Ministry of Agriculture, Forestry and Food Security
The Republic of Sierra Leone

The Agricultural Development Project in Kambia in the Republic of Sierra Leone

Final Report

Agricultural Technical Support Guidelines

Part IV
Annexes

March 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

RECS International Inc.

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Annex 1
Pilot Project for Rice Production

Annex 1 Pilot Project for Rice Production

1.1 Pilot Project in 2007

1.1.1 Intr oduction

As a core action of the Agricultural Development Project in Kambia district, Sierra Leone, a pilot project (PP) on rice cultivation was carried out in 2007. The PP aimed at obtaining 1.0-1.5 ton/ha of grain yield by improving rice culture practices, whereas the prevailing yield level was about 0.5 ton/ha.

Note that ‘grain’ signifies rough rice (brown rice and husks) in this text.

The principles for how to accomplish this goal were discussed between the two parties: the Ministry of Agriculture, Forestry and Food Security, Kambia district (MAFFS-K) and the JICA Agricultural Team (JPT). They agreed on following principles:

1) The techniques are sustainable (self-supportive).
    a) They should be acceptable by the farmers.
    b) They should be low-input (or low-cost) and profitable.
2) The techniques are environmentally friendly.

    Before executing the PP, a draft version of the technical package (draft TP, see Supplement 1 at the end of this Annex 1.1) was prepared to provide guidelines by referring to the available information and past observations of the farmers’ fields. The draft TP was intended to be verified and improved with the implementation of the PP.

1.1.2 Meth ods

(1) Site selection

One village in each chiefdom was selected: 7 in total in Kambia District (Table 1.1-1 and Figure 1.1-1). One or two representative agro-ecological regimes for rice culture were selected for each village so that all the prevailing agro-ecological regimes in Kambia district were included: *i.e.*, upland, inland valley swamp (IVS), mangrove swamp and boliland. Riverain grassland was excluded due to its minor level of occupancy in the district.

Table 1.1-1 Village and Agro-ecological Regimes Selected in Each Chiefdom

Chiefdom	Village	Agro-ecology of rice culture			
		MS	IVS	Boliland	Upland
Mambolo	Makoth	x			
Samu	Rosinor	x			
Magbema	Robat	x (a)			
Gbinle Dixon	Kunthai		x		x
Masungbala	Robennah		x		x
T. Limba	Karlington			x	
Bramaia	Sabuya		x		

Abbreviations: MS, mangrove swamp; IVS, inland valley swamp
a) Agro-ecology at Robat is sub-classified into associated MS.

General information on the socioeconomic conditions of the villages is shown in Table 1.1-2. The size of the villages varied widely from 26 to 316 households. The major economic activity was farming in the lowlands and uplands.

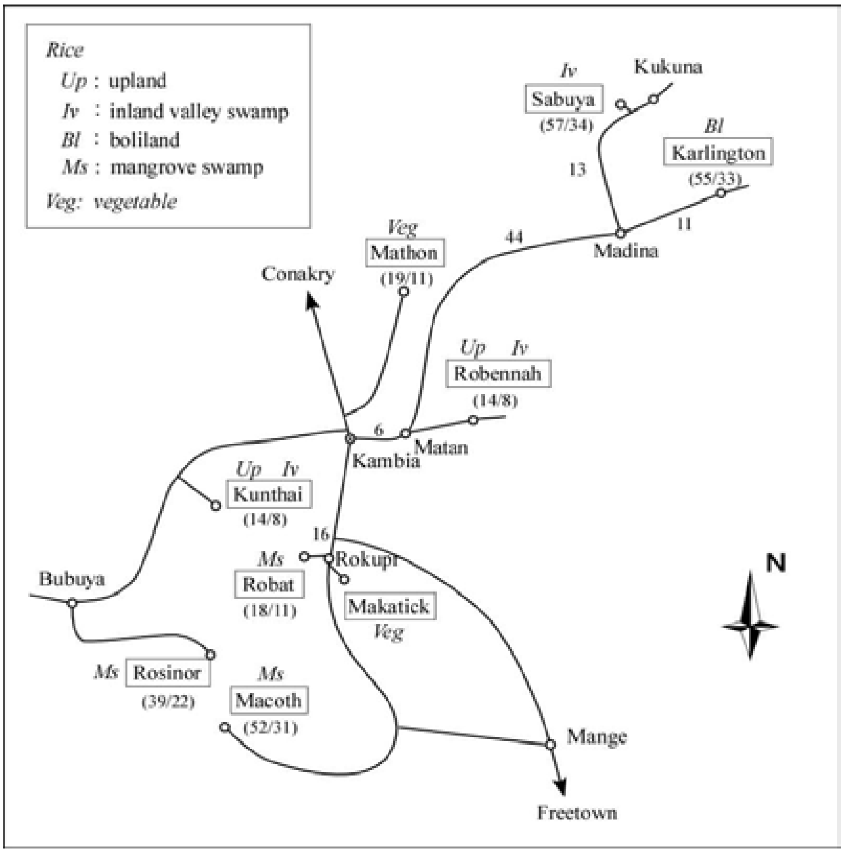


Figure 1.1-1 Location of the Seven (7) Pilot Project Sites for Rice Culture in Kambia District

The names of the sites are enclosed in a box shown with the symbols for their associated agro-ecological regimes. The figures in parentheses are the approximate distance (km/mile) from KambiaII (checkpoint). Two (2) pilot trial sites for vegetables are also shown.

Table 1.1-2 (1) Some Socioeconomic Conditions of the Seven Villages Where the Pilot Project was Carried Out

Village	Total number of HHs	Total number of popula-tion	No. of persons /HH	Dominant ethnic group	Major economic activity First	Major economic activity Second	Major economic activity Third
Makoth	310	1,240	4	Temne	Lowland rice	Trading	Fishing
Rosinor	250	3,000	12	Temne	Lowland rice	Field crop (a)	Trading
Robat	195	2,055	10	Temne	Lowland rice	Upland rice	Trading
Kunthai	40	250	6	Temne	Lowland rice	Field crop (a)	Trading
Robennah	32	275	9	Temne	Lowland rice	Upland rice	Field crop (a)
Karlington	26	136	5	Limba	Lowland rice	Upland rice	Field crop (a)
Sabuya	50	300	6	Susu	Cash crop (b)	Wood cutting	Trading

Data source: Baseline survey - village information, 2006.
Abbreviation; HH: household.
a) Except upland rice.
b) Importane was in the order of groundnut >> pepper > palm oil > ginger.

Table 1.1-2 (2) Some Socioeconomic Conditions of the Seven Villages Where the Pilot Project was carried out

Village	Existence of (c)					No. of WG	Average wage (d)
	Public building			Comm. well	Drying floor		
	Court	Mosque	Church				
Makoth	No	Yes	No	No	No	2	1.0
Rosinor	Yes	Yes	No	-	No	3	1.7
Robat	No	Yes	No	No	No	3	1.7
Kunthai	No	Yes	No	Yes	Yes	3	1.0
Robennah	No	Yes	No	Yes	No	4	1.7
Karlington	No	No	Yes	Yes	No	2	1.7
Sabuya	No	Yes	No	Yes	No	3	1.0

Data source: Baseline survey, 2006

Abbreviations; HH: household, Comm. Well: community well, WG: working group, Court: local court.

c) Primary school exists in all villages, but no market nor community center exists.Post harvest facility like grain store, rice mill, nut craker, cassava grater and palm oil mill are unavailable in all villages.

d) For hired laborer (US$ per person.d)

(2) Farmers' groups

A farmers' group comprising 10 members was organized for each agro-ecological regime of every village: *i.e*. one group in every village except Robennah and Kunthai where two groups were formed due to the plural agro-ecological regimes selected in the villages (Table 1.1-1). Every group chose the positions required for working in a group: one leader for each group, an assistant leader, a secretary, a treasurer, and an organizer, and 5 members. They spared one or two working days a week for the PP.

(3) Key techniques introduced

The important techniques emphasized are:

a) Timely farming activities based on a well-planned cropping calendar.
b) Rational seeding rates.
c) Proper land preparation.
d) Appropriate transplanting methods in the lowlands including:
  - d-1) Use of young seedlings
    (3-week-old seedlings for IVS and boliland and 4-week-old ones for the mangrove swamp area),
  - d-2) Reduced number of seedlings per hill (2 to 3 per hill).

The rice varieties recommended were ROK 3 in the uplands, ROK 5 in the IVS, and ROK 10 in the mangrove swamp and boliland. The seeding rate was at 40 kg/ha for transplanting in the lowland areas, at 60 kg/ha for the upland areas, and 75 kg/ha for direct sowing in boliland. The method of uniformly broadcasting seeds was explained at the taskforce meeting before the start of the PP (see the handout in Supplement 2).

The types of fertilizers were modified from those in the draft TP since the indicated fertilizers such as phosphorus fertilizer were unavailable in the market. Hence the quantity and types of fertilizers were modified to 2 bags (= 100 kg)/ha of compound fertilizer (15-15-15) as a basal application and 2 bags/ha of urea for top-dressing. In the Sabuya IVS, the fertilizer used for top-dressing was replaced with 2 bags/ha of the compound fertilizer due to the properties of the soil (tropical peat): otherwise an excess of N would have induced severe physiological injury.

Since the farmers are used to mixed cropping of sorghum with upland rice, the PP included treatment with and without sorghum in the upland trials. The standard mixing rate was set at 20 g of sorghum seeds with 25 kg of rice seeds.

(4) Provision of the necessary materials

The JPT supplied the seeds, fertilizers, tools (hoe and cutlass) and post-harvest machines (thresher, winnower and rice huller) to the PP villages.

(5) Field layout

The farm size of every PP site was set at 1 ha. Figure 1.1-2 shows the standard layout of the main field in the uplands and lowlands. In several cases, the field layout was modified subject to the site-specific conditions: *e.g.*, Robennah IVS (Figure 1.1-3).

The treatment was not duplicated to avoid a complicated plot layout: instead, the plot size was extended so that it was large enough to enable the farmers to make a profit. The reason for this was that the trial was extension-oriented and emphasized ease of understanding by the farmers.

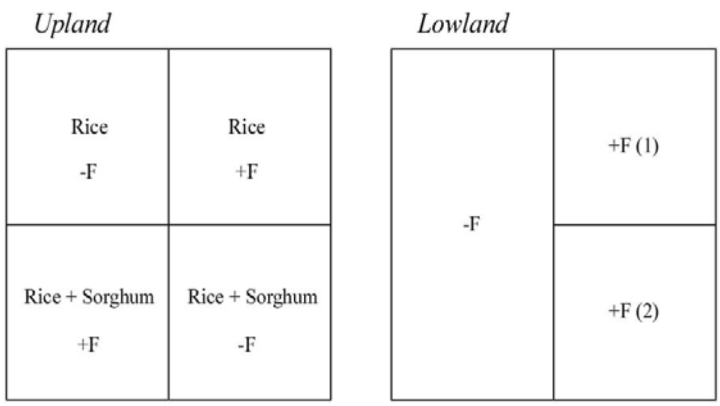


Figure 1.1-2 Standard Layout of Treatments in the Upland and Lowland Areas

-F: without fertilizer, +F: with fertilizer

+F(1): top-dressing (once),

+F(2): split into two separate applications of the top-dressing

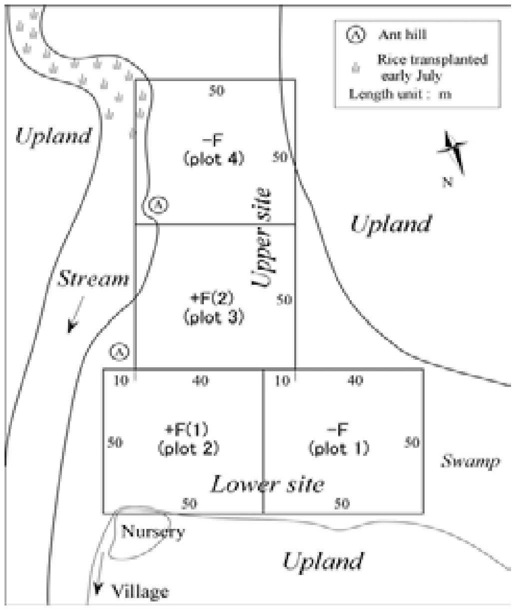


Figure 1.1-3   Field Layout of the IVS Area in Robennah

(6)   Supporting system

Seven FEWs were assigned to the respective sites, and 3 BESs and 5 SMSs acted as supervisors. MAFFS-K staff and JPT members held a taskforce meeting every week, where all members reported their observations at the sites, discussed any problems that had arisen and found ways to solve them, and confirmed the activities in the coming week.   The JPT delivered several handouts at the taskforce meeting when any technical information was needed.

The JPT members frequently visited the fields, inspected the plant growth, and gave technical advice to the staff and farmers. Unfortunately, no JPT member was stationed in August, which is the important season for transplanting, because a presidential election was scheduled.

(7)   Monitoring

Farming activity and plant growth were routinely monitored throughout the whole season.   The former covered the items of the number of persons assigned to each form of crop management and of any events in the growth stages on a daily basis. For the latter, three sub-plots (1 m x 1 m square) were established within a treatment plot, and every 2 weeks, by selecting 3 hills per sub-plot, the total number of hills per sub-plot was counted, and the plant height and the number of tillers were measured. Recording sheets were delivered to each FEW assigned to the PP sites.

The method of measuring these items was explained at the taskforce meeting before the start of the PP: *e.g.*, see the handout in Supplement 3). The plants within the sub-plots were harvested and the grain yield was measured.

At harvest time, two yield sub-plots (48 m^2 each) within a treatment plot were set up at a place with representative plant growth. All the plants in the sub-plots were harvested and threshed, and the grains were dried and weighed.   The grain yield was calculated as an arithmetic mean of the two measurements. The grain yield and 1,000-grain weight were adjusted to account for 14% moisture. All the remaining plants were harvested by farmers (whole plot harvest) and the total grain production was estimated by volume or weight.

(8) Training

For the MAFFS-K staff, the JPT provided an opportunity for on-the-job training through advice, guidance, practice, and discussions in the fields and during the task force meeting, since the JPT understood that they were equal partners. For the farmers' groups, a Leaders' Training Workshop was held on November 1, 2007, by inviting representative personnel from all the farmers' groups.

(9) Evaluation and appraisal of the PP

Several attempts were made to gather the farmers' and extension workers' opinions and experiences for the evaluation of the PP (2007-2008) and for improving the project in 2008. They were (a) a series of meetings with the farmers' groups at each site on January 25-30, 2008, (b) collection of opinions from all the MAFFS-K staff in a questionnaire format, and (c) an appraisal workshop held on February 7, 2008.

