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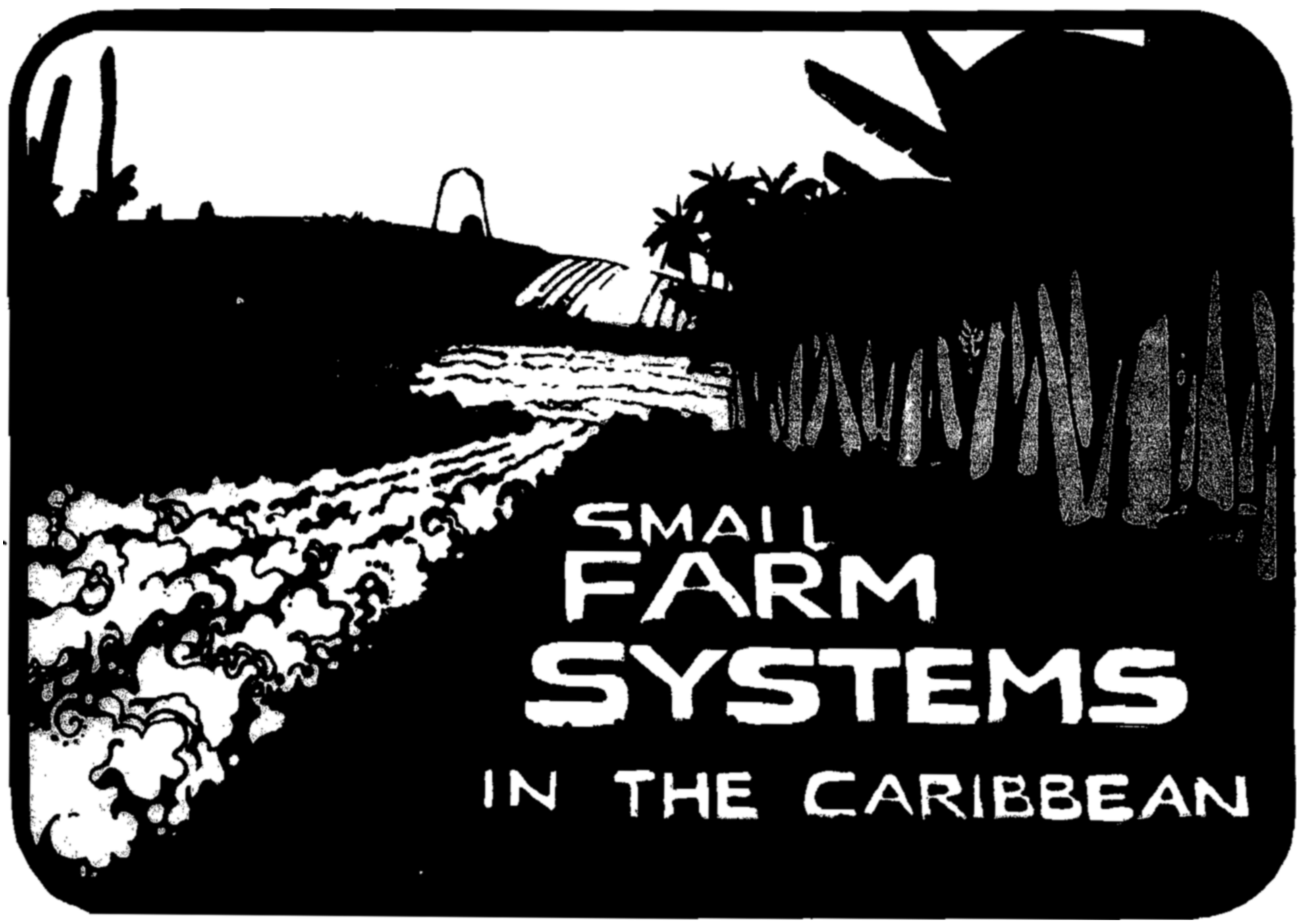

