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Pest-management technologies for peasants: a farming systems approach

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ABSTRACT. The development of crop-management technologies for peasant agriculture must fit the socio-economic and ecological features of small farming systems. Only through research that is multidisciplinary and agroecologically orientated, is it possible to understand fully the agro-socio-economic circumstances that determine the management criteria and levels of resource use by small farmers. Results from these agroecological studies, coupled with the farmers' practical knowledge, can serve as a starting point to develop pest-control technologies which are adapted to the farmers' resource base and local conditions. Throughout the process, technology generation must start and end in the farmers' fields.

Introduction

About 60% of the world's cultivated land is still farmed by traditional and subsistence methods (Ruthenberg, 1976). This type of traditional agriculture has the advantage of centuries of cultural and biological evolution that has adapted it to local conditions (Egger, 1981). Thus small farmers have developed and/or inherited complex farming systems that have allowed them to meet their subsistence needs for centuries, even in adverse environmental conditions (i.e. on marginal soils, in drought- or flood-prone areas, with scarce resources) without depending on mechanization or modern chemical fertilizers and pesticides (Harwood, 1979).

By implication, research recommendations aimed at improved crop production in these systems should be based on a full understanding of small farmers' agro-socio-economic circumstances. Unfortunately, most research programmes in the tropics are patterned after those in the developed countries, and not surprisingly many agronomic recommendations have proved to be unsuited to the socio-economic and ecological heterogeneity of small farming systems (Harwood, 1979). In rural development projects such as Puebla in Mexico, Garcia Rovira in Colombia (led by the Instituto Colombiano Agropecuario, ICA) and Cajamarca in Peru (led by the Peruvian Ministry of Agriculture and CIMMYT), researchers failed to consider basic features of peasant agriculture—ability to bear risk, labour constraints, symbiotic crop mixtures, diet requirements, etc.—that determine the decision criteria and resource use by farmers. At the termination of these three projects, an

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overwhelming conclusion seemed unavoidable: no significantly new technological packages capable of yielding increased net returns could be offered to peasants (de Janvry, 1981). These and other case histories have prompted a re-examination and re-orientation of agrarian development strategies. The new approach, more holistic in nature, entails an understanding of (1) present farm practices, (2) why they are practised and (3) what is required of a new technology if it is to be accepted (Hildebrand, 1979). Thus, by focusing on the interrelationships that exist among elements of the farm system, this 'farming systems approach' to research facilitates the generation and testing of appropriate agricultural technology.

Methodologies for on-farm cropping systems research

Detailed descriptions of research methodologies attuned to the actual conditions of traditional farmers have recently become available (Collinson, 1972, 1978; Harwood, 1979; Hildebrand, 1979; Norman, Pryor and Gibbs, 1979; Byerlee *et al.*, 1980; Zandstra, Price, Litsinger and Morris, 1981; Shaner, Philipp and Schmehl, 1982). The basic premise of these methodologies is that generation of technological modifications appropriate to small farmers must emerge from agro-socio-economic studies which determine the conditions influencing the traditional cropping systems. Only through research that is multivariate and multidisciplinary can the collective and interactive effects of the limitless combinations of variables that traditional crop systems face, be unravelled (Wiese, 1982). In this context, farm development (defined here as attempts to improve human welfare through sustainable agricultural productivity) signifies a progression to more efficient and more productive use of limited farm resources (Harwood, 1979).

The analysis of small farm systems cannot be done from a conventional farm-management appraisal, whereby labour scarcity, small farm size, lack of modern technology or low land productivity are singled out as the main constraints. Although productivity per unit of land may be low, the farmer may obtain a high level of productivity from other resources which are scarcer for him, or may unknowingly enhance the energy efficiency of his cropping system by maximizing the ratio of food calories obtained to cultural energy investment (Hildebrand, 1979). Thus meaningful analysis must incorporate the farmers' management standards and farmers' production criteria, especially with regard to risk. Risk avoidance is traditionally expressed through farm diversification, often by using products of one enterprise in the production of another. A common example of this type of system is the combination of crop and livestock enterprises.

In Mexico, farmers often plant maize at high density and use the thinnings for their animals (Byerlee *et al.*, 1980). In eastern Guatemala, some farmers let weeds grow in their vegetable fields to increase feed supply for cattle, even though they know it reduces the yield of their crops (Hildebrand, 1979). They also prefer lower-yielding local maize varieties to higher-yielding improved varieties because the leaves and husks of the traditional varieties are more palatable to their animals. In the western highlands of Guatemala virtually all farmers use the same lower-yielding potato variety, despite the availability of other improved varieties, because it matures early allowing two crops per year, a clear advantage for marketing purposes. An understanding of the effects of these interactions of current cropping patterns and management practices is vital to the prescreening of new technological components appropriate to farmers' circumstances.

