Nutrient Management on Vegetable Farms; What Will be the Future?

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Abstract

Production of field vegetables is known for its high nitrogen input and consequently high nitrogen losses towards the environment. All over the world research tries to find opportunities to reduce these losses. In 2000 the Dutch government initiated and funded a research project ("Telen met toekomst") to explore the possibilities to reduce the adverse effects of nitrogen and phosphate inputs on the quality of soil and surface water by farm management.

A participatory research approach was chosen, so the farmer, the consultant and scientist work closely together in making annual plans to reach a number of set goals for fertilization on the farm level. By registration of all activities concerning fertilization on the farm, the nitrogen input and output could be monitored.

The gap between the reference point at the start of the project and the environmental goals is big for nitrogen: the nitrogen balance surplus on the whole farm level should be reduced from 300 kg N/ha to 90 kg N/ha. First results show that this gap is unlikely to be bridged on all farms within the set period of time, without affecting the farmer's income. However, distinct differences could be observed in the farmers' attitude towards the challenge, the rate of progress varied significantly among farmers.

INTRODUCTION

The last two decades consumers got more and more aware of the impacts of modern agriculture on the environment. The consumers demand produce that is produced in an environmentally sound way. Regarding nutrients in field vegetable production losses of in particular nitrogen and phosphorus should be low, so that nitrate and phosphate concentration in the ground- and surface water can meet the standards (Anonymous, 1980) Meanwhile the farmers income should remain on an acceptable level.

Current research is focussed on methods to increase nitrogen use efficiency (both from organic sources and fertilizer), so that losses could be reduced (Rahn, 2002). However, implementation of the knowledge that was developed all over the world on the commercial farms, lags behind. This implies that environmental goals as set by governments are unlikely to be reached within a set period of time.

For that reason, the Dutch Ministry of Agriculture initiated and funded a project ("Telen met toekomst", translation; "Farming with a future") to explore the opportunities to reach environmental goals as related to water quality on commercial vegetable farms. This project started in the year 2000 and will continue for a period of five years (De Buck et al, 2000).

The aim of this paper is to present the results of the first two years of this project and to discuss the problems that were encountered.

MATERIALS AND METHODS

The approach used in the project was described by Vereijken (1999). For the project nine commercial vegetable farms on sandy soils were selected in two different areas in the south of the Netherlands. Characteristics of the farms in both groups are given in Table 1. The selected vegetable growers were formed a discussion group for each

region separately. The regional field vegetable consultant, a scientist specialized in plant nutrition in field vegetables and a process coordinator participated in each discussion group. Obtained results, planning and encountered problems are discussed in the group, so that exchange of ideas is optimized.

At the start of the season for each farmer a fertilization plan for his whole farm was made jointly with the consultant and the scientist. In the plan clear goals on farm nutrient inputs and surpluses on the farm nutrient balance were set and related to targets for these surpluses. Although the experts can be consulted at any time, the farmer remains responsible for his/her own decisions, during the execution of the plan.

During the season farmers register their management practices (e.g. sowing or planting date, cultivar), the nutrient inputs (e.g. fertilizer type, manure, amount and when it was applied) and outputs (e.g. marketable yield) for each field on his farm. At the end of the season this information is used to calculate total nutrient inputs and nutrient outputs (yield * a set nutrient concentration in the produce) on a farm level. The outcome is analyzed and compared with the fertilization plan and the set targets.

Within the project two goals were defined, namely, 1) a short term target to be reached in 2003 on nutrient inputs (nitrogen and phosphate from organic manure and fertilizers) entering the farm gate, and 2) a long term target regarding the nutrient balance (Table 2) for the whole farm. Aim of the project is to explore to what extent these set goals can be reached on the commercial farms within the set period of time (5 years), without adverse effects on the farmer's income.

RESULTS

The Challenge

The average situation on the participating farms with respect to the nitrogen and phosphate inputs from organic manure and fertilizers are concerned is given in Figure 1. The same is done for the surplus on the nitrogen and phosphate balance, as calculated according the items given in Table 2.

