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Dealing With Novelties: a Grassland Experiment Reconsidered

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ABSTRACT *This article discusses a controversy that arose out of a grassland experiment in the Netherlands. Using the same data, one group of farmers and scientists concluded that a newly developed trajectory towards sustainability in dairy farming was highly effective, whilst a second group of scientists linked to the Research Institute for Animal Husbandry (PR) concluded the opposite. This article seeks to disentangle this controversy and, in so doing, discerns three levels of discussion. The first regards the understanding of agricultural processes of production as constantly changing practices. Here the concepts of co-production and novelties are introduced. The second level regards the methods for research design and analysis. Thirdly, there is the level of institutionalized research routines. These routines come down, amongst other things, to more or less standardized research questions, hypotheses and methods. Basically, level three contains a specific, and necessarily narrow, selection of concepts and methods from the first and second levels. The question, though, is whether such a selection is in line with markedly changing practices in agriculture. The article concludes that institutionalized research routines are unable to represent, understand and support novel and promising practices correctly.*

KEY WORDS: Grassland production, manure, novelties, field laboratories, environmental co-operatives

Co-production and the Importance of Novelties

Agricultural production can be conceptualized in different ways. Within the currently dominating paradigm, agricultural processes of production are understood basically as the (more or less optimized) unfolding of natural and economic laws encapsulated in different subsystems (land, cattle, crops, water, markets, etc.) which together make up the agricultural system of production (Wit, 1992). These 'underlying' laws, identified by scientists, are assumed to govern the behaviour of

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these resources. It is assumed that they do so independently of time and space—i.e. that they are universal laws (Koningsveld, 1987; Ploeg, 1987, 2003; Vijverberg, 1996).

Contrasting with this view is the agro-ecological or constructivist approach in which agriculture is understood as co-production of humans and living nature. Agriculture, then, represents the ongoing combination, interaction and mutual transformation of social and material resources.

Thus, agriculture is being differentiated and transformed constantly (Altieri, 1990; Sevilla Guzman & Gonzalez, 1990; Toledo, 1992). New constellations emerge, containing remoulded resources and new combinations of resources. Hence, 'nature' as entailed in farming is "not the one from Genesis" as Koningsveld (1987) beautifully phrased it. Instead, 'living nature' is constructed, reconstructed and differentiated within long and complex historical processes, through which particular characteristics are built into the resources concerned (be they horses, cows, fields, crops or manure; Groen *et al*., 1993; Sauvant, 1996; Seabrook, 1977, 1994; Smeding, 2001; Sonneveld, 2004; Wiskerke, 1997). Thus, particular regularities emerge that characterize the behaviour of the involved resources. These patterns of regularity are neither fixed nor universal: they might be *modified*, at particular conjunctures in time, into other, possibly even contrasting, regularities (Groot *et al*., 2003; NRLO, 1997; Ploeg, 2003).

In theoretical terms this implies that the behaviour of natural resources cannot be understood properly outside the pattern of land use (or style of farming) within which they are combined (according to a particular balance) and through which they are reproduced, developed and particularized into distinct entities that fit optimally with the other entities that form part and parcel of the same land-use pattern (Ploeg, 2003; Sonneveld, 2004). Concrete resources are the outcome of co-production: they are shaped and reshaped in and through the constantly evolving interaction between humans and nature. That is, co-production feeds back on the resources on which it is built. Farming is not a uni-directional process. It is not simply based on resources, but entails also *feedback* effects through which the involved resources are unfolded in differentiated ways.

Novelties are located on the borderline that separates the known from the unknown. Novelties often are the vehicle of changing co-production. A novelty is something new: a new practice, a new insight, an unexpected but interesting result. It is a promising result, practice or insight (Wiskerke & Ploeg, 2004). At the same time, novelties are, as yet, not fully understood. They are deviations from the rule. They do not correspond with knowledge accumulated so far—they defy, as it were, conventional understanding. Novelties go beyond existing and explained regularities. A novelty contains the promise of shifts in the established patterns of co-production (a more extended discussion of novelties is provided in Ploeg *et al*. (2004) and Milone (2004); empirical illustrations are given in Swagemakers (2002), Roep (2000), Wolleswinkel *et al*. (2004) and Scetri (2001)).

The VEL and VANLA Approach to Sustainability

VEL (*Vereniging Eastermar's Lânsdouwe*) and VANLA (*Vereniging Agrarisch beheer Natuur en Landschap in Achtkarspelen*) were amongst the first environmental co-operatives in the Netherlands. Environmental co-operatives are farmers' associations build upon a negotiated exchange between the state and farmers' collectives (Renting & Ploeg, 2001; Stuiver & Wiskerke, 2004; Wiskerke *et al.*, 2003a). The co-operatives commit themselves to an accelerated and convincing realization of general environmental goals (such as reducing mineral losses to less than 180 kg N per hectare per year; or a far-reaching reduction of ammonia emissions, whilst the state offers the farmers space for manoeuvre—that is the possibility to develop their own strategies to reach these goals. Thus the co-operatives are able to function as 'field laboratories' (Stuiver *et al.*, 2003).

Environmental co-operatives emerged as a response to the highly generic and means-centred agro-environmental policy that exists in the Netherlands (for a critical discussion of this see Frouws (1993), WRR (2003) and Bouma (2003)). Farmers are obliged legally to adopt a range of prescribed technologies (such as injection of manure into the soil) and to align their process of production to strict rules, procedures and parameters. This external prescription and sanctioning (Benvenuti, 1989) tends to petrify farming: it increasingly excludes any deviation from the imposed rules. The co-operatives, with their negotiated space for manoeuvre, form an important exception. Within the 'field laboratories', novelty production might blossom and co-production can be realigned with the needs of farmers, society and nature (Ploeg, 2006). As an alternative to the agro-environmental regime imposed by the state, the VEL and VANLA farmers, together with a few scientists, developed a different approach that became known as '*re-balancing*' (Reijs *et al.*, 2004; Verhoeven *et al.*, 2003). This approach is illustrated in Figure 1, which shows how each of the involved resources is reshaped and how they are simultaneously recombined so as decrease total N-input and increase overall N-efficiency (Groot *et al.*, 2003, 2006a; Verhoeven *et al.*, 1998).

