



Apple production in the Netherlands where integrated pest control is increasingly widespread (Photo ANWB)

There is another way

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Agriculture may be defined as a human activity that uses the sun's energy to convert plants and animals into useful organic materials. Few resources are necessary: a suitable crop, a piece of land, some sun and rain and human labour. Man tries to manage the crops and soils so as to achieve a reasonable return on his input of capital, labour and energy.

During the past fifty years, agriculture has been strongly influenced by industrialisation and by advances in biological and environmental science. For example, new information about plant nutrition and plant breeding has led to marked improvements in crop yields. The vagaries of human nature, climate, and individual skill and knowledge have meant that farming systems seldom operate at an optimum in economic, social or, for that matter, biological terms. Increasingly, however, knowledge of production methods and plant biology means that, theoretically, maximum yield is no longer governed by human whim and fallibility.

The last ten years have seen an increasing interest in nature conservation, the demand for landscaping on amenity grounds has grown, more and more land has been required for urbanisation and recreation. Compromises therefore have had to be reached. This article describes some policies for land use and emphasises one direction for selective development. So far as agriculture itself is concerned, its principal aim should be regarded as the production of food and other organic products in such a way that their prices are reasonably low and the use of energy and other resources is optimal. Agriculture must be economical also

in its use of land. Within the agricultural landscape there must still be space for other human activities, and agricultural operations should not be to the total detriment of nature and landscape conservation. The agricultural work-force should be maintained at optimal level and its income should be comparable with that of skilled industrial workers.

Present-day, modern agriculture

Modern high-technology agriculture is a heavy consumer of energy and chemicals derived from fossil sources. Fossil energy is used to power labour-replacing machinery and fossil chemicals are the source of fertilisers which may increase production levels. At present, the use of fossil energy in Dutch agriculture amounts to 420 g. Joule per agricultural labourer per year, which compares with manufacturing industry and, incidentally, equals the energy use of fifteen average Dutch families. Agriculture is thus among the more energy-intensive human activities. The very large increase in agricultural production during recent decades is mainly due to the growth of technological knowledge and the input of additional fossil energy.

The following figures illustrate these changes: in 1950 the average yield of wheat amounted to 3 500 kg/ha; in 1970 that average had increased to 5 000 kg/ha; in 1978 the average yield was 6 700 kg/ha, and yields of 7 000 to 8 000 kg/ha were no exception. Similar trends can be observed for sugar-beet, potatoes and grass.

The fossil energy used per kg of wheat produced has stayed the same since 1950, but labour has been halved. These data characterise the increased efficiency in production. If this trend continues one must wonder what its effects will be on nature conservation, ecology and environmental pollution. The answer to these questions must be sought within the relationship between increased production and input of labour and fossil energy.

The law of diminishing returns

When other production factors are kept constant, an increased application of nitrogen results in an increase in yield; each additional amount of nitrogen, however, gives a smaller additional yield. This is an illustration of the law of diminishing returns. However, no farmer will apply only nitrogen; rather he will adapt the input of different production factors so that more nitrogen is applied only when the amount of phosphorus is correct and the water availability etc. is sufficient. A good farmer takes care that his husbandry is such that all growth factors are considered and controlled as effectively as possible. One may ask if the law of diminishing returns is also valid when a combination of growth factors and agricultural engineering is considered. Then the contrary is true. Without external inputs, factors such as low natural nitrogen and disease limit yield to a low level. Small inputs of fossil energy (such as fertilisers) can greatly increase that efficiency. If we then consider the total response curve on an energy basis we can have an increasing

output per unit of input. This unexpected response is due to the nature of the production process. A soil with a pH of 6 is necessary for normal production levels, say 5 000 kg/ha of wheat, but may also yield at a much higher level (10 000 kg/ha). An increase of the production factor lime is then not needed. Very important prerequisites for high yield, however, are protection against pests and diseases and the availability of water. However, protection against pests and diseases does not require so much energy but rather the skill and experience to apply appropriate chemical and biological controls. Pest and disease control must be carried out at the right time; so too must the various stages of crop husbandry, especially harvesting, since poor timing sometimes causes serious reductions in yields. With grass production, it has become increasingly clear that a potential yield of 20 tons dry matter per ha can be reached in North-West Europe. However, mowing and grazing losses are very high, so that in practice the yields are not very much more than 7 to 8 tons dry matter/ha. Bad timing and lack of attention to the crop are the principal causes for these big differences between potential and actual yield. The techniques to limit these considerable losses are known, but lack of labour at the right time affects efficiency. In fact, the input of fossil energy to increase yields is only fully effective when backed by the knowledge, skill and expertise of the farmer. As a result of our expanding knowledge of water use and water management, of soil structure and texture, and as a result of the increased use of nutrients and the considerably increased knowledge of pests and diseases, these factors, which are all subject to the farmer's control, are no longer so limiting for agricultural production. Solar radiation, temperature and the physiological characteristics of the crop are now frequently found to be the principal limiting factors.

