ISSN 0215 — 1650

MARIF Monograph Number 3

Maize On-Farm Research in The District of Malang

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Cover design : Achmad Winarto

Series MARIF MONOGRAPHS

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MARIF Monograph No. 3	Maize On—Farm Research in the District of Malang.

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ABSTRACT

Maize on-farm research in the District of Malang, East Java.

This paper describes principal results of the on-farm research program (OFR) with a farming systems perspective (FSP) for palawija farming systems in the District of Malang, East Java Province, Indonesia, as conducted by the Malang Research Institute for Food Crops (MARIF) in the period 1984-1986. The work was carried out mainly in the regionally important maize growing area on young volcanic soils.

The main objectives were :
(1), to identify major constraints to crop productivity
(2), to carry out research, aimed at overcoming these constraints in farmer's fields, and
(3), to translate the principal results of this research into practical recommendations for farmers.

The program has been implemented by an interdisciplinary team, consisting of plant breeders, entomologists, plant pathologists, agronomists and agro-economists. This team has cooperated closely with farmers and extension workers in the study area. The approach with was followed had been developed by the International Maize and Wheat Improvement Center (CIMMYT) and was adapted to local conditions. The salient aspects of this approach included: a close linkage between surveys and on-farm trials; a sequential approach whereby each cycle of research activities is planned in conjunction with the findings of previous research; formulation and testing of explicit hypotheses on problems that limit productivity and their causes and interactions. The program was started in January 1984 with an exploratory survey. Since then, five crop cycles of on-farm trials, a maize production survey and other survey and research activities have been conducted. A sixth cycle of trials is underway (November 1986 - February 1987).

As a result of the research to date, major production problems and their causes have been identified, together with interactions between these problems within the context of the farming systems parameters.
These include :
- Shootfly infestation
- Severe overplanting and early season interplant competition
- Plant stand manipulation resulting in low harvest densities
- Nitrogen/phosphate nutrient imbalance
- Ineffective timing of fertilizer application.

In addition, the following problems have been identified on tentative evidence:
- Lower yield potential of traditional maize varieties
- Poor quality of farmer's maize seed
- Availability of potassium and sulphur.

Possible solutions for these problems were identified and tested with the result that farmers cooperating in the on-farm trials have been able to increase maize yields from 1.8 to 4.8 tons of dry grain per hectare. The recommended practices can be implemented piecemeal, in a sequential adoption, or in a package. The observed sequence for spontaneous adoption is for farmers to adopt first crop protection methods, and lower plant densities, usually, in conjunction with an improved variety, and subsequently to adopt improved fertilizer management practices.

The recommended practices require only modest increases in inputs and simple changes in management. Their adoption is within the scope of most farmers in the study area, as all aspects of the improved management practices were easily understood by cooperating farmers, whose conditions were generally representative for the study area.

ACKNOWLEDGEMENTS

An essential contribution to the present OFR research program was made by farmers in the study area. The MARIF team wishes to thank in particularly the twenty-eight farmers, who participated in on-farm trials.

The assistance of the staff of the extension service in the district (DIPERTA, Malang) is herewith acknowledged.

Thanks are also due to Dr. R.N. Wedderburn and Dr. Carlos De Leon from the maize program of CIMMYT- Bangkok for their valuable suggestions.

The authors are grateful to Dr. Soetarjo Brotonegoro, Director of the MARIF and Dr. K.G. Eveleens, Teamleader of the ATA 272 project for their encouragement and assistance given during the implementation of the study.

The participation and help of the following MARIF-ATA 272 staffmembers was highly appreciated :

Ir. Bambang Sulistyono
Ir. Bedjo
Ir. Chamdi Ismail
Ir. Herman Subagio
Ir. Joko Purnomo
Ir. Laumans, Q.J.
Ir. Ruly Krisdiana
Ir. Sugiyatni Slamet
Ir. Sumartini
Ir. Supriyatin
Ir. Tutiek Yogiarti
Dra. Widjorini Eveleens-Soemartojo
Ir. Yudi Widodo
Mr. Cipto
Miss Lilik Qomaria
Mr. Muchdar
Mr. Muchlish Adie
Miss Nunung
Mr. Sutarno
Mrs. Ulfah Marsum

We are very thankful to Mrs. Els Lumansik who patiently typed many drafts for this paper and the working papers on which this paper is based.

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ACRONYMS

AARD - Agency for Agricultural Research and Development of the Ministry of Agriculture, Jakarta
ATA 272 - Technical Cooperation Project between Indonesia and The Netherlands
BULOG - Badan Urusan Logistik, Jakarta - the national logistics agency
CIMMYT - Centro International de Mejoramiento de Maiz y Trigo The International Maize and Wheat Improvement Center Mexico
CRIFC - Central Research Institute VcFp Crops, Bogor
CSR - Centre for Soil Research, Bogor
DIPERTA - Dinas Pertanian - the provincial agriculture; services bureau
FSP - Farming Systems Perspective
MARIF - Malang Research Institute for Food Crops
OFR - On-farm research

DEFINITIONS

- palawija = non-rice food crops such as maize, soybean, other grain legumes, cassava and sweet potato
- sawah = bunded land, water supply from man-made sources or rain dependent
- tegal = unbunded land rain dependent, often with light textured soil, ranging from flat to slopy
- urea = nitrogen chemical fertilizer with 46% N
- TSP = phosphate fertilizer with 45% P_2O_5

EXCHANGE RATES

Period : January 1984-September 1986 - US$ 1 = Rps 998 - 1125
after September 1986 - US$ 1 = Rps 1635.

MEASUREMENT SYSTEM

All measurements are according to the metric system.

1.0 INTRODUCTION

This paper summarizes work conducted to date in on-farm research (OFR) by the Malang Research Institute for Food Crops (MARIF), located near Malang, East Java, Indonesia.

The program was initiated in January 1984 in cooperation with the International Maize and Wheat Improvement Center (CIMMYT) and the Agricultural Technical Cooperation Project between Indonesia and The Netherlands (ATA-272). The interdisciplinary MARIF OFR team consists of plant breeders, entomologists, plant pathologists, agronomists and economists.

The objectives were : 1. Try out OFR procedures on a pilot basis in order to ascertain their appropriate role in MARIF activities, 2. Develop useful recommendations that farmers in a study area would rapidly adopt. Because of the pilot nature of the program, it was decided to restrict initially OFR activities to one relatively homogeneous study area in Malang District. As the program developed, OFR work started in other study areas as well. However, the main body of this report only covers the original OFR pilot effort.

The activities in the study area to date include an initial exploratory survey, a production survey, additional surveys on specific issues, five crop cycles of on-farm experiments and soil analyses. Currently a sixth cycle of on-farm experiments is underway (from October 1986 to February 1987). With two cycles of experiments per year, research has been on-going for about three years. These activities have been described in detail in a series of nineteen working papers (see Annex 1).

The program is based on the procedures for "on- farm research with a farming systems perspective (OFR/FSP)" developed by CIMMYT, documented in BYERLEE, COLLINSON (1980) and numerous other publications. The major steps in these procedures are diagnosis, planning, experimentation, assessment and formulation of recommendations. The guiding principles of the OFR/FSP procedures are:

- A careful focus on important problems and possible solutions
- On-farm research under representative conditions
- A focus on defined groups of farmers
- Farming systems perspective
- Near-term solutions
- Participation of farmers and extension service
- Interdisciplinary cooperation among biological and social-scientists
- Feed-back between on-farm and on-station research.

This paper contains a synopsis of relevant information on the study area, followed by a diagnosis of main problems and a discussion of evidence on possible solutions, obtained from the on-farm trials, and needs for further research.

2.0 DESCRIPTION OF THE STUDY AREA

The pilot study area is located in the District of Malang, East Java Province as shown in Figure 1.

Farmers in the District of Malang operate complex farming systems, featuring an intensive use of a small land resource base. Major enterprises include livestock, annual crops, home garden and perennial crops. The object of the present research was annual palawija cropping but interactions with livestock and home garden enterprises will be indicated where relevant.

2.1 Crop production systems in the District of Malang

Crop production systems in the District of Malang are largely determined by land-type (sawah versus tegal), soil and elevation. Sawah systems include irrigated and rainfed wetlands with rice-based cropping systems, in which palawija crops are generally grown after rice. Tegal fields (rainfed, unbunded drylands) are used for the bulk of palawija production. A summary of major crop production systems is shown in Table 1.

The tegal systems on young volcanic soil (system 2) was chosen as the first OFR study area, as it represents a relatively simple production system. A more complicated system with maize, cassava and other crops was selected in early 1984 for a second study area. This second area is not discussed in this paper.

Figure 1. Map of Indonesia.