The starting point for the process of re-balancing was located in the construction of *improved manure* (see Eshuis *et al.* (2001), Eshuis & Stuiver (2004) and

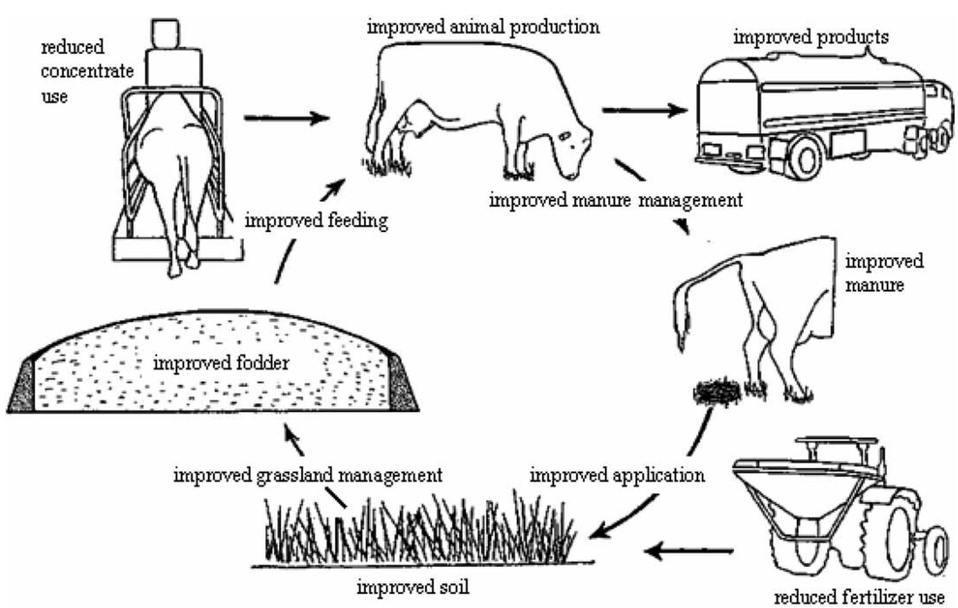

Figure 1. Re-balancing the soil–plant–animal–manure system

Stuiver *et al*. (2004) for a description of the underlying learning processes). 'Improved manure' represented a novelty. It is 'different' in terms of composition, outlook, smell and effects. Its major characteristics are a low N-content and a high C: N ratio. Whilst the very notion of 'improved manure' was perceived by many outsiders (especially scientists) as a monstrosity, the involved farmers assumed that improved manure would, especially when combined with *improved application techniques* (basically surface application as opposed to injection), result in *improved land*—that is, a soil characterized by a changed soil biology, resulting in improved nitrogen delivery capacity (later on, this was shown to be the case; see Goede *et al*., 2003; Reijs *et al*., in press). Thus, improved land would result in similar or even higher levels of grassland production, whilst reducing the use of chemical fertilizer. Improving the available manure and simultaneously reducing fertilizer use became the cornerstones of the process of re-balancing.

It was thought that this strategy, in combination with *improved grassland management* (notably mowing later), would result in *improved feed* (high in fibre, low in protein), which in turn could result in *improved animal production* (less stress, greater longevity, less veterinarian intervention, etc.). In turn, this would yield two other benefits: *improved products* (reduced urea content in milk) and *improved manure*. Consequently, the cycle as a whole would be, indeed, re-balanced and new self-reinforcing and more sustainable patterns of production would emerge.

It is important to stress that initially most of the indicated adaptations (or novelties) were considered by the leading expert systems to be irrelevant, counter-productive or downright impossible. These perceptions can be explained probably by the fact that these expert systems had produced the scientific grounding (and the central technical parameters) of the existing agro-environmental policy prescriptions. The discussed novelties evidently run counter to several of these prescriptions. Yet, the accompanying research over the years that followed showed that the different interrelations implied by the process of re-balancing, did indeed result in the emergence of new regularities: in a new patterning of agricultural production (for an overview see Wiskerke *et al*. (2003b), Wiskerke & van der Ploeg (2004); Bouma & Sonneveld (2004) discuss the wider implications).

A Contested Grassland Experiment

Following an agreement with the Minister of Agriculture, the VEL and VANLA co-operatives were permitted to start an extended test of the proposed re-balancing in 1996. This test, known as the Nitrate Management Programme (Reijs *et al*., 2004), was designed as on-farm research, involving the participation of 60 farmers. Of these 60 farmers, 20 were allowed to practice surface application of manure. This was an exception to the legal prescription that all manure is to be injected into the soil. They could also apply additives to their manure and implement other novelties. The conditions attached to this experiment were, first, that the co-operatives, and especially the participating farmers, had to reduce their environmental impact considerably and, secondly, that the outcomes of the novel practices were to be documented carefully through scientific research. Thus, several lines of inquiry started, some regarding soil biology and the interaction between properties of the land, others focusing on socio-economic and environmental impacts of the different novelties. This implied, among other things, measuring ammonia emissions (both *in situ* and in the laboratory), soil, feed and manure analyses, and a careful analysis of farm accounts.

The accompanying research also included a grassland experiment. This aimed to assess the "effects of management of manure, additives and application techniques on grassland production and soil fertility"(Kok *et al*., 2004). It was carried out at two locations, carefully selected by the co-operatives. One location represented (according to the co-operatives) improved land,[1] whilst the other location was perceived, at that time, as being 'conventional' (i.e. not improved) land. On both locations, two types of manure were applied: nitrogen-rich and nitrogen-poor, the latter being understood by the co-operatives as improved manure. This improved manure was produced at Hoeksma's farm, whilst the 'conventional' one came from Sikkema's farm. Beyond that, both types of manure were combined with different additives as Euromestmix, FIR and EM. The application method was also varied: both surface and injection methods were employed, the former being defined by the co-operatives as improved application.[2]

The design and management of the grassland experiment were delegated to the PR (*Proefstation Rundveehouderij*), the state agency for applied research in dairy farming. According to existing institutional routines, the PR shaped the grassland experiment as a multifactorial experiment. Technically the experiment was reduced to a randomized complete block with two replicates on each farm: two types of manure $\times$ two methods of application $\times$ two levels of additive use (none, EM $+$ 2 controls) $\times$ two nitrogen fertilization levels[3] $\times$ two replicates per farm $\times$ two farms, resulting in 80 experimental plots.[4]

At the start there was considerable debate. Several of the points raised are, in retrospect, still valid. A field research, involving all 60 farmers, would probably have been preferable. But then, part of the established research routine of PR (and similar institutes) is to translate research questions into controlled experimental set-ups. It was also questioned whether the design of the experiment would allow for an adequate analysis of possible interactions. And, finally, both farmers and scientists wondered about the inclusion of 'zero plots'(receiving only manure and no chemical fertilizer). Later on it became clear that this was also an important part of 'framing' the grassland experiment into the established routines: it allowed for an interpretation of the outcomes in terms of 'workability coefficients'.