1.1.3 Results and Discussion

(1) Dates of the growth stages and farming activities

The seeds were sown more or less as scheduled except for the upland nursery in Robat where the sowing was delayed due to a lack of rain (Table 1.1-3).

In Kunthai IVS, flooding after transplanting damaged the plants so that a short duration cultivar, Buttercup, was re-planted after the flood receded. The rice plants were harvested from the end of October to early November in the upland areas, in the middle of November in the IVS areas, and at the end of December in the mangrove swamp areas.

Table 1.1-3. Dates of key farming activities and growth stage at seven (7) pilot project (PP) sites (2007-2008)

Agro-ecology (a)	PP site (village)	Cultivar	Growth durat'n [d]	Plant-ing method (b)	Type of nursery (c)	Date of growth stages and farming activities: Sowing	Fertilizer on nursery	Basal fertilizer appl. (e)	Transplanting	Transplanting 1st d. (DAS)	Transplanting [dur'n] [d]	Top dressing 1st	Top dressing 2 nd	50% flower-ing (k)	Harvest
Mangrove	Macoth	ROK 10	180	T/P	-	25-Jun	12-Jul	7-Jul	15,16-Aug	51	2	6-Oct	21-Oct	27-Nov	29-Dec
swamp	Rossinor	ROK 10	180	T/P	-	9-Jun	23-Jun	24-Aug	9,10-Aug	61	2	6-Oct	20-Oct	15-Nov	27-Dec
Assiciated mangv. sw.	Robat	ROK 10	180	T/P	Upl'd (f) Lowl'd	21-Jul (d) 14-Jun	5-Jul 2-Jul	none (h)	3,4,5,12 Aug	43-50	9	7-Sep	24-Sep	17-Nov	22-Dec
Boliland	Kalintin	ROK 10	180	DS	-	24-May	-	28-May	-	-	-	11-Jul	-	27-Oct	3, 15Dec
IVS	Robennah	ROK 5	160	T/P	-	19,22-Jun (g)	6-Jul	30-Jul	l) 29,30-Jul u) 18,22,24-Aug	l) 30 u) 70	l) 2 u) 6	26-Sep	-	l) 7-Oct u) 13-Oct	l) 11-Nov l) 23-Nov
	Sabuya	ROK 5	160	T/P	Wet Dry	29-Jun 25-Jun	29-Jul 9-Jul	10-Aug 24,31-Jul	24, 31 Jul 10-Aug	25 46	2 1	18-Sep	13-Jul	13-Oct 15-Oct	20-Nov 15-Nov
	Kunthai (j)	ROK 10 Butter cup	180 90	T/P T/P	-	9-Jun 3-Oct	23-Jun -	none (h)	8, 10 Aug -F) 18-20 Nov +F) 29-Oct-2 Nov	60 46 26	3 3 4	none (i)	-	- 15-Dec 21-Dec	- 21-Jan 21-Jan
Upland	Robennah	ROK 3	140	DS	-	12-Jun	-	12-Jun	-	-		8-Aug	-	3-Oct	30,31-Oct
	Kunthai	ROK 3	140	DS	-	23,24-Jun	-	23,24-Jun	-	-		10-Aug	-	8-Oct	3,4-Nov

Abbreviations: [dur'n]: duration of transplanting in days, '- : Not applicable Unit; d: day, DAS: days after sowing.

a) Agro-ecology; Mangr. sw.: mangrove swamp, Mangr-ass.: associated mangrove swamp: IVS: inland valley swamp
b) Planting method; T/P: transplanting, DS: direct sowing (broadcasting)
c) Type of nursery; Upl'd: upland, Lowl'd: lowland
d) Sowing on upland nursery was delayed due to a lack of rain.
e) Including fertilizer application shortly after transplanting
f) Sown on nursery at Robat: 35 kg seeds in lowland (former pepper mound) and 15 kg on upland.
g) Two another dates were found in the Faming Activity sheet.
h) No basal fertilizer application due to flood
i) Not top-dressed owing to flood
j) Abandoned because of flooding (damaged with flood: to be replanted).
k) Exact dates were not defined due to mixturte of seeds: mid-day was estimatged.
l and u) lower and upper site, respectively, at Robennah IVS

(2) Grain yield

1) Main results

(a) A grain yield of 1 ton/ha was attained in many sites of the various agro-ecological regimes with the improvement of the culture practices even without the application of fertilizers (Table 1.1-4 and Figure 1.1-4).

Table 1.1-4 Grain Yield and 1,000-grain Weight of the Pilot Project (2007-2008)

Agro-ecology	Site (village)	Cultivar	Treatment Specific	Treatment Fertilizer	Date of harvest	Grain yield (ton/ha)	(error)	1,000-grain weight (g)
Mangrove swamp	Macoth	ROK 10	-	-F	2007/12/29	1.02	*	22.0
			-	+F (1)		1.35	*	21.1
			-	+F (2)		1.55	**	21.8
	Rosinor	ROK 10	-	-F	2007/12/26	0.91	**	21.5
			-	+F (1)		1.40	*	21.6
			-	+F (2)		1.59	**	22.2
Associated mangrove swamp	Robat	ROK 10	-	-F	2007/12/22	2.16	*	21.3
			-	+F (1)		2.28	**	20.8
			-	+F (2)		2.59	***	21.3
Boliland	Kalintin	ROK 10	-	-F	2007/12/3	0.39	**	22.4
			-	+F	2007/12/15	0.61	****	22.6
IVS	Robennah	ROK 5	Lower site	-F	2007/11/12	1.28	**	30.1
				+F		1.84	*	30.5
			Upper site	-F	2007/11/23	0.65	**	29.0
				+F		1.07	*	29.8
	Sabuya	ROK 5	Dry nursery	-F	2007/11/15	1.40	**	28.6
				+F		1.63	**	28.7
			Wet nursery	-F	2007/11/19	0.87	***	28.3
				+F		1.00	*	28.5
	Kunthai	Butter cup	-	-F	2008/1/21	0.14	*	20.4
			-	+F		1.31	*	22.8
Upland	Kunthai	ROK 3	Rice	-F	2007/11/4	0.34	**	27.3
				+F	2007/11/3	0.74	**	27.6
			Rice + sorghum	-F	2007/11/4	0.47	**	27.2
				+F	2007/11/3	0.83	**	27.9
	Robennah	ROK 3	Rice	-F	2007/10/30	1.23	**	27.1
				+F	2007/10/31	1.09	**	27.5
			Rice + sorghum	-F	2007/10/30	1.01	*	26.5
				+F	2007/10/31	1.26	*	28.0

a) Grain yield and 1,000-grain weight were based on fully ripened grains (rough rice), and the moisture amout of grains was adjusted to 14%.

b) The approxiamate error of grain yields between the two replicated sampling plots in a treatment were: * 10%, ** 20%, *** 30%, and **** 40%.

c) Marginal production to recover fertilizer cost is 1.0 ton/ha, assuming that (1) fertilizer cost is Le.150,000/bag (50 kg/bag), (2) fertilizer rate is 4 bag/ha, and (3) price of rough rice is Le.30,000/bu (50 kg/bu).

d) To estimate total production in each site, two factors should be considered: (1) The total acreage was less than one hectare in many cases and (2) the grain yield indicated does not represent genenal situation of the whole fields (*e.g* ., irregular growth of rice plant, physical and crab damages, etc.). For the latter, the proportion of field area with the indicated grain yield could be 0.6-0.7 in Karlintin, 0.8 in Sabuya and Macoth (-F), and 0.9 in Kunthai IVS.

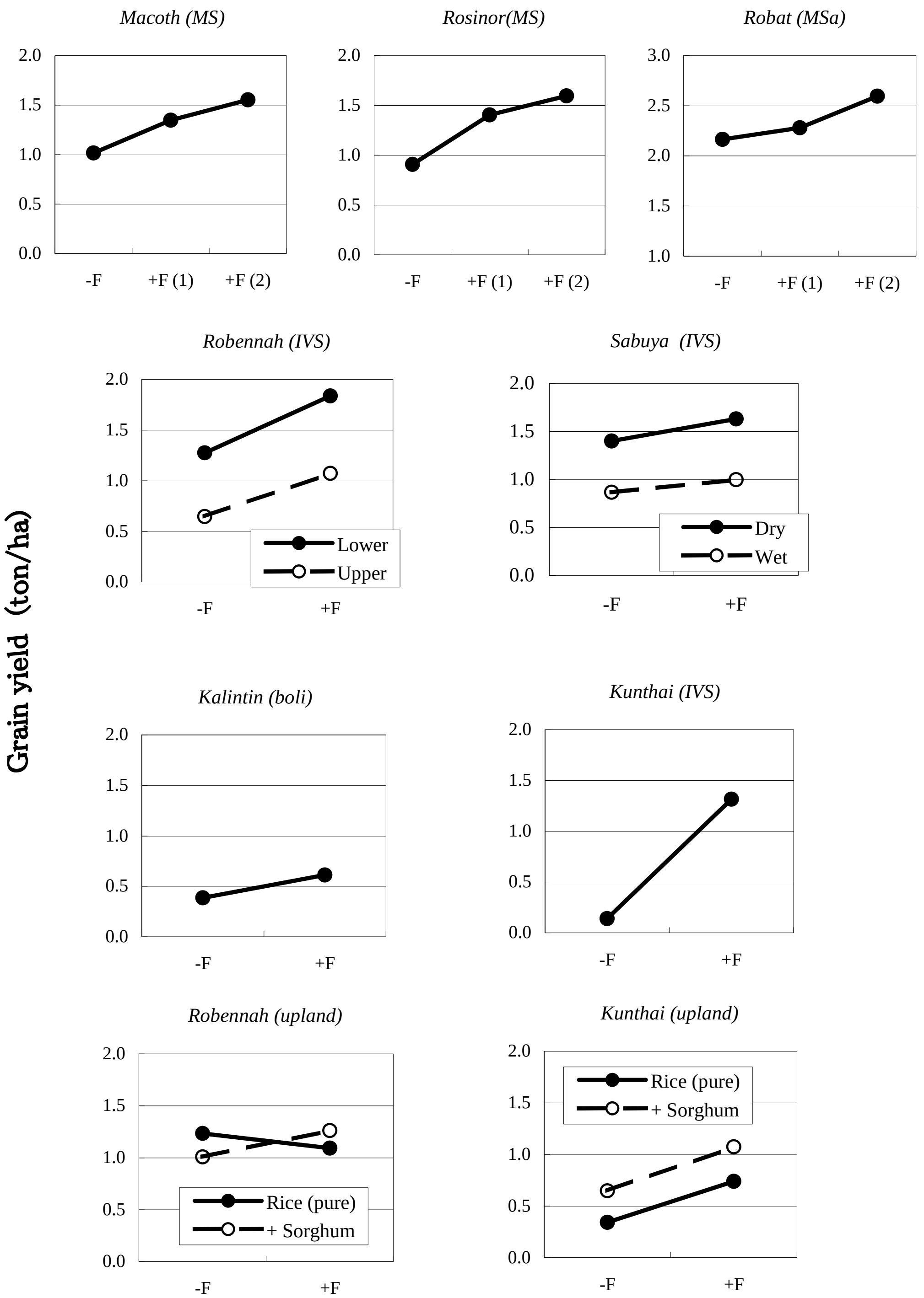


Figure 1.1-4 Grain Yield Response to Fertilizer Application at the Pilot Project Sites (2007-2008)

MS: mangrove swamp
MSa: associated mangrove swamp
boli: boliland, IVS: inland valley swamp

-F: not fertilized, +F or +F(1): basal and one top-dressing of fertilizer
+F(2): basal and split into two separate applications of fertilizer

Upper and Lower: upper or lower site of the slope, respectively.

Dry and Wet: seedlings grown in a dry or wet nursery, respectively.

Exceptions were: for instance, Kunthai IVS (-F) due to delayed transplanting, Kalintin (boliland) due to early and prolonged flooding, and Robennah IVS (upper site) due to delayed transplanting and a shortage of water.

(b) No significant difference in the rice grain yield with or without sorghum was observed in the upland areas.

(c) The fertilizer response was about 0.5 ton/ha with an application rate of 4 bags/ha: 2 bag/ha each of compound fertilizer (15-15-15) and urea.

(d) Splitting into two separate applications of top-dressing tended to increase the grain yield compared to a single top-dressing of fertilizers.

Note on the expected grain yield increment due to the nitrogen fertilizer

In the PP (2007), the quantity of nutrients added was N-P_2O_5-K_2O = 61-15-15 kg/ha because 2 bags of compound fertilizer (15-15-15) as a basal application and 2 bags of urea (46% N) as a top-dressing were applied on each hectare.

Assuming that the nitrogen concentration of grain and straw is 10 mg/g (0.01 g/g or 1%), the nitrogen absorption efficiency is 50%, and the harvest index of the rice plants is 0.33 (or the grain : straw ratio = 1 : 2), the grain yield increment due to the nitrogen (61 kg/ha) application can be calculated as about 1 ton/ha (= 1/0.01 x 61/0.5 x 0.33)/1,000.

2) Yield variation in the main fields

The variation from the expected grain yield measured with duplicated yield-plots was 10%-40% (Table 1.1-4). This variation was mainly caused by yield variation within each treatment plot, which was derived from the uneven soil fertility in the plot. Some examples of yield variation (estimated visually) are shown in Figures 1.1-5 and 1.1-6. Based on the entire situation, the grain yield variation from the expected must be nearly 0.5 ton/ha.

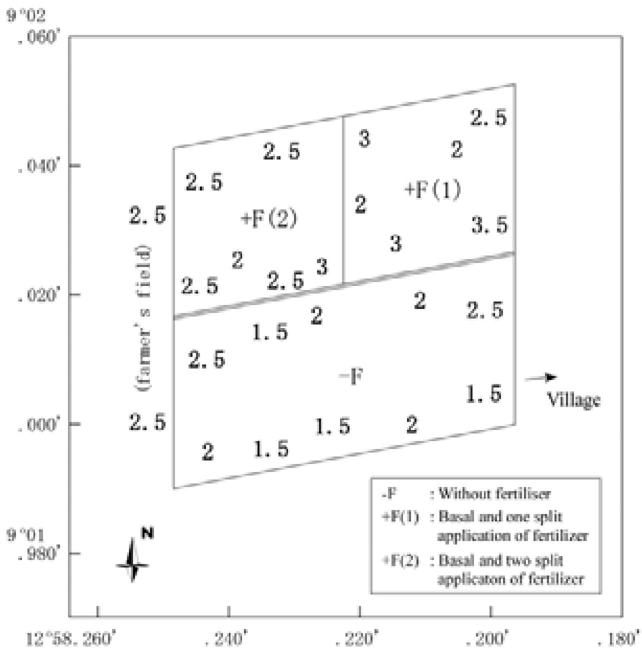


Figure 1.1-5 An Example of Grain Yield Variation in Robat (Associated Mangrove Swamp Areas)

Numerical values show the grain yields determined by visual observation on December 14, 2007.