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Developing Pest Management Strategies for Small Farmers Based on Traditional Knowledge

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For centuries traditional farmers have kept pest damage within acceptable levels by employing a wide variety of cultural practices based on local lore and resources. One such practice is the use of polycultures. Factors involved in pest regulation in polycultures include: increased parasitoid/predator populations, available alternative prey/hosts for natural enemies, decreased colonization and reproduction of pests, feeding inhibition or repellency from non-host plants and prevention of movement and emigration. These elements of natural pest control built into small farming systems should be examined, so that the valuable ones are retained in the course of agricultural modernization. Thus, traditional knowledge must be considered to guide changes and attain optimum yields in regions with low-input agriculture. All development approaches should be village-based, with emphasis on self-sufficiency, use of local resources and indigenous agricultural regimes.

Traditional farming systems represent centuries of accumulated experience of interacring with the environment, by farmers withour access to scienrific information, external inpurs, markets, capital, institutional services and high quality natural resources (de Janvry, 1981). Such skills, using locally available energy and materials, have often translated into farming systems with sustained yields (Wilken, 1977; Egger, 1981). Western agriculturalists, however, often have curious perceptions of these systems and their productivity potential, considering small farms to have low productivity. Therefore, obtaining "bigger yields" becomes the goal, and the justificarion for claiming rhe necessity of technology transfer and institutional innovation (Alverson, 1984). Although productivity per unit of land may seem low, peasants may obtain a high level of productivity from other resources thar are scarcer or more essential. Little attention is paid by researchers to the ecological context and cultural organization of agriculture. Not surprisingly, few significant technological packages, capable of yielding increased net returns, have been successfully offered ro rhe majority of peasants (de Janvry, 1981).

Improvemenr of peasant income by increasing agricultural production through the use of expensive purchased inputs may no longer be appropriate. Alternatively, what may be more appropriate is to promote strategies centered on self-sufficiency in production, so that the dependency of peasants on costly inputs and industrial technology is minimized. To develop such systems, traditional "know-how" must be assessed to guide the use of modern agricultural science to progressively and carefully improve the productivity of small farming systems. Such assessments have gradually increased in the lasr decade (see Altieri, 1983, and references cited therein) and many of them have provided the basis for successful rural development projects. An example is the development of alley cropping in Nigeria, in which selected leguminous trees and shrubs are planted in association with food crops to accelerate soil-nutrient regeneration, thus shortening the fallow period required for shifting cultivation (Wilson and Kang, 1981). Another example is the replacement of rhe rradirional lucerne undersown in barley fields of the Bolivian highlands with vetch (*Vicia villosa*) to increase forage production after the grain harvest (Augstburger, 1983).

Evaluations of the dynamics of insect, weed, and pathogen populations and of the methods of pest control commonly used in traditional farming systems are few. The scattered informarion of pests in subsistence agriculture is mostly of an anthropological nature and does not provide quantitative derails about the effects of various cultural control practices on pest dynamics or about the ecological mechanisms involved in the regulation of specific pests (Matteson et al., 1984). Most of our understanding about the effects of crop diversity on pest incidence derives from experimental measurements often obtained in isolation from the total context of farming systems and of social reproduction.

Pest Management in Traditional Agriculture

The magnitude of pest problems in traditional agriculture is in part a matter of perspective, because subsistence farmers may have low yield expectations and tolerate relatively high pest losses (Brown and Marten, 1984). Pests are tolerated because they are either regarded as fellow creatures entitled to a share of the crop, or merely because certain animal or plant "pests" are used for food or other purposes. Many weeds are used by farmers as food, medicine, animal fodder, fuelwood, etc. (Datta and Banertee, 1978). In fact, peasants in tropical Mexico manage a "nonweed" concept; non-crop plants are classified according to use potential and complementary positive effects on the one hand, and negative effects on soil, pests and crops on the other (Chacon and Gliessman, 1982).