The grassland experiment continued for five years and provided an enormous mass of data (Kok *et al*., 2004). It also provoked considerable debate because the results were 'read' in contrasting ways. After just three years, the researchers from the PR concluded that none of the novelties had any positive effect (Kok *et al*., 2002). This was echoed in a scientific publication that observed that the "N utilization of slurry manure was 18 per cent higher with slit injection as compared to surface application" (Schils & Kok, 2003, p. 63). This would imply that more nitrogen got lost and that the novelties represented a considerable step backwards. The PR interpretation of the results also claimed that "slurry manure type . . . had no consistent effect on the manure-N utilization" (Schils & Kok, 2003, p. 63). The Final Report states explicitly that "the effective use of nitrogen out of slurry was, after surface application, lower than after injection . . .. This decreased use might be caused by higher losses of ammonia". It was also concluded "that no differences emerged between the different types of manure . . .. Beyond that, the difference between distinct types of manure cannot be but irrelevant"

(Kok *et al*., 2004, p. 24). The same goes for the assumed interactions between the different novelties: they are hard to find and if they are encountered they are of no use (Kok *et al*., 2004, p. 24).

Yet, the results of the experiment were 'read' in different ways. Figure 2 (based on data of the first year) synthesizes the interpretation given to the results by the involved farmers. At the extreme left, there are the experimental plots that represent the simultaneous presence of all novelties. At the extreme right there are the plots lacking all these elements. In between there are, first, the optimal situation minus one ingredient, then (in the following column) the optimal situation minus two ingredients, and so on and so forth (this perspective also underlies the application of GRM statistics in Goede *et al*. (2003) and Verhoeven *et al*. (2003)). When presented and analysed in this way the grassland experiment confirms the validity of the new strategy of 're-balancing'.

This particular view was supported by the opinion of former grassland experts who indicated that "you start, of course, by looking to the best yielding plots" (Wieling, pers. comm.). Some university researchers applied multivariate analysis that supported the particular view of the VEL and VANLA farmers. Other scientists reacted by arguing that this was just "selective shopping" (WB, 2003) and that the indicated differences would probably be just an incidental effect of differences in soil fertility. Thus, a controversy was born. The grassland experiment became a "battlefield of knowledge" (Long & Long, 1992). The next section attempts to decipher the backgrounds of this controversy.

At the Interface of Established Research Routines and Novel Practices

Current research routines tend to be reductionist. This characteristic is emerging at different levels and in different forms (Verschuren, 2001). It can be introduced through the understanding of resources as entities that are 'given' once and for all. It might also enter at the level of research design (what questions are being asked, how do they translate into a particular design of field research or experiment and how are the obtained data analysed?). Finally, it might result from the way the research is 'framed' into a particular trajectory or tradition.

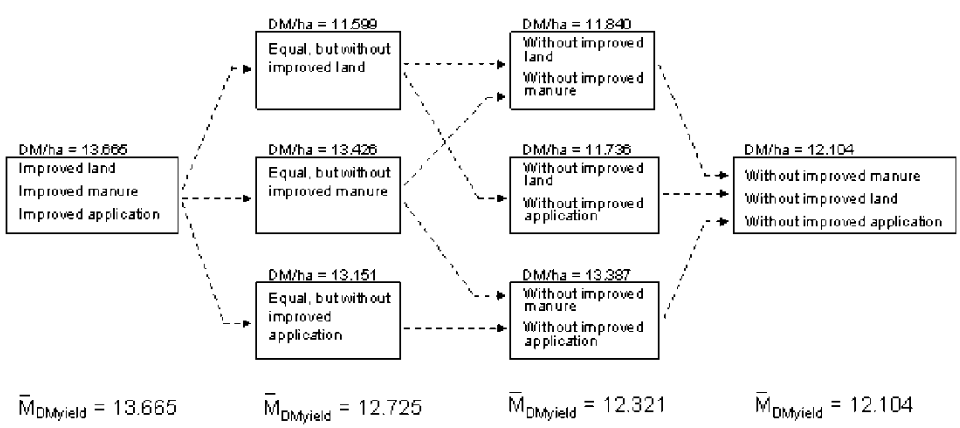

Figure 2. The farmer's interpretation

For the two co-operatives the question underlying the grassland experiment was simple and solid. Can one demonstrate that, with an identical N-input, the new approach (as illustrated in Figure 1) results in similar, or even higher, levels of grassland production compared with the 'conventional' approach? If this were the case, the implication would be clear. The available nitrogen would be used more effectively and, consequently, losses would be lower. This was exactly the same question that interested the Minister. The research institute (PR), however, rephrased this general question into the following ones:

(i) does surface application of slurry as such have any advantage (in terms of N recovery) compared with injection into the soil?;
(ii) does the use of additives as such have any significant effect?

Within an *unaltered* pattern of dairy farming these essentially reductionist questions (that only consider partial relations) could have been useful. However, in an exploration of novelty production they are inadequate, because they ignore the possibility of newly emerging properties and interactions at higher levels of aggregation. The questions that are not addressed in the PR analysis include the following:

(iii) how does nitrogen-poor manure (i.e. improved manure) compare with current nitrogen-rich manure?;
(iv) does improved manure (i.e. nitrogen-poor manure) result in improvement of soil quality?;
(v) does improved manure combined with improved soils and improved application techniques produce superior results in terms of grassland production?

In short: The PR analysis addressed the first two, reductionist type of questions only and ignored, or overlooked, the possibility of interactions at higher levels of aggregation. It could be argued that such interactions, if present, would emerge out of the experiment—but the design and management of the experiment, as well as the analysis and the theoretical notions underlying it, precluded this possibility.