On average the nitrogen and phosphate inputs from organic manure and fertilizers were respectively almost 300 kg N/ha and 85 kg P_2O_5/ha (Fig. 1). For phosphate this value is close to the short-term target, however, for nitrogen a reduction of 75 kg N/ha is required to reach this target. The surplus of nitrogen and phosphate on the balance was approximately 280 kg N/ha and 60 kg P_2O_5/ha. Comparing these values with the long-term goals for these nutrients, surpluses on the nitrogen and phosphate balance should be reduced with respectively 200 kg N/ha and 60 kg P_2O_5/ha (Fig. 1). These goals can only be reached by a strong reduction on the inputs. As the challenge is highest for nitrogen, we focus in the present paper mainly on this nutrient.

Nitrogen Input

Preliminary results for the first two years of the project are given separately for both groups of farmers.

Among individual farms there was a huge difference in nitrogen input from organic manure and fertilizers (Fig. 2). At the start of the project one of the nine farms V08) showed a lower nitrogen input than the short term target for nitrogen input (225 kg N/ha). Two years after the start of the project five out of nine farms had nitrogen inputs lower than the short-term target. The two groups differed significantly as far as the magnitude of the reduction is concerned. Group 2 (VG07-VG10), showed the strongest progression (Fig 2). In this group the decrease in nitrogen input from organic manure and fertilizers did not affect the nitrogen output by marketable produce (Fig. 3), which simply means that marketable yields were not affected by the reduction in nitrogen inputs. Also for group 1 the nitrogen output remained unaffected (Fig. 3).

Farmers Strategy

In both groups there was a strong reduction in nitrogen input from organic manure during the studied period of time (Fig. 4). However, in group 1 (Fig. 4a) this reduction in animal manure was accompanied by an increase in plant manure and a slightly increase in nitrogen fertilizer input. Contrarily in group 2 the decrease in animal manure was not compensated by an increase in the application of plant manure. In the last group even a decrease in nitrogen input from fertilizers could be observed (Fig. 4). Both opposing strategies resulted in a similar effect on the nitrogen output, the change in strategy did not affect the nitrogen output in the marketable produce (Fig. 3).

In the first year of the project most farmers applied on average more for uptake available nitrogen (i.e. mineral fertilizer and from manure), than needed according current standard recommendations (Van Dijk, 1999) (Fig. 5). During the second year of the project most farmers in group 2 applied an amount that was in agreement with the recommended rates, while in group 1 all growers applied more than the recommended rate. The main reason for applying more than recommended was because not all nitrogen that was available for uptake from organic manure was accounted for.

Also in the planning cycle differences in attitude among individual growers became clear. In Fig. 6, the comparison of planning and realization on the balance surplus is given for both groups. For group 1 the results of two strawberry farms are given, while for group 2 the results of two leafy vegetable farms are given. VG01 started with a plan, aiming at a lower balance surplus than obtained in the previous year. However, a higher surplus was realized than planned (Fig. 6). The other farmer (VG04) shows a nice learning process. Based on the results obtained in the previous year, the goal is set at a lower surplus in the following year. A nice example of learning and a difference in attitude of the farmer is shown for the two leafy vegetable growers (Fig. 6). In 2001 the realized surplus on the balance was for both lower than was foreseen in the planning (Fig. 5b). This was due to mouth and food disease in that area in 2001, which prohibited the transportation of animal manure during the spring of 2001. This new experience, a lower surplus due to not applying animal manure and no complete replacement by fertilizers (Fig.6) and without affecting yield (Fig. 3), resulted in a lower balance surplus in the planning for 2002 by one farmer (VG07), while the other (VG10) planned only a slightly lower balance surplus in 2002 than he planned for 2001. Interesting is now, to explore the reasons for responding so different.

DISCUSSION

The results presented in this paper are focussed on nitrogen, because for this nutrient the challenge to reach the environmental goals is the biggest. Realization of the targets for phosphate are easier, since (i) the short term target was already met at the start of the project (Fig. 1) and (ii) the soil phosphate levels were higher in the soils concerned (Table 1) than needed for optimal growth (Van Wijk et al., 2002). This high level of soil fertility has been reached through high inputs of organic manure in the past.

For nitrogen the gap between the current situation and the long-term target is still very big on most farms (Fig. 1). Even if the nitrogen would be applied according the current recommendations, the gap will be still significant (Fig. 5), in particular on the strawberry farms and the farms with a significant proportion of spinach an/or lettuce. The next step will be the introduction of management strategies to increase the nitrogen use efficiency (Rahn, 2002). Further steps needed might affect the set-up of the whole farm and would have consequences for the farmer’s income. Therefore, whether the targets as set by the water quality requirement will be met at the end of the project is still questionable. Although the project can be also successful, if can be demonstrated how far the current commercial vegetable farms can get, after successful implementation of all relevant current knowledge.

