, 2000). These approaches need to contain understanding and prediction based on case studies (Albertsson-Wikland *et al.*, 2000), and multidimensional factorial designs (Van der Geer, 1986; 1988, Chapter 8.2).

Finally, the work reported in this dissertation opens a fresh discussion in the philosophy of science. According to Looijen (1998), a radical version of holism asks for an ethical approach in which *'biological wholes are to be respected and not analysed, dissected or otherwise manipulated. This view is especially found in exoteric circles in biology, such as in animal protection movements and in nature conservation groups.* In addition, such topics in organic farming as homeopathic remedies are not easily accepted in conventional science (Baars E. *et al.*, 2002 in prep). Roosendaal and Bouter (2002) posited that research in homeopathy was irrelevant because the fundamentals of a causal explanation in chemistry, biology and pharmacology did not allow for the effectiveness of highly diluted solutions. Both examples show that serious philosophical bottlenecks exist with respect to the acceptance of research in organic farming. Therefore, if research is to develop organic farming as a serious alternative, it is important to pay attention to the history of holistic thinking (see for instance Gloy, 1996) and to the choice for reductionism and positivism that have been made in the past.

As I have shown in this dissertation holism is a starting point in two different aspects. Firstly, there is a focus on emergent properties and secondly there is a way of explanation of findings. The presented methods of Goethean science and experiential science reconcile the contradiction of holism and reductionism and leave room for fundamental research and detailed research, as has been worked out in Part 2 of this dissertation. However, different methods of research should be used side by side to investigate several elements of the whole as emergent properties. A different viewpoint might appear at the level of explanation. In this dissertation I have shown how Goethean science expresses the parts out of a holistic entity or force due to the inherent relationship of the parts to the whole. Goethean science, therefore, is principally different from

integrated biology, which is based on a composition of disciplines and a causal explanation of materialistic relationships only.

8.1. Casuistic (outcome) research and pattern recognition

Erik Baars⁷⁶ and Ton Baars

Research is often primarily aimed at establishing relationships between variables. Results of this type of research range from establishing (greater or smaller) associations to establishing causal relationships between variables. 'Experimental impact research' is currently regarded as the standard for establishing causal relationships. Associations are expressed in terms of numerical relationships between quantities. Numbers are obtained by weighing, measuring and counting various pre-set values. Replicated trials, comparisons between groups, randomisation, control over and management of extraneous influences, statistical calculations of probability and the associated group sizes, are seen as the necessary methodological ingredients to make a convincing case for a causal relationship between experimental intervention and its impact.

The power of statistical research to reveal correlations and to integrate numerical relationships into models, and the experimental testing of these models in the manner described above, as well as the success of implementing this model-based approach in agriculture, may suggest that there is no need for casuistic research. Many researchers believe that casuistic research is a descriptive method which can only play a small part in impact research and that experience leading to individual opinions and appropriate situational behaviour can only play a small role in science-based farm practice. However, these elements can be traced back in a logical line to the origins of organic agriculture. Below, we will try to provide a scientific justification of casuistic methods.

Whereas an experimental research set up typically strives as far as possible 'to exclude the possibility that something else has caused the effect', casuistic outcome research aims to identify the cause on the basis of its unique pattern. Casuistic outcome research makes it possible to establish a causal relationship in one or several cases. The 'Abbildungs Korrespondenz'⁷⁷, 'pictorial correspondence or pattern matching' (Kiene, 1994; 1998) make it possible to establish a causal relationship, not by excluding all other possibilities (negative), but by recognising the

⁷⁶ Louis Bolk Institute, Department of Health care and Nutrition.

⁷⁷ Compare with a footprint or fingerprint, which unique patterns correspond with a single person.

originator. Here the singularity of the pattern, the transference of this unique pattern by the therapist or researcher, and the establishment of the correspondence in unique pattern, play a central methodological role. In casuistic outcome research this principle is used in various different ways - for example in space, time, process and theory patterns (Kiene, 1994; 1998; Baars E, 1997; 2000).

This approach to outcome research and casuistic methodology is supported by the work on case study methods by the methodologist Swanborn (2000). To increase the power of expression of a case, he proposes increasing the number of data points. This can be done, he contends, by increasing the number of measurement points or increasing the number of predictions. The key feature of this intervention is that a *more unique* pattern is created. *Pattern matching* is used in the analysis of the case studies. This means that the score pattern on a number of variables is simultaneously compared with, say, a previously predicted pattern based on a model group and validation group. The more extensive the predicted pattern, the better the test of the hypothesis. Pattern matching can thus be regarded here as establishing the correspondence with the unique pattern.

Pattern recognition takes place in numerous places. In many fields, people work with, say, spatial, time, process and/or statistical patterns. Experienced workers - experts - have learnt more or less consciously to deal with the prevailing laws and situations of their workplaces (expertise, tacit knowledge, clinical view, skill, green fingers, simple heuristics, etc.). This experience yields valid knowledge (Kuhn, 1977; De Groot, 1978; Snoek, 1993; Glas, 1997).

The philosopher and psychiatrist Glas (1997) in this context speaks about prototypical knowledge, which is concerned with the recognition of patterns, in this case the observation of a 'Gestalt'⁷⁸. According to Glas, the immediacy and the primacy of the whole over the parts are characteristic of pattern recognition. Individual observations serve largely to confirm the image (Gestalt) that an experienced clinician will form, often in the first minute of the interview, of what is going on. The rest of the time is used to exclude the possibility that it could be something else (e.g., something more serious). This process of exclusion starts by using that prototypical knowledge, then proceeds to laboratory tests and other additional investigations. Scientific knowledge does play an important role, but once more in a *practical* sense: ideally the only investigations carried out are those which are known to be capable of excluding, with

⁷⁸ Gestalt means physiognomy or build.

certainty or a high degree of probability, other common complaints which could explain the image (Glas, 1997). The highest form of pattern recognition is the development of the operational idea (Baars E., 2000). This gives an entirely *transparent insight into the situation* and how to act appropriately and adequately (Kiene, 1998; 2001). There is adequate knowledge, both of the relationship between the problems and the healthy state, and of how to proceed from the problematic to the healthy state. There is nothing that is not understood. This knowledge of operational ideas is the basis for the self-regulating person. The ideal of organic agriculture is for the individual farmer to obtain this knowledge.

In *casuistic outcome research*, a causal relationship is demonstrated by establishing the correspondence between the unique pattern in the intervention and the subsequent effect. The use of unique patterns also plays a central role in participatory action research, carried out in the manner described in this thesis. In reflecting on the so-called unexpected, successful operations (De Vries, 1999) made by farmers during their practical daily action, the first thing is to characterise the operation. This characterisation can be seen as the general direction from which behaviour is unwittingly shaped. Once we are aware of it, this general characterisation can become a source of inspiration for future operations. In similar circumstances in which the unexpected, successful operation was effective, the characterisation can become a source of inspiration for future operations. The art and objective is to take the *general* characteristic and to make it into a *specific* form of behaviour, which is suited to the specific context in which the operations take place. Here the characterisation can be regarded as a unique pattern.

8.2. Farmers' language, holistic expressions and statistics

The use and understanding of the language of experienced farmers and the holistic expression or metaphor used in Goethean science are part of a soft system approach. Although the languages and concepts of farmers and scientist differ, it is possible to learn the language of the farmer if a dialogue is present (Kersten, 2000). McClintock (2000) used the method of clustering of metaphors as a first step towards inter-subjectivity. In his study about the future of the countryside over 100 participants were involved. Clustering refers to a grouping of 'like ideas'. The results confirm that an explicit use of metaphors can provide a tool to understand and share different understandings. One of the main potentials of this method is mentioned as raising awareness with respect to explaining, appreciating and creating a diversity of understandings. Wemelsfelder *et al.* (2001) used statistical tools for clustering personal expressions about pig behaviour. This so-called 'free choice profiling approach' ⁷⁹ was applied as a qualitative assessment of behaviour and took place under controlled experimental conditions. The method gave the observers complete freedom to choose their descriptive terms and it was used as an

integrative welfare assessment tool. A specific multivariate statistical technique was used for the analysis of the personal expressions about behaviour. Observers achieved significant agreement in their assessment of pig behavioural expressions, and could accurately repeat attributing expressive scores to individual pigs across several tests. An important result of this method was that these spontaneous qualitative assessments show very high inter- and intra-observer reliability. There was a high correlation between observer terminology and the principal dimensions of the consensus profiles. The approach showed a transformation from a loose collection of terms into a structured and meaningful framework for characterising observations, called semantic word charts. In another paper Wemelsfelder (2000) entitled her contribution as 'qualitative welfare assessment: reading the behavioural expressions of pigs'. It is exactly this explanation of 'reading' we are looking for. This reading refers to the holistic expression in Goethean science in which involvement leads to a relation with the object in search. The approach can also tackle the discussion on inter-subjectivity that is raised both in Goethean science as in farmers' languages.

Wemelsfelder and Lawrence (2001) said that 'the qualitative assessment integrated and summarised the different aspects of an animal's dynamic style of interaction with the environment.' As a holistic method it assumes the animal as an integrated being, not as conglomerates of separate physical systems. This emergent level is based on direct observations and will be developed through knowledge, skills and reflected experience. Wemelsfelder (2000) considered these multivariate statistics as 'pattern-detection mechanism'. The 'Gestalt', mentioned in paragraph 8.1, can be analysed with these statistical tools and, therefore, this statistical technique will be helpful in the analysis of patterns.

⁷⁹ Free Choice Profiling methods are developed in food science to tackle the problem of the subjectivity of tasting and smelling between people. These methods consist of two phases. In the first phase each observer is allowed to generate their individual terminology, which is provided to an analogue scale. In the second phase observers are instructed to use these individual terminology as a quantitative measurement tool (Wemelsfelder *et al.*, 2001).



Summary

At the end of the 1990s, organic agriculture and the associated research were rapidly emerging from isolation. Food safety and organic agriculture have become key elements of government policy (LNV, 2000). The once 'alternative' group of organic farmers, like the researchers at the Louis Bolk Institute, now have become important actors. The Institute's research experience may be expected to make an important contribution as new players enter the innovative theatre of organic agriculture.

This dissertation therefore focuses on the following research question: what is peculiar to agricultural research when its purpose is to support the conscious development of organic agriculture? And more specifically, what approaches, designs and methods are used for such research? To answer this the author analysed the methodological aspects of seven case studies. Each of these sheds light on an aspect of the Louis Bolk Institute's approach to research.

In the discussion of these case studies only limited attention is given to the agronomic results. There is an important exception in the case of the project on '*manure use and clover varieties in organic grass-clover swards on a sandy soil*'. The technical results of this project were based on the traditional research approach consisting of experimentation, analysis and modelling. These are discussed in Part 2 of the dissertation, which is used to demonstrate the importance of such a multidisciplinary research approach for organic agriculture. In Part 1 the methodological aspects of this project are discussed with reference to the chosen research method. Otherwise the Summary relates only to Part 1.

In Chapter 1 I describe the personal transformation I underwent after coming into contact with organic agriculture, and specifically bio-dynamic agriculture, in the mid-nineteen-seventies. This reference to my personal history seemed justified in the light of the three levels of reflection in this dissertation. I was (1) personally involved (an actor) in the case studies, but I also wanted (2) to act as observer of my own research path and the technical and agronomic results achieved. Finally I was also (3) an observer at meta-level, when I reflected on the overall research strategy illustrated throughout the various case studies.

Like organic farmers during the process of conversion, I too experienced organic agriculture as a new paradigm. Epistemological, ontological and methodological changes in my way of thinking came about in response to discussions about holism versus reductionism and positivism versus constructivism. My own scientific position can ultimately best be described as a '*radical holistic*

research strategy'. This means that all organisational levels of the living are important and must be researched by examining the new, additional values of each higher level. Also, life is too complex to be reduced to pure physical and chemical laws. I take the view that intangible forces are also present as a holistic feature of life which must be taken into account when considering causality. This approach is supported by my anthroposophical outlook on life.

Having read Hugo Alrøe (Alrøe *et al.*, 1998) I was aware of the importance of explicitly communicating the underlying standards and values in my own research. In my dissertation those values arise from opting for the principles of organic agriculture, for ecology as a relatively young science and for anthroposophy as a personal approach to life. These values, which are brought together in a research strategy, form the background to the voyage of discovery and the learning process reported in this dissertation. They give a different view of organic agriculture and how research could be further developed for the benefit of organic agriculture.

The research methods and strategy presented in the case studies needed to do justice to the nature of organic agriculture. Three criteria were formulated for this purpose. The research strategy must (1) support the self regulation of farming systems and the farmers therein, (2) be based on the involvement of farmers and respect the specific farm conditions from location to location in order to develop a range of farming systems and (3) respect the integrity of life and living organisms. Organic agriculture can be described as a world movement which can be traced back to around fifty pioneers in various areas of agriculture, the environment, economy and food quality. Organic agriculture is defined as a method following the IFOAM intentions and guidelines. The author was also inspired by the supplementary principles of bio-dynamic agriculture. The findings in this dissertation are applicable to all forms of organic agriculture, though the reader should be aware that the author has adopted the most complex and most restrictive definition of organic agriculture. The additional research methods described in this analysis thus culminate in the highest holistic standards for research. Consequently, I do not expect this dissertation to be used as a handbook or general guide for research in organic agriculture. The purpose of the exercise is to open the debate on research and development strategies now that so many new researchers are entering this field.

The dissertation refers to various barriers to further development in organic agriculture. The grey areas arise from the political decision to involve as many new people as possible in a short time in research on organic agriculture, and the changing socio-economic climate in which organic agriculture finds itself. The pressure on agricultural prices inherent in the treadmill of technological innovation, economies of scale and intensification, provides a difficult environment for the development of the new values of organic agriculture. The orientation towards the world

market, and towards technological industrial solutions contrasts sharply with an attitude to life which seeks to respect life and encourage regional development. In terms of work and land use, western agriculture should focus far more on the needs arising from the intrinsic nature of the animals, plants and soil instead of primarily on technological development. Supply and demand could then be determined by land-related production and by values such as the integrity of life instead of prices relying on the world market and share prices. Failing this, organic agriculture will be restricted to largely 'non-chemical' food production with consideration for environmental issues, without taking any further steps towards integrated ecological land use and essential animal welfare.

The desired changes can be well illustrated by the different ways in which the concept of '*naturalness*' is interpreted in organic agriculture. Two of the three interpretations are used to define the holistic character of organic agriculture. The first holistic interpretation relates to the concept of the farm as a functioning agro-ecosystem. Instead of symptomatic (partial) solutions and the rejection of artificial chemicals, farmers seek solutions which lead to a self-regulating agricultural business. A second, metaphysical interpretation relates to holism in the sense of '*the nature of the other*', its make-up, its being or integrity. This reflects 'respect for the integrity of life' as one of the essential elements of organic agriculture, but it also refers to the view of 'the farm is a living organism' and of 'a living soil'.

The Louis Bolk Institute uses both interpretations of holism in its strategy for research and development. It applies the concept of integrity not only to the animal and the human psyche, but to all elements of agriculture, including plants, soil and economics.

Chapter 2 describes two important conceptual frameworks which, with appropriate adaptations, are used to analyse the research methods in the case studies. The first framework is a four-quadrant matrix, which presents the modified paradigm in terms of epistemology and ontology. The second framework is a triangle which can show the relationship between the underlying values, the involvement of the actors and the nature of the scientific process.

The four-quadrant matrix is based on the juxtaposition of holism and reductionism on the vertical axis and that of positivism and constructivism on the horizontal axis. This matrix, which is used at Wageningen University to reflect on agricultural research, is supplemented in two ways in this dissertation, and specifically in the constructivist part of the matrix. First Goethean science is included as a holistic counterpart to multidisciplinary system ecology. Secondly, experiential science is included for comparison with mono-disciplinary experimental research.

The second matrix charts numerous methods used in agricultural research in a triangular relationship. The triangle is based on a dynamic interaction between human imagination and

action in relation to knowledge of the laws of nature. The original triangle specifically presented positivist research methods. The triangle was adapted for a constructivist interpretation. Three points of entry for research were named as '*perception, emotion and action*'. The selection of case studies was such that each centred on one of the three terms, but there was always a relationship with the other points in the triangle. Besides the research methodology adopted, it was largely the farmers who defined the research agenda.

Chapter 3 outlines the history and development of the two most important organic movements, i.e. ecological (EKO) and bio-dynamic (Demeter) agriculture. The changes in the market for organic milk and the structure of the dairy farm are described. In the Netherlands, as in other European countries, the growth of organic agriculture from 1990 came about as a result of the growth of EKO. Three styles are distinguished within the organic movement, based on interviews with key figures in the world of organic agriculture. These styles can also be seen as three parallel approaches to organic agriculture, each with its own criteria and particular considerations. These are referred to as (1) '*no-chemical or replacement farming*', (2) '*agriculture aimed at management of the agro-ecosystem*' and (3) '*agriculture based primarily on the integrity of life*'. These three styles are related to differences in fundamental bio-ethical attitudes about, among other things, animal welfare and naturalness, but also about the integration or segregation of agriculture and nature. The styles may in time develop their own standards and labels as three different forms organic agriculture. However, it is also possible to see the three styles as levels of increasing complexity during the conversion to organic agriculture. This dissertation assumes an interpretation of organic agriculture based on the third, most complex level. In the case studies no consideration was given to seeking alternative natural chemicals, but instead fostered the concept of integrity as the distinguishing feature of organic agriculture.

Chapter 4 describes changes in R&D within the Louis Bolk Institute and the official agricultural research establishment. The mission statement of the Louis Bolk Institute associates science with pioneering farmers, with ethics and with ecology in the service of quality of life. Since 2000 Wageningen University has incorporated the Organic Agriculture Innovation Centre, which coordinates research into organic agriculture. It has announced that in the coming years 10% of the Wageningen research budget will be devoted to organic agriculture.

In Chapters 5 and 6, seven case studies are discussed, each following the same format: background of the project, methods used, a reflection on the methods based on two analytical matrices and, to a limited extent, agronomic results.

The first project, entitled '*multidisciplinary research into a soil-grass-clover system*' focused on the

development of knowledge (perception). The project was prompted by a lack of insight into early spring development of grass-clover under organic conditions. Existing, conventional knowledge about grass-clover cultivation had to be adapted, and two possible directions for solutions were suggested in an international research forum. First, the use of new varieties of white clover, bred for better survival in the winter, and second, the use of a strategic application of manure in the spring. The trial was based on a split-plot layout, with controlled external conditions. After six years of trials the quantitative data were analysed and modelled (see Part 2). The data were used to describe how manure affected the growth of grass-clover and how underlying factors interacted.

The second project '*grassland development at Warmonderhofstede – mutual learning based on the actions of the farmer and on-farm experimental research*' centred on actions and is presented as a case study in which experiential learning on the part of the farmer ran parallel to experimental research on his holding. The project was based on the mutual or co-learning process of the researcher and the individual farmer. One of the agronomic results was further insight into the grass component of grass-clover mixtures for leys.

First of all the researcher examined the farm system and the self-imposed limits of the farmer as the context for any possible answers. In addition data were collected and measurements taken to build up a reference framework about the structure of the farm and its operation. Annual, successive experimental field trials were carried out to test and improve the grass component in the mixtures. Experiments took the form of replicated field trials on the farm. Ideas for new experiments were partly influenced by the intuition of the farmer and driven by his empathetic involvement in the subject of the research. Mutual learning is fed by the combination of the rich, daily observations and experiences of the farmer and the limited but exact measurements in the grass-clover plots by the researcher.

The farmer's learning process is partly based on reflection on his own experiences using '*pattern recognition*'. He recognises the positive relationship between his own actions and, for example, the patterns of crop growth in the field. Another aspect of the learning process during the reflective experience is the '*intuition*' which leads to adequate action and which combines '*knowing how and knowing that*'. The evaluation of the farmer's experience and the experimental trials by the researcher leads to an adapted management style as a new system consisting of actions tailored to the situation combined with a different attitude on the part of the farmer: in short, a system that works in practice. The end of a research journey is reached when the farmer has gained insight which enables him to adapt his actions to particular situations. Scientific evaluation and the recognition and description of the underlying processes mean that the insight

obtained can be conveyed to others and applied in other situations.

Experiential science based on reflection on experience and intuitive action conflicts with traditional scientific ideas about forming hypotheses and experimental testing. However, the farmer's observations over time provide an important resource which increases confidence about the effect of his actions.

The third project, entitled '*partner farms in the province of North-Holland – cooperation within a farmers' group*', was an extension of the previous study in terms of method. The cooperation between researcher and each individual farmer was in principle comparable. The learning process of individual farmers was however enriched by the exchange of information within a group of farmers. Each holding was concerned with different aspects of the same problem area. Each individual search and learning process can support that of another farmer. A second feature distinguishing this from the previous project was the level of integration. The partner farms project evaluated the development of farm systems, while the previous project addressed the integration level of soil and crop.

The concept of the partner farm aims for sustainable collaboration between specialist arable and livestock farms. The exchange of energy-rich crops plus straw for farmyard manure was instituted as a priority. The lack of adequate organic pricing system for the products to be exchanged, and the adaptations the individual farms had to make for the long term to become part of the 'mixed system at a distance' created serious problems for the further development of the concept. Various points arose for consideration, such as the consequences of a reduced dose of manure for soil fertility, the increase in the acreage of cereals and leguminous crops in relation to income, the cultivation of high-quality feed crops and the exchange of labour and knowledge. Ultimately, to enable the partner farm concept to succeed, farmers need to learn to base their thinking of the principles of the mixed farm. They have to want to base their actions on their role in a greater entity. Regular meetings were important instruments for discussion of ethical options and exchange of practical knowledge. Ultimately however, each farmer had to make his own choices, suited to his situation.

The fourth project, '*Exploring tacit knowledge generated by dairy farm practice: family breeding*', centred on both 'emotion' and 'action' and was based on the tacit knowledge of the farmer. The breeding system already existed in the practice of FH breeder, Dirk Endendijk, but it was still surrounded by a certain mystique, which meant that Endendijk's insight was not accessible to other farmers. The idea of breeding using their own bulls was of interest to organic livestock farmers, particularly since it involved natural mating. The breeding data were analysed over 5-6 generations and qualitative in-depth interviews were held as a research method to reconstruct

the characteristics of the breeding system retrospectively. Endendijk uses a specific form of family breeding which can be described as *'moderate family breeding'*. His breeding objectives are not far removed from those of other livestock farmers. The difference is that Endendijk knows all the character traits of his breeding bulls and females. Such character descriptions are not reduced to the abstract list of estimated breeding values found in every sire catalogue, but include many qualitative characteristics.

Fathoming out the breeding system required a change in thinking about breeding. In conventional breeding programmes much emphasis is placed on the sire and population genetics at world level, while this system stresses the importance of the regionally developed breeding family in its entirety. A new form of pattern recognition came to the fore in this project, consisting in the reflection of the farmer on his inner conceptual images of the ideal cow as a *'living prototype'*.

The fifth project, *'vision formulation: breeding for local genetic diversity, herd adaptation and harmony'* concerned the ethical debate on breeding and reproduction and was an extension of the previous project. This project centred on the area of 'emotion', and specifically the significance of one's personal view of life and pre-scientific principles in relation to the development of concepts. The project examined the development of a breeding strategy for organic livestock farming. Brainstorming sessions between practitioners and researchers were used to discuss findings and values related to the subject. Various farmers and researchers were consulted who had unconventional views on breeding practice. The strategy eventually selected arose from personal feelings, holistic awareness and scientific insight. It is important for such concept development to be embedded in a debate about the underlying fundamental bio-ethical attitudes in order to see the points of view concealed by different visions. This ultimately led to a clearer formulation of views concerning a breeding strategy for organic livestock farming. This could then be discussed further in practice and the implications could be tested for practical consequences.

The sixth project, *'landscape planning for the Noorderhoeve farm'* is an example of Goethean science. In this case there was a participatory set-up involving collaboration with the people on the farm. The emphasis was on 'perception' (knowledge), but not based purely on causal statements and material correlations. As a scientific method, Goethean science involves an individual research protocol based on empathetic observation without the intervention of instruments. There is repetition of observations both in space and time, which reveals the specific context of the object and its development over time. All the information is ultimately transformed into an *'imaginative conceptual image'* and expressed in symbolic concepts. The formulation of

symbolic concepts is comparable to the use of metaphors which refer to what is specific about 'the Other'. The symbolic concepts in this case express the feelings and ideas of researcher and farmer about the farm situation and the landscape. They indicate the direction for future change and adequate farm-specific ecological solutions. Solutions are drawn from the 'inner understanding' of the landscape combined with the objectives and motives of the farmer. The solutions are aimed at the integration of agronomic and ecological improvements.

The seventh and last project is BIOVEEM, an interdisciplinary research project in organic dairy farming. This project brings together various methodological elements from the first six case studies. The experiential knowledge developed by pioneering farmers is the point of departure for future developments. There is a circle of 17 pioneering farms, each one a self-selected farming prototype. This is where the detailed research takes place and where the farm system is further developed. The learning process is driven from the bottom up by the pioneers in organic livestock farming. Farm-specific solutions are supported by and elaborated with researchers from different scientific disciplines. The unit in this project is the farm system and the farmer within it. Experiential science and experimental research at each farm are the main methods for development. Insight is gained beforehand into the biographical elements of each farm by means of in-depth interviews. These affect the way the farm is run and describe the opportunities and threats affecting the farm in relation to the strengths and weaknesses of the farmer. Various themes are suggested for further development of the farm.

In addition to these pioneering farms, a second group of farms is working towards 'the desired future organic agriculture practice' on the basis of existing knowledge and insight. Farmers who have recently converted form a third group, who are advised on the major organic principles arising from this project and elsewhere. The interaction between the groups ensures farmer-to-farmer exchange of knowledge.

Chapter 7 is the meta-reflection on the research methods used in the various case studies. The two adapted matrices from Chapter 2 are used to chart the research strategy of the Institute. The case studies in this dissertation each had their own limitations, imposed mainly by the history of the projects. Important or new elements of research which emerged were the systemic orientation in terms of a cohesive set of management measures and actions. This systemic orientation also encompasses holism in terms of Goethean science. In addition there is the participatory action research referred to as experiential science and based on intuitive action and pattern recognition. The reflection on the methods made it clear that their acceptance was influenced by the underlying scientific philosophy. The constructivist character of both Goethean science and experiential science particularly distinguishes these methods from mainstream science.

The entire research strategy of the Institute is thus based on two different interpretations of knowledge. Experiential science focuses on the actions of the farmer and is based on the epistemology of action. In addition there is an epistemology of knowledge, where it relates to interdisciplinary research and Goethean science. The nature of the research process in Goethean science entails bridging the gap between the direct experience of farmers and their observations of soil, crops and animals on the one hand, and a holistic life science and agro-ecological science on the other hand. Both experiential science and Goethean science are casuistic in nature. There are barriers to the acceptance of these scientific methods in the current lack of suitable statistical evaluation methods, and also in the absence of accepted methods for explicitly exploring reality as constructed by people. These methods, which examine inter-subjective harmonisation, form an essential link between the observer and the observed. In an epilogue to this dissertation suggestions are made for both statistical testing and scientific evaluation of the inter-subjective nature of the methodology. New forms of statistics can objectify pattern recognition as the key issue in experiential learning.



Samenvatting

Biologische landbouw en het onderzoek er naar komen aan het einde van de jaren negentig snel uit hun isolement. De overheid heeft voedselveiligheid en biologische landbouw tot speerpunt gemaakt van haar beleid (LNV, 2000). De eens 'alternatieve' groep van biologische boeren evenals de onderzoekers van het Louis Bolk Instituut zijn nu deelgenoot geworden in het veld van geïnteresseerde en belangrijke actoren. Naar verwacht kan de onderzoekservaring die het Instituut heeft opgedaan een belangrijke bijdrage leveren wanneer nieuwe spelers het 'innoverende toneel van de biologische landbouw' betreden.

In deze dissertatie staat dan ook de volgende vraag centraal: wat is het bijzondere aan het landbouwkundig onderzoek wanneer dat de intentionele ontwikkeling van de biologische landbouw wil ondersteunen? En meer specifiek, welke benaderingen, ontwerp en methoden worden gebruikt voor dergelijk onderzoek? Om deze vraag te beantwoorden heeft de auteur de methodische aspecten van zeven voorbeeldprojecten (case studies) geanalyseerd. Elk project belicht een deel van de onderzoeksbenadering van het Louis Bolk Instituut.

In de bespreking van deze voorbeeldprojecten wordt slechts beperkt ingegaan op de agronomische resultaten. Er is een belangrijke uitzondering, namelijk het project *'mestaanwending en keuze van klaverrassen voor een biologisch geteelde grasklaver zode op zandgrond'*. De technische resultaten van dit project waren gebaseerd op de traditionele onderzoeksopzet bestaande uit experimenteren, analyseren en modelleren. Deze zijn opgenomen in deel 2 van de dissertatie. Het is gebruikt om het belang van een dergelijke multidisciplinaire onderzoeksbenadering te laten zien voor de biologische landbouw. In deel 1 zijn de methodische aspecten van dit project bediscussieerd met betrekking tot de gekozen onderzoeksmethode. De samenvatting hieronder heeft verder alleen betrekking op deel 1.

In hoofdstuk 1 beschrijf ik de persoonlijke veranderingen die ik doormaakte, nadat ik in het midden van de jaren zeventig van de vorige eeuw in aanraking kwam met de biologische landbouw en specifiek de biologisch-dynamische landbouw. Zo'n persoonlijke uiteenzetting is hier op zijn plaats, omdat ik in deze dissertatie drie niveaus van reflectie hanteer. Ik was (1) zelf actief betrokken in de voorbeeldprojecten, maar ik wilde (2) ook de waarnemer zijn van mijn eigen onderzoekstraject en de technische en agronomische resultaten die zijn behaald. Tenslotte was ik (3) een waarnemer op meta-niveau, toen ik de reflectie deed van de gehele onderzoeksstrategie zoals die geïllustreerd is door de diverse voorbeeldprojecten heen.

Net als de biologische boeren tijdens hun omschakelingproces, beleefde ook ik de biologische landbouw als een nieuw paradigma. Veranderingen in het denken deden zich voor zowel op epistemologisch, ontologisch en methodisch gebied samenhangend met discussies over de tegenstellingen holisme versus reductionisme en positivisme versus constructivisme. Mijn eigen wetenschappelijke positie kan uiteindelijk het beste omschreven worden als een *'radicale holistische onderzoeksstrategie'*. Dit betekent, dat alle organisatieniveaus van het levende belangrijk zijn en onderzocht moeten worden door aandacht te geven aan de nieuwe, additionele waarden van elk hoger niveau. Ook is het leven te complex om gereduceerd te worden tot slechts fysische en chemische wetmatigheden. Ik ga ervan uit dat ook niet-stoffelijke krachten aanwezig zijn als een holistisch kenmerk van het leven, waar in termen van oorzakelijkheid rekening mee kan worden gehouden. Met name dit laatste punt komt voort uit mijn persoonlijke antroposofische levensvisie.

Ondersteund door de dissertatie van Hugo Alrøe (Alrøe *et al.*, 1998) was ik mij bewust van het belang om de achterliggende normen en waarden in deze dissertatie expliciet te communiceren. Deze komen voort uit een keuze voor de principes van de biologische landbouw, voor de ecologie als een relatief jonge tak van wetenschap en voor de antroposofie als een persoonlijk inzicht op het leven. Deze waarden, die in relatie gebracht worden met een onderzoeksstrategie, vormen samen de achtergrond voor de ontdekkingstocht en het leerproces in deze dissertatie. Zij geven een aparte blik op biologische landbouw en op de manier waarop het onderzoek voor de biologische landbouw zich verder zou kunnen ontwikkelen.

Zoals gesteld wil ik laten zien hoe methoden en strategie voor onderzoek, die in de voorbeeldprojecten gepresenteerd zijn, recht kunnen doen aan het karakter van de biologische landbouw. Daartoe zijn drie criteria geformuleerd. De onderzoeksstrategie moet (1) de zelfregulatie van bedrijfssystemen en de ondernemers daarin ondersteunen, (2) zijn gebaseerd op de betrokkenheid van boeren en de specifieke bedrijfsomstandigheden van plaats tot plaats respecteren teneinde een scala aan bedrijfssystemen te ontwikkelen en (3) de integriteit van het leven en het levende respecteren.