On top of the issue of what questions were being asked there were also some decisive methodological issues. These might appear, at first sight, as highly incidental, but in fact they are not mere incidences, but institutionalized features of current routines. They reflect the reductionist approaches in applied agronomic research.

First, in on-farm research it is necessary to come as close as possible to 'real life' conditions. Similarity to these conditions is crucial if one wants to check the value of new approaches. In the first year, however, PR applied manure to the experimental fields in quantities that far exceeded those normally applied by farmers in the area. Equally, weather conditions were not taken into account, whilst mowing dates were far earlier than those generally employed by farmers. It was only after extensive discussions that changes were introduced to address these dissimilarities (Eshuis *et al.*, 2001, pp. 102–103).

Secondly, experimental research requires that relevant conditions should remain as stable as possible. If, for instance, the differences between conventional (N-rich) and improved (N-poor) manure are at stake, the N-contents of the different types of manure should remain more or less constant from year to year. The problem, though, is that in on-farm research such a constant level is not guaranteed automatically. For many reasons, the composition of manure might change. 'Disturbances' might emerge. This requires thorough monitoring and, if needed, appropriate corrections in the subsequent analysis.

Thirdly, the phenomenon of *statistical interaction* needs to be taken into account. This phenomenon implies that the causal effect that one variable has on another one may be moderated or even hidden through the influence of a third (fourth or fifth) variable. That is: a causal effect may exist in one condition, whereas it does not emerge in another. The opposite phenomenon might also show up. In methodological literature this is referred to as *multiple conjunctural causation* (Ragin, 1989). The problem in quantitative research is that, in general, tests for 'multiple conjunctural causation' are relatively rare, complicated and difficult to carry out. Moreover, their results are extremely difficult to interpret. Although this type of effect very often occurs in social and physical realities, often all the possible mechanisms are not known in advance. Without a valid theory that can steer the selection of relevant testing variables, it is unfeasible to check for this mechanism. Multiple conjunctural causation may especially remain undiscovered by researchers, if theory says that a variable X has a zero or a negative effect on variable Y. So, if somebody wants to improve Y he or she will not try to do this by manipulating X. However, this does not exclude the fact that, in combination with other variables, X may have an effect on Y, even a positive one. For instance, in general, moisture (X) as such is known to be an unfavourable phenomenon in all kinds of production processes (Y). However, if there is a lot of dust (Z) in the production room (which is also unfavourable to Y), the disadvantage of moisture may turn into an advantage, as moisture and dust will neutralize each other. Ragin considered the existence of multiple conjunctural causation as a justification for a more holistic type of research. Looking at a case as a whole, one will discover multiple conjunctural causation more easily than when breaking down reality into separate variables. Transferred to the case of the grassland experiment, it might be argued that farmers tend to perceive situations more holistically than scientists following a reductionist approach. This may be a reason for agricultural researchers checking the observations and ideas of farmers (Verschuren, 2001).

The 'technicalities of research' discussed under the previous three points interact with more general features at the epistemological level. In current research routines, properties of specific resources (application techniques, types of manure, soils, etc.) are understood and represented mainly as being intrinsic to the studied resources, and not as emerging out of the broader constellations of which these resources form part.[5] Properties of soils, for instance, are represented as being intrinsic to these soils. The same applies to, say, manure and application techniques. Within the PR approach, manure is what it is—regardless of the way that it is produced, applied and combined with, for example, specific soils (Kok *et al.*, 2004, p. 24). In the context of relatively stable patterns of co-production such a segmented approach (that corresponds with the high degree of specialization in agrarian sciences) has a place. However, when patterns of co-production are changing, the same approach might become a considerable pitfall.

Finally, there is the strong belief in the institutes for applied research, such as PR, that empirical findings, of whatever type and nature, are meaningless if they cannot be explained by accepted theories. In itself this is a rational position. If, however, the models used for the required explanation reflect specific, historically rooted modes of co-production (and consequently exclude others), it then becomes extremely difficult if not downright impossible to come to grips with newly emerging and promising practices—that is, with novelties.

The following sections will demonstrate that it is possible to go beyond the indicated forms of reductionism. It will be shown that a re-analysis, starting with the right kind of questions and taking into account the complexities of field experiments and novelty production, renders scientifically grounded and statistically significant conclusions. These align with, and support, the farmers' interpretation, whilst they simultaneously show that the PR conclusions are definitely inadequate.

Changing Manure Composition: a Crucial, Yet Overlooked Variable

There were clear differences in the composition of the manure types used in the experiment. Schils & Kok (2003) summarized these differences, showing that per ton of *standardized manure* Hoeksma's manure contained 3.9 kg N whilst, in Sikkema's manure, this was 4.8 kg. There were also differences in ammoniacal and organic nitrogen (1.9 versus 2.2 and 2.1 vs. 2.5, respectively). Table 1 also shows that over the years, the manure produced on Hoeksma's farm is relatively N-poor (it is improved manure), whilst the manure produced on Sikkema's farm is N-rich. It is important to note that the table refers to standardized manure. It shows the N-content of the manure if this manure had a dry matter (DM) content of 85 per cent. However, this hypothetical manure was not the one that was distributed ultimately over the different experimental plots. On Sikkema's farm, the manure was—at least in some years—highly diluted with cleaning water from the milking parlour.[6] Such dilution is quite a common practice in the Netherlands, where a few farmers deliberately dilute their manure with large quantities of canal water in order to improve the sustainability performance of their farms.

The considerable volumes of cleaning water added to the manure on Sikkema's farm[7] imply that, at least in some years, the manure actually distributed over the plots was not the same as the calculated one. As Figure 3 shows, the real amount of nitrogen distributed (a fixed quantity of slurry, expressed in cubic metres, was brought onto the plots) fluctuated widely as far as Sikkema's slurry is concerned. These same fluctuations affected the ranking of the two types of manure. Due to dilution with cleaning water Sikkema's manure entered the experimental plots as relatively N-poor manure in years 2, 3 and 5. Things are not

Table 1. Average composition per year of standardized N-poor and N-rich manure as used in the grassland experiment

Year	Hoeksma (N-poor)		Sikkema (N-rich)	
	N_{tot} in DM	C: N	N_{tot} in DM	C: N
1999	48.0	7.3	52.7	7.0
2000	46.2	7.9	59.2	6.3
2001	44.6	8.3	61.7	5.6
2002	43.0	8.5	47.9	7.5
2003	45.0	8.1	61.8	5.9

From Kok *et al*. (2004).

