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Farmer field research:
An analysis of experiences from Indonesia

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The FAO Programme for Community IPM in Asia

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Chapter 1. Introduction

1.1 Traditional generation of knowledge

Over the millennia, farmers have developed the seeds and methods to grow the crops that have been feeding the world. Developments took place because farmers operated selectively and reactively in the interface between crops and their environment. Farmers observed how the performance of plants varied within the fields, between fields, and between seasons. They responded to perceived risks and opportunities by selecting seed and by adapting their practices. Rice was cultivated in Indonesia as early as 1600 BC and a host of local varieties evolved in accordance with environmental conditions and peoples' preferences. Moreover, the practice of transplanting is believed to have started because farmers needed to reduce competition with weeds. Flooding suppressed weeds but was tolerated by rice provided that the plants had established. Hence, seedbeds were started to give rice a growth advantage over weeds, after which seedlings were transplanted. Wet rice cultivation became widespread throughout Asia wherever sufficient water was available.

Perhaps because their profession is prone to complex and uncontrollable variables, farmers are generally observant and analytical, used to making sense of what happened to their crops and ready to respond to problems by making a change in what they can control. For example, Javanese farmers learned to use the appearance of the Orion star as a signal to start sowing rice in time for the rains. Similarly, the observation of freshwater crabs burrowing in the bunds is associated with a period of drought. Myths and beliefs which lack an empirical basis undoubtedly played a role in farming practices even if they hampered agricultural progress. Continued observation and experimentation, however, would have overcome many erroneous myths.

Traditional knowledge was shared among farmers and was accumulated and modified through the generations. People’s forums at the village level served as a means through which the experiences were communicated. The evolving resource was an important asset of farmer communities – it provided plant genetic material and knowledge on locally suitable practices. Equally important were the attitude and methods of farmers to actively modify their farming practices in the crop–environment interface.

1.2 Modern agricultural developments

Today, traditional agriculture exists at different levels in the more remote upland or marginal areas of Indonesia. Elsewhere, in particular on Java where sixty percent of the national population resides, a sequence of agricultural programmes was implemented by the government with far-reaching consequences for farmers. Certain areas, such as Pekalonan in Central Java, were at the centre of government intervention from the colonial period onwards. Other areas were affected later or less intensively.

Colonial period

Government intervention in traditional farming started in the early 19th century under Dutch colonial rule when an exploitive form of agriculture was imposed on farmers to grow crops for export (coffee, spices, sugar, tobacco and tea) while having to pay tax for land use. Other areas remained under traditional, mostly rice-based, agriculture, although these areas were impoverished by a lack of labour due to a concentration on the export crops. Until 1866, farmers were required to store rice seed at village stores, a rule which discouraged seed selection and stimulated corruption. Dutch documentation from this period reported that irrigated rice fields were poorly tilled with poor seed and high competition of weeds[1]. After a collapse of the export market towards the end of the 19th century, farmers reverted their attention to rice but their traditional knowledge base had been affected. Recognising the growing relevance of rice-based farming to the stability of their colony, the Dutch set floor prices for rice and established the Department of Agriculture. Field demonstrations were initiated to familiarise farmers with the recommended farming practices and new chemical inputs, while their traditional knowledge was mostly disregarded. Some important pests such as rodents and white stemborer where dealt with through enforced campaigns on baiting and regulation of planting times, respectively.

After Independence

From Independence onwards, the Indonesian government launched a sequence of rice intensification programmes to encourage farmers to grow improved varieties, adopt appropriate cultivation practices, and to increase the use of fertilisers and pesticides. Irrigation systems were developed which together with new short-duration varieties increased the cropping rate. In 1968, the first large-scale programme, the 'Bimas Gotong Royong', combined new high-yielding varieties – which responded strongly to nitrogen fertiliser – with credit packages of subsidised fertilisers and pesticides. The adoption rates of high fertiliser levels were initially low[2], but the forceful extension methods – involving local government and the army – eventually resulted in a wide-scale implementation of the new technology by farmers and a steady increase in national rice production.

Indonesia's use of insecticides in rice was immense during the 1970s. Multinational companies were contracted to provide arial pesticide spraying over large expanses of rice. The chemicals caused an increase in populations of the now infamous brown planthopper. To deal with this new problem, resistant varieties were introduced and pesticide subsidies raised. But the pest adapted in a matter of years and the problem aggravated[3]. For the first time in history, farmers became accustomed to the sight of serious insect outbreaks. By 1977, yield loss due to insecticide-induced planthopper outbreaks amounted to more than one million tons of rice. The selection pressure on brown planthopper due to high pesticide usage even began to break down the resistance found in locally-bred varieties.

Farmers as 'users'

It goes without saying that these events made a lasting impression on rice farmers. Having been subjected to forceful extension messages and new technology, they adopted the practices and were rewarded with higher yields. However, farmers did not understand how the new technology came about or how it worked. The rice crop was seen as a black box that receives inputs and gives outputs. Intensification programmes discouraged farmers' traditional skills, including the habits of questioning, testing and reflecting. A 'good farmer' was one who readily adopted the technology and who complied with extension messages. As a result, farmers became increasingly reliant on the technology while many traditional rice varieties disappeared. Farmer control over their fields was further reduced by centrally-operated pesticide spraying over large areas.

Admittedly, the Green Revolution brought a rapid expansion in the adoption of high-yielding technology which increased national rice production to stay ahead of population growth during a politically volatile period. By concentrating on national production, however, the researchers, policy-makers and extensionsists overlooked the damage being done to the rice environment, the genetic diversity of rice and the traditional knowledge and skills of rice farmers.

1.3 The need for farmer field research

Important lessons

In retrospect, it is remarkable that the 'closed-system' thinking of Green Revolution developers provided no answer to the problem of pest outbreaks, while trying to solve the problem with more insecticides, better spraying methods and more genes for plant resistance. The answer had to be found, however, by looking back to the time of traditional farming when farmers had been in control of their own fields. It involved an ecological and a methodological element. Research demonstrated that broad-spectrum insecticides were responsible for the pest outbreaks. In unsprayed fields it was found that brown planthopper was under complete natural control due to a diversity of predators and parasitoids feeding on it. However, insecticide spraying suppressed the natural enemy populations giving the highly mobile and fecund pest a tremendous growth advantage which resulted in explosive populations[4].

Meanwhile, it was found on-station in the Philippines that high-yielding technology was in itself unstable and when applied continuously its advantageous effects would slowly erode. On-farm, however, progressive farmers who had adopted the improved technology but continued to adjust it to their own situation easily surpassed the yields of those achieved on-station[5]. This experience challenged the transfer of technology because it indicated about the value of farmers being able to adapt technologies to their own situations, a value which had hitherto been overlooked.

The transfer of technology had been obsessed with homogeneity and predictability, thereby taking control out of the hands of farmers. Even though agricultural systems were homogenised in terms of synchronised planting and modern varieties, in reality, a great deal of variation remained. Sources of variation which influence farming include soil properties, water supply, a dynamic environment and a rich agroecosystem. Last but not least, there is variation among farmers regarding their knowledge, skills and mutual cooperation. The impact of the transfer of technology was so large because its message was simplistic. A centralised approach could not possibly deal with variation at the farm level, which would demand local decision-making. The recognition that farmers act as an integral part of a rich and dynamic system suggests that farmers need to regain a hold on their farms. They need to make innovative adaptations within their local situation. Farmers themselves are a crucial factor in the development process.

Recapitulating, there is a need for farmers to do their own observations and research for two reasons: From the ecological perspective, locally conducted studies are essential to deal with site-to-site variation and dynamic agroecosystems. From the methodological perspective, farmers as stakeholders are an important resource in the process of development.

Site-to-site variation

Each district, site and field has its unique properties, history and environment. Consequently, the degree of field problems varies between sites, as do the solutions to deal with these problems. The question is: What is the extent of site-to-site variation? Is it small, in which case blanket recommendations or technologies would suit the majority of sites, or is variation too large to justify generalised recommendations? These two possibilities are clarified in Fig. 1. The first graph illustrates a situation where most sites show little variation around the introduced technology. The situation in the second graph, however, suggests that the technology is suitable only to a minority of sites.

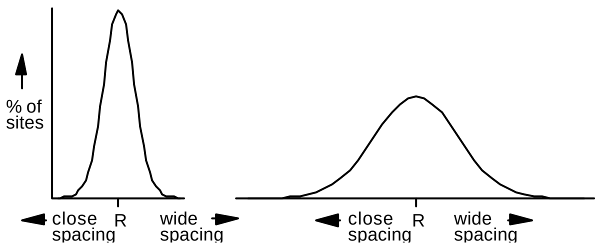

Fig. 1. Comparison of two hypothetical situations: one with little and one with much site-to-site variation around the introduced technology of plant spacing.

An evaluation of farmer studies on soybean grown after rice harvest at a large number of sites in Indonesia indicated that the degree of site-to-site variation depends largely on what aspect of farming is considered[6]. Certain aspects, such as the effect of planting method or pest management, showed more or less consistent effects over a number of sites. Spaced planting was consistently better than broadcast seeding of soybean, and the reduction of pesticides consistently did not reduce yield (Fig. 2a). Other aspects, however, such as the use of straw as mulch or the dosage of inorganic N fertiliser, showed large variations between sites (Fig. 2b). Straw mulch would do little to improve soybean production at certain sites, but it would cause a dramatic yield increase elsewhere. Similarly, the advantage of applying inorganic N fertiliser was obvious at some sites but was absent at other sites. Local soil characteristics, field history and water stress are important variables in determining the effect of a farming practice or technology. Certain practices have a predictable effect on the crop in most field situations, whereas the effects of others practices will vary greatly from site to site. Therefore, blanket technologies or recommendations are frequently not optimal at the farm level. No systematic evaluation has been conducted of agronomic practices in rice, but undocumented experience from the Integrated Pest Management (IPM) programme suggests that site-to-site variation is important in rice. Moreover, there is variation in time, because the agroecosystem varies amidst a dynamic environment. Sound management of the rice crop thus requires decisions which are both site-specific and time-specific.

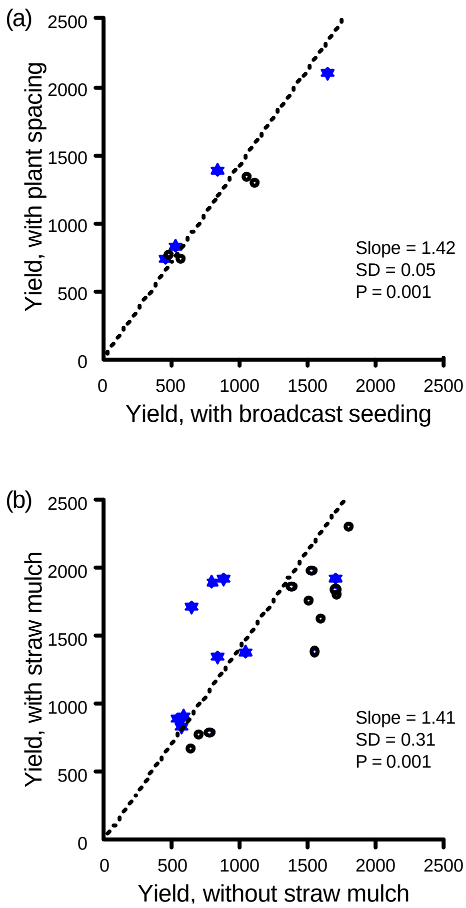

Fig. 2. Comparison of soybean yield (kg ha^{-1}) in treatments pairs at farmers' field sites; open circles indicate individual sites; asterisks indicate sites with a significant effect (*t* test, n = 3, P < 0.05). (a) Broadcast seeding versus fixed plant spacing; (b) rice straw removed versus rice straw used as mulch. Indonesia, 1996-97. The slope is similar in both graphs but the degree of site-to-site variation (SD) is larger in (b).

Farmer involvement

Even if recommendations and technologies take account of environmental variables, farmers are still clients who are on the receiving end. A number of comparative studies have shown that a critical factor for the success of development projects is the degree of stakeholder participation[7]. A high level of participation consistently increases the chance of success. This suggests that farmers should be given influence in the development effort. Rather than being passive participants in a project's agenda, they need to play an active role in setting the agenda in terms of identifying the problems and deciding on the course of action to address those problems.

Hence, there are three approaches to agricultural development (Fig. 3). First, the reductionist approach of the transfer of technology is a centralised process which uses blanket recommendations. Second, a more holistic approach, dubbed 'precision agriculture', conceives crops as site-specific ecosystems and aims to develop a range of pre-designed management options in accordance with local factors. With this approach, however, development is still determined externally.

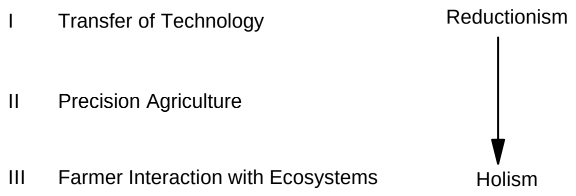

Fig. 3. Three approaches to agricultural development.

The third approach expands the definition of ecosystem further to include humans. Farmers are seen as part of their farming systems, interacting with their crops through their knowledge, skills and mutual cooperation. According to this view, development is not controlled externally but is created from within the community by active groups of farmers. The second approach encompasses the first, whereas the third approach encompasses the first and the second and is thus most comprehensive.

1.4 Conceptual framework

Three concepts

We formulate three concepts to be tested in the ensuing chapters. The way they are stated, these concepts suggest implications for the success and sustainability of farmer field research.

1. EDUCATION – NON-FORMAL EDUCATION IS NEEDED TO INCREASE THE CONFIDENCE AND SKILLS NECESSARY TO INITIATE FARMER FIELD RESEARCH.

This concept presumes that farmers' traditional skills to innovate and experiment have been negatively influenced by rice intensification programmes. We propose that a relearning and strengthening of those skills will improve the present farming situation.

2. OWNERSHIP – ONLY IF FARMERS HAVE OWNERSHIP OVER THE RESEARCH PROCESS, FROM STATING THE QUESTION TO INTERPRETING THE RESULTS, WILL FARMER FIELD RESEARCH BE EFFECTIVE.

Farmer participation in rural development programmes takes place at different levels, ranging from contractual to collegiate[8]. We hypothesise that the problems created by the transfer of technology can be overcome only if farmers regain full control over their crops and over the innovations and experiments to improve them.