Interesting is the difference between the two groups of farmers in their behavior. Progress made by group 1 is far less than in group 2. Why do they act so differently, although their farms are not that different? The farmers in group 2 are probably more

eager to take the challenge and are willing to take more risks. But also other socio-economic factors affect the attitude towards innovations (Montalvo Corval, 2001). Besides the technical aspects of the project, these aspects deserve special attention. Especially these aspects should be considered, when the results of the project are to be disseminated to other farmers. The participants of this project have the ability to consult a team of experts, but their colleagues who have to adopt the results cannot. This points out the second highlight of the project, namely the importance of communication.

A project like "Telen met toekomst" ("Farming with a future") with farmer's participation as the core, shows that the technical state of the art sets the potential, but that the willingness of the farmer to implement the findings determines the final result.

ACKNOWLEDGEMENT

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Tables

Table 1. Farm and soil (layer 0-30 cm) characteristics of the participating farms. (Pw: plant available phosphate).

Farm	Crops	Soil organic matter %	Pw (mg P/l)
Group 1		4.2	83
VG01	Strawberry	4.9	52
VG02	Spinach, Lettuce	4.4	87
VG03	Spinach	3.6	57
VG04	Strawberry		
Group 2			
VG06	Broccoli, potato, asparagus	2.3	82
VG07	Endive	3.2	105
VG08	Endive, Chinese cabbage	3.0	126
VG09	Broccoli	3.7	72
VG10	Leeks, celeriac	3.2	90

Table 2. Items included in the nitrogen and phosphate balance for the whole farm.

Input	Output
Organic animal manure	Marketable produce
Plant organic manure	Byproduct (e.g. straw)
Fertilizers	
Plant materials (seeds, tubers, peat blocks, etc.)	
Other materials (e.g. straw)	
N-fixation (legumes)	
Deposition	

Figures

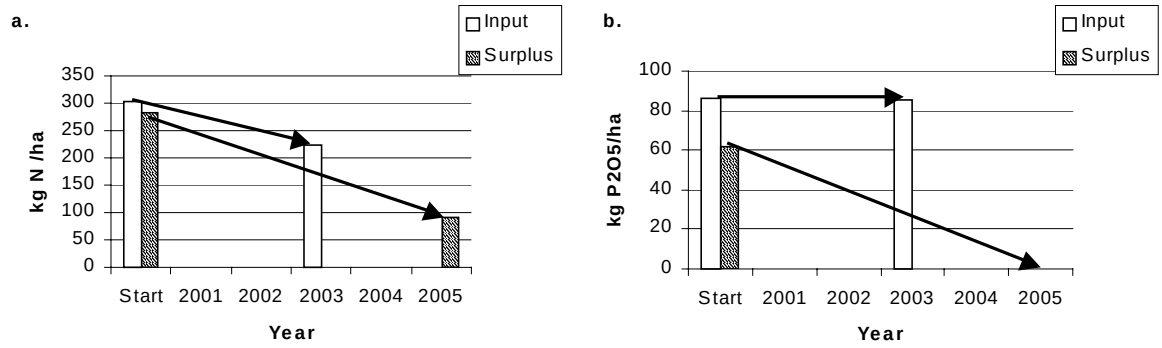

Fig. 1. Point of reference (start) and the targets within the project regarding inputs (fertilizer and organic manure) for nitrogen (a) and phosphate (b).

