OPTIONS FOR INTEGRATED AGRICULTURE IN EUROPE

R. RABBINGE

THEORETICAL PRODUCTION ECOLOGY, WAGENINGEN AGRICULTURAL UNIVERSITY

SUMMARY

The development of sustainable agriculture is more and more accepted as a long term objective for agricultural research in general and for crop protectionists more specifically. The possibilities for integrated agriculture in the European Community are described in this paper and the characteristics are given. It is in many cases crop production at high yield levels with per unit of product a very high efficiency of use of inputs such as nutrients and crop protection measures.

Scenarios in which the possibilities of various ultimate aims of land use at the level of the European Community are made explicit are described. Resource use efficiency is highest and consequently negative side effects for the environment lowest when agriculture is concentrated at agriculturally well endowed land. This requires a strong research supported integrated agriculture in these areas. The IOBC has the lead in the development of such agricultural systems and should maintain that.

1. INTRODUCTION

During the last 10 years integrated agriculture has been intensively discussed within various circles. The International Organization of Biological Control (IOBC) has contributed considerably to that discussion. In that period the IOBC developed from an organization of scientists who study possibilities of biological control of insect pests and mites in various agricultural systems into an organization that promotes the development of crop and cropping systems in which preventive and curative biological control methods for pests and diseases are optimized. This means a shift from an organization dominated by entomologists into an organization where entomologists, phytopathologists and also agronomists gather.

It became increasingly clear that single-issue activities are not sufficient and are in some cases counterproductive for the development of an environmentally friendly and viable agriculture. Sustainability became a buzzword. The development of sustainable agriculture has become a major aim of the IOBC. In the coming decades such an agriculture should be developed and implemented. But what is sustainable agriculture and what is the role of research in general, and more specifically of the IOBC, in this goal?

2. CONCEPTS

The concept of sustainable agriculture has received much attention during the last decade. It was introduced in the well known Brundtland report. The concept means that the present generation considers in its activities the needs of future generations. This implies that the present generation has to know the needs of future generations. These are not defined and require an explicit definition. For that reason the concept of sustainable development is loose in its definition. It indicates a direction but is not an explicit description.

In agriculture sustainable development can be worked out. However, economists, ecologists and agronomists very often have different interpretations and each discipline has its own interpretation. Some consider that "sustainable" is not a particular form of farming of a certain piece of land, but emphasize that what has to be sustained are rather the possibilities to maintain farm employment at such a level that a decent modern livelihood for farmers and their employees is guaranteed. Then labour replacing techniques and inputs, such as tractors, threshers and herbicides, (which replace labour by cash purchases, and require more skilful management to sustain the environment) are not desirable and hence there is a strong reluctance against any subsidy and research into such inputs. This definition is therefore ambiguous. In agriculture a more elaborate description is desirable.

Agriculture should be both productive and sustainable. This may imply that, from the ecological viewpoint, renewable resources are maintained, non-renewable resources are used with foresight and the intrinsic value of the environment is recognized. From the socio-economic viewpoint, farm families should be able to make a decent living and the increasing and changing demands for agricultural products should be satisfied at reasonable prices. The goals and boundary conditions are thus qualitatively formulated and this may help to reach consensus between groups of people representing different interests. However, it does not reveal clearly the way farm policy and agricultural policy should be implemented. The objectives are conflicting.

A political, rather than a scientific, debate is needed to reach conclusions about how conflicting objectives of productivity and sustainability are matched. The outcome of such a debate depends on political and ideological views rather than on biotechnical or technical-economical possibilities and limitations. It is, however, the task of science to rationalize the debate and to distinguish facts from opinions and beliefs. Too often the 'sustainability' issue has led to mystification and conservation of strategies and methods that are counter-productive, in the sense that they divert from agronomic, socio-economic and environmental goals.

