3 A practical case in the Southwest of the Netherlands

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3.1 Introduction

The Dutch integrated vegetable systems are located at Westmaas in the south-west clay region of the Netherlands. Approximately 18% (7 466 ha in 1996) of the Dutch outdoor vegetable surface is located in this region. The main vegetable crops in this region are onions, chicory, winter carrots, Brussels sprouts, celeriac, and to a smaller, but growing, extent, iceberg lettuce, and various other vegetable crops such as fennel, cauliflower and broccoli. Most of the farms are specialised vegetable farms (mainly in Brussels sprouts) and arable farms with vegetable crops. In the south-west region, specifically, but also nation wide, there is a growing tendency to include vegetable crops in arable rotations. Either specialised farms rent land from arable farms, or arable or organic farmers start to grow vegetable crops. This could be a beneficial tendency in that it extensifies the existing intensive vegetable rotations. Research on the integrated and organic system variants at Westmaas is trying to find answers to the specific sustainability issues that accompany this development.

3.2 Crops and Rotations

Two types of extensive integrated vegetable systems and one extensive organic vegetable system were tested at one location. The crop choice in both systems was based on the possibilities offered by the region and the soil. Moreover, the same main crops were used in both systems. The basis of the integrated systems at Westmaas is a 4-year arable rotation, including cereals and potatoes as arable crops, and with either Brussels sprouts or iceberg

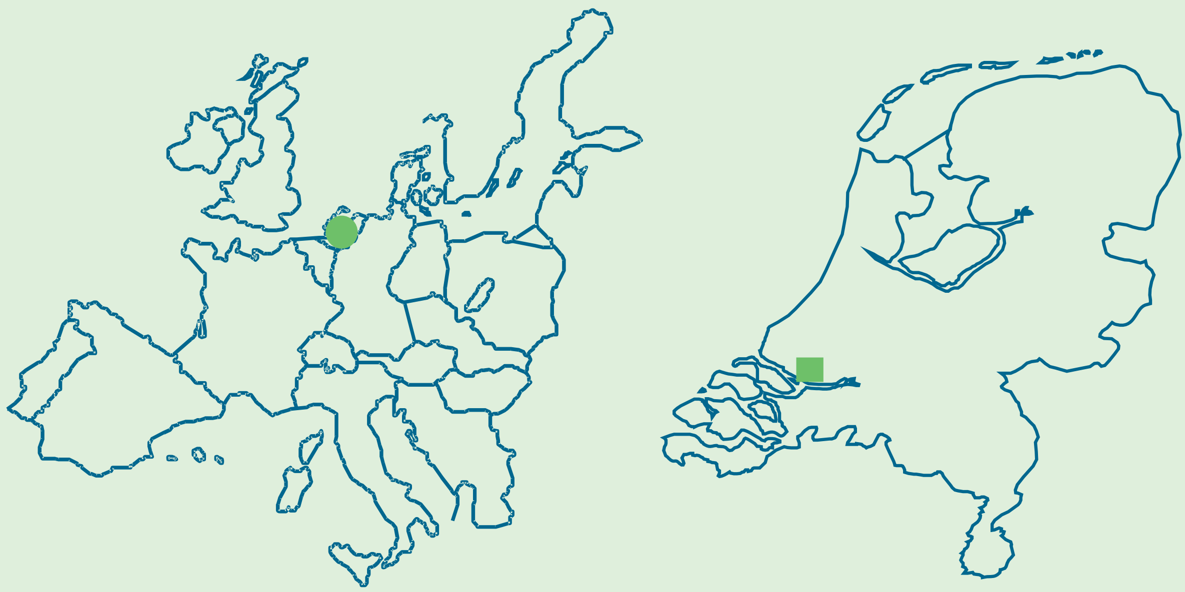


Figure 3.1 Location of the experimental integrated and organic vegetable farming systems in the Netherlands

Table 3.1 General scheme of integrated and organic farming systems in the Netherlands

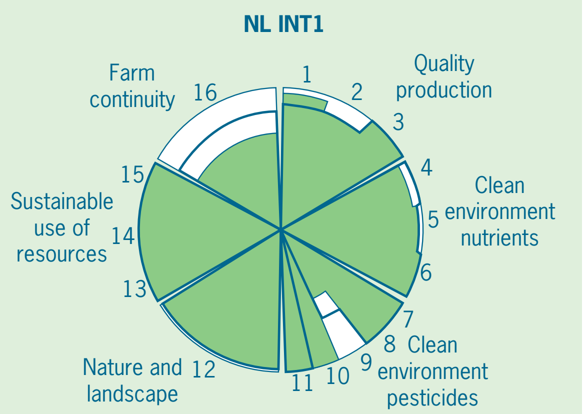
Year/ block	Integrated NL INT 1 Brussels sprouts systems (4 variants; 4 parcels/variant)	NL INT2 Iceberg lettuce systems (3 variants; 4 parcels/variant)	Organic NL ORG Organic system (1 variant; 12 parcels)
1	potatoes	potatoes	potatoes
2	Brussels sprouts	fennel/celeriac/cauliflower	iceberg lettuce
3	winter wheat/spring barley	winter wheat/spring barley	grass/clover
4	fennel/celeriac/iceberg lettuce	iceberg lettuce	Brussels sprouts
5			fennel
6			barley/clover

lettuce as the main vegetable crop. The second vegetable crop is either celeriac, fennel or cauliflower. This set-up has led to seven system variants that covered two cropping plans, with the main vegetable crops and the range of cultivation types (periods) within the vegetable crops.
The organic system has a 6-year rotation with includes the same main crops as in the integrated systems.
Per rotation block, two parcels were available to test the different cultivation periods per crop.

