Integrated Farming Systems and Sustainable Agriculture in France

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Abstract
The concept of sustainable agriculture includes important components of economic, environmental, agricultural and social sustainability. To obtain a better under-standing of the concept and interactions of these components, trials were implemented in 1990 in different agroecological regions by ITCF and ACTA to compare the performance of conventional farming systems (CFS) with integrated farming systems (IFS). CFS is a cropping system that is commonly employed by many farmers and requires substantial off-farm inputs such as chemical fertilizers and pesticides. IFS is a low input system which attempts to minimize environmental impacts. Trials were established on farms of 15 to 75 hectares using large plots of 1 to 5 hectares to better evaluate the system's feasibility, and its economic and environmental parameters. After four years, results for the IFS have shown that a significant reduction in production inputs and costs (25 to 37%) are possible, especially for agrichemicals. Compared with CFS, IFS strategies may lead to lower crop yields (up to 30%) although the economic net return is often higher because of lower production costs. However, studies will continue because there are many aspects of IFS that need to be improved to enhance the system's economic viability, including intercropping, reduced tillage, and non-chemical weed and pest control.

Introduction

Agricultural productivity in France has made tremendous progress in the last 30 years, during which time crop yields have more than doubled. Nevertheless, these technological advances have not been achieved without great cost to the environment and to society. For example:

- The quality of surface waters and groundwater has been impaired from excessive use of chemical fertilizers and pesticides.
- The high level of production inputs such as machinery, chemicals and energy have contributed to the depletion of non-renewable natural resources.
- The development of intensive conventional farming systems (CFS) has led to a reduction in the number of cultivated crops, both species and varieties.
- The specialization of French agriculture has led to an unusual concentration of certain enterprises in specific regions of the country to the exclusion of others. This disparity has caused severe socioeconomic and environmental problems.

The concept of sustainable agriculture is increasingly viewed as a system within which farmers can produce high quality crops at a reasonable price, over the long-term, without adverse effects on soil quality and the environment. Thus, sustainable agriculture must be economically, environmentally and socially acceptable and sustainable for now and for future generations. To achieve these objectives a new method of farming is envisioned, i.e., an integrated farming system (IFS).

Integrated Farming System: Principles and Prospects

Integrated farming systems (IFS) are based on the integration of crops and livestock into production systems that, through best management practices, maintain a high level of soil fertility and productivity, and seek to replace external inputs of energy, agrichemicals and labor with on-farm resources and natural biological cycles and processes.

Mixed crop-livestock systems, the basis of integrated farming, allow the most effective and efficient use of natural resources and biological cycles. The terms "integrated farming systems" and "mixed production systems" need to be understood in their broadest sense in which a farmer attempts to incorporate annual vegetable crops, cereal crops, orchards, pastures, forage crops, woodlands and animals into a productive, stable and sustainable system. The components are not thrown together randomly but rather, systematically integrated because they are mutually compatible and

complementary. Mixed faming can be successfully practiced on individual farms or within a region. The farming “mix” provides an effective means of reducing the inevitable risks associated with poor crop yields, market price fluctuations, and agricultural policy shifts leading to variations in subsidies. Moreover, mixed or integrated farming is the best means of recycling animal manures and crop residues as soil conditioners and biofertilizers to maintain and improve soil quality.
Another advantage of integrated farming systems is the selection of crops into creative crop rotations that can effectively achieve the following:

- Minimize insect and disease problems.
- Minimize energy requirements.
- Minimize the need for chemical fertilizers and pesticides.
- Maximize vegetative cover to control soil erosion and protect the environment.
- Minimize risks from climatic and economic fluctuations.

To achieve these benefits, it is important that rotations be maintained for at least three years and possibly even five years. Where farms have a viable animal component, longer rotations are possible and strongly recommended. Longer rotations allow better control of weeds, insects and diseases. The inclusion of legumes in the rotation enhances biological nitrogen fixation and reduces the need for chemical nitrogen fertilizers and, thus, lowers the overall energy consumption.
Land parceling, or the distribution of land, is vital if the maximum benefits of crop rotation systems are to be achieved. Cultivated land parcels that comprise a rotation must be of reasonable size. The size should provide a balance to ensure that work can be done efficiently, yet allows an acceptable range of crop species that can be cultivated within the allotted space. The shape of a land parcel is as important as its size.

Ecological Compensation Zones

Effective functioning of agroecological systems are generally enhanced by certain landscape features that are maintained as natural spaces including hedges, woodlands and sod-based, green-divider strips. These elements or features have multiple functions. For example, they serve to increase biological diversity of both flora and fauna and encourage the development of beneficial insects which are effective as biocontrol agents for integrated pest management. These vegetative elements also help to control soil erosion and nutrient runoff; and provide windbreaks and shelter for animals, including wildlife. A11 of them should be considered as important features of any farm plan.