3. IMPETUS – BY DOING RESEARCH FARMERS WILL BE STIMULATED TO DO MORE RESEARCH AND TO DISSEMINATE THE RESULTS.

We postulate that observation and experimentation generate motivation, which triggers a self-propelling mechanism of research. The sharing of results follows automatically. Farmers' insights into functional relationships in ecology also change the way farmers deal with broader issues, which in turn stimulates community development.

Target group

The target group of farmers for this study, and for the IPM programme, were rice-based farmers, predominantly in full-irrigation (sufficient water for year-round irrigation) and half-irrigation (sufficient water only during the main raining season) rice production systems. These systems are concentrated on the island of Java, with additional pockets in northern and southern Sumatra, southern Sulawesi, Bali and Lombok. The target group is affected by agricultural intensification and the transfer of technology, as described in 1.2.

Composition

In chapter 2 we elaborate on the issue of farmer education in the context of the IPM programme, because we assume that farmer education is a starting point for farmer field research. Chapter 3 describes five cases of farmer field research. Chapter 4 provides an analysis of farmer field research, based mainly on the five cases. It discusses the process of field research, roles in field research and the impact of field research. Chapter 5 examines the role of formal research in supporting development programmes. Finally, the three concepts are revisited in Chapter 6 through a synthesis of the experiences with farmer field research in Indonesia.

Chapter 2. Farmer education

Farmer field research is discussed in the context of the IPM programme. This programme acknowledged that farmers themselves are an important factor in sustainable agricultural development but that they need re-education and strengthening of farming skills. These skills are needed to deal with the environmental variables ignored in the transfer of technology. We describe the educational activities of the programme – in particular the farmer field school – each of which contains elements of farmer field research or structures through which field research becomes part of farmer communities.

2.1 The IPM programme

The Indonesian government learned quickly from the problems brought about by the transfer of technology. Rice production had been rising steadily along with the use of fertilisers and insecticides, but the correlation with the latter had proven to be deceptive. First, the government decoupled insecticides from the production equation through a gradual removal of insecticide subsidies and a ban of broad-spectrum chemicals from use in rice. Second, new methods were embraced for the education of farmers on rice ecology to enable local decision-making.

The initial results in 1986 were encouraging: participating farmers sprayed much less while yields stabilised or improved. The National IPM programme, with technical assistance from the FAO, started to educate large numbers of IPM staff in full-time, season-long courses. Graduated trainers conducted farmer field schools in their own areas. Between 1989 and 1999, an estimated 1.2 million farmers graduated from farmer field schools. In the major rice-growing regions, thirty to sixty percent of farmer groups received the training. The majority of field schools were in rice, but ten percent were in soybean and three percent in the vegetables cabbage, shallots and potato[9].

The role of trainers at the sub-district level was gradually taken over by farmer trainers; farmer trainers (currently totalling 20,000) are farmers who are trained to be farmer field school leaders. Furthermore, approximately ten percent of farmer field school graduates received follow-up training to strengthen farmer group activities and networking between groups (see 2.4). The pest outbreaks of the 1970s never recurred and rice yields remained stable through the 1990s.

2.2 The farmer field school

Learning approach

The farmer field school evolved from the concept that optimal learning derives from experience – in the case of farmers, from observations in the field. First-hand experiences or observations have a more lasting effect than information received from others. The farmer field school integrates the domains of ecology and non-formal education to give farmers the opportunity to learn about their crop and to learn from each other. The training involves four basic principles: (i) Grow a healthy crop, (ii) Observe the field regularly, (iii) Conserve natural enemies, (iv) Farmers become experts in their own fields. In the course of the field school, the fifth principle can usually be added, i.e. (v) Farmers work together as a group. In a farmer field school, a group of fifteen to thirty neighbouring farmers meet weekly to take field observations and, after learning from their findings, to improve their crop management practices in accordance with local conditions. Every week, various components of the agroecosystem are recorded, including plant condition, beneficial insects and microclimate. Additional field exercises provide farmers with insights into the functions and inter-relations of the components that make up the ecosystem.

Within this approach of 'open-system thinking', the answers are not preset but depend on a number of field variables. Consequently, farmers learn to refine their intuitive skills and art of decision-making by enriching their ecological understanding of natural processes and balances. Invariably, as a result of their increased awareness, farmers reduce their reliance on chemical inputs while improving the overall condition of their crop. Group activities encourage learning from peers, and strengthen communicative skills and group building. Group building is important because farming decisions made by one farmer influence the fields of other farmers. The trainer who facilitates the farmer field school avoids instructions or lectures but provides the opportunities for first-hand experience by the participants. He introduces an activity, explains the process and sets the farmers to work. Shortcuts to the learning process are seen as missed opportunities. During group discussions the facilitator fills in with questions rather than solutions. Facilitation demands practice and confidence and has been given major emphasis in the training-of-trainers to safeguard the training model.

Weekly activities

The weekly curriculum consists of an activity called agroecosystem analysis, followed by a group dynamics exercise and a special topic exercise. In agroecosystem analysis, farmers divide into small groups of four to six. Each group observes ten rice hills per plot and records various aspects (the growth stage, plant condition, damage symptoms, weather condition, insects, spiders, diseases and weeds). On large sheets of newsprint paper, the groups draw all these components of the ecosystem and add their records. An evaluation of the crop condition, and measures thought necessary, is added to the drawing (see Box). Each group presents its findings for discussion in the larger group. External sources of information are only consulted during or after the discussion. A consensus is reached on the management practices in the IPM plot during the coming week. Group-dynamics exercises are meant to maintain motivation and strengthen group cohesion. These exercises address problem solving, communication, leadership and team building, and help farmers to develop their organisational skills. Furthermore, special topic exercises on a certain aspect of the plant or ecosystem add technical content to the curriculum which is linked to the growth stage of the crop or selected according to local problems. Special topics cover a range of issues including crop physiology, field ecology, food webs, life cycles, rat management, health and safety, fertilisers, water management, weed management and economic analysis.

Fig. 4. Farmers taking observations for the exercise on ‘agroecosystem analysis’. This group is following a special training to become farmer trainers for others. Ngawi, East Java.

Supporting studies

Two types of supporting studies are normally added to the farmer field school. The first is to study the ability of the rice plant to tolerate insect attack. Damage by stemborers or leaffeeders is imitated by clipping tillers (i.e. independent shoots) or leaves of rice plants at different levels, or at different times, within small marked plots. Plant growth and yield in the clipped treatments are compared with the control. The second type of study helps farmers understand the behaviour, function or development of arthropods. In so-called 'insect zoos', made from cups or cages, farmers subject insects to observation and experimentation, for example to find out whether an insect feeds on the plant or on other organisms. The results of these studies helps farmers making better crop management decisions.

Farmer's introduction to research

The emphasis in the farmer field school is to improve farmer skills of decision making and to enhance group building. Even though the curriculum does not purposely prepare farmers to do their own research, it provides an introduction to research. Participants learn to see their crop as an ecosystem, and are motivated to ask questions and look for answers. Moreover, they learn to conduct simple studies and compare treatments, while the activities resemble demonstrations rather than original research.

2.3 After the farmer field school

The farmer field school provides an education after the completion of which follow-up activities can start. The field school, by enhancing knowledge and skills, often compels farmers to do further activities. In response, the IPM programme provides several types of follow-up activities. Field studies and follow-up field schools on soybean help farmers with conducting their own experiments. Follow-up training on participatory planning helps them with analysing their farming situation to design actions by which this situation can be improved. These actions often involve field experiments. In addition, farmer seminars at the sub-district level enable the sharing of plans and results between groups. Selected farmers who graduated from field schools are given training to become trainers themselves and to conduct their own farmer field schools. To date, more field schools have been led by farmers than by trainers. Hence, farmers increasingly take ownership of IPM-related activities in their areas. Indeed, a gradual transition has taken place from 'farmer as recipient of technology' via 'farmer as IPM expert' to 'farmer as implementer of community-based programmes'. Self-mobilizing IPM programmes that are run by farmers, often with the support of local authorities, are gaining ground in Indonesia[10]. Knowledge generation through farmer field research is a driving-force behind these local programmes as shall be discussed in the following chapters.

Chapter 3. Five cases of farmer field research

The roughly 50,000 farmer field schools conducted during the 1990s prompted spontaneous field experimentation in numerous instances. In addition, the programme introduced follow-up activities in around one thousand locations to encourage farmer field research and participatory planning. Unfortunately, detailed information on farmer field research is mostly missing or incomplete. The five cases selected for analysis represent different types of farmer field research. The first case describes spontaneous research by an individual farmer; it is the only detailed description of spontaneous research available to us although this type of research was known to be widespread. The second case describes farmer field research in the context of a regular programme activity; this particular case was selected because it was one of the cases which showed benefits of experimentation and because it was visited by one of the authors on several occasions. The remaining three cases are so-called action research facilities, established by the IPM programme on the basis of specific field problems. For a period of two to three years, the programme provided resources to each facility in terms of a facilitator, rent of land for initial experimentation and a simple house as 'laboratory' and meeting place.

3.1 Case I: A farmer improving his planting method

"I noticed that barnyard grass in my rice field had more tillers and flowered earlier than rice – How can a plant so similar to rice grow so much quicker?" This is how Mr Aep Saepudin, an IPM farmer in Tasikmalaya, West Java, started his research in 1993. "It bothered me for a week. I uprooted several plants, looked at the tillers and roots and came up with two ideas." His first idea was that barnyard grass grew from a single seed and, hence, there was no competition between tillers; in contrast, rice was normally transplanted by putting five to nine tillers per hole. His second idea was that seeds of barnyard grass emerged near the soil surface which allowed them to develop quicker; he then transplanted rice seedlings in 6-cm deep holes. "I asked myself: what happens if rice were planted like barngrass and if barngrass were planted like rice?"

Mr Aep planted rice as if it were barngrass in shallow holes of two centimetre deep, each with only one to three tillers. The surrounding field was planted to rice in the usual way. The next season, he planted barnyard grass in 6-cm deep holes with five to eight tillers per hole, as if it were rice.

Shallow-planted rice had more tillers, less problems with weeds, and a higher yield than deep-planted rice, while it matured earlier and more evenly (Table 1). It also saved on the amount of seed used. He explained the difference as follows: "If planted deep, the plants have to spend more energy on expanding their roots which affects the production of tillers. In shallow planting the roots can develop more easily and the plants grow faster." In addition, the shallow-planted field had less weeds and required only one hand-weeding. According to Mr Aep, the shallow-planted rice developed a closed canopy two weeks earlier than the deep-planted rice which could explain the lower incidence of weeds.

Fig. 5. Mr Aep displaying shallow-planted (left side) and conventionally planted rice.

Table 1. Mr Aep's field observations of rice in his two planting treatments (conventional planting method versus shallow-planted seedlings at low seed rate).

Parameters	Conventional	Shallow planted
Development of 1st tiller	Week 2-3	Week 1
Full canopy cover	Week 6	Week 4
Hand weeding	Twice	Once
Productive tillers per 10 hills	200	270
Seeds per 10 panicles	1,600	2,160
Age at harvest	115 d	100 d

What also contributed to the difference, according to Mr Aep, was that the seedlings prepared for shallow planting were not rinsed, whereas the seedlings for normal planting were rinsed to clear the roots of soil as is common practice. He was sure that washing the roots caused a disturbance resulting in a slow recovery in normal-planted rice. In the end, Mr Aep was convinced that his method of planting was better than the common method. His method had actually incorporated three variables, planting depth, seedlings per hills and the rinsing of roots. He emphasised his hypothesis that shallow planting caused the yield increase due to better conditions for the roots in the top layer of the soil. He also recognised that the cleaning of roots – which was not one of his hypotheses to be tested – had a possible impact on the crop too. Hence, the study tested the effect of a combination of practices. He did not attend further to the hypothesis that a reduced number of seedlings per hill causes less competition between rice plants.

Table 2. Mr Aep's yield of rice (t ha^{-1}) in his two planting treatments measured during three consecutive seasons.

Season	Conventional	Shallow planted
November 1993	5.5	7.5
March 1994	5.7	7.2
July 1994	5.6	7.7

Mr Aep gained experience with his new planting method during three seasons, and the results were confirmed. Yields rose from 5.6 to more than 7 ton per hectare (Table 2). Meanwhile, other farmers in his village became interested in his experiments. "During my last trial, farmers who passed my field noticed the difference and became interested in my studies. I had a meeting with several farmers who asked me a lot of questions. They tried out my new method of planting in different areas around the village. Soon, more farmers tried out my method, and their results were not different from mine. Now, more than half of the farmers in our village are using this new method of planting."

3.2 Case II: A farmer training activity on field research

Soybean is commonly grown during the dry season in rotation with rice, but yields of soybean are generally low. A group of farmers in Prambon, East Java, graduated from a field school in rice and participated in a follow-up field school on soybean. Soybean field schools were conducted at a large number of locations between 1996 and 1999. Regular observations of an IPM plot and farmer practice plot were made to make better decisions on crop management. Special topics were conducted on aspects of soybean production. In addition, a curriculum was incorporated to help farmers carry out their own field research.

The trainer, Mr Winarto, introduced the farmers to concepts and methods to help them conduct a sound experiment. The group started by identifying the most urgent problem. Having been frustrated with a poor production of soybean grown after rice, they had previously attempted to increase yield by adding urea fertiliser (contains 45% N), since rice responded positively to urea. Some farmers used 150 kg per hectare whereas others used as much as 225 kg. After a debate on the best dosage of urea in soybean, the group decided to select the dosage of urea as topic of their experiment. Weekly training sessions covered topics related to their study, i.a. the ability of the soybean plant to bind N from the air, and observations on root nodules.

Mr Winatro helped the group to formulate ideas to be tested, not just the effect of urea on yield but also its effect on other aspects of the farming system. This exercise, called the 'idea matrix', avoids the single hypothesis by adding alternative hypotheses (see Annex). The group figured that, apart from the effect on yield, urea might also influence the incidence of weeds and insects and plant development. Subsequently, the type of observations needed to test these ideas were planned. The trainer introduced the concepts of natural variation and interference between treatments, which the group used to design their experiment. To deal with uneven field conditions, they planned three replications of each treatment. A high dosage of urea was compared with a moderate dosage and with no urea at all. Observations were conducted in accordance with the ideas to be tested. Treatment plots were observed weekly to record plant height, leaf and pod development and the numbers of weeds and insects. To their surprise, the treatment without urea developed most pods. Plants in the treatment with highest urea were tall and luxuriant but beared fewer pods. They concluded that high doses of urea stimulated growth of leaves and stems but suppressed the production of pods.