Some traditional cropping systems exhibit built-in pest supresssion mechanisms resulting from the integrated interaction of factors such as:

1. arrangement of crops in time and space;
2. composition and abundance of non-crop vegetation within and around fields;
3. species and genetic diversity of crops;
4. soil characteristics;
5. the surrounding environment; and
6. the type and intensity of cultural management.

Pest populations may fluctuate depending on their degree of association with one or more of the vegetational components of the system or their sensitivity to change in crop patterns, soil management, etc. Although pest losses in traditional agriculture can reach 40% (Brown and Marten, 1984), these losses fall in the same range in modern agriculture, despite its use of chemical pesticides. When pesticides are removed from modern systems, losses can often approach 100% (Schwartz and Klassen, 1981). Conversely, in traditional systems, pest damage is kept within certain bounds by a variety of management practices based on locally available resources.

Temporal and spatial crop diversity which characterizes traditional polycultures often results in lower pest incidence. The factors and mechanisms involved in this regulation are the subject of active research (see Risch et al., 1983; Altieri and Letourneau, 1982, and references cited therein). For example, paddy rice systems of southeast Asia are characterized by high genetic diversity, which confers at least partial resistance to pest attack. Farmers exchange seeds because they observe that any particular variety tends to accrue pest problems if grown on the same land for several years (King, 1927). In the Andes, farmers grow as many as 50 distinct varieties of potatoes in their fields. The maintenance of this wide genetic base is adaptive since it reduces the threat to crop loss due to pests and pathogens which are specific to particular strains of the crop (Brush, 1982). The clearing of comparatively small plots, typical of shifting cultivation, in a matrix of secondary forest vegetation permits easy migration to the crops of natural control agents from the surrounding jungle. Shade from forest fragments still standing in new fields reduces shade-intolerant weeds and provides alternate food and shelter for beneficial insects (Matteson et al., 1984).

These built-in pest suppressive mechanisms are complemented by environmental manipulations conducted by farmers as part of their farming operations. Thus farmers, in addition to intercropping and use of resistant varieties, utilize cultural practices such as crop rotation, synchronous planting, increased seeding rates and changing time of planting (Litsinger et al., 1980). For example, Pangasinan farmers in the Philippines planting mungbean after rice, often sow at increased densities and delay planting for one or two months to avoid flea beetles during the early growth stages. Sowing of cowpeas into standing rice stubble interferes with host finding by bean flies, thrips and leafhoppers. Many farmers also place branches of plants (*Glaricidia sepium* and *Cordia dichtoma*) within or beside the fields as pest repellants (Litsinger et al., 1980).

In China peasants utilize a variety of cultural practices to control diseases in rice and wheat. Stripe rust of wheat is kept under control by utilizing local varieties, postponement of sowing winter wheat to reduce the chance of autumnal infection, increased frequency of irrigation and eradication of wheat ratoons. *Fusarium* is reduced in wheat by avoiding the use of fertilizers of high nitrogen content and proper water management (Chiu and Chang, 1982).

In shifting cultivation systems, weeds can be controlled by farmers provided that weed densities are relatively low and fallow periods long. Long fallow periods effectively suppress annual grasses and troublesome perennials. Burning can delay the need for weeding up to five weeks after planting, while weeding is recommended within two weeks after planting in unburned croplands (Akobundu, 1980). In tropical Mexico, farmers utilize a legume cover crop (*Stizilobium* sp.) in the off-season to smother weeds (Gliessman, pers. comm.). The adoption of cropping patterns which provide rapid canopy cover minimize weed competition. Intercropping short season crops such as maize and melon with longer season crops such as corn and cassava can help prevent buildup of weed species.

Improving Pest Control Systems

Procedures for determining appropriate technologies for small farmers through the farming systems approach (Shaner et al., 1982) have been adapted to develop insect-control recommendations by IRRI's scientists (Altieri, 1984). The methodology includes:

1. understanding farmers' current perceptions of pests, insect control practices and resources available for control;
2. determining yield losses for each crop growth stage;
3. matching key pests to measured yields;
4. selecting appropriate insect-control technology;
5. testing the technology on farmers' fields over several years; and
6. evaluating the costs and returns of the technology.