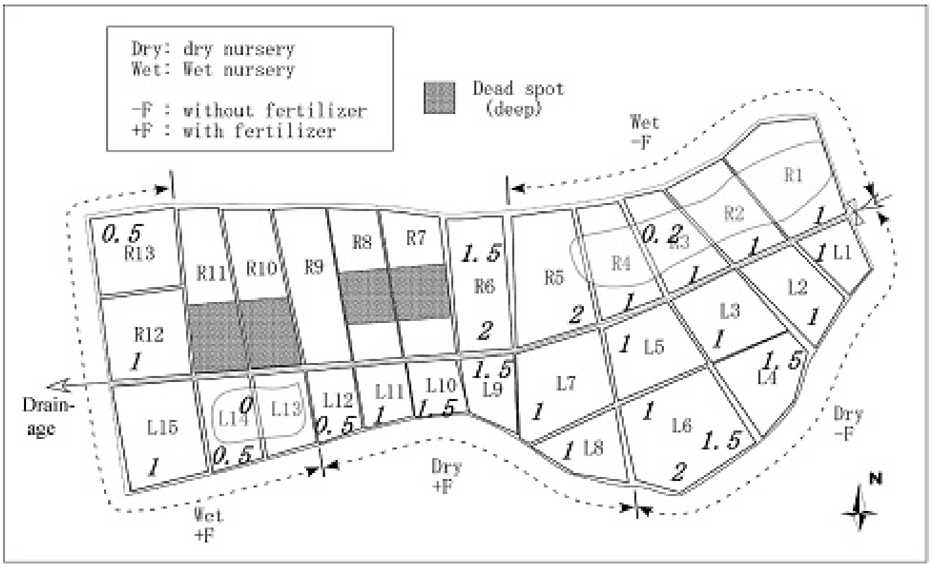


Figure 1.1-6 Variation in the Grain Yield in Sabuya (2007)

The figures in italics are the grain yield (ton//ha) and figures with the prefix R and L are the plot number on the right and left bank, respectively.

3) Comparison of the grain yield between yield plot and whole plot harvesting

The grain yield presented above was not necessarily representative of that for the whole plot, mainly because the yield sub-plots were set only for places where the rice plants were growing, in addition to the yield variation in the field. For instance, at the harvesting time in Kalintin boliland, a large portion of the main field was almost vacant due to prolonged flooding and where few rice plants had survived and some aquatic weeds were growing. The grain yield was measured only in places where the rice plants had formed a population to some extent. Hence, the grain yield using the sampling method multiplied by the plot area does not give the total production for the whole plot.

To link the two measurements using the sampling method and the whole-plot harvest, a factor for the effective coverage (Ec) was introduced to the yield data using the sampling method. The total production measured by the sampling method can be calculated as:

Total production = GY x Area x Ec

where GY: grain weight per unit field area (ton/ha) at 14% moisture.

Area: acreage of the plot. Note that many PP sites were not a regular square, but had some deformation of the shape, and thus the net total acreage was measured.

Ec, Effective coverage: the proportion of the field area represented (covered) by the grain yield measured, varied from 0 to 1 depending on the rice occupancy in the field. (1-Ec) signifies the damaged or affected proportion of the plot area. The Ec in ordinary sites (undamaged plots) should be one (1).

Table 1.1-5 shows the Ec values observed. For example in the unfertilized plots (-F) in Macoth, 25% (1-Ec) of the plot area was seriously damaged by H_2S, where the GY was nominal.

Table 1.1-5 Effective Coverage of the Grain Yield Measured (Ec)

Place	Ecology	Treatment	Ec	Cause of reduction
Macoth	MS	-F	0.8	H_2S toxicity
		+F(1)	0.9	*ditto*
Kunthai	upland	-F	0.9	Bird damage at emergence
	IVS	+F	0.9	Former compost heap plot & stream
Kalintin	boli	-F	0.7	Early and prolonged flood
		+F	0.6	*ditto*
Sabuya	IVS	Dry (-F)	0.95	Fe excess
		Wet	0.85	*ditto*

Ec: Proportion of the field area effective with the measured grain yield for calculating total production in a whole area, visually estimated.

The two measurements, grain yield using the sampling method adjusted with the factor Ec and that for the whole-plot harvest, agreed reasonably well each other (Table 1.1-6 and Figure 1.1-7). This fact verified the reliability of the grain yield using the sampling method to a certain extent. However, some discrepancies between the two measurements can be observed. Discrepancies were attributable to both measurements. As for the sampling method, the yield-plot selection might not be representative of general rice growth since the yield variation was large among the fields (Figures. 1.1-5 and 1.1-6). As for the whole plot harvesting, production by weight itself was converted from volumetric measurements in many cases (see the footnotes in Table 1.1-6), the grain moisture level was not adjusted when the production was estimated, and losses during harvesting and threshing were plausible due to the difficulty in handling the bulky materials.

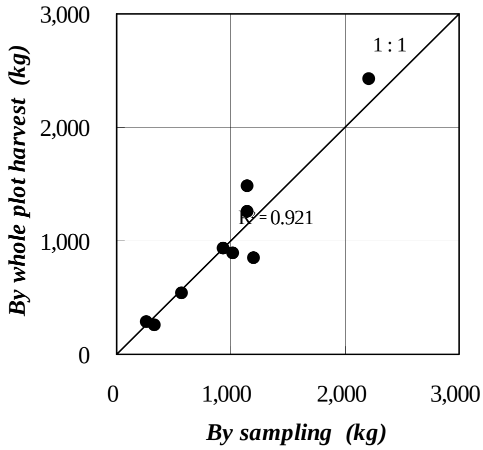


Figure 1.1-7 Relationship between the Total Production of a Whole Field Calculated on the Basis of the Grain Yield Measured Using the Sam pling Method and That for Harvesting the Whole Plot by the Farmers

Table 1.1-6 Total Grain Production at the PP Sites Using the Sampling Method Corrected with the Ec and that for the Harvesting of the Whole Plot by the Farmers

PP site	Agro-ecology & cultivar	Treatment: Specific	Treatment: Fertilizer	Grain yield (ton/ha)	Field area (ha)	Effective coverage	Production (kg) by the sampling: Within a treatment	Production (kg) by the sampling: Total at the site	Production (kg) by whole plot: Within a treatment	Production (kg) by whole plot: Total at the site (a)
Macoth	Mangr.	-	-F	1.02	0.49	**0.75**	373	1,019	-	890
	swamp	-	+F (1)	1.35	0.23	**0.90**	280		-	(870) b
	ROK 10	-	+F (2)	1.55	0.24	1.00	366		-	
Robat	As. mangr.	-	-F	2.16	0.48	1.00	1,042	2,216	-	2,420
	swamp	-	+F (1)	2.28	0.24	1.00	549		-	(2,385) c
	ROK 10	-	+F (2)	2.59	0.24	1.00	625		-	
Rosinor	Mangr.	-	-F	0.91	0.25	1.00	227	937	278	924
	swamp	-	+F (1)	1.40	0.24	1.00	332		307	(905) b
	ROK 10	-	+F (2)	1.59	0.24	1.00	378		339	
Kunthai	Upland	Rice	-F	0.34	0.25	**0.90**	77	576		532
	ROK 3		+F	0.74	0.25	1.00	185			(520) d
		Rice +	-F	0.47	0.25	**0.90**	107			
		sorghum	+F	0.83	0.25	1.00	208			
Kunthai	IVS	-	-F	0.14	0.17	1.00	24	330		250
	Butter cup	-	+F	1.31	0.26	**0.90**	307			(242) e
Robennah	Upland	Rice	-F	1.23	0.25	1.00	308	1,149		1,485
	ROK 3		+F	1.09	0.25	1.00	273			(1,462) f
		Rice +	-F	1.01	0.25	1.00	252			
		sorghum	+F	1.26	0.25	1.00	315			
Robennah	IVS	Lower	-F	1.28	0.25	1.00	319	1,208	316	844
	ROK 5	site	+F	1.84	0.25	1.00	459		459	(820) g
		Upper	-F	0.65	0.25	1.00	162			
		site	+F	1.07	0.25	1.00	268			
Kalintin	Boliland	-	-F	0.39	0.40	**0.75**	116	269	152	280 h
	ROK 10	-	+F	0.61	0.38	**0.65**	153		128	(275)
Sabuya	IVS	Dry	-F	1.40	0.27	**0.95**	366	1,151	-	1,250
	ROK 5	nursery	+F	1.63	0.24	1.00	392		-	(1,225) i
		Wet	-F	0.87	0.27	**0.85**	198		-	
		nursery	+F	1.00	0.23	**0.85**	195		-	

a) Values in parentheses show grain production reported from each PP site. Production sampled by GY determination (field area = 48 m^2 + (1 m^2 x 3) = 51 m^2) was added.
b) By actural weighing
c) 45 bag x 53 kg/bag = 90 bu x 26.5 kg/bu = 2,385 kg
d) 17 baff-pan x 30.6 kg/baff-pan = 520.2 kg
e) e-mail data from BES to JPT on 2008/02/21.
f) 34 bag x 43 kg/bag = 1,462 kg
g) 820 kg as a total? GY at upper site = 820 - (310+450) = 60 kg: too small?
h) no valid information
i) 35 bu (by Baf pan) x 35 kg/bu = 1,225 kg (air-dried weight)

(3) Profitability due to the fertilizer application

The maximum GY increment due to the fertilizer application (200 kg/ha) was about 0.5 ton/ha (= 500 kg/ha). Assuming that (a) the fertilizer cost is Le150,000/bag (50 kg/bag), (b) the fertilizer rate is 4 bag/ha, and (c) price of rough rice is Le30,000/bu (50 kg/bu),

Total cost	= Le150,000 x 4	=	Le600,000
Rice sales	= Le30,000/50 x 500	=	Le300,000
Net profit		=	- Le300,000

Therefore, the application of fertilizer is concluded to be not profitable but it simply results in a loss, at least under the current socioeconomic conditions in the country (under the conditions of the present price of fertilizers and rice).

The marginal production to recover the fertilizer costs is 1 ton/ha, which is equal to the expected yield increment (see the note in the main results sub-section). In turn, this result implies that the nitrogen absorption efficiency was about 25%. Such a low absorption efficiency was certainly due to poor crop management. Fertilizer does not offer an overwhelming advantage, but it can express its full benefit when the fertilizer application is combined with proper crop management.

(4) Fertilizer response of the upland rice

The fertilizer response of the grain yield in upland areas was greater in Kunthai than in Robennah (Figure 1.1-4). Fertilizer plots were allotted on the lower slopes in Kunthai and on the upper slopes in Robennah.

In general, the soil fertility was more favorable on the lower slopes. Hence, the result indicates that in Robennah, the originally poor productivity on the upper slopes was compensated for by enrichment from the fertilizer nutrients, and the yield of the two different slopes apparently became similar (Figure 1.1-8). In contrast, in Kunthai, the potentially greater productivity on the lower slopes was enhanced with the application of fertilizers and this enhancement resulted in the greater difference between the slopes.

The grain yield of the fertilized plots in Kunthai could have been even greater if the proper fertilizers had been selected. In the trial, urea was used as a fertilizer for the top-dressing. A few days after the application, there was a severe development of leaf scald. This is a physiological disease and it is stimulated with excess nitrogen supply.

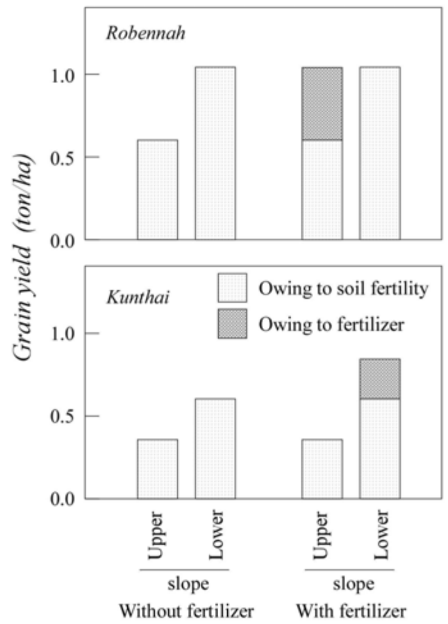


Figure 1.1-8 Plausible Differences in the Effects of Fertilizers on the Grain Yield of Upland Rice in Robennah and Kunthai

(5) Problems in crop management - transplanting

Among the several defects in crop management that were observed, delayed and prolonged transplanting and deep transplanting were the most serious issues.

The recommended age of the seedlings is 3 weeks for IVS and boliland and 4 weeks for mangrove swamp areas. However, old seedlings with an age of 50 or more days were transplanted (Table 1.1-7). Besides, the duration of the transplanting was prolonged for up to 9 days.

Table 1.1-7 Seedling Age and Duration of the Transplanting

Agro-ecology	PP site (village)	Plant-ing	(plot)	Seedling age (day) (a)	Duration of transplanting (day)
Mangrove swamp	Macoth			51	2
	Rossinor			61	2
Assoc. MS (b)	Robat			43	9
IVS	Robennah		Lower st	30	2
			Upper st	70	6
	Sabuya		Wet	25	2
			Dry	46	1
	Kunthai	1st		60	3
		2nd	-F	46	3
			+F	26	4

a) The 1st day of transplanting (days after sowing)
b) Assoc. MS: associated mangrove swamp

To make matters worse, the transplanting depth was too deep (Photo 1.1-1). Under normal planting at a depth of a few cm, the mesocotyl does not develop, but if the seedlings are planted too deep, the mesocotyl becomes extended, as in the case of Photo 1.1-1 where the mesocotyl is shown extended by as much as 15 cm. The greatest disadvantage of deep planting is that is causes a delay in tiller development (Figure 1.1-9). The situation deteriorates in short duration cultivars since the time available to allow for recovery is limited.