Table 3. Soybean yield measurements in three fertiliser treatments by the farmer group in Prambon (in g per 3 m^2).

Treatment	Replicate 1	Replicate 2	Replicate 3
No urea	360	390	420
150 kg urea ha^{-1}	300	270	330
225 kg urea ha^{-1}	270	240	300

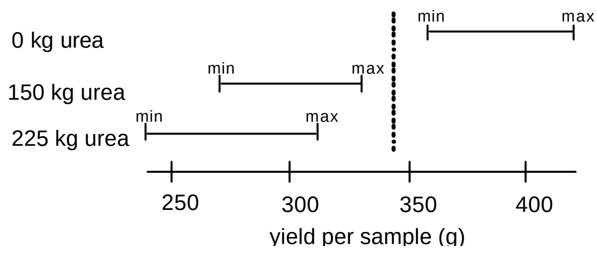

Fig. 6. Graphical presentation of variation in yield measurements used by the farmers in Prambon to examine whether differences between treatments are convincing. The 1st treatment displays no overlap in values with the other treatments and is therefore clearly different.

At harvest, they summarised all their observations and revisited each of the ideas to be tested. The average plant weight was similar in the three treatments but the weight and number of pods differed. Hence, the group concluded that the amount of N in the soil after harvest of rice was sufficient for soybean, and that extra N undermined the production of soybean. The trainer introduced a simple statistical tool, as part of the curriculum (see Annex), to help the group analyse the degree of variation in their data to decide whether the differences between treatments were convincing or not. For each treatment, this tool determines the minimum and maximum value from the three replicates and examines whether their minimum-maximum ranges overlap (Table 3, Fig. 6). If they don't overlap, then the two treatments are convincingly different (which is comparable in accuracy to the *t* test for studies with three replications[6]). The farmers depicted the variation (as illustrated) and concluded that the treatment without urea produced a convincingly better yield than the treatments with urea. They also discussed why replicates of the same treatment produced a different yield. The trainer helped them prepare a partial cost-benefit analysis (Table 4) which demonstrated that the benefit was clearly higher in the treatment without urea.

Table 4. Partial cost-benefit analysis of three fertiliser treatments by the farmer group in Prambon.

Treatment	Yield[a]	Urea input[b]	Output[b]	Benefit[b]
No urea	1.3	0	1,430	1,220
150 kg urea ha^{-1}	1.0	62	1,100	828
225 kg urea ha^{-1}	0.9	90	990	690

[a] t ha^{-1} [b] '000 Indonesian Rupiah ha^{-1}

3.3 Case III: Farmers learning how to control stemborer in rice

White stemborer in West Java

Kalensari is a typical village in the irrigated plains on the dry northern coast of West Java. Rice is grown as far as you can see during two seasons per year. From August to October, however, the land is fallow under a prolonged period of drought. An endemic pest problem in this part of West Java is the white stemborer (*Scirpophaga innotata*) (Fig. 7). Being adapted to the local climate, stemborer moths emerge in large numbers at the onset of the rains after a period of drought. Moths deposit their egg masses on rice seedlings and the larvae feed inside the stem section of developing rice plants. Damage is widespread despite the use of broad-spectrum insecticides which has been promoted by the district government. In 1990 and 1994, two farmer field schools were conducted in Kalensari. Despite the education on the rice plant and the agroecosystem, the high incidence of white stemborer remained a problem.

Identifying the problem

An 'action research facility' was set up in Kalensari to help farmers develop alternatives to the reliance on insecticides for the control of white stemborer. A one hectare field plot was rented to provide fields for learning, and a village house provided a place for farmers to meet and a place for one of us (A.L.H.) to live. In several ways this arrangement resembled a farmer field school: there were twenty-five farmer participants who met regularly and conducted field observations. Until then, the participating farmers had not asked themselves the question what caused the moth flights. Broad-spectrum insecticides were sprayed to kill the moths, while granular insecticides were applied to the soil for uptake up by the plant to kill larvae feeding inside the plant. The facilitator helped the group identifying their most important problem, which was stemborer damage despite insecticide applications. The facilitator challenged the group by asking how the problem came about and how they could find out more. They speculated that perhaps the method of spraying was not effective or perhaps new moths invaded the field after spraying. These ideas resulted in a series of field studies on how to break the life cycle of white stemborer.

Fig. 7. Moth of white stemborer.

First experiments

To test the idea that spraying was ineffective, the farmers placed white stemborer moths inside a container and treated them with insecticide. To their surprise, the moths spawned eggs before they died, and after a few days healthy larvae emerged from these eggs. The farmers concluded that by spraying the moths, egg laying could not be prevented. Then, they asked themselves whether the eggs were killed by spraying. Freshly laid egg masses were collected and sprayed at a normal dosage; four types of insecticides were tried. But after a week, healthy larvae emerged in all treatments, and hence spraying did not kill the eggs. They reckoned that the velvet hairs covering the egg masses protected the eggs against pesticides. Next, the group examined several seedbeds that were treated with granular insecticide and found that although some larvae had died, others were still alive. Again, the insecticide was found to have only a limited effect. Based on these three studies, the farmers concluded that the life cycle of white stemborer cannot easily be broken by insecticides. Thus began their search for alternatives.

After studying the biology of white stemborer, the group wondered where the moths came from. They suspected that the moths originated from fallow fields. Hence, during the drought, the farmers examined the rice stubbles from the previous season and to their surprise found live stemborer larvae inside the stubbles beneath the soil surface (Table 5). The group returned regularly to the same stubbles and found the larvae in the same position with their heads pointing downwards. After the onset of rain, they noticed that the larvae turned around and moved upwards inside the stalk. If more drought followed, the larvae resumed their downwards position, but if the rain persisted, the larvae entered pupation inside the stubble. Twelve days after pupation, the moths appeared. Through discussions with resource persons, the farmers learned that the larvae are diapausing in order to survive the dry period. Having identified where the moths came from, the group experimented with methods to control the diapausing larvae in the fallow field. First, they burned the rice stubble but found that the larvae were still alive in the stem section underground. Then, they flooded a field for seven days but found no evidence of dead larvae but all encountered larvae were still alive. Besides, they expected that flooding during the dry period was not feasible. Hence, controlling diapausing larvae was not an option.

Table 5. Larvae found inside rice stubble during the dry season by the learning group in Kalensari. 1995.

Field unit	Larvae found	Hills checked	Larvae m^{-2}
Block 1	4	60	1.1
Block 2	5	60	1.3
Block 3	1	60	0.3
Block 4	7	60	1.9

Cleaning seedbeds

The farmers drew their attention to the seedbeds which seemed most vulnerable to stemborer attack. At this time (October 1995) there was an unusually large flight of moths, and the farmers recorded a staggering 123 egg masses per square meter of seedbed on average. Removing egg masses by hand was seen as the most logical method to break the life cycle of the stemborer. Egg masses are easily visible on young rice plants in seedbeds. Farmers knew this method but rarely practiced it because of the convenience of applying insecticides. But to be successful, this strategy of 'clean seedbeds' meant mobilising farmers in the entire area, including farmers of the neighbouring village, Bunder. The group of Kalensari contacted farmers from Bunder to explain about the need for hand-picking egg masses. The village head of Kalensari, who actively supported the research, met his colleague from Bunder to discuss the plan for a wide-scale campaign prior to transplanting. The campaign involved meetings for farmers in four sections of the area to discuss the control strategy. School children were also involved. Jointly, they removed egg masses in every single seedbed in the area. Follow-up meetings were held to review the field situation. The campaign appeared to have some impact because the damage incidence was only five percent of rice tillers, compared to twenty-five percent damage in the surround. The farmers realised, however, that the strategy of clean seedbeds demanded a major effort, especially if the area of operation was to be expanded. An additional strategy was required.

Avoiding attack

From what they had gathered so far, the group concluded that stemborer larvae survived the dry season and that moths emerged by the time the seedbeds were planted. During the next season, the group discussed how the seedbeds could be kept clean. They noticed during their surveys the previous season that two adjacent fields showed a remarkable difference. One field had been heavily damaged by stemborer, whereas the other had been spared. After enquiring from the owner they learned that, although the variety and inputs were the same, the spared plot had been planted one week after the damaged plot and, apparently, just missed the moth flight. The farmers determined the days with rainfall and calculated when the moth flights must have occurred. They discovered a pattern. After a certain amount of rain following the drought, moths emerged and, if seedbeds were present at that time, a heavy infestation was to be expected.

The group hypothesised that if seedbeds are planted after the moth flight, damage could be avoided. This idea was tested during the following season. Rainfall was measured daily, using a measuring gauge made after an example the farmers had seen at a research station. Moth flights were recorded by using home-made light traps (Fig. 8, 9). As soon as the moth flight occurred, a series of seedbeds were planted at daily intervals with the last seedbed planted ten days after the flight. The seedbeds were sampled daily for egg masses. It was found that seedbeds planted after day seven had considerably fewer egg masses than seedbeds planted earlier. Thus, the group discovered that stemborer attack could be avoided by planting the seedbeds at least a week after the moth flight. As one of the farmers explained: "The stemborer uses seedbeds like a bridge to infest the rice field. We will take away this bridge." By the time of the next rains in November 1996, the farmers made a plan to implement the avoidance strategy in the entire area. They organised coordination meetings for other farmers in several places to inform them that seedbeds were not to be planted until the signal was given. At the onset of rains, moths emerged but found no seedbeds to deposit their eggs. The operation seemed to work because stemborer infestation was low in the entire area. "But we are still concerned," a farmer added, "that stemborer might re-colonise the area during the season either through migration or by trying another 'bridge'."

Fig. 8. Farmers of Kalensari examining a kerosene light trap to monitor the incidence of white stemborer moths.

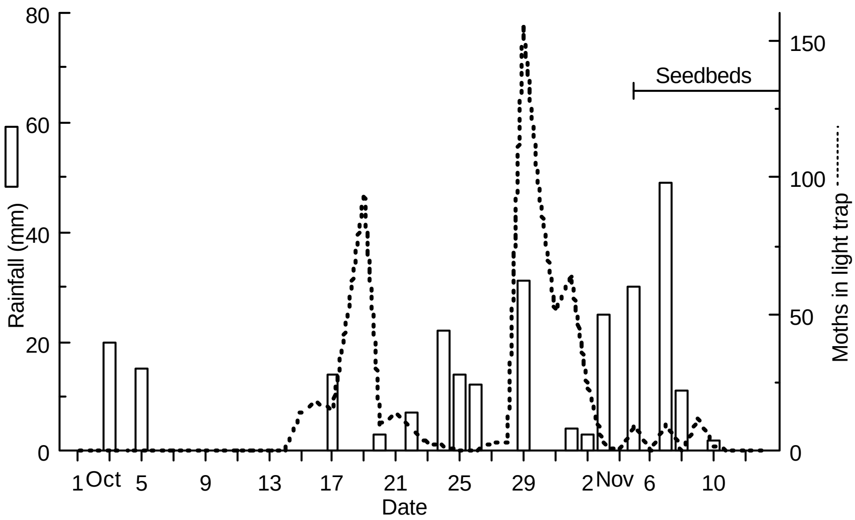

Fig. 9. Rainfall measurements and light trap catches of white stemborer moths by the learning group in Kalensari, 1996. The first rains after the drought on 2 Oct were followed by the 1st peak flight. Rains resumed on 17 Oct causing a 2nd peak flight. To avoid infestation of rice, farmers prepared the seedbeds only after 3 Nov, i.e. 7 d after the 2nd flight.

From village to district

Committed to expand their non-chemical strategy of 'clean seedbeds' and 'avoidance' even further, the farmers arranged a seminar for farmer trainers from the entire district. (Farmer trainers are farmers who were trained to conduct farmer field schools on IPM). The participants decided to implement the proposed strategies in their own villages. They also called for a meeting with the district secretary, district agricultural officials and sub-district officials. This 'high-level' meeting gave the farmers the opportunity to present their strategy and propose a plan for the implementation of their strategy throughout the district. The officials were amazed by the insight of these farmers and readily supported their plan. The five-year agricultural programme for the district was revised. A policy statement was issued which enforced a scheme (i) to plant seedbeds after the peak moth flight, (ii) to avoid insecticides against stemborer, (iii) to remove insecticides from the government credit package, and (iv) to collect egg masses from seedbeds where the avoidance strategy can not be implemented. During the main season of 1996/97, the District Head personally visited every sub-district to supervise the implemented strategy.

Over the years, many resources have been used to control stemborer at a considerable expense but without lasting success (every season, nearly 3,000 t of broad-spectrum insecticides were offered on credit in Indramayu district alone). The farmers from Kalensari and Bunder found a way to break the life cycle of white stemborer by using non-chemical methods. They disseminated their strategy to others in their area and throughout the district. The avoidance strategy continues to disperse to new areas of Indramayu while being adjusted according to local field conditions.

3.4 Case IV: Farmers addressing multiple problems

The 'problem tree'

Tungro is a disease of rice which is transmitted mechanically by a green leafhopper. It is a recurring problem in the intensive rice-growing district of Boyolale, Central Java, where rice is grown throughout the year. In addition, infestations of brown planthopper and yellow stemborer are frequently reported from the district. To address these problems, an action research facility was established in the village of Sambon, in a part of the district where the problems were considered most serious. One of the authors of this document (H.A.) was facilitator on-site. While attending a routine village meeting in Sambon, the facilitator introduced the concept of action research. Several villagers, mainly those who had graduated from a farmer field school during the previous year, expressed their interest in the idea. They were asked to draw a map of the rice area in their village to indicate (i) who owned the individual plots, (ii) who was a farmer field school graduate, and (iii) what was the type and spatiality of field problems. This map was then used to select a learning group of farmers.

There was a general unhappiness about the poor performance of the rice crop and a number of factors were considered responsible for this situation. The facilitator asked the farmers to write on blank cards all the problems that came to mind. All pieces of paper were then arranged as a 'problem tree' (Fig. 10). Apparently, the problems were related to other problems, as problems existed at different levels in a cause-effect relationship. Low yields had six identifiable causes: brown planthopper damage, tungro disease, stemborer, rice bug and improper use of fertiliser. At the next level of problems, the incidence of tungro, brown planthopper and stemborer were ascribed to three other problems: vulnerable rice varieties, staggered planting and ineffective natural enemy populations. Staggered planting was attributed to staggered land preparation which was in turn related to insufficient farm labour. Furthermore, ineffective populations of natural enemies were considered a result of poor pest management practices and the use of toxic chemicals. These practices were attributed to a lack of field observations. After translating each problem into a goal to be achieved, the facilitator asked the farmers to prioritise their problems and to design actions to tackle them.