3.3 Results

3.3.1 Results overview

Figure 3.2 and Table 3.2 give the relative overall performance of the systems, compared with the desired level of performance. The desired level is that for an all-round sustainable farm. The results of the last testing year (2000), and the average results over 4 years, are indicated below.
The main shortfall in the integrated systems could be found in the theme's environment pesticides, farm continuity, and, to a small extent, in production quality.



The apparent shortfall for 2000 in the 'environment nutrients' theme was caused by a year effect. The average achievements for this theme were close to target. For the organic system, the main shortfall could be found in production quality and in the potash balance in the theme 'environment nutrients'. We will focus on the specific themes below.

It can be rather discouraging to look at shortfall, compared with an ideal situation. When possible, therefore, an additional comparison was made, using estimations of the average performance in practice. This gives an impression of the progress that might be expected in average practice in the future. The estimations of average practice are based on statistical data, data from projects with practicing farmers, and on expert knowledge.

3.3.2 Farm continuity

The results under 'farm continuity' are quantified with the system parameter 'net surplus', which is defined as total revenues minus total costs. For net surplus we focus on the underlying costs to get a picture of the main factors that determine costs. Figure 3.3 shows the economic performance of the three farmtypes that were tested. The economic calculation is based on a farm size of 47 ha for NL INT1 and 28 ha for NL INT2 and NL ORG. The gross revenues are yield times realised price. Fluctuating product prices mainly influenced the fluctuation in the gross revenues. Unfortunately, the average price level in the testing period was very low. This had a negative influence on the economic performance. The costs were included in the costs for own labour (valued against a standard hourly rate) and the interest on capital goods. If these last two cost categories are not included in the total costs, then one arrives at the entrepreneur income (in the case of 100% own capital). The net revenues for the integrated farm types were negative, which resulted in an income per 100 costs of 80 for the NL INT1 and 84 for the NL INT2. This result is

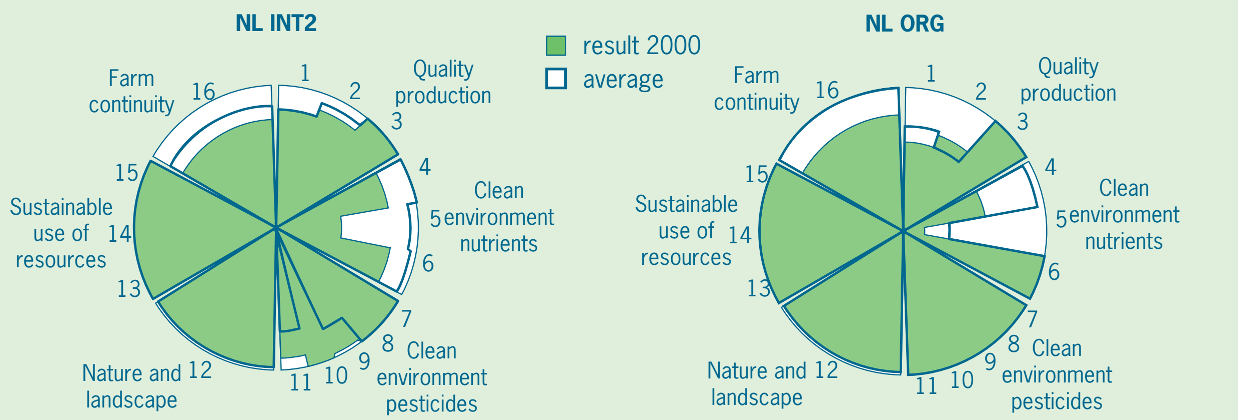


Figure 3.2 Relative realisation (2000 = coloured and average = thick line) of the parameter targets for the systems tested in the Netherlands

comparable to average practice (agronomic statistics and expert knowledge). The organic farm had higher costs per ha (Figure 3.3), but net revenues were still positive because of the high prices paid for organic produce. The compilation of the costs (Figure 3.4) shows that, for these types of farms, the main cost categories are labour (25-32%) and seeds and plants (16-19%). The 4-year average labour input per ha was 139 hours ha^{-1} for NL INT1, 219 hours ha^{-1} for the NL INT2 and 264 hours ha^{-1} for the NL ORG. The differences in input per hour are related to the highly mechanised harvest of Brussels sprouts and the extra labour input for hand weeding in the organic system. The 4-year average input for hand weeding was 9 hours ha^{-1} for the integrated systems and 41 hours ha^{-1} for the organic system. The input needed for hand weeding in the organic system has increased over the years. Together with increasing labour prices, serious attention needs to be given in the coming years to finding ways of dealing with the number of hours spent hand weeding.

3.3.3 Quality production

The results under 'quality production' were quantified by the parameters 'quantity of produce' (QNP), 'quality of produce' (QLP), and the 'nitrate content of leafy crops' (NCONT).