For this reason explicit discussions on sustainability should take place and various concepts should be described and made operational. An important issue in every concept of sustainable agriculture is the management of renewable and non-renewable resources. Integrated agriculture may be considered as one concept of sustainable agriculture. It aims at resource management that best serves various goals. Agricultural goals, such as maximization of productivity and minimization of cost, and environmental goals, such as minimization of the use of pesticides per unit of product and/or per unit of acreage and minimization of emission of nutrients per unit of product or per unit of acreage, should be achieved.

3. RESOURCE MANAGEMENT

For ages the need for more food for an increasing world population has been met by using more agricultural land. When population numbers were low sustainable farming systems were developed, in the sense that they were continued for ages. Examples of such farming systems are shifting cultivation in tropical forests, and rainfed, bunded rice production in Asia.

However, in most situations productivity demands overruled sustainability demands, so that soil resources were over-exploited. Vast areas of once good agricultural land have been lost and become deserts, due to mismanagement and subsequent wind and water erosion, exhaustion or salinization, and ultimately resulted in land that can no longer be used for agriculture. Well known examples are the bare hills in the Mediterranean region, the saline soils in the Middle East, the mining for nutrients of common agricultural land in Western Europe ('tragedy of the commons') and the destructive dust storms in the 1930's in the USA. It is only in this century that various methods were developed by which productivity demands could be fulfilled and overuse of agricultural land might be prevented. The slow increase of productivity during centuries accelerated in this century as a result of better agricultural methods: green revolutions took place. The first green revolution in the industrialized Western world took place during and shortly after World War II. This revolution, a discontinuity in the increase in productivity, from a rate of between 2-5 kg grain equivalents per ha per year to 80-200 kg grain equivalents per ha per year, was due to innovations coming from various disciplines: better and more timely water management, mechanization, higher soil fertility by the use of more and synthetic nitrogen fertilizers, a better control of weeds, pests and diseases through the use of biocides and improved crop varieties with higher harvest index and more resistance to pests and diseases. This high increase in productivity per unit of acreage was combined with an even higher increase in labour productivity, due to mechanization, other agronomical methods such as chemical weed control and better farm structures and organization.

For example, the production of a single ha of wheat in the Netherlands required about 370 hours per ha at the beginning of this century, whereas now 10-15 hours per ha are needed. In the USA and Australia this is even less, not more than 8 hours per ha. Yield levels in the Netherlands rose from c 1100 kg per ha in 1900 to 7500 kg per ha^{-1} at present (Fig. 1), so that labour productivity increased c 200-fold. Similar increases in productivity are found in other crops such as potatoes, rice, maize and onions.

A very important role in the increase in productivity was played by crop protection. The possibility of eliminating crop growth-reducing factors, such as pests, diseases and weeds, was extended considerably by the introduction of pesticides earlier this century. The increase in pesticide use after World War II may have enhanced crop productivity, on the one hand, but pesticide overuse and limited pesticide selectivity may have polluted and destructed natural resources on the other hand. The promotion of biological control, integrated pest and disease management and integrated agriculture may eliminate the negative effects of pesticide use and in that way promote a proper use of resources in agriculture.

The green revolution in the Western industrialized world coincided with a decrease in the number of people to feed, and although diets became more luxurious with more meat, increase in production was so high that a net import of food in Europe until the 1980's changed into a surplus of food in the European Community nowadays. This now creates difficulties for the Common Agricultural Policy and may affect agricultural development in developing countries, as the food surpluses of the EC are dumped on the world food markets where developing countries try to sell their agricultural commodities. In the EC policy decisions are needed which take into account the development in many third world countries.

The first green revolution in the industrialized world was followed by a second green revolution in many developing countries. Productivity per unit of acreage increased considerably from about 2-5 kg grain equivalents per ha per year before 1968 to 125 kg grain equivalents per ha per year in the 1970's and 1980's (De Wit, 1987). Despite an almost three-fold increase in the third-world population since 1945, global food shortages have been averted and the occurrence of famines has been reduced in both number and size. The green revolutions have improved the world food situation even though the world population has increased from 1 billion at the beginning of this century to over 5 billion nowadays. The increase in population continues, especially in the developing world. To feed all these people a considerable increase in food production is still necessary, not only because of an increase in the number of people but also due to the change in diet at increased incomes.