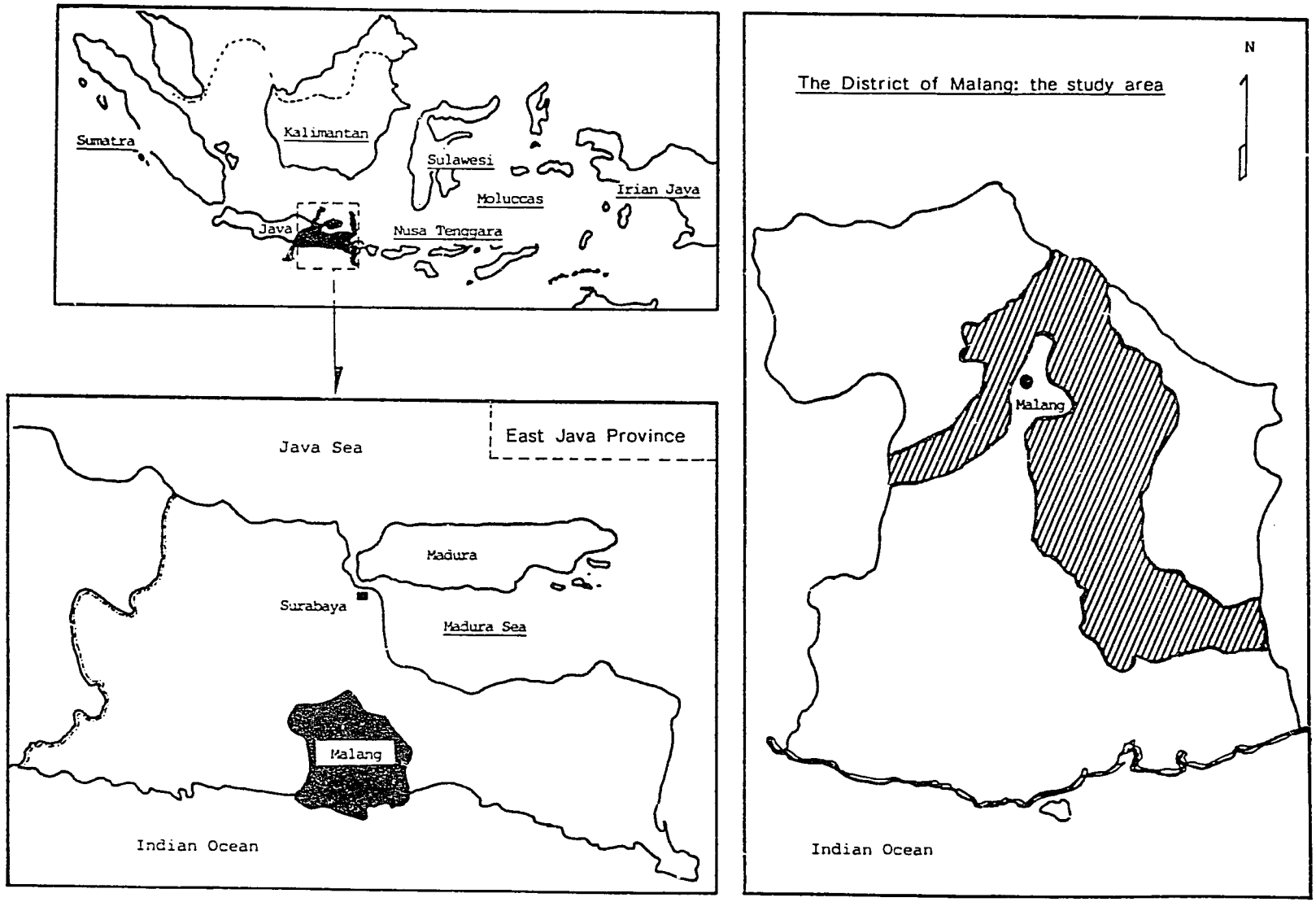


Table 1. **Major crop production systems in the District of Malang**

System No.	Land type	Soils	Dominant crops	Altitude a.s.l.	Physical area (%)
1.	tegal	limestone	maize cassava grain-legumes sugarcane	< 600	43
2.	tegal	young volcanic	maize dry seeded rice	400-700	37
3.	sawah	alluvial & young volcanic	transplanted rice maize	400-700	15
4.	tegal	young volcanic & volcanic ash	maize and horticultural crops	400-1500	5

Major characteristics of the selected system are: young volcanic soils; tegal land type; medium altitude; maize-maize or upland rice-maize cropping pattern. Maize is by far the most important enterprise in this crop production system. More details on maize cropping patterns and the role of maize in East Java can be found in Monograph 2: Palawija Crops, chapter 3.1 (BROTONEGORO *et al.*, 1986).

The selected system, henceforth referred to as the "study area", covers about 30,000 ha of physical area in Malang or roughly 60,000 ha of annual harvested area, and includes an estimated 40,000 farms, each operating on approximately 0.8 ha of tegal farmland. Extrapolation to other districts within East Java with similar conditions for which these recommendations are valid, results in an area base of approximately 150,000 ha, or 10-15% of the total maize area in East Java, and would include up to 200,000 farms.

It should be noted that 28% of farmers in the study area operate on both tegal and sawah. That is, they operate system 3 as well as system 2, as defined in Table 1. This leads to certain system interactions, viz. increased labor scarcity in the early stages of the first crop cycle, a lower dependence on maize as a starch staple, etc . These interactions will be pointed out again in the relevant sections, when technology adoption is affected.

Apart from this, the farmers in the study area encounter reasonably similar circumstances, problems and opportunities and for most purposes would likely use similar kinds of new technology.

2.2 Physical conditions

Climate: The average rainfall in the study area amounts to 2130 mm per annum with 5 to 6 wet months (over 200 mm rain/month) and 2-4 dry months (less than 100 mm of rain/month), which results in sufficient moisture for two crops per annum. The annual rainfall pattern, however, shows considerable variation between years and locations. Fifteen years' rainfall data for two locations are presented in Annex 3. The average temperature is 24°C with an average minimum of 18.6°C and maximum of 25.7°C. The relative humidity ranges from 77 to 85% (ANON., 1984). According to OLDEMAN (1975) this zone is classified as agro-climatic zone C.

Soils: The main soil categories occurring in the District of Malang are: young volcanic soils (36%), volcanic ash (18%), limestone and lithosoils (37%) and alluvial (9%). The study area covers the young volcanic soils which consist of latosols (inceptisols) (60%), regosols (entisols) (26%) and other soil types (14%). These soils are locally known to be low in organic matter and highly deficient in phosphate and other plant nutrients (potassium, sulphur and zinc). General characteristics of major soil types and their occurrence are presented in Annex 4.

2.3 Economic circumstances

There are a number of socio-economic circumstances influencing farmer decision-making in the Malang study area. Of interest are input markets, government price policy for inputs, marketing, and consumption patterns and taste preferences. Given the predominant position of maize in the crop production system, economic circumstances that affect maize are highlighted.

Input markets: Input markets in the Malang area operate reasonably well. Fertilizer and pesticides are readily available at highly subsidized prices. For example, a farmer in Malang can buy one kg of nitrogen or phosphate in the most readily available form (urea or TSP) in exchange for only 2 kg of maize. In contrast, a farmer in Thailand can buy one kg of nitrogen in the most readily available form (21-0-0) in exchange for 9.5 kg of maize. In the past, improved maize seed was not easily available to farmers in the study area. This situation has improved considerably since 1983, when government policy changed to encourage private firms to participate in seed production and marketing. Currently, two hybrids and one improved variety (Arjuna) are commercially available. Other input markets, like labor, animal traction, etc., are reasonably efficient.

Marketing: The marketing of maize for cash sale is largely in the hands of private traders, who compete to purchase this crop in order to meet the rapidly expanding demand by feed-mills in Surabaya. Other maize is marketed through the government marketing agency (BULOG).

Consumption patterns and taste preferences: Maize production in Malang has two major end uses: it is a major starch staple, especially for low income producers, and an important source of cash. About 70% of the maize produced is used for direct human consumption. Maize is the main non-rice starch staple in East Java. In the study area many farm families consume more maize than rice. The importance of maize as a starch staple raises some concerns about cooking and taste preferences, and how these might effect farmer adoption of new varieties. In East Java farmers prefer yellow varieties. Both traditional and improved varieties, such as Arjuna and the Cargill C-1 Hybrid, have a yellow grain colour. There are reports, however, that Arjuna is more difficult to crack than other varieties for the preparation of local dishes. These dishes rely on the boiling of maize cracked to resemble rice.

2.4 Crop-livestock interactions

Crops and livestock interact in the study area in three major ways :

- Cattle provide draft power for land preparation and weeding
- Cattle manure is applied as fertilizer to selected fields
- Maize thinnings serve as one source of livestock feed.

Manure: In any given year about half of the farmers apply manure to their maize fields. This takes place before the first plowing for the rainy season crop. Those farmers who do not apply manure tend to be those without livestock, or those who use the manure for higher-valued crops. At least once every few years nearly all fields used for maize cropping receive manure, which is said to be one source of deficient nutrients.

Fodder: Only 25% of the farmers report using maize thinnings as a major source of cattle fodder. Other fodder sources (including grasses and weeds) are reported to be more important, even in the maize season. Furthermore, all farmers with livestock report having sufficient alternative fodder sources (MARIF, 1985).

2.5 Maize production practices in the study area

Taking into account the dominance of the maize enterprise in the study area, selected maize production practices deserve some description. Farmers in the study area follow fairly similar practices. Some of these are listed in Table 2.

Table 2. Maize production practices in the study area.

Practice	Findings Quantity	Unit
Plant traditional, unimproved varieties	48	%
Plant older improved varieties	29	%
Plant modern improved varieties	23	%
Use self supplied seed	75	%
Average density at seeding(unimproved varieties)	150,000	seeds/ha
Take out bad plants	83	%
Applied manure last season	57	%
Apply nitrogen	100	%
Average nitrogen dose	162	kg N/ha
Apply phosphate (only in specific villages)	30	%
Average maize yield,local varieties	1.8	ton/ha

Source: MARIF (1985).

Land preparation and planting dates: Farmers use fairly intensive land preparation practices. They plow their maize fields 2-4 times, using cattle for draft power, then harrow and level the soil. In case manure is applied, it is spread during the dry season before plowing. The rainy season maize crop is seeded between September and November, depending on the onset of the rains. This crop is harvested in December-February. The post-rainy season maize crop is - ideally - seeded immediately afterwards. However, excess rain at this time frequently forces some farmers to delay this planting for up to several weeks. Farmers, who grow upland rice as the rainy season crop (which is usually harvested after 120 days or more) automatically are forced to plant their post-rainy season maize crop later. Thus seeding of their maize takes place several weeks after the main post-rainy season planting period.

