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From conventional to integrated agriculture

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Motivation

Conventional agriculture mainly aims at a maximum financial return. This demands permanent technological innovation and intensification of the farming systems to enable a steady rise of production among others necessary to keep pace with the costs. This evolution in agriculture has besides positive also negative consequences, especially for:
(1) environment
(2) dependency of agriculture on (the delivers of) energy and raw materials
(3) income and employment of the farmers
(4) quality of food products
(5) nature and landscape
(6) well-being of the animals
The main negative effects will shortly be highlighted.
1. Pollution of the environment by pesticides is already known for a long time. More recently also fertilizers cause pollution problems, for example nitrate in groundwater and drinking water, phosphate in surface water and volatilization of ammonia from organic manure. As in the Netherlands, within a few years far-going legal restrictions concerning the use of fertilizers can be expected in several other countries to reduce the above effects.
2. Because of the enormous increase in the use of energy and raw materials including animal feed, agriculture in Western Europe has become more and more dependent on the availability and the price of these resources. This dependency also concerns the export policy of the countries involved, which may rapidly change under influence of various factors.
3. The steady progress in yield is leading to surpluses on the international markets. Within the EC one tends to counter surpluses by taking all kinds of production-limiting measures, including levies on production above certain levels. Thus the intensification of farming is reaching the stage in which it restricts rather than enhances the income of the farmers. Considering this situation the best long-term strategy for farmers to maintain their income and employment seems to be to pay more attention to cost reduction and efficiency rather than to raise yields.
4. Thanks to modern food technology the composition and quality of our diet have drastically changed. These changes do not all seem so favourable. Among others one is worried about the use of food additives and the occurrence of contaminants in

the food, such as residues of fertilizers, pesticides, hormones, antibiotics and heavy metals. In reaction to this, legislation in many countries considering the demands on food quality is adjusted in order to oblige farmers and industry to generate products of better quality.

5. In many places modern agriculture threatens nature and landscape in various ways, for example by lowering groundwater levels, noxious use of pesticides and fertilizers, cutting hedges and woodland, etc. The alarming decline of flora and fauna and the levelling down of landscapes are meeting increasing resistance from the public. Adaptation of the farming practices is called for, to avoid these negative side-effects.

6. The profit principle has led to animal husbandry systems which are far from optimal with respect to the well-being of animals. Also in these situations the public concern urges to look for more appropriate solutions.

From the foregoing it may be clear that conventional farming systems with their predominantly agricultural aims cannot sufficiently meet the complex of environmental and social aims. Therefore we have to look for farming systems which pursue a broader goal than just the agro-economic one. To indicate the integration of various aims in the field of economy, employment, environment, nature, landscape, quality of food-stuffs and well-being, this new search direction may be called 'integrated farming'. On the basis of this integrated vision on agriculture, a new and appropriate technology has to be developed. This demands research and development at the farm level, such as on the experimental farm at Nagele.

Research and development

The national experimental farm for development and comparison of alternative agricultural systems was started in 1979 under the name 'Development of Farming Systems (DFS)'. It is situated near the village of Nagele in the Northeast Polder, 3 to 4 m below sea level on heavy sandy marine clay (lutum fraction 0.24). The size of the farm is 72 ha.

Three farming systems – Biodynamic (bd), Integrated, and Conventional – are being studied. The three farms are being run by only one manager and four other workers on a commercial basis and independently of each other. The main research topics are: soil fertility, health and productivity of cattle and crops, quality of the produce, farm economy, use of energy and other resources, and effects on nature and environment.

In 1977 the *bd farm* (22 ha) started. Its main objective is to be self-supporting in fertilizers and fodder. No pesticides are allowed. To fulfil the aim of self-sufficiency in fertilizers and feed the biodynamic farm is set up as a mixed farm with 20 dairy cows and a rotation of ten years. Only the arable crops and vegetables are sold. The grass-clover pastures and fodder beets serve as feed for the cattle. By returning the manure to the land, a nutrient cycle within the farm is maintained.

The *conventional* and the *integrated* farms, started in 1979, are exclusively concerned with arable farming. The size of each is 17 ha and they have the same 4-year rotation. The conventional farm serves as a reference. Its main aim is a maximum

financial return. The integrated farm should produce a corresponding financial output, but another aim is minimum input of fertilizers, pesticides and machinery to avoid pollution of the environment and save non-renewable resources. Therefore it may be characterized as an intermediate system.

Dutch arable farms are on an average only some 25 ha, so farmers have to use their land very intensively. Therefore high-yielding crops are grown in as short rotations as possible. Potatoes are the most profitable, followed by sugar-beet and vegetables such as onion and cabbage. Cereals are financially less attractive but are needed as break crops.

