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ASPECTS OF TRADITIONAL FARMING SYSTEMS IN RELATION TO INTEGRATED PEST MANAGEMENT*

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INTRODUCTION

Pest management is the domain of entomologists, ecologists, biologists, agriculturalists, toxologists and chemists.

The subject is highly complex and a multidisciplinary approach seems necessary. Unfortunately, however, there has been a tendency for each specialist to only consider his own discipline, thereby ignoring the numerous interactions between the dynamics of pest populations, the environment, crops, etc.

It is therefore recommended that agricultural pest management is always viewed in its ecological context and that the whole farming system is studied before it is manipulated with external pest control measures, particularly toxic chemicals.

The usual approach to pest management is pest oriented rather than crop-oriented (Van Emden, 1977). However, since crops are more important than pests, it is suggested that the subject should be approached through experimental variation of crop management rather than of pest-control possibilities, and emphasis on data on cropping system characteristics rather than on pest populations.

Prevailing traditional tropical farming systems

A simplified classification of tropical farming systems recognizes the following three main systems (Beets, 1982; Whittlesey, 1974):

(i) extensive shifting cultivation;

(ii) intensive subsistence agriculture; and

(iii) commercial crop production.

Shifting cultivation is one of the oldest forms of agriculture and it still covers about 40 per cent of tropical crop land. The system is ecologically quite sound as long as there is an abundance of land and sufficiently long rotation cycles can be maintained.

Until fairly recently, the intensive lowland rice-based subsistence systems of Asia were also quite stable. However, since the introduction of the 'green revolution' with its high-yielding varieties and chemical inputs, this is no longer the case. The same applies to the maize and other cereal-based semi-intensive, largely subsistence systems of Africa.

The less common commercial systems are ecologically quite unstable and rely very heavily on external inputs.

Aspects of traditional farming systems

Traditional farming systems tend to be self-reliant, "closed systems", that is to say, they rely on locally available resources, and only few external inputs are used. This usually means that outputs are quite stable, albeit on a low level: one might refer to it as low-level equilibrium farming. This has both disadvantages and advantages. One apparent advantage is that energy input/output ratios for these systems are relatively high. The typical range for extensive subsistence agriculture is 1:15-30; for more intensive subsistence systems with some fertilizers and other chemicals, it is 1:5-10. This compares favourably to 1:1.5 for highly mechanized rice in the USA and 1:2.5 for maize in the U.K. (Leach, 1976). In this context it is interesting to note that pesticides are the most energy-intensive agricultural input; the total energy required to supply a kilogram of pesticide has been estimated at about 101 x 10^6 joules or 2.4 kilograms of petroleum equivalent (Leach, G. & Glesser, M., 1973).

Another characteristic of tropical farming systems is that multiple cropping practices, such as mixed cropping and agroforestry rather than monocultures, are the norm. This not only implies a multi-species situation but also means that within species there is a much wider genetic base than in, for example, the hybrid maize monocultures in the U.S.A corn belt. This results in basic differences between the pest dynamics of western style monocultures and the traditional multiple cropping systems.

Pest and diseases in traditional multiple cropping systems

When considering the incidence of pests and diseases in traditional multiple cropping systems, there are two widely contrasting possibilities:

(i) Multiple cropping provides a longer period of plant life which is likely to increase insect and disease problems; and more intensive cropping could increase pest problems by creating a more favourable environment for pests and diseases by increased disturbance of the ecosystem; and

(ii) Crop diversity may lead to greater pest stability and the longer period of plant life may allow naturally occurring biocontrol agents to sustain higher population levels (Litsinger and Moody, 1976).

In multiple cropping systems, pests are a concern throughout the cropping period. The pests of the various crops often do not affect only one crop. In sequential cropping systems the pests of one crop might be influenced by the previous crop while in mixed cropping systems, the pests of one crop might be influenced by the other component of the association (Moreno, 1979).

Pest management in multiple cropping systems

The pest management characteristics of a multiple cropping ecosystem can be described as follows:

(i) There is considerable opportunity to "mimic nature"; many of the natural constraints on pest populations can be encouraged; and

(ii) The risk that pesticides may upset natural biological control is particularly high (Van Emden, 1977).