Quantity and quality

Most crops in the integrated systems performed equally well or better with respect to quantity than the regional good yields (GAP, Figure 3.5). The performance of wheat, barley, potato, fennel and celeriac has been stable over the years. The quantity and quality results for iceberg

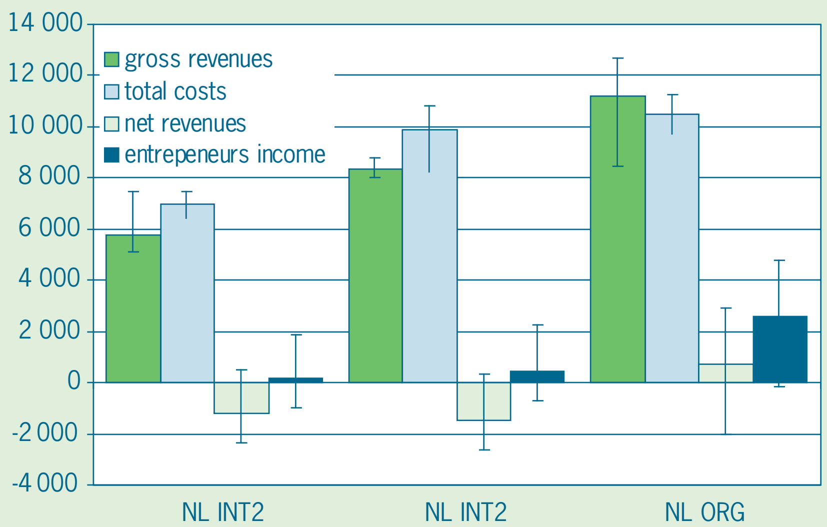


Figure 3.3 Four-year average economic performance of the three tested farm types (€ $farm^{-1}$)

Table 3.2 Absolute target values and realisation (for 2000 and the average for 1997-2000) per parameter

Theme	No	Parameter	Desired results [1]	NL INT1 2000	NL INT1 97-00	NL INT2 2000	NL INT2 97-00	NL ORG 2000	NL ORG 97-00
Quality	1	Quantity of produce	1.0 (GAP)	0.96	0.88	0.83	0.83	0.62	0.73
Production	2	Quality of produce	1.0 (GAP)	0.88	0.90	0.88	0.93	0.71	0.62
	3	N-content produce	< 2500 ppm	952	896	554	966	234	658
Environment	4	P_2O_5-balance	1.0	1.06	0.99	1.20	1.00	1.42	1.05
Nutrients	5	K_2O balance	1.0	1.03	1.02	1.4	1.06	1.85	1.68
	6	N-available reserves	<70 kg ha^{-1}	32	41	83	73	41	47
Environment	7	Pesticide a.i. input	6.0; 4.1; 0 kg ha^{-1}	2.5	2.3	2.3	2.2	0	0
Pesticides	8	Pesticide copper input	0 kg ha^{-1}	0	0	0	0	0	0
	9	Pesticide emission air	0.45; 0.42; 0 kg ha^{-1}	0.66	0.59	0.43	0.51	0	0
	10	Pesticide emission gr. water	0.5; 0.5; 0 ppb	0.01	3.90	0.01	5.17	0	0
	11	Pesticide emission soil	240; 144; 0 kg d ha^{-1}	167	199	156	183	0	0
Nature, landscape	12	Ecological infrastructure index	>5%	4.9	4.9	4.9	4.9	4.9	4.9
Sustainable use	13	Available reserves of P_2O_5	20<Pw-count<30	24	28	29	30	23	28
of resources	14	Available reserves of K_2O	20<K-count<29	22	24	23	24	25	25
	15	Organic matter balance	>1.0	1.42	1.54	1.61	1.73	1.43	1.39
Farm Continuity	16	Income per € 100 cost	> € 100	63	80	75	84	80	106

[1] If the target values are the same for all systems, then one value is mentioned; if there are system-specific target values, three values are mentioned

Table 3.3 Nitrate content in the integrated systems for iceberg lettuce and fennel

System	Crop	Nitrate content (mg kg-1 fresh matter)				
		1997	1998	1999	2000	Average
Int	iceberg lettuce	647	692	566	844	687
Int	fennel	1 870	1 093	930	942	1 209
Org	iceberg lettuce	804	175	626	403	502
Org	fennel	1 547	729	917	65	815