Varieties: Relatively few farmers use recently released improved varieties (23%), although most farmers are familiar with them (72%). Few farmers purchase new seed from stores, whether certified or non-certified. Farmers indicate that yield and tolerance to insect damage and lodging are important considerations in selecting maize varieties. Few farmers indicate that cooking quality is a major factor in varietal selection. It should be noted, that the "farmer's variety" is a complex mix of traditional varieties, like e.g.Goter and Genjah Tongkol, improved varieties released more than a decade ago, e.g. Harapan, and a touch of the recently released improved varieties, e.g. Arjuna.

Plant population and thinning: Farmers grow maize at quite high densities, with early plant stands of about 150,000 plants/ha. Farmers using improved varieties, e.g. Arjuna, plant at a somewhat lower density, around 105,000 - 110,000 plants/ha. Most farmers (83%) manipulate their plant stands and remove poorly developed and diseased plants. Seeding is done by hand, either in holes made by sticks or in the plow furrow. Spatial distribution varies from 70 x 25 cm to 100 x 50 cm, according to variety and individual practices.

Weeding: Maize fields in the study area are rarely weedy. Weeding is generally done twice. Cattle are used for weeding between rows, while weeding within the row is done by hand. The first weeding takes place about 3 weeks after seeding and is often combined with a fertilizer application and the commencement of "thinning" in which weak or poorly developed plants are removed. The second weeding, at about 5 to 6 weeks after seeding, usually takes the form of a "hilling-up".

Fertilizer: All farmers use nitrogen fertilizer with an average dose of 162 kg N/ha. Nitrogen, in the form of urea, is usually applied twice, coinciding with the first and second weedings. These high doses are a reflection on the availability and low farm-level price of urea. Relatively few farmers use phosphate, although phosphate as TSP is sold at the same subsidized price as urea. It should be noted that most phosphate users identified in the farm survey come from the same few villages. Potassium is seldom used on maize by farmers in the study area.

Table 3. Fertilizer use by variety

Variable	Unimproved varieties and older improved varieties	Modern varieties	All varieties
Farmers using nitrogen	100 %	100 %	100 %
Average N dose in kg/ha	158	168	162
Farmers using phosphate	19 %	50 %	31 %
Average phosphate dose in kg/ha (users only)	48	69	60
Farmers using potassium	0 %	20 %	8 %
Farmers using manure	64 %	47 %	57 %
Farmers using nitrogen at seeding	8 %	33 %	18 %
Farmers using nitrogen at 3 weeks after seeding as first application	86 %.	66 %	78 %

Source : MARIF (1985)

Pests, diseases and crop protection : Farmers are familiar with many pests and diseases, but report that these seldom reduce yields seriously. Regarding crop protection, only 13% of farmers report using pesticides, mainly Ridomil applied as a seed treatment for *Peronosclerospora maydis* (downy mildew). Researchers noted, however, severe and widespread infestations of *Atherigona* spp.(shootfly) and *Phyllophaga helleri* (white grub) particularly in plantings carried out several weeks later than the main planting period and in the post-rainy season.

Post harvest operations and disposal of produce : Maize is harvested by farmers 10 to 20 days after physiological maturity. Harvesting is done by hand. Ears are carried to the farm house and sun-dried for several days. After drying the moisture content of the grain is still above 18%. Seed for the next planting is mostly selected from the last harvest. Selected ears or seed for planting are stored above the cooking place to prevent losses caused by storage insects and rodents. Only a few farmers buy new seed after the original purchase of a new variety. Most farmers in the study area use their maize crop for home consumption, with occasional sales of surplus quantities.

Differences between rainy- and post-rainy season cropping: So far the discussion dealt with the rainy season and the post-rainy season maize crops as being managed in a similiar way. However, differences between the two crops exist and are indicated below:

- Land preparation is usually more intensive for the rainy season crop
- Manure is mainly applied before seeding of the rainy season crop
- Throughout the study area, seeding of the rainy season crop takes place more or less at the same time, that is immediately after the onset of the first rains, and cover only a few weeks. However, seeding of the post-rainy season crop shows considerable variation , and may cover a period of over one and a half months.
- In most years, shootfly problems appear to be more severe in the post-rainy season.

3.0 DIAGNOSIS : PROBLEMS AND THEIR CAUSES

In this section problems are discussed associated with maize production in the study area. Initially, the team noted that :

> "Despite intensive management, including proper tillage practices, row planting, adequate weeding practices, high nitrogen and manure applications, maize crops in the domain, regardless of variety, show symptoms of spindly stalks, and discoloured leaves. Yields are low, with an average of 1.8 t/ha grain and only few farmers obtain yields above 2 t/ha. Yet on-station research indicates that 5 t/ha can easily be obtained from Arjuna (MARIF, 1985).

At first, attention was focussed on three factors: variety, plant population and fertilizer management. However, it became evident during the field work that other problems required attention, like early season insect damage. As research continued, the team gained a better appreciation of the interaction of these problems, and the particular causes of each of them.

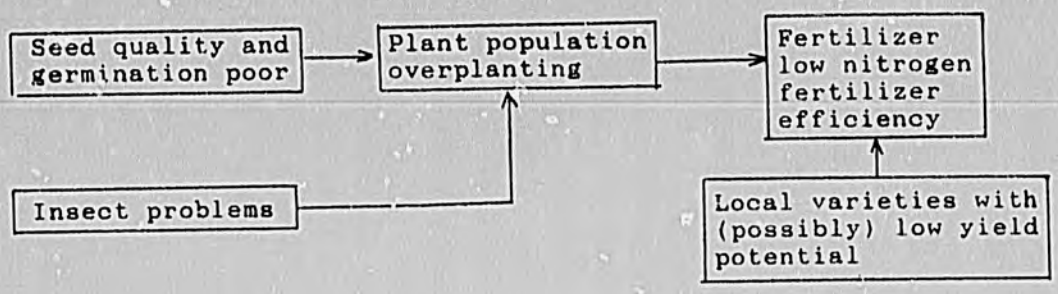
According to current knowledge the following factors adversely affect maize production :

- Damage occurring during the early growth stage caused by *Atherigona* spp.(shootfly) and *Phyllophaga helleri* (white grub), causing growth retardation and reduction of plant stands.
- The use of excessively high seed rates, causing interplant competition during early growth stages, and plant stand manipulation that leads to low harvest densities.
- Low fertilizer efficiency causing higher production costs.
- The possible use of low quality seed and of varieties with a lower yield potential.

These problems and some of their interactions are presented in Figure 2. Note that poor seed quality and shootfly damage contribute to overplanting, and that overplanting contributes to a lower nitrogen fertilizer efficiency.

Each problem and its respective causes are discussed in more detail in the following sections.

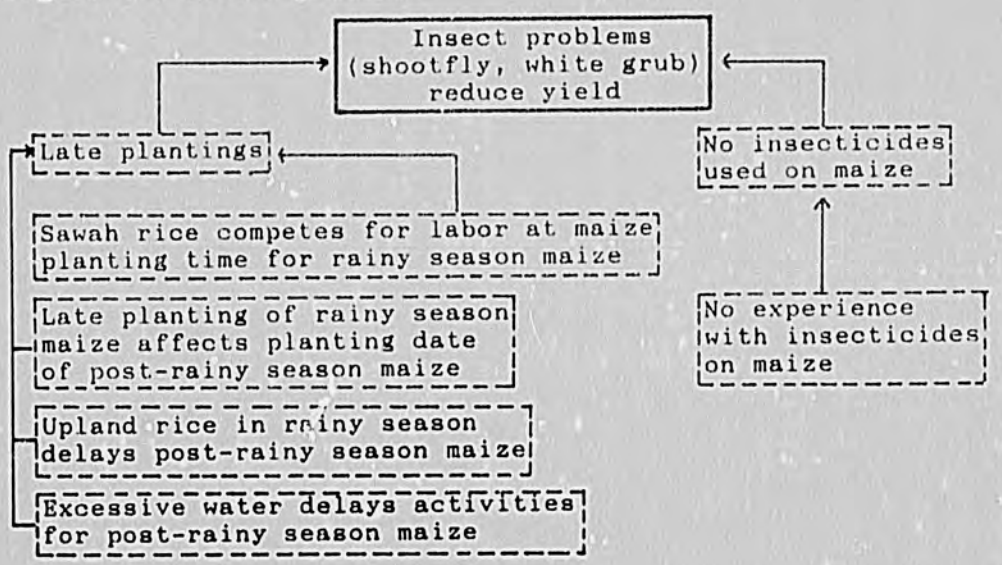
Figure 2 : Components of the main problem



3.1 Insect damage

Maize in the study area is often damaged in the early stages of growth by shootfly and white grubs. Major causes of this problem include a high natural incidence of these insects, and late planting of maize. In turn, late seeding of rainy season maize is caused by uneven distribution of early rains and competition for labor with sawah crops. Late seeding of the post rainy season maize is caused by: (1) late planting of the rainy season maize crop; (2) planting maize after rainy season upland rice; (3) excessive rainfall extending the turn-around period between the two maize crops. The severity of insect problems varies greatly from one year to another. The rainy season maize crop usually suffers somewhat less from insect damage than the post-rainy season crop. Interactions between the insect problem and its causes are shown in Figure 3.