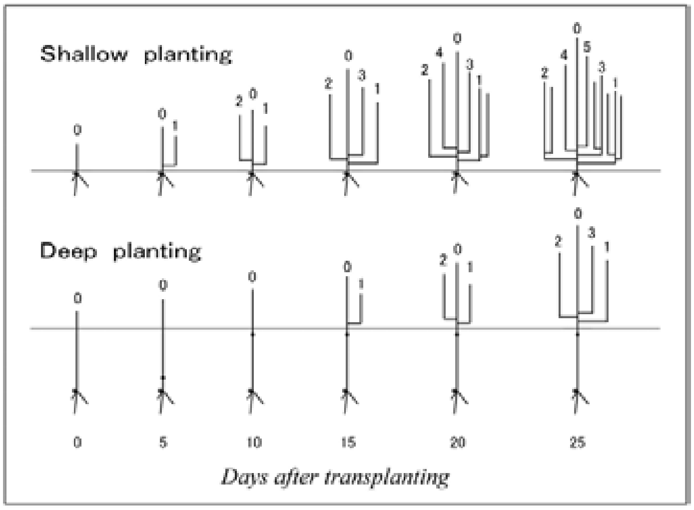


Photo 1.1-1 Examples of Deep Transplanting. the
*The length of the ballpoint pen in the photo is 14 cm.

Figure 1.1-9 T iller Development Affected by Planting Depth

(6) Field layout

The total production of grains is the product of the grain yield (grain production per unit field area) and the harvested (or cropped) area. The simplest area determination is that of a square or rectangle. If the field shape is not a strict rectangle, with some deformation of the shape, it is not easy to measure the area correctly. Measurement of the correct area of the field is essential for yield estimation and also for fertilizer application at the proper rate.

However, except for the upland plots that the JPT laid out, none of the field layouts was a strict rectangle. Several examples of irregular shaped plots are shown in Figures 1.1-10 and 1.1-11, in addition to Figure 1.1-5.

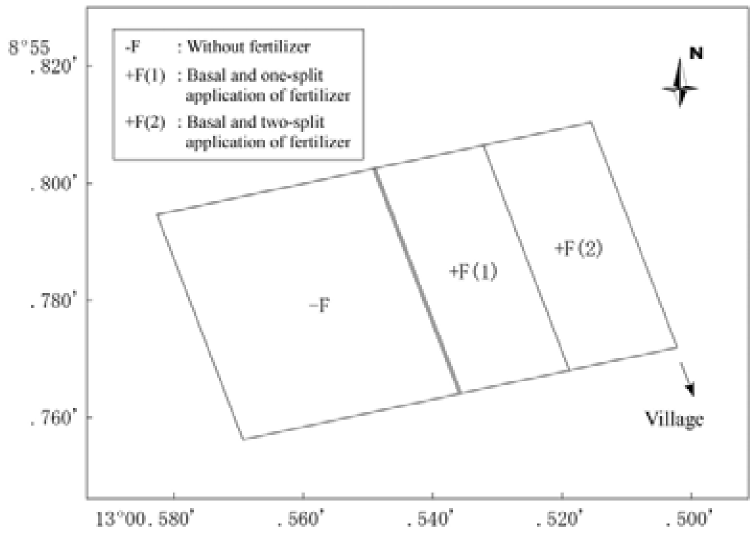


Figure 1.1-10 Field Layout of the Pilot Project in Macoth (Mangrove Swamp)

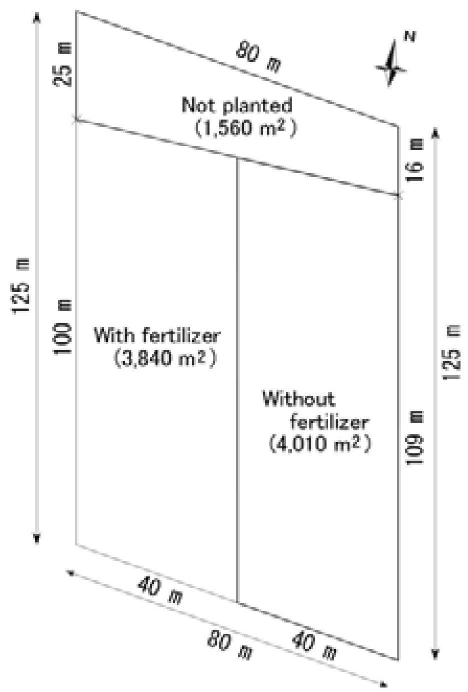


Figure 1.1-11 Field Layout of the Pilot Project in Kalintin (Boliland)

(7) Growth monitoring in the sub-plots

Plant growth in the sub-plots was monitored throughout the growth stages. The majority of the ratios of the grain weight in the sub-plot to that in the yield-plot were, however, greater than 1, or a grain weight of about 70% of the sub-plots was 1.5 times or greater than that in the respective yield-plots (Figure 1.1-12). This result caused difficulty in the grain yield analysis through yield components.

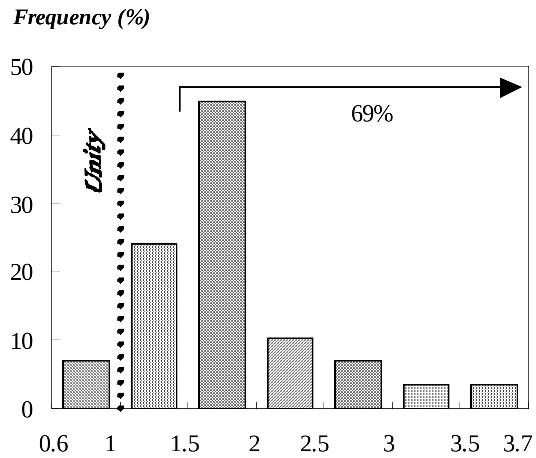


Figure 1.1-12 Grain Weight Ratio (sub-plot/yield-plot)

(8) Labor requirements

To understand the real status of farm management, the labor requirements are a key factor. The total labor requirements for rice cultivation were 113 to 845 person days/ha (Table 1.1-8). So far, no good reason has been found to explain such a large variation. By conducting a careful examination, the labor requirements for transplanting can be summarized as being 26 to 44 person days/ha, although some variation existed (Table 1.1-9).

Table 1.1-8 Total Labor Requirements per Hectare of Rice Cultivation in the Various Agro-ecological Regimes

Agro-ecology	PP site	person -hour	person -day
Mangrove swamp	Macoth	1763	220
	Rosinor	906	113
Mangrove swamp (assoc.)	Robat	1965	246
Boliland	Karlington	6786	848
Inland valley swamp	Robennah	2933	367
	Sabuya	5219	652
Upland	Robennah	1947	243
	Kunthai	3596	450

a) Summarized data on the Farming Activities of the PP (2007)
b) assoc.: associated
c) Conversion rate: 8 working hours a day

Table 1.1-9 Labor Requirements for the Transplanting of Rice Plants

Place (PP site)	Agro-ecology	Labor requirement / ha p.h	p.d
Macoth	MS	211	26
Rosinor	MS	287	36
Robat	MSa	310	39
Robennah	IVS	349	44
Kunthai	IVS	207	26
Sabuya	IVS	353	44

a) included uprooting
Abbreviation; MS: mangrove swamp, MSa: MS associated, IVS: inland valley swamp. p.h: person x h, p.d: person x da

(9) Leaders' training workshop

During the Leaders' Training Workshop for the farmers groups, instruction was given on the importance of group work, the responsibilities of the leaders, and the general features and essence of the PP. Special emphasis was given to saving the seeds for the following year and the self-provision of all the necessary materials for harvesting such as bags for storage and drying sheets. The most important thing that the JPT requested of them was self-reliance: the farmers should understand that outsiders were only assisting so that they could soon stand on their own feet.

(10) Evaluation and appraisal of the PP

1) Evaluation by the farmers

The farmers appreciated the PP activity, and recognized the approach used by JICA as being unique compared to other NGOs (Supplement 4).

Highly appreciated techniques were the timely work accomplished with the planning of the cropping calendar, the transplanting of a few seedlings per hill and group work. They confirmed that planting 2 to 3 young seedlings per hill was sufficient to produce enough tillers (panicles) to produce a high yield. This practice reduced the seed costs greatly, since they used to transplant 5 to 10 (sometimes even 20) seedlings per hill.

At the same time, the farmers indicated the difficulty of practices related to the transplanting of a small number of seedlings and shallow planting. Although the farmers did not reveal this clearly, they faced various problems of working in a group. The farmers also complained about the impurity of the seeds, which had already been observed at the time of germination test by the JPT. The seeds were obtained at the Seed Multiplication Project in Kobia, the only official source of seeds in this country.

Although the farmers expressed their thanks to the project, they requested material assistance as ever (and as usual): power tillers, tractors, drying floors, storage facilities, cassava graters, microcredit schemes, etc. Unfortunately, they lacked self-reliance, tending easily towards dependency on others, whereas the JPT had repeatedly emphasized the importance of independence. This tendency has hardly changed since the MAFFS staff, acting as a mediator between the farmers and the JPT, themselves hold a similar attitude towards others (e.g., foreign aid) .

Even under these circumstances, however, signs of some good prospects that reflected the JPT approach began to develop among the farmers. For instance, the farmers’ groups in Robat, Robennah and Macoth formed a new group for assistance with seeds and labor. In addition, in some cases, they created a microcredit scheme in the village using as starting capital the rice produced from the PP.

2) Evaluation by the MAFFS-K staff

MAFFS-K staff expressed valuable opinions and views on the PP from their experiences (Supplement 5). The appreciated techniques and the difficulties in adopting the practices were similar to those indicated by farmers.

Some problems encountered in the group work were (a) the negative attitude of the model farmers to the recommended changes as indicated in the TP, which was probably owing to the high level of illiteracy among the farmers, (b) getting the farmers to work on time, (c) slow adoption of the new technology, and (d) lack of cooperation. In many cases, MAFFS-K staff solved the problems by explaining to them the purpose of the PP and what benefit they would receive from it. They also indicated the problem of the seed mixture, which resulted in a substantial loss of the rice harvest.

Several extension workers accepted on-the-job training: they expressed their opinions even with happiness or wholeheartedly, and insisted on its continuation. Such training provided them with an opportunity to improve their skills and enabled them to learn new techniques and to refresh their minds on what they had learnt before. The JPT attitude was evaluated as being 'down to earth'. Unfortunately, such appreciation was given by a limited number of experienced staff: many others requested a more formal pattern of training or capacity building.

3) Appraisal workshop on the PP

All information collected in above-mentioned evaluation and appraisal of the PP made by farmers and MAFFS-K staff was compiled and discussed in the workshop. Presenting the PowerPoint material entitled as 'Yield analyses and the issue of the PP (2007-2008)', the JPT explained the summarized results of an overall picture of the project. The main subjects were (a) some aspects of the grain yields measured, (b) profitability due to fertilizer application, and (c) problems, defects, etc. Such a series of evaluation procedures certainly helped in improving the subsequent PP.

(4) Operational performance of the rice huller

The rice huller installed at each PP site was operated for rice harvested in the 2007 season. The total quantity of rice milled was large at Macoth and small at Sabuya (Table 1.1-10). There was competition with private mills, so the milling charge was set lower for Macoth and Rosinor. The milling charge and fuel consumption per bushel was high at Sabuya because the volumetric weight per bushel was larger and also possibly due to inefficiency in the milling.

Table 1.1-10 Operation of the Rice Huller Installed in the Pilot Villages (2007 Harvest Season)

PP site (a)	No. of days operat-ed	Total quantity of grains (b) milled (bu)	Milling charge Total (Le)	Milling charge per bu (Le/bu)	Fuel cost Total (Le)	Fuel cost per liter (Le/L)	Fuel consumption Total (L)	Fuel consumption per bu (L/bu)
		A	B	B/A	C	C/D	D	D/A
Macoth	63	424	649,000	1,532	352,000	4,093	86	0.20
Rosinor	22	202	404,000	2,000	224,000	5,091	44	0.22
Robat	15	122	316,000	2,590	80,000	3,200	25	0.20
Kunthai	30	263	656,000	2,494	247,000	4,491	55	0.21
Sabuya	22	47	188,400	4,000	120,000	3,750	32 (c)	0.68

Abbreviation: bu, bushel (the unit weight varied among villages); Le, SL Leone; L, liter.

a) Excluded two villages owing to no record at Robennah and no-operation at Kalintin.

b) Grains signify rough rice. c) Eight gallons.

【Supplement 1】: Draft Technical Package (2007)

1. Rice Cultivation in Inland Valley Swamp (IVS)

1) Seeds

Use pure, viable, high yielding and resistant seeds/varieties. Here the use of pure seeds should be emphasized.

1-1) Germination test

To be sure of the seed viability, conduct a germination test using any suitable container. Line the container with any suitable absorbent material (*e.g.*, Tissue paper, gauze, cotton wool, *etc*.). Select seeds at random from three (3) points in the intended seed-stock (Top, middle and bottom). Select apparently 100 good seeds from the randomly selected seeds and evenly spread them on the absorbent. Pour water on the absorbent until it is completely wet. Place the container where there is sufficient light. Examine the test on daily basis for 4-5 days while ensuring maintenance of the moisture level. The germination percentage should be 80% or above, *i.e*., 80 germinated seeds or more. If the germination percentage is below 80%, discard the stock and use for consumption.

1-2) Seed selection

Select matured seeds for better germination and growth using water. This is done by pouring the seeds into a sizable container already filled with water and stirring it well. The mature seeds that are heavier will settle at the bottom whilst the immature lighter grains will float on the surface of the water. The floating grains are then removed and the water drained.

1-3) Seed soaking

Soak the selected seeds in water for 24 hours to promote even germination. Use a sizable container.

1-4) Incubation of the seeds

Having soaked the seeds for 24 hours, drain the water and place the soaked seeds into jute bags up to half full and tie them firmly for up to 48 hours with the intermittent sprinkling of water to maintain the moisture level or completely submerge them for 24 hours.

As an alternative measure, the soaked seeds are thickly spread on a locally made mat or any suitable material and covered with banana leaves and then jute bags to maintain heat. Sprinkle water on the seeds periodically to keep them moist for 48 hours.

2) Nursery establishment

2-1) Wet or dry nurseries

a) Wet nursery: 37.5 kg of the selected seeds should be nursed in a 375 m^2 area for 1 hectare of main field or 15 kg of selected seeds nursed in 150 m^2 for 1 acre of main field. In constructing the seed beds, the width should not be more than 1 m so as to facilitate subsequent operations such as weeding, removal of off-types, etc. especially at the center of the bed. 40-cm furrows should be prepared between the beds to allow ease of movement.

b) Dry nursery: A dry nursery can be prepared in upland areas. Select an area of flat land and prepare a fine tilth. Sow the seeds (no need to pre-germinate) either on the flat land or on raised beds.

2-2) Sowing on nursery beds

For good and healthy seedlings, uniformly sow the seeds on the nursery beds.

