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Rice Research Priorities for Madagascar's Middle West

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RICE RESEARCH PRIORITIES FOR MADAGASCAR'S MIDDLE WEST

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ABSTRACT

A goal of rice research in Madagascar is to help the country regain the rice self-sufficiency it lost in the early 1970s. A diagnostic survey was conducted in 1989 in the Middle West, one of six major rice-growing areas. Agroecosystems, farmer practices and knowledge, major problems affecting the productivity and sustainability of farming systems, farmer problem solving behavior, and interactions among system components were examined. Three priorities were identified for research on rainfed lowland rice: improved germplasm with tolerance for excess water, control of rice hispa disease, and improved water management in the rice-growing minivalleys. Four priorities for research on upland rice were identified: control of insect pests (especially *Heteronychus* spp.), improved soil nutrient management and soil erosion control, weed control (especially *Striga* spp., *Rottboellia* spp.), and breeding higher yielding varieties. The survey also served as a training exercise for national rice scientists.

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RICE RESEARCH PRIORITIES FOR MADAGASCAR'S MIDDLE WEST

Although some 2.1 million t of rice are now produced on about 1.3 million ha in Madagascar, per capita production has declined. The country has been a net rice importer since 1971 (Table 1). Factors that have contributed to the loss of rice self-sufficiency are low yields (1.8 t/ha for the last 10 yr), high per capita consumption (135-150 kg/yr), and an increasing population (2.8% growth/yr). The annual rice shortfall in 1980-89 was 200,000-400,000 t. The country has six major rice-growing regions. Lac Alaotra and Marovoay produce surpluses. The Central Highland North (and Northeast), East Coast, and Middle West are areas of rice deficits.

The International Rice Research Institute (IRRI) has collaborated with the Foibem-Pirenena Momba ny Fikarohana Ampiharina Amin'ny Fampandrosoana ny Ambanivohitra (FOFIFA: the National Center for Applied Research in Rural Development) since 1984 in efforts to improve research on rice and rice-based cropping systems to increase national production.

During this time, FOFIFA has established a foundation for multidisciplinary, regionally based rice research concerned with

- varietal improvement (including plant-environment relations and grain quality),
- soil nutrient management (including soil conservation and exploitation of unfavorable soils),
- farming systems research,
- farm implement development,
- crop protection,
- postharvest grain losses,
- technology transfer, and
- seed production.

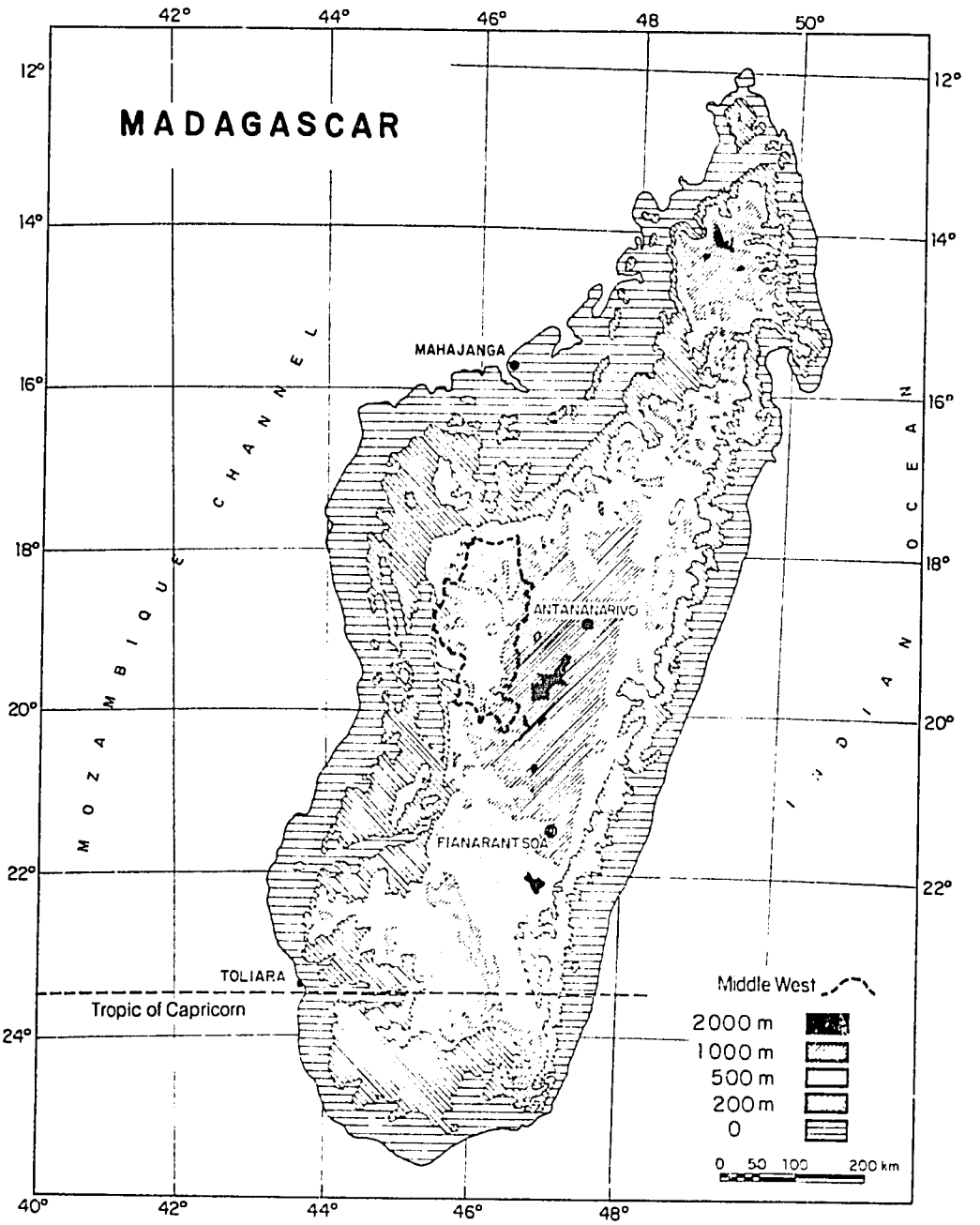
Two resident IRRI scientists have assisted in developing procedures to evaluate and purify the national rice collection, to introduce improved rice germplasm into the national breeding program, and to develop improved cultural practices. IRRI has also provided training at its headquarters in the Philippines for FOFIFA scientists and has assigned IRRI scientists for in-country consultancies. In response to requests by FOFIFA, IRRI also assisted in diagnostic surveys of the rice-growing regions. Surveys of Marovoay (Abel Ratovo et al 1987) and the Central Highland (Fujisaka 1990) described agroecosystems and farmer practices, identified key problems, and analyzed data to provide bases for prioritizing research. The surveys also achieved another FOFIFA goal: to develop farming systems research capabilities through participation in survey work of an interdisciplinary group of scientists from FOFIFA departments. Here we describe results of the 1989 diagnostic survey in the Middle West.