Figure 3 : Insect problems



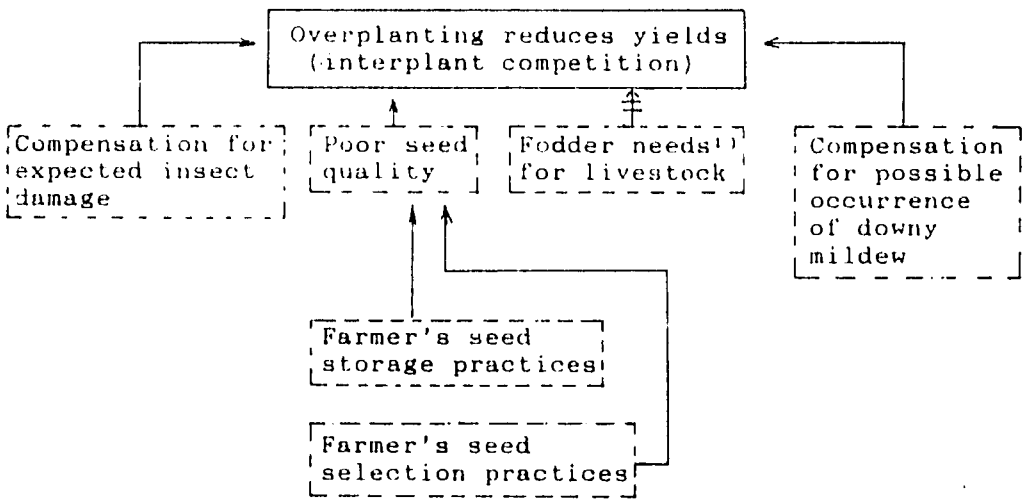
3.2 Plant population management

The farmers' practice of overplanting leads to severe interplant competition in the early growth stages with plant densities of about 150,000 plants/ha. This is particularly true for traditional unimproved varieties. The practice of systematically taking out bad plants, necessary in the absence of pest control, results in low harvested densities of less than 50,000 plants/ha. There are a number of reasons for these practices :

- To compensate for expected damage and loss of plant stand due to shootfly and whitegrub attacks
- To compensate for a possible occurrence of downy mildew
- To compensate for expected low seed germination rates and poor plant vigor, in turn caused by farm-level seed storage problems (?)
- To provide fodder for livestock. It was originally thought that farmers overplant and thin their maize in order to obtain fodder for their cattle. However, as was seen in an earlier section (2.4), farmers do not largely depend on maize as a fodder.

Interactions between the plant population problem and its causes are shown in Figure 4.

Figure 4 : Plant population management



[1] Not supported by research results.

3.3 Fertilizer management

Farmers apply on average 162 kg/ha of N to their maize fields, but do not ontain high yields. This problem is explained as follows:

Overplanting: High plant populations during early growth are due to high seed rates. These high populations often lead to severe competition between plants, causing a reduction of the grain production per kilogram of nitrogen applied.

Nutrient imbalance : Most farmers use only nitrogen fertilizers. They generally do not use phosphate or potassium on their maize crop, though the soil analysis shows that most of the young volcanic soils are deficient in both elements. One source of nutrients is manure, which during 1984 was applied by about half of the farmers.

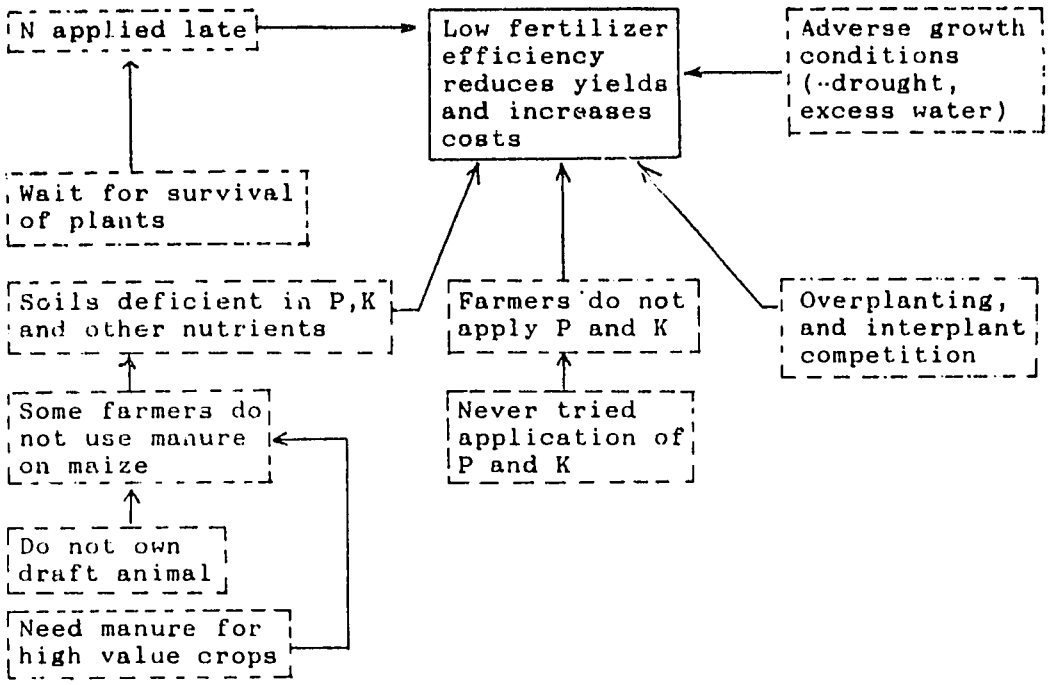
Timing, amount and method of nitrogen application:
The majority (80%) of the farmers give the first nitrogen application between 2 to 4 weeks after seeding and the second application at about 6 weeks after seeding.
Farmers, aware of the damage caused by shootfly and white grub and of plant losses due to poor seed quality, prefer to postpone fertilizer application until a good plant stand is obtained. Sometimes replanting is required. Some farmers also have learned that fertilizer mixed with seed will burn the seed. They have little experience with other application methods, e.g. fertilizer placed in an adjacent hole, 10 cm away from the seed.

Approximately 20% of the farmers apply some nitrogen at seeding. If the fertilizer is mixed with the seed, only 3-4 kg/ha of ammonium sulphate is used (< 1 kg N/ha).

About 18% of the farmers apply all nitrogen at one time only.

The problem of fertilizer management and related causes are shown in Figure 5.

Figure 5 : Fertilizer management



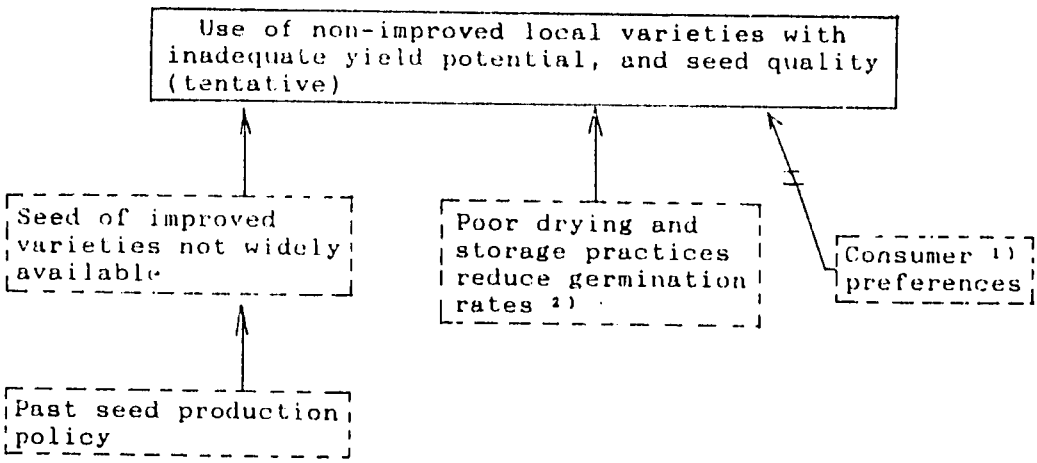
3.4 Variety and seed quality

Another factor explaining low farm-level yields may be seed. Regarding variety and yield potential, many farmers use improved varieties released many years ago, such as Perta (1956), Harapan (1964) and more recently Arjuna (1980). These farmers save from each harvest some seed for the next planting. Due to cross pollination with traditional varieties and land races, genetic erosion occurs. This results in a gradual decrease of varietal purity and possibly yield potential. In some of the on-farm trials, these older, improved varieties performed very well and yields were not significantly lower than those of recently introduced improved varieties, grown under the same conditions of improved management. However, many other farmers (48%), continue to use traditional, non-improved varieties (Goter, Genjah Tongkol). As yet there have been few direct comparisons of these latter materials with improved alternatives.

As can be seen in Table 2, only 23% of the farmers plant Arjuna, the most recently released variety. Arjuna matures in 95-100 days, other varieties have a maturity range from 85 to 115 days. About 48% of farmers report using traditional, unimproved varieties.

Regarding seed quality, farmers who experience low germination rates and poor seedling vigor tend to overplant. This was indicated by the outcome of the formal production survey in which 42% of the farmers reported low seed quality as one reason for overplanting.
Varietal and seed-related problems and causes are shown in Figure 6.

Figure 6 : Variety and Seed Quality



1) Not supported by research results.
2) Currently being investigated.

4.0 EVIDENCE FROM ON-FARM EXPERIMENTS

The problems discussed in the previous chapter were examined in the five cycles of on-farm experiments conducted so far. Some experiments served to further define problems, while other experiments were aimed at finding possible solutions. As will be seen, the results of the trials are fairly consistent and tend to support the hypotheses outlined in the diagnosis. It appears that farmer's maize yields can be doubled through simple improvements in management practices at a moderate increase in cost. The team conducted during five crop cycles altogether seventy-one on-farm trials in seven villages, with twenty-eight different farmers participating. Some farmers cooperated with only one trial in one season, other farmers participated during all cycles, but not necessarily with the same field.