Possibilities for increasing food production are still there. There are still large land areas that could be reclaimed in some parts of Africa and South America, but in many regions of South-East Asia most of the land that is suitable for some form of agriculture is already in use. In South-East Asia more than 50% of the world population is fed from an area of not more than 8% of the cultivatable land of the world. In these areas production levels are already very high and the use of pesticides causes the well known problems in this region. An urgent need for an integrated agriculture is obvious. In other places the possibilities for increasing productivity per unit of acreage are still very large, since most agricultural production takes place in situations where water and/or nutrients are limiting during at least a part of the growing season. About 90% of agricultural production in the world takes place far below potential levels. In developing countries most agricultural production takes place at levels below 30% of what is potentially possible. The potentials for increasing production are still so large in most countries of South and Central America and Africa, that the increase in population size could be met.

An increase in production per unit of acreage and per man requires an increased use of external inputs from the industrialized sector of the economy. For that reason, large scale reconstruction and reallocation of land in those regions with agricultural perspectives is needed. When production is concentrated in well endowed regions and overuse of inputs is prevented, optimal production systems may be developed in which efficacy and efficiency of inputs is optimized and negative environmental effects are minimized.
In the often too intensive agricultural production systems in North-Western Europe this would usually mean a reduction of inputs, whereas in situations elsewhere an increase of inputs would be needed. This is due to the big discrepancy between "Best Technical Means" and "Present Practice".
Best Technical Means are defined as the production technique where each of the external inputs is used at a minimum level in such a way that the efficiency of each of the variable inputs is maximal. This holds for all variable inputs, such as nutrients and pest, disease and weed control. In general Best Technical Means have the highest efficiency at high levels of production per unit of acreage. Given the yield level, dictated by environmental conditions such as water availability Best Technical Means lead to the highest efficiency of inputs per unit of output. As many of the variable inputs, such as pesticides and nutrients, are low in price per kg and high yield levels are aimed at, the tendency to overuse is obvious. This is mainly due to the extremely low price of such inputs in relation to the price of the end product. By imposing an eco-tax on pesticides and nutrients overuse could be impeded and other techniques leading to Best Technical Means would be promoted. Present Practice with overuse of pesticides will then decrease.
Recent analysis of resource management (De Wit, 1990) confirms the notion that the so called law of diminishing returns is absent in agriculture when the inputs for various purposes are mixed in the proper way. De Wit demonstrates that, in many cases, the efficiency of resource use increases with increasing yield. This is due to a synergy of various inputs. When this does not hold unlimitedly, it is definitely true at lower production levels.

These considerations would lead to the conclusion that for environmental reasons, such as minimizing emission of nutrients and maximizing outputs per unit of input, a concentration of agricultural production should be advocated in well endowed regions. For technical reasons this may be preferable. In combination with a proper crop rotation in arable farming avoiding too narrow rotations, and as a consequence high yields per crop and

properly applied inputs, this will lead to optimal use of inputs.
Crop protection is a small though vital part of agronomical measures. The development of measures tailored to the needs of individual fields requires a wide range of crop protection research. Much of that research has already resulted in practical advice and recommendations. The implementation of integrated agriculture not only is a matter of research and extension; it also is highly important to create the conditions for incentives to use biological control instead of preventive chemical control methods. An example of such conditions could be the mentioned eco-tax on cheap and environmentally unfriendly compounds, and eventually a (temporary) subsidy on more environmentally friendly techniques and compounds.