Biologische landbouw is beschreven als een wereldomvattende beweging die terug te voeren is op circa vijftig pioniers op verschillende gebieden van landbouw, milieu, economie en voedselkwaliteit. Biologische landbouw is gedefinieerd als een methode in navolging van de IFOAM intenties en richtlijnen. Daarnaast is de auteur geïnspireerd door de additionele principes van de biologisch-dynamische landbouw. De uitkomsten van deze dissertatie zijn echter toepasbaar voor alle stromingen binnen de biologische landbouw, waarbij de lezer zich moet realiseren dat de auteur de meest complexe en meest restrictieve definitie van biologische landbouw hanteert. De toegevoegde onderzoeksmethoden die uit de analyse naar voren komen,

leiden daarom tot de meest holistische normstelling voor onderzoek. Ik verwacht dan ook niet, dat deze dissertatie een handboek of een algemene leidraad voor het onderzoek in de biologische landbouw wordt. Het doel is om het debat te openen over onderzoeks- en ontwikkelingsstrategieën nu op dit moment zo veel nieuwe onderzoekers deze wijze van agricultura gaan onderzoeken.

In de dissertatie zijn verschillende belemmeringen genoemd voor de verdere ontwikkeling van de biologische landbouw. De onzekerheden betreffen de politieke keuze om in een korte tijd zoveel nieuwe mensen te betrekken in het onderzoek voor de biologische landbouw in combinatie met het veranderende sociaal-economische klimaat waarin de biologische landbouw zich bevindt. De druk op de landbouwprijzen, die inherent is aan de tredmolen van vertechnologisering, schaalvergroting en intensivering, vormen een slechte omgeving om de nieuwe waarden van de biologische landbouw tot bloei te laten komen. De oriëntatie op de wereldmarkt en op technologisch-industriële oplossingen staan in scherp contrast met een levenshouding die de integriteit van het leven wil respecteren en met de wens voor regionale ontwikkeling. De westerse landbouw zou zich qua arbeid en landgebruik veel meer moeten richten op de behoeften die voortkomen uit de eigen aard van de dieren, de planten en de bodem in plaats van vooral de technologische verdinglijking van de landbouw. Vraag en aanbod kunnen dan gevormd worden op basis van een grondgebonden productie en door waarden als de integriteit van het leven in plaats van dat prijzen leunen op de wereldmarkt en de beurskoersen. Als dit faalt, dan dwingt men de biologische landbouw om de grenzen van vooral een 'niet-chemische' voedselproductie op te zoeken met aandacht voor milieuvraagstukken, zonder daarbij een verdere stap te maken in de richting van geïntegreerd ecologisch landgebruik en noodzakelijk dierwelzijn.

De gewenste veranderingen laten zich goed illustreren aan de verschillende manieren hoe het begrip '*natuurlijkheid*' in de biologische landbouw wordt geïnterpreteerd. Twee van de drie invullingen definiëren het holistisch karakter van de biologische landbouw. De eerste holistische invulling betreft de visie op het bedrijf als een functionerend agro-ecosysteem. In plaats van symptomatische (deel)oplossingen plus het afwijzen van chemisch-synthetische stoffen zoeken boeren naar oplossingen die leiden tot een zelfregulerend landbouwbedrijf. Een tweede, metafysische interpretatie heeft betrekking op holisme in de zin van '*de natuur van de andere*', zijn aard, zijn wezen of integriteit. Dit refereert aan 'het respecteren van de integriteit van het leven' als één van de essenties van de biologische landbouw, maar het refereert ook aan de opvatting dat 'het bedrijf is als een levend organisme' en is er sprake van 'een levende bodem'. Het Louis Bolk Instituut gebruikt beide interpretaties van holisme in haar strategie voor onderzoek en ontwikkeling. Daarbij heeft de toepassing van het integriteitbegrip niet alleen

betrekking op het dier en de menselijke psyche, maar op alle elementen van de landbouw, inclusief plant, bodem en economie.

Hoofdstuk 2 beschrijft twee belangrijke conceptuele raamwerken die na aanpassing zijn gebruikt om de onderzoeksmethoden uit de voorbeeldprojecten te analyseren. Het eerste raamwerk is een vier kwadranten matrix, dat de mogelijkheid biedt het veranderde paradigma in termen van epistemologie en ontologie weer te geven. Het tweede raamwerk is een driehoek die de mogelijkheid biedt om de relatie tussen de achterliggende waarden, de betrokkenheid van de actoren en de aard van het wetenschappelijke proces te laten zien.

De vier kwadranten matrix is gebaseerd op de tegenstelling van holisme en reductionisme op de verticale as en die van positivisme en constructivisme op de horizontale as. Deze matrix, die binnen de Wageningse Universiteit gebruikt wordt om te reflecteren op landbouwkundig onderzoek, is in deze dissertatie op twee manieren aangevuld met name in het constructivistische deel van de matrix. Ten eerste is de Goetheanistische fenomenologie gepresenteerd als een holistische evenknie van de interdisciplinaire systeem-ecologie. Ten tweede is de ervaringswetenschap beschreven in vergelijking tot het mono-disciplinaire experimentele onderzoek.

De tweede matrix positioneert tal van methoden gebruikt in het landbouwkundig onderzoek in een driehoeksrelatie. Deze driehoek is gebaseerd op een dynamische wisselwerking tussen de menselijke voorstelling en handeling in relatie tot het kennen van de wetmatigheden in de wereld. De oorspronkelijke driehoek presenteerde met name positivistische onderzoeksmethoden en is daarom aangepast voor een constructivistische invulling. Er zijn drie entrees voor onderzoek benoemd in termen van *'perceptie, emotie en handeling'*. De keuze van de voorbeeldprojecten was zodanig dat elk zijn zwaartepunt had in één van de drie termen, maar er was altijd een relatie met de andere punten van de driehoek. Los van de uiteindelijke onderzoeksmethodiek waren het vooral de boeren die sturing gaven om de onderzoeksagenda.

In hoofdstuk 3 wordt de historie en de ontwikkeling van de twee belangrijkste biologische bewegingen geschetst, namelijk de ekologische (EKO) en de biologisch-dynamische (Demeter) landbouw. De veranderingen die zich hebben voorgedaan in de markt van biologische melk en de structuur van het melkveehouderijbedrijf zijn beschreven. Net als in andere Europese landen is de groei van de biologisch landbouw na 1990 veroorzaakt door de groei van EKO. Op basis van interviews met sleutelfiguren uit de biologische landbouw en handel zijn drie stijlen binnen de biologische beweging onderscheiden. Deze stijlen kunnen tevens worden opgevat als drie naast elkaar staande invullingen van de biologische landbouw, elk met eigen criteria en aandachtspunten. Deze zijn aangeduid als (1) *'de geen-chemie of vervangingslandbouw'*, (2)

'landbouw gericht op het management van het agro-ecosysteem' en (3) *'landbouw die zich primair oriënteert op de integriteit van het leven'*. Deze drie stijlen zijn gerelateerd aan verschillen in bio-ethische grondhoudingen over onder meer dierwelzijn en natuurlijkheid, maar ook over de integratie of segregatie van landbouw en natuur. De stijlen kunnen zich op termijn ontpoppen als drie verschillende praktijken van biologische landbouw met eigen normen en een apart merk. Het is echter ook mogelijk om de drie stijlen te zien als een toenemende complexiteit gedurende de omschakeling tot biologisch boer. Deze dissertatie gaat uit van een invulling van biologische landbouw die gebaseerd is op het derde, meest complexe niveau. In de voorbeeldprojecten is geen aandacht geschonken aan onderzoek dat zich richt op alternatieve, natuurlijke chemische stoffen, maar het begrip integriteit is als een onderscheidend criterium gekoesterd.

Hoofdstuk 4 beschrijft de veranderingen met betrekking tot onderzoek en ontwikkeling binnen het Louis Bolk Instituut en de officiële landbouwkundige onderzoeksinstanties. In haar missie komt tot uitdrukking dat het Louis Bolk Instituut wetenschap verbindt met pionierende boeren, met ethiek en met de ecologie in dienst van de kwaliteit van het leven. Sinds 2000 bestaat er binnen de Wageningse Universiteit het Innovatiecentrum Biologische Landbouw, dat het onderzoek voor de biologische landbouw coördineert. Zij geeft aan dat in de komende jaren 10% van het Wageningse onderzoeksbudget besteed gaat worden aan de biologische landbouw.

In de hoofdstukken 5 en 6 worden zeven voorbeeldprojecten besproken, elk vanuit de volgende structuur: de achtergrond van het project, de toegepaste methoden, een reflectie op de methoden gebaseerd op de twee analytische matrices en in beperkte zin de agronomische resultaten.

Het eerste project, genaamd *'multidisciplinair onderzoek aan een bodem-gras-klover systeem'* had als belangrijkste aandachtspunt het ontwikkelen van kennis (perceptie). De reden om het project te starten was het gebrek aan inzicht over de vroege voorjaarsontwikkeling van gras-klover onder biologische omstandigheden. Bestaande, reguliere kennis over gras-klaverteelt kon worden aangepast, waarbij er twee oplossingsrichtingen zijn gesuggereerd in een internationaal forum van onderzoekers. Ten eerste het gebruik van nieuwe rassen witte klover, veredeld voor een betere overleving in de winter en ten tweede het gebruik van een strategische startgift van dierlijke mest in het voorjaar. De proef is aangelegd volgens een split-plot opzet, waarbij de externe omstandigheden gecontroleerd zijn. Na zes jaar onderzoek zijn de kwantitatieve data geanalyseerd en gemodelleerd (zie Deel 2). De gegevens zijn gebruikt om te beschrijven hoe dierlijke mest de groei van gras-klover stuurt en op welke wijze de onderliggende factoren elkaar beïnvloeden.

Het tweede project is genaamd *'veranderingen in het grasland op Warmonderhofstede – wederzijdse leerprocessen door handelingen van de ondernemer en door experimenteel onderzoek'*. Het project heeft zijn zwaartepunt in het handelen, waarbij het ervaren leren van de ondernemer parallel loopt met het experimenteel onderzoek op zijn bedrijf. Het project stopt op het wederzijdse leerproces van de onderzoeker en de individuele ondernemer. Één van de agronomische resultaten is het verder inzicht in de grascomponent van gras-klavermengsels voor kunstweiden.

Als eerste heeft de onderzoeker het bedrijfssysteem en de zelfgekozen beperkingen van de ondernemer onderzocht als de context voor eventuele antwoorden. Daarnaast zijn er data verzameld en metingen verricht om een eigen referentiekader op te bouwen over de bedrijfsstructuur en het functioneren van het bedrijf. Jaarlijks is er experimenteel veldonderzoek verricht om de grascomponent in de mengsels stapsgewijs verder te testen en te optimaliseren. Experimenten zijn in herhalingen gezaaid op het bedrijf. Ideeën over een nieuwe experimenten zijn mede beïnvloed door de intuïtie van de ondernemer en aangestuurd door zijn inlevende betrokkenheid bij de vraagstelling. Het wederzijdse leren is gevoed door de combinatie van de rijke, dagelijkse waarnemingen en ervaringen van de ondernemer en de beperkte, maar exacte metingen aan de gras-klover objecten door de onderzoeker.

Het leerproces van de ondernemer is onder andere gebaseerd op de reflectie op zijn eigen ervaringen aan de hand van *'patroonherkenning'*. Hij ervaart de positieve relatie tussen de eigen handeling en bijvoorbeeld de patronen die in de gewasgroei, zoals die in het veld verschijnen. Een ander aspect van het leerproces tijdens het reflecterend ervaren is de *'intuïtie'* die aanleiding geeft tot adequaat handelen en waarbij het *'weten hoe en weten dat'* worden gecombineerd. Uit de evaluatie van de ondernemerservaring en de experimentele toetsing door de onderzoeker ontstaat een aangepast management als een nieuw systeem bestaande uit op de situatie toegesneden handelingen in combinatie met een veranderde ondernemershouding, kortom een systeem dat werkt in de praktijk. Het einde van een onderzoekstraject is daar, wanneer de ondernemer het inzicht heeft hoe hij zijn handelen situationeel kan inzetten. De wetenschappelijke evaluatie en het herkennen en beschrijven van onderliggende processen verzorgen dat het verkregen inzicht kon worden overgedragen naar anderen en toegepast op andere situaties.

De ervaringswetenschap op basis van ervaringsreflectie en intuïtief handelen staat tegenover de traditionele wetenschappelijke opvattingen van hypothesevorming en experimentele toetsing. Daarbij zijn de waarnemingen van de ondernemer door de tijd heen een belangrijke, additionele informatiebron die de zekerheid over het handelen vergroot.

Het derde project, genaamd *'koppelbedrijven in de provincie Noord-Holland: samenwerking binnen een groep van ondernemers'* is methodisch gezien een uitbreiding van de vorige studie. De samenwerking tussen de onderzoeker en elke individuele ondernemer is in principe vergelijkbaar. Het leerproces van individuele ondernemers is echter verrijkt door de uitwisseling van informatie binnen een groep ondernemers. Elk bedrijf heeft te maken met verschillende, elkaar aanvullende elementen binnen hetzelfde thema. Elk individueel zoek- en leerproces kan dat van een andere ondernemer ondersteunen. Een tweede verschil met het voorgaande project is het integratieniveau. Het project koppelbedrijven evalueert de ontwikkeling van bedrijfssystemen, terwijl het voorgaande project gericht is geweest op het integratieniveau van bodem en gewas. Het concept van het koppelbedrijf werkt toe naar een duurzame samenwerking tussen gespecialiseerde akkerbouw- en veehouderijbedrijven. Als eerste prioriteit is er de uitwisseling van energierijke gewassen plus stro voor strotorrijke dierlijke mest tot stand gebracht. Belangrijke problemen voor de verdere ontwikkeling van het concept zijn het gebrek aan een adequate, biologische prijsvorming van de uit te wisselen producten en de aanpassingen die verschillende bedrijven moeten maken om voor de lange termijn goed te passen in het *'gemengde bedrijf op afstand'*. Er zijn verschillende aandachtspunten gesignaleerd, zoals de gevolgen van een verlaagde dierlijke mestgift voor de bodemvruchtbaarheid, de toename van het areaal granen en vlinderbloemigen in relatie tot het inkomen, de teelt van hoogwaardige voedergewassen en de uitwisseling van arbeid en kennis. Om het koppelbedrijvenconcept uiteindelijk te laten slagen moeten ondernemers denken vanuit de principes van het gemengde bedrijf. Daarbij is het belangrijk dat zij willen handelen vanuit hun rol binnen een groter geheel. De gezamenlijke bijeenkomsten zijn belangrijke instrumenten geweest om ethische keuzen te bediscussiëren en praktische kennis uit te wisselen. Uiteindelijk moet echter elke ondernemer zijn individuele, passende keuzen maken.

Het vierde project, genaamd *'het verkennen van verborgen kennis uit de praktijk: familieteelt'*, heeft zijn zwaartepunt liggen in zowel 'emotie' als 'handeling' en is gebaseerd op verborgen kennis van een ondernemer. Het fokkerijsysteem bestond al in de praktijk van FH-fokker Dirk Endendijk, maar was omgeven met enige mystiek wat ertoe leidde dat het inzicht niet toegankelijk was voor andere ondernemers. Het fokken met eigen stieren heeft de interesse van biologische veehouders met name door de inzet van natuurlijke dekking. Als onderzoeksmethode zijn de stambomen over 5-6 generaties geanalyseerd en zijn er kwalitatieve diepte-interviews afgenomen. Op een retrospectieve wijze zijn zo de karakteristieken van het fokkerijsysteem blootgelegd. Endendijk hanteert een specifieke vorm van familieteelt die omschreven kan worden als *'gematigde familieteelt'*. Zijn belangrijkste fokdoelen wijken niet sterk af van andere veehouders met dien verschil dat Endendijk alle karaktertrekken van zijn fokstieren en

stiermoeders kent. Dergelijke karakterbeschrijvingen zijn niet teruggebracht tot een abstracte lijst van fokwaardeschattingen zoals die verschijnt in elke stierencatalogus, maar omvatten vele kwalitatieve kenmerken.

Om het fokstelsel te doorgronden is een andere denkwijze over fokkerij noodzakelijk. In de reguliere fokkerij ligt een sterke nadruk op het mannelijke fokdier en de populatiegenetica op wereldniveau, terwijl in dit systeem de regionaal ontwikkelde fokfamilie in haar geheel van belang is. In dit project komt een nieuwe vorm van patroonherkenning naar voren, namelijk de reflectie van de fokker op zijn innerlijke voorstellingsbeelden over de ideale koe in termen van een *'levend prototype'*.

Het vijfde project is genaamd *'het formuleren van een fokkerijvisie: fokken, opdat de lokale genetische diversiteit tussen plaatsen vergroot wordt; met de aanpassing aan lokale omstandigheden en gericht op harmonie in bouw van het individuele dier'*. Het project betreft de ethische discussie rondom fokkerij en voortplanting en is een uitbreiding van het voorgaande project. Het zwaartepunt van dit project ligt op het gebied van de 'emotie', namelijk de betekenis van de persoonlijke levensvisie en de voorwetenschappelijke uitgangspunten in relatie tot de ontwikkeling van begrippen. Het project heeft betrekking op het ontwikkelen van een fokkerijstrategie voor de biologische veehouderij. In brainstormsessies van praktijkmensen en wetenschappers zijn bevindingen en waarden bediscussieerd die betrekking hebben op het onderwerp. Verschillende ondernemers en onderzoekers zijn geconsulteerd die een niet-regulier fokkerijconcept hanteren. De uiteindelijke strategie is tot stand gekomen door een combinatie van persoonlijke gevoelens, een holistisch bewustzijn met wetenschappelijk inzicht. Het is van belang dat een dergelijke conceptontwikkeling is ingebed in een discussie over de onderliggende bio-ethische grondhoudingen teneinde de standpunten te zien die achter verschillende visies schuil gaan. Dit proces heeft uiteindelijk geleid tot de formulering van een standpunt voor een fokkerijstrategie in de biologische veehouderij. Deze kon verder worden bediscussieerd in de praktijk en de implicaties getoetst worden op zijn praktische gevolgen.

Het zesde project, genaamd *'landschapontwikkeling voor het bedrijf Noorderhoeve'* is een voorbeeld over Goetheanistische fenomenologie. In dit geval is er tevens sprake van een participatieve opzet door samenwerking met de mensen op het bedrijf. Het zwaartepunt ligt op de 'perceptie' (kennis), die echter niet alleen gebaseerd is op causale verklaringen en materiele correlaties. Als wetenschappelijke methode omvat de Goetheanistische fenomenologie een eigen onderzoeksprotocol dat is gebaseerd op inlevend waarnemen zonder tussenkomst met instrumenten. Er is sprake van een herhaling van waarnemingen zowel in de ruimte als in de tijd, waardoor de specifieke context van het object in beeld komt evenals de ontwikkeling in de tijd.

Alle informatie is uiteindelijk tot een *'imaginatief voorstellingsbeeld'* omgevormd en uitgedrukt in symbolische begrippen. Het formuleren van symbolische begrippen is vergelijkbaar met het gebruik van metaforen die het specifieke van 'het andere' aanduiden. De symbolische begrippen geven in dit geval de gevoelens en ideeën van onderzoeker en ondernemer weer over de bedrijfssituatie en het landschap. Zij geven de richting aan voor toekomstige veranderingen en adequate bedrijfsgerichte ecologische oplossingen. Oplossingen zijn afgeleid uit het 'innerlijke begrip' van het landschap in combinatie met de doelstellingen en motieven van de ondernemer. Met de oplossingen is er gestreefd naar een integratie van agronomische en ecologische verbeteringen.

Het laatste, zevende project is BIOVEEM, een interdisciplinair onderzoeksproject in de biologische melkveehouderij. In het project komen diverse methodische elementen uit de eerste zes voorbeeldprojecten samen. De ervaringskennis, ontwikkeld door pionierende voorloperbedrijven, is het uitgangspunt voor nieuwe toekomstige ontwikkelingen. Er is een kring van 17 pionierende ondernemers die ieder functioneren als een zelf gekozen bedrijfsprototype. Zij zijn de plaats waar het detailonderzoek plaatsvindt en voor het verder uitbouwen van het bedrijfssysteem. Het leerproces is van onderaf aangestuurd door deze pioniers. Bedrijfsgerichte oplossingen zijn ondersteund door en uitgewerkt met onderzoeker uit verschillende wetenschappelijke disciplines. De eenheid in het project is het bedrijfssysteem en de ondernemer daarin. Ervaringswetenschap en experimenteel onderzoek op elk bedrijf zijn de belangrijkste methoden voor ontwikkeling. Voorafgaand zijn met diepte-interviews de biografische elementen van elk bedrijf inzichtelijk gemaakt. Deze beïnvloeden de bedrijfsvoering en beschrijven de kansen en bedreigingen van het bedrijf in relatie tot de sterke en zwakke kanten van de ondernemer. Er zijn diverse thema's benoemd waarbinnen de verdere bedrijfsontwikkeling plaats kan vinden. Naast deze pionierbedrijven neemt er een tweede groep bedrijven deel die op basis van bestaande kennis en inzicht naar 'de gewenste toekomstige biologische landbouwpraktijk' toewerken. Recent omgeschakelde ondernemers vormen een derde groep boeren die geadviseerd worden over de belangrijkste biologische principes die onder meer uit dit project naar boven komen. De interacties tussen de groepen zorgt voor het leren van boer-tot-boer.

Hoofdstuk 7 beschrijft de meta-reflectie op de gepresenteerde onderzoeksmethoden uit de voorbeeldprojecten. De twee aangepaste matrices uit hoofdstuk 2 zijn gebruikt om de onderzoeksstrategie van het Instituut te positioneren. De voorbeeldprojecten in deze dissertatie hebben elk hun eigen beperkingen met name door de historie van de projecten. Belangrijke of nieuwe elementen van onderzoek die naar voren zijn gekomen, zijn de systemische oriëntatie in termen van een samenhangende set van managementmaatregelen en handelingen. Deze

systemische oriëntatie omvat ook het holisme in termen van de Goetheanistische fenomenologie. Daarnaast is er het participatieve actie-onderzoek aangeduid als ervaringswetenschap en gebaseerd op intuïtief handelen en patroonherkenning. In de reflectie op de methoden wordt duidelijk dat de acceptatie van de additionele methoden beïnvloed wordt door de achterliggende wetenschapsfilosofische aannames. Vooral het constructivistische karakter van zowel de Goetheanistische fenomenologie als de ervaringswetenschap geeft aanleiding tot een onderscheiding met de traditionele wetenschap.

De algehele onderzoeksstrategie van het Instituut is derhalve gebaseerd op twee verschillende invullingen van kennen. Ervaringswetenschap richt zich op het handelen van de ondernemer en is gebaseerd op de epistemologie van het handelen. Daarnaast is er sprake van een epistemologie van kennis daar waar het gaat over interdisciplinair onderzoek en Goetheanistische fenomenologie. De aard van het onderzoeksproces in de Goetheanistische fenomenologie brengt met zich mee dat er een brug wordt geslagen tussen de ervaringen van de ondernemers en hun directe waarnemingen aan bodem, gewas en dier enerzijds en anderzijds een holistische levenswetenschap en de agro-ecologische wetenschap. Zowel de ervaringswetenschap als de Goetheanistische fenomenologie zijn casuïstisch van aard. Belemmeringen in de acceptatie van deze wetenschappelijke methoden zijn vooralsnog het gebrek aan geschikte statistische evaluatie, maar ook de afwezigheid van geaccepteerde methoden om expliciet in te gaan op de realiteit zoals die door mensen wordt geconstrueerd. De methoden vormen een essentiële stap tussen de waarnemer en het geobserveerde, maar vragen om een intersubjectieve afstemming. In de epiloog van deze dissertatie zijn voorstellen gedaan om voor zowel de statische toetsing als het intersubjectieve karakter op een wetenschappelijke manier te evalueren. Nieuwe vormen van statistiek kunnen de patroonherkenning objectiveren als kernpunt van het ervarend leren.



Curriculum vitae

Name: Anthonie (Ton) Baars

Born: Amsterdam, August 16, 1956

1974-85: University of Utrecht: biology studies with specialisation in ecology. Master of Science degree (MSc): landscape ecology and nature conservation (12 months), animal production (6 months), farm economics (3 months) and biology and society (3 months), teaching qualification (3 months)

1976-78: Volunteer work at Sloterland bio-dynamic farm (vegetables, fruit) at Badhoevedorp (1 day/week)

1980-81: Course in bio-dynamic farming at Kraaybeekerhof, Driebergen (1 day/week)

1981-83: Taught biology and Goethean science on bio-dynamic farming course at Kraaybeekerhof, Driebergen

1983-present: Member of the Anthroposophical Society

1983-84: 19 months full-time co-working at three bio-dynamic dairy farms, practice in farming, Gouda cheese-processing and fresh cheese

1984-86: Taught the practice of processing of Gouda cheese at Warmonderhof, Kerk-Avezaath, bio-dynamic farming education

1986-89: Taught at Warmonderhof, Kerk-Avezaath, bio-dynamic farming education: theory of bio-dynamic farming systems, agricultural course and theoretical backgrounds of cheese-processing (part-time)

1986-present: Researcher at the Louis Bolk Instituut, Driebergen. Part-time to 1989, now full-time

Posts held in the institute: 1990-94: Head of the Agriculture Department; 1994-present: Head of the Department for Grassland and Animal Production (10 people in 2002)

EU-projects: Partner in AIR-project 'Economics of conversion' (co-ordinator F.MacNaiedhe, Teagasc, Ireland); Partner in concerted actions 'European Network for Researchers in Organic Farming' (co-ordinator J.Isart, Spain); 'Network for Animal Health and Welfare in Organic Agriculture' (co-ordinator M.Hovi, VEERU, UK); Member of international FOA-lowland pasture group for grass/white clover (co-ordinator J.Frame, Scotland).

Married: Gerda Peters in 1985. Two children: Brechtje (1986) and Jelle (1987).

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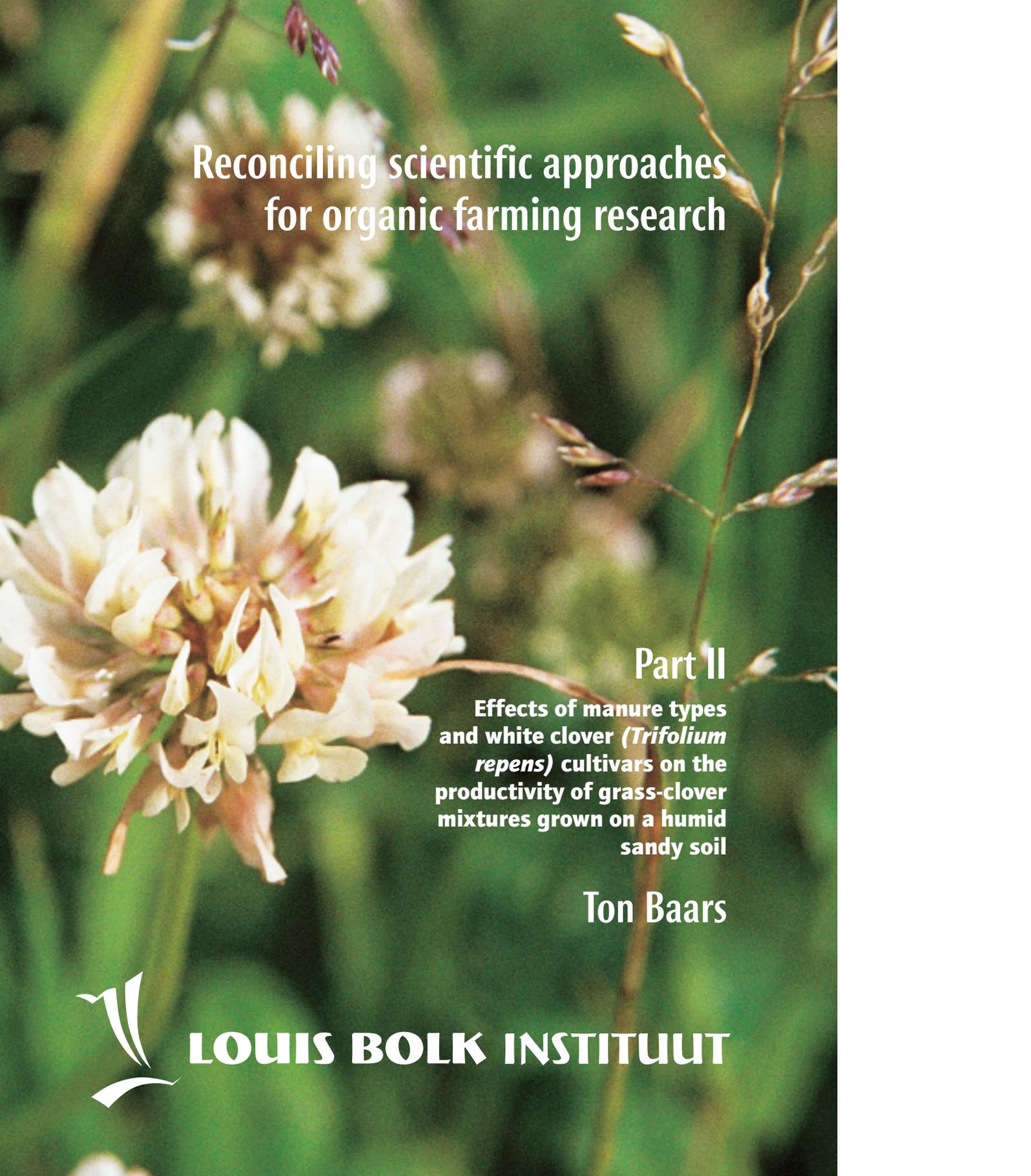
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Reconciling scientific approaches
for organic farming research

Part II

Effects of manure types
and white clover (*Trifolium
repens*) cultivars on the
productivity of grass-clover
mixtures grown on a humid
sandy soil

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Reconciling scientific approaches for organic farming research

Part II:

**Effects of manure types and white clover (*Trifolium repens*) cultivars on the
productivity of grass-clover mixtures grown on a humid sandy soil**

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Abstract Part 2

This Part describes the agronomic results of the multidisciplinary grassland study. This project concerned the effects of clover varieties and spring applications of animal manure on the yield of grass-white clover mixtures on a moist sandy soil (1993-1996). To be aware of the context of the findings in a multidisciplinary approach, attention was paid to: chemical soil fertility, damage to clover by slugs and soil borne nematodes. To increase the understanding of soil fertility, earthworm dynamics were also measured. At the end of the period the botanical composition of all plots was assessed. Factors measured besides total yield and clover yield were N, P and K yield. It was found that these 'context'- measurements were important for the overall explanation of the scientific results. Data were used for modelling several relationships between yield parameters. The overall findings of this project led to an understanding and description of the main aspects of manure with regard to grass-white clover growth on a moist sandy soil.

It was concluded that on a moist sandy soil the amount of inorganic and organic N, the N release and the K input were the main manure factors relating to fluctuations in total yields on white clover development and on N yields in the first six years after sward establishment. The inorganic N component in manure can be used strategically to improve the growth of the herbage in spring. Maintenance of soil fertility in terms of P, K and Ca levels is an important key factor for a successful organic grass-clover sward.

Carbon rich FYM derived from a deep litter stable and composted before application increased the earthworm population, reduced the number of nematodes and maintained the highest level of soil pH, all factors which might positively affect white clover growth in the long term. FYM applied in spring resulted in the typical extended growth season in the second part of the growing season. On a sandy soil the high concentration of K in the FYM positively affects the potential white clover growth.

The choice of a persistent white clover cultivar is another important factor affecting herbage and N yields of an organic grass-clover sward. However, winter losses were not found to be the main cause of white clover reductions over the years. Losses in the growing season were related to slugs which reduced white clover leaf area. The literature shows that the cyanide concentration in DM herbage affects the susceptibility of white clover to pests.

Key words: organic agriculture, grass-clover, white clover cultivars, animal manure, potassium, nematodes, earthworms

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1. Introduction

1.1. Legumes and manure in organic farming

Since the first biodynamic farm, Loverendale, was converted in the Netherlands in 1926, organic farms have been mainly located on the more fertile peat and old clay soils in the coastal areas. These soils have a high soil fertility. In the coastal areas, specialised organic dairy farms have been based on permanent pastures with a low content (10-15%) of white clover, mainly a wild type of white clover (Ennik *et al.*, 1982; Baars *et al.*, 1983; Kramer, 1994). For instance, in 1995 most organic dairy farms in the province of Friesland were extensive (1.5 LU ha⁻¹) and based on a traditional and natural way of farming with a low production per hectare (5.900 kg milk ha⁻¹ year⁻¹). Mixed farming systems consisting of cattle, arable crops, fodder crops and short term leys were and are rare and mainly located on young clay soils in the central polder area and on clay soils in the coastal areas. Short term leys, based on red and white clover, were extremely suitable for clover growth and therefore had legume contents of over 70% (Van der Meer and Baan Hofman, 1989; Baars and Veltman, 2000).