An overview of research activities is presented in Table 4. In the following sections a summary is given of the on-farm trials by subject. Details on treatments, lay-out, management and findings of these trials are found in MARIF OFR Working Papers (1984-1986) which cover the first to fifth cycle of on-farm trials.

Table 4. Activities in the young volcanic study area carried out in the period 1984-'86.

Activities	Cycle					
	1 1984 p-rainy	2 1984/85 rainy	3 1985 p-rainy	4 1985/86 rainy	5 1986 p-rainy	6 1986/87 rainy
On-farm trials						
Exploratory	*	-	-	-	-	-
Variety	*	*	*	*	*	-
Fertilizer	-	*	-	*	*	*
Crop protection	-	-	-	*	*	-
Seed	-	-	*	*	*	-
Farmers observation	-	-	*	*	*	-
Verification	-	-	*	*	*	*
Survey						
Exploratory	*	-	-	-	-	-
Maize production	-	*	-	-	-	-
Seed storage	-	-	*	-	-	-
Shootfly	-	-	-	*	*	*
Other activities						
Pot experiments	-	*	-	*	*	*
Soil analysis	-	*	-	-	*	*
Field days	*	-	*	-	*	-

4.1 Plant protection

Conceivably early insect damage might be reduced by finding ways to eliminate late planting. However, intensive land use practices and actual rainfall patterns would prevent most farmers from planting earlier. A simpler and more effective way is the use of an appropriate insecticide. The major insect control treatment tested by researchers was the application of carbofuran 3% granules in the hole at planting time, at the rate of 0.3 kg/ha active ingredient. Evidence on attack was obtained from a number of research activities. These verification trials, which included a comparison of crop protection versus no protection, are shown in Tables 5 and 6.

Table 5. Effect of plant protection.
Verification trials 3rd cycle, yields in kg/ha - 8 locations.

Location	Crop protection		
	No[1]	Yes[2]	Response
Bambang	2049	2295	246
Kemantrin	1359	2513	1154
Argosari	2109	3625	1516
Randu Agung 1	2448	3560	1112
Randu Agung 2	2217	2934	717
Pakisjajar	2716	3095	379
Dengkol	3006	2724	282
Sukoanyar	2666	4618	1952
Average	2321	3171	850

[1] This is treatment 5, the completely unmodified farmer practice. Crop cuts were made in non-experimental parts of the trial yield in a similar fashion as in the experimental parts of the field.

[2] Treatment 1. The only difference from treatment 5 is that carbofuran was applied at planting. Planting and all management was conducted entirely by farmers in the same way as treatment 5.

Table 6. Effect of plant protection.
Verification trials 5th cycle, yields in kg/ha - 3 locations[1]

Fertilizer management [2]	Crop protection No	Yes [3]	Difference
Farmer	2887	3889	1002
Improved	3856	4347	491
Average over fertilizer treatments	3372	4118	746

1) Treatment combination shown, were all planted with Arjuna, and with the improved plant management practice. The yield for the unmodified farmer practice was 2442 kg/ha.
2) The farmer practice was selected by the farmer, usually N only, applied at the first weeding. The improved practice included 46 - 92 - 0 NPK kg/ha at planting, followed by 92 kg/ha additional nitrogen at 30 days.
3) Carbofuran 3% granules in the hole at planting time, at a rate of 0.3 kg/ha active ingredient.

Table 7 contains a summary of the evidence on shootfly incidence and on yield losses due to early insect attack obtained from four cycles.

The economics of the carbofuran treatment appear quite favorable. Costs that vary (insecticide and application costs) are only Rp 3850 per ha (US$1 = Rp 1635). Using the government minimum guarantee prize for maize of Rp 110 per kg., the break even yield increase is estimated to be only 35 kg/ha. Carbofuran is heavily subsidized, due to its importance in rice cultivation. Early farmer adoption of plant protection measures was observed and spontaneous reductions in seed rate and plant population in villages, where OFR activities are regularly conducted. The extend of this adoption will be quantified in a forthcoming survey.

Table 7. Summary of findings on plant protection, 1984-1986.

Activity	Cycle	Result
Exploratory trial	1	Trials were heavily damaged by shootfly. No control measures were used. Plantings were 2-4 weeks later than the main planting time.
Verification trial	3	Use of the carbofuran treatment, superimposed on the unmodified farmer practice, resulted in a 850 kg/ha yield response (8 locations)
Verification trial	4	The carbofuran treatment, superimposed on the improved practice, increased yields by 700 kg/ha. (1 location)
Shootfly survey	4,5	Observations were made on three-week-old plants. Maize planted early in each season showed shootfly incidence ranging from 1 to 30% in the rainy season and from 8 to 51% in the post rainy season. Maize planted 3-4 weeks later in each season showed shootfly incidences of up to 80%. These records, however, do not include those plants that died and disappeared in the 3-week period between seeding and record taking. Thus the incidence of damage may have actually been higher than recorded.
Shootfly trial	4	Carbofuran treatment gave a 900 kg/ha yield response (1 location on-station)
Verification	5	Yield response of 746 kg/ha to carbofuran application (3 locations)

Source : MARIF, 1984-1986.

N.B. Trials were planted early in cycles 4 and 5, leading to levels of shootfly infestation *lower* than observed for neighboring farmers.

4.2 Plant population

Farmers overplant and thin largely due to their concern about damage caused by shootfly, other insects and perhaps because of other factors, e.g. seed quality and the possibility of a recurrence of downy mildew. Farmers, who plant non-improved varieties, typically employ very high plant densities, often in excess of 150,000 plants per ha. Virtually all farmers, regardless of variety, manipulate their plant stands (remove damaged, diseased or spindly plants) and usually harvest fewer than 50,000 plants per ha. A number of OFR activities have generated data on the issue of plant population. These are summarized in Table 8.

Table 8. Summary of findings on plant population, 1984-1986.

Activity	Cycle	Result
Exploratory trial	1	A reduced *initial* plant stand from 150,000 to 90,000 plants/ha increased yields by 700 kg/ha and reduced costs (5 locations)
Verification trial	3	Increased plant stand at *harvest* from 55,000 to 70,000 plants/ha increased yields by 400 kg/ha, at reduced costs (11 locations)
Verification trial	4	Increased plant stands at *harvest* from 53,000 to 61,000 plants/ha increased yields by 700 kg/ha at no increase in costs (1 location)
Plant population study	5	Increased plant stand at *harvest* from 55,000 to 71,000 plants/ha increased yields with 400 kg/ha at no increase of costs (3 locations)

Source: MARIF, 1984-1986.

Results indicate that higher yields at lower costs are feasible through improved manipulation of the plant stand, including the use of a lower seed rate together with shootfly control. The yield can be further increased by ommission of thinning thus resulting in a higher plant stand at harvest.

Details of the results of the cycle 1, exploratory trial, containing data on the contribution of lower seed rates to yield improvement are shown in Table 9.

Table 9. Effect of seed rate.
Exploratory trials 1st cycle, yields in t/ha - 4 locations

Location	Treatment [1]			
	1	2	3	4
1	2.5	1.9	2.4	2.4
2	4.1	3.9	5.1	5.5
3	2.8	3.9	5.0	5.0
4	2.4	2.1	2.3	3.3
Average	3.0	3.0	3.7	4.1
Marginal contribution at lower planted density	---------- 0.7 ----------			

[1] Treatment 1 is the farmer practice, as selected and managed by the farmer. Treatment 2 adds on the new variety (Arjuna) to the farmer practice. Treatment 3 adds on a lower planted density (90,000 plants/ha, thinned to 60,000 plants/ha at 3 weeks) plus the new variety. Finally, treatment 4 adds to the above improved fertilizer management practice (earlier nitrogen application, along with a lower nitrogen dose of only 138 kg/ha plus a phosphate application P_2O_5 of 90 kg/ha.

4.3 Fertilizer management

It was observed during the exploratory survey and production survey held in 1984, that farmer's maize yields were generally less than 2 t/ha, despite high inputs of nitrogen chemical fertilizer and use of manure. Under farmer's practice, the nitrogen is applied in equal amounts at about 3 and 6 weeks after seeding. Observations in the field showed discoloured leaves during early growth, frequent stem lodging and spindly plants. All these factors points to an imbalanced nutrient system.

OFR activities on fertilizer management examined the following alternatives to the farmer's practice by Table 10.

Table 10. Comparison of farmer- and alternative practices.

Factor	Farmer's Practice	Alternative
N dose	162 kg/ha	92-138 kg N/ha
N timing	1/2 at 20 days 1/2 at 40 days	1/3 at planting 2/3 at 30 days
P dose	(-0-)	60-90 kg P_2O_5/ha

A large number of OFR activities were used to study fertilizer issues. During the second cycle of experimentation, a NPK factorial trial was conducted at four locations. In this same trial, observations were also made on the timing of nitrogen application. Soil samples from 5 locations in the study area, were used for chemical analysis and for a fertilizer experiment in the greenhouse. During the fourth and fifth cycles, the response of maize to combinations of nitrogen and potassium was studied over locations and seasons, while the response to potassium applied in combination with nitrogen and potassium was separately studied in the field. To support the fertilizer studies in the field, greenhouse research was also conducted. The method of the "double pot" technique (JANSSEN, 1974; BRUNT, 1982) was employed to examine 11 nutrients using soil from 5 locations. Responses of maize grown at similar NP levels in other trials, such as the varietal trial, were compared to maize grown in fertilizer trials. Detailed results of these research activities are given in the working papers. A summary of OFR results is given in Table 11.