Field procedures

The methodologies for on-farm cropping systems research follow a logical sequence of steps (Harwood, 1979):

1. Selection of the target area. Within regions, there is considerable variation in cropping systems and farmers' practices. Sites with similar relative cropping patterns, agroclimatic characteristics and economic circumstances are selected by multidisciplinary teams, usually a group of economists, sociologists, agronomists and plant protectionists. The team then proceeds to gather relevant information on the selected zone by analysing background data from published or unpublished material, by conducting field surveys that include interviews with farmers and others knowledgeable about the local situation, and by direct field observations. Researchers are then able to formulate hypotheses about why farmers use particular practices. It is frustrating to note that the current literature on traditional agriculture has little information on pest problems and the role pests have had in the evolution of this agriculture (Glass and Thurston, 1978).

2. Field surveys. The survey describes existing cropping systems and associated cultural techniques in a selected area, with a careful consideration of the socio-economic constraints, resource base and resource use. The biophysical component of the survey entails (1) collection of data on climate, soil, topography, hydrology, pests, etc.; (2) identification of land types at the site; (3) identification of existing crops, cropping patterns and systems; (4) description of cropping systems determinants; and (5) description of farm types and the resource base at the site. Several excellent approaches to land classification, landscape analysis, cropping systems descriptions, soil surveys, etc. are available (Vink, 1975; Myers and Shelton, 1980).

Researchers also describe the land preparation, tillage operations, planting and fertilization methods, plant populations, spatial relations between crops (i.e. inter-cropping), water irrigation and management, cultivars, pest-control methods and harvesting practices. The pest-control component of the survey must include the farmers' singular perceptions and objectives as well as the available control measures: specifically, which pests does the farmer think attack his crop, how often, what damage do they cause on average, what is his damage threshold, what control measures is he aware of, and how effective does he think that they are (Norton and Mumford, 1982)? Completed surveys of this type (Litsinger, Price and Herrera, 1980a) have revealed that peasants employ a variety of traditional methods (i.e. addressing spirits, avoiding planting on the death date of parents, application of ashes or salt, hand picking, use of plant parts as repellents or attractants, etc.), cultural controls (i.e. increasing seeding rates, intercropping, crop rotation, and time of planting), use of resistant varieties and chemical control. A major trend described by these researchers for farmers in South-East Asia is that they apparently do not recognize most of the key pests and are not aware of many biocontrol organisms that parasitize or prey on insect pests. Many farmers use insecticides: however, mistiming of the applications and use of improper dosages hinder effective control. In three areas of the Philippines, 64% of mungbean farmers did not use insecticides and their low yields were no different from those using insecticides (Litsinger *et al.*, 1980a).

3. Socio-economic evaluations. The economic portion of the survey analyses the resources that go into cropping systems, which can be grouped into off-farm and on-farm. Off-farm resources include: location and capacity of markets; product prices; availability of production inputs; input prices; transportation facilities for products and inputs; availability of processing facilities for farm products; help from extension services; available labour; farm co-operatives, etc. Important on-farm resources are: size and tenure of farms; soil types; water availability; presence of animal enterprises; seasonal labour and cash availability; family labour and skills; farmers' technical knowledge; farm fixed capital, etc. Results of this survey should explain the economic aspects and viability of the farming system (Perrin *et al.*, 1979).

When measuring the economic benefits of a new pest-control technology, cost and return analysis (which identifies the benefits associated with treatment alternatives) is a good method for comparing the economic impact of a new technique at the field level. However, a whole-farm analysis must be conducted to qualify the results of this analysis. Cost and return analysis measures the economic benefits of both new and historical pest-control techniques in the context of *all* the economic activities, including other agricultural enterprises, household and off-farm operations. The major resources of land, labour, and capital are all valued with regard to their actual availability, and to the demand which exists for them at a particular time (Byerlee *et al.*, 1980). Derived recommendations from cost/benefit data should be consistent with the farmers' desire to increase income, with the farmers' desire to avoid risk and with the scarcity of investment capital (Perrin *et al.*, 1979).