THE MIDDLE WEST REGION

Delineation of Madagascar's Middle West and Central Highland is somewhat arbitrary. French geographers combined the regions as The Highlands (ORSTOM 1981). The Middle West

Table 1. Population and rice area, production, yield, and availability, Madagascar, 1960-85 (adapted from unpubl. Food and Agriculture Organization statistics and Szal 1988).

Year	Population (thousand)	Rice area (thousand ha)	Rough rice production (thousand t)	Yield (t/ha)	Milled rice		
					Net imports (thousand t)	Total supply (thousand t)	Per capita supply (kg)
1960	5409	838	1229	1.5	- 15	677	125
1965	6031	-	-	-	+ 60	873	145
1970	6740	997	1945	1.9	- 48	1047	155
1971	6899	943	1873	1.9	+ 25	1090	158
1972	7061	1008	1687	1.7	+ 23	1106	156
1973	7237	1055	1730	1.6	+ 70	1167	161
1974	7416	1134	1844	1.6	+122	1155	156
1975	7604	1078	1972	1.8	+ 59	1213	154
1976	7799	1064	1043	1.9	+ 68	1213	155
1977	8003	1175	1067	1.8	+ 93	1301	163
1978	8217	1133	1922	1.7	+152	1205	147
1979	8439	1158	2045	1.8	+155	1313	156
1980	8672	1178	2109	1.8	+176	1361	157
1981	8974	1186	2012	1.7	+193	1320	148
1982	9225	1188	1970	1.7	+351	1396	152
1983	9484	1189	2147	1.8	+179	1334	142
1984	9689	1163	2112	1.8	+111	1394	144
1985	9960	1200	2178	1.8	+106	1356	136

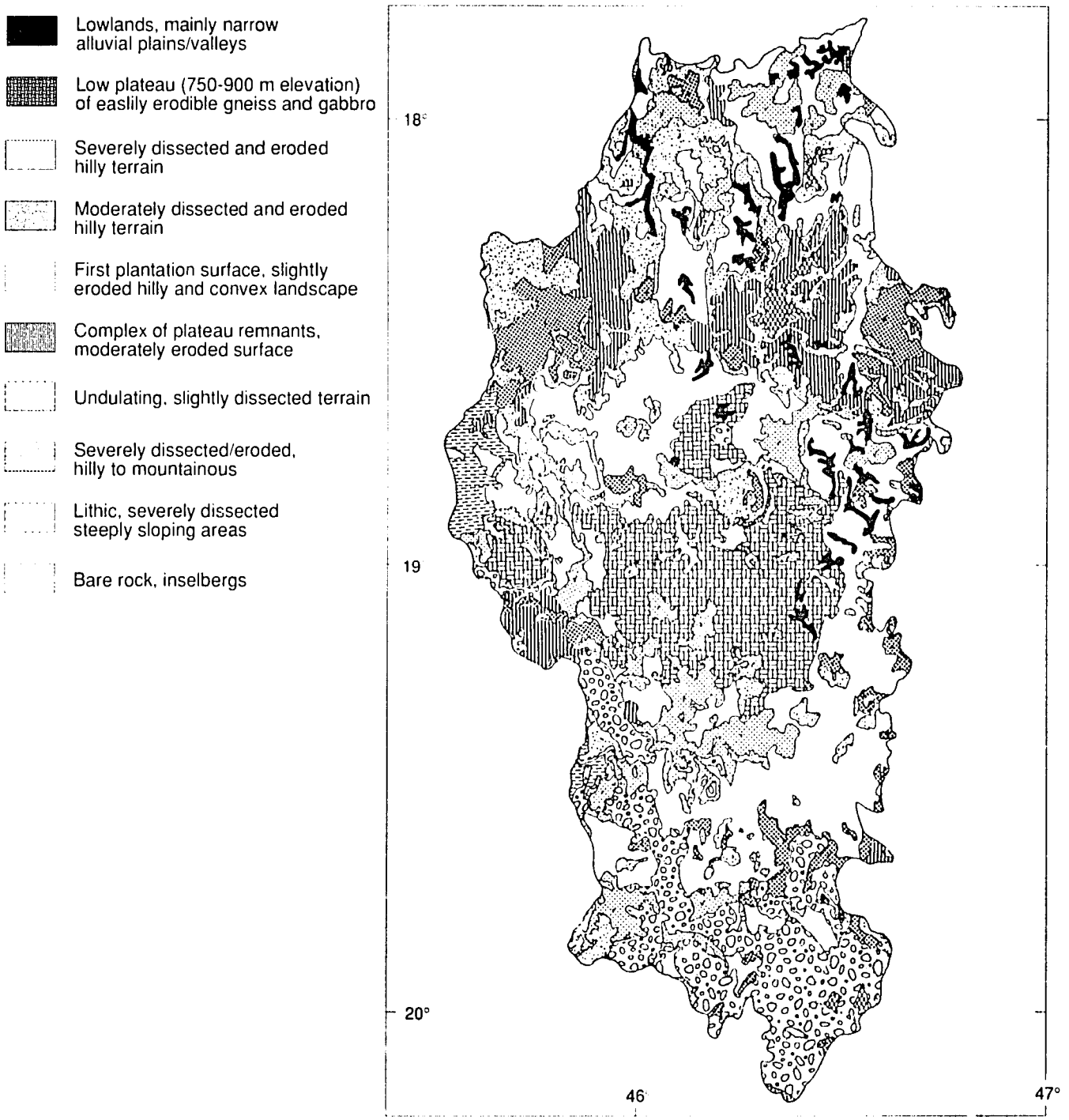


1. The Middle West Region of Madagascar.

covers 23,500 km² lying at a lower elevation (700-1000 m above sea level [asl]) and west of the Central Highland (above 1000 m asl). Figure 1 locates the region within Madagascar. Figure 2 maps physiographic units within the region.

For the Middle West, mean temperatures decrease from north to south and with increasing altitude (0.6 °C/100 m). Rainfall decreases from northeast to southwest, with annual rainfall ranging from 1,100 to 1,900 mm. The climate is semihumid tropical, with a warm, rainy season from November to April and a cool, dry season from June to October (Fig. 3). The landscape features small valleys, in which rainfed lowland rice is grown, surrounded by larger undulating to rolling areas devoted to upland crops and pasture.