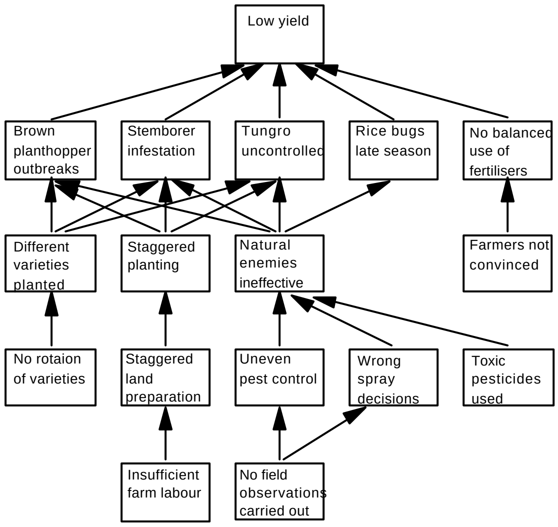

Fig. 10. The ‘problem tree’ prepared by the learning group at Sambon.

Studying the problems one-by-one

A series of studies were conducted to address the main problems, the first of which was tungro. One of the farmers suggested to test the method of roguing, i.e. the periodic replacement of plants which show symptoms with healthy ones. The group designed a study to compare this sanitation method with no action taken. The replicated plots were inoculated with five infected hills planted within each plot. Twice a week until forty-five days after transplanting, plants with yellow signs indicative of tungro were rogued. The treatment with no action taken had more infected hills per plot than the treatment with roguing (Fig. 11). After conducting the statistical test (see 3.2) it was concluded that the difference was obvious indicating the importance of roguing. However, it was also considered important to prevent tungro from entering the field by keeping the seedbeds clean. In a follow-up study, they compared the tolerance of different rice varieties to tungro.

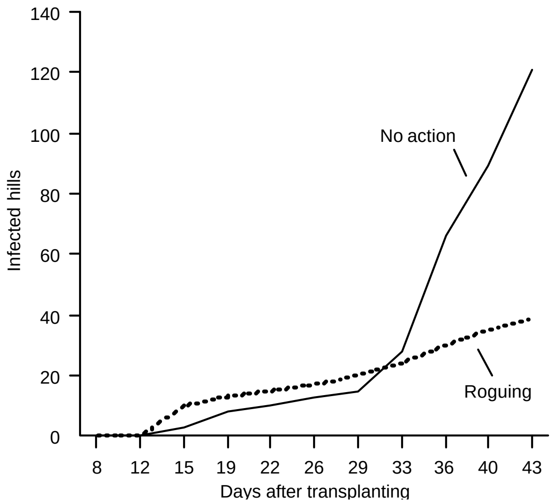

Fig. 11. Rice hills infected by tungro disease in inoculated field plots in replicated treatments with no action taken and with roguing (i.e. the periodic replacement of plants which show symptoms with healthy ones). Study by the learning group in Sambon.

Brown planthopper was studied next. The ability of different predators to feed on this insect was examined inside plastic cups and field cages. In an additional field experiment, the effect of different control methods on the insect was evaluated. The non-chemical method of draining the field and shaking rice plants to disturb brown planthopper produced lower densities of the insect than applications of a chemical insecticide or an insect growth regulator (Table 6). The farmers attributed the difference to the enhanced action of natural enemies in the treatment with draining, even though the densities of natural enemies had not been recorded.

Table 6. Brown planthopper densities in unreplicated rice plots under three treatments, measured before the 1st application of the threatments, and after each on three applications. Sambon, 1996.

	Brown planthopper hill^{-1}			
Treatment	Before	After appl.-1	After appl.-2	After appl.-3
Chemical insecticide	8.0	3.9	10.3	6.0
Insect growth regulator	8.0	4.7	5.0	5.0
Draining and shaking	9.0	3.3	2.5	2.2

To reduce the incidence of rice bug, the group tested the traditional practice of placing dead crabs on top of bamboo stakes in the field. The odour attracted large numbers of adults which were collected every morning in plastic bags. As an improvement to the traditional practice, the group designed traps from plastic water bottles based on their knowledge of fish traps so that rice bugs could enter but not leave the trap. They also compared the attractiveness of several baits and found chicken dung to be most attractive to rice bug[11]. Following the suggestion of the facilitator, the farmers learned to distinguish male from female rice bugs and found that only the males were attracted to the baits, which diminished the relevance of this control method. Additional studies were conducted on stemborer, green leafhopper and grasshoppers.

Organised action

Meanwhile, the group discussed their experiences with rice varieties and asserted that the rotation of varieties from season to season reduces the incidence of tungro. This assumption could not be further tested because it would require large-scale studies and a complex design. Similarly, farmers' experiences with staggered planting indicated that late-planted fields attracted more pests and, therefore, it was assumed that synchronised planting reduces pest problems, another idea which could not be tested. Based on these assumptions, a plan was laid out for a coordinated action over an area of fifty hectare in which the village head assisted.

The farmers divided the area into ten blocks of five hectare each. The choice of the block size was made for practical and economic reasons. Five hectare of rice could efficiently be harvested with the available labour; moreover, the harvested produce could easily be marketed without overloading the supply of rice. From then on, planting was synchronised within each block but not between blocks. The coordination of labour at planting and harvest increased the efficiency of rice production. Previously, there was only one farmer group in the village of Sambon, but recent developments prompted two new groups to be formed.

Main findings of the field experiments were implemented in the blocks. Regular observations were made by farmers of each block aided pest management decisions and, as a result, insecticide use was drastically reduced in the entire area. Fields were drained whenever brown planthopper densities increased. Roguing of tungro disease was carried out routinely in all the blocks, and may have contributed to the low incidences in the ensuing seasons. Moreover, varieties which were found susceptible to tungro were avoided.

The action research at Sambon illustrates how a complex of problems was addressed in a coordinated manner. Despite uncertainty about the influence of synchronised planting and rotation of varieties in controlling pests, the farmers organised a system of planting in blocks. Economic factors drove the execution of this plan, which has been operational for several years and has proven its value. As a consequence of the 'block system', organised action is taken for the management of field problems using non-chemical methods (Fig. 12,13).

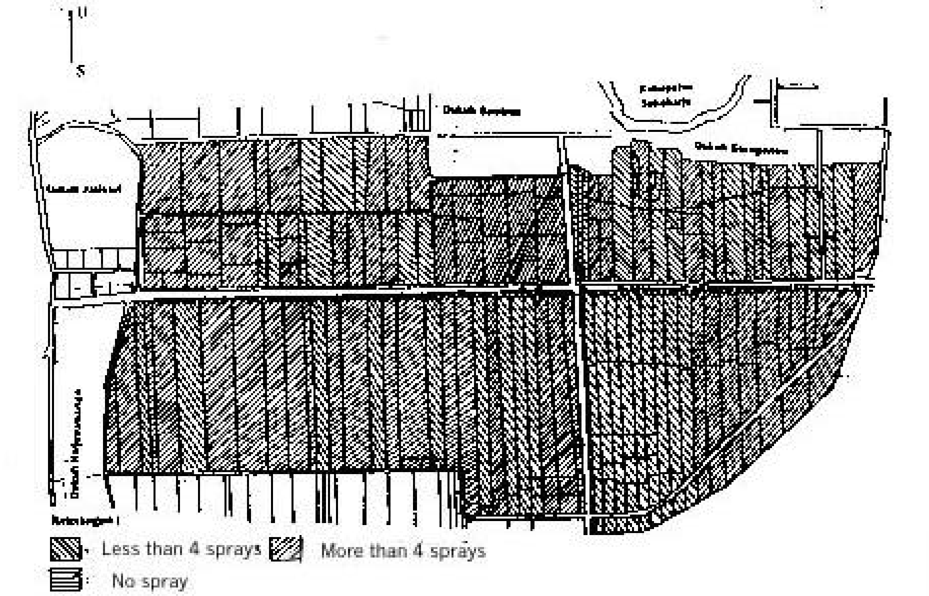

Fig. 12. Map drawn by farmers of Sambon village of spraying practices before the farmer field school, indicating the absence of unsprayed fields.

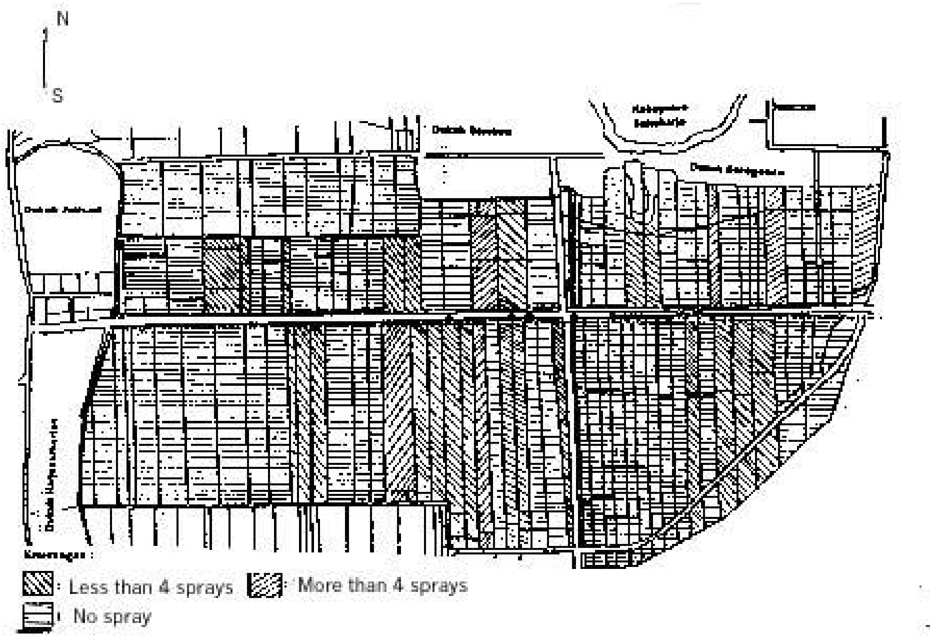

Fig. 13. Map drawn by farmers of Sambon village of spraying practices after the field school and field studies.

3.5 Case V: Farmers adapting an 'external technology'

Onion farming in Brebes

The district of Brebes in Central Java is known for its production of red onion. The crop is found throughout the year with farmers growing two to four crop cycles, frequently inter-cropped with red pepper. The shallot armyworm, *Spodoptera exigua* (Fig. 14), is the major problem in onion production. The moths deposit their egg masses on the leaves and, after hatching, large numbers of tiny larvae feed close together on the leaves. The growing larvae disperse and continue their development hidden inside the tube-shaped leaf and their feeding affects the onion bulb. Farmers have depended on the use of insecticides to control onion caterpillar, but they have found that a range of chemicals have lost their effectiveness, even at high dosages or in mixtures. The pest clearly developed resistance to insecticides, causing farmers to spray every other day. Formal research contributed two important findings with relevance to onion production in Brebes. First, it was shown that farmers in this area suffered a high incidence of acute pesticide poisoning which was associated with the frequency of spraying[12]. Second, field surveys had yielded an effective strain of an insect virus from shallot armyworm, called *Se*-NPV[13]. When a formulation of the virus was sprayed in test fields, it caused an epidemic which controlled larval populations. The virus proved to be specific to shallot armyworm without harmful effects to other organisms. It was mass-produced in the laboratory by infecting field-collected caterpillars with an inoculum. The researchers studied the feasibility of the virus being produced and used by farmers on their own.

Fig. 14. Shallot armyworm feeding inside an onion leaf.

The urgency of the situation in Brebes and the availability of the insect virus lead to the initiation of an action research facility in 1996. The village of Dukuhwringin was the selected site, and one of the authors of this document (W.C.) was facilitator. Thirty motivated farmers who were willing to commit their time were selected as counterparts. The challenge was obvious: Here was an unequivocal problem of shallot armyworm related to insecticide over-use and a possible, simple solution in the form of an insect virus. History had taught, however, that the introduction of an external technology was often followed by poor adoption because farmers did not understand the technology. Therefore, it was decided to initiate the process of farmer field research and only when the time was right introduce the insect virus.

Getting started

The learning group of farmers started by prioritising the pest and disease problems in their crops of onion and red pepper. Interestingly, fruit borer (*Helicoverpa armigera*) in red pepper and stunting in onion initially received priority over shallot armyworm. It was apparent how much the farmers had depended on pesticides since for every pest problem the facilitator was asked "*apa obatnya*?" ("what is the best medicine for this?"). If these farmers wanted to conduct field research, their recipient attitude would have to change. The facilitator suggested to begin by looking at the problem more closely and find out what the adult fruit borer looked like and where and how it deposited its eggs. The ensuing observations motivated the learning group to start their first field experiment. They found that sprayed plots suffered more fruit borer damage than unsprayed plots, while the numbers of spider, beetle and ant predators were reduced. Apparently, their attitude towards field problems began to change.

They turned attention towards their major crop, onion, in particularly to the problem of stunting. To challenge the group, the facilitator asked them to figure out what stunting was and how it was caused. Stunting was believed to be related to compact, unairated soils, a hypothesis which was tested through a field survey. The results quite clearly indicated that stunting could be reduced by proper land preparation. The group continued to expand their research options, with encouragement from the facilitator, and examined the problem of shallot armyworm. They noticed larvae with different colour markings and wondered if these were separate species. After studying the life cycle and observing that the colour markings of individual larvae changed during their development, the group concluded that the larvae were of one species.

A common practice in between spraying operations was to hand-pick infested onion leaves which contained eggs or larvae. The picked leaves with eggs or larvae were habitually discarded in the field. But now it was questioned whether discarded larvae would be able to re-infest onion plants. The group observed larvae crawling out of the picked leaves – apparently in search for fresh onion plants – and concluded that picked leaves should not be discarded in the field. Instead, they developed an alternative method whereby the picked leaves were put inside plastic bags which were left in the sun until the eggs and larvae had died (Fig. 15). Despite the improved method, however, shallot armyworm remained a problem. The farmers heard about someone in the neighbouring village spraying gasoline in the field to kill egg masses, allegedly with good results. They tested this idea in a small field experiment but found the method ineffective.