4. CONVERGING AND DIVERGING DEVELOPMENTS

In detailed studies on agricultural development in the EC it was shown that the distribution of production in the various regions is skewed. The agriculturally well endowed regions are producing an ever increasing part of the total production volume. When a maximum is set to the total production (e.g. aiming self-reliance) to facilitate entrance to the world market for developing countries, [due to a continued increase of productivity per unit, for the reasons mentioned above (distance between actual and potential production and greater production efficiency at higher production levels), the total amount of cultivated land in the EC should decrease with at least 40 percent in the coming decades]. Some figures may illustrate this: At present the EC has 128.10^6 ha of cultivated land and 10.10^6 farmworkers. In scenarios that presume production methods according to Best Technical Means on the best land, the same production volume may be achieved at between 30.10^6 and 70.10^6 ha of cultivated land and with 2.10^6 and 5.10^6 farmworkers, respectively. In those scenarios pesticide use may be reduced by 70 to 80 percent. Marginalization of agriculturally less endowed regions is not a new phenomenon. Contraction of agricultural areas also took place in the 10th and 17th century in many areas of Europe, due to decimation of population numbers caused by epidemics. Recently abandonment of vast tracts of land in, for instance, the USA also illustrates such developments. The fact that there are regions where agricultural production continues to increase and regions where agriculture disappears as an important source of income has divergent consequences for agriculture, both in economic and in ecological terms. Nowadays, continuity in economic terms is impossible for all those who find a living in agriculture in the less endowed regions. Off-farm employment and stimulation of other economic sectors seem the only way to go. Still, for ecological continuity, farming or other forms land use seem necessary to prevent degeneration. Ranching, forestry, nature development and conservation are probably feasible, although very extensive options, both in terms of labour and other inputs. In this way a bimodal agricultural production situation may occur, on the one hand intensive, highly productive and environmentally sound agriculture, on the other hand very extensive, poorly productive and also environmentally sound agriculture, which is more a form of land and nature conservation.

This phenomenon of bimodality in agriculture will take place on all scales, be it at country, regional, or supranational level. The continuity of agriculture and maintenance of environmental integrity seem best guaranteed in this way. To guide such developments and to see in what way developments which occur too quickly can be mitigated by government policy or support, scenario studies at various scale levels are needed. The first and second green revolution, like any revolution, know their victims; as developments in the near future will be as radical as during the last decennia, policy makers should be aware of this and act accordingly. This may mean that support of agricultural development in agriculturally less endowed regions at the cost of production in well endowed regions may be necessary for political reasons. This will happen at the expense of efficient resource use, but other objectives such as socio-economic convergency or political stability may very well be worth it.

5. SUSTAINABILITY AND AGGREGATION LEVELS

Sustainable development in agriculture requires insight as how to produce and manage resources at various aggregation levels. Most discussions on sustainability take place at the crop level. Detailed analysis of nutrient uptake, nutrient use and functioning of crops, the role of weeds, pests and diseases, water management etc. are done for different crops. This crop level dictates the types of disciplines involved in the design and development of crop systems that minimize inputs per unit of output, minimizes pesticide input per unit of product and maximize output per unit of labour. A great deal of plant physiological knowledge, agronomical knowledge, soil fertility studies, irrigation studies, breeding, crop protection studies and, to integrate them all, production ecological studies are needed. Such insight and knowledge may lead to optimal use of inputs and maximization of outputs per unit of input. However, it should not be a single-issue activity but a whole integrated crop management system. Single issue management systems are not profitable and acceptable for farmers.

A second level of aggregation is the cropping system level. At this level rotations and/or mixing of crops are considered. To minimize external inputs per unit of output excessively dense cropping systems should not be used. Again, various disciplines, such as agronomy, crop protection and soil science, should contribute to the development of various cropping systems.

However, in many cases the biotechnical possibilities and limitations do not determine production; limitations and possibilities at farm level are more important determinants. Therefore studies at the farm level are very important. How agronomical measures are determined, for example socio-cultural considerations, labour allocation, tradition and other factors, may govern decision making rather than biotechnical efficiency or purely economic goals. To integrate biotechnical, and socio-economical studies at this level, various procedures and methods have been developed.