So far the methodology has centered around the quantification of yield losses for each growth stage of the crop by successively ommitting insecticide protection during each stage, while providing control in the others. Results of these trials provide information on the correct timing of insecticide applications. It does not provide an idea of insect dynamics and damage at various growth stages when using farmers' management, thus excluding those farmers who wish to maintain their traditional management and those who cannot afford purchase of inputs (Altieri, 1984). Researchers ar IRRI recognize that no matter how strategies of chemical pest control are approached, farmers will have to spend more money (Litsinger et al., 1980). Given the economic circumstances facing developing countries (*i.e.*, external debt, transportation costs, international commodity price fluctuations, etc.) effective non-chemical means of pest control, both innovative and traditional, should be thoroughly explored and preferred: resistant crop varieties, augmentation and conservation of natural enemies, cultural control, natural botanical insecticides, microbial pesticides, etc. (Matteson et al., 1984).

Management Possibilities

Polyculture management is basically the design of spatial and temporal combinations of crops in an area. There are many possible crop arrangements and each can have different effects on insect, weed and pathogen populations. For insects, the attractiveness of crop habitats in terms of size of field, nature of surrounding vegetation, plant densities, height, background color and texture, crop diversity, weediness, etc. are subject to manipulation.

In intercrop systems, the choice of a tall or short, early- or late-maturing, flowering or non-flowering companion crop can magnify or decrease the effects on particular pests (Altieri and Letourneau, 1982). The inclusion of a crop that bears flowers during most of the growing season can condition the buildup of parasitoids, thus improving biological control. Similarly, the inclusion of legumes or other plants supporting populations of aphids and other soft-bodied insects that serve as alternate pre/hosts can improve survival and reproduction of beneficial insects in agroecosystems. The presence of a tall associated crop such as corn and sorghum may serve as a physical barrier or trap to pests invading from outside the field. The inclusion of strongly aromatic plants (*i.e.*, onion, garlic, tomato, etc.) can disturb mechanisms of orientation to host plants by several pests.

The date of planting of component crops in relation to each other can also affect insect interactions in these systems. An associated crop can be planted so that it is at its most attractive growth stage at the time of pest immigration or dispersal, diverting pests from other more susceptible or valuable crops in the mixture. Planting of okra to divert flea beetles (*Podagria* spp.) from cotton in Nigeria is a good example (Perrin, 1980). Corn planted 30 and 20 days earlier than beans reduced leafhopper population on beans by 66% compared with simultaneous planting. Fall armyworm damage on corn was reduced by 88% when beans were planted 20-40 days earlier than corn, when compared to the simultaneously planted intercrop (Altieri and Letourneau, 1982).

We still understand little of how spatial arrangements (*i.e.*, row spacings) of crops affect pest abundance in intercrops. For example, it has been noted that there is a greater reduction in damage to cowpea flowers by *Maruca testulalis* in intra-row rather than inter-row mixtures of maize and cowpea (Matteson et al., 1984). Selection of proper crop varieties can also magnify insect suppression effects. In Colombia, lower whorl damage by *Spodoptera frugiperda* was observed in corn associated with bush beans, than in corn mixed with climbing beans. In the same trials, maize hybrid H-207 seemed to exhibit lower *Spodoptera* damage than H-210 hybrid, when intercropped with beans. Clearly, much further work is needed before appropriate crop mixtures and row spacings are to be achieved.