Conversion to organic dairy farming increased rapidly in the last decade. The production levels increased as well and fodder production relied much more on newly established grass-white clover leys often combined with a second fodder crop to supply energy to animals (Van Eekeren, 2000). There was a shift to other soil types, when dairy farms also started converting to organic farming on sandy soils on the old Pleistocene areas in the east, middle and south of the country. In each European country, organic farming systems show some similarity with the practices of conventional systems. Therefore organic farming in The Netherlands developed as highly specialised and highly productive systems. Nowadays Dutch organic farming consists of stockless arable systems, specialised vegetable or fruit growers and dairy farming mainly based on permanent pastures or resown grass-clover, fodder maize or whole plant silage. The choice for rotation is very much soil related, in coastal clay and peat areas only grassland is found. Because of the specialisation, feed concentrates of (partly) organic origin were imported into dairy farms from outside the farm (Baars and Van Ham, 1996). On the other hand, organic arable or horticulture farms are mainly dependent on animal manure from conventional systems. In arable systems legumes are used as intercropping or green manures. Within these specialised systems there is only a small area of legumes (Nauta and Elberse, 1999). In other countries, however, stockless organic arable systems were based on legumes (Stopes *et al.*, 1996; Cormack, 1996).

The regulations on the use of manure have been adapted to this dependency on conventional animal manure. Manure level, manure quality and manure origin have been restricted since 1991, when the organic standards were formulated by the European Commission. Animal manure was restricted for all forms of farming to a level of 170 kg total N ha⁻¹, which is related to the manure production of 2 LU ha⁻¹ (EEC N° 2092/91). However, in the near future, organic arable systems must use manure produced by organically kept and fed animals. A co-operation between specialised farms is allowed as a solution for the cycling of organic manure, straw and fodder between farms. In future, organic cattle farmers should therefore reduce the amount of manure N applied to grass-clover pastures, because this animal manure should partly be exported to arable parts on their own farm or to specialised arable and horticulture farms. This change in regulation means, that specialised animal farms should not only produce meat and/or milk but also organic manure (Nauta *et al.*, 1999). The reduction of external N sources in the totality of organic farming systems will lead to a more central role of legumes in crop rotations and in leys and pastures (Lantinga and Oomen, 1996; Baars, 1998, 2001).

In the first place the type and quality of animal manure used on organic farms depends on the housing system. Two main housing systems are distinguished in modern organic farming: the deep litter stable and cubicle housing. Tied barns will no longer be allowed after 2010, because of welfare standards. In the deep litter stable, large amounts of straw are used to keep the animals clean. Once a day 9 kg (range: 7-14 kg) straw per cow is spread for bedding (Krutzinna *et al.*, 1996). In most of the deep litter houses slurry is also produced as the exercise area usually has a slatted floor. In cubicle houses often only low amounts of fibre rich products are used for bedding, like chopped straw or sawdust. Therefore, in cubicle systems only slurry is generally available.

N losses during storage and application of slurry are very low (Buchgraber, 1983; 1984). Since 1990, slurry has to be injected into grassland by law and ammonia losses are strongly reduced compared to above ground application (Van der Meer *et al.*, 1987, Bussink and Bruins, 1992). FYM from deep litter systems has to be collected in the barn and is often composted in a large heap. During storage ammonia losses cannot be avoided. During the heating phase of the compost process considerable amounts of carbon and ammonia are lost by respiration (Bockemühl, 1978). The C/N ratio declines from 21 to 9, if the heap is re-mixed or 11 if not re-mixed (Gottschall, 1985). In the first six months of the transformation, the N percentage increases from 1.8 to 2.8 (Kirchmann, 1985) and is stabilised after this period. Kirchman (1985) found total N losses of 20-35% after composting, but the respiration losses of C and N depend on the method and time of storage, heap density and moisture, amount of straw and maximum temperature during the process (Bockemühl, 1978; Gottschall, 1984). Some N, but mainly K can

be lost by leaching, if composting is done in the open air without storage of effluents (Kolenbrander and De la Lande Cremer, 1967; Buchgraber, 1983; MacNaiedhe, 1994). If FYM is spread on the top of the soil, losses of ammonia can be high if the weather conditions after application are windy and hot (De la Lande Cremer, 1953).

1.2. Prerequisites of legume based grasslands

Legumes commonly used in organic farming systems are white clover (*Trifolium repens*) for permanent pastures (grazing and cutting), red clover (*Trifolium pratense*) for ley pastures (mainly cutting) and lucerne (*Medicago sativa*) in arable crop rotations (cutting only).

With regard to nutrients, much information is available about the effects of single fertilisers on white clover development. With regard to soil fertility and availability of minerals, positive and site specific effects on the development of legumes in general and specifically for white clover, were found from the application of P, K, Ca and S (Andrew, 1960; Fothergill *et al.*, 1996). Vigorous clover growth requires appropriate use of P, K and Na fertiliser, otherwise severe nutrient deficiencies can develop (Jones and Sinclair, 1991). For instance in the UK, in long term experiments on grassland at Rothamsted research station the supply of K-fertilisers was of vital importance for clover growth, whereas at Cockle Park the importance of P fertilisers for legume growth was stressed (Cooke, 1976). In a mixture of grass and clover Simpson *et al.* (1988) found a significant response of white clover to increased levels of K. The grass component did not respond to increased K application, because the grass yield was N-limited. Newton (1995) investigated the yields of organic swards on commercial farms in relation to the production-site classes in the UK. The production of leys and permanent pastures was site specific. There was a highly significant correlation between herbage yield and the level of soil P. Soil K and the percentage of clay or sand in the soil did not affect yields. Bowdler and Pigott (1990) also found significant increase from applied S to total yields of a two-year-old irrigated grass-white clover mixture on a heavy clay soil, whereas P and K fertilisers did not affect yield. Effects of mineral application (P, K, Ca, S and even Na) therefore might be positive, neutral or negative, depending on soil type and availability of nutrients (Frame and Newbould, 1986). Effects also can be linear, quadratic or exponential depending on the level of soil fertility and fertiliser application (see for instance Hernán Acuña, 1995). Fertiliser N, on the other hand, in general negatively affects white clover growth, especially at higher rates of application and after repetitive applications (Frame and Boyd, 1987). Fertiliser N, but in general the level of soluble N in the root zone, negatively affects N fixation by the legume (Nesheim *et al.*, 1990). Nevertheless, N is used in spring as a strategic fertiliser to improve spring herbage growth and to improve the content of protein in the 1st cut. In conventionally managed grass-clover swards, an amount of 50-60 kg N ha⁻¹ is often used in spring (Laidlaw, 1980; Frame, 1987), but only if there is an adequate initial

white clover level in spring (Frame, 1989). White clover growth will be slightly depressed by the N application, but might recover later in the season (Frame, 1987). This was confirmed by a New Zealand study by Pinxterhuis (2000), who showed that in N fertilised pastures (100 kg N ha^{-1}) grazed by cattle the clover content of the swards was moderately reduced directly after application. Effects, however, were not permanent.

1.3. Long term FYM effects on grassland

Manure on grassland is used to replace minerals removed in cut herbage, to compensate for leaching (N and K) and aerial losses (N), to build up soil fertility (C, N, P and K) and for N-fixation (P). The N component of manure is used strategically to improve the grass growth rate of the mixture in spring. Animal manure and especially FYM from cows is used for building up the soil quality as well, in terms of water holding capacity, soil structure, release of minerals and to feed the soil fauna. Although the humus content (C) of the grassland soil will always increase in time, the increase in soil C content was greatest after FYM application (Kolenbrander and De la Lande Cremer, 1967).

There are often positive effects of FYM in arable crop rotations (Raupp, 1999). In comparison with soils receiving no fertiliser or only artificial fertilisers, the organic matter content in soils receiving FYM is higher. The increase of soil organic matter positively affects soil structure, water holding capacity, ease of ploughing, number of bacteria and number of soil invertebrates. Negative effects of FYM include, among others, the possibility of importing weed seeds, especially when the temperature during storage is kept low (Ferwerda, 1951a).

Effects of FYM on grassland productivity were summarised by Kolenbrander and De la Lande Cremer (1967). In several parallel trials, Frankena (1936, 1937 and 1938) investigated the effect of fresh FYM levels (20 and $40 \text{ tonnes ha}^{-1}$), application time (December, January and early March) and soil type (sand, clay and peat) on the yield of the 1st cut in permanent pastures. His results showed that the effects of FYM (both level and timing) were most sensitive on a sandy soil, whereas other soil types had a better buffer capacity for FYM application. Results, however, were based on permanent pastures with a low clover content and a traditional management system with a high 1st hay cut yield in June .

Losses of N from FYM can occur, because of early leaching or by ammonia volatilisation. Timing of application in spring is therefore an important factor in controlling N losses. Brünner (1954) evaluated his experiments with FYM on grassland production in the Bavarian Algau area. Precipitation in spring increased spring herbage yield, because of the leaching of nutrients out of FYM into the soil and the better breakdown of the manure. An early winter application (November) was the best solution in relatively dry areas with low winter precipitation. In areas with a high winter precipitation spring application was possible.

An application of FYM late in spring should be avoided, because of aerial losses of N. On arable land N losses were measured over a 4-day period, in relation to the time of ploughing. N losses in April can be up to 25% of the total N in the FYM, if weather conditions are dry and windy with sunshine, but only 2% in February when the weather is damp with rainfall (Iversen and Jensen in: Gerretsen, 1928).

In an experiment on pastures with a high clover content, diluted urine was applied once at five different times between the end of November and the end of March (Drysdale, 1963). The highest yield response was found to urine applied at the end of March. Earlier application showed a stepwise reduction of the N efficiency and there was a strong reduction if urine was applied in November and December. Additionally the N concentrations in DM herbage were highest if urine was applied in March. In grass-only leys the response to November and December application was much higher.

Coleman *et al.* (1987) analysed long term effects of plots with and without application of FYM at Cockle Park. Data from the 1st cut hay yield were recorded over a period of 80 years. Plots receiving FYM varied less in yield from year to year, showing a more independent reaction to the soil moisture balance from year to year. However, there was not a higher level of available water holding capacity on the FYM treated plots. The different species diversity of the plots as a result of treatments and differences in rooting pattern and drought tolerance might explain the variations in response to the moisture balance. Shiel (1995) suggested that herbage growth was more buffered in the manure- treated plots at Cockle Park. FYM plots were less affected by delay or absence of manuring, or by drought, compared with the variation in plots receiving fertilisers. The manure-treated plots contained more N, which was presumably the reason why yield levels were maintained in years without manure application. Manure produced a large herbage yield and good quality with a small annual variation. There was a large botanical diversity and the aftermath was intensively grazed. Only the P-treated plots were comparable in terms of diversity and reliability of yield, but yields were smaller because of an inadequate N supply. Plots receiving FYM and basic slag alone were less dense (bulk density) than the other plots. This was combined with a relatively high pH (pH (H₂O) about 5.6-5.9). Arnold *et al.* (1976) showed that in the Cockle Park soils K could be mineralised from illitic clay and even after 80 years without additional K applications the DM yields were unaffected.

In a 65 years long term comparison between fertiliser NPK and FYM on permanent pastures on a sandy soil, a steady, but significant yearly increase of production was found after yearly applied FYM (De la Lande Cremer, 1976). In this period the yield ratio for FYM compared to that for NPK increased from about 80% to 120%. This increase was accompanied by a higher organic matter content under FYM (7.4% versus 6.2%).

Over a period of 40 years Cooke (1976), however, did not find much difference in effect from animal manure on 1st cut hay yields at Rothamsted (UK) in comparison with NPK fertiliser. FYM was only used every four years.

1.4. Goals and challenges

The input of N into organic systems relies on animal manure, biological N fixation by free living soil micro-organisms, atmospheric deposition and biological fixation by legumes (Watson and Stockdale, 1999). Of these N sources, manure and legume N are the most important on mineral soils, whereas mineralised soil N and manure N are the most important sources on organic soils (peat). As a matter of principle the N input to organic systems in general should be mainly based on legumes. Therefore a basic understanding is necessary of the best ways to introduce and to maintain legumes in the organic system, to develop suitable, site adapted grass-clover mixtures (with a well balanced amount of clover and grass) and to reduce losses of minerals in all parts of the cycle. If organic dairy farmers are pushed to reduce the level of manure applied to grass-white clover pastures, questions will be raised about acceptable minimum levels of soil fertility for maintaining white clover in the sward.

Besides the maintenance of the long term soil fertility in terms of Ca, P and K, also the choice of the clover type plays a key role for a balanced grass-white clover mixture (Evans and Williams, 1987). New cultivars of white clover bred for a better winter survival of stolons (Collins *et al.*, 1991; Rhodes and Fothergill, 1993; Fothergill and Collins, 1993), are positively correlated with clover yields in spring and with total annual clover yields (Collins *et al.*, 1991). Newly bred cultivars combine a better cold-tolerance with a higher spring yield. In comparison with the often-used New Zealand cv. Huia, the cultivar Aberherald bred by IGER (UK) has been shown to give a significantly higher survival of stolons during the winter period (Rhodes and Ortega, 1996).

Data are lacking about the productivity of newly established organic grass-clover swards on sandy soils, and the interactions between manure quality, soil fertility factors and productivity of grass-white clover mixtures on sandy soils are unknown. Baars and Van Dongen (1993) found that the productivity of the sward and the persistence of white clover in resown grass-clover mixtures were poor on a sandy soil in comparison with those on old marine clay, river clay, or peat soils. It was also clear from farmers experiences, that the development of grassland systems on sandy soils needed much more attention to maintain long term soil fertility, and that there were also specific problems of drought in summer. The low buffer capacity of sandy soils forces organic farmers to develop systems to reduce losses of nutrients.

Early herbage production is an important issue in dairy farming. The start of the growing season

on organic farms is delayed by a period of about two weeks compared to conventional farming. To improve spring growth for early grazing two possibilities are suggested, improved white clover cultivars and optimising the timing of manure application as part of the management of manure handling.

Three parallel experiments were carried out on effects of animal manure on grass-white clover mixtures. The first (overall) aim of these experiments was to understand the effects of animal manure on the productivity of grass-white clover swards and to understand the interaction between positive effects of manure on the development of white clover in terms of P and K and negative aspects of the manure in terms of total and mineral N, also affecting white clover. Specific attention was paid to effects on spring yield and protein yield of the 1st cut silage. The second aim was to understand the essential preconditions with regard to soil fertility for the growth of grass-white clover on sandy soils, if in the future animal manure would be unavailable due to its use in stockless arable systems or arable crops in a mixed system. Therefore, there is a need to understand the factors necessary to maintain legumes in grassland systems. Effects of manure application on herbage intake by the grazing animal are not known. Therefore, the third aim was to look at effects of manure type on herbage residues after a grazing period.

The work on the clover cultivars and manure (1993-1995) started as part of a network experiment at three sites in Europe (Wales, Ireland and the Netherlands) (see also Humphreys *et al.* 1997; MacNaiedhe *et al.*, 1997), which was funded by the EU (Organic livestock farming, nutritional, environmental and economic implications of conversion (AIR-3C 92-0776)). The continuation of the work was financed by the Dutch Ministry of Agriculture, Nature Conservation and Fisheries (1996-1999).

Results of the trials have been described in Baars *et al.* (1996), Baars (2000), Van der Burgt and Baars (2001), Baars (2001 a and b) and Baars (2002).



2. Methodology, treatment and layout of experiments

Three different trials are described, which will be referred to as: trial 'cutting', trial 'grazing' and trial 'levels'. The first two trials were based on a split plot design of manure types and clover varieties. The last trial set was based on a split plot design of manure types and manure levels. The white clover cultivar Alice was part of all trials and these grass-clover plots were used to compare effects between the three trials.

In this chapter only the methodology, which is relevant for all trials, is described. Specific methods used for analysing the soil fauna and botanical composition are described in those chapters, where results of these analysis are presented.

2.1. Layout of the experiments

All three trials were located in the same pasture of the experimental farm 'Aver Heino' at Heino (52°25' north and 6°15' east), in the eastern part of the Netherlands. The humid sandy soil has been classified as a gleyey sand with a semi-permeable loam horizon at 70 to 80 cm. The history of the field was as cloverless permanent pasture.

2.1.1. Trials 'cutting' and 'grazing'

Experimental site and establishment

The two trials had a comparable plot lay-out. The trials were established in the first week of September 1992 as part of a six-year study on effects of manure types and white clover cultivars on spring yield and total yield. The initial level of soil fertility was: pH (KCl) 5.4, organic matter: 3.0%, phosphorus as P-Al 44.0 P₂O₅ 100 g⁻¹ air-dry soil; potassium as K-HCl 13.0 K₂O 100 g⁻¹ air-dry soil, indicating a slightly acid soil of good P and adequate K status.

Three cultivars of white clover were sown in a mixture with perennial ryegrass (*Lolium perenne*) (cv. Magella): Aberherald, Alice and Retor. Cv. Retor was used as a Dutch medium-leafed standard. Grass seed was drilled with a row width of 7 cm at a rate of 30 kg ha⁻¹. White clover was sown afterwards by hand at 3.5 kg ha⁻¹ (Figure 2.1). Only in the trial 'cutting', after the 1st cut in 1993 pure grass plots were created by chemically killing the clover. Only one out of the four grass plots was used as a pure grass stand. The other three plots were used in trial 'levels' (Figure 2.2).

CHAPTER 2

Trials 'cutting' and 'grazing' had the same experimental layout: a split-plot design with randomised blocks replicated four times, with manure type as the main treatment and white clover cultivars as subplots. Trial 'cutting' was trimmed to a height of 4-5 cm five times annually. Trial 'grazing' had a mixed management of cutting (twice) and rotational grazing (three times) by dairy cows or young stock. Cutting and grazing were alternated. Plot size was 10 m x 3 m ('cutting') or 10 m x 6 m ('grazing'). In the trial 'grazing', all treatments were grazed by one group of animals that had access to all treatments at once. After each grazing cycle the herbage residue was measured.

Two different animal manure types were compared, with a fertiliser application without N as a control. Composted farmyard manure from deep litter barns (FYM) and slurry which was shallow injected at a depth of 4-5 cm (SLU), were compared with superphosphate¹ and K salt as 'Kali-60' (PK). Manure and fertiliser were generally applied in the middle of March, except in the first year (see Table 2.1). The objective was to apply FYM and SLU at a rate which supplied approximately 100 kg total N ha⁻¹ (1993-1995) or 150 kg N ha⁻¹ (1996-1998). Dressings of P and K were applied at an intermediate level between FYM and SLU. The manure was analysed by the Laboratory for Soil and Crop Testing at Oosterbeek (Blgg) for total N, inorganic N, total P and total K.

FYM	Retor	Barfiola*	Aberherald	Alice
SLU	Aberherald	Retor	Barfiola	Alice
PK	Aberherald	Barfiola	Alice	Retor

* Plots with Barfiola were no longer sampled after 1993 and therefore left out of these results

Figure 2.1. Lay-out of the trial 'grazing' (one of four replications). All plots on the same row received the same type of manure, as indicated on the left side. Plot size: 10 x 6 m.

¹ Neither superphosphate nor potassium salt as 'Kali-60' were allowed under organic conditions

PK	Alice, level-2	Grass	Alice, level-3	Alice, level-1
PK	Retor	Aberherald	Alice	Barfiola*
SLU	Alice, 30m ³	Grass	Alice, 40m ³	Alice, 50m ³
SLU	Alice	Retor	Barfiola	Aberherald
FYM	Alice, 40t	Grass	Alice, 50t	Alice, 30t
FYM	Aberherald	Alice	Barfiola	Retor

* Plots with Barfiola were not sampled after 1993 and therefore results were discarded

Figure 2.2. Lay-out of the trials 'cutting' (grey) and 'levels' (clear) (one of four replications). All plots on the same row received the same type of manure, as recorded on the left side. In the trial 'cutting' all cultivars received the lowest level of manure (level-1, 30m³ or 30t). Plot size: 10 x 3 m.

2.1.2. Trial 'levels'

Establishment

This trial was established in the same field as the trial 'cutting' (Figure 2.2). Three grass plots created after killing the clover in 1993 were oversown with white clover using the so called 'Pedestrian strip seeder'. Plots were oversown at three different dates between May and August 1994 with white clover *cv. Alice* in a split plot design with manure type as the main treatment and date of sowing as subplots. White clover was sown at a rate of 8 kg ha⁻¹. From 1993-1995 the grass plots were treated as in trial 'cutting'. Plot size was 10 m x 3 m. The cutting interval was the same as in trial 'cutting'.

The average level of soil fertility in the top layer at the start of trial 2 was (average 1994-1995) pH (KCl) 4.9, organic matter: 3.7%, phosphorus as P-Al 39.0 P₂O₅ 100 g⁻¹ air-dry soil; K as K-HCl 12.5 K₂O 100 g⁻¹ air-dry soil, indicating a slightly acid soil of good P and adequate K status. After the establishment of white clover in 1995, the plots were reshuffled for another experiment on effects of three increasing manure levels. Randomisation of the oversown plots was undertaken in November 1995. The lay-out of trial 'levels' was a split plot design with manure type as the main level and level of application as a subplot. Three levels of the manures used in trials 'cutting' and 'grazing' were investigated during a three-year period (1996-1998).

2.2. Manure application, timing and nutrient concentrations

2.2.1. Trials 'cutting' and 'grazing'

In the 1st year (1993) only the manure was applied after the 1st cut (Table 2.1) to prevent damage of the young sward. On average, FYM was applied about two weeks before SLU and PK. Due to the heavy rainfall in autumn and winter in 1993 (Figure 2.3), the soil conditions were

CHAPTER 2

Table 2.1. Temperature sum (T-value) of 200 °C, rainfall in the 1st two weeks after manure application, application dates of manure and level of nutrient application and dates of cutting (trials 'cutting' and 'grazing' 1993-1998)

Year	1993 (1)	1994	1995 (2)	1996	1997	1998 (3)	Mean
Application date							
PK	26 Mar	30 Mar	24 Mar	03 Apr	19 Mar	25 Mar	26 Mar (4)
SLU	14 May	21 April	23 Mar	03 Apr	14 Mar	23 Mar	29 Mar
FYM	12 May	30 Mar	16 Mar	07 Mar	04 Mar	28 Feb	14 Mar
T-value (date)	18 Feb	28 Feb	15 Feb	05 Apr	27 Feb	12 Feb	01 Mar (4)
Rainfall (mm)							
SLU		6.9	41.0	8.2	25.1	17.3	19.7
FYM		67.8	52.7	0.0	8.9	75.4	41.0
Cutting dates (5)							
1st	05 May	13/17 May	11/17 May	29 May	22 May	19 May	23 May (6)
2nd	08 Jun	14 Jun	27 Jun	18/24 Jun	17/19 Jun	23/25 Jun	22 Jun
3rd	29Jun/5Jul	7/11 Jul	20/26 Jul	08 Aug	23 Jul	05 Aug	01 Aug
4th	16 Aug	30 Aug	10 Oct	02/06 Sep	18/20 Aug	21/23 Sep	06 Sep
5th	3 Oct	10 Oct	-	30 Oct	30 Sep	-	15 Oct
Total N kg ha⁻¹							
SLU	101	124	94	141	154	141	126
FYM	129	106	103	174	150	177	140
Inorganic N kg ha⁻¹							
SLU	47	59	46	72	76	72	62
FYM	7	12	14	30	30	39	22
Kg P ha⁻¹							
PK	22	24	24	24	24	24	23
SLU	15	17	15	21	18	21	18
FYM	26	32	25	30	38	45	33
Kg K ha⁻¹							
PK	87	133	266	130	130	130	146
SLU	137	150	250	208	198	348	188
FYM	177	128	235	158	260	188	218

(1). In the year of establishment animal manure applied only after the first cut.

(2). In 1995 all plots received an extra K application after the second cut: 133 kg K ha⁻¹.

(3). In 1998 Aberherald plots received an extra K application for experimental reasons.

(4). Averages of 1994-1998.

(5). In the first year the trials were cut mainly to reduce annual weeds. In 1994 and 1995 the 1st cut started as a grazing cycle (2.0-2.5 t DM.ha⁻¹). In 1996-1998 the 1st cut started as a silage cut (3.5-4.0 t DM.ha⁻¹). After each silage cut the following cut was a grazing cycle. If two dates are written, this means the difference between the date of cutting for the 'grazing' trial (1st date) and for the 'cutting' trial (2nd date). At this 2nd date the grazing aftermath was measured in the grazing trial and the whole field was topped.

(6). Averages of 1996-1998 for the date of the 'cutting' trial.

such that slurry application in spring 1994 was delayed. In 1996 there was also a delay, due to the long and severe winter (1995/96) (Figure 2.4). After the dry and mild winter of 1997/98, FYM was applied very early in spring. In the Netherlands it is advised to start manure application when the T-value reaches a value of 200 (T-value = the sum of average daily temperatures above 0 °C after the 1st of January). This T-value reflects the earlyness of the growing season (Table 2.1).

At the end of the first three year period the amount of applied manure was increased from 20 to 30 tonnes (FYM) or m³ (SLU) ha⁻¹. The application of the PK fertilisers was not increased. Therefore the average K level was lowest for PK. The slurry composition was constant over the years for all nutrients, but the FYM showed significant fluctuations for P (1.0-1.6 kg t⁻¹ DM) and mainly K (5.1-11.6 kg t⁻¹ DM). The nutrient concentration of the manure was measured only after its application. The levels of K in FYM were much higher in the last two years. On average FYM plots received most P and K. The amount of directly available N was always highest for SLU. Extra K was applied after the 2nd cut in 1995. Excessive rainfall (Figure 2.3) in the autumn and winter period of 1994/1995, combined with the low levels of soil K, led to a depletion of K in the soil. The older leaves of the clover plants showed typical symptoms of K deficiency and died. After an application of 133 kg K ha⁻¹ all these symptoms immediately disappeared.

2.2.2. Trial 'levels'

FYM was applied immediately before the first cut for all levels: 30, 40 or 50 t ha⁻¹. PK and SLU were divided between the first three cuts as follows (per ha): SLU30 as 30m³ before the first cut, SLU40 was as SLU30 plus an extra 10 m³ before the second cut; SLU50 was as SLU40 plus an extra 10 m³ before the third cut. PK-1 received a full dose before the first cut; PK-2 was as PK-1 plus an extra half a dose before the second cut; PK-3 was as PK-2 plus an extra half a dose before the third cut (Table 2.2). The application of manure in spring was at the same date as in trials 'cutting' and 'grazing' (Table 2.1).

On average FYM was applied three weeks before PK and SLU. PK plots received the lowest amount of K and an intermediate level of P. Due to differences in composition of FYM over the experimental period, the average K application in FYM was 75% higher than in PK and 44% higher than in SLU. The application of P in FYM was 75% higher than in SLU and in PK 32% than in SLU. The SLU treatment received the highest amount of directly available N: 73 kg ha⁻¹ before the first cut (243% of FYM). For FYM the total N amount was equal to SLU.

Table 2.2. Average date of manure application and total input of nutrients ha⁻¹ (1996 – 1998), amounts of SLU (m³ ha⁻¹) and of FYM (t ha⁻¹) (trial 'levels').

Manure Treatment:	---- Date of application -----			Amount t ha ⁻¹ or m ³ ha ⁻¹	Total N	Inorg. N ----- in kg ha ⁻¹ -----	P	K
	1 st cut	2 nd cut	3 rd cut					
PK-1	26 Mar				0	0	24	130
PK-2	26 Mar	1 June			0	0	35	195
PK-3	26 Mar	1 June	26 Jun		0	0	47	260
SLU30	24 Mar			29.3	145	73	20	198
SLU40	24 Mar	28 May		39.3	198	98	27	268
SLU50	24 Mar	28 May	26 Jun	49.3	246	122	33	336
FYM30 (1)	4 Mar			26.7	148	30	34	238
FYM40 (2)	4 Mar			36.7	203	41	47	323
FYM50 (3)	4 Mar			46.7	259	52	59	408
Mean:								
PK					0	0	35	195
SLU				39.3	196	98	26	267
FYM				36.7	203	41	47	323
Low level					98	34	26	188
Medium level					134	46	36	262
High level					168	58	46	335

(1, 2, 3). In 1996 FYM was applied at 20, 30 and 40 t ha⁻¹ instead of 30, 40 and 50 t ha⁻¹.

2.3. Meteorological data

The daily meteorological data (Figures 2.3 and 2.4) were obtained from the automatic meteorological station present at the experimental site. The winters of 1992/1993, 1994/95 and 1997/98 were mild and those of 1995/96 and 1996/97 were severe. The average temperatures were low from December 1995 until February 1996 and the absolute minimum temperatures were between -10 and -15 °C. The growing season in 1996 was delayed because of the long duration of the winter. The T-value of 200 °C was only reached by the 5th of April (Table 2.1). Additionally, the winter of 1996/97 had absolute minimum temperatures ranging from -10 to -15 °C between November and January. The temperature increased rapidly in early spring with high maximum values in February and March. Therefore, the growing season had an early start. In almost all years average daily temperatures in spring and summer were above the long term average. Rainfall was very different between the years. For instance in March 1994 heavy rainfall delayed the time of manure application. A dry period occurred between August 1995 and September 1996, but in 1997 the amount of rainfall was also well below average.

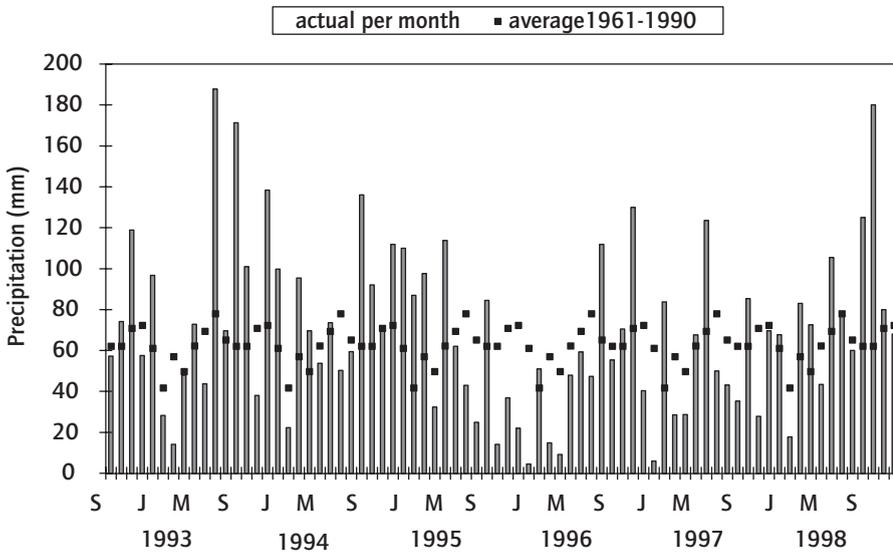


Figure 2.3. Rainfall per month (mm); actual rainfall versus long term average

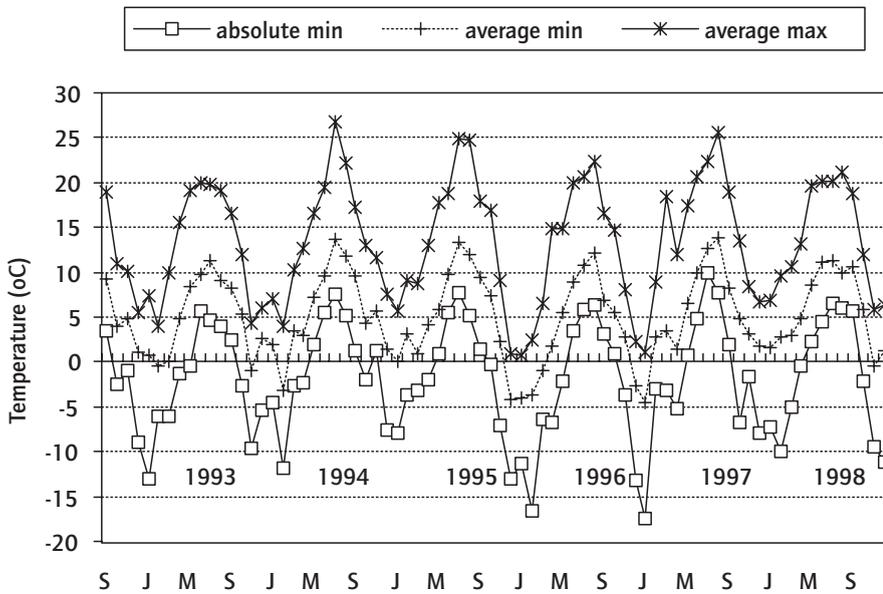


Figure 2.4. Monthly minimum and average temperatures (°C); actual daily temperature versus long term daily average

2.4. Soil sampling

For each manure treatment in February of each year, a single soil sample was taken at a depth of 0-5 cm. In trials 'cutting' and 'grazing', the 40 subsamples were bulked for the three clover cultivars (1993-1996) or only of cvs. Alice and Aberherald (1997-1999). The samples were analysed by the Laboratory for Soil and Crop Testing at Oosterbeek (Blgg) for organic matter, pH, available P (as P-AI) and K (as K-HCl), and Mg. The soil fertility values in trials 'cutting' and 'grazing' were averaged per year to study effects of manure type on soil fertility development or were averaged per trial to compare effects of management regime.