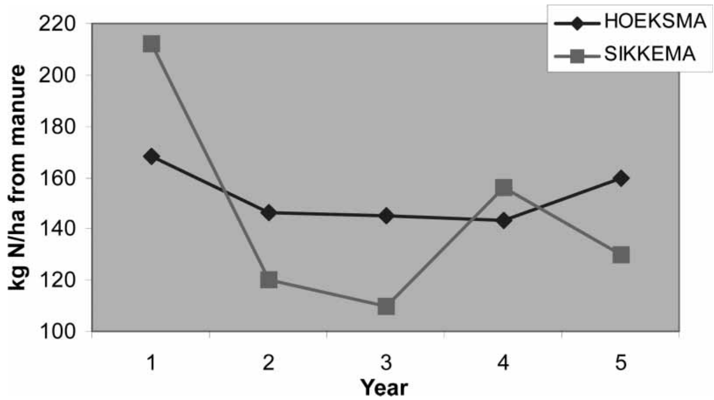

Figure 3. The amount of N per hectare from equal quantities of slurry

always what they seem (or are supposed) to be, but are sometimes altered through the process of their construction. More precisely: due to the addition of large quantities of cleaning water, Sikkema's manure was *de facto* rebuilt into relatively N-poor manure—at least in some years.

While the final PR report does refer to this problem (see also Schils & Kok, 2003, p. 47), its analysis is not based on the real N-contents (as reflected in Figure 3), but on the assumed N-contents (Table 1).[8] Thus, the 'disturbance' is neatly left out of the analysis. The consequence is that the PR analysis itself became distorted right from the beginning.

The Omission of Yet Another Crucial Variable: Land

A crucial assumption underlying novelty production in the VEL/VANLA co-operatives is that N-poor manure can improve the quality of the soil and thereby result in improved land. By the end of the research programme this claim had been underpinned and proven by several research projects, notably those of De Goede *et al*. (2003), who convincingly demonstrated that soil biology is changing and improving, and of Sonneveld (2004), who showed how the utilization of land affects its properties strongly. Building on the earlier work of Pulleman *et al*. (2000), Sonneveld argued that understanding land as such, that is as a *genoform* having its own intrinsic properties, is unsatisfactory. Through co-production a particular genoform will unfold in contrasting *phenoforms*. Thus, through contrasting patterns of utilization, land is moulded into different constellations, with different properties that emerge out of the differential relationships between land and the way it is used. Sonneveld & Bouma (2003, table 2) demonstrated that one particular genoform (in this case *cHn23*) might be unfolded into at least three, highly contrasting phenoforms, each characterized by particular levels of organic C, organic N, particular C: N ratios and specific rates of mineralization. The decisive factor here is the *biography* of the fields, i.e. their particular treatment.

The PR analysis, by contrast excludes land as a variable. The reason for doing so is 'that only two types of land are included, which does not allow for any statistical inquiry'. This reasoning is, in the authors' view, incorrect—both substantially and methodologically. From a methodological point of view, 'land' is perceived by PR as a dichotomous variable (just as 'man' and 'woman'): in the experiment there are, one could say, 40 'men' (2 × 20 pieces of normal land) and 40 'women' (2 × 20 pieces of improved land). Substantially, because every plot receives, within the experimental design, a different treatment, this implies that the initially probably identical, plots are unfolded, during the experiment, into contrasting phenoforms.[9] That is, the experiment is dealing here indeed with 2 × 40 actively differentiated pieces of land.

The Validity of the Novel Trajectory

When attention is shifted from partial research questions, towards questions that are relevant at higher levels of aggregation (questions iii, iv and v discussed previously) and when the changing nature of manure and land are taken into account, an interesting image emerges. When improved land, improved manure and improved application are combined and understood as *improved management* (to be compared with standard management, in which the combination of novelties is lacking), this shows that improved management affects the overall performance of grassland positively. There is, in the first place, a significant improvement in N-recovery: the conversion of applied nitrogen into available nitrogen (see Figure 4) is augmented. This refers to a better functioning soil biology. Secondly, the ratio between applied nitrogen and total DM production also improves significantly (see Figure 5). In the standard management system every kilogram of applied nitrogen is converted into 43 kg of dry matter per year per hectare, whilst in the improved way this increases to 51 kg DM per year per ha.[10]

Lastly, Figure 6 takes into account the possible effect of fertilizer. If attention is focused on the plots receiving fertilizer and manure, then improved management results in higher DM yields per ha per year compared with the conventional management. In the plots receiving manure only, the effect is diametrically opposed (which is, by the way, a typical example of multiple conjunctural causation).

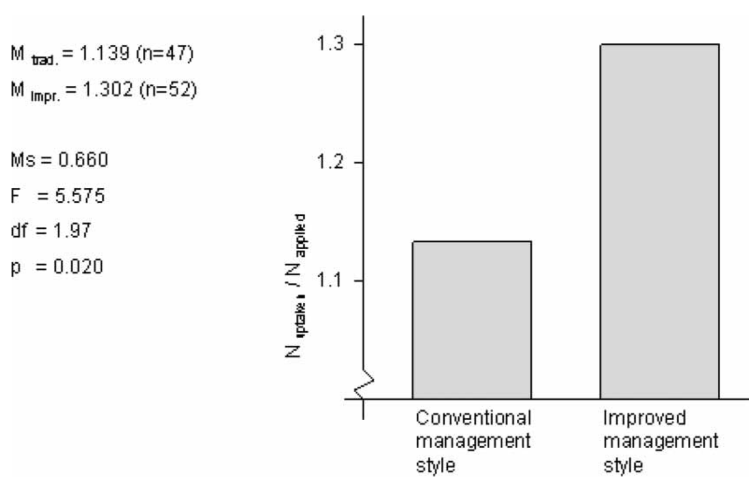

Figure 4. N-recovery according to management style

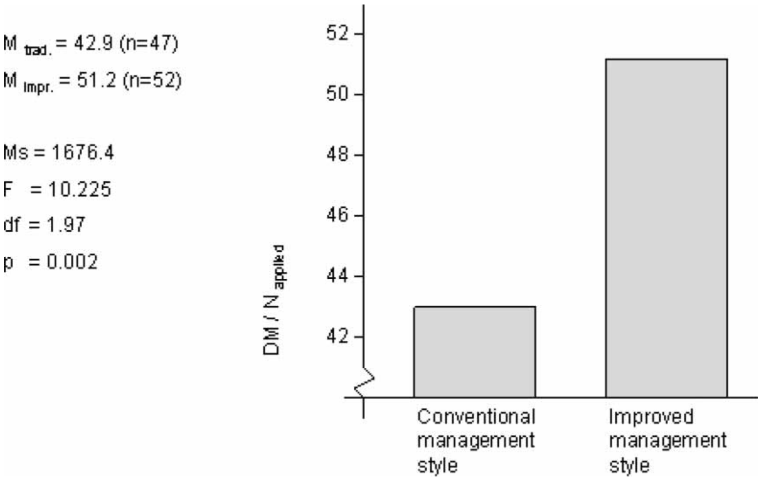

Figure 5. Dry matter production per applied kg N according to different management styles