Most rotations take only three or four years. Consequently, beet and potato cyst nematodes cause increasing problems, forcing farmers to regular soil fumigation as a curative or preventive measure. Since the farm income is strongly related to crop rotation, the integrated farm is set up with the same four-year rotation as the conventional farm. So, the integrated approach mainly applies to the crop level.

Table 1 shows the rotations of the three farming systems. Table 2 lists the main components of the integrated, the conventional and the biodynamic systems. Yearly a detailed management scheme is made for every crop, based on knowledge available from the extension services and research institutes elsewhere and experience from previous years.

In the first 10 years the main objective of research will be the development of the farming systems. Later on, comparison of the systems will become more important. This does not mean that comparative research will not yet take place during the first years, but it mainly concerns the first of the two types of comparative research which can be discerned as follows:

a. internal comparison: can the farming system meet its own objectives and principles?

b. external comparison: how does the system perform compared with the other systems?

The first type of research fully are at the service of the system development. The

Table 1. Crop rotations of the three farming systems in Nagele.[1]

Conventional + Integrated	Biodynamic
1. ½ ware potato, ½ seed potato	1. ½ ware potato, ½ onion
2. ½ pea, ¼ onion, ¼ winter carrot	2. winter wheat
3. sugar-beet	3. ½ chicory, ½ winter carrot
4. winter wheat	4. pea
	5. mowing pasture with red clover, lucerne and Italian ryegrass
	6. ½ fodder beet, ½ white cabbage
	7. winter wheat
	8-10. grazing and mowing pasture with white clover and grass, mainly English ryegrass

[1] Rotations from 1985 on. Before, vegetables were not grown. On the conventional and integrated farms winter barley was grown instead of pea and winter carrot. On the biodynamic farm oats, winter barley and grass-clover were grown instead of chicory, winter carrot and white cabbage.

Table 2. Description of the main variables in arable farming on DFS.

System variable	Conventional	Integrated	Biodynamic
Fertilization	principally inorganic	principally organic	exclusively organic and mainly from own farm
– basic gift of P and K	gift > withdrawal by the crops	equal to withdrawal	no
– N fertilizer	economically optimal	N gift < withdrawal	no
– green manure	grass + N fertilizer	mixture of grass and clover, mustard	same as integrated
– organic manure	only before potatoes	frequently	frequently, mainly from own farm
– leaves of sugar-beet	plough under	plough under	plough under
– straw	sell or plough under	plough under	for cow stable
– bd preparations	no	no	several
Control of weeds			
– mechanical	limitedly	mainly	exclusively
– chemical	principally	limitedly	no
– weed-suppressive varieties	if economic	as much as possible	as much as possible
Control of pests and diseases			
– resistant varieties	only if high-yielding	as much as possible	as much as possible
– biological	if economic	as much as possible	as much as possible
– chemical	economically optimal	as last resort	no
– soil fumigation	preventively against potato cyst nematodes	no	no
Other measures			
– sowing-seed	purchase, often own seed potatoes	purchase, often own seed potatoes	as much as possible from own farm
– use of equipment and machinery	economically optimal	economically optimal	economically optimal
– energy use	economically optimal	reduced	reduced

Table 3. Survey of the research programme.

1. Soil: chemistry, physics and biology
2. Health of cattle and crops: diseases, pests and weeds
3. Productivity of cattle and crops
4. Quality of the produce: external and internal
5. Farm economic results: yields and costs, labour input, gross margins, net surpluses
6. Effects on nature and environment
7. Energy use

second type should provide data from which conclusions concerning the viability and social significance of the experimental systems can be drawn. These conclusions are only valid if the systems have reached a more or less optimum state.

Table 3 presents a survey of the research programme. In this programme about 30 to 40 research workers and students have been involved since 1979.

Preliminary results

Table 4 lists the kind, number and quantity of pesticides used in 1984. On an average, only 3.1 chemical measures per field had to be taken in the integrated system while in the conventional system the average was 8.0. If the pesticide input is expressed in active ingredients the differences are even clearer: 10.31 versus 3.03 kg/ha, and even 60.31 versus 3.03 kg/ha if the soil fumigation of the conventional system is included.

The average physical and financial yields of the main three marketable crops on the experimental farm are listed in Table 5. It appears that the conventional system had the highest physical yields but the biodynamic system had the highest gross

Table 4. Chemical control in the conventional and integrated systems in 1984.