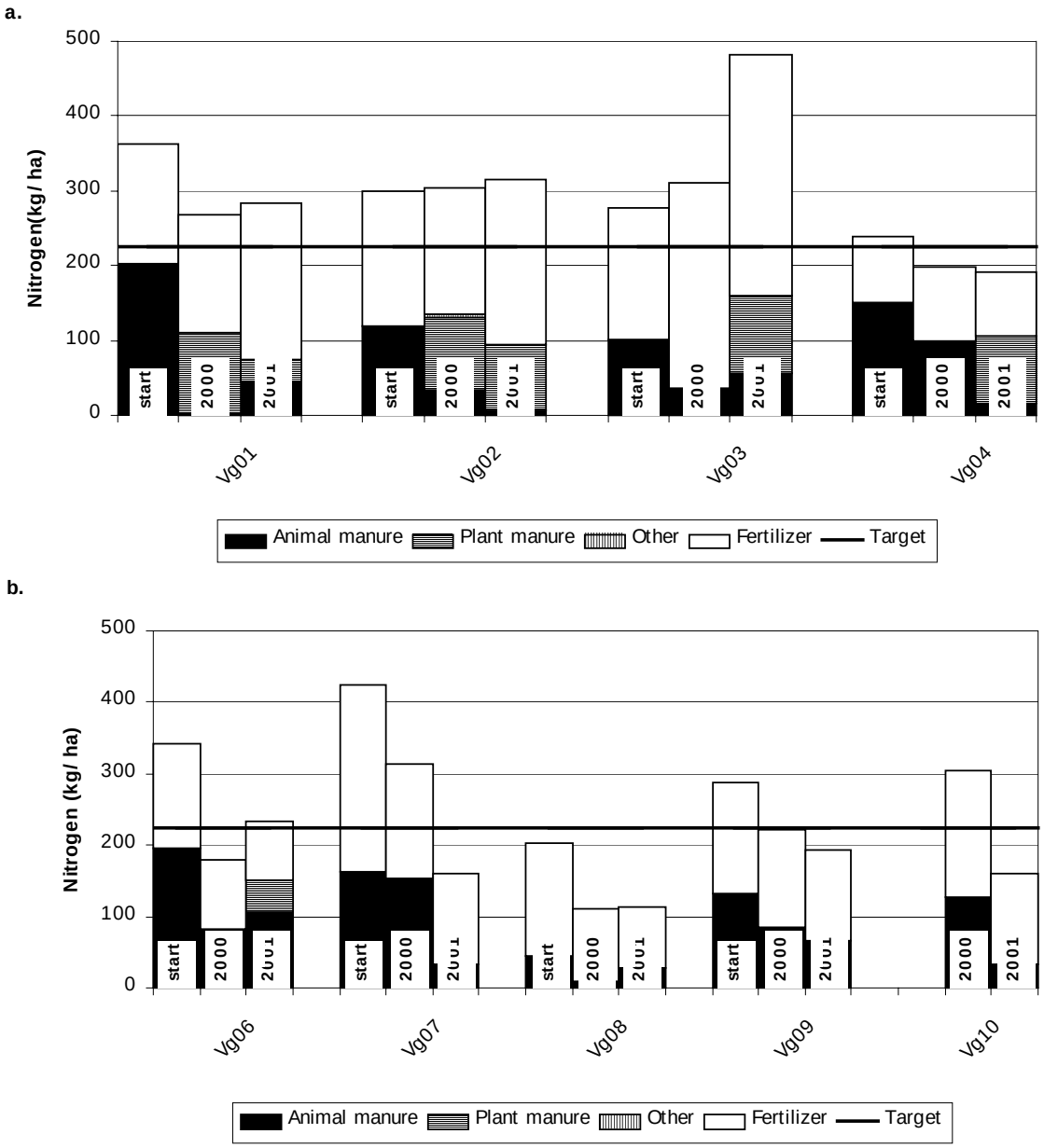

Fig. 2. Nitrogen inputs from different sources for group 1 (a) and group 2 (b) at the point of reference and the first two years of the project. The horizontal line represents the short term target on input.

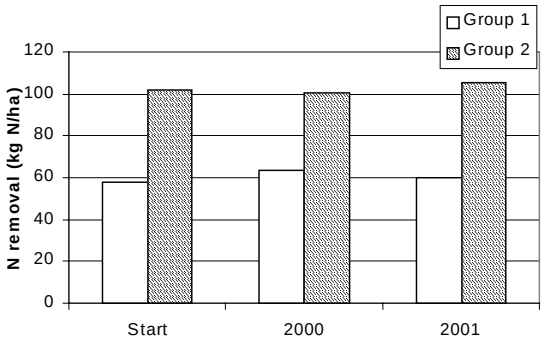

Fig. 3. Mean nitrogen output (nitrogen removed with the marketable produce) for both groups at the point of reference and during the first two years of the project.