Focusing on Manure

The previous section subsumed the effects of using N-poor manure within the broader effects of improved management. Here, the effects of N-poor manure will be singled out.[11] Following theoretical agronomy (de Wit, 1992), grassland production is understood as a two-fold process of conversion. First, there is the conversion of distributed nitrogen into available nitrogen. The latter is assumed to be equal to the nitrogen uptaken by the plants. This process is illustrated in the first, lower-lying quadrant of Figure 7. The second, upper right, quadrant illustrates the conversion of uptaken nitrogen into DM production. The last quadrant (upper left in Figure 7) summarizes the direct relations between the distributed nitrogen on the one hand, and DM production on the other. This third quadrant is a synthesis of the first two: it gives the actual 'direct' relation between N-applied and dry matter production per hectare.

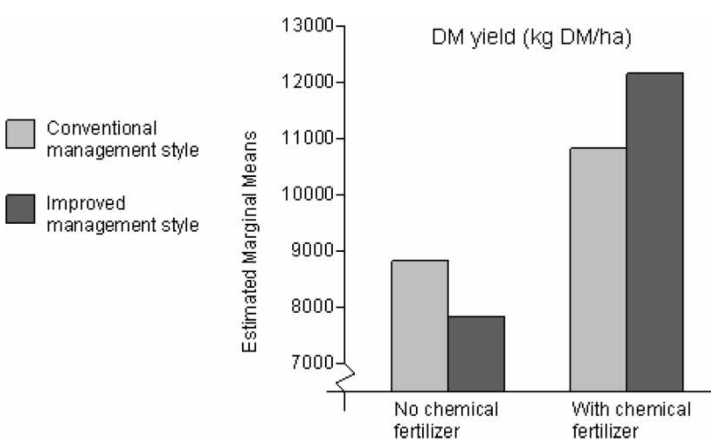

Figure 6. Dry matter yield per ha according to management styles and fertilization level

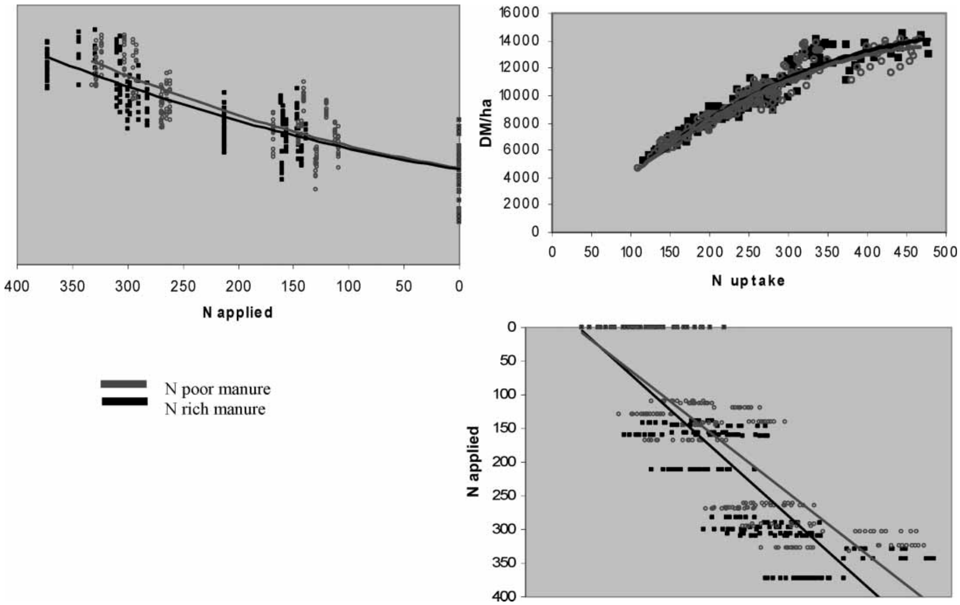

Figure 7. A three-quadrant diagram

The first quadrant[12] contains two regression lines that specify recovery: one for improved manure (equation 1), the other for nitrogen-rich manure (equation 2). The two regression lines are statistically different from each other: with a given total N application (consisting of equal amounts of manure and fertilizer), the improved manure results in a small, but statistically significantly higher N-uptake by the plants. This occurs regardless of the location.

$$N_{\mathrm{uptake}} = 95.6 + 0.77\,N_{\mathrm{applied}}(r^2 = 0.58)(\text{for N-poor manure})(10.3)(0.04) \quad (1)$$

$$N_{\mathrm{uptake}} = 90.6 + 0.70\,N_{\mathrm{applied}}(r^2 = 0.57)(\text{for N-rich manure})(11.5)(0.04) \quad (2)$$

As Figure 7 indicates, there is considerable variation within the first quadrant. Most of this variation can be accounted for by annual differences in climatic conditions and, to a lesser extent, by differences in application methods and soil. If these variables are introduced into the equation, the total variance explained rises to 91 per cent.