Fig. 15. Pest disposal bag to deposit larvae of shallot armyworm

Introducing the insect virus

The facilitator considered this the right time to introduce the concept of the insect virus. He did not want to introduce the virus upfront but instead have farmers 'discover' the virus for themselves. Consequently, he applied the virus secretly to the study field. After a few days, while conducting their regular observations, the learning group noticed that the armyworm larvae looked weak and yellowish, different from larvae killed by chemicals. They assumed that the larvae got sick because their larval bodies were filled with a malodorous liquid which the farmers suspected contained germs of a disease. During discussions which the facilitator occasionally directed with questions, the idea arose to test if this liquid was infectious to healthy larvae. The contents of five sick larvae were squeezed into a glass of water and the emulsion was sprayed onto a potted plant. Several healthy larvae were added. The larvae died after a few days with the same symptoms as those observed earlier. After this test, the virus was applied to the field and caused an epidemic in the armyworm population. Separate tests showed that the fruit borer was not vulnerable to the disease.

Discussions now concentrated on how to obtain a stock of the infectious liquid for treating larger areas. The facilitator helped by asking questions but did not give suggestions. Eventually, it was decided to collect the hand-picked larvae on a regular basis, to keep them inside a cage and infect them with the virus. The affected larvae were used to prepare the emulsion. After a substantial amount of emulsion was prepared, the farmers tested the effectiveness of the virus in comparison with the usual farmer practice. Several farmer fields were used as replicates. Application of the virus in combination with improved hand-picking produced a higher yield than the farmer practice of chemical spraying plus discarding of hand-picked leaves. The improved hand-picking method alone did not provide sufficient control. The experiment was repeated in other fields with similar results, and it was concluded that the virus was effective and cheap compared to chemical insecticides.

The virus, which the farmers called '*wabah menular*' or 'epidemic', was sprayed on a regular basis in the fields belonging to the learning group of farmers, and eliminated the need for chemical insecticides. Moreover, the frequency of application could be reduced to four to eight per crop cycle. Although the numbers of natural enemies had been low due to a history of spraying, generalist predators were frequently observed in the virus treatment. Predators did not show symptoms of the disease, from which it was concluded that the virus was safe to the ecosystem. In search for more insect diseases, field-collected larvae were reared in farmers' homes until the emergence of an adult moth or until the expression of a disease or parasitoid.

Having kept stocks of the virus for some time, the facilitator suggested to test whether the virus material was still effective. To their surprise, the emulsion killed healthy larvae immediately unlike the original virus which made the larvae sick before dying. Moreover, the caterpillars turned black instead of yellow. The farmers were excited about this concoction which seemed to them better than their original virus. The facilitator asked the learning group to find out why the larvae died so quickly and why the symptoms were so different from those of the original virus. Observations showed that the concoction also killed other insects, whereas the original virus had affected only shallot armyworm. The farmers concluded that the original virus in the stock must have been replaced by a poison developed through a process of decay. They started new cultures of the virus from fresh larvae.

Scaling up

Despite the improved management of shallot armyworm, moths continued to invade the study fields from the surroundings, demanding repeated control action. The farmers observed that moths were capable flyers and, at night, were attracted to light sources some distance away from the onion fields. They contemplated that the improved management of shallot armyworm had to be expanded over a wider area to have a better effect. Hence, neighbouring farmers had to be involved. As a first step, posters were prepared on the improved method of hand-picking and a leaflet was made on the use and production of the insect virus. The posters were exposed in the field but had limited impact on farmer practices. Next, a large tent was erected in the field which attracted many farmers from an area covering 200 hectare. Farmers who attended were taught about the research and about the improved methods of armyworm control. Many of them agreed to join the improved practice of hand-picking. Twenty 'deposit sites' were arranged in the area for the disposal and collection of hand-picked leaves. This provided a continuous source of larvae for the rearing of virus.

Still, the learning group wanted more onion farmers to benefit from their experiences. They organised a series of meetings in the neighbourhoods of several villages, with the help of civil authorities, and encouraged the villagers to test the improved control methods. In addition, they joined seasonal farmer seminars at the sub-district level, a forum which was organised by the IPM programme. A network of motivated onion farmers was thus established. Regular cross-visits between farmer groups and the learning group in Dukuhwringin helped transmitting the process of learning about the insect virus. The refined method of hand-picking was readily adopted in several villages. The rearing of virus, however, was taken up by only few farmers, presumably because it demanded more effort.

The learning group did not intend to become entrepreneurs who mass-produce and supply the virus to others, but they encouraged other farmers to begin their own virus culture. The virus was seen as an interim measure since the farmer group observed how the onion ecosystem slowly restored itself in the absence of chemical insecticides, resulting in a lower natural incidence of shallot armyworm. Interestingly, virus-producing farmers in one of the neigbouring villages were offered a sponsorship by a national newspaper to become commercial suppliers of the virus to other farmers. They refused the offer because, as they said, other farmers should get the same opportunity to learn about the virus. However, a farmer group in Leces, East Java, which received the virus technology but had not experienced a similar process of learning, took up the challenge of mass-producing and selling the virus to others. They received regular technical support from the plant protection division.

In retrospect

Four years after the introduction of the insect virus at the farm level, its production is still being sustained. Unfortunately, though, only few new farmers have taken up the challenge to start their own culture, suggesting that the technology requires a certain specialisation on the part of the farmer. Entrepreneurship could make the production more effective and rewarding, but could not replace the learning process which generates the understanding and motivation necessary for a sustained management of farmers' problems. The farmers in Dukuhwringin refused a superficial substitution of chemical insecticides with the virus because they had experienced the value of the learning process. Groups of innovative farmers remain 'islands' surrounded and influenced by a system which relies on centralised extension methods. If mainstream programmes were to actively promote farmer field research, this would help ensure that the onion farmer community in Brebes convert their control practices to become less reliant on simplistic solutions to field problems.

Chapter 4. Analysis

In this chapter we attempt an explanatory analysis of the process of field research, the roles in field research and the impact of field research, based on the five cases presented in Chapter 3. Experiences from other locations are added.

4.1 Process of field research

What can we learn about the process of farmer field research? Is there a pattern? Can the process be strengthened? We will go through the different stages of field research from initiation to interpretation.

Initiation of field research

Field research typically starts with a question or idea, usually after an observation in the field. The origin of questions or ideas is often difficult to determine in retrospect because the creativity involved does not necessarily use logical reasoning but makes jumps or unexpected connections in thought. Creativity is a valuable asset in field research because it enables real progress in farming. We postulate that the open-system thinking which is promoted through the activity of 'agroecosystem analysis' in the farmer field school enhances the level of creativity among farmers because of the absence of ready-made answers.

Mr Aep's research (3.1) started with the observation of how barnyard grass grows. This observation was accompanied by the question of how the grass could grow so much faster than rice. Creativity enabled Mr Aep to connect the observations on barnyard grass to his rice crop, which is an unusual association. He hypothesised that if rice was planted like barnyard grass it would be more productive. His is a case of spontaneous research which started without any outside interference. Another example of spontaneous research is that of Mr Sujai in Pasuruan, East Java. When in 1987 his rice crop suffered from tungro disease, he observed that some plants remained unaffected while being surrounded by diseased plants. His idea was to test if healthy plants would produce offspring tolerant to the disease, which they did. Over the years, this farmer has selected his own resistant rice seed and, reportedly, his crop has not suffered from the disease ever since. The seed is currently being sold and used by many farmers in the district. The importance and incidence of spontaneous research are generally underestimated because projects rarely try to find out what farmer are doing already, except where they begin with participatory planning tools or tedious baseline studies.

The research in Prambon (3.2) was initiated by a trainer as part of a follow-up field school on soybean. The farmers were asked to review their farming problems, to describe the potential to improve their current practices and to outline the constraints in doing so. One problem was selected as topic for study through consensus among the group. Prior to the exercise, the topic may have been on the mind of individual farmers but had not earlier compelled them to conduct the experiment. Likewise, at other locations where we attended similar training activities, the farmers had limited experience with conducting comparative trials. The curriculum of follow-up field schools emphasises the hypothesis. Any treatment affects not only the parameter of main interest but also other parameters which indirectly affect the main parameter or which result in undesired side effects. The use of the 'idea matrix' (see Annex) prevents the single, reductionist hypothesis by adding alternative hypotheses. For example, the farmers at Prambon hypothesised that a reduced use of urea might increase yield, but it might also affect weeds, insect pests, and lodging. Observations are planned accordingly to test each of the hypotheses.

The group at Kalensari (3.3) was aware that white stemborer caused damage to their rice crop despite the application of insecticides. However, they had not attempted to find out more about this problem, and accepted the situation as their fate. Due to the questions of the facilitator, the first idea emerged: Perhaps the spraying was not effective against stemborer moths. They sprayed and observed the moths in a simple test. The moths died quickly suggesting that the hypothesis of ineffective spraying was wrong. In doing the test, however, the farmers made an accidental observation: before dying, the moths deposited viable egg masses. This observation was unexpected, purely a side-effect of experimentation. Logically, the farmers' next question was whether spraying affected the eggs, which was tested in another trial. This process of asking and testing was repeated several times as the results of each test gave rise to a new question. Each test brought the farmers closer towards understanding the dynamics of white stemborer. There was no shortcut for this process. The ultimate strategy of adjusting the time of planting to avoid stemborer flights was the outcome of a long process in which an answered question resulted in the next question. The value of accidental, unintended observations must be stressed. After the farmers had settled with their laborious strategy for clean seedbeds, they accidentally observed two bordering fields with very different levels of stemborer attack; the only difference was the date of planting. This observation prompted the development of the 'avoidance strategy'.

The case of Dukuhwringin (3.5) describes how the facilitator introduced the concept of the insect virus without disturbing the learning process of the farmer group. The introduction of the virus literally remained a secret. In Sambon (3.4), the facilitator initiated the research by helping the farmers to systematically analyse their farming problems. Recognising the cause-effect relationships between different problems, they began to search for ways to address the issues through field studies. They entered into the same mode of asking and testing. This 'learning cycle' of farmer field research (Fig. 16) starts with a question (or with an observation that produces a question). An idea is formulated and tested, and results are analysed and interpreted. During the test, 'accidental' observations are made which generate new questions. This active process of research gradually brings the farmers closer to understanding their object.

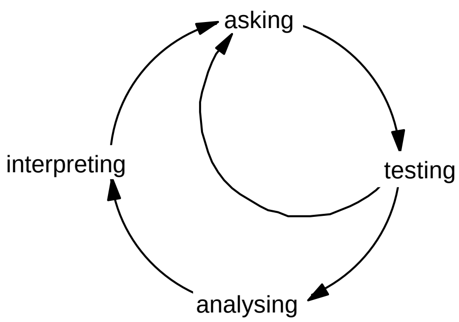

Fig. 16. The learning cycle of farmer field research.

Design of a study

Three general types of studies can be distinguished. First, 'observational studies' on the biology of an insect or a plant are very common both in the farmer field school and in follow-up activities. Popular objects for study are the lifecycle and feeding behaviour of plant-feeding insects and natural enemies, and insect-plant damage relationships. The design of observational studies is usually simple and does not normally involve treatments. The objects of study are observed at regular intervals either in the field or inside cages or containers.

Second, 'natural experiments' make use of observations taken under more than one environmental condition to study an object in relation to its environment. Examples are light traps observations to determine stemborer flight in relation to rainfall, observations of diapausing stemborer larvae before and after rainfall, or a try-out of a new variety or practice during several seasons. Here, rainfall, time or the season is the 'natural treatment'. The experiments rely on observations taken over time of the object and its environment (e.g. daily rainfall). Another form of natural experiment uses the variation between sites without imposing a treatment effect. At Dukuhwringin (3.5), a survey was conducted to record the incidence of stunting in relation to the history of land preparation for a large number of fields. There was a correlation between stunting and poor land preparation. Analysis of data involving multiple locations, however, is often confounded by unknown sources of variation, especially where the observed effect is less obvious. In such cases, a comprehensive collection and analysis of data is required before sound conclusions can be drawn. This type of research is beyond the scope of farmers' own research, and is discussed further in 5.2. This limitation of farmer field research is highlighted in the case of Sambon (3.4) where staggered planting and the rotation of varieties was assumed to reduce pests, without being tested. A study would have required a complex design and a major effort.

Third, the most common type of farmer field research is the 'controlled experiment' in which one or more variables are manipulated while others are kept constant in all treatments. A simple form of a controlled experiment is the test whether stemborer moths die after spraying, which is a before/after comparison where the treatment is the action of spraying. Alternatively, different treatments are applied to different experimental units (field plots, cages, traps, etc.) to enable a comparison. The campaign for clean seedbeds in Kalensari (3.3) was essentially a controlled experiment because a comparison was made between the treated area and the untreated surround. Experimental plots are often chosen for easy access, with a likely bias towards above-average field conditions. Interference between treatments is an occasional problem in experiments on pest management and fertilisers, but the training curriculum on field experimentation (see Annex) helps reduce this problem. Cages or pots are useful in studies on certain topics (e.g. insect biology) but lack representation of the field. A pot study was conducted in Sambon to compare the effect of different soil treatments (lime added, manure added, and the control) on plant performance produced results which were difficult to extrapolate to the field situation. If soil is removed from the field, however, several soil properties (structure, temperature, water content, chemical processes) change. Consequently, a particular treatment may have a different effect in pots than in the field. Therefore, follow-up experiments in the field are important.

Unreplicated treatments suffice in case of a clear treatment effect under uniform field conditions. Occasionally, as in Mr Aep's case (3.1), an unreplicated comparison is repeated during several consecutive seasons. The repeated testing under different conditions each season increases the robustness of results. However, we also encountered poorly designed studies with unreplicated treatment plots positioned in separate fields, each with its own planting date or irrigation schedule. Replicated treatments are common in farmer field research, perhaps for two reasons. First, the follow-up field schools on soybean (3.2), which encourage the use of replications, were conducted in every district. Second, there was an apparent spill-over of methodology from the soybean activities to other farmers who conducted their own experiments. If asked why they replicated their treatment plots, farmers often responded to us that single treatment plots could give a false result because of uneven soil conditions over the field, whereas replicates would 'represent' the different parts of the field. Hence, farmers mostly understand the importance of replication. They are aware of sources of variation in their fields and how this influences their results. Moreover, in the field school farmers learn that different samples are needed to obtain a reasonable estimate of the field situation. Small field sizes often limit experimentation, forcing farmers to reduce the size or number of treatment plots. To circumvent this problem, farmers often use bordering rice paddies as 'blocks', each with a complete set of treatments.