Some of the individual fertilizer trial results warrant further description. In the cycle 2 fertilizer trials, for example, responses to nitrogen and phosphate, and early nitrogen application, were observed despite a prolonged drought. Curiously, phosphate and potassium appeared to be good substitutes in this trial set as each element only raised maize yields in the absence of the other element. (See Tables 12 and 13).

Table 11. Summary of findings on fertilizer management, 1984-1986.

Activity	Cycle	Results
Exploratory trial	1	Reduction in nitrogen dose from farmer practice to 138 kg N/ha did not result in a yield reduction. Application of phosphate with 90 kg P_2O_5/ha increased yields with over 1 t/ha (5 locations).
Fertilizer trials	2	Yield response of 700 kg/ha when nitrogen increased from 46 to 138 kg/ha. Yield response of 150 kg/ha to phosphate[1] dose (drought during this cycle). No effect of potash on yields, in the presence of phosphate. Change in nitrogen timing gave yield increase of 350 kg/ha compared to later application (4 locations)
Verifications	3	Improved fertilizer management increased yields by 1100 kg/ha (11 locations)
Fertilizer trials	4	Reduction in N from 138 to 92 kg/ha led to no yield decline. Application of 45 kg P_2O_5/ha led to 420 kg/ha yield increase. No strong nitrogen phosphate interaction (2 locations)
Verifications	4	Improved fertilizer management lower nitrogen dose, earlier nitrogen and phosphate application led to 1.7 t/ha yield increase. (1 location)
Fertilizer trials	5	Reduction in nitrogen from 138 to 92 kg/ha did not result in yield decline. Application of 90 kg P_2O_5/ha led to 360 kg/ha yield response (2 locations)
Verifications	5	Improved fertilizer management increased yields by 490 kg/ha (3 locations)

Source: MARIF (1984-1986)

[1] Deep placement of the phosphate chemical fertilizer is of importance. A placement deeper than 10-15 cm below the soil surface level is optimal, and can only be obtained by deep ploughing or by application with a tractor. Farmers in the study area do not have access to these alternatives in the foreseeable future and will continue to use the plant stick for phosphate application. However, after weeding and hilling up is carried out at three weeks after seeding, the phosphate is covered by 5-15 cm of soil.

Table 12. Effect of fertilizer levels.
Fertilizer trial 2nd cycle, yields in kg/ha - 4 locations

N level (kg/ha)	P and K level[1] (kg/ha)			
	P 0		P 135	
	K 0	K 50	K 0	K 50
N 46	3100	3406	3428	3348
N 138	3790	4079	4165	4042

Nitrogen response over levels of phosphate and potassium : 699 kg/ha of maize.
Phosphate response over levels of nitrogen, in the absence of potassium : 350 kg/ha of maize.
Potassium response over levels of nitrogen, in the presence of phosphate : 102 kg/ha of maize.

[1] P(phosphate) and K(potassium) appear in this trial to be good substitutes. The reason for this is not clear.

Table 13. Effect of nitrogen application timing.
Fertilizer trials 2nd cycle, yields in kg/ha - 4 locations

Treatment	Description [1]	Yield
1	One third of the N applied at planting, the rest at 30 days after planting (DAP)	3790
2	Half of the N at 21 DAP, the rest at 42 DAP	3434
Difference		356

[1] Fertilizer dose for both timing treatments was 138 - 0 - 0 NPK (kg/ha).

In the fertilizer trials in cycle 4, a reasonably good response (420 kg/ha of maize) was observed to a fairly low dose of phosphate (only 45 kg/ha of P_2O_5) at two levels of nitrogen application (Table 14).

Table 14. Effect of phosphate applications at two levels of nitrogen. Fertilizer trials 4th cycle, yields in kg/ha 2 locations

P dose (kg/ha)	N dose (kg/ha) N 92	N 138	Average
P 0	3560	3590	3575
P 45	4055	3935	3995
P 90	3755	4010	3883
P 270	4490	4240	4365

However, the most convincing evidence of the effect on yields of the whole package of improved fertilizer management practices (less nitrogen, more phosphate, earlier split application) comes from the verification trials. Table 15 presents the effect on yields, by location, of improved fertilizer management for three cycles of research. It shows that the improved fertilizer management practices results in an average yield increase per hectare of over one ton.

Summarizing these results, the evidence obtained so far indicates that farmers can profitably use less nitrogen. Improved timing of nitrogen application also seems quite important. Financial resources previously used for high doses of nitrogen may profitably be spend on phosphate application. The need for potassium and sulphur on maize in the long term seems likely. However, so far not enough evidence on the profitability of these elements has been obtained. It should be noted that the response of maize to fertilizers was studied in trials where shootfly control and improved plant population were uniformly implemented. This approach anticipates the likely path of farmer adoption, whereby adoption of plant protection measures and improved plant population management will probably preceed innovations in fertilizer management.

Table 15. Effect of improved fertilizer management. Verification trials cycles 3-5, yields in kg/ha - 15 locations

Location (village)	No. of trial	Cycle	Improved practice plus farmer - fertilizer management [1]	Improved practice plus improved - fertilizer management [2]	Increase in yields
Sukoanyar	-1	3	2570	4097	1527
Sukoanyar	-2	3	1647	3587	1940
Dengkol	-1	3	4796	4942	146
Dengkol	-2	3	4007	5612	1604
Pakisjajar	-1	3	2463	3493	1030
Pakisjajar	-2	3	4772	5617	845
Pakisjajar	-3	3	1911	3887	1976
Randu Agung	-1	3	3105	4433	1328
Randu Agung	-2	3	3897	4860	963
Argosari		3	3933	3696	237
Kemantrin		3	2143	3671	1528
Pakisjajar		4	4405	5445	1040
Pakisjajar	-1	5	2783	4002	1219
Pakisjajar	-2	5	5283	4876	407
Sumbersekar		5	3504	4165	661
Average					1011

[1] Farmer practice, plus Arjuna seed, the improved plant population management, and crop protection (carbofuran). The farmer's fertilizer management practice varied from location to location, but typically included high nitrogen doses (in excess of 150 kg/ha) applied in two equal doses, the first of which coincided with the first weeding at about three weeks after seeding without any phosphate and the second about six weeks after seeding.

[2] The improved fertilizer management practice used 46 kg/ha nitrogen and 92 kg/ha phosphate applied at seeding and an additional 90 kg/ha nitrogen applied at 30 days after seeding. Other practices, the same.

The economics of improved fertilizer management are reasonably attractive. Costs that vary are as follows:

Table 16. Comparing cost that vary of fertilizer applications (Rp/ha)

Category	Farmer's practice	Alternative
Nitrogen dose	162 kg/ha	92 kg/ha
Nitrogen fertilizer	44,000	25,000 [1]
Phosphate fertilizer (92 kg/ha)	0	25,000
Additional labor cost for fertilizer application	0	2,000
Total	44,000	52,000

[1] 1 kg urea (46 % N) Rp. 125
1 kg TSP (45 % P_2O_5) Rp. 125.

The increased costs of Rp. 8,000 can be recovered with an insignificant yield increase of 73 kg/ha, taking a maize field price of Rp. 110 per kg. Agronomic data indicate, however, that the expected response is often over 1 t/ha ; see Table 15.

4.4 Variety

Variety trials were conducted in four of five cycles. A total of 19 trials were planted, with 1 to 2 locations per cycle. The objectives of the variety trials were: 1) to study the performance of improved varieties under representative conditions and 2) to compare these improved varieties with varieties used by farmers. Improved management practices were used throughout. Lay-out, management and observations for each of these trials were roughly similar over all crop cycles and are described in detail in the working papers. Arjuna from the seed stock of the MARIF was used as reference for all cycles. A summary of these results is presented in Table 17.

Table 17. Comparison of varieties. Variety trials cycle 1, 2, 4 & 5, yields in kg/ha - 14 locations

Entry	Cycle 1	2	4	5
Muneng Synthetic	5108	4130	3479	4689
Suwan 1	5045	4065	-	-
Arjuna (MARIF)	4835	4064	3975	5087
Harapan (farmers)	4963	3680	-	-
Malang composite	-	3978	3401	5302
Hybrid C-1	-	4243	4336	4696
Hybrid CP-1	-	-	4027	4995
No. of locations	4	5	3	2

[1] Data on trial management and layout, and statistical significance can be found in the individual working papers.

Experimental data from individual trial sets indicate that there is little yield difference between hybrids, recently released improved varieties (Arjuna), improved varieties released more than a decade ago (Harapan), and experimental materials not yet released. There is as yet insufficient evidence to make a direct comparison between local, unimproved varieties (Genjah Tongkol, Goter) and any of the improved materials.

4.5 Verifications

Verification trials with large plots and replicated over farmers, were conducted in cooperation with extension workers in cycles 3, 4, 5. The objective of these trials was to double-check the consistency of yield responses and net benefits for the alternative practices described in previous sections. Treatments, lay-out, management and observations for each cycle of these trials are described in detail in the relevant working papers.

Verification trial treatments were changed between cycles 3 and 5, as researchers improved their understanding of farmers' problems and likely solutions. Treatments that were common to both cycles of trials and their corresponding yields, are summarized in Table 18.