A synthesis of disciplines and a synthesis of concepts are needed for that reason. Farming systems research may contribute there. Proper analysis and description of farming systems is necessary to enable the development of strategies and methods. Agronomists working at the crop level have the tendency to overestimate the possibility of changing agronomical measures, as they are not familiar with the background of agronomical systems in which tradition, property rights, religion and other non-biotechnically determined factors play such an important role. Very often the idea occurs that, due to lack of knowledge, farm systems operate below optimal levels. That very often is not true. For example pastoralists in the Sahelian region exploit the excellent pastures in the north of the Sahel at the border with the Sahara during the short rainy season by transhumance and survive the rest of the year in the south of the Sahel, where little fodder but sufficient drinking water is available during the dry season. This herding system is labour intensive, but measured by production per unit acreage, it is the most productive system that can be visualized under such agro-ecological circumstances (Breman, 1982). Any attempt to improve production by introducing other techniques will fail when the introduction of external production resources is not considered.

This example demonstrates that any intervention or proposal for change should be based on a detailed analysis of both the biotechnical and socio-economic characteristics, the possibilities and limitations of present systems, as well as a good evaluation of the potential for change.

Farming systems operate at regional levels. At this level other analyses are needed. Again, a clear formulation of various concepts of sustainability is required. The distinction between agrotechnical, socio-economic, environmental and spatial objectives should be formulated explicitly in such a way that they can be made operational. From the very beginning it should be made clear which part of the rural economy is taken into account. Such studies may help to rationalize decision making at the regional level and to design various strategies rural for development. Examples of such programs are scarce. However, in some places in South-East Asia, Western Africa and Central America efforts are made to develop such methodologies. The need for such studies is amplified by the emphasis on environmental issues, the tendency to move progressively into marginal agricultural land with more and more environmentally hazardous developments.

The last level at which additional studies are urgently needed concerns the national/supra-national level. At this level international political interests and objectives dominate. Such developments determine the possibilities within lower levels. They determine "the weather" under which the regions function. Strategic studies should demonstrate the opportunities for choices local governments possess and make clear how various issues, such as environmental objectives, determine the limits for decision making. In the Netherlands such studies at the European level have been done by the Netherlands Scientific Council for Government Policy.

6. PERSPECTIVES FOR INTEGRATED AGRICULTURE IN EUROPE

The study at the European level done by the Scientific Council for Government Policy demonstrates the possibilities for various developments in rural areas. In all options and scenarios reduction of cultivated land is found. The bimodality described above is present in all scenarios. Total amount of required food can be attained on a very small part of the total land area. The size of this area, be it 30.10^6 or 70.10^6 ha, depends on the preference for various goals. For example, to reach environmental objectives production techniques that minimize use of pesticides below the optimal use of pesticides per unit of product may then be applied more generally. Therefore, more acreage is then needed. This is not much more than the situation in which Best Technical Means, as described above, are applied. The maximum of 70.16^6 ha is much less than the 128.10^6 ha of cultivated land in the European Community (12 countries) and can be higher (90.10^6 ha) when more extensive land use is promoted. The reduction of pesticide use in all scenarios is tremendous. At present over 400.10^6 kg active ingredients are used in the EC, whereas in the scenarios a margin of 40.10^6 to 90.10^6 kg active ingredients is found. The considerable decrease in pesticide use is due to three different reasons.

1. The area on which pesticides are used is much smaller than the present area. The higher productivity per ha causes a less than proportional increase in pesticide per ha.
2. The use of pesticides due to narrow crop rotations, for example 1:2 potatoes, is eliminated. Through structural adjustment of farm size and farm structure excessive use of pesticides, such as soil fumigants against cyst nematodes, is no longer necessary.
3. The application of integrated pest and disease management systems is standard in all crops. This operates where farmers' risk is very limited.

These figures illustrate that the potential for pesticide reduction, without decreasing the economic and agricultural viability, is possible. However, it is not a process that will take place autonomously. It is a possibility that is only realized by promoting an increase in productivity within well defined environmental limits. A ban on too intensive cropping systems is not possible, but the conditions that urged such an intensification beyond Best Technical Means can be eliminated for economic reasons.