Component technology research

Interpretation of the survey data allows researchers to plan experiments in farmers' fields. A group of farmers is selected at the outset to help design, test and evaluate experiments. A broad cross-section of farmers must be included in order not to bias the recommendations towards farmers of recognized ability (Farrington, 1977b). Experiments are designed to test particular component technologies (i.e. varietal selection, tillage and crop-establishment methods, fertilization and pest-management strategies, etc.) against farmers' current practices as a basis for comparison (Zandstra *et al.*, 1981). A guiding principle is that the component technology should be expected to fit the resource limits of most farmers in the region, and should therefore be environmentally sound, socially acceptable and economically viable. The farmer, however, should have the last word about which innovations are to be made on his land. The introduction of a crop-production innovation may disturb the farmer's economic equilibrium and require a period of adjustment (Farrington, 1977a).

The productivity of the system should not be evaluated solely on the basis of crop yield per unit of land, but should incorporate the farmers' perspective on productivity, centring around the maximization of returns to the most limiting factor (i.e. labour, capital, water, etc.).

Field trials usually include treatments that (1) simulate and test the farmers' management level, without any purchased material inputs; (2) incorporate the level of component technology assigned to the cropping pattern, and (3) evaluate a level of component technology that is expected to produce higher yields than the cropping patterns at the same or higher input levels (Zandstra *et al.*, 1981). Most experiments must be repeated several times over several seasons to demonstrate the adaptability of the new technologies to the varying societal and agroclimatic conditions of the target area.

Determining insect-control recommendations

Procedures for determining insect-control recommendations have been developed by the Asian Cropping Systems Working Group in collaboration with the International Rice Research Institute (IRRI) (Litsinger *et al.*, 1980b) for transplanted rice, maize, mungbean and cowpea. The methodology includes the following steps: (1) understanding farmers' current insect-control practices and resources available for insect 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 in cropping systems managed under stable conditions over several years, and (6) evaluating the costs and returns of the technology (Litsinger *et al.*, 1980b). The pest-control technology offered to farmers should be biologically stable over time, adaptable by farmers and acceptable to consumers.

Locational differences caused by intrinsic site properties can lead to pronounced variations in pest dynamics. There can exist significant differences in optimum insecticide spraying levels between years of good and poor rainfall. In Malawi, farmers reduce their spraying levels in low-rainfall seasons (Farrington, 1977b). Insect populations may shift over time in response to new control technologies introduced through a new cropping pattern. This variability in the dimensions of pest attack must be accounted for when developing recommendations for farmers, and attention should be directed towards such aspects as the rate of technology adoption, regional synchrony and the proximity of other cropping areas.

IRRI's methodology has been used in the Philippines, Thailand, Bangladesh and Indonesia (Litsinger *et al.*, 1980b), and it centres around the quantification of yield losses for each growth stage of the crop by successively omitting insecticide protection during each stage, while providing control in the others. Results of the yield-loss trials provide information on the correct timing of insecticide applications. There is no attempt to quantify insect-caused losses at different phenological stages when using farmers' traditional techniques or improved cultural practices. This approach excludes those farmers who maintain their traditional management and those who cannot afford to purchase insecticides.

Moreover, IRRI's methodology does not attempt to formalize the body of complex relationships between crops, non-crop vegetation and insect communities implicit in traditional subsistence agroecosystems. In fact, the study of 'primitive' agroecosystems where inorganic inputs are almost negligible and the degree of disturbance is low, can help to identify an array of plant–insect interactions which are simply not present in more 'technified' systems. The potential interactions identified can then be compared with current production systems, and criteria can be suggested for evaluating different agroecosystem configurations for pest control that might be viable under changing conditions of resource availability, climate, pests, etc. (Edens and Haynes, 1982).

Determination of economic thresholds in small farming systems is especially complex because more than strict profit–loss relationships are involved, and generally a whole pest complex (insects, weeds, diseases) affects the crop. Moreover, farming circumstances at the individual farm level are so highly variable that separate pest-density thresholds should be established to suit individual circumstances (Farrington, 1977a). This is, of course, as unrealistic as the alternative of applying a single threshold to a heterogeneous group of farmers. Because of their vegetational diversity, traditional agroecosystems usually enjoy a high degree of natural control (Altieri, van Schoonhoven and Doll, 1977; Altieri, Francis, van Schoonhoven and Doll, 1978; Risch, 1981): therefore, in those systems with relatively high numbers of natural enemies, economic thresholds should be adjusted upward. How to make thresholds appropriate to farming circumstances in peasant agriculture remains a major challenge.