2-3) Nursery management

Practice timely weeding. Irrigate as necessary. Apply fertilizer if necessary. Keep the nursery site clean by removing possible sites that could harbour insects, rats, etc.

3) Land preparation

3-1) Brushing

Brush and clear the vegetation.

3-2) Ploughing

About 2 weeks before the establishment of the nursery, thorough ploughing or tilling of the main field should be carried out. This is to provide ample time for the weeds to decompose. Shortly before transplanting, the field should be tilled or puddled.

3-3) Basal fertilizer application

Apply 40 kg P_2O_5/ha and puddle or 100 kg/ha of 0:20:20.

4) Transplanting methods

Line planting is recommended but due to its time-consuming and labour-intensive demerits, random planting at rational close spacing (*i.e.*, correct planting density of 20 cm - 30 cm according to the variety) is considered more appropriate for small-scale farmers.

Sparse planting is recommended for varieties with higher tillering capacity and dense planting for the lower tillering varieties.

Seedlings must be properly and gently held close to the roots and transplanted at an angle of 80-90 degrees to ensure healthy growth.

Seedlings that are held in the middle part may either break during transplanting or be planted at the wrong angle, which will impede growth.

Transplant 2-3 vigorous seedlings per hill that are 3 to 4 weeks old and at a depth of 2 to 3 cm. Deep planting can affect tillering, causing poor growth and subsequent low yields.

4-1) Irrigation

Construct water control structures using locally available materials like earth, bamboo pipes, sticks, etc.

The water requirements of rice plants vary according to the stage of growth. However, deep water can hamper tillering of the plant and shallow water can enhance weed growth. A 3 to

5 cm depth of water is recommended. Drain the field about 10 days before harvesting.

4-2) Replacement of missing hills

About 10 days after transplanting replace the missing hills.

5) Weeding and fertilizer application (top dressing)

Due to the farmers' numerous activities, weeding is seldom done two times.

With single weeding, it is recommended that weeding be done 4-6 weeks after transplanting followed by the application of 100 kg urea per hectare. With the application split into two, the first application is carried out 4-6 weeks after the transplanting at 50 kg/ha of urea and the second application is carried out at 12 weeks after the transplanting at 50 kg/ha of urea.

6) Bird scaring

Bird scaring should commence immediately the rice starts heading.

7) Harvesting

Harvest the rice using a sickle or harvesting knife when 80% of the colour has changed to brown.

7-1) Threshing

For the preservation or maintenance of good quality seeds, the harvested rice should not be allowed to remain in the field for long prior to threshing. Manual or mechanical threshers are used.

7-2) Drying

In the absence of drying floors, use tarpaulin sheets, locally woven mats, etc. and make sure the grains are properly dried for good milling quality. The grains must be dried to a 14% moisture content.

7-3) Winnowing

Use a winnowing machine to separate the filled grains from the partially filled ones and impurities. In the absence of winnowing machines, local winnowers are used or any other traditional method.

7-4) Packing

To bag the rice, bags that are free of insect pests and impurities are used. In the absence of sacks, locally made baskets lined with clay or cow dung or other suitable containers are used.

2. Rice Cultivation in Mangrove Swamps

Note: Seed selection, seed soaking, seed incubation, nursery establishment and management, are the same as for IVS.

1) Land preparation

1-1) Brushing

The vegetation is cleared by felling the mangroves and brushing the grasses known as *Paspalum vaginatum, Panicum repens, Cyperus difformis* L. and *Cyperus rottundus* L.

1-2) Burning and clearing

Burning is carried out on the upper part of the swamp towards the dry land while in the flooded areas, the sticks or wood are removed by hand. This operation is carried out before the rains.

1-3) Ploughing

The traditional method of ploughing is the use of a long-handled hoe designed for heavy clay soils. Deep ploughing (preferably with the use of a power tiller) in March, April and early May is recommended.

1-4) Puddling

This involves the breaking down of large clods into smaller particles that enhance root penetration and soil impermeability to water.

2) Basal fertilizer application

Apply 40 kg P_2O_5/ ha.

3) Planting

3-1) Direct sowing

Rice can be seeded directly on seasonally dry areas of associated swamps where flooding is a gradual process. This operation is normally done within the months of July, August and September. Direct seeding can be done in tidal areas with good timing due to labour shortages.

3-2) Transplanting methods

Transplant 5 to 6-week-old vigorous seedlings in July, August and early September. The prolonged period of establishing seedlings in the nursery is required to produce sturdy plants capable of withstanding the twice daily tides, crab attack and the difficult soil conditions.

Plant 6 to 10 seedlings per stand to compensate for those that might be damaged by crabs and the effects of the tide.

Handle the seedlings with care and transplant at a rational close spacing of 20 cm to 30 cm depending on the variety, either in rows or at random.

4) Weeding

Prevent weed competition by timely weeding, *i.e.*, 4-6 weeks after transplanting.

Hand weeding is the oldest and most direct way of controlling weeds in rice fields.

The push-type rotary weeder is the most effective mechanical weeder for wetland rice but the rice must be planted in straight rows with a spacing not closer than 20 cm x 20 cm.

5) Fertilizer application (top dressing)

Weed once every 4 to 6 weeks after transplanting and apply 60 kg N/ha as urea.

6) Water/tidal management

Plant suitable mangrove species in strips to control the impact of the tide (1 m x 1 m spacing and about 5-meter wide strips).

7) Crab pests

Several species of crab attack rice in mangrove swamps during transplanting and for 2 to 3 weeks after transplanting. Crabs feed on the newly transplanted rice by cutting the stem or leaf and eating the succulent tissue in the plant. This can cause a reduction in the yield.

7-1) Control measures

Rice culture control methods involve the transplanting of vigorous seedlings, transplanting them with close spacing and using resistant varieties.

Chemical agents such as Malathion, etc. are effective in controlling crabs.

7-2) Application methods

Seventy (70) ml of Malathion, which is equivalent to one tomato cup full is mixed in one gallon of water. The solution is then applied to one bushel of seed-rice (25 kg) and then directly sown. Alternatively, the solution can be applied to rice bran and broadcast in the rice field as poisoned bait prior to planting.

3. Rice Cultivation on the Uplands

1) Land preparation

1-1) Brushing and felling of trees

Brush the undergrowth of matured forest (7-10 years) followed by felling of the trees and allow the vegetation to dry. This operation spans from January to late May or early March.

1-2) Burning and clearing

Burn and clear the vegetation in March.

2) Sowing

At seeding, apply 40 kg/ha of 0:20:20. Sow viable seeds at a rate of 80 kg/ha, after which shallow tillage at 15 to 20 cm is carried out to cover the seeds while simultaneously removing the weeds. Clear away the weeds carefully.

Depending on the rainfall pattern, sowing is accomplished in May and June.

3) Weeding and fertilizer application

Weed at 4 to 6 weeks after seeding. Apply 75 kg/ha of urea.

4) Fencing

Since rodent attacks on upland rice can be severe, fencing is recommended with the use of local materials. This activity could be simultaneously carried out with the weeding or immediately after weeding.

5) Bird scaring

Commence bird scaring at an early stage.

6) Harvesting

Harvest using a sickle or harvesting knife when 80-90% of the grains form and the panicles becomes golden in colour.

Note: For the post-harvest operation techniques, see guidelines for rice cultivation in IVS areas.

4. Rice Cultivation in Bolilands

1) Land preparation

1-1) Burning

Brush and burn the vegetation in January and February. Carry out clearing if necessary.

1-2) Ploughing

Plough the field with traditional hoes or use machines (tractors or diesel engine powered tillers). Minimum tillage to a depth of 20 to 25 cm is recommended. The time for ploughing is February to March.

1-3) Harrowing

Use tractors or power tillers.

In the absence of machines, use traditional hoes. In the event that the ploughing was carried out using hoes, broadcasting of the seeds and harrowing are simultaneously carried out manually rather than just harrowing.

The time for harrowing is April – May.

1-4) Seed harrowing

This operation is carried out mechanically in May and June.

1-5) Transplanting

In areas that are prone to inundation, transplant four-week-old seedlings at a rate of 2 to 3 seedlings/hill at a density of 20 cm to 30 cm in June up to early August.

2) Basal fertilizer application

Apply 40 kg P_2O_5 at seeding or transplanting.

2-1) Weeding and fertilizer application

Weed once 4 to 6 weeks after seeding or transplanting. Apply 60 kg N/ha as urea.

3) Bird scaring

Start bird scaring at the heading stage.

4) Harvesting

Harvest when 80-90% of the grains turn brown.

Summary of Useful Information on the Rice Varieties Released in Sierra Leone

Agro-ecological regime	Variety	Duration (days)	Plant height (cm)	Yield range (ton/ha)
Upland	ROK 3	140	125	2.0 – 3.5
Upland	ROK 16	120	120	2.0 – 3.0
Upland	ROK 17	135	125	1.5 – 2.5
Upland	ROK 20	115	105	2.0 – 3.0
Upland	NERICA 1	100	100	2.0 – 2.5
Upland	NERICA 3	96	100	2.0 – 2.5
Upland	NERICA 6	105	100	2.0 – 2.5

Agro-ecological regime	Variety	Duration (days)	Plant height (cm)	Yield range (ton/ha)	Remarks
Mangrove swamp	ROK 5	155	135	2.5 – 4.5	Slightly salt resistant
Mangrove swamp	ROK 10	180	130	2.0 – 3.5	Slightly salt resistant
Mangrove swamp	ROK 21	155	130	2.5 – 4.5	Slightly salt resistant
Mangrove swamp	ROK 22	125	110	2.5 – 4.5	Slightly salt resistant
Mangrove swamp	ROK 23	180	130	2.0 – 4.0	Slightly salt resistant

Agro-ecological regime	Variety	Duration (days)	Plant height (cm)	Yield range (ton/ha)	Remarks
IVS	ROK 6	150	100	2.5 – 4.5	Suitable for second cropping.
IVS	ROK 10	180	130	2.0 – 3.5	Suitable for second cropping.
IVS	ROK 11+	120	100	2.5 – 5.5	Suitable for double cropping.
IVS	ROK 14+	140	95	2.5 – 6.0	Suitable for double cropping.
IVS	ROK 23*	170	130	2.0 – 3.5	Recommended for Iron toxicity
IVS	ROK 24*	145	115	2.0 – 3.5	Recommended for Iron toxicity
IVS	ROK 26	150	120	2.5 – 3.5	
IVS	ROK 31+	130	90	2.0 – 3.5	Suitable for double cropping.
IVS	ROK 32+	130	100	2.0 – 4.0	Suitable for double cropping.

*Recommended for Iron toxicity. +Suitable for double cropping.

Agro-ecological regime	Variety	Duration (days)	Plant height (cm)	Yield range (ton/ha)
Boliland	ROK 3	150	130	1.5 – 3.0
Boliland	ROK 10	180	140	1.5 – 3.5
Boliland	ROK 23	185	140	2.5 – 4.0
Boliland	ROK 29	155	120	2.5 – 4.0
Boliland	ROK 30	170	130	2.0 – 4.0

【Supplement 2】: How to monitor plant growth in the fields of the Pilot Project

1. Establish sub-plots for monitoring the plant growth in every treatment.

Note 1) The location of sub-plots should be a place in which the growth of rice plants represents the average growth for the entire plot. This is the most difficult task, so Yamaguchi or Kimijima will find such places together with the FEW (preferably with BES and SMS) assigned to the site.

Note 2) The location of sub-plots will not be moved when the rice is transplanted, but will be moved after weeding when the rice has been broadcast.

(2) The number of sub-plots for each treatment should be three (3).

(3) The size of a sub-plot is 1 m^2 (1 m x 1 m), marked with 4 wooden sticks at each corner and surrounded with twine.

(4) Monitoring of the plant growth starts immediately after transplanting or two (2) weeks after broadcasting.

(5) The plant height and tiller number is recorded every two (2) weeks. The interval need not be very rigid. The day of the week could be fixed (Monday, for instance), but it can be the next day or so if it is raining, and it can be a few days later if the site is inundated (flooded). Stop the monitoring when deep flooding occurs, and re-start as soon as the water has drained off.

The number of hills should be recorded at the beginning for the transplanted plots, and every monitoring time for the broadcast plots.

How to uniformly broadcast seeds or apply chemical fertilizers

(1) Collect as many containers such as buckets or pans as possible from the members of the group involved: e.g., ten (10).

(2) The total quantity of the seeds or fertilizers should be equally split into the containers: it is sufficient to do this by visual splitting or with the use of a suitable container as a standard unit (its volume should be less than the one-tenth of the total quantity of the seeds or fertilizer.
Note: Use a plastic sheet or any other mats, if available, to make the splitting easier. If not available, spread the seeds or fertilizers on the ground (the earth) in upland areas.

(3) Divide the area into the same number as the number of containers; equally split the total area into 10, for instance.

(4) Double broadcasting or application in a sub-divided area is essential for uniform distribution.

First, broadcast or apply two-thirds (2/3) of the quantity of seeds or fertilizers in one direction (walk in a north-south direction, for instance), and secondly broadcast or apply the remaining one-third (1/3) in the other direction (east-west) while amending any errors or uneven distribution that occurred in the first broadcasting or application.

【Supplement 3】: Measurement of Grain Yield at Pilot Project

1. Precondition (concept)

1) To evaluate the effect of various treatments, we should recognize that a measurement of final yield (grain production in a unit field area) holds the most importance. At the same time, we should consider the work efficiency too.

2) Assuming that the maximum yield is 200-300 g/m^2 (= 2-3 ton/ha = 80-120 bu/acre), and also considering the size and strength of bags prepared for yield measurement and a sampling error, a plot size of yield measurement is to be set to about 50 m^2 (grain weight will be 10-15 kg).
Yet, the sampling size is modified to 6 m x 8 m (= 48 m^2), based on the fact that the right angle measurement is locally common by the 3-4-5 method. Two replications in each treatment are required.
Note that the plot size for yield measurement is similar to that used by the PMSED.

3) To obtain coordinated results on yield component measurement, a simple and easy method on measurement of the number of grains in each panicle is adopted: calculation method.

4) We assume that the proportion of grain weight per panicle number in the growth monitoring plot is represented with that of the entire plot in each treatment.

5) Harvest index will not be measured simply because of no facility to dry straw.

6) JPT expert should be presented in all procedure.

7) 'Grain' implies rough rice (brown rice with husk). Milling percentage will be measured separately as a part of post-harvest process.

8) All information obtained should be conveyed to the farmers' group as soon as possible. Besides, the pilot project team is fully responsible to understand them to spare enough rice as seeds and fertilizer purchase for the next year planting. JPT will not provide them further to make rice production independent (subsistent).