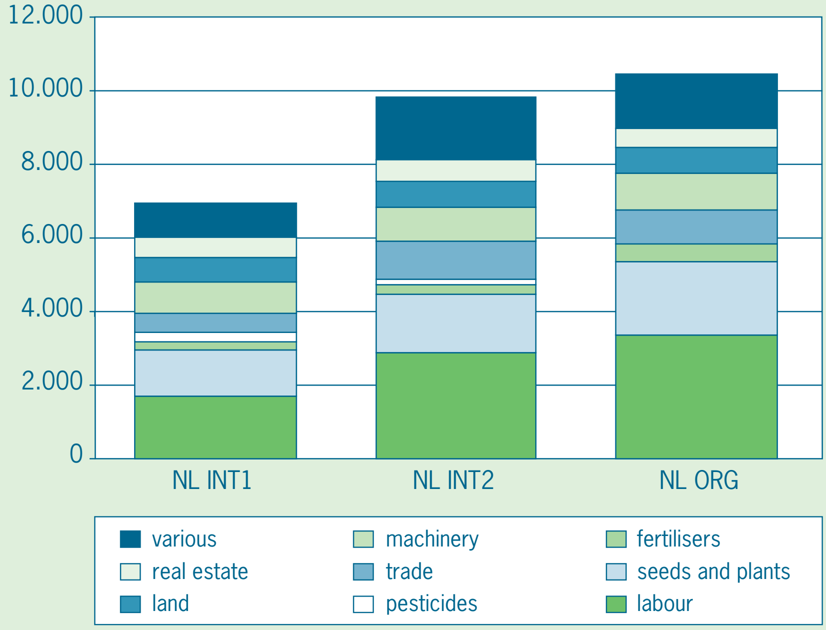


Figure 3.4 Production costs per ha per cost categories for the three tested farm types (€ ha-1)

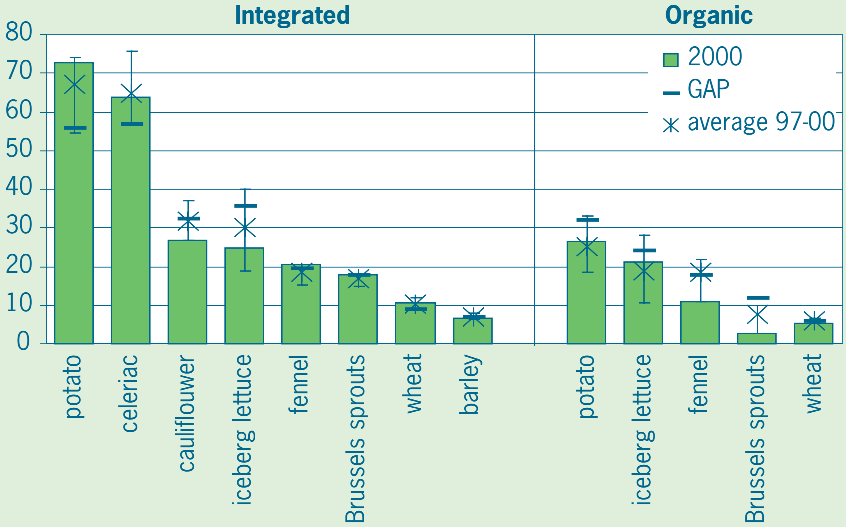


Figure 3.5 Realised quantity per crop in the integrated and organic systems for 2000 (tonnes ha-1); the average is compared with the target quantity

lettuce, and to a smaller extent the quality of Brussels sprouts, have been very variable between years and between cultivations within those years. This variability is partly a characteristic of these crops (susceptibility to weather conditions, pests and diseases), but it is also partly due to insufficient crop protection strategies. The strategy applied in iceberg lettuce and Brussels sprouts was aimed at low pesticide input and emission, but this could not always prevent quantity and/or quality losses.

Yields in the organic systems were much lower than in the integrated systems (Figure 3.5). This was mainly due to fungal diseases in potato, iceberg lettuce and Brussels sprouts. Disease control with 'bio-chemicals' was not used in the organic system. The 4-year average yield for fennel was almost the same in both the integrated and the organic systems. This was mainly due to the absence of noxious organisms for this crop. In some cases, in iceberg lettuce and Brussels sprouts, a secondary reason for lower quantities was insufficient nitrogen availability.

Nitrate content

Iceberg lettuce and fennel are the crops that produce high nitrate contents. As shown in Table 3.3. These crops never exceeded the maximum level of 2500 ppm.

3.3.4 Environment nutrients

The results under 'environment nutrients' were quantified under the system parameters 'nitrogen available reserves at the start of the leaching season' (NAR), and the 'annual balances of phosphate and potash (PAB/KAB).

Nitrogen

The nitrogen fertilisation strategy was aimed at providing optimal nitrogen availability to the crops during crop production and minimising the amount of available nitrogen in the soil at the start of the leaching season. For some crops, the nitrogen availability appeared to be very close to the limits necessary for an optimal crop production.

The nitrogen balance is relatively stable (see Figure 3.6). The variation in off-take and surplus was mainly caused by the flooding of the fields in 1998, which meant that a number of crops could not be harvested. The average nitrogen surplus realised per system was 50 to 70 kg ha^{-1} lower than the indicative values in average practice.