2.5. Herbage yield measurements

Plots were harvested with a Haldrup forage harvester. The cutting height was approximately 4 to 5 cm above ground level. After harvest a 'core sample' of herbage (300-400 g) was taken from each plot and dried at 70 °C for 24 hours. These herbage samples were used for analysis of dry matter and total N, P and K. From each plot a second 'grab sample', based on 20-25 subsamples was taken for hand-separation into grass, white clover and other species. The separated samples were dried at 100 °C for 16 hours.

Grass-clover plots with cv. Alice and pure grass plots were analysed for N, P and K in herbage.

2.6. Statistical analyses

Data were analysed by analysis of variance (ANOVA) using GENSTAT for Windows (Lane and Payne, 1998; Oude Voshaar, 1995). The experiment was analysed as a split plot design (manure type x manure level) or as a one way ANOVA with randomised blocks (manure type).

Regression analyses were conducted in GENSTAT 5.22. Linear as well as polynomial models were used.



3. Effects of white clover cultivars on yields of grass-clover mixtures

3.1. Additional methodology

In this chapter only data of the trials 'cutting' and 'grazing' are used to analyse effects of the white clover cultivars on herbage yield and early spring growth during 1994-1996 (cvs. Aberherald and Alice compared with cv. Retor as the local standard). Clover cultivars were evaluated using an average of the three manure types (FYM, SLU and PK). Results of the year of establishment (1993) are excluded from this evaluation.

From 1993-1996 SLU and FYM plots received the equivalent of about 100 kg N ha⁻¹ and in 1996 the level increased to 150 kg N ha⁻¹.

In 1994 and 1995 slug damage was measured as the area of leaves eaten by slugs. Three cuts were analysed for slug damage (May, June 1994 and May 1995) by the method described in Clements and Murray (1992).

Stolons were measured twice a year, in November and in spring after the 1st cut. Per plot, three core samples were taken of 56.4 cm² each at a depth of 10 cm. Losses during winter were calculated as the difference in stolon length and weight between November and the following measurement in spring. Relative losses were calculated as (November values – Spring values)/November values.

3.2. Herbage yields, white clover yields and nitrogen yields

The effects of white clover cultivars on total herbage yield, white clover yield and N yield are shown in Table 3.1, 3.2 and 3.3 respectively. The development of white clover in DM herbage per cut is shown in Figure 3.1.

In both trials mixtures with cv. Retor had the lowest total herbage yield in 1995 and 1996 (Table 3.1). Compared with the trial 'cutting', effects were somewhat delayed under 'grazing'. Cv. Alice out-yielded cv. Aberherald in 1995 ('cutting') and 1996 ('grazing'). In 1995 and 1996 there was an interaction between clover cultivar and manure type for both trials. The interaction was caused by a larger yield reduction in mixtures with cv. Retor for PK than for SLU and FYM compared to the reduction in cvs. Alice and Aberherald in 1995. In 1996 in the trial 'cutting' the interaction was caused by the reduced yield from the mixture with cv. Retor for PK and FYM

compared to cvs. Alice and Aberherald. In the trial 'grazing' the mixture with cv. Retor was reduced in the SLU plots.

In all years white clover yields were lowest for mixtures with cv. Retor under 'cutting' ($P < 0.001$), (Table 3.2). Cv Retor had almost disappeared from the sward in 1996. There were no interactions

Table 3.1. Total herbage yields (t DM ha⁻¹ year⁻¹): effect of white clover cultivars averaged over three manure types of trials 'cutting' (left) and 'grazing' (right) (1994-1996).

Year	1994	1995	1996	1994	1995	1996
Trial	----- 'cutting' -----			----- 'grazing' -----		
Mean	10.46	9.79	8.88	9.83	9.63	8.81
Clover cultivar						
Retor	10.21	8.97 a	7.77 a	9.85	9.30 a	7.94 a
Aberherald	10.56	9.89 b	9.21 b	9.62	9.63 ab	8.83 b
Alice	10.61	10.40 c	9.45 b	10.01	9.96 b	9.66 c
P value						
Clover cultivar	0.220	< 0.001	0.001	0.488	0.053	< 0.001
Clover * manure	0.722	0.021	0.042	0.664	0.252	0.042
LSD (5%)						
Clover cultivar	0.50	0.47	0.74	0.67	0.53	0.43

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

Table 3.2. White clover yields (t DM ha⁻¹ year⁻¹): effect of white clover cultivars averaged over three manure types of the trials 'cutting' (left) and 'grazing' (right) (1994-1996).

Year	1994	1995	1996	1994	1995	1996
Trial	----- 'cutting' -----			----- 'grazing' -----		
Mean	4.50	2.48	2.37	3.85	3.30	2.61
Clover cultivar						
Retor	3.28 a	0.80 a	0.61 a	3.62	2.05 a	1.07 a
Aberherald	5.20 b	3.12 b	2.73 b	4.09	3.71 b	2.67 b
Alice	5.01 b	3.53 b	3.78 c	3.84	4.14 b	4.09 c
P value						
Clover cultivar	< 0.001	< 0.001	< 0.001	0.124	< 0.001	< 0.001
Clover * manure	0.529	0.487	0.301	0.831	0.740	0.626
LSD (5%)						
Clover cultivar	0.50	0.61	0.74	0.45	0.53	0.83

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

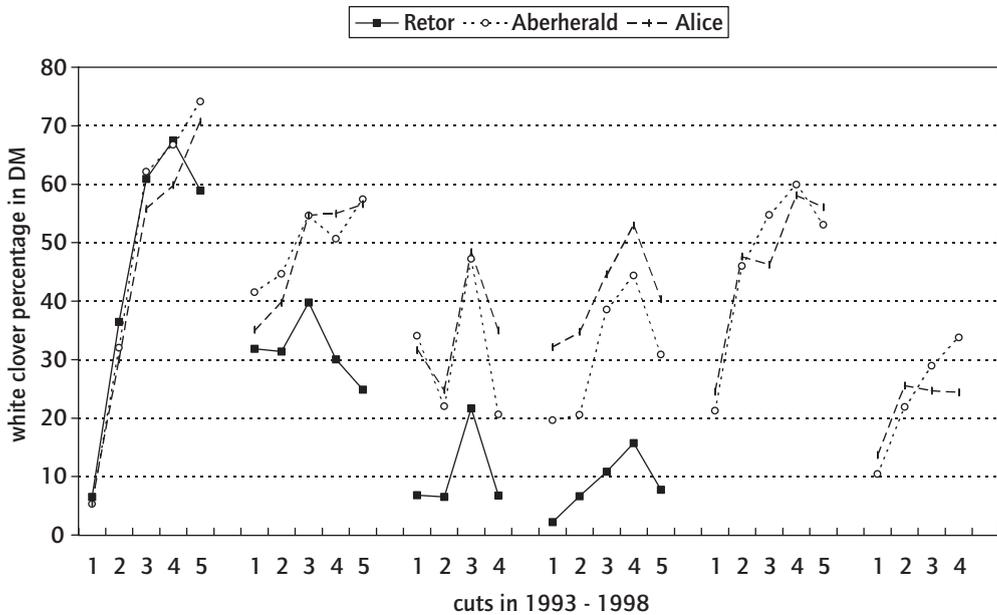


Figure 3.1. White clover content in DM herbage per cut (1993-1998)

Table 3.3. Nitrogen yields(kg N ha⁻¹ year⁻¹): effect of white clover cultivars averaged over three manure types of the trials 'cutting' (left) and 'grazing' (right) (1994-1996).

Year	1994	1995	1996	1994	1995	1996
Trial	----- 'cutting' -----			----- 'grazing' -----		
Mean	365.9	269.4	-	370.8	295.8	-
Clover cultivar						
Retor	343.2 a	195.8 a	-	371.4	271.3 a	-
Aberherald	380.1 b	302.3 b	-	368.4	305.1 b	-
Alice	374.5 b	310.0 b	-	372.6	311.1 b	-
P value						
Clover cultivar	< 0.001	< 0.001	-	0.921	0.001	-
Clover * manure	0.267	0.385	-	0.981	0.585	-
LSD (5%)						
Clover cultivar	16.4	20.2	-	22.2	19.5	-

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

with manure type. Under 'grazing' cv. Retor persisted much better than under 'cutting'. In 1995 and 1996 mixtures with cv. Retor had a lower clover yield than mixtures with cvs. Alice and Aberherald ($P < 0.001$). White clover of cv. Alice out-yielded cv. Aberherald in both trials in 1996. From the last cut in 1993 onwards, the percentage of cv. Retor declined and by the end of 1995 it had virtually disappeared (Figure 3.1). In all years mixtures with cvs. Alice and Aberherald contained the highest amount of white clover in DM ($P < 0.001$).

N yields in the harvested herbage were reduced for the mixture with cv. Retor in 1995 for both trials ($P < 0.001$ and 0.001), (Table 3.3) and under 'cutting' also in 1994 ($P < 0.001$).

3.3. Slug damage

The clover leaf area removed by slugs was twice as high for mixtures with cv. Retor compared to the other two cultivars ($P < 0.001$), (Table 3.4). There was no interaction with manure type ($P = 0.530$).

Table 3.4. Percentage of leaf area removed by slugs as an average of three measurements (3rd and 4th cut 1994 and 3rd cut 1995), trial 'cutting'.

	Percentage leaf area removed by slugs (%)
Mean	18.2
Clover cultivar	
Retor	26.2 b
Aberherald	14.9 a
Alice	13.6 a
P value	
Clover cultivar	< 0.001
LSD (5%)	
Clover cultivar	2.8

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

3.4. Stolons

Effects of manure types and white clover cultivars on stolon length and weight in 1993-1996 are shown in Table 3.5 for the trial 'cutting' and in Table 3.6 for the trial 'grazing'.

Cv. Aberherald had the highest stolon length and weight in comparison with the other cultivars, except in June 1996, when the results were the same for cvs. Alice and Aberherald. From June 1994 on, cv. Alice outyielded cv. Retor as well.

In the trial 'grazing' cv. Aberherald had the highest stolon length and weight in comparison with the other cultivars, except in June 1996, when the results were the same for cvs. Alice and Aberherald. From November 1994 on, cv. Alice outyielded cv. Retor as well. In the trial 'grazing' the decline of cv. Retor was somewhat delayed in comparison to 'cutting'.

Table 3.5. Stolon weight (g m^{-2}) and length (m m^{-2}): effect of white clover cultivar on values in spring (06.1994, 05.1995 and 06.1996) and autumn (11.1993 and 11.1994) in the trial 'cutting'

Date as month.year	1193	0694	1194	0595	0696	1193	0694	1194	0595	0696
	---- weight in g m^{-2} ----					---- length in m m^{-2} ----				
Mean	224.0	81.1	130.8	80.2	35.0	176.1	111.2	136.6	122.7	54.1
Clover cultivar										
Retor	183.1 a	62.5 a	65.5 a	30.1 a	9.5 a	166.8 a	106.0 b	86.1 a	58.6 a	20.2 a
Aberherald	311.8 b	112.1 b	192.4 c	126.2 c	45.5 b	218.2 b	131.5 c	182.3 c	177.0 c	67.7 b
Alice	176.9 a	68.8 a	134.5 b	84.2 b	50.0 b	143.3 a	96.1 a	141.4 b	132.5 b	74.4 b
P value										
Cultivar	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001
M x C	0.734	0.064	0.535	0.335	0.254	0.833	0.536	0.508	0.895	0.280
LSD (5%)										
Cultivar	33.7	12.8	20.7	18.0	18.3	24.1	18.9	16.2	31.0	26.1

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

Table 3.6. Stolon weight (g m^{-2}) and length (m m^{-2}): effect of white clover cultivar on values in spring (06.1994, 05.1995 and 06.1996) and autumn (11.1993 and 11.1994) in the trial 'grazing'

Date as month.year	1193	0694	1194	0595	0696	1193	0694	1194	0595	0696
	---- weight in g m^{-2} ----					---- length in m m^{-2} ----				
Mean	208.3	82.0	99.2	53.9	39.2	148.9	113.6	97.5	81.2	61.7
Clover cultivar										
Retor	171.2 a	78.4 a	61.2 a	30.9 a	15.6 a	142.9 a	100.1 a	68.0 a	51.7 a	30.5 a
Aberherald	279.9 b	117.8 b	147.0 c	79.3 c	49.5 b	180.3 b	148.9 b	135.4 b	112.4 c	72.4 b
Alice	173.9 a	80.4 a	89.4 b	51.5 b	52.4 b	123.4 a	91.7 a	89.1 a	79.5 b	82.2 b
P value										
Cultivar	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
M x C	0.902	0.770	0.770	0.044	0.950	0.922	0.917	0.920	0.274	0.979
LSD (5%)										
Cultivar	32.8	23.5	23.5	12.3	16.4	22.4	25.3	22.8	18.5	24.1

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

The interaction between manure type and clover cultivar in June 1995 ($P = 0.044$) for stolon weight was caused by different effects of manure in cv. Retor compared to cvs. Aberherald and Alice. Cv. Retor was lowest in PK and did not show differences between FYM and SLU, whereas the other cultivars were highest in FYM.

Specific stolon weight

Stolons of cv. Aberherald had the highest specific stolon weight (g/m), whereas this was lowest for cv. Retor. Specific stolon weight increased from June till November in all cultivars. The correlation between stolon length and weight was stronger in May than in November (Table 3.7).

Stolon losses during winter

Differences between May or June and the previous November measurements were regarded as winter losses. The best calculated average regression line of two succeeding winters was curvilinear (Table 3.8). Losses were higher if stolon weight in November was higher. Losses were lowest for cv. Aberherald. Cv. Retor had the highest losses.

At a level in November of about 150 g m^{-2} stolons, cv. Aberherald only lost 37% of weight, whereas cvs. Alice and Retor lost 50% and 60%, respectively.

Table 3.7. Specific stolon weight (g per meter stolon) based on stolon weight (Y in g m^{-2}) and stolon length (X in m m^{-2})

Clover cultivar	May	November
Retor	$Y = 0.59 X (R^2 = 0.95)$	$Y = 1.07 X (R^2 = 0.89)$
Aberherald	$Y = 0.75 X (R^2 = 0.91)$	$Y = 1.32 X (R^2 = 0.70)$
Alice	$Y = 0.67 X (R^2 = 0.92)$	$Y = 1.16 X (R^2 = 0.71)$

Table 3.8. Correlation between stolon weight in November (X in g m^{-2}) and losses during winter as the difference between May/June and November counts.

Retor:	stolon weight losses from Nov. till spring = $0.3587 X + 0.0016 X^2 (R^2 = 0.93)$
Aberherald:	stolon weight losses from Nov. till spring = $0.1595 X + 0.0014 X^2 (R^2 = 0.88)$
Alice:	stolon weight losses from Nov. till spring = $0.0908 X + 0.0027 X^2 (R^2 = 0.83)$

3.5. Discussion

3.5.1. White clover persistency

The main effect of the clover cultivar choice was the reduction followed by a complete disappearance of cv. Retor. The loss of white clover affected average total yield, white clover yield and percentage, N yield and N concentration in the trial 'cutting'. Under 'grazing' the effects on the different yield parameters were delayed for one year and effects were smaller under 'grazing' than under 'cutting'.

In comparison with 'cutting', the average white clover yields and percentage of cv. Retor were higher under 'grazing' for Retor (24% to 16%). Differences between the trials 'grazing' and 'cutting' could be explained by the differences in internal recycling of nutrients. All plots were grazed at the same date and N in urine and dung from grazed animals was spread over all grazed treatments, PK-plots included.

In other comparisons of white clover cultivars, positive outcomes of winter survival and the higher spring yield of cv Aberherald were found by Collins *et al.* (1996). Cv. Huia was used as a control cultivar and differences between cultivars were more pronounced in the colder areas of Europe. In the same period Elgersma and Schlepers (1997) also found a lower yield in mixtures with cv. Retor in comparison to cv. Alice in a three year trial. In the third year the clover percentage in the mixture with cv. Retor still made up 40% of the total DM production, whereas in our trials this was reduced to 8% ('cutting') and 13% ('grazing'). In the subsequent years of production Elgersma *et al.* (1998) again found significant effects from white clover cultivars. Under cutting mixtures with the large-leaved cultivar Alice generally produced the highest total yield, the highest white clover yield and contained the highest N concentration, whereas mixtures with cv. Retor generally showed the lowest figures. In a comparison of leaf damage by invertebrates cv. Retor had the most severe leaf damage compared to cvs. Alice and Gwenda (Li Fengrui, 1999). Schils *et al.* (2000) compared cvs. Alice and Retor under farm conditions. Fields resown with cv. Retor all showed a significant reduction of clover abundance after 2 or 3 years, whereas fields containing cv. Alice all showed a constant level of white clover (40-60%) at the end of each growing season. Therefore, the comparison of clover cultivars under Dutch conditions all with the local standard cultivar Retor showed the same effect of white clover cultivars.

Damage to clover foliage by weevils and slugs was negatively related to the cyanogenic potential of clover (Mowat and Shakeel, 1989). Cv. Retor is described as a low cyanogenic clover, whereas new cultivars such as Alice and Aberherald show very high levels of HCN. Crush and Caradus (1995) investigated the cyanide concentrations of 51 white clover cultivars. The HCN concentrations in cv. Alice ($942 \mu\text{g g}^{-1}$ DM) were 7.8 times higher than concentrations in cv. Retor. Cv. Alice was one of the eight cultivars where the concentration exceeded $800 \mu\text{g g}^{-1}$ DM.

The authors concluded, that cultivars that were agronomically successful in New Zealand were mainly highly cyanogenic.

Because of animal health risks, clover cultivars with medium and high levels of cyanide are not allowed in Switzerland. Thyroid levels in cattle were unaffected by the intake of high amount of cyanide rich clover, but the blood selenium levels (as GSH-pX) were decreased (Lehmann *et al.*, 1990).

In a large field trial, Clements and Murray (1993) calculated an average loss of leaf area in white clover eaten by pest organisms of 12% per year. The main organisms reducing leaf area were *Sitona* weevils (8%). Slug damage was only responsible for 2% of loss. However, in our trial 14-26% of the leaf area was removed. In our study only the 3rd and 4th cut were examined, whereas the maximum leaf area removed by pest organisms according to Clements and Murray, was found in early spring (18%).

Statistically significant differences between mixtures with cvs. Aberherald and Alice were found in 1996, both for 'cutting' and 'grazing' and in 1997 and 1998 for 'grazing' (data not presented here). White clover yields in spring were higher for cv. Alice. Differences between the two cultivars might be affected by the genetic difference in leaf size. Under a cutting regime a positive correlation was found between clover leaf size on the one hand and white clover yield and total herbage yield on the other (Evans and Williams, 1987; Frame and Boyd, 1987; Elgersma and Schlepers, 1997). However, our trials showed opposite results: under a management of alternate grazing and cutting ('grazing') clover of the cultivar with the largest leaf size cv. Alice out-yielded the medium-leafed cultivar Aberherald (Table 3.2). Although cv. Aberherald was selected for a better winter survival, a better performance of cv. Alice after 1996 was found due to severe winter cold in 1995/96 and 1996/97. Cv. Aberherald did not show the expected improved spring yield. In two relatively mild winters, no differences were found in total herbage yield and early spring yield in mixtures with cvs. Aberherald, Abercrest and Menna (Sheldrick *et al.*, 1993). Cv. Menna even showed a tendency to a higher white clover yield, like cv. Alice did in our trial. There was also a better live weight gain by lambs in spring on mixtures with cv. Menna. (Sheldrick *et al.*, 1996).

3.5.2. White clover growth in spring in relation to stolon growth

This study showed that cv. Aberherald had a larger stolon length and weight than cv. Retor, and a greater white clover and N yield. Besides it had a higher N concentration in the first cut (data not shown). However, the total herbage DM yields of the first cut were not affected by clover cultivar. A reduced white clover growth in spring was compensated by increased grass growth. The percentage of stolons lost during winter was lower for cv. Aberherald than for cv. Retor.

Compared with cv. Alice, cv. Aberherald had the highest stolon weight and length in May 1994 and 1995. In May 1996, no differences were found. The comparison of herbage spring yield over the period 1994-1998 did not show any increased herbage spring yield, white clover yield and percentage N or N yield for cv. Aberherald. Mixtures with cv. Alice produced the highest spring yield (1997) and white clover yield in the 1st cut (1996 – 1998), (data not shown). Even after the most severe winters (1995/96 and 1996/97), there were no signs of a better white clover production in mixtures with cv. Aberherald. Sheldrick *et al.* (1993) also did not find any increased yields of mixtures with cv. Aberherald, compared to other clover cultivars (Menna, Abercrest). Stolon length and weight in spring, therefore, were poor indicators for herbage growth in spring. Instead of stolon weight in spring, high levels of total non-structural carbohydrates (TNC) in the stolons in winter were the most important factor affecting early spring yield. Other morphological characteristics were of no importance (Frankow-Lindberg *et al.*, 1996). For Nordic areas it was concluded that TNC levels in autumn were associated with low losses of stolons during winter. Swedish cultivars had a much better ability to accumulate TNC than cv. Aberherald. Collins and Rhodes (1995) used artificial freezing to investigate winter survival of white clover. Results of their trials also suggest that stolon carbohydrate content is an important factor in the overwintering of white clover. Further glasshouse experiments of Turner and Pollock (1998), showed an accumulation of starch in young stolon tissue. The synthesis and maintenance of starch reserves during cold periods was an important factor to explain differences in winter hardiness. Spring growth of white clover was found to be correlated with high levels of stolon starch (Frankow-Lindberg and Frame, 1997).



4. Effects of manure types on herbage yields, mineral yields and botanical composition of grass-clover mixtures with cv. Alice

4.1. Additional methodology

In this chapter the effects of manure type are analysed. Only data from mixtures with cv. Alice will be presented here from all three trials 'cutting', 'grazing' and 'levels'. The effects of manure type in the trial 'levels' will be analysed as an average of the three levels. Except for K yields, effects of manure levels will not be discussed, because as a result of the plot history. Effects of manure levels were confounded with the previous experimental design of different oversowing dates of white clover in 1994.

In the trials 'cutting' and 'grazing', manure and fertiliser were generally applied in March. In accordance with the plan, FYM plots received the manure earlier (14 March) than the SLU-plots (29 March) and PK-plots (26 March). These timings were strategically chosen on the basis of the supposed optimum timing for each manure type. The objective was to apply FYM and SLU at a rate which supplied approximately 100 kg total N ha⁻¹ (1993-1995) or 150 kg total N ha⁻¹ (1996-1998) (Table 4.1).

In the trial 'levels', on average, the application of FYM (4 March) was about three weeks earlier than the 1st application of PK and SLU. All FYM was applied before the 1st cut, whereas SLU and PK applications were split over the 1st three cuts.

In all trials, the PK plots received the lowest amount of K and an intermediate level of P. The ratio of K to P was highest in SLU and lowest for PK. The SLU treatment received the highest amount of directly available, inorganic N. For FYM the total N amount was equal to SLU.

The botanical composition was assessed once only, in August 1998. Data were used from trials 'cutting', 'grazing' and 'levels'. All measurements were based on visual estimation by an experienced person. All species were listed and the abundance per species was estimated. The sum of all abundance values was 100%.

From an agronomic point of view grass species were divided into three groups: good, moderate and poor. This judgement was based on a mixture of plant characteristics: growth, digestibility and negative elements like being poisonous and stoloniferous (Kruyne *et al.*, 1967 and De Boer and De Gooyer, 1979).

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Table 4.1. Overall input of nutrients (kg ha⁻¹), trials 'cutting', 'grazing' and 'levels'. For the trial 'levels' values are presented as an average of three application levels.

Manure type	--- trials 'cutting' and 'grazing' --- (1993-1998)				--- trial 'levels' --- (1996-1998)			
	Total N	Inorga- nic N	P	K	Total N	Inorga- nic N	P	K
PK	0	0	23	146	0	0	35	195
SLU	126	62	16	188	196	98	26	267
FYM	140	22	33	218	203	41	47	323

* after the 2nd cut in 1995 all plots received an extra potassium dressing of 133 kg K ha⁻¹. This amount is included in the average figures

All Dock plants were removed every winter between 1994-1996. The number of removed plants per plot were counted.

4.2. Total herbage dry matter yields

In 1994 and 1995 in the trial 'cutting', no differences were found between the manure treatments (Table 4.2). From 1996 on, when the amount of applied manure was increased by 50%, differences in yield were significant. Plots fertilised with PK always had the lowest yield. Only in 1997 plots fertilised with FYM out-yielded SLU ($P < 0.001$). The overall DM yield for 'cutting' was lowest for PK in comparison to the plots who received FYM or SLU (on average: - 1.21 t DM ha⁻¹; $P = 0.003$).

In the trial 'grazing' plots fertilised with FYM and SLU out-yielded PK in 1995-1998. Differences between FYM and SLU showed a larger yield fluctuation between years than in the trial 'cutting'. The overall DM yields were the same in FYM and SLU. The application of animal manure (FYM or SLU) increased the overall DM yield by 1.27 t DM ha⁻¹ ($P = 0.004$) compared with PK fertilised plots.

In the trial 'levels' the yields were highest for FYM and SLU in all years. Only in 1996 plots fertilised with SLU had the same yield as PK fertilised plots. The overall DM yields were not significantly different for SLU and FYM, which both out-yielded PK (on average: + 0.97 t DM ha⁻¹; $P < 0.001$).

Table 4.2. Total yield (t DM ha⁻¹ year⁻¹) for the trials 'cutting' and 'grazing' (1994-1998) and the trial 'levels' (1996-1998): effects of manure type.

Year	1994	1995	1996	1997	1998	Mean
	----- 'cutting' -----					
Mean	10.60	10.40	9.44	10.61	9.37	10.09
Manure type						
PK	10.11	9.95	8.21 a	9.31 a	8.83 a	9.28 a
Slurry	10.80	10.75	9.82 b	11.05 b	8.92 a	10.27 b
FYM	10.90	10.50	10.30 b	11.46 c	10.37 ab	10.71 b
P value	0.214	0.259	0.008	< 0.001	0.001	0.003
LSD (5%)	1.05	1.08	1.09	0.40	0.60	0.60
	----- 'grazing' -----					
Mean	10.01	10.00	9.66	-	11.07	10.18
Manure type						
PK	9.41	9.42 a	8.50 a	-	9.87 a	9.34 a
Slurry	10.44	10.11 ab	10.68 b	-	11.21 b	10.61 b
FYM	10.18	10.47 b	9.79 b	-	12.00 b	10.61 b
P value	0.252	0.030	0.010	-	0.039	0.004
LSD (5%)	1.40	0.71	1.16	-	1.46	0.64
	--- 'levels' ---					
Mean			10.40	11.64	9.78	10.61
Manure type						
PK			9.94 a	10.76 a	9.17 a	9.96 a
Slurry			10.38 ab	11.98 b	10.01 b	10.79 b
FYM			10.89 b	12.17 b	10.16 b	11.07 b
P value			0.031	< 0.001	0.002	< 0.001
LSD (5%)			0.46	0.32	0.41	0.29

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

4.3. White clover yields

In the trial 'cutting' there was only a significant effect of manure type in 1994, when the clover yield in FYM out-yielded white clover in PK. In the other years no significant effects of manure type on white clover yields were found (Table 4.3). In 1998 the white clover yield was much lower than in previous years for all manure treatments. Effects in the trial 'grazing' were similar to those in the trial 'cutting'. Overall effects were not found.

In the trial 'levels', the white clover yield was negatively affected by the application of SLU in

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1997 and 1998 and FYM in 1998 compared with PK. In 1998 the white clover yield was more than halved, compared to 1996 and 1997.

The overall DM yield was reduced after the use of both types of animal manure (on average: - 1.18 t DM ha⁻¹; P = 0.024).

Table 4.3. White clover yields (t DM ha⁻¹ year⁻¹) for the trials 'cutting' and 'grazing' (1994-1998) and the trial 'levels' (1996-1998): effects of manure type.

Year	1994	1995	1996	1997	1998	Mean
	----- 'cutting' -----					
Mean	5.01	3.53	3.78	4.52	1.84	3.74
Manure type						
PK	4.46 a	2.98	2.50	3.56	1.88	3.08
Slurry	4.74 ab	3.72	4.52	4.51	1.57	3.81
FYM	5.84 b	3.90	4.31	5.48	2.06	4.32
P value	0.042	0.417	0.259	0.221	0.469	0.203
LSD (5%)	1.06	1.67	2.94	2.38	0.92	1.49
	---- 'grazing' ----					
Mean	3.84	4.21	4.09	-	1.71	3.49
Manure type						
PK	3.27 a	3.66	3.87	-	2.27	3.32
Slurry	3.70 a	3.96	4.47	-	1.40	3.56
FYM	4.54 b	5.01	3.94	-	1.55	3.61
P value	0.021	0.098	0.769		0.350	0.739
LSD (5%)	0.80	1.33	2.27		0.85	0.96
	---- 'levels' ----					
Mean			5.25	5.63	2.16	4.38
Manure type						
PK			5.61	6.34 b	3.26 b	5.17 b
Slurry			4.64	4.97 a	1.73 a	3.78 a
FYM			5.51	5.59 ab	1.50 a	4.20 a
P value			0.223	0.019	0.005	0.024
LSD (5%)			1.31	0.83	0.87	0.91

Within a column, data followed by the same letter are not significantly different at P < 0.05.

4.4. Nitrogen, phosphorus and potassium yields

4.4.1. N yields

In 1994 and 1995 no differences were found between the manure treatments in the trial 'cutting' (Table 4.4). From 1996 on, higher amounts of manure (Table 2.1) were applied and differences in N yield were observed, except in 1998. Plots fertilised with PK always had the lowest yield. In 1997 plots fertilised with FYM out-yielded SLU (+ 33.7 kg ha⁻¹; P = 0.001). The overall N yield was highest for both FYM and SLU treatments (+ 51.6 kg N ha⁻¹; P = 0.025) compared to PK fertilised plots.

Table 4.4. Total nitrogen yields (kg N ha⁻¹ year⁻¹) for the trials 'cutting', 'grazing' (1994-1998) and trial 'levels' (1996-1998): effects of manure type.

Year	1994	1995	1996	1997	1998	Mean
	----- 'cutting' -----					
Mean	374.6	310.0	296.3	359.0	244.7	316.9
Manure type						
PK	353.8	291.0	242.0 a	308.8 a	217.0	282.5 a
Slurry	375.5	323.5	324.6 b	367.3 b	255.8	329.3 b
FYM	394.5	315.5	322.2 b	401.0 c	261.3	338.9 b
P value	0.114	0.367	0.031	0.001	0.164	0.025
LSD (5%)	39.5	53.7	63.6	33.4	52.5	38.6
	----- 'grazing' -----					
Mean	373.2	313.7	297.9	-	282.7	317.0
Manure type						
PK	345.6	296.6	271.5	-	273.6	296.8 a
Slurry	387.3	316.1	329.5	-	295.7	329.4 b
FYM	386.7	328.2	292.8	-	278.6	324.8 b
P value	0.091	0.126	0.150	-	0.510	0.040
LSD (5%)	43.5	31.9	65.2	-	46.2	25.4
	----- 'levels' -----					
Mean			337.2	409.5	255.7	330.0
Manure type						
PK			324.5	388.9 a	258.3 ab	321.5
Slurry			340.5	433.8 b	271.5 b	338.8
FYM			346.7	405.8 a	237.5 a	329.8
P value			0.365	0.003	0.038	0.293
LSD (5%)			36.2	18.4	24.3	24.3

Within a column, data followed by the same letter are not significantly different at P < 0.05.

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In the trial 'grazing' no effects from the manure treatment were found. However, the overall N yield was increased after application of SLU and FYM (on average: + 30.3 kg N ha⁻¹; P = 0.040) compared to PK fertilised plots.

In the trial 'levels', the use of SLU positively affected the N yield in 1997 compared to PK and FYM and to FYM only in 1998. The N yield was much lower in 1998 than in earlier years. There were no overall effects of manure type on N yield.

Table 4.5. Total phosphorus yields (kg P ha⁻¹ year⁻¹) for the trials 'cutting' and 'grazing' (1994, 1996-1998) and the trial 'levels' (1996-1998): effects of manure type.

Year	1994	1995	1996	1997	1998	Mean
			----- 'cutting' -----			
Mean	46.3	-	32.3	39.8	36.7	38.7
Manure type						
PK	46.7	-	29.5	37.3	36.3	37.4
Slurry	46.2	-	33.8	40.3	34.0	38.6
FYM	46.0	-	33.5	41.8	39.8	40.2
P value	0.988		0.101	0.154	0.130	0.378
LSD (5%)	8.5		4.4	4.7	6.0	4.7
			----- 'grazing' -----			
Mean	45.3	-	32.4	-	45.0	41.6
Manure type						
PK	42.9	-	29.3	-	43.0	38.4 a
Slurry	46.3	-	35.6	-	44.8	43.0 b
FYM	46.8	-	32.3	-	47.3	43.5 b
P value	0.172		0.093		0.411	0.024
LSD (5%)	4.8		5.9		7.3	3.6
			----- 'levels' -----			
Mean			37.9	44.1	38.9	39.7
Manure type						
PK			36.7	41.2 a	38.7	38.4 a
Slurry			38.1	45.2 b	38.6	39.5 ab
FYM			38.9	45.9 b	39.3	41.2 b
P value			0.122	0.002	0.767	0.022
LSD (5%)			2.2	1.9	3.3	1.8

Within a column, data followed by the same letter are not significantly different at P < 0.05.