Occasionally, experiments have more than one variable, producing results that are difficult to interpret. For example, Mr Aep (3.1) demonstrated that his set of practices (planting depth, seedlings per hills and rinsing of roots) improved yield, but was not able to understand the role of each practice. Studying a combination of variables is only useful if 'packages' or proven sets of practices are compared (for instance to compare variety A at close spacing with variety B at wider spacing), but ideally this is done only after each factor has been investigated in separate, single-factor studies. Unfortunately, the confusion created by studying multiple variables is frequently utilised by the industry to increase agrochemical sales, not to create understanding. Demonstration plots to compare the company package with a farmer practice often include improved agronomic practices in the former but not in the latter treatment. The observed difference will at least partly be due to the improved agronomy.

The planning of observations deserves special consideration. In simple experiments, observations on single parameters suffice, for example to study the survival of stemborer with or without insecticides. But it is often desirable to measure more than one parameter. In Sambon (3.4) chemical control of brown planthopper was compared with the non-chemical method of draining the field and shaking the rice plants to disturb the planthoppers. Planthopper densities were lowest in the non-chemical treatment but, unfortunately, no observations were made on natural enemies. Hence, the reason for the observed difference remained unknown. Other examples of reductionist observations are studies where crop cuts are the only recorded data. In a farmer field school, however, farmers develop a holistic observational 'habit' by taking regular observations of the agroecosystem, which include observations on plant development, soil conditions, insects and weeds. This habit is frequently extended to farmer field research where farmers learn to plan their observations in accordance with their main and alternative hypotheses. Holistic observations increase the intensity of study, but provide a better understanding of a treatment effect. In their study on urea fertiliser, the farmers in Prambon (3.2) observed yield, plant growth, pod formation, insects, and weeds, which increased their understanding of the effect of urea on the agroecosystem.

Many Indonesian farmers experiment with traditional botanical pesticides. For example, a farmer group in Kulonprogo, Yogyakarta, used extracts of a tuber mixed with tobacco leaves, sulphur and cattle urine. This concoction was sprayed against a range of pests in chilli. Although the product was developed empirically, the approach was reductionist because it did not address the mode of action nor the effect on non-target organisms. Plant toxins (e.g. nicotine) can be extremely poisonous to humans; moreover, the bacterial fermentation of concoctions can produce new toxins. Botanical pesticides, like chemicals, need laboratory and field testing on target and non-target organisms before they can be recommended to farmers.

Analysis of field research

Analysis is usually conducted through a direct comparison of observational records or, with more than one observation per sample, by taking the total or average of the sample. The practice of observing various parameters produces a lot of data, which may overwhelm farmers if not analysed or summarised. In experiments where the units are replicated there is the option of inspecting variation between data. For this purpose, the IPM programme developed a simple statistical tool (see Annex) for use by farmers to assess whether a difference between treatments is convincing or not. The tool helps prevent that erroneous or premature conclusions are drawn from ambiguous data. When treatment effects are not convincingly different, farmers decide whether to repeat the experiment with an improved design or with adjusted treatments. A group in Purbalingga, Central Java, studied whether their local practice of growing soybean without fertilisers could be improved by applying a moderate or high dosage of urea. The results of the replicated experiment indicated a slight yield increase with added fertiliser, which may have caused the farmers to change their farming practice. Yet, after using the statistical tool, the yield increase was found unconvincing.

Interpretation of field research

The interpretation of research results is a grey area to discuss. To explain the meaning of results depends on how these results are perceived by the individuals or groups who obtained them. A result means different things to different people. Moreover, preconceived ideas can hinder a learning process when something is shown that we are not prepared to see. At the stage of interpretation, it is vital to have a sense of dissatisfaction if the observed results differ from the initial concepts, and to use creativity to make sense of the results. New knowledge is generated only if the discrepancy between concept and observation causes us to change our conceptual framework. The following example illustrated how the learning process may be obstructed.

Farmers in Mande, West Java, traditionally removed straw after harvest of rice before planting soybean. Then, one farmer started to burn his rice straw and spread the ashes over his field. He observed that the new practice improved the development of soybean seedlings and suppressed weeds. Soon, his example was followed by neighbouring farmers. As part of a field school on soybean in 1996, these farmers conducted an experiment to compare the use of straw ashes with the removal of straw; in another treatment the straw was used as mulch or soil cover. To their surprise, the ashes hardly increased yield, whereas straw mulch raised yield considerably. Despite these results, the farmer who initiated the use of ashes insisted on the superiority of his practice. He was not prepared to learn from the experiment.

Simple studies, for example on pesticide effects inside cages or containers, are easy to interpret. However, the extrapolation of results obtained under manipulated conditions to the field situation is often a problem, requiring additional field trials. Field experiments produce more realistic but also more complex results, which often lend themselves to several interpretations. While interpreting, farmers have to make a choice whether to accept a treatment effect as true, or representative for the location, or whether to reject the result because of confounding variables or errors. When in doubt, the study is repeated with improved methods. In this regard, observations on additional parameters, as encouraged through the 'idea matrix' (see Annex), strengthen the interpretation of study results by adding related information.

Dissemination of results

We have discussed the self-enforcing mechanism that observation raises motivation which results in more observation. This mechanism is accompanied by an impetus to share new knowledge with others. Results of field research are readily shared among farmers through existing forums, special meetings or media. To encourage sharing between groups, the IPM programme established seasonal farmer seminars at the sub-district level throughout the major rice-growing provinces of Indonesia.

The farmers at Kalensari (3.3) first shared their results in routine village meetings. The action research soon became a regular feature at the monthly meetings and raised public support for their field work. In addition, a wall newspaper called 'Farmers' thoughts' was started to disseminate the new findings. Topics other than agriculture were soon added, while the frequency of editions increased from monthly to fortnightly. Villagers sent in their hand-written contributions which were typed and laid-out by the organisers. The newspaper became a popular medium for sharing information among villagers. The farmers in Dukuhwringin (3.5) tried several ways of disseminating their improved method for mechanical control of shallot armyworm in order to influence other farmers. They were unsuccessful in raising the issue at an official meeting for extension staff. Then, they prepared posters about the improved method and placed them at strategic points in the field, but not many farmers changed their practice as a result. They decided to explain the posters personally to farmers working in the field (Fig. 17), and constructed a large tent to reach more farmers. Finally, the new method was adopted by most farmers in the area. Hence, the group discovered that a poster did not easily change farmer practices whereas direct sharing of experience had more effect.

Fig. 17. Farmers at Dukuhwringin explaining a poster about the new method of collecting shallot armyworm to other farmers working in the field.

4.2 Roles in field research

Rather than discussing the 'degree of intervention' in farmer field research, we assume that there are several roles in research: the direct stakeholder (the farmer), the facilitator, resource persons and civil authorities. These roles are not necessarily attached to persons. In a programme where learning and facilitation are central, farmers frequently find themselves in the roles of facilitators to other farmers or as resource persons at other sites. Some even gain local influence by being elected as head of a farmer association or village, allowing them to promote farmer field research.

The farmer

The term 'farmer field research' implies a type of research in which farmers have the ownership over the process to determine what is to be researched, why and how. Any other player therefore becomes an advisor rather than an instructor. Trainers and resource persons are usually respected by farmers and, consequently, their advise may be perceived as an instruction. When in 1996 new training methods on experimental skills were introduced into the IPM programme, we observed several instances where the farmers did not take sufficient ownership over the study. Presumably, farmers perceived that the topic of study had been instructed by the facilitator since the topic did not emerge from farmers' needs. The studies were conducted as a task while the farmers showed little interest. In one case, farmers did not implement the result of the experiment even though it clearly indicated a higher yield with less inputs. After reviewing the situation with the trainers early 1997, the curriculum was revised to emphasise the process of topic selection and hypothesis building. Thereafter, the role of farmers increased.

Farmer field research is conducted by individuals or groups. Mr Aep was a research-minded farmer who formulated his idea, tested and evaluated it all on his own. However, he lacked interaction or collaboration with other farmers. Possibly as a result, he took his comparison of rice with barnyard grass very literal when he merged three variables into his experiments. The value of collaboration is that different viewpoints are reconciled. In the remaining cases in Chapter 3, research was conducted in groups. Groups consist mostly of farmer field school graduates, whereas the participants for a farmer field school are selected from existing farmer groups. These formal entities are not necessarily active as groups but the training mobilises them. Within the group, different farmers usually fulfil different roles in field research, such as maintaining the field plots, making the field observations, conducting labour-intensive operations, distributing the results, etc. Where a group plans more than one experiment at a time, like in Sambon (3.4) and Kalensari (3.3), the experiments are divided among the participating farmers, and progress is shared among the group.

The facilitator

The incidence of spontaneous research has probably been suppressed in our target group of post green-revolution farmers, as was discussed earlier. Anecdotal evidence has it that spontaneous research among non-trained farmers, while being uncommon, is mostly restricted to simple comparisons of input products. To some extent, the farmer field school is a 'facilitator' of farmers' own research, because it introduces farmers to the study of ecology. Instances like Mr Aep's (3.1) demonstrate that the field school produces spontaneous field research but only for a fraction of farmers. Another example is Mr Oyo, a field school graduate from Boyolale, Central Java, who noticed dragonflies perching from bamboo markers to hunt for planthoppers around his rice seedbed. To encourage dragonflies, he placed more bamboo stakes in the field and refrained from spraying. He also introduced his experience to a farmer field school which he helped facilitate. This field school experience caused farmers in an area of forty hectares to test the use of bamboo stakes while not applying pesticides[14].

During the early implementation of the IPM programme, trainers received numerous requests from field school graduates to help them with their field studies. The field school prepared farmers to implement IPM, but did not sufficiently equip them to conduct their own field research. Therefore, follow-up activities were needed to increase the confidence and skills of farmers. Two different approaches were taken: (i) A training curriculum on experimentation was incorporated in follow-up field schools on soybean which covered single seasons and were conducted at a large number of sites, and (ii) action research facilities were initiated at a few key locations which covered several seasons.

Early experiences with the curriculum on experimentation in follow-up field schools on soybean were learning opportunities. Trainers lacked the confidence to facilitate farmer field research. Their own research experience was limited to standard trials conducted during their own training. Hence, there was a tendency to instruct farmers to do the same studies using the same methods. Several measures helped solving this problem. First, the IPM programme provided some opportunities for trainers to gain experience in field research. Second, trainers received additional training on how to facilitate farmer field research. Third, the curriculum on experimentation was adjusted to increase the role of farmers at all stages of the research. Tools and basic concepts were introduced to assist farmers in conducting their own topic selection, hypothesis building, and study design. Gradually, the role of farmers in field research increased as the role of the facilitator decreased.

Action research facilities imply a long-term relationship between facilitator and farmers. There is no training curriculum but instead the process of research is developed by the learning group as they proceed. The facilitator initially helps the farmers to understand their problems, reflect critically about these problems, and enter into the 'research mode'. Different approaches to initiate farmer field research are taken in each case. In Kalensari (3.3), stemborer was the obvious problem, and the observation that pesticides were not effective was the logical starting point of the research. In Sambon (3.4) where the problem was less obvious, the facilitator introduced a process of problem analysis. In Dukuhwringin (3.5), the availability of the insect virus offered an opportunity to deal with the problem of shallot armyworm, although the facilitator did not present the virus upfront. Once field research has started, the facilitator assumes a role in the background. He continues to encourage the farmers to reflect critically on any issue, aiming to increase their command over the research and learning process. Shortcuts that jeopardise the learning process are avoided. New ideas or options are occasionally introduced but not without being tested. This process demands patience and a humble attitude on the part of the facilitator. The temptation of providing shortcuts are particularly strong if the facilitator has experience with the learning cycles entered by the farmers, or if he knows the outcome of a cycle.

Facilitation is not restricted to the process of research but is also required in the interface between the learning group and the outside world. Research findings which are relevant to a wider audience need to be disseminated. Occasionally, research findings indicate a need for wide-scale actions or policy change. Without the facilitator's encouragement, the impact of farmer field research would be limited. The facilitator in Kalensari, for example, helped farmers accessing neighbouring groups of farmers, village heads, farmer trainers, and the District Secretary.

The role of facilitator is gradually taken over by farmers as they gain experience. Farmers at Kalensari, like Mr Warsiyah and Mr Wahyudin, soon started to help others to go through the same learning process as they did. Similarly, several farmers at Dukuhwringin began to facilitate farmers in neighbouring villages to conduct their own research on shallot armyworm. This continuum of facilitation skills would be an important ingredient for the sustainability of farmer field research.

Resource persons

A resource person is anyone who introduces outside knowledge. When the facilitator introduces a new idea or when he shares his own experience, he finds himself in the role of resource person. Farmers from a neighbouring village may be invited into the group or community to share different experiences. Other resource persons are plant protection officers and researchers. For example, the plant protection office at Pandaan, East Java, actively supported farmer field research. Its staff attended farmer meetings to discuss experimental methods, and to provide advice on and rearing facilities for inundative releases of biological control agents (e.g. *Beauveria*, *Metarizium*). Researchers are occasionally invited to advice on specific problems.

Even though a resource person may enrich the technical content of farmer field research, the benefit depends largely on how new ideas or information are introduced. Proper facilitation and an atmosphere that encourages critical testing will ensure that the process of research remains under the control of farmers. A common problem with researchers visiting farmer groups is that the former do not understand the importance of the learning process for farmers. Researchers are inclined to make shortcut corrections or to introduce abrupt changes to the research. This jeopardises farmer ownership and discourages experiential learning.

Local government

Civil authorities often play a role in farmer field research with regard to providing resources, moral support, organising support and policy support. A group in Klaten, Central Java, was given a piece of land by their village head to conduct experiments. A village head in Gempol, East Java, made a building available to farmers for rearing several types insect fungi as biological control agents of rice insects. Funds are commonly provided by local government to sponsor field studies or other activities. The district head of Lumajang, East Java, sponsored seasonal farmer congresses to encourage field experimentation and to increase the exchange between farmers. But moral support from local officials is equally important. In a study on rice gall midge by a group in Panunggul, West Java, the village head participated actively in the field research which appeared to raise motivation of the group. Local authorities furthermore have the ability to mobilise civilians or to organise forums. The village heads of Kalensari and Bunder were instrumental for the wide-scale campaign for clean seedbeds by mobilising large numbers of farmers and school children (3.3). Lastly, local government provides policy-support, as was the case in Indramayu district where pesticides were removed from credit packages and new regulations promoted the non-chemical strategy for stemborer control (3.3).

4.3 Impact of field research

We discuss how farmer field research affects the situation on-farm, how it affects the farmer researcher him/herself, and what influence it has on the outside world.