In diversified cropping patterns, key pest determination by crop growth stage becomes rather complex, because each crop in an intercropping system follows a different phenology; thus phenological events are not synchronized. The situation is more complicated when crops are planted at different times, such as in crop sequences and relay cropping.

Approaches to determine insect-control recommendations should be planned in conjunction with similar efforts for weed and disease control, so that actions taken for the different purposes are compatible. In this regard, consideration of farmers' perceptions of pest problems, instead of the superimposition of researchers' values on those of the farmer, is vital. In six out of 10 Central American communities, farmers perceived insects as the major factor limiting their productivity (Navarro, 1980), but to another neighbouring group of farmers, diseases were more critical. Chacon and Gliessman (1982) found that farmers in south-eastern Mexico had a 'non-weed' concept, and that non-crop plants were classified according to use potential and complementary positive effects on the one hand, and negative effects on soil and crops on the other. Such classification indicates that local farmers understand the intricate role of non-crop plants in their agricultural activities. Thus, instead of considering all weeds as noxious elements to be eliminated, certain weeds are allowed to remain in the fields. This perception must be incorporated in the design of pest-stable cropping patterns, when relevant. It necessarily requires the interaction of weed scientists and entomologists to reveal discernable linkages between weed and insect components and the rest of the system. Available research data showing that plant diversification of agroecosystems through polyculture cropping or weed management can increase environmental opportunities for natural enemies while reducing herbivore loads (Risch, 1981; Altieri *et al.*, 1977, 1978), suggest fruitful results from research efforts along these lines.

Conclusions

It is becoming apparent that some rural development programmes are unsuccessful because the introduction of technology developed in the West into a peasant community often proves inappropriate. Recommendations, aimed at improving the short-term economic performance of the cropping pattern, invariably further the use of chemical and mechanized technologies, typical of capital-intensive agriculture. Recently, results of studies by researchers working in farmers' fields have suggested that the formulation of technology appropriate and adaptable to farmers' criteria and resource base, requires a full understanding of the socio-economic and biophysical constraints of small farm production (Harwood, 1979). This requires an ecological, economic and agronomic approach which analyses the farming system in a holistic framework. The development of insect-control technology must necessarily fit within this broader context. It also requires a change in attitude so that traditional subsistence agroecosystems are no longer regarded as 'primitive' and as the product of ignorance, but rather as the product of ecological and economic rationales; such systems exhibit a number of ecological features of socio-economic stability, biological resiliency and productivity (Ruthenberg, 1976). Naturally, social and political barriers to the development of sustainable farming methods must also be overcome. Many scientists in developed countries are now beginning to show interest in traditional agriculture, as they search for ways to remedy deficiencies (i.e. soil erosion, loss of soil fertility, pesticide resistance, pest resurgence, etc.) in modern agriculture. If new technology (whether for pest control or other crop-management purposes) is to be used by small farmers, its development must start with them and not at the research station. Moreover, researchers should continue the process of technology development up to the level at which farmers can comfortably use the new practices (Goodell *et al.*, 1982).

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References

ALTIERI, M.A., VAN SCHOONHOVEN, A. AND DOLL, J.D. (1977). The ecological role of weeds in insect pest management systems: a review illustrated with bean (*Phaseolus vulgaris*) cropping systems. *PANS* 23, 185–205.

ALTIERI, M.A., FRANCIS, C.A., VAN SCHOONHOVEN, A. AND DOLL, J.D. (1978). A review of insect prevalence in maize (*Zea mays*) and bean (*Phaseolus vulgaris*) polycultural systems. *Field Crops Research* 1, 33–49.

BYERLEE, D., COLLINSON, M., PERRIN, R., WINKELMANN, D. AND BIGGS, S. (1980). *Planning Technologies Appropriate to Farmers—Concepts and Procedures.* Mexico Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT). 71 p.

CHACON, J.C. AND GLIESSMAN, S.R. (1982). Use of the non-weed concept in traditional tropical agroecosystems of southeastern Mexico. *Agroecosystems* 8, 1–11.

COLLINSON, M.P. (1972). *Farm Management in Peasant Agriculture.* New York: Praeger.

COLLINSON, M.P. (1978). *Demonstrations of an Interdisciplinary Approach to Planning Adaptive Agricultural Research Programs; Serenje District, Zambia. Report No. 3, CIMMYT East African Economics Program, Nairobi.*

DE JANVRY, A. (1981). *The Agrarian Question and Reformism in Latin America.* Baltimore; The Johns Hopkins University Press. 311 p.