The development, implementation and continuous updating and upgrading of IPM-systems is a considerable task for research but an appealing and rewarding one. The IOBC could take the lead in that development. Thus, the IOBC may help in the development of crop production systems that are more sustainable than many current agricultural practices.

REFERENCES

BREMAN, H. 1982.
In: Penning de Vries, F.W.T. et M.A. Djitèye
La productivité des pâturages sahéliens.
Pudoc, Wageningen ISBN 90 220 0806 1

de WIT, C.T., HUISMAN, H., RABBINGE, R. 1987.
Agriculture and its environments: Are there other ways?
Agricultural Systems 23 (1987) 211-236.

de WIT, C.T. 1991
On the efficiency of resource use in agriculture.In: Ziele und Wege der Forschung in Pflanzenbau. Triade-Verlag E. Chaupein, Gottingen.

WRR 1992
Rural areas in Europe.
Publication Netherlands Scientific Council for Government Policy. (In prep.)

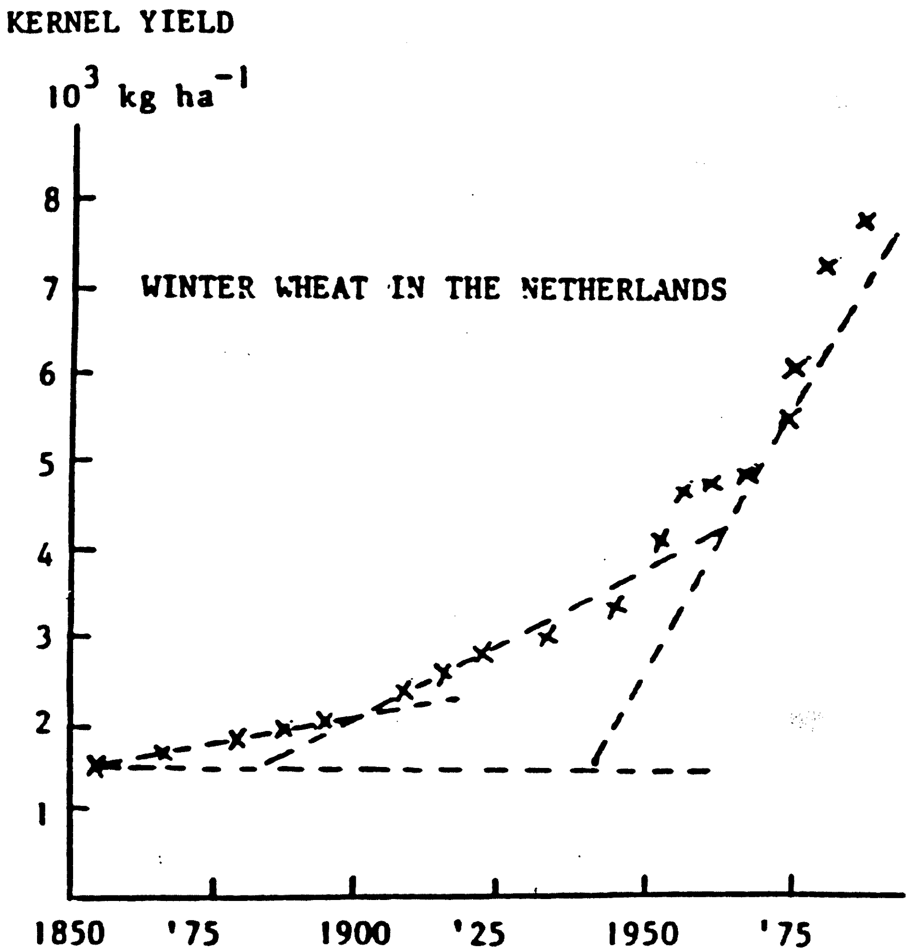

Fig. 1. Average yield of winter wheat in kernels (kg dry matter per ha) for the Netherlands from 1850 to 1985.