Conservation Tillage for Integrated Farming Systems

Integrated farming systems seek to replace conventional tillage methods (e.g., deep, moldboard plowing that inverts the plow-layer) with shallow, disk and chisel implements. This has allowed a substantial reduction in energy and labor requirements. It has also concentrated crop residues and other organic amendments at or near the soil surface, creating an active zone of biological activity to facilitate nutrient cycling, improve soil tilth, and reduce soil erosion.
However, the adoption of such conservation or reduced tillage methods have sometimes led to the proliferation of adventive (i.e., introduced or not naturally-occurring) herbaceous perennial weeds and also annual weeds (including grasses) that are difficult to control with cultivation. This has caused some farmers to resort to the use of herbicides which, of course, is contrary to the basic principles of integrated farming. Extending the crop rotation period, as mentioned earlier, should help to prevent the establishment of such adventive weeds.

Management Annual Crops for Integrated Farming Systems

Crop management must be performed within the overall operational strategy and with the basic goal of obtaining economic crop yields at least one year out of two. The choice of crop cultivars must integrate disease resistance as a priority. Crop quality must also be an equally important selection criteria.

Sowing densities should be carefully considered and accurately calculated. Many plant diseases are favored by excessively high sowing densities. Early sowing dates should usually be avoided. Proper timing should be a compromise between good planting (i.e., seedbed and moisture aspects) conditions and minimum risk of disease, insect and weed problems that might necessitate the use of pesticides.

Fertilizer applications should be dictated by the agroecological conditions and the crop yield potential. Also, the management practices mentioned earlier (i.e., choice of crop rotations, crop varieties, sowing densities and dates, tillage methods, and reduction in the use of chemical fertilizers, especially N) should limit the incidence of plant diseases, insects and weeds. Thus, the number of interventions needed to control such pests should be reduced.

Any decision for the use of pesticides should be based on sound and reasonable management rationale. To the extent possible, interventions should be decided by the presence of the pest, and not as preventive measures. An expert assessment of population dynamics, toxicity thresholds, and likely crop damage should be obtained prior to any intervention.

Integrated Farming Systems in France: Results of Network Trials

Network trials were conducted at various sites during 1991-95 to determine the performance of integrated farming systems (IFS) compared with conventional farming systems (CFS) based on the level of production inputs and crop yields. Results of these trials at two locations are summarized in Table 1. The results at Saint-Hilaire and at other sites show that it is possible to reduce the total production inputs from 25 to 37 percent. The amount of herbicides, insecticides, chemical fertilizers and fungicides used in IFS compared with CFS decreased by 10.1, 28.3, 41.3 and 89.8 percent, respectively. The development of adventive weed species probably prevented further reduction in herbicide use. The results suggest that IFS has greater autonomy and poses a much lower risk to the environment than CFS.

The results obtained at Boigneville (Table 1) show the extent to which winter wheat yields were reduced for IFS as the level of inputs decreased. Wheat yield was reduced by 35 percent in 1991 and by 1994 had narrowed to about 15 percent, compared with CFS. This would suggest that management practices for the IFS had improved substantially over time.

An economic analysis of the results obtained at three trial sites, including Montgaillard, Boigneville and Saint-Hilaire, was conducted using 1995 prices and accounting for any compensatory aid, i.e., subsidies. It is most interesting that despite the lower inputs and lower yields associated with IFS, the net returns per hectare were greater for IFS compared with CFS at all three sites. The probable reason for this is that the IFS are more economical for both operating costs and mechanization efficiency.

Table 1: Reduction of Inputs at Saint-Hilaire (1991-95) and Reduction of Wheat Yields at Boigneville (1991-94) for Integrated Farming Systems Compared with Conventional Farming Systems.

Saint-Hilaire (1991-95) Input Reduction (%)	Boigneville (1991-94) Yield Reduction (%)
Seed (+2.6)	1991 (-34.6)
Herbicide (-10.1)	1992 (-19.6)
Insecticide (-28.3)	1993 (-15.9)
Fertilizer (-41.3)	1994 (-14.8)
Fungicide (-89.8)	Mean (-21.2)

Conclusions

While the results of this study are most encouraging, the trials should continue to verify the results obtained thus far. However, at this time, we can say that it is possible to manage agricultural production systems with fewer inputs, especially agrichemicals, while obtaining economically-viable results. We do not have sufficient data to precisely measure the impact of integrated farming systems on the environment. However, the fact that we can drastically reduce the inputs of chemical fertilizers, pesticides and energy in agricultural production systems strongly suggests a decidedly lower risk to the environment. Moreover, it should be emphasized that the potential success of integrated farming systems for a more sustainable agriculture depends largely upon skilled management by the farmer and particularly the application of production inputs with proper timing and precision.