The available nitrogen reserves (NAR), which represent the leaching risks of nitrogen to the groundwater were, at system level, lower than, or close to, the target level of 70 kg ha^{-1} (see Figure 3.7). In spite of satisfactory performance at this level, the NAR for individual crops was above target. Lettuce, fennel and early potatoes in the organic system also showed high NAR levels. The wide variation between years for iceberg lettuce and fennel were partly caused by the possibilities for growing a successful catch crop after cultivation. In combination with a catch crop, the

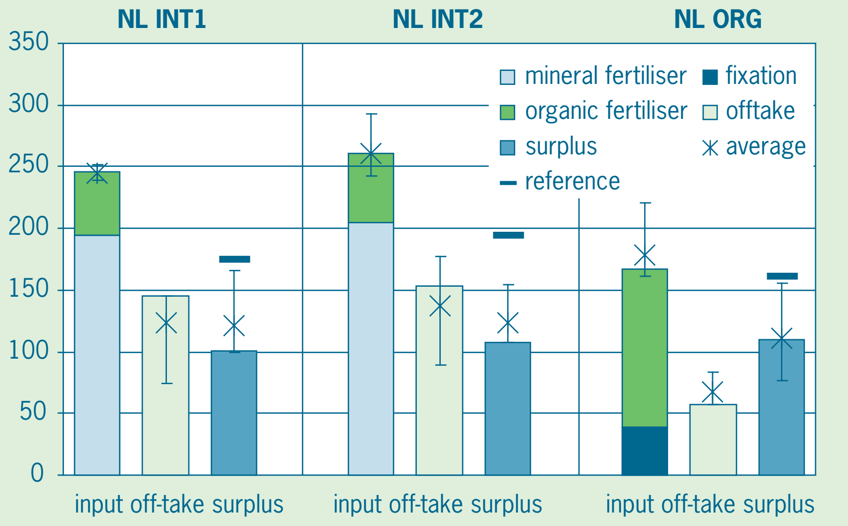


Figure 3.6 Nitrogen balances for the three tested systems (kg ha^{-1})

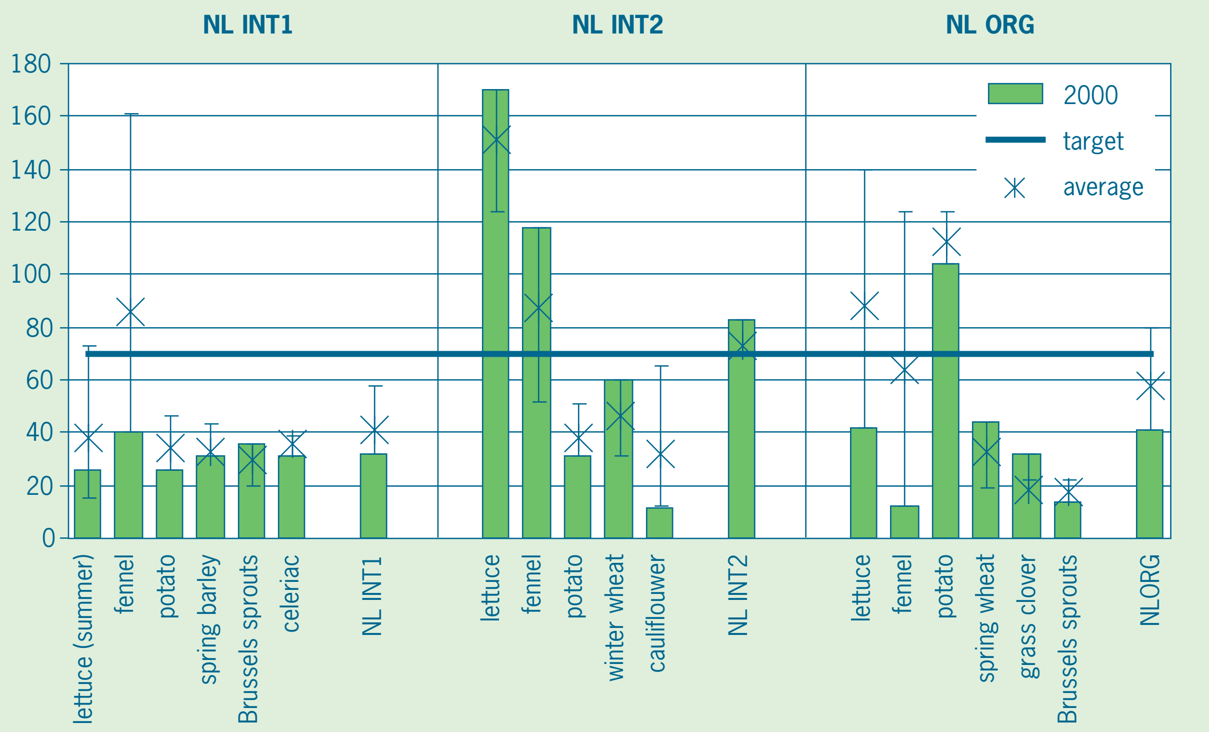


Figure 3.7 Available nitrogen reserves (NAR) per crop and system (kg ha^{-1})

NAR for lettuce and fennel was 25 - 50% lower than in situations where there was no catch crop. This was the case, for example, after autumn cultivations of fennel and iceberg lettuce, when it was too late in the year to grow a catch crop. The variation between crops, and between cultivation periods within a crop, meant that the performance of a system was very dependent on the crop composition of that system. If a large share of crops like fennel and iceberg lettuce were present in the crop mix, and if there were autumn cultivations of these crops, there would be high NAR at the system level.