In the areas visited by the diagnostic survey team, the topography is undulating to mountainous, with numerous scattered minivalleys of 1-25 ha. While the valleys are smaller, they are similar to those of the Central Highland. Narrow upstream sections that include old, upper terraces can be drought-prone or waterlogged, depending on whether they are located on or immediately below natural springs. Wider alluvial upfilled areas lie downstream; due to inadequate natural drainage, some are too waterlogged or flood-prone for rice cultivation. Valley sides are often terraced, with relatively recent bunded fields on the lower terraces and sloping, unbunded fields on the upper terraces. Above the valleys are wider, flat to rolling plateaus or hilly areas. Hilly areas (which

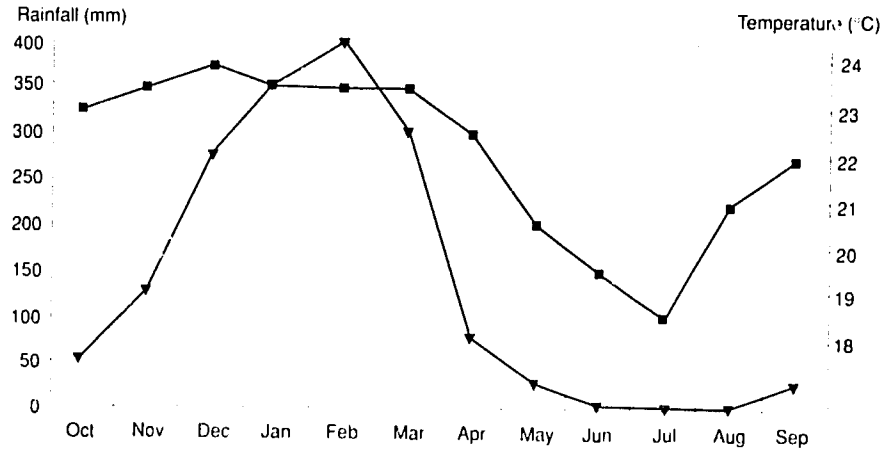


2. Physiographic units, Middle West (adapted from ORSTOM 1981).

generally have little to no tree cover) are used mainly as pasture, although more sloping land is being cropped as the human population of the region increases.

Old terrace soils are described in IRAT (1967). Soils are brown-red ferrallitic, strongly acidic, low in cation exchange capacity (CEC), sandy (probably kaolinite) clay loam Ultisols with moderate to low organic matter (Table 2). The N-supplying capacity is probably low, and P and K are most likely deficient. Problems for rice cultivation include micronutrient deficiencies, low puddling ability, water seepag, and nutrient leaching and dilution (H.U. Neue, IRRI, pers. comm.).

There are 25,000 ha of lowland rice, 44,500 ha of upland rice and other crops, and 921,000 ha of grassland pasture in the Middle West. The Central Highland and Middle West combined account for 350,000 ha of rainfed lowland rice, 52,000 ha of irrigated rice, and 33,000 ha of upland rice (not counting shifting cultivation) (MPARA-FAO 1986).



3. Rainfall distribution (▼) and temperature (■), Middle West of Madagascar; from 16 yr of unpublished ORSTOM records.

Table 2. Characteristics of brown-red ferrallitic soils from old terraces, Kianjasoa area (Sakay), Middle West (IRAT 1967).

pH	4.6
Texture	
Sand	47%
Silt	21%
Clay	32%
Organic matter	2.1%
C/N	11.6
CEC	5.2 meq/100 g
Exchangeable bases	1.84 meq/100 g (35%)

Estimated crop yields in the Middle West average 2.0 t/ha for lowland rice, 1.0 t/ha for upland rice, 1.5 t/ha for maize, 0.8 t/ha for peanut, and 15 t/ha for cassava (MPARA-SATEC 1983). These figures (in contrast to the government classification of the Middle West as a rice-deficit area) imply regional rice self-sufficiency. Given no change in estimated yields, if only 20% of the upland cropped area were planted to rice, the uplands and lowlands would produce 58,900 t rough rice, equivalent to 35,340 t milled rice (177 kg per capita for a population of 200,000).

METHODS

Field research was carried out by the IRRI agricultural anthropologist and 10 FOFIFA researchers. Time and access constraints limited data collection to a limited transect spanning areas around Kianjasoa, Tsiroamandidy, and Analavory.

Team members interviewed randomly selected upland and rainfed lowland rice farmers using open-ended, interactive, but structured interviews. They visited fields, observed crops and field operations, and discussed issues with farmers until farmer perceptions and practices were understood. Each evening, team members synthesized the data and planned the interview issues for the following day. Each day's interviews built on previous findings and unanswered questions to develop an evolving data set. Evolving interview topics included farmers'

- systems of land and soil classification, evaluation, and use;
- crop, variety, and cropping pattern choices;
- individual land, soil, livestock, and other resources;
- rice crop management practices, including inputs and returns;
- crop-related problems and solutions; and
- perceptions about interactions among system components.

The team conducted interviews in a range of areas and villages to describe the region in terms of a general cropping calendar, predominant long-term crop - fallow cycles, and types of rice cultivars available. The survey team also visited FOFIFA experiments at Kianjasoa Station to determine if the on-station research was addressing their tentative list of priorities and farmer problems, if the experiments were appropriate to local farmer circumstances, and what additional research was needed.

FINDINGS

Examination of the data led to

- identification of problems and causes of reduced crop production,
- identification of interactions among system components,
- problem prioritization based on crop loss and farmer assessments,
- identification of research that could address problems and causes, and
- prioritization of future research based on farmer needs, FOFIFA-IRRI research resources, and the potential for increasing or sustaining rice productivity in the Middle West.

The diagnostic findings were somewhat qualitative. The data, however, provided sufficient insights concerning agroecosystems in the Middle West to identify priorities for further FOFIFA and IRRI research. From the diagnostic survey, questions that need to be addressed through future surveys, monitoring, or research were identified.

Farmers' classification and use of land and soil were elicited as a first step in understanding the whole-farm system from the perspectives of both farmers and researchers. Farmers classified lands first as lowland riceland (*tanimbary*) or upland (*tanety*). Lowland rice areas were divided into broader floodplains at the lower portions of the small valleys (*lohasaha*) and upper terraces (*kitrambero, baiboho*). Each land type was subdivided into categories that often reflected only slight differences in elevation and drainage. Poor drainage and flooding were major problems in lower, broader portions; drought or water uncertainty were major problems in the upper terraces (Table 3).

Farmers distinguished soils by color and texture. Lowland rice soils were usually black (*tany mainty*) or blue-grey (*tany manga*), and sandy (*tany fasika*) or clayey (*tany dilatra*). For poorly drained areas, farmers referred to boggy or peaty soil qualities (*tany fompotra*). Lowland soils were generally regarded as sufficiently fertile that organic and inorganic fertilizers were not needed or used (with available rice cultivars). Farmers said that applying fertilizer increased vegetative growth and caused more lodging and no or negative effects on rice yields.