4.4.2. P yields

In the trials 'cutting' and 'grazing' there were no significant differences among manure treatments in any year (Table 4.5). In the trial 'grazing', however, the overall P yields were higher in both FYM and SLU than in the PK treatment (on average: + 4.9 kg P ha⁻¹; P = 0.024).

In the trial 'levels', the P yield was increased in 1997 after the use of both SLU and FYM compared to PK. The overall P yields were lowest for PK and highest for FYM (+ 2.8 kg P ha⁻¹; P = 0.022).

4.4.3. K yields

In the trial 'cutting' there were significant differences among manure types on K yields in 1994 (Table 4.6). Generally, in all years except in 1998, K yields in FYM and SLU were similar. In 1998 FYM out-yielded both SLU and PK. The overall K yields were highest in FYM in comparison with SLU (+ 29.1 kg K ha⁻¹; P < 0.001). Plots fertilised with SLU also out-yielded PK (+ 40.0 kg P ha⁻¹; P < 0.001).

In the trial 'grazing' no effects of manure type on K yields in 1994 and 1995 were found. In 1998 the K yield was highest in plots fertilised with FYM (P = 0.004). In 1995 K yields in SLU fertilised plots were higher than in FYM (P = 0.021). There were no overall differences between manure types. The average K yield in the trial 'grazing' was higher than in the trial 'cutting' (+ 56.6 kg K ha⁻¹), which was due to the recycling of urine and faeces in the trial 'grazing'.

In the trial 'levels', the K yield in 1996 was higher for FYM than for SLU fertilised plots. In 1997 all manure types had a different K yield, FYM was highest, SLU moderate and PK had the lowest K yield. In 1998 FYM out-yielded both SLU and PK. The overall K yields were highest for FYM (+ 63.4 kg K ha⁻¹; P < 0.001), whereas SLU did not affect the K yield compared to PK.

In the trial 'grazing', there was a recycling of N, P and K via animal dung and urine, but this did not affect total N and P yields or N and P concentrations in the herbage (Figure 4.1 and 4.2). The concentration of K in herbage was higher for 'grazing' than under 'cutting' (Figure 4.3). Under 'cutting', the K concentration decreased during the growing season from 27 till 17 g K kg⁻¹ DM.

In the trial 'levels', in 1997 and 1998 the K yields were highest after application of the high level of manure and lowest at the low application level (data not shown). The overall increase of K was + 50.5 kg K ha⁻¹ from the low to the medium level, and + 36.5 kg K ha⁻¹ from the medium to the

Table 4.6. Total potassium yields (in kg K ha⁻¹ year⁻¹) for the trials 'cutting' and 'grazing' (1994-1998) and the trial 'levels' (1996-1998).

Year	1994	1995	1996	1997	1998	Mean
			----- 'cutting' -----			
Mean	258.4	228.1	216.6	235.3	230.3	233.7
Manure type						
PK	224.5	201.3 a	186.8 a	192.8 a	181.5 a	197.4 a
Slurry	277.6	242.0 b	226.3 b	249.5 b	191.5 a	237.4 b
FYM	273.0	241.0 b	236.8 b	263.8 b	318.0 b	266.5 c
P value	0.205	0.006	0.004	< 0.001	< 0.001	< 0.001
LSD (5%)	70.0	21.6	22.8	22.9	26.1	17.6
			----- 'grazing' -----			
Mean	301.2	270.7	270.9	-	311.4	290.3
Manure type						
PK	274.9	252.9	249.4 a	-	242.0 a	260.5
Slurry	322.1	276.7	321.9 b	-	311.2 b	304.0
FYM	306.5	282.4	241.6 a	-	381.0 c	306.4
P value	0.361	0.163	0.021		0.004	0.081
LSD (5%)	75.4	34.4	50.4		56.1	45.1
			----- 'levels' -----			
Mean			287.4	312.6	274.8	287.9
Manure type						
PK			285.3 ab	283.3 a	230.9 a	263.2 a
Slurry			273.8 a	309.2 b	251.9 a	270.4 a
FYM			303.1 b	345.4 c	341.7 b	330.2 b
P value			0.032	0.001	< 0.001	< 0.001
LSD (5%)			20.2	22.3	21.2	18.6

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

high level of application ($P < 0.001$). There was an interaction between manure type and manure level for K yield in 1998 ($P = 0.035$). In FYM, K yields were not affected by the level of application, whereas both other manure types showed significant effects of increased levels of application. Compared to all other yield measurements, only the K yields were affected by an increased level of manure application.

4.5. 1st cut yields

On average, plots fertilised with PK had a lower overall DM yield than SLU-plots (+ 0.71 t ha⁻¹; $P < 0.001$) or FYM-plots (+ 0.50 t ha⁻¹). In 1998 herbage yield was very high. There was an

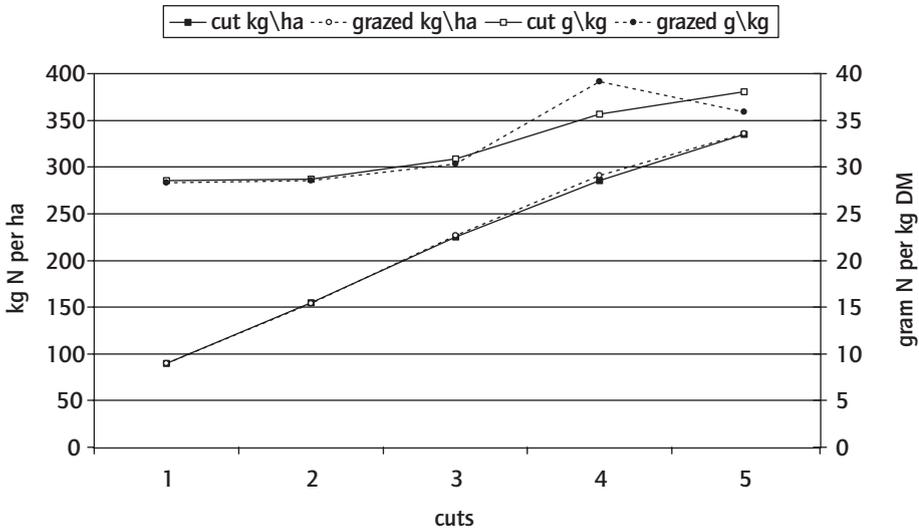


Figure 4.1. Accumulated N yield ¹ and N concentration in DM of each cut in the trials 'cutting' and 'grazing' as an average of three manure treatments (1994, 1995, 1996, 1998)

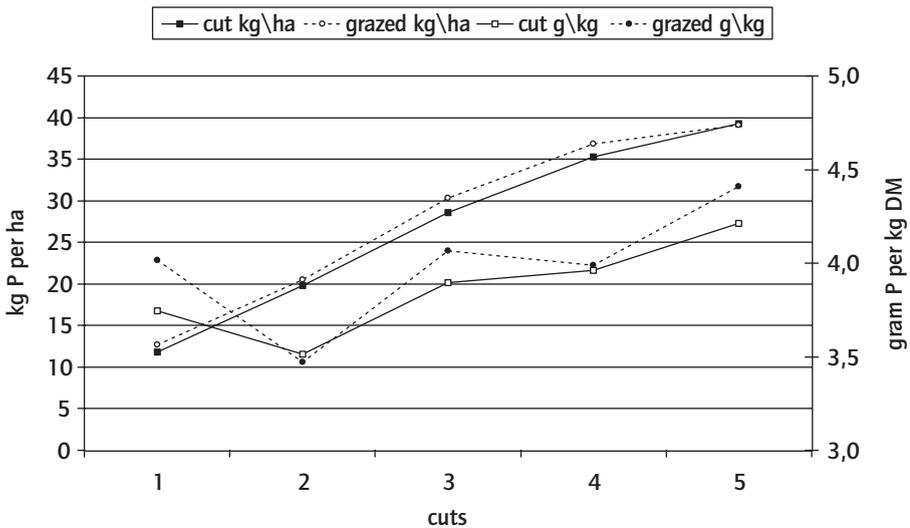


Figure 4.2. Accumulated P yield ¹ and P concentration in DM of each cut in the trials 'cutting' and 'grazing' as an average of three manure treatments (1994, 1995, 1996, 1998)

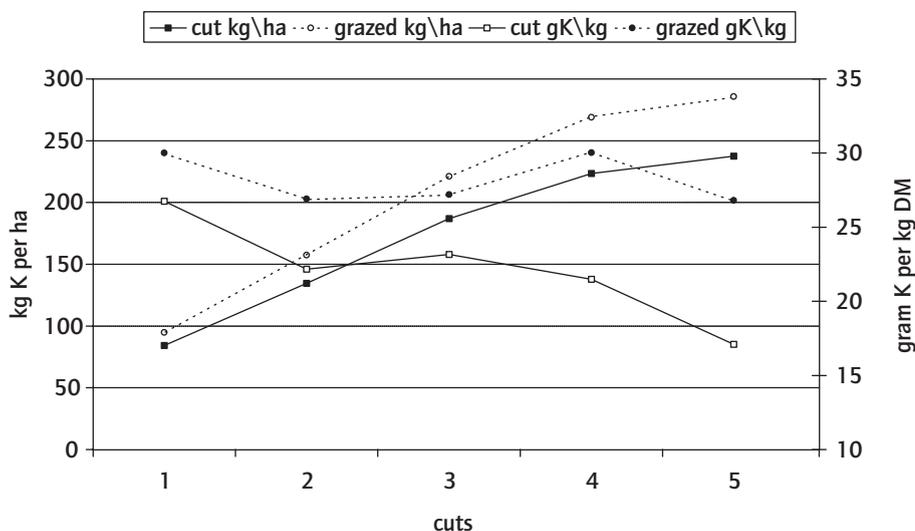


Figure 4.3. Accumulated K yield¹ and K concentration in DM of each cut in the trials 'cutting' and 'grazing' as an average of three manure treatments (1994, 1995, 1996, 1998)

interaction with year ($P = 0.003$). White clover yields and white clover contents in DM herbage were unaffected, see Table 4.7.

The interaction between manure type and year for DM yield (Table 4.8) depended on the time of manure application and weather conditions in winter and spring (Chapter 5.5). In 1994 and 1996 no effects of manure application were found. The lack of effects in 1994 may have been due to late application in spring and in 1996 because of a severe winter followed by a delayed timing of application. Significant effects of manure application on early spring growth were found in years with a mild winter and an early application of manure (1995, 1997 and 1998). In 1995 and 1998 there were no differences between SLU and FYM, whereas in 1997 SLU outyielded FYM ($+ 0.86 \text{ t ha}^{-1}$; $P = 0.003$).

White clover yields and percentages in DM were on average not affected by manure (Table 4.7). Only in 1995 clover yields were lower for SLU ($- 0.37 \text{ t ha}^{-1}$; $P = 0.002$) than PK and FYM. After 1995 white clover yields were reduced and in 1998 clover yields were very low, mainly because of the high herbage yield (4.42 t ha^{-1}). Especially the high total herbage yield for FYM in 1998 negatively affected the white clover percentage in DM ($P = 0.001$). Clover percentage in herbage DM had the same result in 1995 ($- 17.1\%$; $P = 0.002$).

Table 4.7. Yields of the first cut: effect of manure type on the total DM yield, white clover yield and clover percentage in DM, N, P and K yield; trial 'cutting' for mixtures with cv. Alice (1994-1998) Table 4.6. Total potassium yields (in kg K ha⁻¹ year⁻¹) for the trials 'cutting' and 'grazing' (1994-1998) and the trial 'levels' (1996-1998).

	Total	---- White clover ----		N	P	K
	---- t DM ha-1 ----	%		--- kg ha-1 ---		
Mean	3.05	0.79	22.3	88.7	11.5	83.7
Manure type						
PK	2.65 a	0.77	29.1	75.2 a	10.3	66.0 a
SLU	3.36 b	0.75	22.8	100.7 b	12.7	95.4 b
FYM	3.15 b	0.85	27.0	90.1 b	11.4	89.8 b
Year						
1994	2.52 a	0.89 bc	35.7 b	93.6 c	12.1 c	79.2 b
1995	3.32 b	1.05 c	32.1 b	97.6 c	N.A.	62.7 a
1996	2.35 a	0.75 ab	32.3 b	70.8 a	7.8 a	66.1 a
1997	2.67 a	0.65 ab	25.9 b	84.2 b	10.4 b	81.8 b
1998	4.42 c	0.61 a	14.2 a	97.3 c	15.5 d	129.0 c
P value						
Manure	0.003	0.800	0.527	0.003	0.083	0.001
Year	< 0.001	0.007	0.001	< 0.001	< 0.001	< 0.001
M x Y	0.003	0.149	0.227	0.251	0.199	< 0.001
LSD (5%)						
Manure	0.35	0.36	13.0	10.7	2.2	10.6
Year	0.24	0.25	10.3	8.4	1.4	8.8

N.A. = not available

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

Table 4.8. Annual herbage DM yields of the first cut (t DM ha⁻¹): effect of manure type in the trial 'cutting' for mixtures with cv. Alice (1994-1998)

	1994	1995	1996	1997	1998
Mean	2.52	3.32	2.35	2.67	4.42
Manure type					
PK	2.31	2.86 a	2.16	2.00 a	3.94 a
SLU	2.63	3.65 b	2.60	3.44 c	4.51 b
FYM	2.62	3.44 b	2.29	2.58 b	4.80 b
P value	0.113	0.027	0.231	0.003	0.018
LSD (5%)	0.36	0.54	0.57	0.59	0.52

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

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On average, N yields were highest for SLU and FYM in comparison to PK ($P = 0.003$), (Table 4.7). However, after 1995 SLU always out-yielded PK for N yield (Table 4.9). In 1995 and 1998 SLU also out-yielded FYM.

The lowest N yield was found in 1996. Manure application was delayed in that spring.

On average, P yields were not affected by manure type (Table 4.7). P yields were correlated with herbage DM yield. The lowest P yield was reached in 1996. Only in 1997 SLU out-yielded both FYM and PK ($+ 4.9 \text{ kg P ha}^{-1}$; $P = 0.020$).

Table 4.9. Yields of the first cut: effect of manure type per year on N yield in the trial 'cutting' for mixtures with cv. Alice (1994-1998)

	1994	1995	1996	1997	1998
Mean	93.6	97.6	70.8	84.2	97.3
Manure type					
PK	85.3	88.1	58.2 a	64.4 a	95.4 b
SLU	98.5	105.2	85.6 b	98.0 b	116.3 c
FYM	97.1	99.5	68.6 a	90.1 b	80.0 a
P value	0.096	0.414	0.016	0.010	< 0.001
LSD (5%)	13.3	29.7	16.1	18.4	9.8

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

K yields were highest for SLU and FYM ($P = 0.001$). K yields were also correlated to the herbage DM yield, but K yields had an interaction with year ($P < 0.001$), see Table 4.10.

In all years, except 1996, K yields in PK-plots were the lowest. In 1996, however, K yields were lowest for FYM as well. K yields were higher for SLU than for PK. In 1997 SLU also outyielded FYM, which was correlated to the DM yield (Table 4.8). In 1998 FYM out-yielded SLU, which again was correlated to herbage DM yield.

Effects of manure on N concentrations were not significantly different, but PK tended to have the lowest N concentrations (not shown). N concentrations were highest in 1994 and lowest in 1998 ($P < 0.001$). The low level in 1998 was correlated to the high herbage DM yield. Also P concentrations were not different among manure types; P concentrations were highest in 1994 (not shown). K concentrations were correlated to K yields. The use of SLU or FYM increased K concentrations in herbage ($P < 0.001$). There was an interaction with year ($P < 0.001$) (not shown).

K concentrations were lowest in spring 1995 ($1.87 \text{ g K kg}^{-1} \text{ DM}$). An extra fertiliser dressing of K was applied after the 2nd cut for all treatments, to maintain the clover in the sward. In most

years K concentrations were lowest for PK (1994, 1995, 1997 and 1998), although not always significantly so. In 1996, however, K concentrations were lowest for FYM ($P = 0.001$).

4.6. Botanical composition

After 6 years of treatment 25 species were found in the three trials together. The number of grass species was 13, legumes 1 and herbs, 11. Most species were perennial plants, *Polygonum aviculare* and *Poa annua* were annual weed plants (see Appendix 1).

In the comparison of plots with cv. Alice the number of species was the same for all manure treatments in the trials 'cutting', 'grazing' and 'low level' (Table 4.11). The abundance of the 'good' grass species was highest for PK and SLU ($P = 0.002$). The abundance of 'good' grass species was negatively correlated to the white clover abundance, which were highest for FYM ($P = 0.004$). In the trial 'grazing' the amount of white clover was lowest ($P = 0.048$). The amount of 'poor' grass species was highest for SLU ($P < 0.001$) and for the Trial 'grazing' ($P < 0.001$). The higher value was mainly because of the amount of *Poa annua*, which was highest for SLU ($P < 0.001$) and trial 'grazing' ($P < 0.001$). In all treatments only Docks were found in FYM ($P < 0.001$). Dandelion was also highest in FYM plots ($P = 0.002$).

In the trial 'cutting' the number of Dock plants removed from the plots tended to be higher for SLU than for PK and FYM (Table 4.12).

4.7. Yield residues after grazing

In the trial 'grazing', herbage residues after each grazed cut are shown. Manure was only applied before the 1st cut in spring (Table 4.13).

In neither of the cuts results were affected by the white clover cultivar ($P = 0.323$ for all data; data not shown). The overall residues after grazing were negatively affected by FYM ($P = 0.026$), (Table 4.13). The interaction with cut number was highly significant ($P < 0.001$) and effects of manure applied before the 1st cut in spring were only found for the 1st and the 2nd cut. Effects on the 1st cut residues were higher ($P = 0.002$) than on the 2nd cut ($P = 0.042$). The herbage residues after the application of FYM were + 149% and + 69%, respectively.

² This classification is related to characteristics of production capacity, digestibility and negative elements like poisonous and stoloniferous of each grass species Kruyne *et al.* (1967), (see Appendix 1).

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Table 4.11. Botanical composition of trials 'cutting', 'grazing' and 'low levels' as an average of manure type: number of species per plot, total abundance and abundance of white clover, addition of abundance of 'good', 'moderate' and 'poor' species² and Herbs, abundance of *Poa annua* (Pa), *Taraxacum spec.* (Dandelion) and *Rumex obtusifolius* (Docks).

	No species	Total	White clover	Good	Mode-rate	Poor	Herbs	Pa	Dandelion	Docks
	Plot⁻¹	abundance as percentage								
Mean	9.3	88.3	29.8	43.6	15.7	4.6	0.3	4.4	5.3	0.5
Manure										
PK	9.6	88.8	27.4 a	51.7 b	13.0	3.5 a	0.5	3.4 a	3.0 a	0.0 a
SLU	8.9	89.6	22.8 a	46.6 b	19.0	6.6 b	0.3	6.3 b	5.0 a	0.0 a
FYM	9.5	86.7	39.2 b	32.6 a	15.0	3.8 a	0.2	3.6 a	7.9 b	1.5 b
Trial										
Cutting	9.6	88.3	33.4 b	42.7	14.1	4.3 b	0.5	4.0 b	5.0	0.4
Grazing	9.0	88.8	22.8 a	47.0	14.8	7.0 c	0.4	6.8 c	6.5	0.8
low level	9.4	87.9	33.2 b	41.2	18.1	2.6 a	0.1	2.6 a	4.4	0.4
P value										
Manure	0.361	0.312	0.004	0.002	0.112	<0.001	0.330	<0.001	0.002	<0.001
Trial	0.494	0.911	0.048	0.481	0.328	<0.001	0.209	<0.001	0.235	0.262
M x T	0.548	0.347	0.331	0.682	0.826	0.649	0.641	0.551	0.847	0.258
LSD (5%)										
M and T	1.0	4.0	9.5	10.1	5.8	1.5	0.5	1.3	2.5	0.6

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

4.8. Discussion

4.8.1. Effects of manure on yield

The comparison of yields between the trials was hampered by the absence of measurements in 1997 for trial 'grazing' compared to 'cutting' and a shorter range of measurements for the trial 'levels'. Nevertheless, the overall total herbage yield was highest in the trial 'levels'. In all trials, the use of FYM and SLU increased total herbage yields compared to PK (on average + 1.26 t DM ha⁻¹). Application of FYM in 1997 showed that FYM could even out-yield SLU, but positive

Table 4.12. Total number of removed Dock plants between 1994-1996 in the trials 'cutting' and 'grazing', averages of three white clover cultivars (Retor, Aberherald and Alice)

	'cutting'	'grazing'
	No of plants plot⁻¹	
Mean	1.2	1.3
Manure		
PK	0.5	1.1
SLU	2.3	0.7
FYM	0.9	2.0
P value	0.073	0.164
LSD (5%)	1.6	1.4

Table 4.13. Effects of herbage residue after grazing; manure type as an average of three white clover cultivars Retor, Alice and Aberherald in trial 'grazing' 1994-1996. Yields in t DM ha⁻¹

Cut number	1st	2nd	3rd	4th	5th	All
Mean	273	286	418	278	241	287
Manure type						
PK	163 a	213 a	456	246	201	235 a
SLU	251 a	286 ab	397	301	254	285 ab
FYM	407 b	360 b	400	287	269	343 b
P value						
Manure (M)	0.002	0.042	0.581	0.138	0.234	0.026
Cut number						< 0.001
M x Cut number						< 0.001
LSD (5%)						
Manure	91	107	149	59	91	70

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

results were affected by favourable weather conditions and a high FYM quality.

Effects of applied manure on the first cut yield (Tables 4.7 and 4.8), however, showed that in all trials the herbage and N yields of the 1st cut were highest for SLU and lowest for PK (on average + 0.76 t DM ha⁻¹ and + 22.0 kg N ha⁻¹). Although differences in herbage yield between SLU and FYM were significant, on average the extra herbage and N yields after SLU were small (+ 0.25 t DM ha⁻¹ and + 16.5 kg N ha⁻¹).

The average total white clover yields were higher in the trial 'levels' than in 'cutting' and 'grazing'. This difference was also found for the average white clover percentage (42% to 37% and 34% in DM herbage respectively). White clover yields were reduced (- 1.08 t DM ha⁻¹) by the use of animal manure in the trial 'levels' and white clover was replaced by a larger amount of grass (+ 2.02 t DM ha⁻¹; $P = 0.001$) (data not shown). In the other trials, no significant effects were found, although in the trial 'cutting' the average white clover yield was increased by the use of animal manure (+ 0.99 t DM ha⁻¹). Differences, however, were only significant in 1994. In the PK plots, the white clover content was 52% in the trial 'levels' and only 33% and 36% in the trial 'cutting' and 'grazing', respectively (data not shown). The lower levels of applied fertiliser P and K in these trials (Table 2.2) might have mainly reduced white clover growth, because soil pH was similar for all trials.

The expected negative effect of N on white clover growth, irrespective of its organic or inorganic origin, was also found in several other trials (Buchgraber, 1983 and 1984; Van der Meer and Baan Hofman, 1999). In contrast with our trials Van der Meer and Baan Hofman (1999) could

distinguish between separate effects of either N, P and K. Schils and Sikkema (1992) distinguished between the N-effect of slurry application and the fragmentation of the stolons by the slurry injector on the white clover growth. He concluded that negative effects of slurry were explained as an effect of the amount of inorganic N. On a sandy soil, Van der Meer and Baan Hofman (1999) only found a negative effect of shallow injection on white clover in the 1st time of applied spring slurry in a grass-clover sward sown in May the year before. After recovery of the clover, effects of shallow injection could be explained from the level of inorganic N. This is confirmed by our findings. It was only in 1993, in the year of establishment, that SLU negatively affected white clover growth, although slurry was applied after the 1st cut. The more negative results in the 1st year after sowing seems to be more correlated to young clover plants with only a primary root instead of stoloniferous plants.

Another negative effect of the slurry application technique might be caused by wheel damage if soil conditions in spring are wet. Slipping and soil compaction from slurry application negatively affected total yields and yields in spring under wet conditions in a young sward on a clay soil (Humphreys *et al.*, 1997). In our trial on a sandy soil we could not detect any visual damage to the sward or the soil. On the other hand, under practical circumstances the application of FYM in early spring might cause wheel damage, when it is done by heavy machinery. Within an organic farming system it was found that increased tractor traffic significantly reduced the yield, the number of earthworms and N efficiency of the system (Hansen and Engelstad, 1999).

In our trials negative effects of applied manure on white clover yields were only found in the trial 'levels'. The low level of applied P and (mainly) K in the trial 'cutting', compared to the trial 'levels', led to a positive effect of FYM and SLU, because of the higher amount of K. The negative effect within the trial 'levels' was related to the higher and probably sufficient level of K in this trial (see Chapter 5.3).

The average N yields were only slightly higher under 'levels' (+ 13 kg N ha⁻¹) than in the other trials. They were similar for 'cutting' and 'grazing'. N yields were increased in the trials 'cutting' (+ 51.6 kg N ha⁻¹) and 'grazing' (+ 32.1 kg N ha⁻¹) by the use of both types of animal manure, but were unaffected in the trial 'levels'. N concentrations in herbage DM were very similar (31.2-31.4 g N kg⁻¹ DM) in all trials (data not shown). The overall N content tended to be lowest in FYM in the trial 'levels' (- 2.6 g N kg⁻¹ DM; P = 0.058) compared to the PK plots. The same tendency was found in the other trials, although differences were small (data not shown). The lower concentration of N in FYM might be caused by the lower level of inorganic N in FYM, compared to SLU. Another possibility is that N from the soil pool was used by microbes for the destruction of carbon in FYM.

Within each trial the N yields were determined by a combination of the grass and the white

clover yield and their respective N concentrations. Grass yield and grass N concentration are affected by the amount of applied N. Irrespective of the differences in average yield of white clover, there were hardly any differences in N yield, which showed a replacement of clover N by grass N. Grass N yields were increased by application of manure N. A comparison of clover DM yield and the average N yields within the PK-plots showed an increased N yield (283, 297 and 330 kg N ha⁻¹), if white clover yields increased (3.08, 3.32 and 5.17 t DM ha⁻¹ respectively).

The P-yields were lowest for PK in all trials compared to FYM plots (+ 3.1 kg P ha⁻¹) and only in the trial 'grazing' did FYM out-yield SLU in P yield. The P yields were correlated with the total herbage yield. The P concentration in DM herbage was negatively affected by the herbage DM yield and positively by the recycling of urine and dung. The PK plots had the highest P concentrations, which was combined with the lowest DM yield. The P concentrations in the PK plots were lowest in the trial 'levels', intermediate in the trial 'cutting' and highest in the trial 'grazing' (respectively, 3.7, 3.9 and 4.1 g P kg⁻¹ DM). All average P levels were sufficient for an optimal herbage growth. The levels were far above the levels of about 2 g P mentioned by several authors (Andrew, 1960; Rangeley and Newbould, 1985).

The K yields showed a different pattern in all three trials. The average K yield under FYM was always highest. Under 'cutting' FYM out-yielded SLU (+ 29.1 kg), whereas SLU out-yielded PK (+40 kg); under 'grazing' effects were not significant, because of the high variation in this trial caused by the deposition of urine and dung by the grazing animals. However, on average both FYM and SLU were very similar and out-yielded PK (+ 44.7 kg). In the trial 'levels' FYM out-yielded both PK and SLU (+ 63.4 kg). K yields were mainly affected by the level of applied K. In the trial 'levels' it was only for K that increasing levels of application showed an increased K yield and K concentration in DM, irrespective of the type of manure.

The K concentrations in herbage DM were lowest in the trial 'cutting' and highest in the trials 'grazing' and 'levels' (23.1, 28.5 and 27.1 g K kg⁻¹ DM respectively), (data not shown). In the trial 'cutting' and 'levels' the K concentrations were lowest for PK (P = 0.002 and P < 0.001) (data not shown). Therefore it was assumed that a low average herbage K concentration and especially the reduction of herbage K during the season, reduced the growth of white clover.

4.8.2. Interaction of manure type and level of K application

It was expected (Evans *et al.*, 1987) that a large-leaved cultivar like Alice would have performed better under the cutting regime (trial 'cutting') than a regime of cutting plus grazing (trial 'grazing'). The return of N in excreta and the behaviour of grazing animals will reduce the amount of clover in grazed swards (Wilkins, 1985). Nevertheless in the trial 'grazing', white clover

yields and clover percentages in DM were higher than in the trial 'cutting'. Additionally the low productivity of white clover in the PK plots of the trials 'cutting' and 'grazing' was in conflict with expectations. Normally N in animal manure should have reduced white clover growth. Negative effects of manure were only found in the trial 'levels', where a higher amount of PK, FYM and slurry was applied. In the trial 'cutting', however, clover yields were low in plots that did not receive any N. The lowest level of applied K in the PK plots reduced white clover more than the extra N in the SLU and FYM plots. Shortages of K suppressed the white clover development for PK in trial 'cutting'. The low herbage mineral concentration and the visual plant symptoms showed that the level of applied K restricted the growth of white clover. K shortages were higher in trial 'cutting' than in trial 'grazing'. The repetitive application of P and K in the trial 'levels' improved white clover growth by 100% compared to the trial 'cutting' (Table 4.3: 1996-1998). Chapman and Heath (1988) investigated the effect of cattle slurry on a mixture of grass-white clover. At inadequate levels of soil K, slurry was beneficial to the clover content of the herbage, although the overall slurry N negatively affected clover content and yield. This was also shown by González-Rodríguez (1993) in experiments on a sandy-loam soil. Higher levels of applied K (0, 83, 167 kg K ha⁻¹) led to a doubling of the white clover yield. Effects were highest at a low or zero level of N application. In a comparison of equal levels of diluted urine and dry NPK fertiliser, Castle and Drysdale (1963) found positive effects of urine, in comparison to NPK fertiliser, on herbage yield and clover content of a newly established mixture of meadow fescue and white clover. In these trials, the soil K level declined during the three experimental years and K concentrations in herbage were different between the types of manure. However, this could be explained by the different levels of applied K, which were about 52% in the fertiliser treatment compared to the diluted urine. From the data presented by Castle and Drysdale (1963), a positive correlation between the K concentration in DM herbage (X in g kg⁻¹ DM) and the white clover percentage in DM (Y as %) at the end of the trial was calculated: $Y = 1.99 + 10.71 X$ ($R^2 = 0.70$). Therefore at the same level of applied N, the amount of applied K also affected the growth of white clover. At low levels of K clover development was reduced.

In a grass-clover mixture with cv. Retor on a sandy soil (1993-1995), Van der Meer and Baan Hofman (1999) could distinguish between effects of P and K on total, white clover and N, P and K yields. In the 3rd year, plots not receiving any K had a clover content of only 1.5%, whereas the content of plots not receiving any P was 5.5%. The control plots had clover levels of 18.9% (moderate PK level) or 25.1% (high PK level). P concentrations in herbage were 4.1, 3.3, 4.2 and 4.2 g P kg⁻¹ DM, respectively of the treatments no K, no P, moderate PK and high PK. P concentrations in white clover herbage were even lower at a level of respectively 3.1, 2.6, 3.0 and 3.1. K concentrations in herbage DM were 16.7, 30.8, 28.5 and 31.8 g K kg⁻¹ DM and in the white clover only 7.7, 32.0, 31.5 and 35.2. Effects on white clover yield were therefore strongly

correlated with both the amount of K and P application. The reaction on K shortages, however, was even stronger than on P shortages. Evans *et al.* (1986) showed the strong relationship between white clover growth and K shortages. K was the primary limiting factor in the soil. In treatments without any applied K, white clover yield was negligible after 2 years, whereas the absence of P fertilisation showed a much later and less vigorous reaction on clover growth. Mean concentrations for P and K in white clover were 17 and 3.8 g kg⁻¹, respectively, as critical values for maximum plant growth. Baily and Laidlaw (1998) showed in a pot experiment that in the phase of establishment, the shoot and leaf development of white clover were more adversely affected by P than by K deficiency. The persistence of white clover in established swards, however, was reduced more by K deficiency than by low or inadequate P supplies. There was a considerable reduction in leaf size, number of growing points, stolons and root masses at deficient K levels. In a 65 year experiment in permanent pastures on a dry sandy soil, De la Lande Cremer (1976) found herbage yields in between 6.7 and 10.1 t DM ha⁻¹. K yields, however, were very constant at 152-160 kg K ha⁻¹ and P yields fluctuated with the total herbage yield. The level of P in herbage was sufficient (0.40-0.41 g kg⁻¹) and the K levels were low (16-17 g kg⁻¹) when N was supplied and moderate (24 g kg⁻¹) when no N fertiliser was used. The level of K restricted the herbage production of all treatments. The results of De la Lande Cremer are very similar to our results, although K levels were higher in our trials. In a survey of Swiss organic farms, Mäder *et al.* (2000) showed a negative trend in soil K concentration after conversion towards organic. Other major elements and trace elements were unaffected. In a small additional experiment in 1998 (trial 'cutting; unpublished results) plots with cv. Aberherald received an extra K dressing at a level of 60 kg ha⁻¹ after the 2nd and 3rd cut. Compared with control plots of cv. Alice a significant increase in total herbage yield, grass yield, P and K yield and K concentration in herbage DM was found (data not shown). White clover contents in herbage DM increased as well, but only significantly in the last cut of 1998.