The manipulation of weed abundance and composition in intercrops can also have major implications on insecr dynamics (Altieri, 1983). When weed and crop species grow together, as it is commonly observed in traditional cropping systems, each plant species hosts an assemblage of herbivores and their natural enemies, thus trophic interacrions become very complex. Many weeds offer importanr requisites for natural enemies such as alternate prey/hosts, pollen or nectar as well as microhabitats which are nor available in weed-free monocultures. Relevant weeds that support rich natural enemy faunas include the perennial stinging nettle (*Urtica dioica*), Mexican tea (*Chenopodium ambrosioides*), camphorweed (*Heterotheca subaxillaris*) and goldenrod (*Solidago altissima*) (Altieri and Whitcomb, 1979). In the last 20 years, research has shown that outbreaks of certain types of crop pest are more likely to occur in weed-free fields than in weed-diversified crop systems. Crop fields with a dense weed cover and high diversity usually have more predaceous arthropods than do weed-free fields. Ground beetles, syrphids, lady beetles (*Coccinellidae*) and other predaceous insects are especially abundant in weed-diversified systems. Relevant examples of cropping systems in which the presence of specific weeds have enhanced the biological control of particular pests can be found in Altieri and Letourneau (1982). These observations suggest that selective weed control may change the mortality of insect pests caused by natural enemies. The ecological basis for obtaining crop-weed mixtures which enhance insect biological suppression awaits further development.

In traditional agroecosystems, the dispersion of crop plants in species rich or genetically divetse mixtures restricts the spread of pathogens. Such diversity gives a measure of stability in that the failure of some species or genotypes due to diseases may be compensated by the improved performance of others (Thresh, 1982). Proper inclusion of immune or resistant crop plants in the mixtures can impede pathogen spread and increase the separation between susceptible plants. Growing of tall plants together with shorter crops can significantly decrease the spread of diseases by either acting as a barrier ro the free spread of propagules or by interfering with rhe movement of insect vectors. For example, in Japan, radish mosaic decreased when radishes were sown between rows of rice, and pigeon peas in Haiti were protected from virus diseases when grown berween rows of tall sorghum (Palti, 1981).

There is also evidence that some plant mixtures adversely affect nematode populations. Marigolds (*Tagetes* spp.) offer great potential for nematode reduction through toxic action in intercrops (Visser and Vythilingam, 1959). Intercropped *Crotalaria*, itself susceptible to nematode attack, diverts nematodes (*Radopholus similis*) from other crops and then interferes with the nematode life cycle within its roots (Palti, 1981).

Although traditional intercropping appears to offer considerable potential as a means of increasing crop dominance over weeds, there is much room to improve the effectiveness of weed control in intercrops by manipulating crop diversity, spatial arrangement, soil fertility, relative proportions of component crops, and use of competitive cultivars. In shifting cultivation systems, the natural regeneration of forest vegetation can be replaced by a legume cover crop such as *Psophocarpus palustaris*, *Centrosema pubescens* and others which provide excellent vegetation cover to the exclusion of weeds (Akobundu, 1980). Similarly, weeds can be effectively suppressed in intercropping systems by the use of low-growing crops (*i.e.*, melon and sweet potato) which quickly shade the soil surface thus minimizing weed growth. Legumes intersown berween maize rows offer the opporrunity for improving soil fertility, crop yield and weed control on otherwise impoverished soils of the humid tropics (Akobundu, 1980). Crop densiry can be easily manipulated ro promote crop dominance over weeds in intercrops. Highest combined crop yields and the greatest degree of weed suppression were obtained from a sorghum/pigeon pea mixture with a normal density of pigeon pea sown with a twice normal population of sorghum (Shetty and Rao, 1981).

Extension of Appropriate Pest Management Practices to Small Farmers

Generally in developing countries, the extension approach consists of researchers developing recommendations, preferably wirh continuous suggestions and critical input from farmers via the extension service. Thus, extension agents are the principal link between researchers and farmers. They reach farmers through demonstrations, training courses, follow-up visits, often with local pilot farmers as examples and demonstrators for others. Seeds, pesricides, equipment, subsidies, credit, etc. are part of the "package deals" and must be available at the proper time and at an accessible place (Matteson et al., 1984). So far, the few technological breakthroughs made in peasant farming, have inevitably been accessible to those peasants of recognized ability and to those most favored in terms of control of resources and access to markets, roads and credit (de Janvry, 1981). Moreover, due to the heterogeneity of peasant farmers, global recommendations have proven to be seriously unfit for the majority of small farmers who are usually confined to marginal areas. Thus, the recommendations have only been confined to accommodated peasants that enjoy better soils, natural resources, and institutional support.