Improves farmer income

Cultural practices are often not optimally adapted to account for local conditions, indicating a potential for farmers to improve their practices. Farmers' own research demonstrates a potential to reduce input of seedlings, fertilisers, or pesticides while producing the same or higher yields. Mr Aep (3.1) found during three consecutive seasons that he can improve his method of planting; shallow planting with fewer seeds per hole and without rinsing seedlings increased his yield by thirty percent. His results persuaded half of the farmers in his village to use the same method. Likewise, the farmers at Prambon (3.2) found that the local practice of applying high doses of urea produced lower yields – but costed more – than to the treatment without urea. They discovered that they had been wasting money on fertiliser.

Numerous other studies on the use of fertilisers and pesticides indicate that a reduced level of inputs frequently results in more profits for the farmer. In an analysis of a number of farmer studies on soybean in Indonesia, the modified treatment often produced a greater benefit than the current practice, and the effect was most pronounced in low-yield situations (Fig. 18). The benefits arise from an increased yield and/or a more efficient use of inputs. Wherever the industry or credit arrangements promote the use of agro-chemicals there is the tendency towards over-use. Farmer field research can help to counteract this harmful effect.

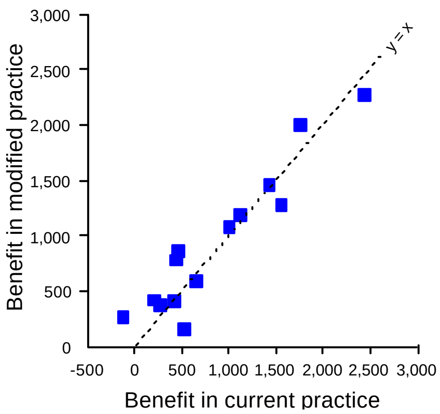

Fig. 18. Comparison of economic benefits of soybean production in current practices versus modified practices at 14 farmers' field sites (in '000 Indonesian Rp.); squares indicate individual sites. Squares above the dotted line are sites where a modified practice increased benefits over the current practice.

Improves ecosystems

An inherent benefit of farmer field research is that it results in healthier ecosystems. By observing and experimenting, farmers increase their understanding of the agroecosystem which makes them less reliant on chemical inputs. Also, after graduating from a field school, farmers are generally aware of the natural balance in rice and understand the importance of natural enemies. As a result, farmer field research frequently aims at restoring a damaged agroecosystem or reducing the reliance on chemical inputs for agriculture.

Initial studies at Kalensari (3.3) guided farmers towards non-chemical alternatives for the management of white stemborer. As a result of the strategy they developed, the use of carbamate insecticides dropped drastically in the entire district. Pesticide use in a young rice crop is detrimental to populations of aquatic and flying organisms and thus to the stability of the rice ecosystem as a whole[15]. Farmers in Sambon (3.4) used to spray against rice insects on a regular basis. Insects, they reasoned, affected yield and, hence, the fewer insects the higher the yield. Fast-acting insecticides which left the insects dead immediately after spraying were preferred. The farmer field school and ensuing field research changed these habits. Pesticide use was substantially reduced in the entire area, as was illustrated in Fig. 12 and 13. Likewise, at Dukuhwringin (3.5), onion farmers depended on insecticides for armyworm control. After 'discovering' the insect virus, they developed effective, non-chemical methods of control which helped restore predator populations. A farmer group in Deli Serdang, North Sumatra, experimented with methods to control golden apple snail, an exotic pest feeding on rice seedlings. They learned in a field school that early spraying can upset the rice ecosystem and, hence, they experimented with non-chemical methods. Plant remains of papaya, star fruit and cassava were found to be effective baits for the snails. The baits were regularly replaced to remove the snails.

Many other examples could be quoted to demonstrate that farmer field research increases farmers' understanding of the agroecosystem and thereby promotes sustainable farming practices. A few exceptions have been mentioned earlier, such as the use of botanicals to substitute chemical pesticides. If the learning process halts at reaching a 'silver-bullet' solution, continued facilitation is obviously required.

Develops farmer capabilities

The most important benefit of farmer field research, according to a questionnaire distributed among the groups at the action research facilities, is their increased knowledge[16]. We observed that farmer field research can influence the capabilities of farmers in many respects and that it can change mutual relations. Field research develops a sense of curiosity, the way of thinking, self-confidence, technical skills, and organising abilities.

All research starts with a sense of curiosity. Mr Aep's curiosity compelled him to do his research. But the farmers at Kalensari initially lacked this drive to discover. Instead, they became curious only after their observations were rewarded with new insights as they searched for alternative solutions for stemborer control. This resulted in a change in how they approached their problems. Development of one's curiosity is actively encouraged among academic scientists who learn to sharpen their observing and inquisitive abilities during their education. As the case of Kalensari suggests, curiosity needs to be encouraged among farmers too. Agricultural modernisation has removed the motive for experimentation. Curiosity grows when fed with new observations or experiences, suggesting a self-enforcing mechanism. This process starts at the farmer field school and continues in field research. Curiosity rewarded through observations motivates farmers to embark on a new experiment. Mr Aep's confidence grew over the seasons, as others learned from him and started to imitate his improved planting method.

Field research influences the way of thinking. Farmers learn to formulate testable ideas for which there are no ready-made answers. This challenges their intuition and their creativity to think across patterns. Moreover, while interpreting results, farmers develop their reflective thinking. Field research furthermore improves farmers' experimental skills and sampling methods through their understanding of confounding factors and natural variation. Lastly, field research enhances the organising skills of farmers. The farmers at Kalensari started off as researchers but when their results showed area-wide implications they became the organisers of a campaign. Subsequently, they facilitated a farmer seminar at the district level and learned to negotiate with the district's authorities. These are important social attributes in the context of community development.

Contributes to community development and networks

A community develops if its members develop in terms of new insights or skills, and if their interactions develop, resulting in new structures, forums and actions. Within the IPM programme, three elements of community development have been identified: education, generation of knowledge and organisation[17]. The process of development often starts with education, which entails the introduction of new principles and tools to aid in self-directed learning. In the context of IPM, initial education is through the farmer field school. The second element, the generation of knowledge, occurs through observation and original research, producing new, locally-relevant information. The third element, organisation, occurs through the sharing of knowledge and skills, resulting in new structures, forums and actions within the community. If one of the elements is weak or missing, community development will be sub-optimal. A lack of knowledge generation will thus obstruct development, whereas a lack of organisation will lead to individuality. The relative need for research skills or organising skills depend on the type of local problems and the stage of the research. The case of Kalensari (3.3) had a strong element of knowledge generation, whereas in Sambon (3.4) the organisational element predominated. In practice the three elements are intertwined because a strength in one element creates the need for another.

The self-enforcing mechanism of observation is accompanied by an impetus to share the new knowledge with others. As a result of their field research, farmers feel they have something to contribute to the farmer community, which strengthens their relationships and affects their status within the community. The cases of Kalensari (3.3) and Dukuhwringin (3.5) describe how farmer field research affects communities in a more direct way. The studies on white stemborer and shallot armyworm, combined with observations on the flight radius of moths, convinced the learning groups that their findings had wide-ranging implications. A need was created to involve neighbouring villagers in the control strategies which prompted the formation of networks with farmers in other villages.

To encourage networking, the IPM programme established seasonal farmer seminars at the sub-district level throughout the major rice-growing provinces of the country. The meetings enable farmers from different villages to share their research experiences and to make plans for the coming season. In many sub-districts, the seminars developed into an active forum with objectives beyond the exchange of experiences. A similar forum emerged at the district-level, frequently with financial support from the local government. In Lumajang, East Java, farmer seminars take place every season in each of eighteen sub-districts. In addition, a farmer congress is held seasonally for farmers from the entire district. This forum was initiated by farmers but is now fully sponsored by local government. Hence, farmer field research contributes to the structures, forums and actions within and between communities.

Influences policies

Field research can affect policies at different levels. Kalensari (3.3), Sambon (3.4) and Dukuhwringin (3.5) are examples of how field research resulted in village-level policy making. After having been exposed to farmer field research, the village heads called for area-wide campaigns to manage insect problems. The research at Kalensari affected policies at the district-level too. Farmers met with government officials to present their research, question the inclusion of insecticides in credit packages, and call for action against stemborer. Their presentation impressed the officials. A new policy statement was issued which explicitly stated the different steps suggested by the farmers. Seedbeds were to be planted after the moth flights, and egg masses were to be hand-picked from seedbeds and transplanted fields. Moreover, pesticides were removed from credit packages, while additional district funds were allocated to conduct farmer field schools. In several other districts, the government came up with more general decisions to support IPM training or farmer networking. These decisions emanated from community-level IPM activities, which included an element of field research. Farmer field research is not always recognised by local government. For instance, the earlier-mentioned work by Mr Sujai in East Java on the selection of a tungro-resistent rice variety was unknown to local authorities.

Influences formal research

The interaction between farmer researchers and scientists has mutual benefits. It may enrich or guide farmers' own research (see 4.2) or it may change the way formal research is conducted. A common problem with formal agricultural research is that it is insufficiently linked to the farmer situation. The analysis of opportunities and options is mostly conducted without the involvement of farmers. Moreover, studies are frequently conducted on-station, resulting in technologies which are ill-suited for farmers or not adopted by them due to inappropriate extension methods. The involvement of scientists as resource persons in farmer field research may influence the approach, methods and direction of formal research. Moreover, the involvement of farmers in scientific seminars may help reduce prejudices to enhance mutual respect and understanding (see Box). This opens the way for more effective farmer-scientist interactions.

Chapter 5. Supportive research

In the previous section, we pointed out that formal research is often insufficiently linked via the extension system to the farmer situation. Rural development programmes have attempted to fill this niche where formal structures have been weak. From the research angle, programmes have involved farmers in their research at various levels of participation[18]. From the 'extension' angle, programmes have embraced non-formal educational methods to help farmers adapt research findings to their own situation, as was the case with the IPM programme. In either case, there is a continued role for formal research to support increasingly farmer-driven programmes. This role consists of providing backup information and guidance on issues which are relevant to farmers.

5.1 Research base

Every development programme has its research base or its body of knowledge which compels it to take action towards a certain direction. The problems brought about by rice intensification during the Green Revolution called for new research. In the 1980s, brown planthopper outbreaks were found to be caused by the chemicals meant to protect rice against stemborers and defoliators. Concurrent studies on insect damage relationships showed that modern rice varieties–by having a high tillering capacity–could tolerate substantial damage to its stems or leaves; this type of damage had triggered the majority of insecticide applications on-farm. Through cross-disciplinary collaboration, the 'soft sciences' developed and field-tested farmer educational methods to challenge the ineffectiveness of hierarchical extension methods. The resulting research base prompted the launching of the IPM programme.

5.2 Responsive research

The positivist thinking of formal structures advocates that technology is delivered to farmers as a finished product. It thereby neglects the importance of adaptations and improvements which are constructed from within a programme by its direct stakeholders[19]. The research base sufficed for initiating the IPM programme. During implementation of the programme, however, a number of problems and issues arising from the field demanded attention in the form of research. Below, we discuss several examples of responsive research within the IPM programme.

Despite a progressive national policy on IPM, granular insecticides continued to be included in credit packages for use in seedbeds and at transplanting. Young rice plants and an immature rice ecosystem were considered particularly vulnerable to insect attack, suggesting the need for insecticides. A hypothesis opposing this view was tested through responsive research into the ecology of wetland rice[20]. The exploration unveiled a vast number of arthropod species. Most common were aquatic organisms or water surface dwellers, feeding on algae, on other arthropods or on dead organic matter. These 'neutral' organisms were found to fulfil an important function by providing food for predatory organisms which include the natural enemies of rice-feeding insects. Generalist predators of rice insects are abundant in unsprayed fields even before the time of transplanting. They feed predominantly on neutral arthropods, switching to rice insects only in due course. Insecticide applications rendered the young rice crop more vulnerable to insect attack by upsetting the aquatic fauna and suppressing predator populations before the appearance of rice-feeding insects.

Another example of responsive research involved the rice bug, a conspicuous insect which feeds on the developing panicle of rice. Being another target for continued insecticide applications by farmers, this particular insect received almost one third of all applications in rice. Threshold levels for spraying were available for traditional rice varieties only, and had been obtained by extrapolating damage levels from feeding rates. These levels did not take into account that rice normally leaves part of its grain unfilled as if to anticipate some level of loss. Farmers learned about rice bug in field schools but could not ascertain the influence it had on rice yield. Responsive research was conducted to elucidate the importance of the insect in modern rice[21]. The study involved observations by farmers in farmer field schools at 169 sites in East Java where fields were planted to one variety of rice. Trainers made additional observations on rice panicles and on soil characteristics to account for site-specific variables. The analysis showed a negligible effect of rice bug on yield at densities many times higher than had previously been assumed.

After the training in rice, farmers continued to misuse pesticides in soybean grown in rotation with rice. The research base for soybean was largely absent at the beginning, but the IPM programme began to train its trainers nevertheless. The initial training content was extrapolated from foreign soybean research and drew upon the experiences from rice IPM. Alongside the training, issues emerging from the field work were to be studied with the involvement of the trainers. This has proven to be an effective model of training development. Like rice, soybean was found to exhibit a considerable tolerance for leaf damage[22], the dominant cause of spraying. The population dynamics of soybean aphid, a fearful pest, were studied by trainees through field observations of predator behaviour. The results were modelled against the aphid growth rates showing that aphids had a growth advantage during the early season but were soon surpassed by the predation pressure of ladybirds which controlled the aphid in unsprayed fields[23]. Other soybean insects, such as defoliating caterpillars, stemflies, and pod-sucking bugs were also found to be under a significant level of natural control. These findings justified the initial emphasis of the training on plant tolerance for leaf damage and on natural enemy conservation.

5.3 Development of training curricula

Responsive research made use of simple methods and farmers' fields, in most cases with the involvement of farmers or trainers, producing results that could easily be replicated by farmers. Responsive research was part of the process of curriculum development. The results were used to develop tools and exercises to strengthen farmer education covering a range of topics, skills and disciplines. Occasionally, topics were purposely omitted from the curriculum if they guided the training in the wrong direction. Training on the so-called 'safe-use' of pesticides, for example, was never included because it de-emphasises the ecological approach and offers false security. Evolving tools and exercises were field-tested and subsequently introduced into the training programme at yearly workshops to raise the skills and knowledge of the trainers. Trainers tested the new content and incorporated it in on-going field activities, usually followed by an evaluation. Hence, the curricula and exercises underwent several iterative cycles of tests and adjustments with the participation of the programme's stakeholders.