Phosphate and Potash

Phosphate and potash balances at system level cannot be evaluated without taking the phosphorus and potash reserves into account. For all systems, phosphorus and potash reserves were within the desired range (agronomically sufficient and environmentally acceptable, see Figure 3.10). In this case, the strategy at system level was aimed at an input that equaled off-take for potash and an input that equaled off-take + 20 kg ha^{-1} of unavoidable losses for phosphate. This balance was based on the total cropping plan. The yearly phosphate and potash fertilisation was crop based and directed at the crops with high demands for phosphorus and potash. For example, phosphate fertilisation preceded early crops and potash was applied before potatoes. In the integrated systems, this strategy was applied successfully for both potash and phosphate (see Figure 3.8). The 4-year average surplus in both systems was close to 20 for P_2O_5 and to zero for K_2O. There were no indications that the phosphorus and potash fertilisation strategy had a negative influence on production quality.

Because of the exclusive use of organic fertilisers, such a balance, for either phosphate or potash, is difficult to realise in an organic system. Priority was given, and achieved, to balancing phosphate in the organic system. The K_2O surplus — 70 kg ha^{-1} — was above the desired level. In all systems, the actual surplus was considerably lower than the surplus estimations in average practice.

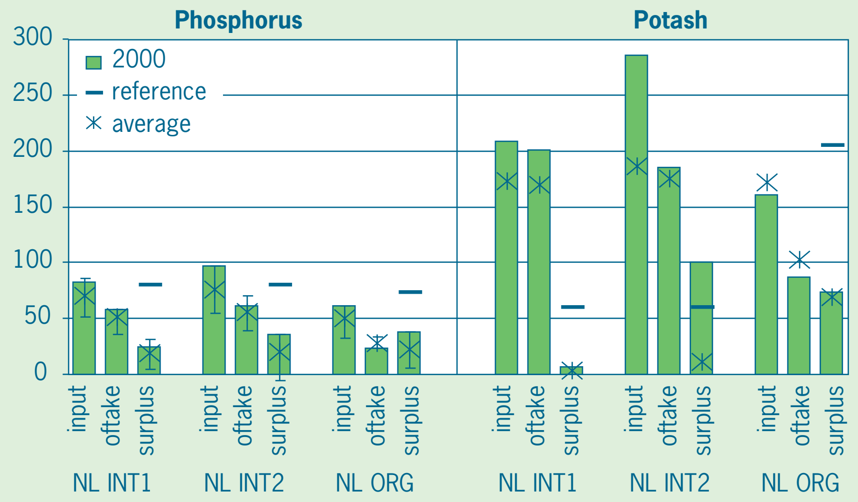


Figure 3.8 Phosphorus (kg P_2O_5 ha^{-1}) and Potassium (kg K_2O ha^{-1}) balances per system

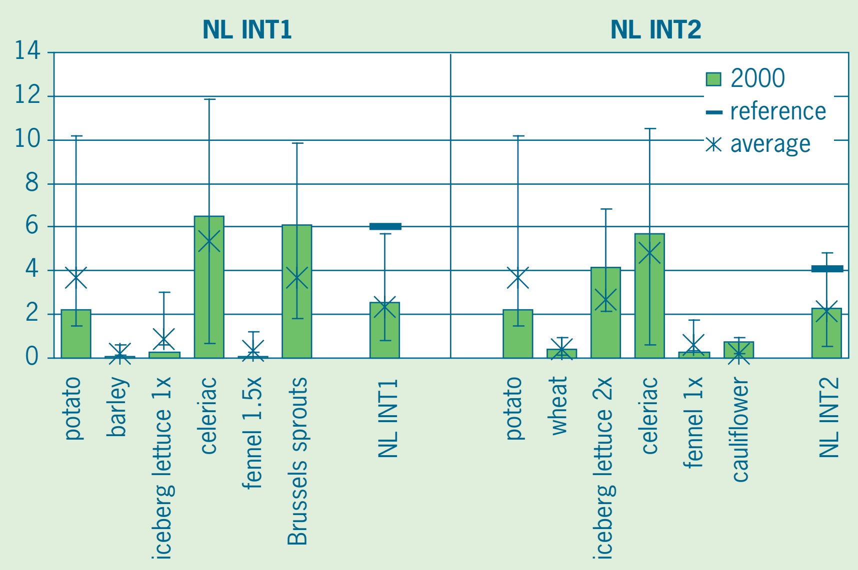


Figure 3.9 Active ingredient input per crop and per system

3.3.5 Environment Pesticides

The results under 'environment pesticides' were quantified by the system parameters 'pesticide active ingredient input' (PESTAS) and 'environment exposure to pesticides' (EEP), a measure for the three environment compartments: air, soil and groundwater.

Pesticide input

The targets for pesticide input at system level (50% reduction of the input in average practice) were amply reached (see Figure 3.9). However, the inputs of active ingredients varied significantly between different crop cultivations. Celeriac, Brussels sprouts and iceberg lettuce contributed strongly to the inputs of active ingredients. For iceberg lettuce, this was mainly due to the break-through brought about by the cultivation of the resistant strain Bremia lactucae, and to aphid control. For celeriac, it was due to the absence of a good prevention strategy for Septoria apiicola and to the non-availability of low input, but effective, pesticides for this disease. No pesticides were used in the organic system.