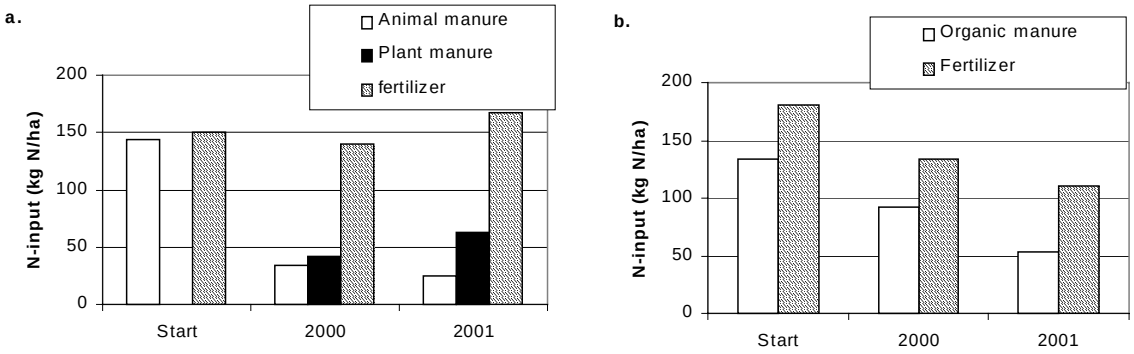

Fig. 4. Mean nitrogen inputs from different sources for group 1 (a) and group 2 (b) at the point of reference and during the first two years of the project.

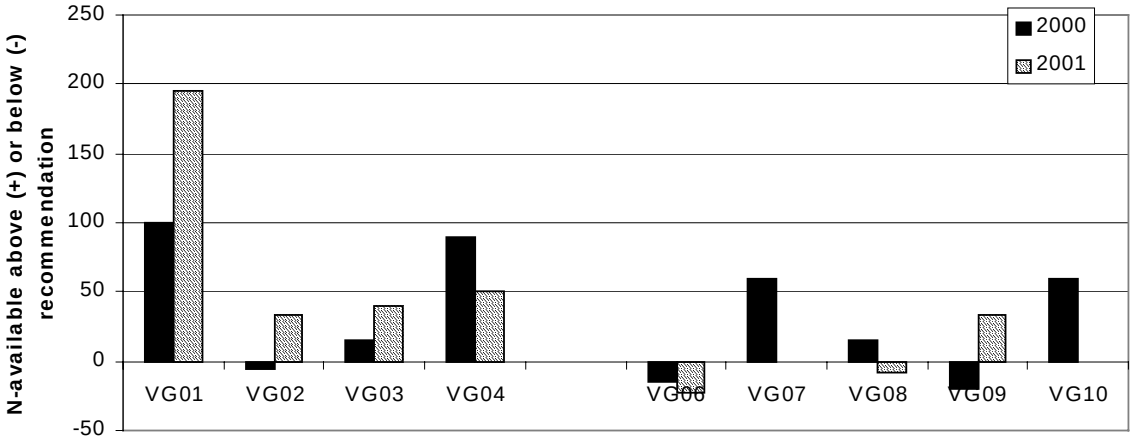

Fig. 5. Difference between the available nitrogen for uptake from organic manure and fertilizers and the recommended amount of available nitrogen according to the current recommendations for the individual farms during the first two years.

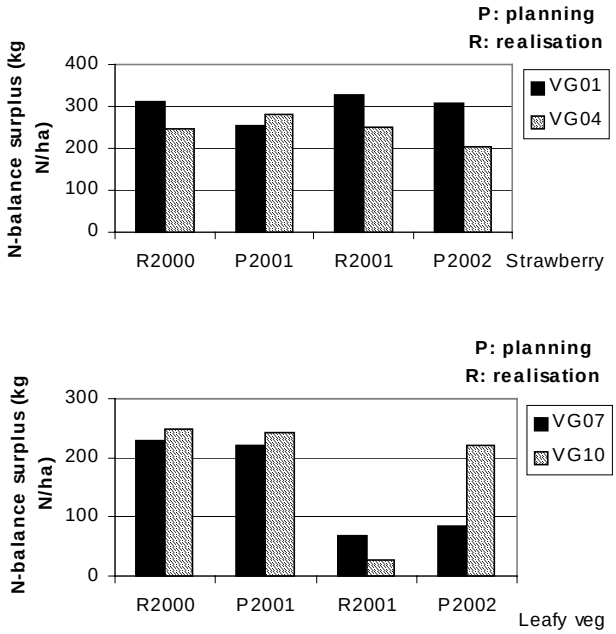

Fig. 6. Planning and realization of the surplus on the nitrogen balance for two farms within group 1 (top) and group 2 (bottom).