Upland croplands were divided into unbunded terraces (*baiboho*) located directly above uppermost rice terraces (*kitrambero*), upland plateaus (*marimarina*), and sloping lands (*silasila*). Upland soils were described as mostly poor and red (*tany mena*). Darker or volcanic soils found in limited areas in a few places were "good" or *manjamanja* (Table 4). Farmers complained of declining upland crop yields due to cropping and soil erosion. In response to such yield declines, farmers applied farmyard manure (FYM) to selected upland crops and fallowed the fields for 1-5 yr to allow soils to "rest" or regenerate.

Table 3. Farmers' land types and use.

Land type	Land use comments
Tanimbary	Minivalleys of lowland rainfed or irrigated rice
Lohasaha	Broader, open floodplains at lower portions of small valleys; perhaps 60-80% area of minivalleys
Mandrevo	Perhaps 10% of the lowland rice area; sometimes hand tilled due to waterlogging; not planted in some areas due to excessive flooding waterlogging; also referred to as *hotsaka* or *valareba*
Heniheny	Same as *mandrevo* or has slightly better drainage
Tsy mandrevo	Lower area but not waterlogged; best rice area
Upper terraces	Terms for upper terraces vary by subregion; 20-40% of area of minivalleys
Baiboho	Slightly higher terraces; rainfed rice; drought stress
Kitrambero	Bunded rice area nearest to upland; sometimes not planted due to late rains or drought; also referred to as *sakamaina*
Tanety	Upland area planted to maize, cassava, upland rice, legumes (especially peanut and groundnut), vegetables
Baiboho	Unbunded, often hand-terraced upland above terraces
Marimarina	Nonsloping upland, flat miniplains in some areas
Silasila	Sloping uplands

Table 4. Farmers' soil categories.

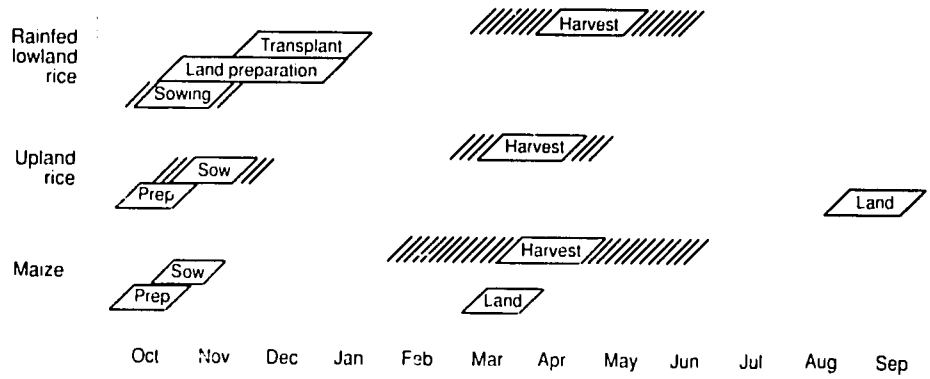
Category	Land type/comments
By color	Farmers first distinguish soils by color.
Tany mainty	Black, usually fertile lowland soil
Tany manga	Blue-grey, often in waterlogged areas
Tany mavo	Yellow, upper terraces or upland
Tany mena	Red, most common upland soil, divided into *menakely* ("little red") and *menabe* ("very red")
By texture	Soils are also categorized by texture.
Tany fasike	Sandy
Tany fompotra	Boggy or peaty
Tany dilatra	Clayey
Other	
Manjamanja	"Good soil" usually refers to fertile upland; can be a volcanic soil

A subsample of 11 Kianjasoa-area farmers reported having averages of 1.2 ha of lowland rainfed rice (range 0.15-3.0 ha), 2.4 ha of cropped upland (1.1-5.0 ha), and 10 cattle (1-42) used for draft and held as capital. Average yields were 2.4 t/ha of lowland rice (1.2-4.2 t/ha) and 1.4 t/ha of maize (1.0-2.0 t/ha). Upland rice yields ranged from total loss to 2.4 t/ha.

Farmers' choices of crop, cropping patterns, and rice variety, and respective reasons for choices were elicited to further understand their whole-farm strategies. Main crops, in order of importance, were rainfed lowland rice, maize, upland rice, cassava, legumes (peanut *Arachis hypogaea* and groundnut *Voandzeia subterranea*), and vegetables in some areas. Almost all of the lowland rice raised by the farmers interviewed was rainfed; and perhaps 70% of their rice came from lowland rather than upland fields. Maize and, to a lesser degree, vegetables were major cash crops. Cassava was a low-input crop mainly for livestock consumption. Although peanut and groundnut do well in the area, farmers complained of low prices and high labor requirements for these crops.

Two transplanted rice crops are possible in limited areas: a first crop is sown in August and harvested in late-January or February; a late crop is sown in February and harvested in May-June. Competing labor demands made two crops unfeasible for most farmers with suitable land-water conditions. Seedbeds for a single rainfed lowland rice crop were sown in early October to mid-November (Fig. 4). Land preparation was done in November-December, and transplanting followed as water became available in late-November to mid-January. Harvest was in early March to early June, with timing depending on transplanting date, cultivar duration, and photoperiod sensitivity.

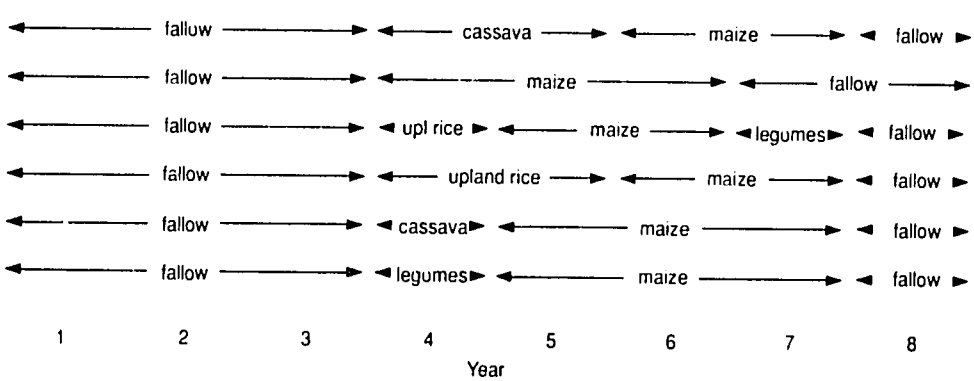
Another subsample of farmers in the Kianjasoa area discussed lowland rainfed rice management. They prepared land with a single moldboard plow and box harrow pulled by two oxen, did further puddling by hand spading (or animal trampling in the Tsiroanomandidy area), and sowed an aver-



4. Major cropping and field operations calendar, Middle West (not shown are secondary enterprises: cassava, peanut/groundnut, and a limited double rice pattern).