Because of the great number of variables and interactions possible, the pest management implications of the various possible inputs are numerous and complex. They can be listed as follows:

Table 1 Cropping system variables with pest management implications involved in devising (multiple)cropping systems. (modified from Litsinger and Moody, 1975 and Van Emden, 1977)

Choice of crops

Crop species
- Annual or perennial
- Height, shade, ground cover
- Maturation period
- Flowering or nonflowering
- Pest spectra

Crop varieties
- Susceptible, resistant or tolerant
- Height, shade, ground cover
- Maturation period

Crop arrangement in time

- Sequence of rotation
- Continuous or discontinuous
- Asynchronous or synchronous in area
- Seasonal position of each crop

Crop arrangement in space

Pure stand, seed mixtures, intercrops, or strip crops
Planting density
Large or small fields
Regional host crop area
Distribution of host crop fields

Pesticides

Choice of material
Number of applications
Type of application
Partial or complete treatment of crop area
Time of application

Experiments conducted with the variables listed in Table1 over the past two decades have shown that there are a number of more or less practical ways to manage pests by other means than applying insecticides. They can be summarized as follows:

I. Planting a trap or diversionary crop. (Crop A can trap insects for crop B where the are harmful on crop B but not on crop A).

II. Planting a crop which attracts or repulses insects through visual stimuli (action the same as under I).

III. Planting a physical barrier which reduces mobility of harmful insects (as in strip cropping).

IV. Planting a pest resistant camouflage crop to hide a susceptible second crop.

V. Planting genetically diverse crops to buffer the explosive build-up of pests and diseases (as in multiline varieties) and to create more ecological niches for predators.

VI. Planting a crop that changes the micro-climate of a second crop so that the growth conditions for insects become less favourable.

VII. Planting alternate host crops for predators.

VIII. Planting crops with a **repellant action** (crops that emit chemicals that adversely affect pests).

IX. Planting pest and disease **resistant crops** or cultivars.

X. Practising **crop rotation** with crops that host different pathogens.

Note: Some examples are given in the following text.

For each plant species there is a range of pest and disease susceptibility which has to be taken into consideration in selecting the components of the cropping system. Generally, it is advantageous to combine pest- or disease-susceptible species (or different genotypes of the same species) with resistant species (or genotypes) to reduce the absolute effects of the disease. Tropical farmers have traditionally done this-most likely unconsciously. In recent years there has been considerable scientific interest in this practice, and in several plant-breeding institutions there is now an attempt to breed "multiline varieties", particularly of cereals. This approach is adopted because plant breeders have been fighting literally an endless battle to devise cereal varieties resistant to attack by pests and diseases. The lines used in such mixtures are phenotypically very similar but slightly different genotypically. The main difference is the resistance to pests and diseases. When these multiline varieties are planted, pathogens cannot spread as quickly as in a monoculture system because they can only attack plants of the line which is susceptible to that particular pathogen. This new approach, of using cereal mixtures containing strains with resistance of different genetic origins, and thus promising a more dependable defence, is now almost fully accepted. This is a good example of an aspect of traditional farming systems used for the development of a modern technique.

Multispecies associations (i.e. agroforestry*) often play important roles vis a vis pest population dynamics. Heterogenous plant and/or animal populations as encountered in agroforestry systems offer various mechanisms whereby pest problems may be minimized. For example, some pests are attracted to host crops by **"visual stimuli"**. Multispecies in intimate mixtures can hide the susceptible host species. Even if the pest eventually finds the host, the cumulative effect of delay in doing so can have a significant effect in reducing the scale of eventual pest outbreak (due to increased pest mortality, etc.).

Non-host or resistant species can form a **"physical barrier"** which interferes with pest dispersal, e.g., cassava/beans or melon intercropping prevents/minimizes cassava blight (Xanthomonas manihotis) because the beans act as a cover crop and minimize rain splash of innoculum from the soil (Arene, 1976; Moreno, R.A. 1979).

Increased numbers of ecological niches allow the establishment of biological control. For example, coconut bug (Pseudotheraptus wayi) can be controlled by the ant Oecophylla smaragdina, which, in turn, is preyed upon by another ant (Pheidole megacephola). However, where cononuts are grown in conjunction with a cover crop, this provides not only a favourable habitat for Oecophylla but also enables it to avoid Pheidole while moving from tree to tree (Van den Bosch and Telford, 1976).