Pesticide emission

In both system variants, the realisation for EEP-air was close to the target (reducing emission by 70% of the levels found in current practice) due to low pesticide inputs and a careful selection of pesticides (see Table 3.4). More than 65% of emissions to the air came from Fluazinam, used against Late Blight in potatoes, and thiomethone, used for aphid control in Brussels sprouts. There are no better alternatives available at the moment. The leaching risks in EEP-groundwater, as quantified in the year 2000, (see Table 3.4) amply meet the target of 0.5 ppb. From 1997 to 1999 the target level was greatly exceeded, because of the use of maneb fentinacetate to protect celeriac crops against Septoria apiicola. In 2000, this product was replaced by chlorthalonil, which significantly lowered the risk of leaching.
Regarding emission risks to the soil (accumulation) the target of a reduction in emissions of 70% of that in conventional practice was almost met. The highest emission, (50%) in EEP-soil, came from the use of Fluazinam (Shirlan) on potato crops.

3.3.6 Nature and landscape

The results under 'nature and landscape' are quantified in system parameters that indicate the presence of the right circumstances for the development of an attractive landscape and varied nature. The methodology for quantifying the potential for on-farm nature values is still being developed. The Dutch experimental systems (both organic and integrated) were on too small a scale to test and improve the resulting methodology. Instead, the total farm level — the total number of farms included in the experimental system — was used to test the methodology and quantify the results.
The methodology developed and the resulting improvements in nature and landscape are described in the Vegineco publication: Manual on ecological infrastructure management. The main improvements were that an extra 4.9% of the farm surface was gained for ecological infrastructure to connect nature elements and to act as buffer zones to protect them.

3.3.7 Sustainable use of resources

The parameter used for this topic in the Vegineco project was 'energy input', and also a number of soil-fertility parameters. At the time of the project, energy input was a new parameter, and it had only been established at crop level (see Section 2.4). The soil-fertility parameters used to quantify system performance were 'available phosphate and potash reserves' (PAR/KAR) and the 'organic matter balance' (OMAB).

Phosphate and potash reserves

The response of available phosphorus and potash reserves in the soil to fertilisation is slow, and the year to year variation of these parameters can be substantial. For this reason, the 4-year project period was too short to make a valid judgement of the effect of the fertilisation strategy on the level of these parameters. At the start of

Table 3.4 Realisation of parameters related to pesticide use and emission

	no.of applications no ha^{-1}	a.i. input kg ha^{-1}	EEP-air kg ha^{-1}	EEP-ground-water ppb	EEP-soil kg days ha^{-1}	EYP-surface water no. appl. > 10
NL INT1						
Conventional: 2000	21.8	11.9	1.5	6.23	801	13
Realisation: 1997	12.9	3.3	0.6	5.98	250	10
Realisation: 2000	10.1	2.5	0.7	0.01	167	6
Vegineco target	-	5.9	0.5	0.50	240	0
% reduction in 2000-conventional	54	79	57	99.9	79	54
NL INT2						
Conventional: 2000	19.0	8.1	1.4	8.01	479	9
Realisation: 1997	9.8	2.6	0.7	7.96	217	6
Realisation: 2000	8.2	2.3	0.4	0.01	156	4
Vegineco target	-	4.0	0.4	0.50	144	0
% reduction in 2000-conventional	57	72	69	99.9	67	58

the experiment, the levels of reserves of available phosphorus and potash were within the desired range. The fertilisation strategy was aimed at maintaining these levels. During the project period, the levels of available phosphorus and potash reserves stayed within, or just above, the desired range (see Figure 3.10) In the year 2000, however, the level of available reserves was lower than in the other years. Taking into account the year-to-year variability of these parameters, there is no conclusive evidence of a decrease in available nutrient reserves.

Balance of organic matter

The strategy for organic input was to compensate at least the estimated losses of effective organic matter in the soil. Such losses are difficult to assess, but an estimation was made using the standard figure for respiration in clay soil, which is 2.5% of the total organic matter in the plough layer. The input of effective organic matter in both systems more than met the target (see Table 3.11). The biggest input of effective organic matter was from the residues of vegetable crops and the straw from cereal crops. A surprising, but substantial, input in these vegetable systems came from the peat pots used during planting.

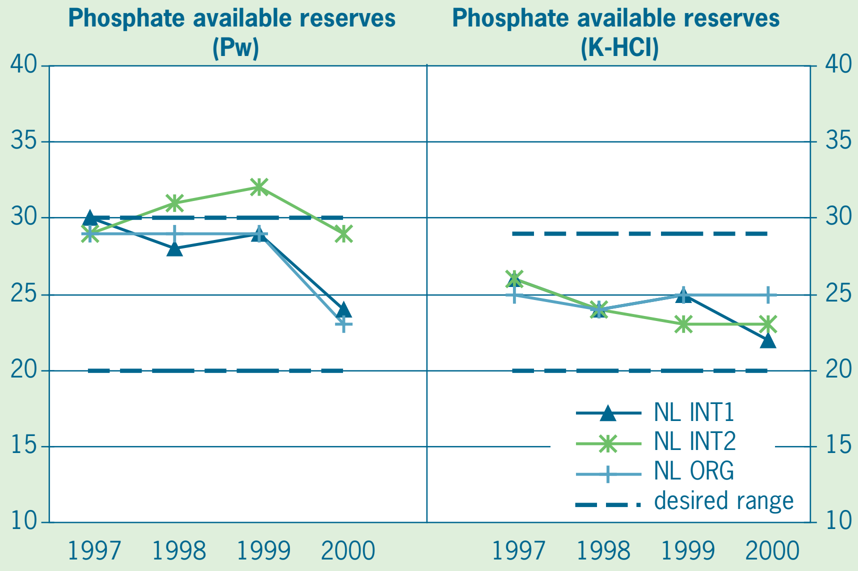


Figure 3.10 Available phosphate (Pw) and potash (KHCl) reserves, averaged over all fields from 1997 to 2000