2. Definition of measurement plot

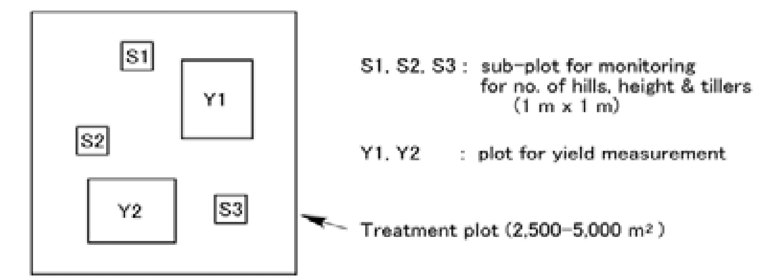


Fig. yp. Plot name for monitoring and yield measurement within each treatment

3. Measurement items and their abbreviations

	No. of panicle	Grain wt. (g)	1,000 grain wt. (g)
Sub-plot	Np(S1), Np(S2), Np(S3)	Wg(S1), Wg(S2), Wg(S3)	Wt(1)
Yield plot	-	Wg(Y1), Wg(Y2)	Wt(2)

1, 2, 3 signifies the replication number within a treatment.

4. Work (measurement) procedure

1) Harvest all hills (plants) in a whole sub-plot of S1, S2 and S3. Thresh by hands or feet, and store grains into a bag (5 kg volume). When the moisture content is high, panicles will be harvested and threshed after drying.

2) Harvest a whole plot of Y1 and Y2, thresh grains with a thresher, and store in a bag (20 kg capacity). A marker composed with sticks and twin by a size of 6 m x 8 m (including a diagonal line) should be prepared before sampling.

Note that grains will be threshed outside (dry place) of a sub-plot by containing plants in a plastics sheet, bucket or container. This procedure should be essential, especially when the land is wet like mangrove swamp, IVS and boliland.

3) Samples (all grains) will be taken back to Kambia, dried, winnowed and weight.

4) Determine a moisture content of cleaned grains.

5) Measure 1,000 grain weight on a mixed sample of sub-plot and yield-plot). All weighing procedures are highly recommended to do in a same day to avoid an error caused with a moisture difference between days.

5. Calculation

Sub-plot (average)

Np(S) = { Np(S1) + Np(S2) + Np(S3) } / (1 x 3) [No.of panicles/m^2]

Wg(S) = { Wg(S1) + Wg(S2) + Wg(S3) } / (1 x 3) [g/m^2]

Yield plot (average)

Wg(Y) = { Wg(Y1) + Wg(Y2) } / (48 x 2) [g/m^2]

Treatment (average)

grain yield (GY)

= {Wg(Y) x (48 x 2) + Wg(S) x (1 x 3)}/{(48 x 2) + (1 x 3)} [g/m^2]

Number of panicles (Np) = GY x Np(S) / Wg(S) [No.of panicles/m^2]

1,000-grain weight (Wt) = { Wt(1) + Wt(2) } / 2 [g/1,000 grain]

Number of grain per panicle (Ng) = GY / (Pn x Wt/1,000) [No. of grains per panicle]

6. Necessary tools

Twin	Plastics sheet
Stick	Bamboo colander (winnowing fan)
Sickle	Thresher
Scissor	Winnowing machine
Bucket	Bag (20 kg volume)
Jute bag	Bag (5 kg volume)
Moisture meter	Balance
Tag	1,000-grain counter

1.2 Pilot Project in 2008

1.2.1 Introduction

The Pilot Project (PP) in 2008 was carried out based on consistent principles, as in 2007. It was aimed at contributing to the improvement of rice production in various agro-ecological regimes by introducing low cost, profitable and environmentally friendly techniques. The PP was implemented in 2008:

(a) to verify and refine the draft Technical Package, which was modified based on the results of the PP in 2007,
(b) to demonstrate various farming techniques, and
(c) to train farmers and MAFS-K staff.

1.2.2 Meth ods

The means of execution were essentially the same as the PP in 2007, especially the provision of the necessary materials (seeds, fertilizers, and tools) and the supporting system. However, several items were modified to improve practices and solve the problems encountered during 2007.

(1) Site selection and the farmers' groups

The villages and their respective agro-ecological regimes were the same as in 2007. The only difference was in Kalintin, where the trial site was changed to another area of boliland since the boliland area in 2007 was prone to flooding, and the planting method was changed from direct sowing to transplanting.

The total acreage at each site was reduced from 1 ha to 0.5 ha based on the labor availability and for ease of uniform farm management. The JPT activity was more concentrated on three sites: Macoth, Robat, and Robennah, where the total acreage was set to be 1 ha.

The same farmers' groups that were formed in 2007 were assigned to the PP in 2008, whereas several members were replaced in some villages based on their performance in 2007: Macoth, Rosinor, and Sabuya.

(2) Key techniques modified

The key techniques recommended were identical to those in 2007. However, several important cultivation practices were modified to make them more efficient for increasing productivity based on experience from 2007. The modifications made were to the varieties, nursery, fertilizer management, etc. (Table 1.2-1).

Some additional information on the modification is as follows (the Note number in the text corresponds to the one in Table 1.2-1):

Note 1) Varieties and seeds: Local varieties preferred by farmers (Table 1.2-2) were accepted because the farmers had experienced better yields with them than with the varieties of the

ROK series used in 2007 and the seeds used in 2007 were poor in quality due to impurities (badly mixed seeds) and the low germination rate. The germination rate of the seeds in 2008 was 90-100%, but the impurity was again serious, not only in the seeds obtained from the farmers, but also in those from RRS-R.

A short-stature variety, ROK 14, was tested at the most fertile site, Robat, to seek high production. The plant trait of ROK 14 was expected to enhance the productivity due to its high harvest index (Annex 1.4). However, the introduction of an exotic variety presented the risk of incurring a total loss because its performance was unknown at the site. Hence, the acreage for this variety was confined to a smaller plot (*c.f.*, Fig. 1.2-3).

In practice, the actual acreage was much smaller than the projected one (500 m^2 each) because there was a shortfall in the available amount of seedlings due to bird damage and the gravelly texture of the nursery bed: 250, 360, 290 and 110 m^2 at -F, +F, ++F and +F(1p) treatment, respectively. As a result, the harvested area for yield measurement was smaller than that of the standard size (48 m^2 with duplication): the smallest was only 12 m^2 with single replication (Table 1.2-3).

Note 2) Water control: Dike (bund) construction helped in efficient fertilizer absorption. It was practiced in the Rovennah IVS, Kalintin boliland and Robat associated mangrove swamp.

Note 3) Transplanting with a single seedling per hill was introduced on a trial basis at Macoth and Robat. Rice production would not be affected even by planting with a single seedling as long as the rice fields are properly maintained. The reduction in the amount of seeds used by transplanting 2 to 3 seedlings per hill was highly appreciated by the farmers since this practice contributed to a reduction in the cost of the seeds.

Note 4) Fertilizer: Modification of the type of fertilizer emphasized the importance of the potassium and phosphorus nutrient supply. This was intended to help suppress brown spot and related fungal diseases. For the peaty soil in Sabuya, the type of fertilizer for top-dressing was only compound fertilizer (17-17-17), which was the same as in 2007, in order to avoid excess nitrogen supply, which would help avoid the occurrence of fungal diseases.

The compound fertilizer content was changed from 15-15-15 to 17-17-17 in 2008 simply due to its availability on the market.

Table 1.2-1 Crop Management (techniques) Modified in the Pilot Project, 2008

Item	Results or problems in 2007	Modification in 2008
Variety selection	ROK 3, ROK 5 and ROK 10	Farmers' choice (Note 1)
Provision of seeds	Procured from the Seed Multiplication Project at Kobia were low in quality	From RRS-R and farmers (Note 1)
Pre-treatment of seeds (soaking in water)	Resulted in poor germination if no timely rain after sowing	Not recommended
Nursery		
Duration	Nursery period was too long	Strictly subject to the TP (3 weeks for IVS and 4 weeks for MS)
Dry and wet nursery	Severe occurrence of diseases and nutrient disorders, and etiolation at wet nursery	Recommended dry nursery
Fertilizer application	Induced etiolation and disease occurrence promoted with prolonged nursery period	Depend on situation
Land preparation	Delayed in work due to insufficient labor Poor puddling	Obey the cropping calendar with well organized group work Sufficient puddling to allow shallow transplanting
Water control	Planned but not practiced	Coping with proper dike construction (Note 2)
Transplanting		
Planting depth	Tended to be deep	Shallow planting (2-3 cm)
Seedlings per hill	Too many seedlings (even failed in filling the whole plot)	Strictly obey the recommended rate: 2-3 seedlings (Note 3)
Fertilizer management		
Treatment	With and without fertilizer application, and in the former, one and two top-dressings.	With and without fertilizer application, and in the former, only one top-dressing at panicle initiation stage.
Fertilizer type	100 kg/ha of compound fertilizer (15-15-15) as a basal and 100 kg/ha of urea for top-dressing	100 kg/ha of compound fertilizer (17-17-17) as a basal and 50 kg/ha each of 17-17-17 and urea for top-dressing (Note 4)

TP: technical package, MS: mangrove swamp, IVS: inland valley swamp, RRS-R: Rice Research Station, Rokupr (presently Rokupr Agricultural Research Center, RARC)

Table 1.2-2 Dates of Main Growth Stages and Fertilizer Application in the Pilot Project (2008-2009)

Agro-ecology	Site	Variety	Variety: Growth duration (month)	Treat-ment	Plant-ing method	Date of growth stage: Sowing	Date of growth stage: Trans-planting	Date of growth stage: Flower-ing (50%)	Date of growth stage: Full maturity (harvest)	Date of fertilizer application: Nursery	Date of fertilizer application: Main field (d) Basal	Date of fertilizer application: Main field (d) Top-dress
Mangrove swamp (MS)	Macoth	ROK 10	6	-F	T/P	15-Jul	14-16 Aug	30-Nov	3-Jan	- -	-	-
				+F, +F(1p)					7-Jan		22-Sep	22-Nov
	Rosinor	ROK 10	6	-F	T/P	21-Jun	8-10 Aug	27-Nov	29-Dec	6-Jul	-	-
				+F					5-Jan		22-Aug	21-Nov
Associated MS	Robat	ROK 10	6		T/P	3-Jul	11-Aug	2-Dec	28-Dec	18-Jul	11-Aug	6, 11 Nov
		ROK 14 (a)	4.5	-F, +F, ++F	T/P	16-Aug	8-Sep	20-Nov	22-Dec	16-Aug	8-Sep	6, 11 Nov
				+F (1p)					28-Dec			
Boliland	Kalintin	Lansana (b)	5	-F	T/P	12-Jun	8-Jul	23-25 Oct	29-Nov	24-Jun	-	-
		Conteh		+F			12-Jul				3-Aug	11-Oct
IVS	Kunthai	ROK 10	6		T/P	16-Jun	21-26 Jul	*	*	27-Jun	21-Jul	14-Nov
	Robennah	Yam Besay	4	-F	T/P	3-Jul	19-Aug	23-Oct	18-Nov	18-Jul	-	-
				+F				20-Oct			25-Aug	10-Oct
	Sabuya	CP4 (c)	6		T/P	16-Jun	29-Jul	17-20 Nov	16-Dec	27-Jun	29-Jul	8-Nov
Upland	Kunthai	Kissy Fundy	3.5		DS	23-Jun	-	8,11 Sep	11-Oct	-	23-Jun	24-Aug
	Robennah	ROK 3	5	Upper	DS	10-Jun	-	1,3 Oct	1-Nov	-	10-Jun	6-Sep
				Lower					31-Oct			

a) Formerly called as Mange 2. b) Bai Junu in Guinea. c) Locally called as Tonsok Kiri. D) Applicable to fertilized plot.
Abbreviation: IVS, inland valley swamp; T/P, transplanting; DS: direct sowing. (1p), single planting per hill.
Symbols: - not applicable. - - not applied. * Abandoned.

(3) Field layout

The farmers secured 1 ha of land in 2008 as well. The standard layout of the PP was simply set up by splitting a half (0.5 ha) of the main field into two, allotting each part (0.25 ha) to treatment with and without fertilizer. The remaining area (0.5 ha) was used by the farmers.

In several cases, the field layout was modified subject to the site-specific conditions and also to additional treatments (Figs. 1.2-1 to 1.2-4).