	Total number of treatments per field		Active ingredients (kg/ha)	
	conventional	integrated	conventional	integrated
herbicides	2.0	0.9	3.99	0.92
fungicides	4.6	1.6	6.08	1.88
insecticides	1.1	0.6	0.24	0.23
sub-total	7.7	3.1	10.31	3.03
nematicides*	0.3	0.0	50.00	0.00
total	8.0	3.1	60.31	3.03

* Fumigation of the soil with 200 kg/ha DD (dichloropropene) after each potato crop against potato cyst nematodes in the conventional system. In the integrated system a resistant cultivar is grown.

Table 5. Average physical and financial yields of the three main marketable crops over the years 1982-1984.

	Conventional			Integrated			Biodynamic		
	potato	sugar-beet	winter wheat	potato	sugar-beet	winter wheat	potato	sugar-beet	winter wheat
physical yield[1]	51.4	9.76	8.3	31.8	10.02	7.4	23.8	8.26	5.2
total returns[2]	12.32	7.26	4.55	13.17	7.33	4.05	11.00	6.06	4.92
allocated costs[3]	5.46	1.90	1.20	4.84	1.81	1.02	2.29	1.11	0.68
gross margin[4]	6.85	5.36	3.35	8.33	5.52	3.03	8.70	4.95	4.24

[1] t/ha (yield of sugar-beet is expressed as t/ha sugar).
[2] Price/t × t/ha in 1000 guilders. Special prices for bd grain (0.85 guilder/kg, 70 % higher than conventional) and bd potato (0,50 guilder/kg, 100 % higher than conventional).
[3] Costs of pesticides, fertilizers, hired labour, sowing seed, insurance, interest.
[4] Total returns minus allocated costs.

Table 6. Overall farm economic results of the three farming systems over the years 1982-1984 (in 1000 guilders).[1]

	Conventional	Integrated	Biodynamic
farm size (ha)	17	17	22
labour (man/year)	0.5	0.6	1.9
total returns	127.8	118.2	156.7
total costs	131.2	118.8	249.9
(including own labour)[2]	(31.6)	(35.2)	(88.6)
net surplus	−3.4	−0.6	−93.2

[1] From: Meijer + Steenbergen in the 1982-1984 DFS annual reports.
[2] 25 guilders are the mean costs of labour per hour.

margins, thanks to considerably higher prices per kg crop and lower costs. It can also be concluded that the lower physical yields on the integrated system were compensated more or less by cost reduction, as a result of the lower input of pesticides and fertilizers. However, it should be mentioned that the potato cultivar Irene in the integrated system mostly reached a substantially higher price per kg than Bintje in the conventional system, which almost compensated for the lower yield. Table 6 shows some overall farm economic data. The integrated farm had the best mean economic results, but the conventional farm did not stay very much behind, contrary to the biodynamic farm. It must be stressed, however, that it is still to early to draw definitive conclusions about the economic viability of the two alternative systems: both are still in development.

Perspectives

The first results of the experimental farm DFS at Nagele show that by an integrated approach considerable reduction of inputs is possible without loss of income for the farmer. But it should be emphasized that reduction of inputs is not just a matter of abandoning pesticides and fertilizers. Otherwise the farmers' income would certainly decrease to an unacceptable degree.

Integrated farming requires a higher input of knowledge than the conventional system, amongst others concerning pests, weeds and diseases. This condition may impede a rapid propagation of the system among farmers. In this way, recent developments in the field of automation may offer good chances to bridge the knowledge gap between research and practice. Recently we started to develop detailed cropping models to be used in a microcomputer on the farm. In the near future this microcomputer will be an important tool for the farm manager in decision-making and registration of the numerous cropping measures.

Besides computerized guidance of cropping systems, enlargement of research efforts is another important condition for the propagation of integrated farming. The prospects for more research are favourable, considering the increasing interest in integrated farming among the policy-makers in agricultural research. They are more and more aware of the serious and complex problems, which call for drastic

policy changes in research as well as in practice. In the field of research some first encouraging developments can already be mentioned.

Within the framework of the EC program 'Energy in Agriculture' relevant research projects are being financed and a series of work-shops are being organized, one of which, on integrated farming, has been held in June 1986 at Lelystad. Within the framework of IOBC (International Organization of Biological Control) efforts are being made to start a working group on integrated farming. The aim is to set up a number of experimental farms in various European countries to develop integrated arable farming systems which are appropriate to the local circumstances. A design for this type of experimental farm is already described in general terms (Vereijken et al., 1986).

Finally, in the Netherlands a second experimental farm was started in 1986, namely in the 'Veenkoloniën' on peat soils, where potatoes for starch production are being grown in a two-year rotation. A complex of problems has arisen here, such as intensive soil fumigation, nevertheless an increase of cyst nematodes, increase of costs and decrease of yields. For this problem area the solution will first of all be sought in a healthy crop rotation and low-input cropping systems, based on the experience thus far obtained at Nagele.

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