This conclusion is in accordance with the historical development of agricultural production. Increasing yields may enhance labour productivity and may promote a more efficient use of fossil energy, but one should realise that the keystone for these benefits is the management skill it takes to apply productivity-increasing measures at the right time and in the right manner.

Aspects of nature conservation

At first glance a description of the developments in high-technology agriculture may seem strange in a journal about nature conservation, and about conservation of wildlife and its habitat. However, high-technology agriculture is with us, and it is essential to ensure adequate food supplies in heavily populated countries. Policies for nature conservation must take into account this need for a viable agriculture.

Productivity per ha may increase considerably when fossil energy is introduced as nutrients or soil additives and when the availability of skilled labour is guaranteed. This rise in productivity per ha may actually release surplus land for alternative uses such as forestry, urbanisation, recreation and nature reserves, and also for less intensive agriculture. This last possibility is of particular importance in Western Europe, where much of the landscape has been shaped by the agriculture of the past. Because less arable land is needed *per capita* for food supply in high-technology agriculture, the opportunities to put such a concept into practice will arise. Nature conservation, extensive agriculture and intensive agriculture may be integrated in the majority of our farming areas. The systems that provide both a good economic return from an agriculture of low intensity and improved values for wildlife are still to come. Within the next few decades a clearer idea of the options will emerge.

To see how such a technology might work one could look more closely at pastures used for beef rearing.

These extensive agricultural systems must be retained, not so much for their products, but more to retain rural employment opportunities and to maintain historical landscapes.

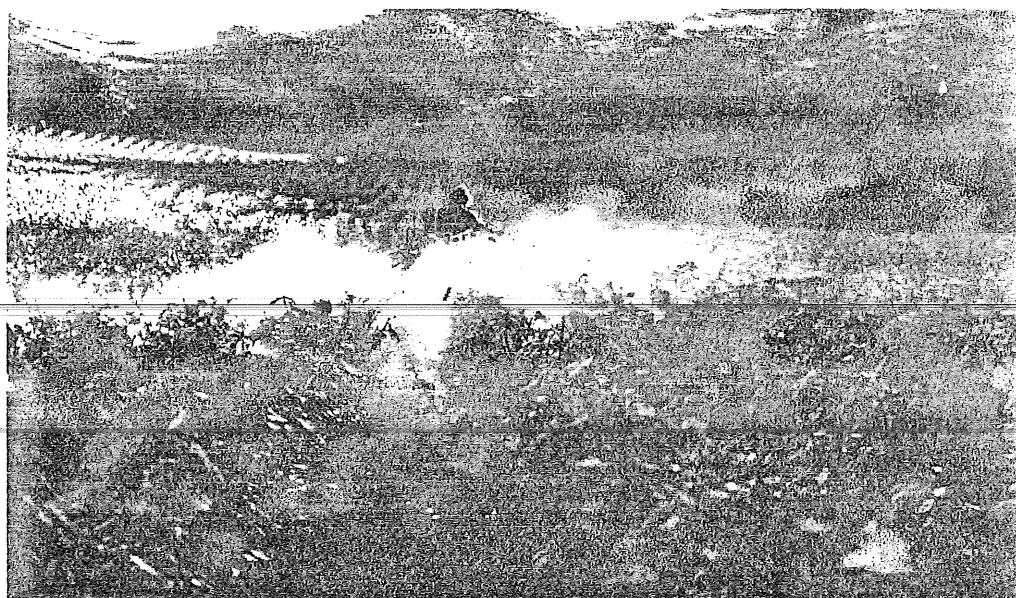
In these low-yielding agricultural areas the number of farm workers per ha should be low and the input of fossil energy need not rise too much. In this way pastures rich in number of species of herbs and plants may stand a better chance of survival. Because this system is primarily aimed at landscape/amenity preservation, stock levels are lower than they would be for maximum productivity. A high proportion of land could therefore be reforested or used for nature conservation.