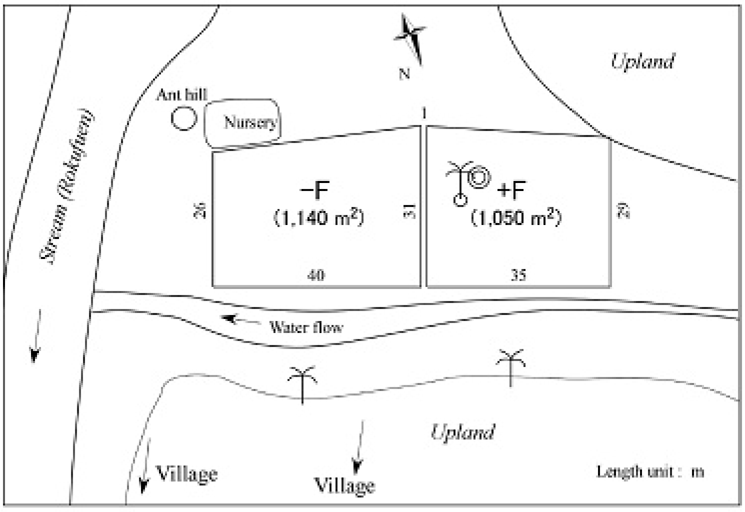


Figure 1.2-1 Field Layout in Robennah IVS (2008)

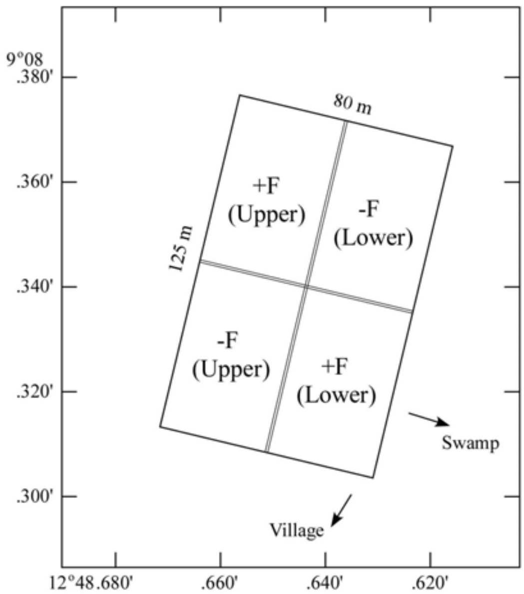
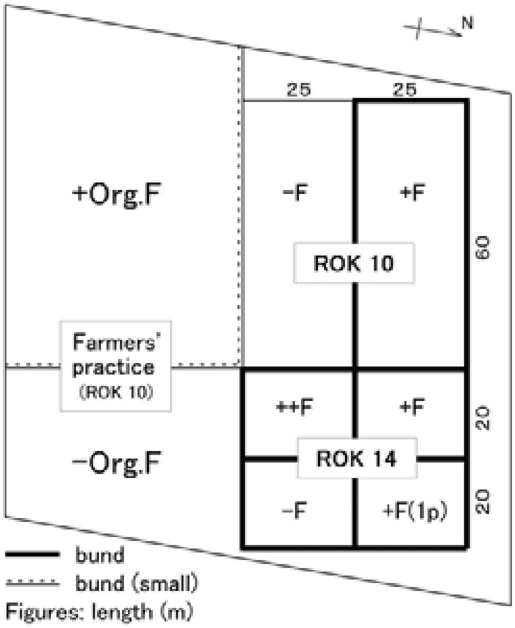


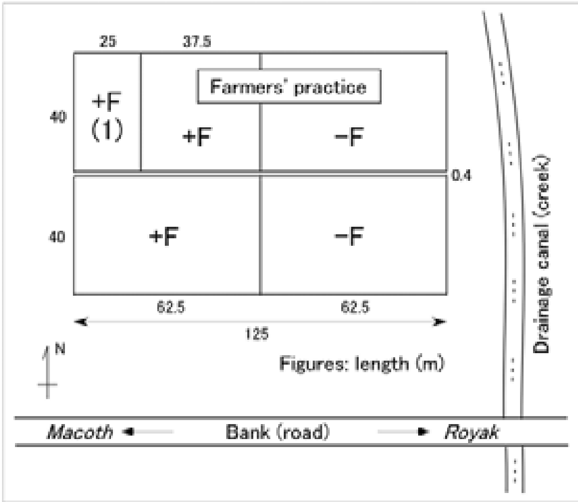
Figure 1.2-2 Field Layout of the PP in the Robennah Upland (2008)



Treatment	Fertilizer		No. of seedlings per hill	Planting depth
	Chemical	Organic		
−F	None	No	2−3	Shallow
+F (a)	Applied	No	2−3	Shallow
++F (b)	Applied	No	2−3	Shallow
+F(1p)	Applied	No	1	Shallow
−Org. F (c)	None	No	2−3	Deep
+Org. F	None	Applied	2−3	Deep

a) Recommended rate. b) Double rate of fertilizer.
c) Control (real farmers' practice)

Figure 1.2-3 Field Layout and Treatments of the Pilot Project in Robat (2008)



Treat-ments		Ferti-lizer	No. of seedlings per hill	Planting depth
−F		None	2−3	Shallow
+F		Applied	2−3	Shallow
+F(1p)		Applied	1	Shallow
Farmers' practice	−F	None	6	Deep
	+F	Applied	6	Deep

Figure 1.2-4 Field Layout and Treatments of the Pilot Project in Macoth (2008)

(4) Monitoring

1) Farming activity

The number of persons engaged in each farming activity and any important events related to plant growth were recorded on a daily basis by the FEW stationed at the site, which was the same as in 2007.

2) Growth monitoring during growth

The method of growth monitoring was modified to obtain more reliable data on yield components (Supplement 1). First of all, the number of hills per unit field area was counted shortly after sowing or transplanting in the enlarged sub-plot (2 m^2 in the upland areas and 3 m^2 in the lowlands), and at harvest in 4 m^2 in the upland areas and 6 m^2 in the lowlands with duplication. The number of panicles per hill was measured on 20 to 40 hills in each sub-plot at harvest time.

The plant height and the number of tillers were measured throughout the whole growth stage as in 2007.

3) Measurement of grain yield and 1,000-grain weight

The rice plants in a yield-plot of 48 m^2 were harvested, and the grain weight and 1,000-grain weight were measured with duplication, which was the same as in 2007.

1.2.3 Results and Discussion

(1) Dates of the growth stage and farming activity

Most crop management was executed according to the projected schedule (Table 1.2-2). Full maturity of the long-growth duration varieties was somewhat delayed, probably owing to the weak and late harmattan.

(2) Grain yield

1) Main results (Table 1.2-3)

a) The grain yield without fertilizer was about 1 ton/ha in the uplands and boliland, and 1.3 to 2.3 ton/ha in the mangrove swamp: the productivity in Robat was the highest.

b) The yield response to the fertilizer application was 0.5 to 1 ton/ha, with a lower response in the uplands and mangrove swamp.

c) A reasonably high yield of about 4 ton/ha was obtained using ROK 14 with a double rate of fertilizer application in Robat.

d) Productivity from planting a single seedling per hill was comparable to that with 2 to 3 seedlings per hill.

Note that grain yield of the remaining area (0.5 ha) planted by the farmers was not measured due to time limitations.

Table 1.2-3 Grain Yield and Yield Components Measured by the Sampling Method (2008) (a)

Agro-ecology	PP site (cultivar)	Treatment: specific	Treatment: Fertilizer (b)	Sampled plot: area (m^2)	Sampled plot: replication	Grain yield (ton /ha)	1,000-grain weight (g)	No. of hills $/m^2$	No. of panicles /hill	No. of panicles $/m^2$	No. of filled grains per pani-cle	No. of filled grains per hill	No. of filled grains per m^2
Man-grove swamp (MS)	Macoth (ROK 10)		-F	48	2	1.34	20.6	21	5.3	109	59	315	6,500
			+F	48	2	1.59	21.5	19	7.1	133	56	394	7,400
			+F (1p)	27	1	1.59	20.4	18	6.8	125	62	424	7,800
	Rosinor (ROK 10)		-F	48	2	1.44	20.7	17	5.1	88	79	402	7,000
			+F	48	2	1.49	20.8	14	7.1	96	74	528	7,100
Asso-ciated MS	Robat	ROK 10	-F	48	2	2.31	20.8	24	5.5	133	84	462	11,100
			+F	48	2	2.82	20.9	21	6.6	140	96	633	13,500
		ROK 14	-F	48	1	2.23	23.1	26	6.3	167	58	367	9,700
			+F	48, 27	1 each	3.65	23.3	29	7.7	219	71	547	15,700
			++F	48	2	4.21	23.5	26	8.5	220	81	689	17,900
			+F (1p)	12	1	4.12	22.9	29	8.5	247	73	615	17,900
Boliland	Kalintin (L. Conteh)		-F	48	2	0.68	28.5	18	3.2	56	43	137	2,400
			+F	48	2	1.57	29.2	33	3.9	127	42	163	5,400
IVS	Robennah (Yam Besay)		-F	48	2	0.88	25.5	30	4.4	132	26	114	3,500
			+F	48	2	1.75	27.7	31	6.0	187	34	204	6,300
	Sabuya (CP4)		-F	48	2	1.46	19.5	17	5.8	98	76	442	7,500
			+F	48	2	2.38	20.3	15	6.0	92	127	766	11,700
Upland	Kunthai (K. Fundey)		-F	48	2	0.88	15.8	48	2.0	97	57	117	5,600
			+F	48	2	1.49	15.0	67	3.4	232	43	147	9,900
	Robennah (ROK 3)	Upper	-F	48	2	0.67	27.0	-	-	-	-	-	2,500
			+F	48	2	0.91	28.8	-	-	-	-	-	3,200
		Lower	-F	48	2	0.41	26.7	-	-	-	-	-	1,500
			+F	48	2	0.75	28.3	-	-	-	-	-	2,600

a) Grain: filled grains with 14% moisture.
b) -F: without fertilizer. +F: with fertilizer. (1p) : single seedling transplanted in each hill.

2) Grain yield variation in the main field

The grain yield varied greatly from spot to spot, mainly due to the variation in the soil fertility. For example, on the upper slopes of the Robennah upland (Figure 1.2-5), it was 0.3 to 1.3 and 0.4 to 1.3 ton/ha with and without fertilizer, respectively. However, the variation was not so great in Robat, Macoth and Kalintin (Figures. 1.2-6 to 1.2-8). The soil fertility was probably more uniform in the mangrove swamp and boliland than in the upland areas.

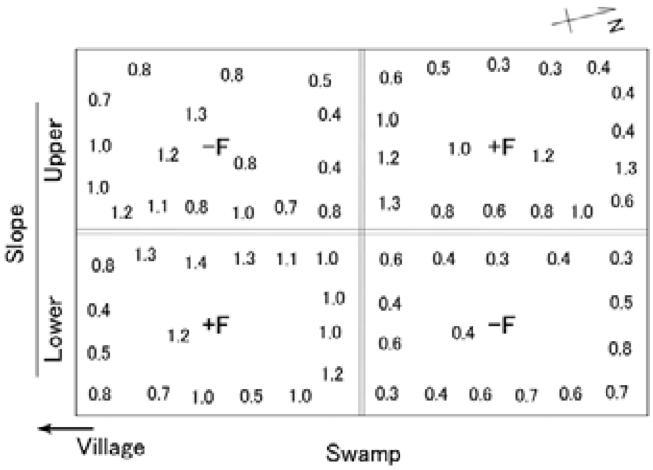


Figure 1.2-5 Variation in the grain yield (ton/ha) in the Robennah upland areas (20 Oct. 2008) (visual estimation)

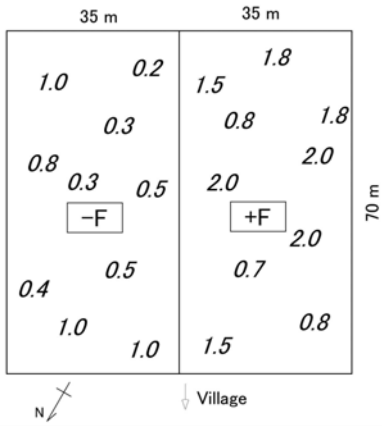


Figure 1.2-6 Variation in he grain yield (ton /ha) in Kali ntin (2008/1 1/29) (visual estimation)

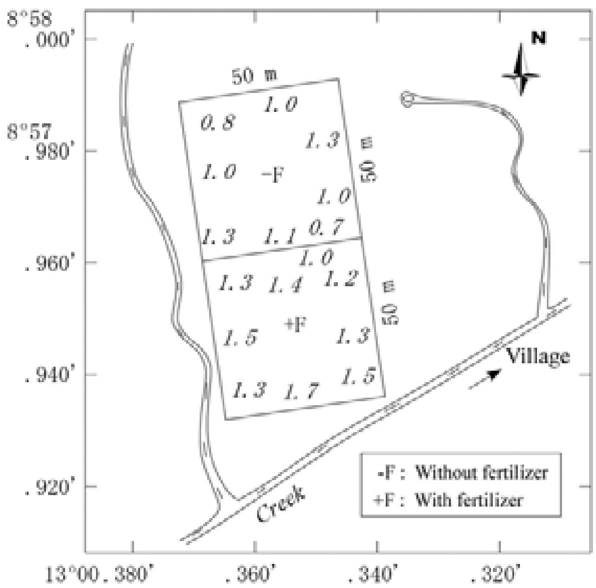


Figure 1.2-7 Variation in the Grain Yield (ton/ha)in Rosinor (2008/12/10) (visual estimation) (200

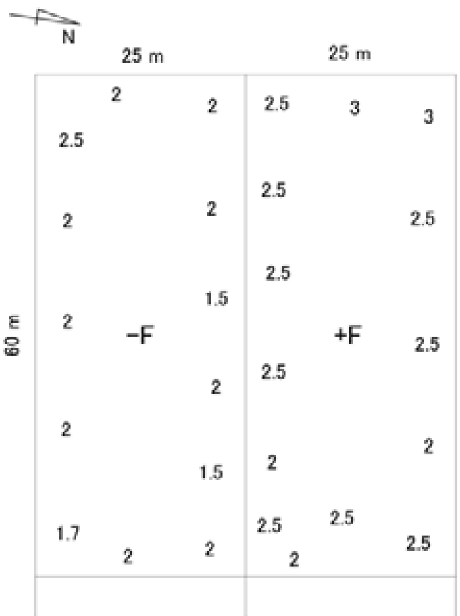


Fig.1.2-8 Variation in the Grain Yield (ton/ha) of ROK 10 in Robat
(ton/ha) of ROK 10 in Robat
8/12/28) (Visual estimation)

3) Comparison of the grain yield between the yield plot and whole plot harvesting

The grain yield in the majority of the sites was similar according to either the plot or the site (Figure 1.2-9). An exception was the yield in Sabuya, especially on the fertilized plot, where the grain yield was greater with whole plot harvesting than with the sampling method. Unfortunately, the reason for this was unclear.

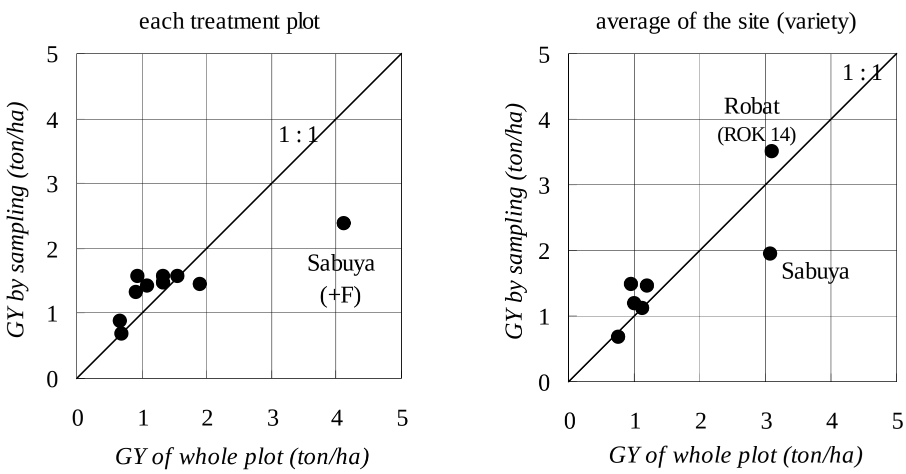


Figure 1.2-9 Comparison of the Grain Yield (GY) Measured by Harvesting a Whole Plot with that Using the Sampling Method: the GY in each Treatment Plot and the Average (weighed) for the Site (or variety).