3.4 Discussion and conclusions

Comparing the performance of the tested integrated and organic farming systems with the all-round

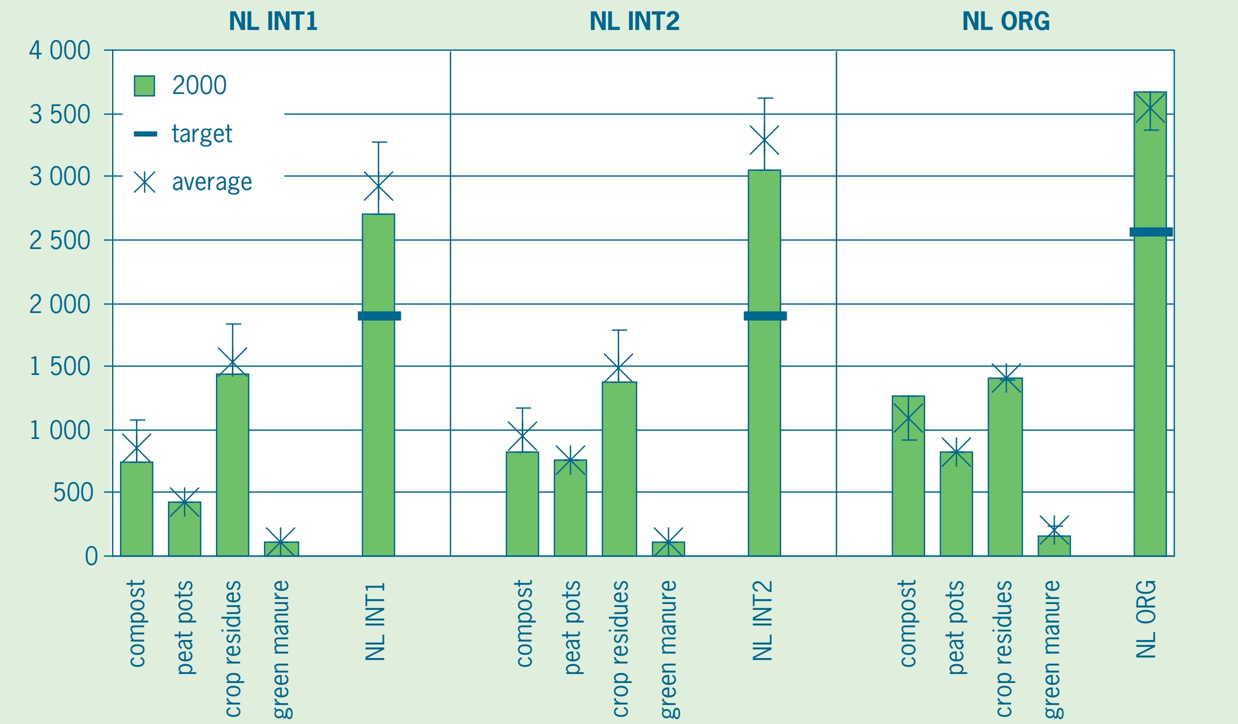


Figure 3.11 Balance of organic matter in the three systems tested (kg ha^{-1})

sustainable target system, the following conclusions can be reached:

1. The economic performance of the integrated systems is insufficient.
2. For specific crop/disease combinations, chemical crop protection still leads to high emissions of pesticides.
3. The quality of production in the organic system is insufficient.

Comparing the performance of the tested integrated farming systems with that of conventional practice, the following picture arises:

1. Large reductions can be made in the use and emission of nutrients and pesticides.
2. Yields and economic results are comparable to average practice.
3. Cost reductions of pesticide or fertiliser inputs can be substantial compared to the same cost categories in conventional practice, but they are marginal compared to the total costs.

To improve and implement integrated farming systems, a key factor that needs to be addressed is the shortfall in economic performancein this system. Farmers are reluctant to convert to integrated farming, because this requires investments in knowledge and machinery. Their income is already very low and the risks of yield losses in vegetable production are high.
Possible options to encourage farmers to take this step are cost reductions, increases in yields, price increases, or a basic reward for acting in the public interest. The last two options are outside the scope of this research, but they could be an important aid to furthering sustainable vegetable production.

The necessary improvement in the performance of the systems tested is dependent on technical innovations. The availability of resistant varieties, the improvement of techniques and mechanisation, better knowledge of the epidemiology of pests and diseases and, as a last option, a broad spectrum of low emitting and safe pesticides could contribute to further improvements in sustainability. The basic choice of not using 'bio' pesticides in the organic system might have influenced production quality in the Dutch organic system, and whether 'bio'-pesticides should be used or not remains questionable. The focus for organic farming systems has to be on prevention rather than control, but the development of indisputable means of 'biological' control could help to solve the problems that remain.