Table 5. Average farmer-reported labor for 1 ha of rainfed lowland rice.

Activity	Person-d/ha	Comments
Seedbed preparation, sowing	7	63 kg seed, various amounts of FYM
Land preparation		
Plowing (once)	11	Using oxen and single moldboard plow
Harrowing (once)	10	Box harrow
Puddling	6	Hand spading (using *angady*)
Pulling, transporting, transplanting	20	Random planting
Weeding	0	No weeding in Kianjasoa area
Harvesting, sheaving, transporting	22	Wide variation depending on yield and distance to threshing site
Threshing (and transporting)	15	Varied by yield
Total	91	average yield 2.0 t/ha of Makalioka and Ambalalava



5. Common upland cropping patterns/rotations, Middle West of Madagascar.

age of 63 kg/ha of seed. FYM was applied to some seedbeds, but not to main fields. Farmers reported difficulty in obtaining sufficient labor for harvesting, transporting, and threshing. The relatively low total of 92 person-d/ha reflects the fact that lowland rice is usually not weeded (Table 5). One informant planted taller, weed-competitive cultivars rather than higher yielding, shorter statured ones to have more labor available for upland crops.

Although fallowed upland fields may have been plowed first in March or April, land preparation for upland rice and maize usually took place with the coming of the rains in October. Plowing was done by 2-3 persons using a wheeled reversible-moldboard plow pulled by 4-8 oxen. Upland rice was sown in October-November, hand weeded one to three times as necessary, and harvested in March-April. Maize harvest spanned early February (green maize) to late-June for cobs "stored" on the stalks in the field (allowing farmers to complete lowland rice harvest, threshing, and harvesting of other upland crops).

Farmers practice various longer term crop rotations on upland fields (Fig. 5). Fields are fallowed 1-5 yr. Because they supposedly improve soils for maize or upland rice by breaking

up clods, cassava, peanut, or groundnut is often planted first after a fallow. Maize or upland rice can follow as second- to third-year crops. Fields are fallowed after 2-3 crop years and may be planted again to maize using FYM, or to legumes without. Farmers may use different rotations on their fields.

The team gathered information on farmers' rice cultivars to understand the "fit" between such materials and local rice subecosystems and to provide a basis for later discussions of types of improved materials needed, available, or suitable to farmers' conditions. In aggregate, farmers had different cultivars suited to upland, lowland rainfed, and irrigated (double-cropped) conditions, both short- and long-duration cultivars, and both traditional and improved materials (Table 6), although seed of some was difficult to obtain in some areas. Farmers in each community usually planted only 2-3 rice varieties, with single varieties often planted in both lower and upper terraces, and others on both upper terraces and upland parcels. Compared with Southeast Asia, less matching of cultivars to lands, soils, and hydrologies was noted.

A schematic of the agroecosystem (Fig. 6) shows a typical upland-to-lowland transect of a small valley, upper slopes, and upper area.

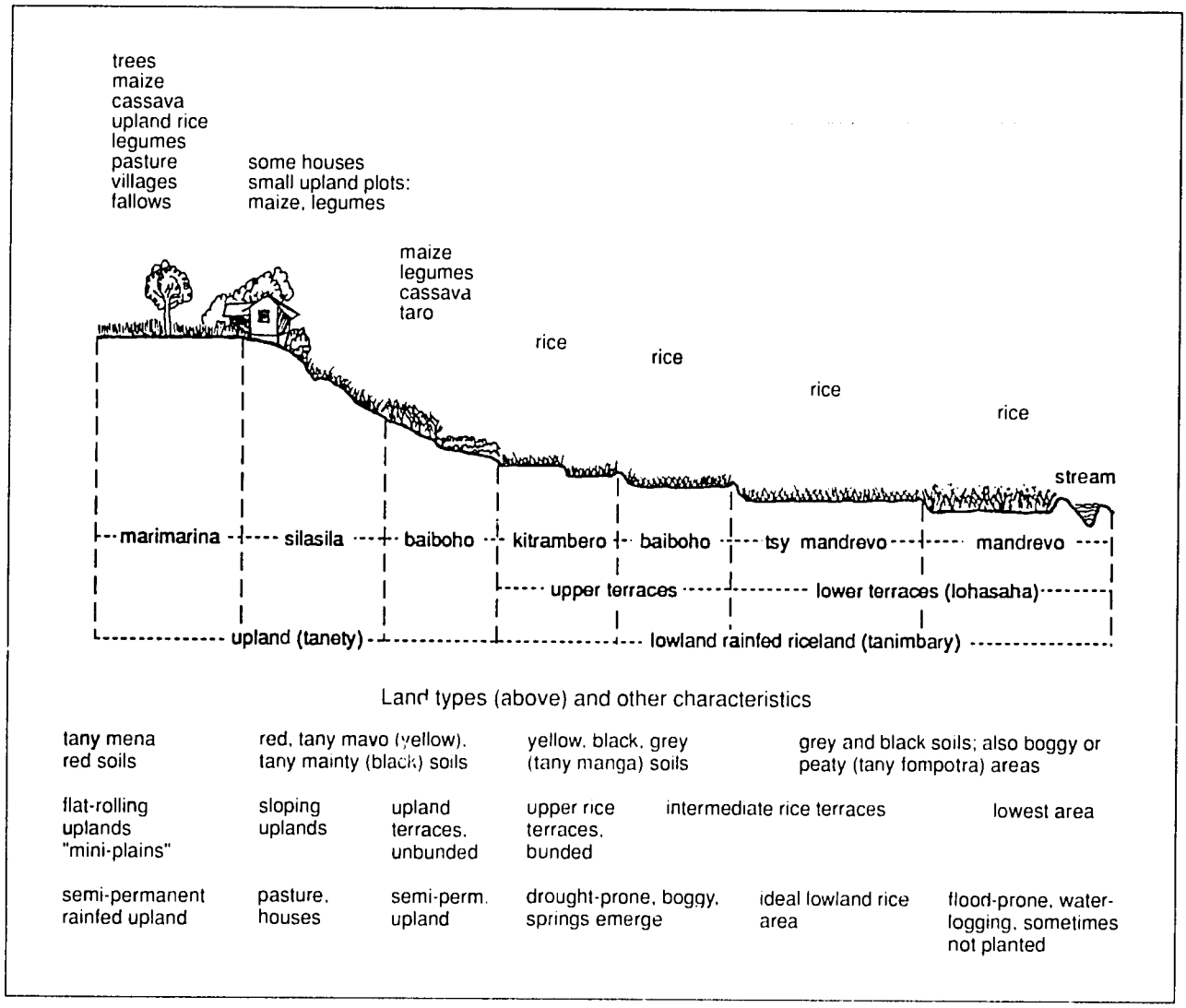
The diagnostic survey was conducted in three areas in the central part of the region. Although differences encountered suggested that components of a future regional research program need to be tailored to different areas, similarities among local circumstances appeared such that the region could be considered a single recommendation domain.