In the second quadrant no significant differences emerge. Efficiency levels are, on average, the same for N-poor and N-rich manure. The relevant results are shown in equation (3):

$$DM_{\mathrm{ha}} = 49.72N_{\mathrm{uptake}} - 0.042N^2_{\mathrm{uptake}}(r^2 = 0.91) \quad (3)$$

When taken together, that is: when represented as a direct input–output relation (quadrant 3), the significant differences between improved and conventional manure re-emerge again. For the former, equation (4) applies, for the latter, equation (5):

$$\mathrm{DM_{ha}} = 4456 + 0.050\mathrm{Ndistr}^2 + 1218\mathrm{yearcode} + 755\mathrm{soil}$$
$$(r^2 = 0.85)(\text{for N-poor manure})$$
$$(230) \quad (0.002) \qquad (77) \qquad (119) \tag{4}$$

$$\mathrm{DM_{ha}} = 4442 + 0.045\mathrm{Ndistr}^2 + 1198\mathrm{yearcode} + 798\mathrm{soil}$$
$$(r^2 = 0.82)(\text{for N-rich manure})$$
$$(231) \quad (0.002) \qquad (95) \qquad (136) \tag{5}$$

In synthesis: the three-quadrant analysis shows that N-poor manure as such results in higher grassland yields. This new pattern is rooted in the first quadrant: it is the effects of improved manure on the soil that are decisive. When applied on improved land these effects are even more significant (see equations 4 and 5). This refers to the centrality of interactions, or, to re-phrase it somewhat differently, to the art of re-balancing.

Figure 8 entails a return to the already discussed farmers' type of view on the experiment. In contrast with Figure 2, Figure 8 contains data from the

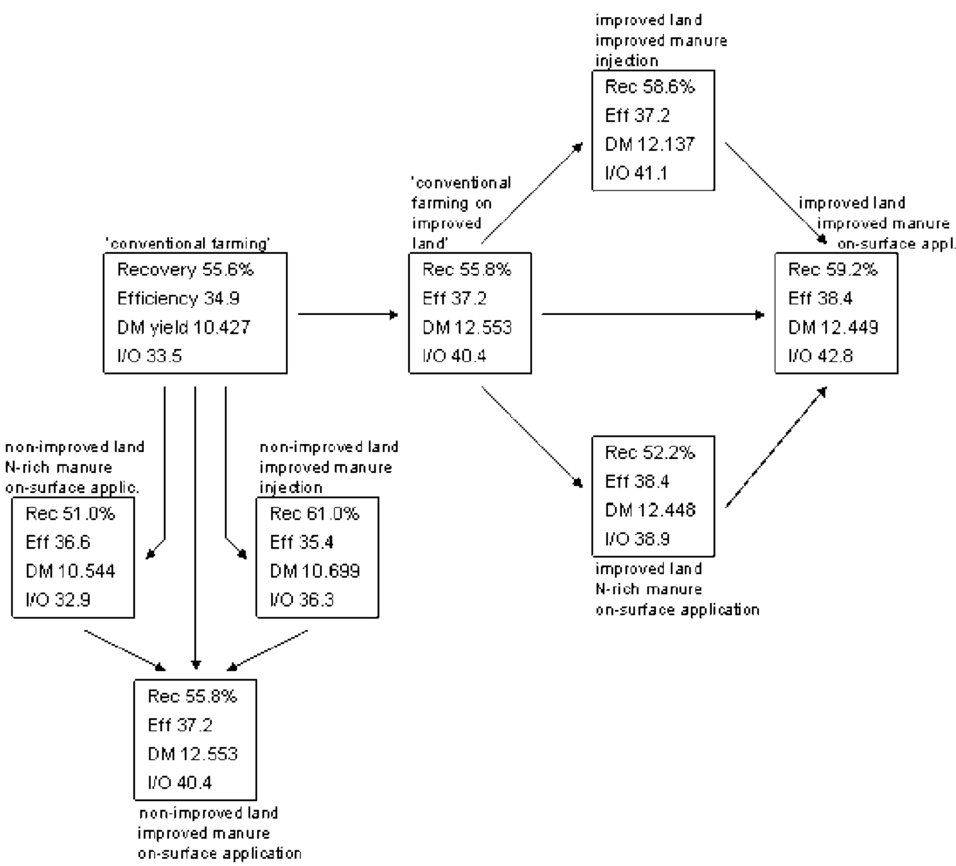

Figure 8. A return to the relevant comparisons

three-quadrant analysis summarized in Figure 7. The horizontal axis of Figure 8 shows the 'long run effects' (including the change towards improved land) of the new trajectory. Both recovery and efficiency show slight changes. Together these result in a substantial increase in DM yield and, consequently, in a significant improvement of the input–output (I/O) relation (from 33.5 to 42.8). The vertical axis shows the 'short run effects'. If applied on 'conventional' (unimproved) land, the combination of N-poor manure and on-surface application results in a decrease in recovery and a slight improvement in efficiency. A modest increase in the I/O ratio is the net effect. This positive net effect is somewhat larger when improved manure is injected. Overall, Figure 8 indicates that, in the short run, the discussed novelties are not counterproductive (as suggested by the PR), whilst, in the longer run, they turn out to be quite successful.

Figure 8 also suggests that surface application affects efficiency positively, whilst injection augments recovery. N-poor manure also has a positive effect on recovery.

Reconsidering Institutionalized Research Routines

It is no surprise that the institutionalized research routine as exemplified by PR was unable to identify these sorts of positive interrelations. First, the PR analysis excluded the possibility of identifying the potential relevance of the difference between N-rich and N-poor manure as the required corrections following the unintended dilution of manure, were not made. Secondly, the potential effects of different soil qualities (different phenoforms) were not taken into account, which meant that little or no attention was paid to potential interaction effects.

Thus, PR's analysis of the experimental data basically comes down to a straightforward comparison of average results related to different experimental conditions (i.e. different 'independent factors'). To check whether or not there is any significant effect of surface application compared with injection, all plots receiving surface application (including the ones receiving no fertilizer) are compared with all plots on which manure is injected. Consequently, potentially relevant exceptions disappear.[13] Specificity—that is the creation of a specific balance of different resources and techniques—is central to the art of farming: this, however, is lost in the PR analysis. As a result, potentially powerful novelties are filtered out.