EDENS, T.C. AND HAYNES, D.L. (1982). Closed system agriculture: resource constraints, management options and design alternatives. *Annual Review of Phytopathology* 20, 363–365.

EGGER, K. (1981). Ecofarming in the tropics—characteristics and potentialities. *Plant Research and Development* 13, 96–106.

FARRINGTON, J. (1977a). Economic thresholds of insect pest infestation in peasant agriculture: a question of applicability. *PANS* 23, 143–148.

FARRINGTON, J. (1977b). Research-based recommendations versus farmers' practices: some lessons from cotton-spraying in Malawi. *Experimental Agriculture* 13, 9–15.

GLASS, E.H. AND THURSTON, H.D. (1978). Traditional and modern crop protection in perspective. *BioScience* 28, 109–115.

GOODELL, G.E., KENMORE, P.E., LITSINGER, J.A., BANDONG, J.P., DE LA CRUZ, C.G. AND LUMADEN, M.O. (1982). Rice insect pest management technology and its transfer to small-scale farmers in the Philippines. In: *Report of an Exploratory Workshop on the Role of Anthropologists and Other Social Scientists in Interdisciplinary Teams Developing Improved Food Production Technology*, pp. 25–41. Sponsored by IRRI.

HARWOOD, R.R. (1974). Farmer-oriented research aimed at crop intensification. In: *Proceedings of Cropping Systems Workshop, IRRI, Los Baños, Philippines*, pp. 12–32. IRRI: Philippines.

HARWOOD, R.R. (1979). *Small Farm Development—Understanding and Improving Farming Systems in the Humid Tropics*. Boulder, CO: Westview Press. 160 p.

HILDEBRAND, P. (1979). Generating technologies for traditional farmers: The Guatemalan experience. In: *Proceedings IX International Congress of Plant Protection, Washington, DC*, pp. 31–34.

LITSINGER, J.A., PRICE, E.C. AND HERRERA, R.T. (1980a). Small farmer pest control practices for rainfed rice, corn and grain legumes in three Philippine provinces. *Philippine Entomologist* **4**, 65–86.

LITSINGER, J.A., LUMADEN, M.O., BANDARY, J.P., BARRION, A.T., PANTUA, P.C., APOSTOL, R.F. AND JHENDI, R. (1980b). *A Methodology for Determining Insect Control Recommendations. IRRI Research Paper Series No. 46*. Los Baños, Philippines. 31 p.

MYERS, W.L. AND SHELTON, R.L. (1980). *Survey Methods for Ecosystem Management*. New York: John Wiley and Sons, 403 p.

NAVARRO, L.A. (1980). *Some Issues in Farming Systems Research: CATIE's Experience in the Central American Isthmus*. Turrialba, Costa Rica; CATIE. 11 p.

NORMAN, D.W., PRYOR, D.H. AND GIBBS, C.J.N. (1979). *Technical Change and the Small Farmer in Haasauland, Northern Nigeria. African Rural Economy Paper No. 21*. Michigan State University. 127 p.

NORTON, G.A. AND MUMFORD, J.D. (1982). Information gaps in pest management. In: *Proceedings, International Conference on Plant Protection in the Tropics. Kuala Lumpur, Malaysia*, pp. 1–9. Malaysian Plant Protection Society: Kuala Lumpur.

PERRIN, R.K., WINKELMANN, D.L., MOSCARDI, E.R. AND ANDERSON, J.R. (1979). *From Agronomic Data to Farmer Recommendations: an Economic Training Manual. Information Bulletin 27*. Mexico City: CIMMYT. 51 p.

RISCH, S.J. (1981). Insect herbivore abundance in tropical monocultures and polycultures: an experimental test of two hypotheses. *Ecology* **62**, 1325–1340.

RUTHENBERG, H. (1976). *Farming Systems of the Topics*. London: Oxford University Press.

SHANER, W.W., PHILIPP, P.F. AND SCHMEHL, W.R. (1982). *Farming Systems Research and Development: Guidelines for Developing Countries*. Boulder, CO: Westview Press. 414 p.

VINK, A.P.A. (1975). *Land Use in Advancing Agriculture*. New York: Springer-Verlag.

WIESE, M.V. (1982). Crop management by comprehensive appraisal of yield determining variables. *Annual Review of Phytopathology* **20**, 419–432.

ZANDSTRA, H.G., PRICE, E.C., LITSINGER, J.A. AND MORRIS, R.A. (1981). *A Methodology for On-Farm Cropping Systems Research*. IRRI, Los Baños, Philippines. 144 p.

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