Comparison of Tsiroanomandidy and Kianjasoa

More upland rice was grown in the Tsiroanomandidy area, with much, if not most, grown on terraces formed between old contour hedgerows of napier grass (*Pennisetum purpureum*). The contour curves, established during the French colonial period (1895-1960) and essentially not maintained since, appear to have remained effective in maintaining terraces and limiting soil erosion. Upland rice in the Tsiroanomandidy area suffered from more damage from grasshoppers, birds, and wind (causing lodging) than in Kianjasoa. In response, a common practice was to intercrop a row of maize for every 6-10 rows of rice to protect the rice from the wind and to divert the grasshoppers. Compared with Kianjasoa farmers, Tsiroanomandidy farmers had larger farms and more cattle (often under an arrangement, *dabokandro sasahatombony*, in which they raised calves for herd owners in return for a share when the animal was sold). With more cattle, farmers did more plowing of upland fields and puddled lowland ricefields by trampling. They also reported more cattle theft.

Table 6. Characteristics of rice cultivars planted by farmers.

Cultivar	Comments
	Rainfed lowland
Congo	New, shorter, short grain, 150 d. for low areas, difficult to thresh, does not lodge
Japone	180 d, good taste, high tillering, many grains per panicle
Kalila	180 d, good taste, long and light-weight grain, needs more volume for cooking, does not shatter, nonglutinous
Madrigal	Various varieties from Madagascar Rice Gallan Company
Makalioka	MK34, widely planted near Kianjasoa Station, long grain, good yield
Mangasomotra	"Bluebeard," also called *Ambalalava*
Menakely	"Small red," high market demand, good taste
Miandrarivo	"From Miandrarivo"
Miandribararata	"Wait for flowering of bamboo," refers to all photoperiod-sensitive cultivars
Rojo	"Chain," probably 1285, red or white grain, medium height
Soamadama	"Pretty"
Tsipala	Traditional local cultivar
Varim Panjakana	"Rice from the state," released in the 1970s
Varybe	"Big rice," tall, for deeper water
Vary Botry	"Round," few tillers, easy to thresh
Vary Lava	"Long grain," tall, lodges
	Upland
Botramaitso	"Green and round," long panicle, does not shatter, difficult to mill
Fotsikely	"Little white," can be eaten plain
Japonica	Probably IRAT134
Mamonjy	"Help you," early cultivar
Mangavava	"Bluish panicle"
Telovolana	"Three months," 120 d, responds to FYM, red husk, thin, white grain
"1345"	Difficult to mill, does not shatter, drought-susceptible, long panicle
"2366"	IAC25, tall, long grain, shatters



6. Schematic agroecosystems transect of small valley, upper slopes, and upper area, and matching uses: Middle West of Madagascar.

Comparison of Analavory and Kianjasoa

Analavory farmers grew more commercial vegetables (with seasonal price fluctuations a problem) and less upland rice, applied FYM to vegetables rather than to maize or upland rice, and did more upland rice weeding and less fallowing. There were no contour hedgerows in the area. The weed-parasite *Striga* spp. was a more recently encountered problem. Differences among areas are summarized in Table 7.

PROBLEMS, CAUSES, FARMER SOLUTIONS, AND POSSIBLE RESEARCH

As fieldwork progressed, broad research areas were prioritized based on relative area planted and on existing productivity and potential for increase. The working group decided that—in order of importance—lowland rice, upland rice, and maize were of primary concern, and that cassava, legumes (peanut and groundnut), and vegetables were secondary concerns. The iterative process of farmer interviews, field observations, follow-up discussions, and synthesis then resulted in the identification of a range of problems, causes, and related farmers' practices intended to address the problems, and of a wide range of needed research.

Rainfed lowland rice

Low and possibly declining productivity was the major problem of lowland rainfed rice. Causes included drought, flooding, and submergence; a possible lack of rice varieties with characteristics addressing local problems; losses to insects, especially *Dicladispa armigera* (rice hispa, locally *hao*); and, possibly, losses to weeds. In the past farmers had selected upper-terrace rice varieties for drought tolerance but were often unable to plant (using available materials) the low, waterlogged, or flood-prone areas. They usually did not apply FYM to lowland rice because of the lack of yield response, and the greater vegetative growth and lodging caused by FYM, but they had selected for lodging resistance. Because of competing labor demands for upland crops, a few farmers preferred traditional, weed-competitive cultivars, with their lower yields, over improved varieties with higher yields but requiring

Table 7. Differences in Tsiroanomandidy and Analavory areas compared with Kianjasoa area.

Tsiroanomandidy area	Analavory area
More upland rice, especially between old contour hedgerows	Less upland rice
Grasshopper and bird problems for upland rice	More commercial vegetable production
More use of maize intercrop with upland rice to protect against winds and reduce upland rice loss to grasshoppers	More weeding of upland rice using hired and family labor
Less FYM applied to maize (FYM + drought = yield reduction)	FYM applied to vegetables rather than maize
More cattle, some raised under *dabokandro sasahatombony*	Few old contour hedgerows
More lowland animal trampling	*Striga* is a new problem
Larger farm size	Some lowland rice - vegetable
More cattle theft	Less fallowing in uplands
More FYM applied to upland rice More plowing of upland (twice)	Price fluctuation

weeding. For hispa, farmers drained fields, applied an insecticide (*Odiparasy*), and/or used botanical pesticides (*Sevalahy* or *Ravinikinina* [not identified]).

Based on the above, the group discussed research needed for lowland rainfed rice (Table 8). Included in the research agenda are further surveys and monitoring to reveal existing conditions, as well as basic on-farm and on-station research for the region. The unprioritized "menu" includes:

- survey of lands, hydrologies, and respective management systems;
- evaluation of soil fertility-related problems;
- development of improved water management systems;
- rice varietal improvement, including review of past work, and screening of traditional and improved varieties;
- assessment of losses due to insect pests and weeds;
- development of appropriate integrated pest management (IPM) techniques, including evaluation of current farmer practices;
- development of improved farm implements; and
- evaluation of labor constraints given whole-farm system demands.