Table 18. Comparing farmer practices with alternative practices Verification trials cycles 3 and 5, yields in t/ha - 14 locations

No.	Treatment[1] V	P	F	C	Dry grain yield Cycle 3 (11 locations)	Cycle 5 (3 locations)
1.	F	F	F	F	2.2	2.4
2.	I	I	F	I	3.2	3.9
3.	I	I	I	I	4.4	4.4

[1] V = variety
P = plant population
F = fertilizer
C = crop protection

F = farmer's practice
I = "improved" alternative

An economic analysis of these verifications has been carried out. The marginal rates of return of the increased investment increments are shown in Table 19.

Table 19. Comparing marginal rates of returns between treatments Verification trials cycle 3 and 5, at 1986 prices

Treatment Change [1]	Marginal Rate of Return in % Cycle 3	Cycle 5
T_1 --> T_2	450	725
T_2 --> T_3	542	167

[1] See Table 18 for treatment descriptions.

5.0 DEVELOPMENT OF RESEARCH THEMES AND PRIORITIES

Research priorities have not remained static during the three years of research in the study area. Some themes thought to be of importance were dropped; other topics, initially under-rated, have taken their place. This is a natural consequence of a continuously improved understanding of farmers' circumstances and problems. Salient features of this evolutionary process include:

Variety

In early research cycles, variety was thought to be a key factor. Research data show, however, that under improved management conditions on representative farmer's fields, many old recommended varieties perform equal to Arjuna and the commercial hybrids. The relative performance of unimproved local varieties remains to be checked. Hence variety is receiving a lower research priority.

Shootfly and seed quality

The importance of the shootfly and seed quality and their effects on plant population and fertilizer efficiency, were initially under-rated. The shootfly problem recognized as important from cycle 2 onwards, has been fairly well studied, and is now declining in importance. Possible seed quality factors were recognized later and are presently pursued.

Fertilizer: nitrogen and phospate

These factors were recognized early and subsequently thoroughly studied. Research activities as such are now about to be finished although verification and farmer assessment continues.

Fertilizer: other nutrients

Soil test data and greenhouse experiments indicated deficiencies of potassium, sulphur, zinc and magnesium. However, the application of potassium, sulphur and zinc in the field has not led to significant increases in yield. Consequently, the research attention on the role of these elements has declined in priority.

6. METHODOLOGICAL ASPECTS

The present maize on-farm research activity in the District of Malang is the first OFR conducted at MARIF. In line with the principles of OFR, the main objective is to develop practical recommendations for the target group of farmers. Considering the pioneering role of the present research efforts, a second research objective was included: "To try out OFR procedures in order to ascertain their appropriate role within the mandate of MARIF".

The present study, as indicated in the introduction (chapter 1), generally follows the on-farm research methodology developed by CIMMYT. It goes without saying, however, that detailed solutions had to be worked out, that were adapted to local conditions.
In this chapter four issues will be discussed, which required special attention :
- The diagnostic process
- Statistical analysis of on-farm trials
- Cooperation with farmers in on-farm trials
- Interactions between surveys and experimentation.

The diagnostic process

The diagnostic process is based on the analysis of previous research findings from experimentation and surveys and is carried out after each crop cycle. An essential aspect of this diagnostic process, is the use of diagrams. For each problem identified, a diagram is constructed showing the relationship between the problem and its possible causes and solutions. Others are used to show the relationship between various problems. The use of this tool allows the team to quickly review progress to date and set priorities for future activities.

Statistical analysis of on-farm trials

An analytical problem is the statistical analysis over crop cycles. Some research topics required attention over several crop cycles. The experience obtained from a particular crop cycle led in a number of cases to adjustment of a specific treatment or to a redesign of the trial in the subsequent cycle. This had led to repercussions on statistical analysis, because imbalanced designs had to be analyzed over crop cycles. A second problem experienced is the need to correct variances on the basis of Barlett's test for homogeneity of variance (see COCHRAN and COX, 1957; and SNEDECOR and COCHRAN, 1980), when comparing data over locations and crop cycles.

Another issue is that particular topics were studied in more then one trial set. For example, a particular fertilizer

dose was studied in specific fertilizer trials as well as in sets of verification trials.
In these cases only main trends can be given when comparing such sets of trials over locations, seasons or with different plot sizes.

Cooperation with farmers

Cooperation with farmers in joint on-farm trials was arranged along the following sequence of steps:
- Formulating hypotheses, on the basis of previous findings
- Selecting representative villages and contact persons in these villages
- Selecting through these contact persons up to six farmers per village who were willing to cooperate and whose farms were representative for the study area
- Making an oral arrangement with each cooperating farmer to work together on the basis of mutual benefit[1], i.e. without financial charge, by one party to the other.

The cooperating farmer:
- to contribute his land and labour
- to carry out all management steps as usual: land preparation
- to receive the benefit of the yield after final observations have been carried out.

The MARIF team to:
- contribute seed, fertilizer and chemicals as required by the specific trial design
- plant the trial together with the farmer
- carry out those management aspects, as required by the specific trial design e.g. fertilization, crop protection, or thinning in cooperation with the farmer
- carry out the observations as indicated in the trial design, in cooperation with the farmer, including the weighing of the harvest.
- compensate for crop failures caused by the implementation of the trial. In over seventy trials, this was only once required for a particular crop protection trial.

Interactions between surveys and experimentation

An important characteristic of an OFR program is the close relationship between surveys and experimentation. Yet this does not imply that findings between surveys and experiments will be always consistent. A case in point is the shootfly problem as experienced in the present program in Malang.

[1] The reason for this arrangement is that the farmer maintains a direct interest in the result of the trial. He will keep this interest in mind judging the result of the alternative technologies tested.

The initial exploratory survey indicated that farmers were familiar with the occurrence of shootfly, but were of the opinion that this had not much impact on yields. This issue was followed up in the formal maize production survey. In this survey it was found that only 15% of the respondents believe that shootfly occurrence reduced yields.

Initially, we were unprepared for the heavy shootfly damage and consequently heavy yield losses occurred in the trials in crop cycles 1 and 2. During the third trial cycle, when problem was tackled, the verification trials showed a large yield difference between untreated and treated fields for shootfly. This result was substantiated in later trial cycles, and has been discussed in chapters 3 and 4.

Further shootfly surveys contributed to the researchers' understanding of the frequency and severity of shootfly attack, for early versus late plantings, and by crop cycles rainy vs. post-rainy season.

7. FUTURE RESEARCH

As outlined in the previous chapters the MARIF maize OFR program has resulted in development of recommendations for maize production. These recommendations enable farmers in the study area to double roughly their maize yields, while requiring only modest increases in terms of inputs and simple improvements in management practices. It is believed, that the above yield increase is within the scope of most farmers, as all aspects of the improved methods were easily understood by the cooperating farmers whose conditions are representative for the study area.

Yet research is never completed and in the following a brief outline is presented of topics currently given attention:

Future activities in the present study area in the young volcanic soils:

- to complete the research on outstanding issues, including variety and crop protection1) problems
- to expand verification of the new recommendations in cooperation with extension workers, eventually covering the entire recommendation domain outside the Malang District.
- assessment by farmers of the alternative management practices developed through study of early adopters of these new recommendations in the villages of the cooperating farmers.
- extrapolation of the results obtained from research in the target study area to other district in East Java with similar physical socio-economic conditions.

Initiation of OFR research in other areas with other crops and different physical and socio-economic conditions.

In January 1986 work was initiated in a second study area with crop associations of maize, cassava and grain legumes on limestone soils in land below 600 metres a.s.l.
An exploratory survey was conducted in January 1986 followed by exploratory trials during cycles 5-6 aimed at fertilizer and variety problems. A maize cassava production survey has been planned for January 1987 and will be followed by further experimentation.

1) During the course of the 5th and 6th OFR trials a new yield reducing factor was observed being caused by Peronosclerospora maydis (downy mildew). At present the scope of the problem is checked and further research will be conducted as required. Note that practically no downy mildew damage was observed during crop trial cycles 1 to 4.

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N.B. The maize OFR team compiled and regularly update a list with references of On-Farm Research with a Farming Systems Perspective.
A copy of this list, updated in December 1986 and copies of the working papers produced by the team and listed in Annex 2 are available from the Institute. Requests should be addressed to the Director of the MARIF, P.O. Box 66, Malang 65101, Indonesia.