4.9. Effects of manure on herbage residues after grazing

Herbage residues after grazing were highest for FYM applied in spring. However, effects were only found in the 1st and 2nd cut after spring application, which might be because of the smell and structure of FYM in the lower part of the sward. Effects were not found later in the season and visually we could not find any remains of FYM.

In our 'grazing' trial animals could choose between the manure plots. In a normal agricultural practice, however, animals cannot choose and effects might be smaller. There may be no effects on total herbage yield by manure type in practice, because in practice grazing is followed by a herbage cut and higher residues are harvested in the following cut or removed when topping the sward after grazing.



5. Effects of manure types on soil fertility and soil fauna

5.1. Additional methodology

In this chapter the effects of manure type are analysed. Effects of manure type on soil fertility are described for the periods 1994-1999 (trial 'cutting' and 'grazing') and 1997-1999 (trial 'levels').

For the trials 'cutting' and 'levels' nutrient field balances were calculated as input per ha in manure minus output in the herbage. Losses caused by leaching or build up in soil organic matter were ignored. In 1995 P yields were not measured. The positive correlation between herbage yield and P yield was used to estimate the P offtake in 1995.

To evaluate the efficiency and timing of manure application the apparent N efficiency (ANE) was calculated in relation to results of the first cut. Rainfall and temperature data in the 1st two weeks after manure application were used to analyse differences between years. The T-value was related to the date of application.

5.2. Soil fertility parameters

The average results for the trials 'cutting' and 'grazing' in soil pH, soil organic matter and soil P showed a proper development which was related to the manure type (Table 5.1 and Figures 5.1-5.4). Although the data were not statistically analysed, the differences in average mineral input in 1993-1998 were reflected in the average soil fertility levels in 1994-1999. Average soil-P and soil-K levels (Table 5.1) showed the same ranking as the average mineral input (Table 2.1, Chapter 2). In the trial 'cutting', the levels of fertility declined further than in the mixed regime of grazing and cutting (trial 'grazing'), (Table 5.1). Under 'grazing' the output of minerals was reduced, because of internal recycling of dung and urine.

The increase of soil organic matter (OM) and the decline in soil pH were different for all treatments. FYM showed the largest and PK the smallest increase in soil OM. Differences in increase were related to the level of input of organic matter. In FYM the pH level remained at the same level, whereas in PK and SLU soil acidity increased.

CHAPTER 5

Table 5.1. Trials 'cutting' and 'grazing': initial level of soil fertility and average soil fertility (layer: 0-5 cm; 1994-1999) as organic matter (OM), soil acidity (pH), P (P-AI) and K (K-HCl); above average value of the trials 'cutting' and 'grazing'; below average value of the three manure treatments ³.

	OM %	pH-KCl	P-AI mg P ₂ O ₅ /100 g	K-HCl mg K ₂ O/100 g
Initial value in 1993	3.0	5.4	44.0	13.0
Average value 1994-1999				
PK	3.9	4.8	37.2	9.3
SLU	4.2	5.0	33.8	10.3
FYM	4.7	5.4	38.3	12.6
Average of manure types (1994-1999)				
Trial 'cutting'	4.0	5.0	34.1	8.8
Trial 'grazing'	4.5	5.2	38.8	12.7

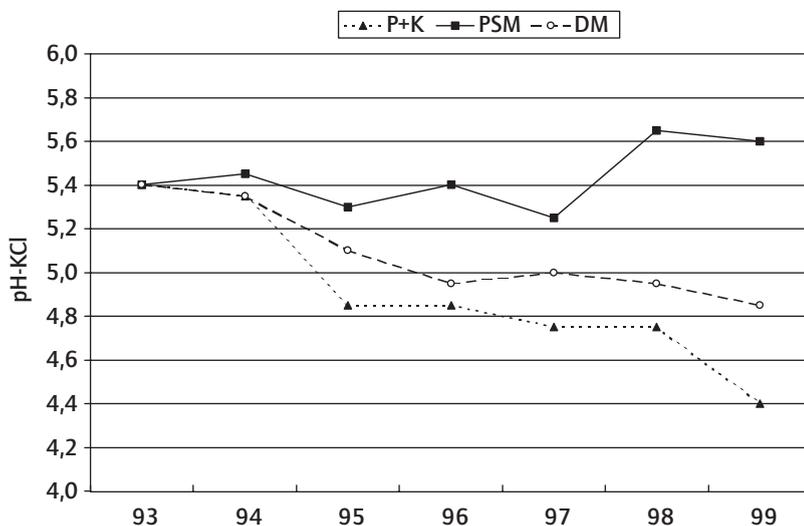


Figure 5.1. Development of soil acidity as pH-KCl as an average of the trials 'cutting' and 'grazing'

³ Soil fertility parameters were not statistically analysed, because only a single soil sample was taken per manure treatment per year. Results, therefore, should be treated as an illustration of a process.

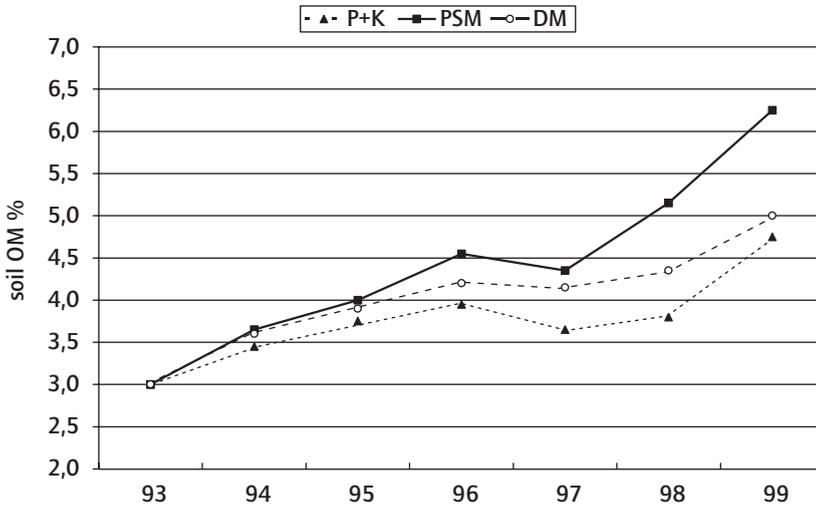


Figure 5.2. Development of soil organic matter as an average of the trials 'cutting' and 'grazing'

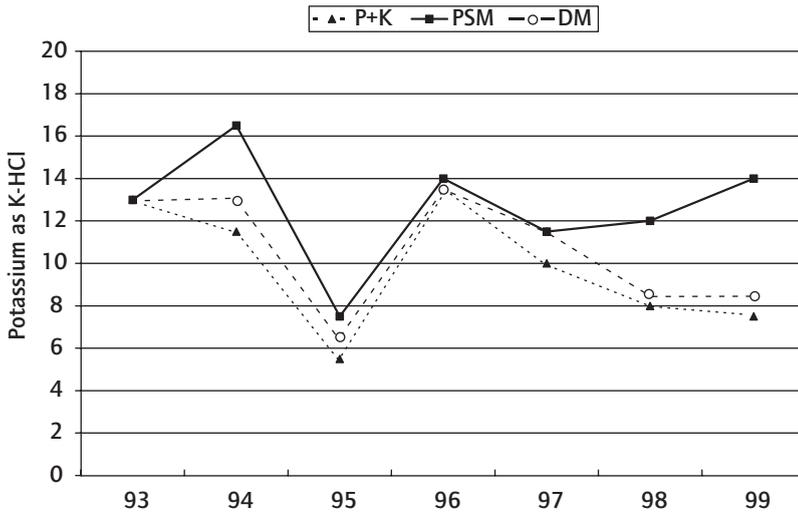


Figure 5.3. Development of soil fertility as K-HCl as an average of the trials 'cutting' and 'grazing'

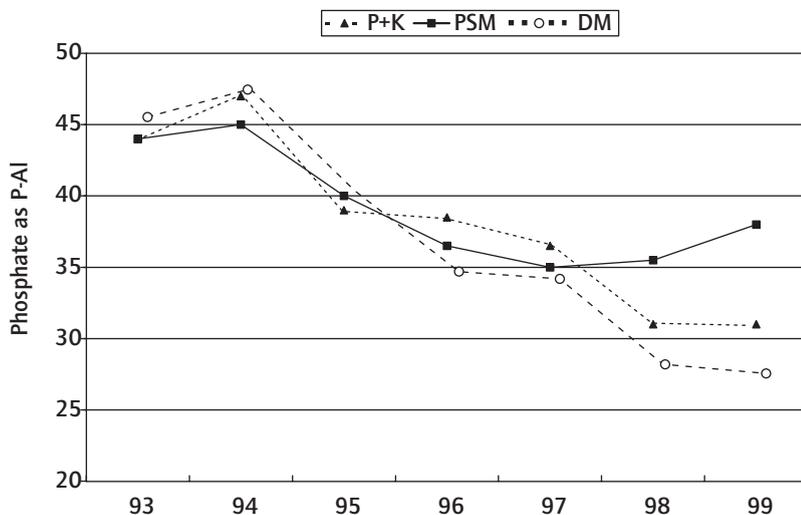


Figure 5.4. Development of soil fertility as P-AI as an average of the trials 'cutting' and 'grazing'

The initial soil fertility levels and the average levels of trial 'levels' in 1997-1999 are presented in Table 5.2.

The pH was highest in the FYM and lowest in PK-plots. The initial pH differences (4.9-5.4) were Table 5.2. Trial 'levels': initial soil fertility (average of 1995 and 1996) and average soil fertility (1997-1999) for three manure types.

	pH-KCl	OM %	P-AI mg P ₂ O ₅ /100 g	K-HCl mg K ₂ O/100 g
Initial level (1995 - 1996)				
PK	4.9	3.7	39.0	12.5
SLU	5.1	3.9	37.5	10.0
FYM	5.4	4.0	42.5	12.5
Average of three levels (1997 - 1999)				
PK	4.6	4.2	34.9	9.0
SLU	5.0	4.3	27.3	8.7
FYM	5.6	5.3	39.1	13.1

further increased during the experiment (4.6-5.6). PK led to a lower and FYM to a higher pH. These effects on pH were consistent with the development of soil pH in the trials 'cutting' and 'grazing' (Table 5.1).

The amount of soil OM increased for all treatments. The largest increase, however, was found for FYM, which was consistent with the other trials (Table 5.1).

SLU had the lowest average soil-P and soil-K levels (1997-1999). On average the soil-P levels were decreased by 10 points in all SLU-levels (data not shown). The medium and high levels of applied PK or FYM, resulted in similar or even higher soil-P levels in the top soil compared to the initial level (data not shown). The decrease of the soil-K level was largest in the PK plots (- 3.5 points). For FYM the soil-K level increased for both the medium and the high level of application (data not shown).

The results on changes in soil fertility were correlated with the different amounts of applied minerals for each treatment (Table 2.2, Chapter 2). A higher level of manure or fertiliser led to an increase of P and K levels in the soil.

5.3. Field balances for P and K

The output of P was equal for all manure treatments. Differences in P input ha^{-1} caused differences in P balances between the three manure treatments. The ranking for K input and K output was the same. FYM had the highest in- and output and PK the lowest (Table 5.3). K outputs reflected the amount of applied K, which was lowest in PK and highest in FYM (Table 2.1, Chapter 2). The field K balance was negative and similar for all manure treatments. The ratio of K and P input in manure was highest for SLU, because of its low level of P. PK and FYM showed on average the same K/P ratio. The K/P ratio in herbage was lowest for PK and highest for FYM.

Only at the highest K input level was the average K application sufficient to compensate for removal by the herbage (Table 5.4) The most negative field balance was found at the low level of PK. The application of P in SLU was lowest and FYM showed on average a surplus of P. At the high manure level, on average the P input showed a surplus as well.

Table 5.3. P and K field balance and the ratio between K and P in manure and herbage of the trial 'cutting' (average of 1994-1998).

	Input/output in kg ha ⁻¹						K/P-ratio			
	----- P -----			----- K -----			----- Manure -----		----- Herbage -----	
	Input	Output	Balance	Input	Output	Balance	Input	Output		
Manure type										
PK	24	39	-15	158	198	-40	6.6	5.1		
SLU	19	39	-21	200	237	-37	10.5	6.1		
FYM	34	40	-6	226	266	-40	6.7	6.7		

Table 5.4. P and K input and output ha⁻¹ and balances and K/P ratio in manure and in herbage: manure types as averages of three manure levels (average of 1996-1998).

	Input/output in kg ha ⁻¹						K/P-ratio			
	----- P -----			----- K -----			----- Manure -----		----- Herbage -----	
	Input	Output	Balance	Input	Output	Balance	Input	Output		
Manure type										
PK	35	39	-3	195	266	-71	5.6	6.8		
SLU	26	40	-14	267	278	-10	10.3	7.0		
FYM	47	41	5	323	330	-8	6.9	8.0		
Manure level										
Low	26	38	-12	188	247	-59	7.2	6.5		
Medium	36	41	-5	262	292	-30	7.3	7.1		
High	46	41	5	335	335	0	7.3	8.2		

Table 5.5. Relationship between mineral yield or mineral concentration and mineral input in the trial 'levels'; data of three manure types at three increasing manure levels as an average of 1997 and 1998 (for each equation N = 9)

	Yield (Y) as kg ha ⁻¹	Concentration (C) as g in DM herbage
Potassium (K):	$Y = 152 + 0.49 I (R^2 = 0.88)$	$C = 17.2 + 0.03 I (R^2 = 0.83)$
Phosphorus (P):	$Y = 38 + 0.09 I (R^2 = 0.38)$	$C = 3.8 + 0.00 I (R^2 = 0.02)$

The ratio of K to P in herbage was lowest for PK and SLU. Compared to P the provision of K was much higher in FYM. However the ratio of K/P in manure was highest for SLU. Increasing levels of manure application increased the K/P ratio in herbage. The output of K increased relatively more than the output of P.

In the trial 'levels' for all manure treatments three increasing levels of P and K were used. K yields (as Y in kg ha⁻¹) and K concentrations in herbage (C as g kg⁻¹ DM) were significantly related to the K input (I as kg ha⁻¹). The effect did not depend on manure type. The relation was poor or even absent for P (Table 5.5).

5.4. N efficiency

To evaluate the efficiency of the manure applied in spring, the apparent N efficiency (ANE) of the 1st cut yield was calculated for SLU and FYM as an average of the trials 'cutting' and 'grazing' (Table 5.6).

On average, the calculated ANE was twice as high for FYM as for SLU. However, differences between years were even larger and showed a range between 1.5 and 31.4 kg DM kg⁻¹ inorganic N. For FYM, rainfall in the first two weeks after application positively affected the herbage yield (1995 and 1998). However, effects were poor in 1994 although there was enough rainfall. Similarly lack of rainfall after slurry application negatively affected herbage yield. In the drier years (1994 and 1996) N-effects on yield were lowest. The lowest ANE for SLU was in 1994, when the application of slurry was delayed till the 3rd week of April, because of rainfall in March and April.

In Table 5.6 the T-value has been calculated for the day of manure application. In 1996 the temperature sum at the day of FYM application was below the advised T-value of 200. Spring N yields were poor, but the results were also affected by the low amount of rain.

Table 5.6. Apparent nitrogen efficiency (ANE): extra yield in kg DM of the first cut kg⁻¹ inorganic N of SLU and FYM compared to PK (average of mixtures with cv. Alice under 'cutting' and 'grazing'), the T-value at the time of manure application, and the precipitation during the first two weeks after application.

	1994	1995	1996	1997	1998	Mean
Apparent nitrogen efficiency						
SLU	1.5	14.9	8.3	17.7	13.0	11.8
FYM	13.5	31.4	6.5	16.6	29.2	22.1
T-value (°C)						
SLU	553	259	192	326	490	364
FYM	406	210	106	241	345	262
Rainfall (mm)						
SLU	6.9	41.0	8.2	25.1	17.3	19.7
FYM	67.8	52.7	0	8.9	75.4	41.0

5.5. Discussion

5.5.1. Effects of manure on soil fertility

The application of FYM to the sward increased soil organic matter faster than did slurry. A higher level of soil organic matter is expected to be positive for the development of white clover with regard to moisture in the soil, but negative from the point of view of nitrogen release. In the long-term experiments at Park Grass (Rothamsted Experimental Station), Cooke (1976) showed that the maximum variation in soil-N level was caused by manuring (0.21-0.35 %N) and by liming (0.21-0.32 %N).

On the humid sandy soil of our experiments, the application of slurry decreased the pH of the top soil. An increased acidity on sandy soils might be caused by the nitrification of ammonia (Van Faassen and Van Dijk, 1985). FYM maintained or even increased soil pH at the initial level of 5.4, which is an acceptable level for white clover (Frame and Newbould, 1986). In the long term, acidification will negatively affect the clover growth and the uptake of P and K from the soil. Extra liming might be needed to maintain an acceptable level of soil pH.

Low levels of soil pH (pH in water below 5.0) and calcium levels reduced nodulation of white clover (Andrew, 1976). In grass-clover swards Sheldrick *et al.* (1990) found a better P uptake in herbage at higher input levels of lime. In a comparative study with the same amounts of applied N, P and K in diluted urine and Nitro-chalk, superphosphate and muriate of potash, Drysdale (1965) explained different reactions on white clover growth by, among others, the reduced pH, because of the use of a combination of superphosphate and Nitrochalk. Urine with a pH of 8.6, on the other hand, increased the pH and K concentration in the top-soil and a positive effect on the clover development was found. Floate *et al.* (1981) described the interaction between soil pH and availability of K on deep peat soils. A low K supply was found when soil pH (water) was lower than 5.0. K deficiency was less acute when extra lime was applied. In our trials the ranking of the average soil K level after 6 years of manure application (Table 2.1) was related to the level of manure input and herbage output, but also to the ratio of K and P in the herbage (Table 5.3). PK plots always showed the lowest and FYM the highest levels. The supplied K did not depend on the manure type. In comparison to SLU and FYM, the shortage of K was highest in the PK plots. Therefore, the level of K application seemed to be more important than the difference in soil pH for the different manure types.

In our trials the negative effects of a decreased soil pH after the use of PK on white clover growth was primarily explained by the low amount of applied K (trials 'cutting' and 'grazing'). The low soil pH of the PK plots after 6 years of application (pH = 4.4 in spring 1999), also might have reduced the white clover growth. The overall growth of white clover in the trial 'levels', however, was high compared to the other manure treatments, despite the decreasing soil pH.

Changes in soil pH, but also in soil OM might have interacted with the availability of the major elements P and K.

The ranking of manure type for the soil P level in 1999 was the same as the ranking for the P field balance. SLU was lowest, PK was moderate and FYM had the highest figures. The SLU plots had the highest soil P depletion. The P output, however, was not restricted by the level of soil P or the input via manure P, which indicates that P was still not the most restrictive major element for plant growth. Shortages of P and K were also reflected in the botanical composition measured after six years of manure application. The vegetation was changed in the direction of the *Lolio-cynosuretum*, a vegetation type of the less intensive pastures (Westhoff and Den Held, 1969). The presence of non-sown species like *Leontodon autumnalis*, *Rumex acetosa*, *Festuca rubra*, *Anthoxanthum odoratum* and *Holcus lanatus* were signs of a decreased level of soil fertility.

5.5.2. Assessment of nutrient status in soil and herbage

To predict a sufficient dose of mineral supply needed for plant growth, chemical soil nutrient measurements can be used. However, data of soil analyses are not reliable for an indication of nutrient availability. They depend on the method of extraction (Salomons, 1998), the buffering capacity of nutrients in the soil (During and Duganzich, 1979), the depth of sampling in relation to the depth of plant roots and on differences in the absorption rate of nutrients between plant species (Dunlop *et al.*, 1979). To estimate the soil K status in grassland, some form of exchangeable K is used (Spencer and Govaars, 1982). With the sampling method used in this experiment (0-5 cm depth and HCl as extractant), the soil K level of 8 in spring was too low and the white clover showed significant K shortages and even died. An extra K dressing in 1995 led to a higher soil K level in 1996 (Figure 5.3). The higher average input from 1996-1998, still caused a gradual yearly decrease of soil K, because of a negative field balance. The higher K input in the FYM plots was reflected in a higher soil K level at the end of the trial and a higher offtake of K in herbage (trials 'cutting' and 'levels'). Nevertheless the K balance for SLU and FYM was the same, which was caused by a lower K concentration in DM herbage in the SLU plots. However, based on these data it was not possible to define the range of normal and luxurious consumption of K.

A factor affecting the estimation of the mineral supply for grassland is caused by differences in the mineralisation of P and K from the manure applied. The efficiency of K and P in shallow injected slurry on grassland, are the same as for artificial fertiliser K and P, if based on the uptake of P and K (Van Dijk, 1989a and b). They found that the uptake of slurry P was higher if the injection in spring was earlier. Most of the P applied in spring was taken up only from the 2nd cut

onwards. However, the mobility of K in the soil was much higher and the uptake of K was already 25% both in the 1st and the 2nd cut. In a 22-years experiment carried out in a typical *Arrhenaetherum*-meadow, comparing solid farmyard manure, slurry and artificial fertilisers, Künzli and Geerling (1973) also concluded that the P and K uptake was similar for all types of fertiliser.

Instead of the estimation of soil minerals, the nutrient status of white clover can be checked by means of the nutrient concentrations in plant tissue. With the critical value method (Jones and Sinclair, 1991) concentrations in plants are indicated as deficient, just adequate or safe excess. In legume based pastures in New Zealand those values have already been estimated for several regions. Problems with the comparison of results are caused by the stage of development in relation to the age of leaves (Wilman *et al.*, 1994), weather conditions and time of measurement. Recently, however, Morton *et al.* (1999) concluded that pasture yield response could be predicted by the level of available soil P, S and K, the amount of soil reserve K, and P, K and S concentration in mixed herbage. A level of 24 g K kg⁻¹ DM in mixed herbage was mentioned as a critical level for maximum yield.

In a soil deficient in P, K and Ca and consisting almost entirely of sand (92%), Andrew (1960) could find clear responses as optimum curves for P and K between mineral concentration in white clover and dry matter yield. In pot experiments critical concentrations were defined as the turning point with levels for P, K and Ca of 2.3, 11 and 10 g kg⁻¹ DM respectively. In field experiments the same levels were found for P and K (2.3 and 12 g kg⁻¹ DM). Higher applications of P and K led to luxury consumption. Visual symptoms of P deficiency were not accurate for the diagnosis of P nutrition, except for acutely deficient plants. Deficiency of K, however, showed a clear relationship with the level of K application. Clover plants grown at levels lower than the optimum all showed visual symptoms of K deficiency. Increased levels of Ca above the critical level showed a small increase in yield. In K deficient pastures Spencer and Govaars (1982) found a response in white clover growth to added K at a critical level of 15 g kg⁻¹ DM, which corresponded with a level of 12 g kg⁻¹ DM in total herbage. Rangeley and Newbould (1985) also calculated critical levels for P, K and Ca of respectively 2.0, 10 – 15 and 20 g kg⁻¹ DM. The results for P and K showed much similarity with other research findings. In this study there were overall differences in K concentration between the three trials (data not shown). Differences in between years were large. The most critical situation was found in 1995, when the K concentration in DM herbage in the first and second cut was only respectively 19 and 15 g K per kg DM (trial 'cutting'). In the second cut the clover died. After a potassium dressing the level increased till 32 g K per kg DM in the third cut and signs of K shortages were fully disappeared.

5.5.3. Field mineral balances

The field balance calculations (Table 5.3) showed a firm relationship between K yield and K application level, irrespective of manure type. A relationship with the P application level was not found. Therefore K uptake was regulated by the level of applied manure-K, whereas the P uptake was more related to the herbage yield.

Based on the experience in these trials, on this soil type an input of about 350 kg K ha⁻¹ and 42 kg P ha⁻¹ is necessary in a full cutting regime, to reach a zero field mineral balance. On the other hand, on sandy soils the buffer capacity for K was low and risks of leaching for N and K were high. Therefore some extra input is needed for building up soil fertility (organic matter and soil life) and to compensate for leaching during winter. For this type of soil with a small K buffer capacity, an even distribution over the growing season of K in farm waste, manure, effluent or fertiliser is important, otherwise this might lead to luxury consumption and undesired levels of K in the herbage (Younie *et al.*, 1994) or to low K levels at the end of the growing season.

5.5.4. Timing of manure application

The low clover yields in 1998 were due to a combination of an effective and early manure N application (28 Feb), a high FYM quality in terms of inorganic N amount (39 kg N ha⁻¹), the high winter and spring temperatures and the low precipitation during the growing season. Although the growing season in 1998 started very early, the total annual herbage yields were low. The early FYM application and the ideal growing circumstances in spring, however, were not followed by an earlier date of cutting. Therefore the spring yields were too high (4.8-5.0 t DM ha⁻¹), although the date of cutting was normal (19 May). The application of slurry was also very effective and 1st cut herbage yields ranged from 4.5-5.0 t DM ha⁻¹). The extreme high spring yields were associated with a very low white clover yield in the 1st cut. In the 2nd and 3rd cut a higher clover yield in the SLU and PK treatments compensated for the lower clover yields of the 1st cut. Plots fertilised with FYM showed a delayed regrowth. The higher annual DM yields in FYM and SLU were negatively correlated with the white clover yield and the white clover percentage. In 1998 FYM and SLU yielded only half the amount of white clover in comparison with PK. Therefore the reduced white clover yield was mainly caused by the poor cutting management of 1998 and not by changes in, for instance, soil pH or soil nutrient status.

The lower white clover yield in 1998 dramatically decreased the N yield for FYM and SLU. Therefore the N content in herbage of the PK plots was higher. The white clover content is one of the factors affecting the average N content. Additionally a higher level of available N in SLU could significantly increase the N content in comparison to FYM. This effect was significant mainly in the first two cuts.

Frame (1987) and Fisher and Wilman (1995) showed that the combination of applied N in

spring and a long interval between two defoliations were harmful for clover persistency. Applied N increased the number of grass tillers, reduced the number of white clover growing points and the amount of leaves in the upper part of mixed canopy (Laidlaw and Withers, 1998). Wilman and Fisher (1996) suggested that the risk of applied fertiliser N in out-competing white clover is higher than the risk of delayed defoliations. In our trial, applied N in spring 1998 in the SLU and FYM plots had the same negative effects on clover, although the date of application was 4 weeks later for SLU. PK plots without N application showed significant higher white clover levels in spring. In a young grass-clover sward on a sandy soil (Van der Meer and Baan Hofman, 1999), deep injection negatively affected white clover yield compared to shallow injection. However, effects were explained by differences in amount of applied inorganic N, which was twice as high for the deep injected plots. The date of cutting was the same for all plots and the double dose of applied N led to a very high grass yield and a reduced white clover growth. These findings are comparable to our results in 1998 and show that the date of manure application, the amount of applied N and the growing circumstances should be further optimised for each manure type separately. The date of the 1st cut herbage also should not be fixed, but should depend on the herbage mass present.

Bussink (1999) analysed the relationship between the T-value and the timing and level of fertiliser N on grass. A total of 5000 records were collected between 1960 and 1983. It was concluded that the optimal timing of fertiliser N application for grazing was at a T-value of 200, but for cutting this was at 300. Heavy rainfall or a cold period in the first two weeks after application reduced the effect of fertiliser N. The soil fertility in terms of P and K, soil type and temperature during fertiliser application, were important factors in explaining differences between years. The level of N was not important for the effect on yield (see also Prins *et al.*, 1988). Wightman *et al.* (1996) showed that timing of slurry application with regard to rainfall is important for the sward responses. Responses were found in above ground application of slurry and simulated rainfall within 3 h after application. Smothering of leaves negatively affected white clover development, but was avoided in our trial because slurry was injected. Another aspect of rainfall, however, is the reduction of ammonia volatilisation under cool and wet aerial conditions. In our trials we could find some evidence that rainfall after spring application affected N efficiency of applied N (Table 5.6).

On a sandy soil Schils (1997) showed that a spring application of 100 kg fertiliser N ha⁻¹ increased the first cut yield with 11.1 kg DM per kg applied N, which is comparable to the results obtained with SLU application in this experiment (Apparent Nitrogen Efficiency in Table 5.6). Differences between years were large and levels of ANE could be contradictory to each other,

depending on timing of manure application, soil conditions in spring and weather. Although rainfall was high in 1994 the effect of FYM was poor and the ANE was low (13.5 kg DM per kg N applied). Late application in 1994 and also in 1996 reduced the N effect for FYM and also SLU. In the winters with a high average temperature (1994/95 and 1997/98) the ANE of FYM was much higher than in other years. In 1998 FYM was applied about three weeks earlier than in other years.

The higher N response of FYM than of SLU might be affected by several factors. Firstly the timing of application was on average two weeks earlier than for SLU. A second possibility is that the lower level of inorganic N in FYM in comparison to SLU led to higher DM responses. In a range of DM responses per year of 3 to 30 kg DM kg⁻¹ N, the highest responses were found at N rates of 30 to 60 kg N ha⁻¹ (Frame and Newbould, 1986). The third possibility is that the methodology of determination of easily degradable N in FYM is not adequate and therefore inorganic N might be underestimated.

De la Lande Cremer (1953) also calculated the N-effect of FYM on herbage yield. The most efficient use of FYM was found after spring application. A low level of application led to higher N efficiencies. The highest N efficiencies were found on sandy soils: 26.5% or 23.5 % of total N in relation to ammonium nitrate at a level of 20 and 40 t FYM ha⁻¹, respectively. Combinations of FYM and fertiliser N did not show a yield improvement. Increased levels of either FYM or fertiliser had the same effect on yield.



6. Interrelationship of results: N-fixation per ton white clover

In this chapter additional calculations are made based on the measurements discussed in previous chapters. Two questions were raised. The first question concerns the amount of N fixation in a sward. There are several reasons to assume an optimum curve instead of a linear relationship. If the amount of N that is cycling in the grass-clover system increases, the amount of fixation will decrease. Another mechanism for controlling the amount of clover is the ratio of grass to clover in the sward. At higher amounts of clover, there is less grass available to act as a nitrogen sink.

The results from previous chapters can also be used to discuss the question whether organic grassland production should be based on manure input or on N fixation.

6.1. Additional methodology

To calculate the amount of N fixation per tonne of white clover, data were used from the trial 'cutting' of the pure grass (data not shown) and the grass-clover plots (cv. Alice) between 1994-1998 and from trial 'levels' of the low level of manure application between 1996-1998 (Chapter 4, Tables 4.3 and 4.4). For each calculation, 52 yield measurements were used. These grass-clover plots showed a range of clover yields (0.5-8 tonne). Relations were calculated separately for the three manure types as polynomial relationships.

To calculate the contribution of manure N versus fixed N, the clover N contribution was calculated as the difference between grass-clover and grass yield or N yield for each of the manure types. The manure N contributions was calculated as the difference in grass-clover herbage or N yield between SLU or FYM results on one hand and PK results on the other hand.

6.2. N yield in relation to white clover yield

The relationship between white clover yield (X as tonnes DM ha⁻¹) and N yield (Figures 6.1-6.3: kg N ha⁻¹) was affected by the amount of directly available manure-N in the different treatments.