Further survey of farmers' rice cultivars, for example, would help in planning rice screening. Although some cultivar information was gathered, more is needed on a) basic descriptors (e.g., duration, stature, resistance, tolerance for various stresses, grain quality, productivity); b) suitability for different lands, soils, and hydrologies; and c) farmer cultivar evaluations.

Upland rice

Low and declining productivity were the major problems of upland rice. Causes included weeds (especially *Striga asiatica* and *Rottboellia cochinchinensis*); soil-borne insect pests (especially *Heteronychus plebejus*); grasshoppers (*Locusta migratoria*); a combination of declining soil fertility, soil erosion, and shorter fallow periods; and sterility or lodging due to winds.

Farmers addressed the problems in various ways. They hand weeded upland rice one to three times, and planted what may act as a trap crop (peanut or groundnut) for *S. asiatica* in upland rotations. For soil-borne insect pests, some farmers broadcast seeded upland rice rather than drilled, or used small amounts of chemical pesticides. Farmers commonly intercropped a few maize rows in rice to act as a trap crop for grasshoppers. More FYM was applied in upland fields (although more for maize) as soil fertility declined. Farmers neither maintained nor established contour hedgerows, although they used the existing terraces for upland crops. These findings suggest that (as an unprioritized "menu") research for upland rice is needed on

- the extent of losses due to weeds, insects, and wind;
- weed succession and crop-management-weed associations;
- appropriate weed and insect IPM (and on current farmer practice);
- improved fallows using different grasses and types of legumes;
- integrated, low-input soil nutrient management;
- current soil fertility trends; and
- potentially effective soil erosion control techniques.

Maize

Low and declining productivity was also the major problem in maize. The several causes were similar to those leading to low or declining rice productivity: weeds (*Striga* and *Rottboellia*); soil-borne insect pests; declining soil fertility, soil erosion, and shorter fallow periods; and rat and rot losses associated with the storage of cobs on the stalk.

Farmer practices addressing causes of low and declining maize productivity were similar to those for upland rice. Exceptions included seed treatment with an unidentified pesticide, and resowing of maize or planting of rice after early crop destruction due to *Heteronychus*.

Except for the additional attention proposed for maize harvest and postharvest technology development, the initial research needed for maize was similar to that for upland rice.

Interactions among whole-farm system components

Interactions among components of the whole-farm system were identified or hypothesized based on group discussions of problems, causes, and farmer practices; and on farmer-reported relationships among factors, as follows:

- Previous crop affects levels of *Heteronychus* in the current crop.

Table 8. Problems, causes, farmer practices, and research agenda (not prioritized).

Cause	Farmer practice	Research agenda
Problem 1: low and declining productivity of lowland rainfed rice		
Drought, floods, submergence	Selecting upper-terrace cultivars for drought tolerance Not planting low areas without drainage	Survey lands, hydrologies, and respective management systems Improved management systems
Lack of varieties that address the causes of the key problems	Selecting for resistance to lodging Not applying fertilizer or FYM to lowland rice Testing and adopting improved varieties if seed is available	Review past work on varietal improvement Further examine farmers' cultivars and their respective characteristics Select, test improved locally suited materials
Losses to insect pests (especially *Dicladispa armigera*)	Draining fields Applying Odiparasy (local pesticide) Applying botanical pesticides; *Sevalahy, Ravinikinina*	Survey extent of losses Develop appropriate IPM technologies (including evaluation of farmers' practices)
Losses to weeds	Little weeding Use of weed-competitive cultivars	Survey extent of losses Develop improved tillage, cultivation implements, practices
Lodging	Selecting for shorter stature Leaving weeds to prop up rice plants	Select for shorter stature
Poor land preparation, lack of implements	Sharing implements or exchanging implement use for labor	On-farm mechanization Further survey of problems and needs
Lack of labor	Hiring labor if possible	Further survey of situation
Problem 2: low and declining productivity of upland rice		
Weeds (*Striga*, *Rottboellia*)	Hand weeding 1-3 times Planting a trap crop (peanut groundnut in rotation)	Survey extent of weed losses Examine weed succession and crop-management-weed associations Develop improved management systems, including tillage and cultivation implements
Insect pests: *Heteronychus* and grasshopper	Limited use of chemical fertilizers Broadcasting rather than drilling Replanting crop Planting a few maize rows as trap crop	Develop appropriate IPM techniques, including further examination of farmer control practices Monitor insect pest populations and extent of damage
Lack of improved varieties	Selecting cultivars over time, as available Seek and use improved seed	Survey farmer cultivars, characteristics, management Review past selection work on-station, on-farm testing (including at farmer input levels)
Declining soil fertility, soil erosion, reduced fallow periods	Applying more FYM Planting rice on old contour terraces Crop rotations with legumes Fallow (although reduced in length) Use of low-input levels, farm-generated inputs	Monitor current soil fertility trends Develop improved fallows using grasses, forage/nonforage, nongrain legumes Further develop integrated, low-input soil nutrient management techniques Develop soil erosion control technologies Possibly rehabilitating old contour hedgerow system
Winds causing sterility or lodging	Planting between old hedgerows	Survey wind-related losses

Table 8 continued.

Cause	Farmer practice	Research agenda
	Problem 3: low and declining productivity of maize	
Weeds (*Striga*, *Rottboeflia*)	Hand weeding Planting a trap crop (peanut or groundnut in rotation)	Survey extent of weed losses Weed succession and crop-management-weed associations Develop improved management systems, including tillage and cultivation implements
Insect pests: *Heteronychus* and grasshopper	Limited use of chemical fertilizers Treating seed with *gaz* Resowing maize Sowing rice after maize failure Early planting Rotating other crops	Develop appropriate IPM techniques, including further examination of farmer control practices Examine seed treatments Crop sequence effects Maize crop management
Declining soil fertility, soil erosion, reduced fallow periods	Applying more FYM Planting maize on old contour terraces Crop rotations with legumes Fallow (although reduce in length) Use of low-input levels, farm-generated inputs	Monitor current soil fertility trends Develop improved fallows using grasses, forage-nonforage, nongrain legumes Further develop integrated, low-input soil nutrient management techniques Soil erosion control technologies Possibly rehabilitate old contour hedgerow system
Rats and rot	Leaving cobs "stored" on plants in field Traditional storage technologies	Survey extent of losses Seek rot-resistant varieties Determine extent of postharvest losses Postharvest technologies, IPM

- Previous crop affects levels of *Striga* in the current crop.
- More FYM in upland crops leads to less *Striga* and more *Rottboeflia*.
- Declining or lower upland soil fertility leads to more *Striga*.
- Increasing human population leads to declines in the upland fallow period.
- Longer fallow periods reduce the amounts of problem weeds in the uplands.
- Extensive pastures/grasslands and fallows maintain root-attacking insect pests.
- Greater use of organic and inorganic fertilizers may be associated with more insect pests.
- Maize losses may be due to losses from rats and rot because of storage in the field while farmers are busy with lowland rice and other upland crops.
- *Striga* may be reduced by using groundnut as a trap crop.
- Use of FYM on cash crops (maize, vegetables) limits its availability for other crops.
- Relative fertile lowland soils combined with a lack of fertilizer-responsive rice cultivars limits the use of FYM in the lowlands.