Conclusions

The foregoing analysis allows for three sets of conclusions. First, improved manure, as developed within the VEL and VANLA co-operatives, turns out to be a promising novelty. Research shows that it tends to improve soil biology (Goede *et al.*, 2003), which is mirrored in the first quadrant of Figure 7. It reduces the amount of lost N (Groot *et al*, in press). It strongly reduces ammonia emissions, according to both field measurements (Huijsmans *et al.*, 2004) and laboratory analysis. In addition, as this article shows, it raises the efficiency of grassland production—especially when improved manure is combined with other novelties, such as improved land, improved application and adapted fertilizer quantities. More generally speaking, the potential value of re-balancing (as a comprehensive strategy to reduce N surpluses) is demonstrated empirically. All this does not imply, of course, that such a value has been 'proven' in the classical sense of the word. It is, as yet, unknown how improved manure would operate within different contexts (e.g. with different ecosystems, different farming styles, different local knowledge systems and communication structures, or different cattle breeds). Unpacking the novelties tried out in the VEL and VANLA cooperatives (disconnecting them from the specificities of time and space) would require another research design. It is clear, however, that—at least in the VEL and VANLA context—these novelties are shaping a new mode of agricultural production.

This then leads to a second series of conclusions. Applied research institutes as they function today are ill equipped to deal with novelties. Several reasons have been outlined above already and can be summarized.

(i) Established research routines find it difficult to deal with the complexities and disturbances inherent to on-farm research.
(ii) Established research routines, and especially experiments, seldom view land as an outcome of co-production. Thus, only through very expensive experiments (repeated in many different locations) can land be slotted into the analysis. With a better understanding of co-production the analysis of even simple experiments could be enriched considerably.
(iii) Novelties are not recognized as such in the current forms of applied research. Empirical deviations are frequently 'put between brackets', lost in aggregation or considered to be anomalies. By including only data and outcomes that can be explained by current theories, institutionalized research blinkers itself to the exploration of novelties.

In the Northern Friesian Woodlands an approach has been developed that might turn out to be a viable alternative for the existing agro-environmental regime. The feeding track (of a diet rich in fibre and poor in protein, in order to obtain nitrogen-poor manure with a high C: N ratio and a low percentage of ammoniacal N) is currently being applied by an increasing number of Dutch dairy farmers. It is an attractive option as it not only reduces N-losses but also seems to raise the gross margin per 100 kg of milk (Ploeg *et al.*, 2003). However, since applied research is the main mechanism informing policy formulation, this promising feeding track has once again been overlooked in new proposals for agro-environmental policies. From this a third series of conclusions can be drawn.

(i) Applied research should function, among other things, as a channel of communication that passes novelties, encountered in practice, to fundamental research.
(ii) As far as methods of analysis are concerned, the focus on average results should be complemented by a search for the exceptional; equally the inquiry into the perceived main effects should be replaced by a focus on re-balancing, interaction and fine-tuning.
(iii) Routine research traditions, mostly focused upon, and thus limited to, just one tiny segment of the broader processes of agricultural production, should be integrated into the complex 'mosaic' of available, neighbouring blocks of knowledge, instead of forming islands by themselves.
(iv) Agrarian policies should not be informed in an uncritical and unilinear way, solely by applied research. This is especially relevant when there is considerable heterogeneity (i.e. a wider range of trajectories towards sustainability). In such cases the dependency of policy on applied research will only augment frictions and conflicts.

(v) Currently the institutional infrastructure for knowledge production is subjected strongly to centralization and to a tight dependency on external funding. Both tendencies are highly detrimental, especially when agriculture is going through complex transitional processes. Hence, these tendencies should be reverted in order to allow for pluralism and debate.

(vi) Agrarian and rural policies should actively encourage local initiatives for self-regulation (such as the discussed VEL and VANLA co-operatives), especially since their focus on local specificities is crucial for the construction of sustainability.

Notes

1. On this location (Drogeham), the concerned farmer had been trying actively, since the beginning of the 1980s, to reduce the overall N-input into his farming system. This process is described in Ploeg (2003, chapter 4). From 1981 onwards Euromestmix was applied and over ten years the organic matter content of the soil increased steadily from about 8 per cent to 12.5 per cent (Eshuis *et al.*, 2001).
2. For outsiders this might be a confusing classification. Yet, many farmers and scientists consider slurry injection methods to be detrimental to soil biology, bird life and economic efficiency, whilst ammonia emission might be reduced in other, more effective ways. Thus (adapted) on-surface application methods are currently reconsidered as improved in comparison to injection.
3. On some plots manure only was distributed (tending towards an overall N application of 90 kg ha^{-1}) whilst, on others, animal manure was combined with chemical fertilizer in such a way that the overall N-application was around 250 kg ha^{-1}.
4. Statistically, such a design is fragile, especially because interaction effects will be difficult to grasp. However, the PR was interested only in so-called ‘main effects’.
5. This tendency has been strengthened, during the last two decades, especially because it was increasingly thought that agrarian sciences could construct ‘superior objects’—superior cows, for instance—which would function under whatever conditions (optimal or suboptimal) in the best possible way. That is, they would function better, regardless of the specific circumstances.
6. Reference to this problem is made in the final PR research report where it is stated that

   > . . . it was very difficult, especially for the manure on Sikkema’s farm, to have a constant composition over the year as a whole . . .. In 1999 and 2001 the problem emerged that during the season the manure became thinner due to an increased amount of cleaning water . . . High variations in the dry matter content of manure imply that nitrogen in manure with a lot of water evaporates less; hence it will be used better.

7. From year 4 onwards, an attempt was made to correct this variable, but the proposed correction failed again in the fifth year.
8. There is another important detail here. When a farmer dilutes slurry, there will be more cubic metres to distribute, but the same amount of nitrogen will be distributed over the land, albeit in a more dilute form. In the grassland experiment, however, Sikkema’s slurry was diluted, but only the *a priori* fixed amount of cubic metres was spread over the land.
9. This was demonstrated by de Goede *et al*. (2003). The analysis of organic matter and nitrogen contents of each plot also show that during the five years of the grassland experiment the number of significant differences between plots rises considerably.
10. In a recent analysis (Groot *et al*., 2006b) it has been shown that “the amount of N not accounted for” (that is lost N) is definitely the highest in the ‘conventional management style’. Through the systematic combination of the different novelties the lost N is reduced considerably.
11. The following analysis is based on real N-contents (as expressed in Figure 2).
12. The analysis is based on all plots and all years. That is, in total, there are 400 observations on which the analysis is built.
13. In the first year, for instance, the improved application (i.e. on surface) of improved manure (i.e. N poor) on improved land resulted in a DM production per ha that was slightly higher than the DM per ha production resulting from the injection of N-rich manure on the same land (13.29 vs. 13.08; data from Schils & Kok (2003, table 6a)). The same goes for the other years.

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