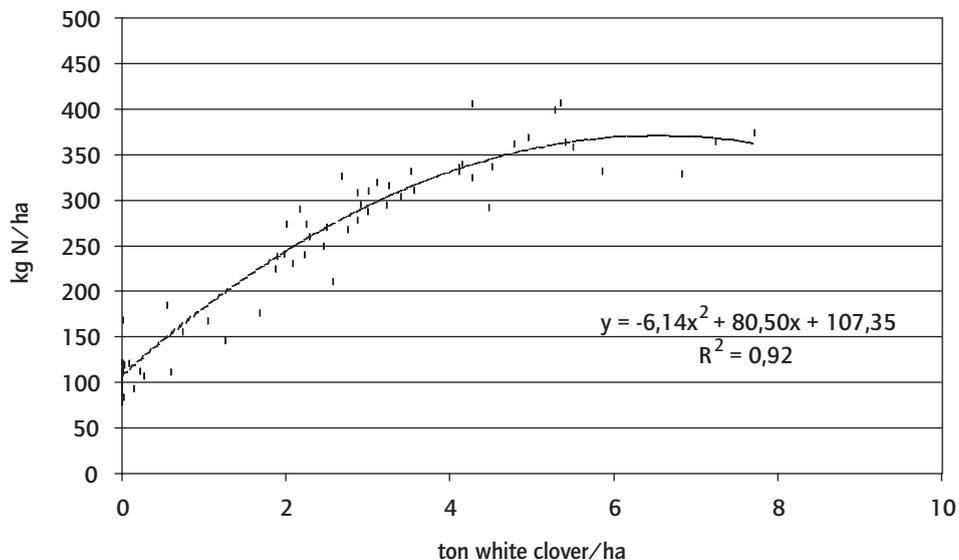


Figure 6.1. Polynomial relationship between white clover yield (t DM ha⁻¹) and total nitrogen yield (kg N ha⁻¹) with PK

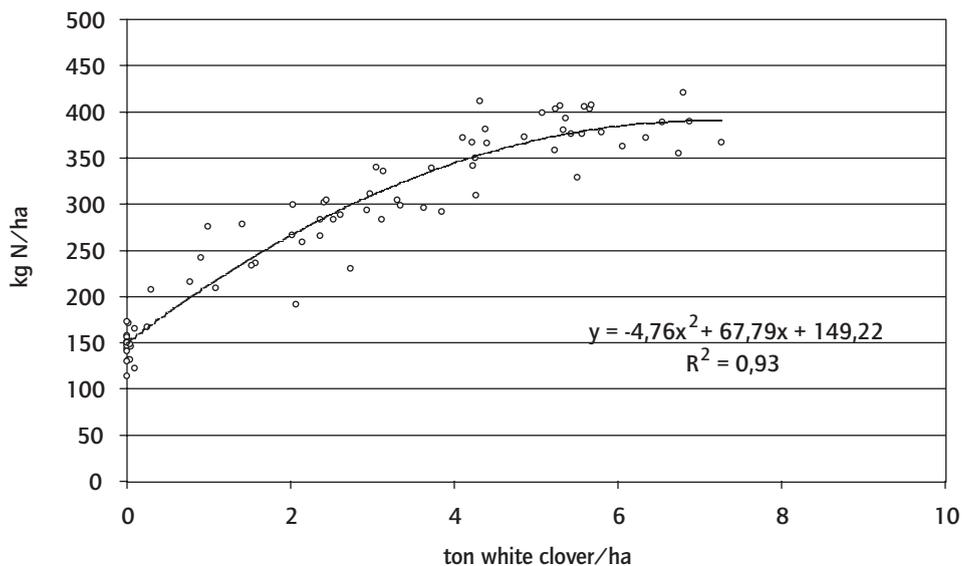


Figure 6.2. Polynomial relation between white clover yield (t DM ha⁻¹) and total nitrogen yield (kg N ha⁻¹) with FYM

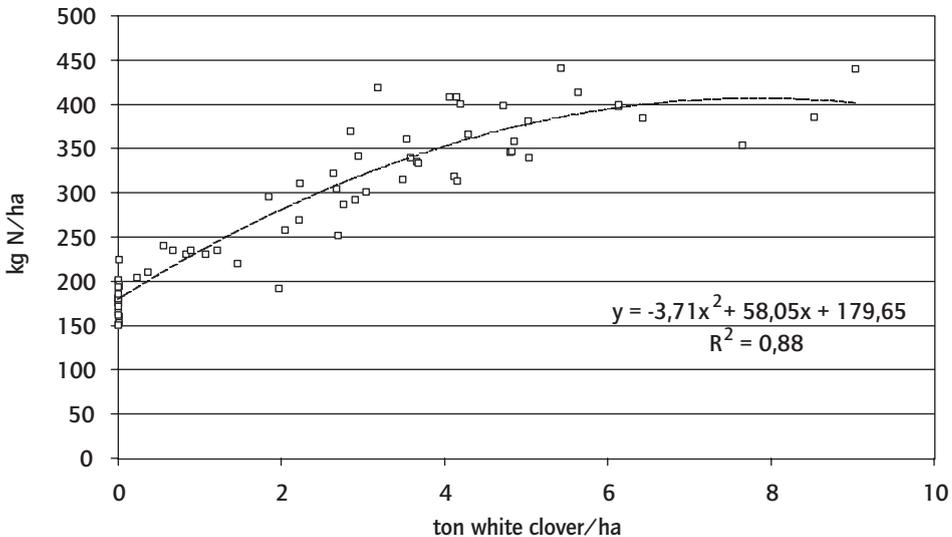


Figure 6.3. Polynomial relation between white clover yield (t DM ha⁻¹) and total nitrogen yield (kg N ha⁻¹) with SLU

In all regression models all values had $P < 0.001$ level of significance.

The polynomial relationship showed decreasing contributions of white clover to N yield if the amount of inorganic N increased. In the PK plots the highest N yield was at a level of 370 kg N ha⁻¹, which was reached at a yield of 6.8 t white clover ha⁻¹. The optimum levels for FYM and SLU were more similar at respectively 8.1 and 8.3 t white clover ha⁻¹ and both yielded 400 kg N ha⁻¹. To reach a maximum N yield, white clover contents in herbage yield were much higher than for the maximum DM yield. Clover contents in DM were respectively 68, 85 and 90%.

6.3. Manure N versus fixed N

The presence of white clover as well as the applied animal manure increased herbage yields and N yields (Table 6.1). To evaluate the importance of white clover versus animal manure as N source, N yields of grass-clover and pure grass stands were compared (Table 6.1 top: clover effect) and within the grass-clover plots animal manure (FYM and PK) were compared to PK (Table 6.1. bottom: manure effect).

Clover effect

In the PK-plots without any applied N, herbage yields on average were increased by 4.3 t ha⁻¹, because of the presence of white clover (Table 6.1 top). Where animal manure was used the yield difference between grass-clover and grass was reduced to 2.2 (SLU) and 3.7 t ha⁻¹ (FYM). The reduction of DM yield was highest in SLU where the highest amount of inorganic N was applied. Similar effects could be calculated for the N yields ha⁻¹. The extra N yield as a comparison between grass-clover and grass was highest in PK (+ 197 kg N ha⁻¹) and lowest in SLU (+ 142 kg N ha⁻¹), whereas FYM showed an intermediate level (+ 181 kg N ha⁻¹).

Manure effect

In the trial 'cutting' the level of white clover in PK was low and animal manure increased the amount of white clover. Within the grass-clover plots a comparison of manure types with (SLU and FYM) and without nitrogen (PK) showed an increase in yield in SLU of 0.9 t ha⁻¹ and in FYM of 1.4 t ha⁻¹ (Table 6.1. bottom). Differences in N yields were 47 and 56 kg N ha⁻¹, respectively. In the trial 'levels' the yield of white clover was reduced, when animal manure was applied. The increase in N yield after manure application in grass-white clover, therefore, was very low, because of an interaction between increased N input of animal manure and decreasing levels of white clover. Differences in N yields were only 8 and 2 kg N ha⁻¹ for respectively SLU and FYM.

Table 6.1. Yield differences of grass-white clover versus grass and N¹ for each manure treatment (top) and grass-clover yield differences between animal manure (as SLU or FYM) and only PK application as t DM ha⁻¹ and kg N ha⁻¹ (bottom). Data from trial 'cutting' (1994-1998) and from trial 'levels' at the low manure level (1996-1998)

Effects of clover	---- yield in tonnes DM ha-1 ----			---- yield in kg N ha-1 ----		
	PK	SLU	FYM	PK	SLU	FYM
Extra yield						
Trial 'cutting': 94-98	3.84	2.21	3.61	174.1	148.1	192.0
Trial 'levels': 96-98	4.73	2.24	3.81	219.2	135.4	170.2
Effects of manure	---- yield in tonnes DM ha-1 ----		---- yield in kg N ha-1 ----			
		SLU	FYM	SLU	FYM	
Extra yield						
Trial 'cutting': 94-98		0.99	1.43	46.8	56.4	
Trial 'levels': 96-98		0.86	1.37	7.7	1.9	

6.4. Discussion

6.4.1. N-fixation figures for white clover

The calculation of N fixation can be done by direct methods, using ^{15}N and by indirect methods, where pure grass stands are compared with grass-clover plots. Ennik (1982) summarised several authors who used this comparison technique and concluded that on average the level of apparent fixed nitrogen was 55 kg N t^{-1} white clover (range of 40-65). On a river clay soil Elgersma *et al.* (1998) and on a sandy soil Elgersma *et al.* (2000) calculated about the same range of N fixation, between $52\text{-}65 \text{ kg N t}^{-1}$ clover, with significant differences between cultivars. On a sandy soil, Van der Meer and Baan Hofman (1999b) investigated several slurry application techniques, timing of application, PK and NPK fertiliser treatments and their effects on N yields of pure grass and grass-clover swards. Differences between N sources and application techniques were negligible and the N fixation was calculated as on average 46 kg t^{-1} clover. In this study, the level of N fixation based on a linear relationship was lower. The calculated N fixation decreased, if applied inorganic N in spring increased. For PK, FYM and SLU, fixation levels were respectively 45, 40 and 34 kg N t^{-1} white clover.

All authors mentioned linear regression relationships between white clover yield and clover fixed N. Such a linear relationship will only be expected at lower levels of clover. However, instead of a linear relationship there are several reasons to look for an optimum relation as a polynomial model. If the clover amount in the sward increases, the N sink as accompanying grass decreases and therefore fixed nitrogen will be recycled by the clover. The optimum relationship between N ha^{-1} and white clover ha^{-1} found for PK, FYM and SLU fits the idea that the behaviour of white clover in a mixed sward is affected by the nitrogen soil pool. Increasing levels of external N sources will not only lead to higher grass yields and lower clover yields, but also to reduced N fixation (Nesheim *et al.*, 1990). In urine spots the amount of fixed N was reduced to half of the amount for spots without urine over a four month period (Vinther, 1998). N fixation by clover is least if the soil N pool is at a sustainable high level of N (Davidson and Robson, 1986). This might be the case if animal manure is used: a constant mineralisation of organic N may lead to reduced N fixation. A greater reduction in N fixation would be expected for FYM than for slurry, because of the higher level of organic N in FYM. Murphy (1985) suggested, that in fertile soils, nitrate levels might limit N fixation by inhibiting nodule formation or by reducing the nodule activities. Therefore the amount of fixed N is reduced at higher levels of soil nitrate. On the other hand, increased levels of white clover will lead to increased total DM and N yields. However, when the amount of white clover in the sward increases, the N fixation will decrease because of the increased amount of N in the soil pool and the turnover from clover fixed nitrogen

to grass. Fixation of N will decrease if the level of soil mineral N (via manure, mineralisation of soil OM or decomposition of white clover roots and buried stolons) increases. At low levels of white clover the sink for organic N will be the accompanying grass. When the clover yield of a mixed sward increases, the transfer of N to grass will decrease, because of the lower grass tiller density. White clover will take up its own fixed decomposed organic N. The transfer of nitrogen below ground from clover to grass was estimated on average as $70 \text{ kg N ha}^{-1} \text{ year}^{-1}$ (range 3 to 102) (Ledgard and Steele, 1992).

This non-linear relationship between N fixation, decomposition, turnover and uptake of mineral N will lead to a reduction of N fixation if the amount of clover in the sward increases. The 1st tonne of white clover will give the highest amount of fixation and this was calculated for PK, FYM and SLU respectively at levels of 70, 63 and 52 kg N t^{-1} white clover. At the optimum level of white clover, which was derived from the polynomial model, the N fixation level was only 7 kg N t ha^{-1} white clover for all manure applications.

This wastage in N response was confirmed by the work of Riffkin *et al.* (1999). In a survey of 71 sites, growth factors for grass-clover were associated with level of N fixation. On sandy loam soils, soil K, the number of rhizobia, the total soil N and the density of the nematode *Pratylenchus spec.* accounted for 72% of the variation in N fixation. The negative relation to total soil N supports the idea of decreasing N fixation at higher N levels.

6.3.2. Productivity effects of white clover-N versus animal manure-N

On commercial organic farms on sandy soils high levels of SLU were often used to maintain the production level of the grass-clover (Baars and Van Ham, 1996). Poor persistency of the white clover could be caused by inappropriate cultivar choice (Tables 3.1 and 3.2, Chapter 3).

Productivity in terms of dry matter yield and N yield of organic swards relies much more on the yield of white clover than on the input of manure. Clover yields in these trials depended on the level of P and K in each manure treatment in relation to the amount of N in the manure.

The increased yield of grass-clover compared to grass (clover-effect) was much higher than the increase of animal manure in relation to PK (manure-N-effect). Losses of white clover, because of management, therefore, will result in a higher dependency of external manure N. If a grass yield is required at a comparable level to the yield from grass-clover only applied with PK fertiliser, an amount of animal manure of over 50 tonnes or $\text{m}^3 \text{ ha}^{-1}$ is necessary. Effects of the absence of clover on N yield were even worse than on herbage yield. Differences between trial 'cutting' and 'levels' were caused by the larger depletion of soil K in the trial 'cutting'. If the soil P and K levels were increased, like in the trial 'levels', fixed N almost completely replaced manure N.

To reach a maximum N yield, a very high white clover content up to 90% was necessary. From an agronomic point of view, such levels are far from optimum. At these high levels, losses of N by

leaching will increase and forage losses at harvest will increase. The optimum levels found for herbage yield (43-65% in DM) are also higher than mentioned for an optimum grass-clover sward (30-40% and under sheep grazing (15-20%). Under cutting, however, levels up to 50-60% are acceptable. Differences in clover economy of organic swards were also distinguished by Newton (1995) in the UK. He found a significantly lower clover content in permanent pastures in comparison with leys (19.4% v 33.4%).

Dyckmans (1989) compared the differences in herbage yield of pure grass plots and grass-clover mixtures of resown fields at 9 sites in Germany. He used a range of N fertilisers between 0 and 300 kg N ha⁻¹. Effects of increasing N were significant in the grass plots ($R^2 = 0.90$), but were poor for the grass-clover plots ($R^2 = 0.32$). The average yield increase per kg N was 26.3 kg DM kg⁻¹ N for the grass plots and only 8.5 kg DM kg⁻¹ N for the grass-clover mixture. So the dependence on external nitrogen is much higher in the plots without clover and the maintenance of white clover in a mixture is therefore very important.

Calculated N-effects of animal manure in grassland

Based on long-term data of Palace leas meadow plots (UK: Coleman *et al.*, 1987) we have calculated the relationship between average yield and applied level of N. For our calculation only plots that received FYM, NPK or additional P and K were used. The relationship between applied N (X in kg total N ha⁻¹) and yield in the 1st cut (Y in kg DM ha⁻¹) was significant :

$$Y = 18.9 X + 3198 \quad (R^2 = 0.99).$$

In a five year trial in Austria, Buchgraber (1983) investigated effects of different types of FYM (fresh, short composting, long composting; 70-120 kg total N ha⁻¹) and slurry (aerated, not aerated, diluted; 100-120 kg total N ha⁻¹) in relation to PK and NPK fertiliser (0-250 kg N ha⁻¹). The cutting regime was only 3 times per year and the trial started when the pasture was 10 years old. Applied N (X) increased total herbage yields (Y) to 9.8 kg DM kg⁻¹ N. The increase of total yield and decrease of white clover did not depend on the choice of manure or fertiliser. We have calculated the following relationships based on average yield data:

$$Y = 6923 + 9.8 X \quad (R^2 = 0.81)$$

N reduced legumes yield (Z) (mainly white clover) by 4.5 kg DM kg⁻¹ N:

$$Z = 1267 - 4.7 X \quad (R^2 = 0.75)$$

From average yield data of Van der Meer and Baan Hofman (1999) we could also calculate a significant relationship between inorganic N application applied before the first cut in spring

($X_{\text{inorg-first}}$ from 0-120 kg N ha⁻¹) as shallow or deep injected slurry, or fertiliser N before the 1st cut in relation to the white clover yield (X) measured as the average yield of the 2nd and 3rd year at the same level of K:

$$\mathbf{Z = 2712 - 10.7 X_{\text{inorg-first}} \quad (\mathbf{N = 6, R^2 = 0.98})}$$

They showed, that a higher level of applied P and K increased white clover yields at the same level of N application. Additionally, surface spread diluted or undiluted slurry showed higher clover yields at the same level of N. Losses of ammonia during application were probably higher for surface spread slurry. Diluted slurry yielded as much as deep injected slurry, the clover level however was significantly higher. Grass growth was very profitable because of slurry dilution. In several plots of Van der Meer and Baan Hofman (1999), extra N was applied after the 2nd cut. With regard to the total inorganic N application per year ($X_{\text{inorg-total}}$) the decrease of white clover in relation to the total amount of applied inorganic N was poorer compared to spring application:

$$\mathbf{Z = 2793 - 7.5 X_{\text{inorg-total}} \quad (\mathbf{N = 6, R^2 = 0.74})}$$

Total DM yields (Y), however, showed a higher correlation with total inorganic N application year¹ than with the application level of inorganic N before the 1st cut:

$$\mathbf{Y = 8390 + 21.6 X_{\text{inorg-first}} \quad (\mathbf{N = 6, R^2 = 0.75})}$$

$$\mathbf{Y = 8497 + 15.5 X_{\text{inorg-total}} \quad (\mathbf{N = 6, R^2 = 0.83})}$$

Effects of animal manure can be seen as the sum of separate effects of the mineral composition. Effects therefore can be positive or negative. The results show that effects of animal manure in a young grass-clover sward can be understood primarily as an effect of applied N, if P and K levels are sufficient. In our trials, white clover yields were negatively (trial 'levels') or positively (trial 'cutting') affected by the use of animal manure. At higher levels of P and K in trial 'levels', repeated application of slurry reduced the white clover content of the sward. At insufficient levels of P and K, animal manure application might increase white clover growth, because of the positive effects of extra P and K. In that case, the positive effect of higher K application using animal manure is more important than the negative effects of inorganic N.



7. Soil Fauna: Effects of nematodes on clover growth ⁴

J. van Bezooijen, A.E. van Baal ⁵, T. Baars

An additional factor besides the chemical soil fertility, and affecting the persistency and growth of white clover is the presence of pests and diseases (Clements, 1996). In a survey in the UK, Clements and Murray (1993) mentioned *Sitona* weevils and molluscs as the major organisms damaging white clover leaves. Ennik (1982 and 1985) investigated the effects of cyst nematodes on the development of white clover and concluded that in several cases nematodes were the cause of a substantial reduction in white clover growth.

One of the strong aspects of a multidisciplinary approach is that the context of research findings can be correlated with other factors. Measurements of slug damage and soil fertility were already presented and discussed in Chapters 3 and 5. In this chapter, changes in the soil nematode population will be discussed as an additional factor affecting white clover performance. Effects of white clover cultivars as well as manure type on nematodes were studied.

7.1. Additional methodology

Soil nematodes were sampled in 1993, 1994, 1995 and 1998. In the first three years, samples were taken in spring in the trials 'cutting' and 'grazing' for all treatments (manure type x clover cultivar combinations). In 1998, plot samples were taken in September only from plots with cv. Alice, for trials 'cutting', 'grazing' and 'levels'.

Extraction of cyst nematodes

After mixing the soil samples from the experimental plots, a sub sample of 200 grams was processed with the Kort elutriator (Kort, 1960) using an up-current of 3500 ml per minute for a 5 minute period. The debris was collected over a 180 micron sieve.

Directly after elutriation the debris obtained was processed by a centrifuge flotation method (Dunn, 1969 modified). A MSE 200 ml beaker centrifuge was used. A teaspoon of Kaolin as pellet-sealer was mixed in the water suspension with the help of a vibro-mixer. A 4 minutes spin

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at R.C.F. 1800 G separated the more or less empty cysts from the heavier well-filled cysts. This fraction was collected separately. A solution of magnesium sulphate (S.G. 1.28) was added and mixed with the pellets by means of the vibro-mixer after which a 3 minute spin at R.C.F. 1800 G was used.

The cysts were collected separately. The two fractions were counted separately under a dissecting microscope using 40 times magnification. The cysts were identified to species level from the magnesium sulphate fraction.

A sample of 10 cysts taken randomly from the magnesium sulphate fraction was homogenised in a cyst-homogeniser (Huijsman, 1957) and the viable eggs and juveniles were counted under a dissecting microscope using 40 times magnification.

Extraction of free-living nematodes

After mixing the soil samples from the experimental plots a sub sample of 200 grams was processed by the Oostenbrink elutriator (Oostenbrink, 1960) using an up-current of 1000 ml while washing the sample into the elutriator and 600 ml during the time of extraction while the elutriator ran. The suspension obtained from 4 sieves with a 30 cm diameter and a 45 micron mesh, was placed on a double layer of nematode filters and left for 48 hours.

From the 100 ml suspension two sub samples of 2.5 ml were taken and identified to genus level under a dissecting microscope using 40 times magnification.

7.2. White clover cultivars

In Table 7.1 the total number of cysts in soil from plots with different clover cultivars is presented.

Table 7.1. Total number of cysts 200 g⁻¹ of soil (*Heterodera trifolii* plus *Heterodera avenae*) affected by the cultivar choice of white clover, as an average of 1993-1995.

	Total cysts
Mean	65
Clover cultivar	
Retor	67
Aberherald	65
Alice	62
P value	0.730
LSD (5%)	14

There was no significant effect of white clover cultivars on the number of cysts ($P = 0.730$).

In Table 7.2. the increase of the cyst population per year within mixtures with cv. Alice is presented.

Table 7.2. Number of total cysts and number of clover cysts (*H.trifolii*) per year in mixtures with cv. Alice

	Total cysts	<i>H.trifolii</i>
Mean	102	27
Year		
1993	48 a	< 0.1 a
1994	50 a	< 0.1 a
1995	87 a	0.1 a
1999	224 b	110 b
P value	< 0.001	< 0.001
LSD (5%)	39	17

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

The number of cysts was only increased in 1999 (Table 7.2). However, if the data were analysed as an effect of clover cultivars x year, there was a significant yearly increase between 1993 and 1995 (data not shown; $P < 0.001$). In the years 1993-1995 cysts were almost exclusively *H.avenae/mani*. The numbers of *H.trifolii* were low. The percentage of plots infected by *H.trifolii* (Figure 7.1), however, showed a regular increase from less than 3% in 1993 to almost 60% in 1995. In 1999 all plots contained *H.trifolii*.

In the years between 1995 and 1999 no measurements were taken.

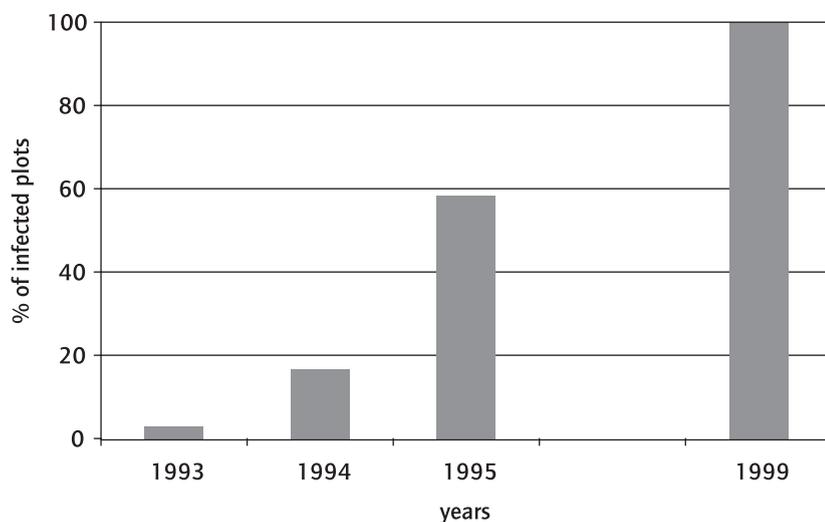


Figure 7.1. Percentage of plots infected by clover cysts (*H. trifolii*)

7.1.2. Effect of manure type

There was hardly any effect of manure type on the number of free-living nematodes (Table 7.3). Only *Paratylenchus*, *Pratylenchus* and the group of other plant-parasitic nematodes showed an effect of manure type. These effects are shown in Table 7.3.

Table 7.3. Effect of manure type on several genera of free-living nematodes

Genera:	<i>Paratylenchus</i>	<i>Pratylenchus</i>	Other plantparasitic (mainly Tylenchidae)
	----- no 200 g ⁻¹ of soil -----		
Manure type			
PK	262 b	38 b	412 a
SLU	188 ab	30 ab	864 ab
FYM	84 a	8 a	1202 b
P value	0.014	0.059	0.034
LSD (5%)	118	26	593

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

Compared to PK fertiliser, both *Paratylenchus* and *Pratylenchus* were reduced in number in the FYM plots. However, the number of other plant-parasitic nematodes increased in the FYM plots. The number of nematodes with SLU was in between numbers for PK and FYM.

In Table 7.4 the number of free-living nematodes found in the grass and grass-clover plots are summarised per genus as an overall effect of manure application.

In Table 7.5 and 7.6 cyst numbers of *H.avaena* and *H.trifolii* are presented from the trials 'cutting' and 'levels'. In both trials manure was applied annually from 1993 onwards. In the trial 'cutting' the level was on average 25 ton of animal manure ha⁻¹ (Table 2.2, Chapter 2). In the trial 'levels' white clover was introduced by over-sowing in 1994 (between May and August). In this trial the level was on average 40 ton of animal manure ha⁻¹.

Table 7.4. Number of free-living nematodes as an overall average of all grass and grass-clover plots for the trials 'cutting' and 'levels' and the least significant difference (LSD 5%) with regard to manure treatment.

	Average no 200 g ⁻¹ of soil	LSD (5%)
Genera		
<i>Helicotylenchus</i>	529	0.508
<i>Hemicycliophora</i>	173	0.293
<i>Heterodera larvae</i>	71	0.517
<i>Meloidogyne larvae</i>	3	0.306
<i>Paratylenchus</i>	178	0.014
<i>Pratylenchus</i>	25	0.059
<i>Trichodorus</i>	145	0.199
<i>Tylenchorhynchus</i>	288	0.179
Other plantparasitic (mainly <i>Tylenchide</i>)	826	0.034
Saprophytic nematodes	16,400	0.708
Total plant-parasitic	2,300	0.141
Total nematodes	18,700	0.563

CHAPTER 7

Table 7.5. Effects of manure type on nematode cysts in grass-clover (cv. Alice) for the trial 'cutting' in August 1999; effect of 7 year application of manure types.

	Total cysts (No. in Mg-fraction)	<i>H.avenae</i>	<i>H.trifolii</i>	Others
Mean	224 (108)	54	110	61
Manure type				
PK	300 (140)	74	158 b	69
SLU	171 (91)	44	63 a	64
FYM	202 (94)	43	108 ab	50
P value	0.132 (0.238)	0.053	0.022	0.891
LSD (5%)	138 (70)	27	60	97

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

After seven years of manure application the number of *H.avenae* cysts was reduced by 40%, compared to PK-fertiliser, ($P = 0.053$). The number of *H.trifolii* was lowest for SLU and highest for PK ($P = 0.022$). FYM did not show significant differences from either PK or SLU.

Manure effects provided the same kind of information as in the trial 'cutting': on average the total number of cysts was reduced by 40% by the use of animal manure ($P = 0.005$). Both *H.avenae* and *H.trifolii* were reduced in FYM or SLU plots ($P = 0.001$ and 0.003 respectively). In comparison with the trial 'cutting', the P value was lower.

Table 7.6. Effects of manure type on nematode cysts in grass-clover (cv. Alice) for the trial 'levels' in August 1999; effect of 3 years application of three manure types.

	Total cysts (No in Mg-fraction)	<i>H.avenae</i>	<i>H.trifolii</i>	Others
Mean	163 (85)	38	84	40
Manure type				
PK	222 b (120 b)	52 b	116 b	54
SLU	141 a (66 a)	31 a	75 a	35
FYM	126 a (69 a)	31 a	62 a	32
P value	0.005 (0.007)	0.001	0.003	0.525
LSD (5%)	47 (30)	9	23	48

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

7.1.3. Nematodes affected by the presence or absence of white clover

In the trial 'cutting' a comparison was made of pure grass plots and grass-clover plots (Table 7.7).

Table 7.7. Effects of presence/absence of white clover on the number of nematodes and cysts 200 g⁻¹ in the soil in trial 'cutting' in August 1999; effect of 7 years of application of manure types

	Plant-Parasitic	Saprophytic (No in Mg-fraction)	Total cysts	<i>H.avenae</i>	<i>H.trifolii</i>	Others
Plot type						
Grass	26,900 b	13,300	118 a (67 a)	47	40 a	32 a
Grass-clover	19,400 a	16,200	224 b (108 b)	54	110 b	61 b
P value	0.015	0.181	< 0.001 (0.011)	0.290	< 0.001	0.042
LSD (5%)	6,700	4,600	50 (29)	14	27	28

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

The number of free-living plant-parasitic nematodes was higher in pure grass plots ($P = 0.015$). The total number of cysts was almost twice as high in grass-clover plots ($P < 0.001$). Differences were caused by the high number of *H.trifolii* ($P < 0.001$) and cysts of other nematodes ($P = 0.042$).

7.3. Discussion

Initial low populations of *H.trifolii* in the experimental plots increased markedly under the influence of white clover populations. Significant differences were observed between plots with only grass and the plots with a mixed cultivation of grass-clover.

The 8 years period of observation was long enough to see the increased levels of the cyst population, but whether it is long enough to establish a balanced situation is questionable. From the results it was evident that with the cultivation of white clover in the grass the clover nematode cyst populations increased in all the fields. If the total white clover yield ha⁻¹ in 1998 and the number of *H.trifolii* cysts found in August 1999 were compared, plots with higher numbers of cysts showed lower white clover yields, whereas in plots with low clover cyst numbers the clover yield fluctuated. This relationship was only found in the PK fertilised plots. In the FYM and SLU treatments other factors affected the relationship, e.g. the level of applied N. In glasshouses Ennik (1982) found significant negative effects of number of clover cysts on the survival of white clover.

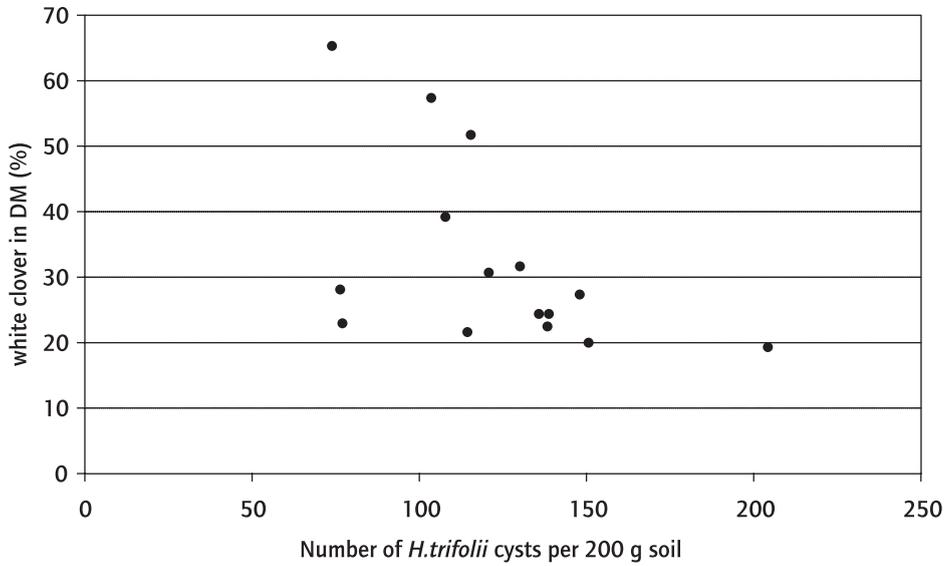


Figure 7.2. The relationship between cyst numbers of *H.trifolii* in August 1999 and white clover yield in 1998 (PK plots in the trials 'cutting' and levels')

The number of other plant-parasitic nematodes was relatively low. A reduction of several plant-parasitic species after the use of FYM, as suggested by Oostenbrink (1960), was found for both *Pratylenchus* and *Paratylenchus*.



8. Soil fauna: Effects of manure on earthworms

G.J. van der Burgt⁶, T. Baars⁷

The living soil is such a basic tenet of organic farming, that effects of manure on the amount and diversity of earthworms were also evaluated in addition to the chemical parameters for soil fertility. Earthworms are known for having beneficial effects on soil properties such as aeration, drainage, soil aggregate stability and for their role in nutrient recycling. Although the soil food web is much more complex, earthworms are used as an indication of soil life.