Interdisciplinary research is needed to address these issues.

CONCLUSIONS AND RESEARCH PRIORITIZATION

Based on current production, potentials for improvement, and research resources, the FOFIFA team decided to concentrate future research on lowland rainfed rice, upland rice, and maize. The group next combined with other FOFIFA and IRRI researchers and administrators to further examine work already accomplished or under way, research resources (including human), and what they had learned in the field. The group then established a) priorities from the "menus" above, b) more specific research activities, and c) a better idea of who would do what. Research prioritization was based on group discussions that weighed farmer needs, FOFIFA-IRRI research resources, and potentials for increasing or sustaining productivity in the Middle West.

Rainfed lowland rice

Three research activities were suggested for rainfed lowland rice.

- Continued testing of improved or adapted local lowland rainfed rice varieties is needed. There is need for varieties that address problems posed by drought or excessive water, that do not lodge, that are fertilizer responsive, are relatively cold tolerant, and/or are tolerant of the apparent soil stresses. Previous work has

shown that IR36, IR38, and 2789 are promising. Farmer-managed on-farm testing and evaluation are needed. The IRRI breeder can contribute to continued efforts by FOFIFA's Direction Scientifique.

- Although assessment of losses due to *D. armigera* is needed, development of a suitable IPM approach to reduce hispa damage was deemed a second priority for rainfed lowland rice. FOFIFA's Departement de Recherche Developpement (DRD) and Departement de Recherche Agronomique (DRA) will request PLI-ALAOTRA, a Swiss organization working on the same problem in the Lac Alaotra Region, to visit the Middle West when hispa is a problem so that they may assess the problem and suggest possible technical solutions or needed research.
- Research leading to improved water management in the minivalleys was the third priority for lowland rainfed rice. A recently completed land survey by FAO and FOFIFA (reportedly covering areas of flood-prone and drought-prone land, upland rice, and other lands) needs to be reviewed. Field research is needed to determine the balance of needs between institutional (e.g., cooperation among farmers and farm communities) and infrastructural (i.e., large earth-moving operations required) factors. Cooperation between FOFIFA's Departement de Recherche Technologique (DRT) and a World Bank-Government of Madagascar (including FOFIFA) project working on small irrigation systems is needed. Finally, it was noted that USAID funds small projects for improved water management.

The diagnostic team was also concerned about possible soil-nutrient problems for lowland rice. Although more basic soil characterization studies may be needed, soil data for the region suggest that liming is unnecessary (and may have adverse effects); phosphate rock may be as efficient as superphosphate for soils that are dried between crops; and FYM mixed with P prior to application should be highly beneficial. Drainage or aeration after addition of heavy organic substrates with high C-N ratios may be necessary to prevent accumulation of toxins because of low pH and high bulk density (H.U. Neue, IRRI pers. comm.).

Upland rice

Five research activities were developed for upland rice.

- Research to control insect pests (especially *Heteronychus* and grasshoppers) is needed. FOFIFA needs to review previous work on *Heteronychus* in Africa and possibly in Reunion (where it was reportedly a pest of sugarcane). Farmers' control methods need to be examined and compared with experimental treatments. DRA entomologists have started research on biological control methods; and DRD and DRA should coordinate efforts as possible technologies are readied for testing on farmers' fields.
- Research on improved soil nutrient management and soil erosion control is needed. FOFIFA researchers need to a) examine past experiments at Kianjasoa Station on pasture grasses and legumes, and b) obtain a more complete characterization of soils in the region. Research could then be conducted on improved fallows using pasture and nonpasture (e.g., creeping live mulches) legumes. Organizations such as the Commonwealth Scientific and Industrial Research Organization, University of Queensland, and Queensland Department of Agriculture could supply promising materials tested in Northern Australia; and IRRI can assist in the design of on-station and on-farm experiments.

  For soil conservation, DRD, DRA, and the Departement de Recherches Forestieres et Piscicoles (DRFP) can examine potentials for rehabilitation of old contour hedgerows using agroforestry technologies. DRD and DRA need to visit the DRFP alley cropping experiments in the Middle West. IRRI can explain the lessons learned from its farmer-participatory research on soil conservation in the Philippines.

  Longer term changes in soils need to be monitored by FOFIFA soil scientists. Current soil fertility trends need to be studied; and the effects of new technologies (e.g., additional organic material) on soil fertility and physical characteristics need to be monitored.
- Research leading to improved weed management is needed. A survey of *Striga* species in the region is needed. Losses due to *S. asiatica* and *R. cochinchinensis* need to be assessed. Legume trap crops can be effective and could contribute to an integrated approach to *Striga* control (Robinson and Dowler 1966). Further research is needed on peanut and bambarra groundnut trap crops, since these are already components of the upland rotations. Farmers, in fact, may be including the legumes in part due to their effects on *Striga*. The resident IRRI agronomist will provide reference materials from past research conducted on *Striga* in Africa. IRRI's agricultural engineer can be invited to provide inputs into DRT's work on improved tillage and weed control implements.
- Farmers need improved upland rice varieties. Past FOFIFA and IRRI work identified promising varieties such as 2366 (IAC25), 2391, IRAT134, IRAT112, and FOFIFA31. Researcher-managed tests on farmers' fields; farmer-managed trials using farmer levels of inputs, cropping patterns, and crop rotations; and farmer evaluations are needed. The use of N, P, and K in varietal screening needs to be reexamined, since it is not certain if P and K are deficient in the Middle West. Seed multiplication is a problem that DRD and DRA can address. IRRI will work with FOFIFA on these issues directly related to upland rice in the region.
- Finally, an agroecosystems or farming systems approach to research is needed. Integrated research on

soil fertility management, pest (including weed) control, and varietal improvement needs to be coordinated and interactive. On-farm and farmer-participatory technology selection, testing, adaptation, and adoption are needed in addition to on-station and laboratory research. Cooperation among government agencies will be a key factor in achieving long-term research goals.

Maize

Problems and causes for maize were similar to those encountered for upland rice. Because much of the research identified for maize overlaps that for upland rice, the working group did not finalize a separate list of research priorities for maize.

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