Thus three different management systems emerge: labour and fossil energy intensive production on a limited land area; a less intensive agriculture that aims at landscaping goals and wildlife conservation and, finally, an area that is used solely for forestry, nature conservation and so on.

Selective development

The suggested alternative agricultural system may cause complications in terms of current agricultural policy.

One must be careful not to imply that high yielding and labour and fossil energy intensive agriculture is totally incompatible with wildlife. The cropped areas may be barren of wildlife; this need not apply, however, to boundaries, field divisions and uncropped corners. We can also make improvements, especially in advanced pest and disease control measures. In many cases production of 6 tons wheat/ha requires no more fossil energy input than a production of 8 to 10 tons/ha. Use of pesticides might be reduced if we could improve biological control measures. An example of this is apple production in the Netherlands, where integrated pest and disease control is becoming an accepted practice. This requires much skill and experience but has sharply reduced the amounts of pesticides required for crop protection.



In the Champagne district, vines are also treated with natural products: spraying with a growth substance containing plant extracts
(Photo R. Zimmermann - Nature et Progrès)

There is another way

Starting in the mid-1960s, the normal practice was to spray apples some twenty-five times a season against disease and pests. Most of these sprayings were preventatively applied according to a set schedule. The problems caused by this system were manifold. Resistance against pesticides developed so that the number of sprayings had to be increased and the range of compounds had to be adapted. To break this vicious circle, and to diminish the negative effects of pest control, integrated control was developed.

Integrated control in this example now involves both the classical methods of biological control, including host plant resistance, and the more advanced new techniques of pest control involving cultivation methods, genetic manipulation of pests and selective use of pheromones and insect hormones, as well as the usual selective pesticides. Considerable progress has been made through research in this field. In apples, the number of sprayings has decreased considerably and the use of the more selective compounds is becoming more and more normal. Biological control is used against many of the secondary species, which became pests after spraying and treatment against primary pests because those sprays also eliminated the secondary species' natural enemies. For example, fruit-tree red spider mite and apple leaf roller, the most severe animal pests on apples, can be kept under control by their natural enemies. Fruit-tree red spider mite is controlled by predatory mites, and apple leaf roller by a combination of parasites and bacteria. Against these secondary pests, sophisticated techniques are being developed which should result in a satisfactory control system.

It has not been easy or inexpensive, since a well-equipped research team was required, working in combination with a skilled management team.

Other alternatives

We have attempted to present a concept of agriculture which is compatible with the aims formulated in the introduction and does not exclude nature conservation, but even paves the way for it. The development of this concept requires fundamental changes in existing practice, since the safeguarding of historic small-scale landscapes requires a low-intensity agriculture running in parallel with an

agriculture dependent on high technology.

An alternative could be the division of the land between nature conservation and high-technology agriculture, but this seems incompatible with the objective of landscape conservation and the maintenance of an agricultural work-force. Much historical agricultural land would then be taken out of production and used for probably poor, natural forests. A third direction for future agricultural development is promoted by those who maintain that agriculture should use less fossil energy and more "biologically" sound methods.

These alternative technologists also wish to remove artificial fertilisers and biocides from the production system. Farms should become more labour-intensive and the number of tractors and other energy-consuming machines should be decreased. Clearly that approach is based on an ideology which ignores the presence of the real world as it now exists. While we might decrease fossil energy input somewhat, the input of labour would be increased considerably. Moreover, all land would then be required for agricultural production, since productivity would be much lower (2 000 to 3 000 kg wheat/ha instead of 7 000 to 8 000 kg/ha in high-technology agriculture). At some point dietary adequacy could be placed in jeopardy. The high number of people in the production process would have either to live at a very low wage or prices would have to increase considerably. The prospect for society would not be very hopeful, nor would that for nature conservation, since too much land would be required for agricultural production.

Selective development is necessary with a high-technology agriculture centred on the best lands. This means an agriculture that is labour- as well as capital-intensive and needing highly skilled and well-equipped farm-workers with sufficient time to apply their knowledge. To limit the use of biocides, more attention should be paid to the development of integrated pest control and early warning systems. More research should be directed into the development of new management techniques for those extensive areas of low-intensity agriculture. These management systems can still apply much modern technology, but in such a way that labour and energy input per unit of land are both kept low. Landscape, wildlife and some nature conservation will be very important in these areas and revenue from them should be sufficient to cover the farmer's expenses.

In this system of selective development a considerable part of all land is available for other activities, such as forestry, nature conservation and urbanisation.

Hopefully, policy makers will start discussion on these options in the near future.

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