8.1. Additional methodology

Earthworms were sampled in the middle of October 1999, March 21 and 22, 2000 and August 11 and 14, 2000. Earthworms were driven out of the soil by means of a changing electric field from 200 up to 600 V and 2 to 4 A between octagonally arranged electrodes (surface 0.125 m²; electrode depth 25 cm) during 7-8 minutes (Thielemann, 1986). Worms were collected and stored in alcohol for identification (Sims and Gerard, 1985). The number of worms were counted for each plot, the species composition was only determined per treatment.

Worms were identified to species only in the cut trials ('cutting' and 'levels').

8.2. Earthworm numbers and composition

In August 2000, the trial 'cutting' FYM had more earthworms than either PK or SLU ($P = 0.020$) (Table 8.1). Averaged over the sampling dates, the number of earthworms in FYM was greater than for PK and SLU ($P = 0.037$). In the trial 'grazing', results were only significant in October 1999 ($P = 0.050$). SLU out-yielded PK, but there were no differences for the FYM plots. The overall number of earthworms was highest for SLU ($P = 0.016$). In the trial 'levels' the number of earthworms was highest for FYM in October 1999 and August 2000 ($P = 0.012$ and < 0.001 respectively). FYM had more earthworms than SLU and PK plots. The overall number of earthworms was highest for FYM ($P = 0.009$). Both 'cutting' and 'levels' trials had similar results.

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⁷ The authors are very thankful for the comments made by Dr. Wim Didden, Wageningen University, department for soil biology and Dr. Bob Clements, IGER, North Wyke, UK

Table 8.1. Earthworms in grass-clover mixtures (no m⁻²): trials 'cutting', 'grazing' and 'levels'

Date	Oct 1999	Mar 2000	Aug 2000	Mean
	--- 'cutting' ---			
Mean	197	87	91	125
Manure type				
PK	154	94	62 a	103 a
SLU	160	106	56 a	107 a
FYM	276	62	154 b	164 b
P Value	0.058	0.054	0.020	0.037
LSD (5%)	109	35	67	48
	--- 'grazing' ---			
Mean	189	158	93	147
Manure type				
PK	108 a	154	64	109 a
SLU	256 b	196	128	193 b
FYM	204 ab	124	86	138 a
P Value	0.050	0.389	0.161	0.016
LSD (5%)	115	189	71	50
	--- 'levels' ---			
Mean	172	105	134	140
Manure type				
PK	163 a	116	60 a	120 a
SLU	136 a	105	94 a	114 a
FYM	218 b	94	249 b	188 b
P Value	0.012	0.679	< 0.001	0.009
LSD (5%)	46	59	38	37

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

8.2.1. Species composition

The differences in species composition of the earthworm populations were clearest if species were grouped according to their function and ecology (Table 8.2). In all manure treatments epigeic species had the largest proportion of the population, with the proportion in the PK-treatment being significantly higher than in the manure treatments ($P < 0.001$). The endogeic part of the population was highest for FYM ($P < 0.001$). SLU also had the greater percentage of endogeic species compared to PK. Differences in epigeic species were caused by varying numbers of *L.rubellus*, which made up the highest percentage under PK. The higher level of endogeic species was due to both *A.caliginosa* ($P = 0.039$) and *A.chlorotica* ($P = 0.091$)

Table 8.2. Species composition expressed as percentage per species, as an average of the trials 'cutting' and 'levels'

	<i>L.cast.</i>	<i>L.rub.</i>	<i>A.chlor.</i>	<i>A.calig.</i>	<i>A.longa</i>	epigeic	endogeic
Mean	0.9	90.4	3.1	5.5	0.2	91.2	8.6
Manure type							
PK	0.4	97.2 b	0.1	2.1 a	0.1	97.6 b	2.2 a
SLU	1.3	89.7 a	3.5	5.4 ab	0.1	90.9 a	8.9 b
FYM	0.9	84.2 a	5.7	8.9 b	0.2	85.1 a	14.6 b
P value	0.284	< 0.001	0.091	0.039	0.806	< 0.001	< 0.001
LSD (5%)	1.1	6.2	5.1	5.2	0.4	6.1	6.0

Within a column, data followed by the same letter are not significantly different at $P < 0.05$.

8.3. Discussion

8.3.1. Extraction method

Collecting earthworms with electricity is a time-efficient method, which is non-destructive for the plots compared to hand-sorting. However, when using the electric method, it had to be accepted that there is a risk of underestimating total earthworm numbers, over-estimating of juvenile worms and exclusion of anecic worms (Edward and Bohlen, 1996). In this study only a few *A.longa* and no *L.terrestris* were found, which might be because of the extraction method. Didden (unpublished data) collected worms by hand-sorting sampling from 49 dairy farms on sandy soils in the Netherlands. The most common species were *A.chlorotica*, *A.caliginosa* and *L.rubellus*. Also in his samples *L.terrestris* was not found and *A.longa* only at a few farms. Five species found by Didden were absent in our work, four out of those five were only found in less than 10% of the farms and one species (*A.rosea*) in 12%. As Didden (unpublished data) found a much higher proportion of endogeic species, however, this may indicate that in this study this group may have been underestimated.

8.3.2. Species composition and earthworm numbers

Sears (1950) already mentioned the correlation between herbage DM production and the total worm population in the soil. For each tonne of herbage DM about 110 kg of earthworms were found in the soil. In a comparison of different fertilisers in an organic situation, Hansen and Engelstad (1999) found the highest density and mass of earthworms in plots with a high manure level compared to plots with a low manure level. The increase in worms was mainly due to an increase of endogeic species and not to epigeic species. Edwards and Lofty (1974), comparing fertiliser with manure, found an increase in worm density when manure was applied and a

decrease when fertiliser was used. Curry (1987) described the effect of organic fertilisers on soil life, concluding that there are two effects working in the same direction: manure is a direct food source for soil life, and manure leads to a higher productivity resulting in an increased organic matter turnover in the field. Both lead to an increase in soil life. Application of inorganic fertilisers has a less coherent effect: it might lead to an increase in soil life by means of an increase in organic matter turnover, but direct negative effects (salt, toxic components, pH) are found too. Such negative effects can also be observed when slurry is applied in large quantities.

In the PK treatment, the highest proportion of litter dwellers was found. The absence of *A.chlorotica* and the presence of only a few *A.calliginosa* under PK, is remarkable. The level of endogeic species was lowest if no animal manure was applied. Only the litter dweller *L.rubellus* was left after PK application. This means that an important biological factor for soil properties (Edwards and Bohlen, 1996) may have been absent, which might affect soil aeration, drainage and compaction, but also the turnover of soil organic matter. Consequently this may negatively affect the productivity of the system in the long term. A negative interaction of the PK application was the decrease in soil pH (Chapter 5.2). The low soil pH (< 4.5) after seven years of application might also negatively affect the number of species (Edwards and Lofty, 1974; Edwards and Bohlen, 1996). Sears (1950) found a correlation between soil fertility and prevalence of specific species. *L.rubellus*, for example, was more prevalent under high soil fertility conditions, whilst *A.calliginosa* was dominant in the areas with low fertility. However, this could not be confirmed in our trials. Both species were highest under FYM.

The number of species living in the top-soil was strongly increased by the use of animal manure and tended to be highest for FYM. Species that move vertically into the deeper soil layers were only found in FYM. The abundance of these species was low, which may have been partly an effect of the sampling method.



9. Overall conclusions

Soil fertility

On a sandy soil, FYM increases the soil pH, whereas slurry causes a slight but steady decrease. The P application level does not affect the output of P in herbage. Even after six years of imbalance between input and uptake, P yields are hardly affected. However, the ranking of applied P levels is the same as for the average soil P level. The ranking of applied K levels is related to the uptake of K in herbage, the ratio of K/P in the herbage and to the average soil K level. Results for K levels are not affected by manure type, but by the amount of K applied. On sandy soils organic farmers should at least compensate for the P and K removal in the herbage by cutting, but a field balance of K is an important factor in maintaining white clover after establishment.

Effects of clover cultivar on grass-clover yield

There are no effects found of cultivar choice on yield of the first cut. Cvs. Aberherald and Alice show similar results under 'cutting', but under 'grazing' cv. Alice produces a higher amount of clover in spring. Mixtures with cv. Alice tend to out-yield cv. Aberherald, whereas mixtures with cv. Aberherald out-yield cv. Retor. Differences are higher in the trial 'grazing' compared with 'cutting'. Differences are found for total yield and white clover yield. The poor persistency of cv. Retor dramatically reduces herbage yield, N yield and N concentration of the mixture.

Effects of animal manure on total grass-clover yield

On a sandy soil the amount of inorganic and organic N, the N release and K level of the different manure types are the main factors to explain fluctuations in total yields, white clover development and differences in N yields. If P and K are sufficient, the level of (inorganic) N shows a high, positive correlation with herbage yield and N yield, but a negative correlation with the white clover yield. N yields are not affected by manure type, because of compensating effects of white clover N and manure N. N concentrations are reduced in FYM, mainly caused by reduced N concentrations in the first cuts. K yields ha^{-1} and K concentrations in herbage DM are related to the amount of available K, irrespective of the manure type, whereas P yields are related to herbage yield and N yield. P concentrations in herbage are not affected by manure type and are negatively correlated with herbage yield. In the 1st full year of production, shallow injected slurry negatively affects white clover growth. After the phase of establishment, the level of N-application is the main effect of slurry application in spring. FYM should be applied on sandy soils as early as possible within the possibilities of legal

regulations . In the Netherlands spring application is only allowed after the 1st of February. The combination of a high level of inorganic N in spring and a high 1st cut yield (4.5-4.8 t DM ha⁻¹) should be avoided with regard to the persistency of white clover. Additionally an application of FYM in spring reduces herbage intake of grazing animals, mainly during the period immediately after application.

Effects of animal manure on herbage spring growth

The increase of spring herbage growth is significant after the application of both FYM and SLU. Differences between SLU and FYM are small, but significant. The average increase of DM yield kg⁻¹ from applied inorganic N is twice as high for FYM as for SLU. White clover yields and percentages are reduced by the use of animal manure, but shortages of P and K interact with this result. This effect is highest for SLU, because of its level of inorganic N and will result in a higher N concentration in DM and DM yield in the first cut. FYM positively affects herbage growth in summer and autumn compared to SLU. After a spring application of manure, white clover will recover in the second half of the growing season. The recovery of white clover will be delayed or can even be absent if there is a shortage of K.

FYM shows the lowest N concentration in 1st cut herbage, which was probably caused by the need for N in the soil pool for the breakdown of carbon in FYM. If the timing of slurry application could be further optimised, spring application of slurry would increase herbage yield more than FYM. Results of applied FYM and SLU are affected by the time of application in spring and the weather conditions after application (rainfall, temperature). FYM should be applied earlier in spring than slurry. To improve early spring production and the N concentration in herbage, FYM used in spring should contain high levels of inorganic N and should have been composted until mature stage.

N-fixation of white clover

The relationship between white clover yield and herbage yield or N yield is best described as a polynomial relation which shows an optimum response. PK, FYM and SLU all have their own typical optimum curve, but the effect of white clover on total herbage yield and N yield decreases from PK to FYM and from FYM to SLU, because of interaction between inorganic N and clover fixed N. Under cutting, the optimum content of white clover is at a level of 50-60% in DM. With regard to herbage yield and N yield for organic systems, clover persistency is of much more importance than the input of manure.

Effects of animal manure on earthworm populations

FYM increases the number of earthworms and the species diversity more than the other manure treatments in terms of endogeic and epigeic species. PK, applied as superphosphate and K-salt-60 negatively affected the earthworm population. Part of the effect could be caused by the decline in soil pH, which is decreased after the fertiliser application.

Effects of animal manure on cyst nematodes

After a grassland period without any white clover of more than 20 years, the plots infected with *H.trifolii* increase up to a 100% infection level within only a few years the introduction of clover. The use of animal manure (FYM or SLU) shows a smaller increase in the numbers of *H.trifolii* and *H.avenae* larvae and eggs than after PK application.



Summary

Part II contains the agronomic results of the multidisciplinary grassland study. This project concerned the effects of clover varieties and spring applications of animal manure on the yield of grass-white clover mixtures on a humid sandy soil. The project was carried out on a research station and the layout of the plots was a split-plot trial. Six years of application were described. To be aware of the context of the findings in a multidisciplinary approach, attention was paid to: chemical soil fertility, damage to clover by slugs and soil borne nematodes. To increase the understanding of soil fertility, earthworm dynamics were also measured. At the end of the period the botanical composition of all plots was assessed. Factors measured besides total yield and clover yield were N, P and K yield. It was found that these 'context'- measurements were important for the overall explanation of the scientific results. Data were used for modelling several relationships between yield parameters. The overall findings of this project led to an understanding and description of the main aspects of manure with regard to grass-white clover growth on a humid sandy soil.

In the trials 'cutting' and 'grazing' effects of white clover cultivar choice were measured on total herbage yield, white clover yield and clover stolons (1993-1996). In assessment of the effects of white clover cultivars the local white clover standard, i.e. medium-leafed cultivar Retor, negatively affected yield parameters in comparison with medium-leafed cv. Aberherald. Cv. Aberherald was bred for cold tolerance and a higher survival of clover stolons during severe winters. Slug damage reduced the leaf area of cv. Retor during the growing season. The area eaten by slugs was twice as high compared to the other cultivars. Large-leafed cultivar Alice had a similar herbage spring yield as mixtures with cv. Aberherald, although the length and weight of stolons of cv. Aberherald in spring was higher than for cv. Alice. The white clover yield was higher for cv. Alice in several years. Total yields, white clover yields and percentage in DM tended to be higher for cv. Alice in comparison to cv. Aberherald.

In three parallel experiments two types of animal manure, available in modern organic systems, were studied: slurry from cubicle systems and farmyard manure from deep litter housing (SLU and FYM) in comparison to P and K fertiliser (superphosphate and K-salt 60). The use of animal manure in organic farming is restricted to a level of 170 kg total N per ha by European law (EEC 2092/91). Effects of manure choice were studied in a mixture of perennial ryegrass (cv. Magella) and white clover (cv. Alice). The role of white clover was investigated in a comparison of grass-clover and pure grass plots for all manure treatments. The main manure application was in mid-March, but FYM was on average applied two weeks earlier than SLU and PK. In the first experiment (1993-1998), the plots were cut five times per year (trial 'cutting'); in the second

experiment (1993-1998), grazing and cutting were alternated (trial 'grazing'). The third experiment (trial 'levels', 1996-1998) was cut as in trial 'cutting'. In this last experiment, a split plot design was used to investigate three manure types at three increasing levels of application (low, medium, high), but plot historical effects of oversowing interacted with effects of increased manure levels. Results on manure levels therefore were not relevant and were left out of the evaluation.

Effects of manure choice showed that the soil pH was strongly reduced after the use of PK-fertiliser and moderately reduced after the use of SLU. Soil organic matter was strongly increased after the use of FYM, moderately after the use of SLU and poorly after PK-fertiliser. The changes in the soil P and K status were correlated with the P and K field balances. P and K balances showed the highest surplus for FYM, whereas the K balance was most negative for PK and the P balance the most negative for SLU.

It was clear that FYM had the greatest positive effect on soil quality in terms of chemical soil fertility and earthworm population. FYM brought about the highest diversity, number and weight of earthworm types. In PK mainly soil surface grazers were found. The number of species living in the top soil was strongly increased by the use of SLU and FYM, but tended to be highest for FYM. Species with a vertical movement into the deeper soil layers were only found in FYM. The presence of this group is an important factor to build up a stable soil humus complex.

Within the period of six years, the number of cysts (*H.avenae*) increased. Clover cysts (*H.trifolii*) were hardly found at the start of the experiment, but after 3 years 60% of the plots and after 6 years all plots were infected. Measurements at the end of the experiment showed increased numbers of *H.trifolii* cysts in plots where the clover content was higher. The use of both SLU and FYM decreased the number of cysts of *H.avaena* and *H.trifolii* in grass-clover plots. Free-living plant-parasitic nematode numbers were higher if clover was absent.

In all trials, the use of animal manure increased total herbage yield. Only in 1997, FYM out-yielded SLU. In trial 'levels' the white clover yield and white clover percentage in DM were reduced by 1.2 t DM ha⁻¹ and 16% respectively after the use of animal manure. If shortages of soil-K occurred, like in trial 'cutting', animal manure improved white clover growth, because of the higher amount of applied K. Additionally the recycling of urine and dung improved white clover growth, if there was a shortage of K (trial 'grazing').

The N yields were hardly affected by the use of manure, if white clover levels in the sward were high (trial 'levels'). N yields, however, were increased if white clover levels in the sward were low (trial 'cutting'). Therefore the overall N yields were positively related to the clover yields and the level of inorganic N application in spring. The P yields were determined by the herbage yield. The K yields were affected by the level of applied K, irrespective of the manure type. Compared with K yields in trial 'cutting', K yields in trial 'grazing' were higher, because of internal recycling of

dung and urine by grazing animals and in trial 'levels', because of the higher level of mineral inputs.

The effects of animal manure, particularly FYM, on herbage residues after grazing by cows or young stock were negative in the 1st and 2nd cut. Effects of SLU were found only in the 1st cut after the application and at higher levels of application (1996 onwards).

Effects of manure on spring yield were evident. A strategic use of shallow injected slurry (SLU) significantly improved herbage yield, N yield and N concentration in the herbage. The yield and percentage of white clover were reduced when animal manure was used compared to plots only receiving fertiliser P and K. FYM resulted in a smaller increase of herbage yield in spring in comparison to SLU, but reduced the N concentration in the herbage. White clover yields in spring were similar. For SLU and FYM the apparent nitrogen efficiencies were 11.8 and 22.1 kg DM kg⁻¹ inorganic manure N respectively.

Measurements on herbage yield, white clover yield and N yield were analysed by means of regression. Results were described for the relation between white clover yield and herbage yield or N yield. A polynomial relationship showed the highest correlation coefficient and therefore the strongest relationship between white clover yield and N yield was an optimum curve instead of a linear line.

Results of sward productivity therefore can be described as an effect of white clover growth with an additional effect of manure.

It was concluded that on a humid sandy soil the amount of inorganic and organic N, the N release and the K input were the main manure factors relating to fluctuations in total yields, on white clover development and on N yields in the first six years after sward establishment. The inorganic N component in manure can be used strategically to improve the growth of the herbage in spring. Maintenance of soil fertility in terms of P, K and Ca levels is an important key factor for a successful organic grass-clover sward.

Carbon rich FYM derived from a deep litter stable and composted before application increased the earthworm population, reduced the number of nematodes and maintained the highest level of soil pH, all factors which might positively affect white clover growth in the long term. FYM applied in spring resulted in the typical extended growth season in the second part of the growing season. On a sandy soil the high concentration of K in the FYM positively affects the potential white clover growth.

The choice of a persistent white clover cultivar is another important factor affecting herbage and N yields of an organic grass-clover sward. However, winter losses were not found to be the main cause of white clover reductions over the years. Losses in the growing season were related to slugs which reduced white clover leaf area. The literature shows that the cyanide concentration in DM herbage affects the susceptibility of white clover to pests.



Samenvatting

Deel II beschrijft de agronomische resultaten van een multidisciplinaire grasland onderzoek. In het project zijn effecten van klaver rassen en de voorjaarstoediening van dierlijke mest beoordeeld op basis van droge stofproducties van gras-witte klaver mengsels op een vochtige zandgrond. Het project is uitgevoerd op het proefbedrijf Aver Heino. De opzet van het veldonderzoek was kleine plots in een split-plot opzet. De looptijd van het onderzoek is zes jaar. Teneinde het vraagstuk van de context in het onderzoek op te nemen is in een multidisciplinaire opzet aandacht besteed aan: chemische en biologische bodemvruchtbaarheid, slakkenvraat in klaver en bodemgebonden aaltjes. Als responsvariabelen zijn beoordeeld naast totale droge stofopbrengst, de klaveropbrengst en de N, P en K-opbrengst. Het is duidelijk, dat het meten van de genoemde 'context'-variabelen belangrijk zijn geweest voor het uiteindelijke begrip van ras- en mesteffect. De langjarige data zijn gebruikt voor het modelleren van enkele relaties tussen de opbrengstvariabelen. De uiteindelijke resultaten van dit project hebben geleid tot een begrip over de belangrijkste aspecten van dierlijke mestwerking op de groei van gras-klaver op een vochtige zandgrond.

In de experimenten 'cutting' en 'grazing' zijn effecten van witte klaverras vastgesteld door meting van gewasopbrengst en opbrengst aan klaverstolonen. Van 1993-1996 is het lokale middelgrootbladige ras Retor als Nederlandse standaard vergeleken met nieuwe cultuurklaverrassen Alice (grootbladig) en Aberherald (middelgrootbladig). Het ras Aberherald was specifiek ontwikkeld als koudetolerant ras met een betere winteroverleving van klaverstolonen. Het ras Retor beïnvloedt de opbrengst parameters negatief in vergelijking met het ras Aberherald. Retor had meer last van slakkenvraat; gedurende het groeiseizoen was het aandeel bladoppervlakte dat door slakken was weggevreten tot twee keer zo hoog als in beide andere rassen. De opbrengst van de eerste snede was gelijk van de rassen Alice en Aberherald, ondanks het feit dat Aberherald een veel hoger gewicht en lengte aan klaverstolonen had in herfst en voorjaar. Alice een hogere totale klaveropbrengst had in verschillende jaren. Zowel de totale opbrengst, de witte klaveropbrengst als het klaveraandeel in de droge stof tenderde tot hogere resultaten voor het ras Alice in vergelijking met Aberherald.

In de experimenten 'cutting', 'grazing' en 'levels' zijn telkens twee typen dierlijke mest vergeleken met een bemesting met alleen P en K (als superfosfaat en kali-60). Mestsoorten die beschikbaar zijn in loopstallen in de biologische melkveehouderij zijn drijfmest, afkomstig uit de ligboxenstal en stalmest uit de potstal. Vanuit EU-richtlijnen is de maximale hoeveelheid dierlijke mest in de

biologische landbouw beperkt tot een niveau van 170 kg N per ha. Effecten van mest zijn bestudeerd in een mengsel van Engels raaigras (ras Magella) en Witte klaver (ras Alice). Het belang van klaver is onderzocht door plots met en zonder klaver te vergelijken in alle mestbehandelingen. De bemesting werd gegeven rond 15 maart, maar stalmest werd gemiddeld twee weken eerder gegeven dan drijfmest en PK-kunstmest. In het eerste experiment (1993-1998) werden de veldjes uitsluitend gemaaid, afwisselend als maai- en als weidesnede ('cutting'). In het tweede experiment (1993-1998) werd daadwerkelijk geweid, afwisselend met een maaisnede ('grazing'). Het derde experiment ('levels' 1996-1998) werd op dezelfde wijze gemaaid als het eerste experiment, waarbij in een zgn. split-plot opzet drie mestbehandelingen op drie oplopende niveaus (laag, middel, hoog) werden vergeleken. Echter door een verknoping met de historie van dit proefveld, waarin veldjes op drie tijdstippen werden doorgezaaid, kon het effect van de toenemende mestgift niet goed worden vastgesteld. De resultaten van de oplopende mestgiften zijn daarom buiten beschouwing gelaten.

De effecten van (kunst)mest werd gemeten aan de totale gewasopbrengst, de klaver-, N, P- en K-opbrengst per ha. Aanvullende informatie werd verzameld over de chemische bodemvruchtbaarheid (per mestbehandeling) en de ontwikkeling van bodemgebonden aaltjes (per veldje). In 1998 werd eenmalig de botanische samenstelling (per veldje) vastgelegd en werd de samenstelling en aantal regenwormen bepaald (per veldje).

Het type mest is op termijn van invloed op de bodem pH en het organische stofgehalte in de bodem. Door PK-kunstmest daalt de pH sterk, door drijfmest in enige mate en door stalmest blijft de pH gelijk. Het organische stofgehalte in de bodem stijgt het sterkste door stalmest, intermediair door drijfmest en het geringste door PK-kunstmest. De veranderingen in de P- en K-concentraties van de bodem zijn bepaald door de veldbalans van de P- en K-aan- en afvoer. Zowel de P- als de K-balans hebben het grootste overschot als stalmest is gebruikt. De K-balans is het meest negatief voor de PK-bemesting, terwijl de P-balans het slechtste is na het gebruik van drijfmest.

Stalmest geeft de sterkste verhoging van bodemkwaliteit in termen van chemische bodemvruchtbaarheid en regenworm bestand. De diversiteit aan soorten wormen, hun aantallen en gewicht waren het hoogste bij stalmestgebruik. Bij PK-kunstmest zijn met name oppervlakte gazende wormen gevonden. Soorten die zich meer verticaal in de bodem bewegen en op grotere diepte worden gevonden zijn alleen gevonden na stalmestgebruik. Deze groep is van belang voor een stabiele humusopbouw van de bodem.

Het aantal havercysten (*H. avena*) in de bodem neemt toe in een periode van zes jaar. Klavercysten (*H. trifolii*) zijn bij de start van het experiment nauwelijks gevonden, maar al na drie jaar

aanwezigheid van klaver is 60% en na zes jaar zijn alle veldjes besmet. Aan het einde van het experiment is het aantal klavercysten hoger in veldjes waar het klaveraandeel hoger is. Door het gebruik van dierlijke mest worden aantallen lager in vergelijking met PK-kunstmest. Het aantal vrijlevende plantparasitaire aaltjes is hoger in veldjes met gras-klaver dan in gras-plotjes.

In alle drie experimenten verhoogt het gebruik van dierlijke mest (drijfmest of stalmest) de opbrengst in vergelijking met PK-kunstmest. Alleen in 1997 hebben veldjes met een stalmestbemesting een hogere opbrengst dan die met drijfmest.

In het experiment 'levels' reduceert het gebruik van dierlijke mest zowel de witte klaver opbrengst als het percentage klaver in ds, respectievelijk met 1,2 ton ds ha⁻¹ en 16%. Wanneer er sprake is van een tekort aan bodem-K, zoals in het experiment 'cutting' dan is er echter een toename van de klavergroei na het gebruik van dierlijke mest, vooral omdat er meer K wordt gegeven. Ook het terugbrengen van urine en mest door de begrazing in het experiment 'grazing' verbetert de klavergroei, wanneer er een K-tekort is.

De N-opbrengst in het gewas is nauwelijks beïnvloed door de mestsoortkeuze, mits de witte klaver opbrengst hoog is zoals in het experiment 'levels'. De N-opbrengsten worden echter wel verhoogd bij een lage witte klaveropbrengst in het experiment 'cutting'. N-opbrengsten zijn bepaald door het niveau van minerale N-bemesting in het voorjaar en de klaveropbrengst. De P-opbrengst is vooral bepaald door de totale ds-opbrengst. De K-opbrengst zijn beïnvloed door de K-gift en zijn onafhankelijk van het type mest. Een vergelijking tussen de experimenten laat zien, dat K-opbrengsten hoger zijn in 'grazing' in vergelijking met 'cutting' door het terugbrengen van mest en urine bij begrazing, maar ook in 'levels' door de hogere aanvoer van mineralen in dat experiment.

De bemesting van dierlijke mest in het voorjaar leidt tot een hogere beweidingsrest na de 1^e en 2^e snede, met name als stalmest is gebruikt. Drijfmest beïnvloedt alleen de rest na de 1^e snede negatief en met name bij hogere giften drijfmest vanaf 1996.

Er is een duidelijk effect van mestkeuze op de opbrengst van de 1^e snede. Een strategische bemesting met drijfmest in het voorjaar verbetert zowel de ds-opbrengst, N-opbrengst en het N-gehalte van de 1^e snede. De opbrengst en het aandeel witte klaver zijn lager, als dierlijke mest wordt gebruikt. Stalmest geeft een geringere opbrengstverhoging in het voorjaar in vergelijking met drijfmest, maar leidt tot een lager N-gehalte in het gewas. Voor drijfmest en stalmest is de berekende N-efficiëntie respectievelijk 11.8 en 22.1 kg ds kg⁻¹ minerale N in mest.

Voor alle drie typen bemesting is een correlatie berekend met behulp van lineaire regressie

tussen klaver-opbrengst enerzijds en totale- en N-opbrengst anderzijds. Een niet-lineaire, curvilineaire relatie geeft de hoogste correlatiecoëfficiënt, waaruit blijkt dat de relatie tussen klaver-opbrengst en N-opbrengst een optimumcurve is in plaats van een lineair verband. De productie van een gras-klavergewas kunnen daarom het beste verklaard worden als een resultante van witte klaver productie met een additioneel effect van N uit mest.

Concluderend ten aanzien van bemesting geldt, dat de interactie tussen minerale stikstof (mest, bodemmineralisatie) en klavergebonden stikstof duidelijk zijn, maar resultaten afhankelijk zijn van aaltjes en de kali-toestand van de bodem. De effecten van dierlijke mest op de groei van gras-klaver is als volgt samengevat: Het totale niveau van N, minerale N en K in mest tezamen met het tijdstip van mestaanwending in het voorjaar zijn de belangrijkste factoren die de verschillen in totale en witte klaver opbrengst tussen jaren verklaren. Wanneer de P en K toestand van de bodem voldoende zijn, dan is er een positief effect van het (minerale) N-niveau in mest op de gewas- en N-opbrengst, maar een negatief effect op de klaveropbrengst en het percentage klaver in de droge stof. Dit N-effect is het grootste bij het gebruik van drijfmest, door het hoge niveau van minerale N, wat leidt tot een hogere N gehalte in de droge stof en een hogere droge stofopbrengst van de 1^e snede in het voorjaar. Een gift gecomposteerde potstalmest in het vroege voorjaar beïnvloedt de groei van het gewas in de zomer en herfst positief in vergelijking met drijfmest. Na een gift dierlijke mest in het voorjaar herstelt de witte klaver zich in de 2^e helft van het groeiseizoen. Dit herstel van klaver kan vertraagd zijn of zelfs afwezig, wanneer er een kali-tekort is. K-gehalten in het gewas op zandgrond moeten boven een niveau van 20-25 g per kg droge stof liggen voor een voldoende klavergroei. Ook de keuze van een persistent klaverras is een belangrijke factor die zowel de ds-opbrengst als de N-opbrengst van een gras-klavertzode op biologische bedrijven bepaald. Echter de verliezen van klaver in de winter zijn niet de belangrijkste oorzaak van de terugval van klaver door de jaren heen. Gedurende het groeiseizoen reduceren slakken het bladoppervlakte van de klaverplant, waarbij het cyanidegehalte in klaver de gevoeligheid voor plagen mede bepaald.



Appendices

Appendix 1. Botanical composition as an average per manure type in three trials: 'cutting', 'grazing' and 'level'; abundance per species in percentage ground cover measured in the first week of September 1998, + means less than 1%; quality code as good (g), moderate (m) or poor (p) grass species according to Kruyne et al., 1967.

Trial	code	-- 'cutting' --			-- 'grazing' --			-- 'level' -- (low)			-- 'level' -- (moderate)			-- 'level' -- (high)		
		PK	SL	FY	PK	SL	FY	PK	SL	FY	PK	SL	FY	PK	SL	FY
Manure type		PK	SL	FY	PK	SL	FY	PK	SL	FY	PK	SL	FY	PK	SL	FY
Total abundance		88	90	88	88	89	84	86	90	88	84	88	85	81	88	88
Lolium perenne	g	54	47	26	50	49	42	46	43	31	36	46	30	26	39	29
Poa trivialis	g	7	14	8	10	13	13	8	18	9	5	10	7	4	11	14
Poa pratensis	g	4	1	3	+	1	+	5	4	4	2	3	6	2	1	7
Phleum pratense	g	+	1	+	+	+	+	1	1	1	1	1	2	1	1	1
Elytrigia repens	m		1			+	1					1			1	
Agrostis stolonifera	m		+		+			1	+		+	1			+	+
Holcus lanatus	m	1	1	2	2	1	2	3	1	2	1	1	1	+	2	1
Dactylis glomerata	m	+	+	1	+	+	1	+	+		1				+	
Alopecurus pratense	m	+			+	+	+			+	+	+	+			+
Poa annua	m	3	7	3	6	7	5	2	4	2	2	3	3	2	4	5
Alopec. geniculatus	m		+		+	1	+									1
Festuca rubra	p	+		+					+							
Anthox. odoratum	p	+														
Trifolium repens		27	24	50	29	23	28	33	25	42	52	32	41	65	35	33
Taraxacum spec.		4	5	7	5	7	11	2	4	8	1	4	8	1	7	8
Ranunculus repens		1		+			+	1	1		+	+	+	+	7	+
Rumex obtusifolius				1	+		1			1			1			2
Ranunculus acris					+		+				+	+	+		+	+
Polygonum aviculare			+	+	+	+		+	+							
Bellis perennis		+														
Leontod. autumnalis					+	+		+	+	+						+
Plantago major			+						+	+						
Veronica spec.		+									+					
Rumex acetosa																+
Anthriscus sylvestris												+			+	



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