To illustrate, the work on rice ecology produced ideas which were turned into field exercises. These included observations of seedbeds to record densities of predators, the preparation of miniature 'aquaria' to observe the development and function of aquatic organisms, and an exercise to evaluate the flow of energy within the agroecosystem. The tools were incorporated into farmer field schools to broaden the ecological scope. Likewise, various field exercises emerged from the research on soybean, involving field samples of grains or insects, direct field observations on predator behaviour, and field-cage experiments. These exercises were added to the soybean field school curriculum. In addition, a curriculum on field experimentation was incorporated in the curriculum for soybean (see 3.2). In contrast, the quantitative result that damage by rice bug was less of a problem than had previously been assumed was more difficult to translate into discovery-based exercises for farmers. The programme initially rejected the use of conservative threshold levels for control of rice bug, and the new findings justified this rejection. Consequently, the traditional method of bait-trapping was promoted as an alternative to chemical control of rice bug, even though the method was considered of limited benefit partly because only male rice bugs are attracted.

These few examples suggest that there is no ready-made procedure for curriculum development. What matters, however, are several concepts behind the process. First, the stakeholders need to participate from the research stage to the implementation of new curricula to ensure appropriate and relevant results. Second, the process should follow the learning cycle through several iterative rounds. Third, scientists need to stay with their objects until after the research stage in order to give advice on, or to suggest adjustments for, the process of curriculum development. The 'handing over' of technology from scientists via developers and extensionists to farmers with no one understanding or feeling responsible for the entire process of development has failed to deliver. The experiences of the IPM programme have demonstrated that the process of curriculum development, or technology development, needs to be both continuous and inclusive.

Chapter 6. Synthesis

In this final chapter we synthesise the information of the previous chapters by revisiting the three concepts stated at the beginning (see 1.4).

6.1 Education

The concept that education is needed to initiate farmer field research was valid in most situations. Traditional knowledge and farmers' skills suffered during the colonial era, when a massive employment of labour to support export crops left rice farming impoverished and caused an erosion of the knowledge base. Subsequently, rice farmers experienced a generation of technology transfer which suppressed the motive for field research. The farmer field school offers farmers a new perspective regarding their crop and helps them making independent decisions on crop management. Field school education motivates some graduates to embark on field research. The majority, however, feels insufficiently equipped and needs follow-up activities to learn about field research. Similarly, action research learning groups, consisting of field school graduates, need initial motivation by a facilitator before they enter into the 'research mode'. After a learning process, they are rewarded with results which encourages them to continue their research.

Farmer field research is an art as much as a science because it implies a process which is creative and holistic as well as analytic and diagnostic. It requires a discovering attitude as well as the scientific methods necessary to obtain unambiguous results. These two attributes of farmer field research are equally important. It has been argued that training farmers on experimental techniques restricts their skills and intuition necessary to interact with a complex environment; it causes farmers' own research to resemble formal research. Others have insisted that unsubstantiated perceptions can only benefit the observer whereas objective data can be shared among farmers. The IPM programme in Indonesia took both angles of entry. On the one hand, farmers were encouraged to initiate their own research by helping them enhance their discovering attitude. On the other hand, education was provided on the underlying principles of field experimentation (i.e. natural variation, interference, simplicity of design and a holistic approach) enabling farmers to design and conduct appropriate studies, while lecturing on standard experimental methods was avoided.

In conclusion, both education and facilitation are needed to help rice farmers enter the learning cycle until they discover that field research has become part of their farming profession.

6.2 Ownership

The concept that farmer field research can be effective only if farmers have ownership over the process was frequently challenged. The trainers of soybean field schools initially lacked confidence to facilitate others to do research and, consequently, decided for the farmers on how to conduct the experiment. This gave them 'ownership' over the research. Farmers participated but did not understand the purpose of research and were not inclined to implement its results. Mere participation of farmers in the research agenda of the trainer is therefore not effective. Appropriate facilitation tools are required to ensure that farmers play a major role in field research. This increases the impact of field research in terms of adoption and dissemination of results. The entry point of the learning process appears to be the most crucial phase in determining the level of farmer ownership. By identifying the options and by formulating ideas to be tested, farmers make the ensuing study their own.

Field research is conducted by individuals or in groups. Research in groups has the advantage that different views are reconciled, resulting in a richer learning process with more ideas and more discussions. Group research receives more attention from others than research by individuals. Moreover, groups are inclined more than individuals to actively disseminate their results or to take steps towards further action. Farmer field research within the IPM programme is for field school graduates and, therefore, they are used to working in groups. Obviously, there is a continued need for skilled and committed facilitators who know when to guide and when to let the learning process take its course, and who have experience with field research. These skills can only be nurtured within programmes which recognise that farmers themselves are a resourceful factor in development.

6.3 Impetus

By doing research farmers are motivated to do more research. This self-enforcing mechanism of farmer field research was observed clearly in the cases of Kalensari (3.3) and Dukuhwringin (3.5). The facilitator started the learning process but soon the group came up with their own ideas to be tested. The role of the facilitator waned as the farmers grew more confident and skilled in doing their own research. Moreover, several farmers began to act as facilitators to others, helping them to discover the value of the learning cycle.

The fact that field research tends to strengthen farmer capabilities -- while improving farming practices -- secures for its continuation and expansion. The IPM programme took two different approaches to establish farmer field research through action research facilities and follow-up field schools. The former, which are few in number and located in areas with specific pest or disease problems, receive long-term assistance. Its success rate was high due to the presence of a facilitator. Conversely, follow-up field schools, which are numerous and deal with general agricultural issues, require less intensive assistance. The success rate was lower but the overall impact considerable.

Results of farmer field research are rarely kept secret because farmers take pride in sharing their findings with the community, with local authorities and through networks. This sharing inspires other farmers to start field research. Farmer-to-farmer 'extension' has been successful within the IPM programme because it removes the boundaries of status, background and communication. Farmer field research plays an elementary role in community programmes at locations throughout the country. It provides the knowledge and motivation which help propel development.

To sum up, farmers need to relearn the skills to adapt their practices to their local environment while benefiting from modern developments in agriculture. Farmers have the fundamental right to take control of their farming situation and are in the best position to do so. We outlined the limitations of farmer field research with regard to studying complex issues (e.g. the effect of staggered planting on pests). Occasionally, there is a need to interfere in the learning process of farmers in order to avoid reductionism, which occurs when the learning process halts at reaching a 'silver-bullet' solution (as we observed in studies on botanical pesticides). Hence, there is a continuous need for backup support from, and interaction with, scientists, provided that the farmers keep the ownership over the research. We mentioned that farmer learning groups are still 'islands' surrounded and influenced by a system which relies on centralised extension methods. Obviously, a suitable environment is needed for the sustenance of farmer field research. Such an environment involves supportive policies and structures and a critical density of empowered farmer groups[24]. Experiences of the IPM programme have indicated the need for a mix of activities involving elements of education, knowledge generation and organisation[25].

More recently, farmer field research has been introduced into the IPM programmes in several other countries in Asia, most notably in Bangladesh, Cambodia, Vietnam, Nepal and Sri Lanka. As in Indonesia, education and facilitation are needed to start the learning process. The programmes in these countries have extended their coverage to marginal areas of rice cultivation which have been neglected by rice intensification programmes. In these areas there appears to be a high potential to improve crop production through farmer field research.

Epilogue

Back in the 1920s and 1930s, the entomologists Middelburg[26] and van der Goot[27] studied the white stemborer in the dry coastal belt of northwestern Java. They found that regulation of the time of sowing of rice in accordance with the pattern of rainfall was the most effective method to control this pest. Sowing times were initially regulated through a centralised supply of water. When the regulation was extended to rainfed areas, civil authorities had to ensure that farmers did not sow before the approved date. An official decree was considered unnecessary since the authorities had sufficient control over the situation on-farm. Farmers occasionally sowed before the approved date, causing the officials to order tilling of these fields while partly compensating for the damage. As a consequence of the enforced campaign, white stemborer seized to be a pest in the area from 1936.

Since the 1960s, improved irrigation and short-duration varieties allowed for double-cropping of rice in north-western Java. White stemborer was initially suppressed by the change in cultivation pattern. But rice varieties of an exotic lineage, which were vulnerable to stemborer attack[28], became widespread and caused renewed stemborer outbreaks in 1990. Despite the progressive national policy on IPM, broad-spectrum insecticides were added to credit packages for stemborer control. The non-chemical method of stemborer control, which had been enforced upon farmers in the colonial days, was rejected in favour of the use of chemicals. This shows that centralised programmes prefer to exercise control over the field situation through simplistic messages.

An ecologically sustainable solution to the recurring problem of stemborer outbreaks was developed within a farmer group in the village of Kalensari, through the encouragement of a facilitator. The rediscovered strategy to manage stemborer was tailored to the conditions in different areas. It received rapid acceptance from other farmer communities because of credibility among peers. Recognising the experience and knowledge of the learning group, the civil authorities decided to change their agricultural policy by putting a degree of control back into the hands of farmers. A critical density of field activities, which was established by the IPM programme, contributed to the success of this case.

Farmers have shown scientists and policy-makers that they are not just the clients of technology. They are a powerful resource with the potential to improve their farming methods and to disseminate their knowledge. Their collective time spent in the field, while creating testable ideas, by far outweighs that of any other section of society. The type of assistance that post-green revolution farmers in Indonesia and elsewhere currently need from agricultural programmes is a re-education on ecology and the facilitation to strengthen experimentation and mutual cooperation.

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[1] Van der Poel, H. ,1864. De schadelijke invloed van het cultuurstelsel voor den inlandsche landbouw. Tijdschrift Nederlandsch Indische Maatschappij voor Economie en Landbouw, 12, Batavia.

[2] Widodo, S., Nasrullah, Prajitno, D., Sumartono, Sudjono, S., Sumangat, Mudjito, P.S., Wurjono, and Widodo, 1979. Identifying constraints to higher rice yields in Yogyakarta, Indonesia. In: Farm-level constraints to high rice yields in Asia: 1974-77 (Ed. International Rice Research Institute), pp. 123-161. International Rice Research Institute, Los Baños.

[3] Oka, I.N., 1993. Pest control in Indonesia: Lessons to be learnt from our experiences. Conference on Environment and Integrated Pest Management, 11-14 January, 1993, Pnom Penh, Cambodia.

[4] Kenmore, P.E., Cariño, F.O., Peñez, C.A., Dyck, V.A. and Gutierrez, A.P. , 1984. Population regulation of the rice brown planthopper (*Nilaparvata lugens* Stål) within rice fields in the Philippines. Journal of Plant Protection in the Tropics 1, 19-37.

[5] Pingali, P.L., Moya, P.F., and Velasco, L.E., 1990. Prospects for rice yield improvement in the post-green revolution Philippines. Philippines Review of Economics and Business 18, 85-106.

[6] van den Berg, H. & Lestari, A.S., 2001. Improving local cultivation of soybean in Indonesia through farmers' experiments. Experimental Agriculture, 37, 183-193.

[7] Pretty, J.N., 1995. Participatory learning for sustainable agriculture. World Development 23, 1247-1263.

[8] Biggs, S.D., 1989. Resource-poor farmer participation in research: a synthesis of experiences from nine agricultural research systems. OFCOR Comparative Study Paper No. 3, ISNAR.

[9] Pontius, J., Dilts, D. and Bartlett, A., 2001. From farmer field schools to community IPM: Ten years of IPM training in Asia. FAO Programme for Community IPM in Asia.

[10] Pontius, J., Dilts, D. and Bartlett, A., 2001. See above.

[11] Ooi, P.A.C., 1998. Beyond the Farmer Field School: IPM and Empowerment in Indonesia. International Institute for Environment and Development (IIED) Gatekeeper Series No. 78. London. 16 pp.

[12] Kishi, M., Hirschhorn, N., Djajadisastra, M., Satterlee, L., Strowman, S. and Dilts, D.R., 1995, Relationship of pesticide spraying to signs and symptoms in Indonesian farmers. Scandinavian Journal of Work and Environmental Health 21, 124-133.

[13] Shepard, B. M. & Shepard, E. F., 1997. Integrated Pest Management Research: Development and Training Activities for Palawija Crops in Indonesia. Final Report. Clemson: Clemson University.

[14] Ooi, P.A.C., 1998. See above.

[15] Settle, W. H., Ariawan, H., Astuti, E. T., Cahyana, W., Hakim, A. L., Hindayana, D., Lestari, A. S. and Pajarningsih. 1996. Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. Ecology 77, 1975-1988.

[16] Meijerink, G., 1999. Personal communication.

[17] Pontius, J., Dilts, D. and Bartlett, A., 2001. See above.

[18] Okali, C., Sumberg, J. and Farrington, J. 1994. Farmer participatory research: rhetoric and reality. Intermediate Technology Publications.

[19] Röling, N.G. and Wagemakers, M.A.E., 1998. A new practice: facilitating sustainable agriculture. In: Facilitating Sustainable Agriculture (Eds. N.G.R. Röling and M.A.E. Wagemakers), pp. 3-22, Cambridge Univ. Press.

[20] Settle et al. See above.

[21] van den Berg, H. and Soehardi, 2000. The effect of rice bug, *Leptocorisa oratorius*, on rice yield. Journal of Applied Ecology 37, 959-970.

[22] Shepard, B. M. & Shepard, E. F., 1997. See above.

[23] van den Berg, H., Ankasah, D., Muhammad, A., Rusli, R., Widayanto, H.A., Wirasto, H.B. & Yully, I., 1997. Evaluating the role of predation in population fluctuations of the soybean aphid *Aphis glycines* in farmers' fields in Indonesia. Journal of Applied Ecology 34, 971-984.

[24] Dilts, D.R. and Pontius, J.C., 2000. IPM and farmer-led development: lessons from Indonesia. In: Farmer-led Integrated Pest Management in Asia and the Pacific (Ed. Asian Productivity Organization), pp. 34-42. Asian Productivity Organization, Tokyo.

[25] Pontius, J., Dilts, D. and Bartlett, A., 2001. See above.

[26] Middelburg, D.J.A., 1932. Rijstboorderbestrijding door zaaitijdregeling in West Brebes. Landbouw 8, 608-646.

[27] Van der Goot, P., 1948. Twaalf jaren rijstboorderbestrijding door zaaitijdregeling in West Brebes (Re. Pekalongan). Mededelingen van het Algemeen Proefstation voor de landbouw, Buitenzorg, Java, No. 78.

[28] Triwidodo, H., 1993. The bioecology of white rice stemborer in West Java, Indonesia. PhD Thesis, Univ. Wisconsin, Madison.