If rural development is indeed successful among small farmers, technical and organizational strategies must emphasize:

1. improvement of use-efficiency of local resources;
2. minimization of dependency on purchased inputs and industrial technology;
3. satisfaction of self-sufficient production; and
4. organization of peasants to enhance their cooperation for economic and social survival.

There are several non-profit groups in the developing world emphasizing the "bottom up" or "grassroots" approach ro rural development. These groups, meagerly funded and isolated from the mainstream agricultural colleges and ministries, have an ecological vent relying on resource conserving technologies that promote nutrient cycling, natural pesr control and soil conservation (Altieri, 1983). The establishment of modular systems in Tabasco, Mexico (Gliessman et al., 1981) and of improved high land cropping systems in Bolivia (Augstburger, 1983) are successful examples. The establishment of a self-sufficient experimental small farm (0.5 ha.) in Chile (CET, 1983), where most of the food requirements of a family of scarce capital and land can be met, has had great impact. Groups of peasants coming from local and distant areas live in CET's farm for variable periods of time, learning through direct participation in the farming operations, all the organic production practices (*i.e.*, composting, raised beds, intercropping, etc.), farm designs, planting dates, proper varieties, etc. After their training farmers are given a basic package of seeds and then return to their communities to teach their neighbors the new methods, and thus apply the model in their own lands.

In the Peruvian Andes, "Grupo Talpuy" has been rescuing and recording the knowledge of local farmers about farming practices (*i.e.*, mixed cropping, use of potato varieties, crop rotations, fertilization, etc.), traditional crops utilized, use of non-crop plants, etc., which is then synthesized and later disseminated in written form (a low cost magazine called *Minka*) throughout the rural areas (*Minka*, 1981). Each issue treats a different subject (*i.e.*, mixed cropping, Andean crops, local herbal medicine, soil conservation, agricultural tools, low-cost house construction, etc.) in a very simple manner, illustrated with a number of drawings and graphics. The idea is that many efficient technologies have originated and are used in very local areas, and can be extended to other farmers in remote areas through the distribution of the magazine. The objective is to make resources, and particularly the resource of knowledge, widely available. *Minka* emphasizes the use of resources that are locally available and that do not require specialized knowledge for their control. In this way, farmers can be selective in choosing technologies or practices that have worked for other peasants that share similar levels of capital, land base and natural resources.

CONCLUSIONS

It appears that there are several misconceptions in the highly touted current view of traditional farming and the recipes for making them "more productive." In a case study from small farms in Botswana, Alverson (1984) convincingly shows that many of the views on small farms are seriously flawed and ideologically motivated, and that technology transfer is both unprofitable and destructive of numerous indigenous institutions. He argues that there is great potential for increased production within traditional agriculture as it is currently practiced, with minor changes in crop management practices and farm organizations.

The few examples of grassroots, bottom-up rural development programs currently undergoing in the Third World suggest that the process of development and diffusion of appropriate technologies for peasants must meet at least three criteria:

1. utilize and promote autochthonous technologies;
2. emphasize use of local and indigenous resources; and
3. be a self-centered, village-based effort with the active participation of peasants.

The ensemble of traditional crop protection practices used by small farmers represents a rich resource for modern workers seeking to create pest management systems that are well-adapted to the ecological and socio-economic circumstances of peasants. Clearly, not all traditional crop protection components are effective of applicable, therefore modifications and adaptations may be necessary, but the foundation of development should be indigenous. Evidence suggests that in traditional farming systems, the critical factor in the efficient use of scarce resources and in the lowering of risks is diversity (Harwood, 1979). Maintenance of biological diversity in these systems should then be the foundation of any pest management strategy.

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