Another example of a traditional practice which has an important role to play in pest control in modern agricultural systems is **crop rotation**. The importance of crop rotation is well understood. Generally, the alteration of crop species decreases the incidence of pests and diseases.

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* Agroforestry is a collective namefor land-use systems/practices in which woody species are deliberately managed with annual crops and/or animals on the same unit of land. This can occur either simultaneously or in rotation.

When making a crop rotation programme, crops should be selected which have the fewest pests in common. Crops which are botanically related have many pests and diseases in common and should not, therefore, be planted at the same time or in the same sequence.

From the point of view of pest ecology the rotation of a legume and a cereal usually has many advantages. Rotations of wheat and soya beans, maize and common beans, and rice and mung beans are therefore widely practised. Sequential cropping of maize alone can generally be practised without too many pest and disease problems; sequential cropping of rice is also widely practised with the same expectations. If a pest or disease breaks out, however, it is often necessary to introduce another crop.

In contrast to maize and rice, such crops as tobacco and cotton should not be planted too frequently on the same land because pests and diseases seriously affect these crops. Moreover, since cotton has many polyphagous insects, the crops associated with cotton in a rotation should be carefully selected.

Life cycles of pests and diseases are often synchronized with those of the host plants and are frequently determined by climatological and ecological conditions. Therefore, a pest can often only thrive when the host plant has reached a certain stage of development. When the host plant moves to another stage of development, the pest often searches for another host, e.g. Hibicus esculentus planted around cotton to attract fleabeatles (Podagria spp) which attack cotton. Another example is soya bean planted around pigeon peas to attract "hairy caterpillar" (Amsacta sp) pests of pigeon pea (Krantz et al., 1976). If there is no such host, the pest population decreases or, if there is a protracted period without an adequate host, disappears.

Some thoughts on strategies for future tropical agricultural development

Past experience in agricultural development in developing countries has made it necessary and indeed fashionable to advocate constant consideration for the farmers' point of view and to promote development within existing systems rather than recommend the adoption of western-style systems, which are heavily dependant on fossil energy, pesticides, good communications and sophisticated institutions. Therefore, one of the philosophies underlying current approaches is that self-reliance and self-sufficiency are preferable to dependence on external inputs and export-oriented economies. However, productivity in few, if any, systems can be increased without **some** external resources, such as fertilizers, pesticides and other borrowed technology. But levels of external inputs should be kept to a minimum, and local resources should be fully utilized before recourse is taken to importation of inputs. For example, when dealing with soil fertility, it is desirable first to make more and better use of organic manures (e.g. farm yard manure, compost and crop residues) and green manures. Only after this should the use of **modest** quantities of imported chemical fertilizers be recommended. The same strategy would apply to pest control. First, the advantages of traditional pests and disease control should be exploited and only after that should **modest** quantities of pesticides be recommended.

Some conclusions and recommendations

Certain aspects of traditional farming systems have advantages over "modern" systems. However, in view of population pressures, land shortages and the ever-increasing quest for food, it is often necesssary to modernize traditional systems to some extent. When this is done, it is necessary first to make an in-depth study of the traditional systems, then identify useful components of these systems, and finally try to modify the systems in such a way that the beneficial components are maintained and that the new, modern component can be accommodated without unduly disturbing the equilibrium.

Examples of combining modern technology with aspects of traditional systems include the development of multiline varieties and scientific crop rotation.

Agroforestry and multiple cropping by definition involve the management of heterogeneous plant/animal populations (either simultaneously or in rotation). As seen above, this makes possible the use of the various opportunities provided by heterogeneous plant/animal populations. Furthermore, we need to remember that pest control is not necessary just for the sake of reducing pests, rather it should be seen in the context of reducing yield losses and thus increasing overall productivity. Agroforestry offers opportunities for sustained production of both food and wood and also integrated pest management.

In the African context this means that traditional cropping practices should be maintained, but they should be scientifically improved and refined. Meanwhile, care should be taken that ad hoc and blanket applications of insecticides do not escalate because this could mean that the cultural controls and mixed farming which at present provide such valuable pest suppression and regulation in the tropics will collapse.

It is envisaged that the development of optimal cropping systems will progress more and more towards eventual minimal use of insecticides and maximum use of manipulation of cropping systems.

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