Annex 2. MARIF MAIZE ON-FARM RESEARCH PROGRAM WORKING PAPERS

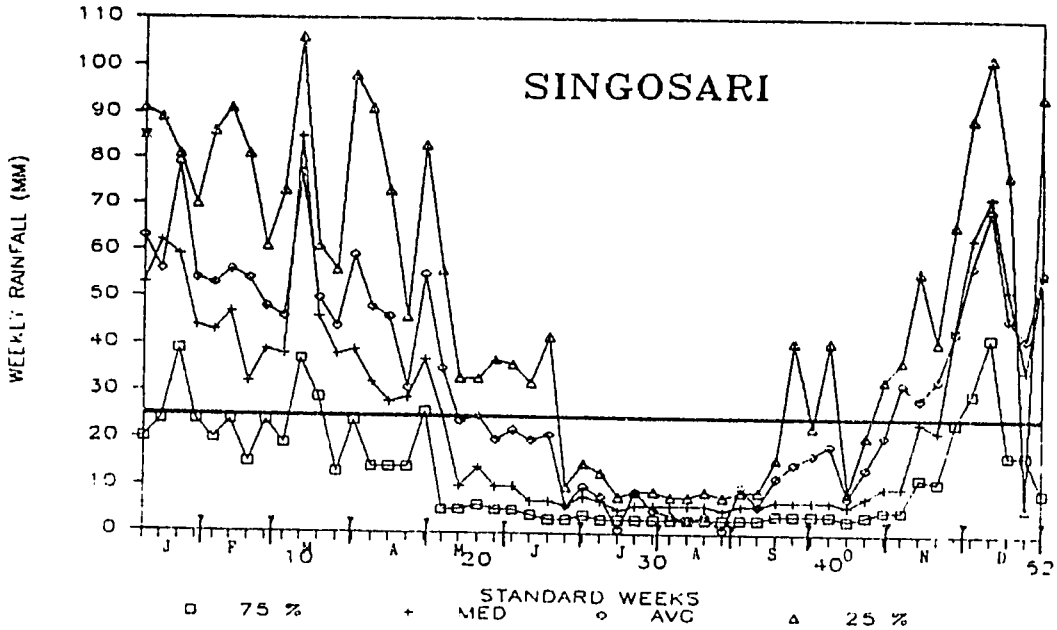
Number of Paper	Title	Status: Completed	Status: Planned for
1.	Joint Proposal for the MARIF On-Farm Research Programme for Maize, 5 pp.	Jan. 1984	
2.	A Maize On-Farm Research Programme - Development of a methodology, 52 pp.	Apr. 1984	
3.	Trials results of the MARIF Maize On-Farm Research Programme -1984 First Dry Season, 17 pp.	Sept.1984	
4.	Report on study tour to Thailand - August 1984, 12 pp.	Sept.1984	
5.	Synopsis: The MARIF On-Farm Research Programme for Maize based farming systems, 12 pp.	Jan. 1984	
6.	An Introduction to the MARIF On-Farm Research Programme for Maize based Farming Systems, 20 pp.	Mar. 1985	
7.	Report on the Trial Results - Series no.2 Rainy season 1984/85, 24 pp.	May 1985	
8.	Report on the Maize Survey - December 1984, 40 pp.	May 1985	
9.	Report on the Trial Results - Series no.3 Dry Season 1985, 18 pp.	June 1986	
10.	Note: The Shootfly Issue, 24 pp.	Aug. 1985	
11.	Notes : On-farm maize seed storage, 7 pp.	June 1986	
12.	Notes : Inputs in maize on-farm trials, 5 pp.	June 1986	
13.	Costs and Benefits of On-Farm Research, 12 pp.	Jan. 1986	
14.	Report on a study tour to Thailand - August 5-14, 1985, 18 pp.	Sept.1985 Sept.1985	
15.	Report on the Trial Results Cycle no. 4 -Rainy season 1985/86, 20 pp.	June 1986	
16.	The Downy Mildew Issue, 12 pp.	May 1986	
17.	The Second Shootfly Report		May 1987
18.	Report on the exploratory survey in the limestone area with maize/cassava based farming systems - Jan.1986/Feb.1987.		May 1987
19.	Report on the Trial Results Cycle no. 5, Post-rainy season 1986.		May 1987

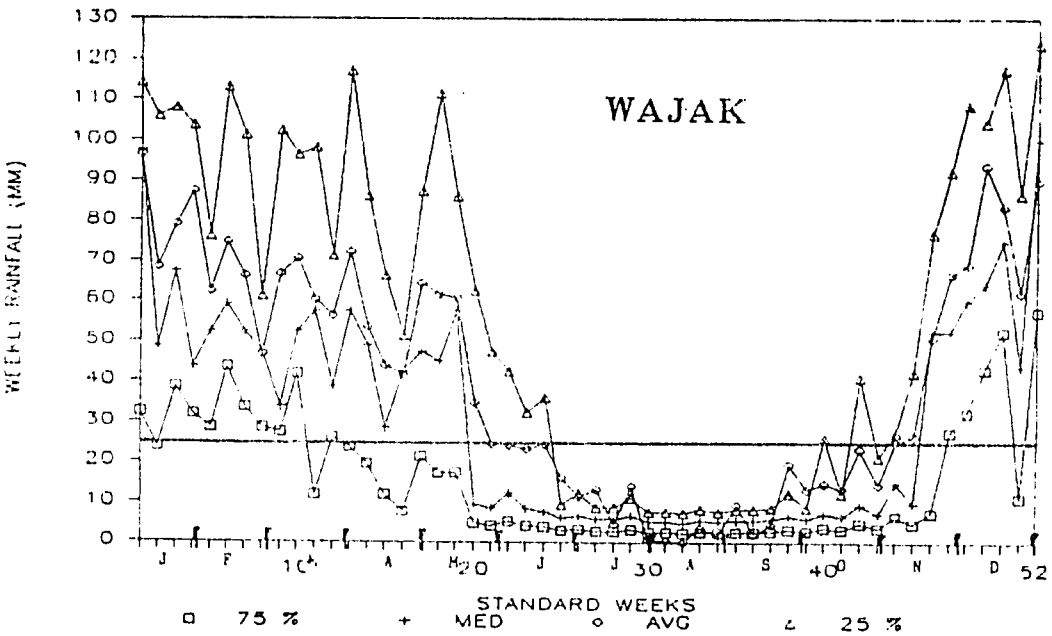
Annex 3. CLIMATE

Weekly rainfall data over the period 1967-1985 for the subdistricts Singosari and Wajak are presented in Figure 7. The figure shows the 75%, 50% (median) and 25% rainfall probabilities and the average weekly rainfall. Palawija cropping on tegal requires on average 25 mm rainfall per week. At Singosari, the cropping period generally starts at the end of October with the onset of rains and terminates by mid May. During this period of approximately 200 days with sufficient rainfall, the farmers can cultivate two maize crops maturing in 95-100 days. However, once in two years (median), the rains may start in mid November, but also may stop in early May. Under these weather conditions, the cropping period is reduced from 197 days with sufficient rainfall to 165. After cultivation of a rainy season maize crop maturing in 95-105 days, rainfall for a post-rainy season crop is sufficient up to flowering. Consequently, this crop only can mature on residual moisture and largely depends for grain production on the water-holding capacity of the soil.

At Wajak the growth season generally starts by the end of October and terminates by the end of June. Once in two years the growth season may start not before mid November, while rains could abruptly cease between mid and the end of May. Under those conditions, the average growth period is reduced from 240 days with sufficient rainfall to 190, which is still enough to cultivate two subsequent crops. Unfavourable weather conditions, do occur once in four years (75%) and may further reduce the growth period to only 120 days with sufficient rainfall. This situation, severely hampers the grain filling of the post-rainy season crop in such years.

Figure 7. Average weekly rainfall data and 75, 50 (median) and 25 percent probabilities in the study area. Compiled from rainfall data from the subdistrict extension office of Singosari and Wajak (1967-1985).





Annex 4. SOILS

In the District of Malang, four major soil types can be distinguished, as shown in Table 20.

Table 20. Dominant soil types in the District of Malang

Soil type	Occurrence (%)	Occurrence (ha)
Alluvial	9	33,775
Young volcanic	36	135,115
Volcanic ash	18	67,555
Limestone and Lithosol	37	138,870
Total area district		375,315
Total agricultural area		221,200

Source: ANON. (1984)

The table indicates that the area with young volcanic soils comprises 135,115 ha of which about 105,000 ha is for tegal crops. Of this, 80,000 ha is annually used for maize production. The present study area covers 30,000 ha from this area. Soil type and extension in the young volcanic area are presented in Table 21.

Table 21. Soil type and occurrence in the young volcanic area in Malang.

Soil type[1]	Occurence (%)	Occurence (ha)	Soil taxonomy[2]
Latosol	60	62,620	Inceptisol
Regosol	26	27,865	Entisol
Mediteran	7	7,715	Alfisol
Brown forest	6	6,180	Inceptisol
Others	1	1,340	-
Total	100	105,720	

[1] SRI (1978).
[2] USDA/SCS (1975).

The Inceptisol and Entisol make up the major part (with over 85%) of the land in the young volcanic area. A general characterization of the main soil types is as follows:

INCEPTISOL (LATOSOL)
These soils are often called "laterite soils". Geographically they are situated between volcanic ash soils (Andosols, occurring at higher elevation > 1300 m) and Mediteran soils, and are derived from volcanic tuff and rock. Latosols have good physical properties, a good natural drainage, are deep and tolerant to erosion. They have a well developed A-B2-C profile, a loamy to clayey texture and a low organic matter content. The soil fertility, however, is medium to low. The agricultural potential may increase considerably by the use of chemical fertilizers, manure and irrigation. Their response to nitrogen and phosphate fertilization is good. Often they are deficient in phosphate and potassium and in other nutrients such as sulphur, magnesium, zinc and ferrum.
Inceptisols are suitable for the cultivation of dry-seeded rice and palawija crops, but also for cash crops such as tobacco and fruit crops. Under conditions of limited water availability, forest cropping dominates.

ENTISOL (REGOSOL)
The Regosols are found in undulating hilly areas and middle slopes of mountains. They commonly have a weak developed A-C profile, a light soil texture (sandy) and high permeability. Consequently, the water-holding capacity is low. Their low agricultural potential is due to a low organic matter content, low availability of phosphate and potassium and a high susceptibility to drought and erosion. Regosols are only marginally suitable for dry-seeded rice and palawija crops. Often the post-rainy season crop can be characterized as a risk crop. Due to the risks involved in food crop production, the entisols are often used for forestry.

ALFISOL (MEDITERAN)
Alfisols occur on the foot-hills of the mountains and in rolling hilly areas. They are geographically situated between the Alluvial and Latosols and are derived from volcanic material and limestone. Alfisols texture are medium (sandy-loam), subject to erosion, have a medium soil fertility and are used for tegal farming. With supplementary irrigation, one rice crop followed by one or two palawija crops can be grown. Without irrigation rice-palawija or palawija-palawija cropping patterns are possible. Due to the sometimes limited waterholding capacity, Alfisols are also used for forestry.