3. Training

1) Training MAFFS-K staff

A series of training sessions was conducted for capacity building of the MAFFS-K staff using various formal methods (Annex 4). The topics were selected from important events in the ongoing cropping calendar and these covered from basic to applied aspects, and were given through lectures in the classroom and practice in the fields.

2) Farmers field study tours

Field study tours were conducted for the farmers. A farmers' group from one PP site visited another PP site: Robennah farmers visited Robat on Oct. 13, Robat farmers went to Kalintin on Oct. 25, Macoth farmers to Rosinor on Oct. 27, Rosinor farmers to Macoth on Oct. 13, and Kunthai farmers to Sabuya on Nov. 7. The rationale for the tours was to share experiences and exchange ideas on rice cultivation techniques and post harvest activities. The study tours were conducted at the ripening stage of the rice plant in most sites, so they visited fields too. The farmers certainly recognized the differences in crop growth and farm management on their own site compared to the other site and learnt various ways of improving their farming activities.

1.2.4 Impli cations and Further Study

(1) Some additional information

1) Potential productivity

The dominant factor limiting the productivity of the crops is solar radiation, which is the driving force for photosynthesis. The sunshine hours were long in the dry season and short in the rainy season, corresponding inversely with the pattern of the rainfall (Figure 1.2-10).

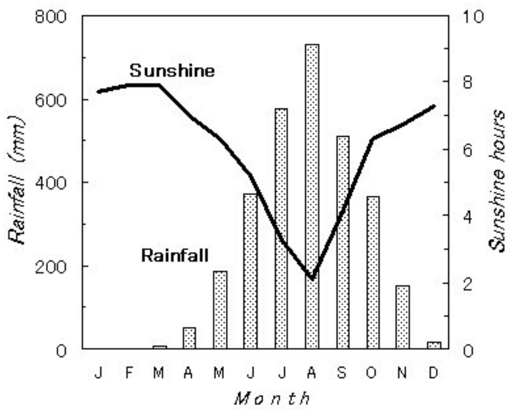


Figure 1.2-10 Mont hly Variation in the Rai nfall and Sunshine Hours at Rokupr

Although solar radiation data is unavailable for Sierra Leone and the conversion of sunshine hours to solar radiation is difficult, solar radiation in the mid rainy season can be estimated to be about 200 cal cm^{-2} d^{-1}. Based on data from Asia and another parts of West Africa, the potential grain yield under this level of radiation can be about 5 ton/ha. The pattern of sunshine hours implies that the yield could be high when planting is delayed to the latter part of the rainy season, as long as water is available during the maturing stage.

2) Potassium nutrients and the occurrence of fungal brown spot disease

The most prevalent rice disease in Kambia district is brown spot (*Helminthosporium spp.*), irrespective of the agro-ecological regime (both in the uplands and lowlands). It should be borne in mind that the occurrence of the disease is closely related to potassium nutrition either of the plants or the soils (Fig. 1.2-11): *i.e.*, the disease appears when the exchangeable K in the soils is lower than 0.12 $cmol_c$/kg or the K concentration in the plants is lower than 12 g kg^{-1}.

Since the potassium status of the soils in Kambia district is poor (Annex 3.1), farmers should seriously consider the above-mentioned relationship in selecting the type of fertilizer whenever they can afford to carry out a fertilizer application.

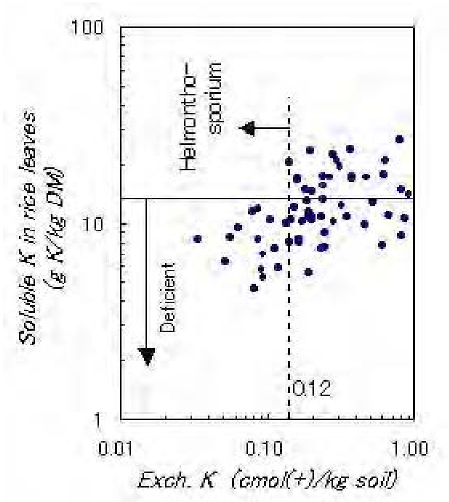


Figure 1.2-11 The Mutual Relationship between the Nutritional Status of the Plants and the Soils and the Occurrence of Brown Spot (data obtained from Ghana and Cote d'Ivoire)

(2) Improvement of fertilizer efficiency

Many chemical fertilizers are salts, which easily dissolve in water. Hence, the fertilizer elements are washed away when they are applied in running water. Nutrient runoff can be stopped by avoiding fertilizer application during the high tide period in mangrove swamps or into running water in the IVSs or bolilands.

The most difficult issue could be coping with the rainfall to make efficient use of the fertilizers in a high rainfall area such as Sierra Leone. August is the month of the heaviest rainfall (Fig. 1.2-10) and is the peak season for transplanting in the lowlands. At the same time, heavy rainfall often occurs at any time of the day: for example, about 350 mm in the night of Aug. 24, 2008. To control such high quantities of rainfall, a dike (bund) of 35 cm high (or higher when the seepage water is taken into consideration) is needed.

The heavy workload for constructing such a high (concrete) dike is not easily accepted by farmers in places where water control work is not common at all. In practice, it might be wise to avoid fertilizer application in the period from mid July to the mid September. The low fertilizer efficiency in 2007 and 2008 could be due to the application of the fertilizer at the peak of the rainy season.

Regarding one aspect of the pattern of rainfall and solar radiation, transplanting too should be avoided in August, especially from the middle to the end of the month.

The Robennah IVS suffered from damage due to running water in 2007. To avoid this problem, central drainage was dug at the beginning of the rainy season in 2008. Since that time, however, no constant rains came in 2008. The central drainage had to be refilled for puddling the main field. Physical labor is able to deal with certain water control, but the result will be affected by the rainfall pattern over a year. Unfortunately, there is no hydrological data in this country to enable better control to be carried out.

In the mangrove swamp area, farmers should always be mindful of the tidal movements, which are easily predictable except for temporary rises due to high rainfall. The most convenient cropping calendar should be planned before the season comes on the basis of adjusting the transplanting time to the low tide period.

(3) Towards the improvement of the TP

Various aspects of the background should be clarified to improve the productivity, such as the natural and anthropological factors, and for extension, the socioeconomic factors as well, and Pilot Projects were carried out to find a way to improve the rice yield in the farmers' fields, with, a technical package being eventually presented based on the lessons from these pilot activities. The real cause of the current low productivity is not yet fully understood mainly due to time limitations. Identification of the most efficient ways of improving rice production should still be pursued.

Several subjects to be studied further and possible approaches to improving the techniques for greater efficiency are:

1) Environmental factors

a) Climate, especially solar radiation variation during the year.

b) Tidal movements and topography to identify possible sites for fertilizer application.

c) Salinity in the mangrove swamp: the desalinization process at the beginning of the rainy season and the salinization process at the beginning of the dry season. These measurements make it possible to identify the proper planting time and possibility of double cropping.

d) Nutrient status of the soils and plants: macro- and micronutrients (Zn, Fe excess, Cu deficiency in the peat soils, sulfur, etc.).

2) Experimental trials on culture practices

a) Optimum seed rate for upland rice: The current seed rate at 1 bu/acre could be too small. The appropriate seed rate for upland conditions is still an open question.

b) Comparison of the varieties: the productivity and plant traits (including grain traits) should be studied for the dominant varieties (including local cultivars). The productivity of NERICA should be tested together with other comparable cultivars. The productivity of short-statured varieties: ROK 14 showed high productivity, but should be further studied to identify if this is persistent or not.

c) Appropriate planting season: For example, in the mangrove swamp, whether the best transplanting time is late July to the middle of August, or early to the middle of September.

d) The relationship between the number of seedlings per hill and crab damage is still under investigation.

e) Efficient fertilizer application methods: Avoidance of the risk of the washing out of the fertilizers with heavy rainfall through more split applications.

f) Varietal tolerance to insect damage: red rice is tolerant of the gall midge.

3) Field surveys needed

a) Actual acreage planted with 1 bu seeds on farmers' fields in the upland and lowland areas: actual seed rate.

b) Grain yield of farmers' fields in the upland and lowland areas.

c) Planting conditions: mechanized acreage in the boliland, acreage with direct sowing in the mangrove swamp, double cropping in the associated mangrove swamp and IVS, proportion of the acreage for short-, medium- and long-duration varieties.

d) Allowable palm tree density: an approach to this has not yet been developed.

Note that (1) The use of draught oxen for plowing should be promoted, although this is limited at present. Plowing with a power tiller or tractor is neither economical nor sustainable under the present conditions. (2) For full-scale water control, construction work on dams or barrages is needed. Considering the total failure of such schemes in many countries in West Africa, we do not advise that it be done in this case.

4) Ethno-social aspect analysis for extension activities

a) Function of traditional working groups and recent changes

5) Farmers' intentions

a) Reasons for transplanting many seedlings (up to 20) per hill.

b) Use of old seedlings (2-month-old seedlings): this might contribute to greater salt tolerance.

6) Facilities needed

a) Laboratory facilities for chemical analysis: the subject of nutritional diagnosis was largely skipped in TP and PP due to a lack of knowledge among the research and extension staff and a lack of the laboratory facilities. Such facilities may help with routine chemical and physical analyses of the plants, soils, and water. Equipment for fragile elements or the status of soils like the redox potential and ferric ions should be facilitated for making in situ measurements.

b) Pure seeds: PP faced a serious problem of the seed mixture. The seeds in 2007 from the Seed Multiplication Center at Kobia and those in 2008 from RRSR were badly mixed.

1.3 Pre-pilot Project

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[MINISTRY OF AGRICULTURE AND FOOD SECURITY (MAFS)]
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REPORT
JICA Pre-Pilot Project Demonstration of Rice Technologies In Inland Valley Swamps (IVS), Kambia District

By
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Leader, Research-Extension-Liaison (REL) Programme
Rice Research Station (RRS), Rokupr

Introduction

A Pre-pilot Project activity was undertaken in the 2006 season to demonstrate the effect of improved rice technology on rice yields and the productivity and income of Inland Valley Swamps (IVS) farmers in the Kambia district. The activity was established at Mongbeh, Robat village in the Kambia district. A single 500 m^2 plot of the improved technology package was compared with a similar plot size of the farmer's practice. The activity was research/farmer managed and comprised the complete rice technology package established adjacent the farmer's practice.

Materials and methods:

The complete rice technology practice consisted of transplanting three weeks old seedlings of the improved iron toxicity tolerant rice variety, ROK 24, in a planting density of 25 hills m^{-2}, with improved cultural practice comprising the recommended fertilizer dose of 100:60:60 Kg NPK per ha., timely weeding at four to six weeks after transplanting; as well as the construction of a 15 cm dyke for water control and more effective use of the applied fertilizer. The farmers' practice comprised random transplanting of older seedlings at an average of 10 seedling per hill, without fertilizer application or weeding.

In the present activity the RRS released lowland rice variety, ROK 24, was used in both the improved technology package and farmers' practice. A 50m^2 nursery of ROK 24 was established for the improved technology package in an upland area adjacent the field on 15th July, 2006. The nursery was uprooted on 5th August, 2006 at 21 days old and the seedlings transplanted in a plant density of 25 hills m^{-1} using two to three seedlings per hill. A basal application of 20 Kg NPK/ha of the complete fertilizer NPK 17:17:17 was made in the improved technology package. Following the hand pulling of weeds on 18th August, 2006, a first topdressing of 40 Kg NPK/ha of the complete fertilizer was applied on 19th August, 2006 (14 days after transplanting). A final topdressing of 40 Kg N/ha as Urea was applied to the improved technology plot on 12th September, 2006 (42 days after transplanting). All fertilizer applications were preceded by weeding. The operations in this treatment were supervised by the research team. Under farmer's practice, 30 days old seedlings were transplanted by the farmer on 6th August, 2006; in the traditional random procedure. No weed control or fertilizers were applied to the farmer's plot.

Plant growth data and the incidence of diseases and pests were recorded throughout the growth of the crop. Plant height and tiller number were sampled in two 1m quadrants placed at opposite diagonals each plot. Ten plants within each quadrant were selected at random and measured for plant height. The number of tillers within each quadrant were counted. The panicles were counted similarly at maturity. The gross plot was harvested, foot threshed, seed paddy sun dried and weight recorded at 14 % moisture content using a moisture meter. Weed biomass was collected from both treatments at harvest.

A partial budget analysis was undertaken to identify the costs, returns and profitability of rice production under the improved and farmers' technology packages. The profitability of the technology packages was measured as the net returns per hectare, expressed as:

$$NR = GR - TVC$$

Where NR = Net revenue per hectare

GR = Gross revenue per hectare [Grain Yield (Kg/ha) x price of paddy rice]

TVC = Total variable cost

Marginal analysis was also carried out to estimate the net benefit and total variable cost (TVC), as well as to compare the benefit associated with the extra cost incurred with using the improved technology. The Marginal Rate of Returns was calculated as follows:

$$MRR = \frac{\text{Marginal Net Benefit}}{\text{Marginal Cost}} = \frac{\text{Net benefit IT} - \text{Net benefit Farmers' Practice}}{\text{TVC IT} - \text{TVC Farmers' Practice}}$$

Results and discussion:

Agronomic Perfor mance: Crop vigour was higher in the improved technology package as compared with farmers' practice. Figure 1.3-1a and 1.3-1b show that plant height and tiller production were consistently higher in the improved technology package, indicating that the condition for plant growth was more favourable with the improved technology package. The incidence of diseases and pests were also less pronounced under the improved technology package (Table 1.3-1).

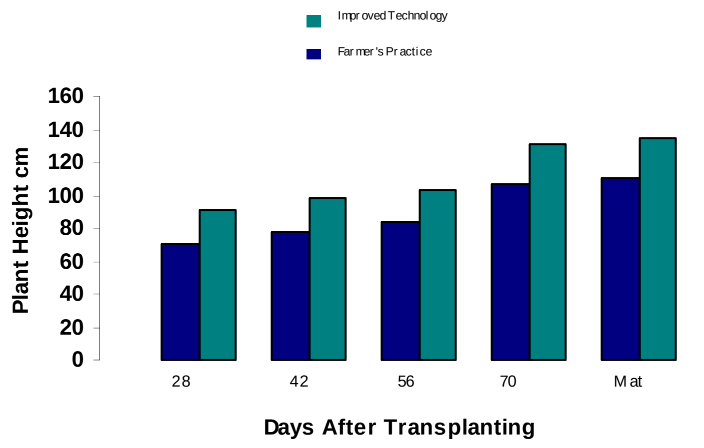

Figure 1.3-1a Effect of Technology Package on Plant Growth in the IVS. Mongbeh, Robat, Kambia District 2006

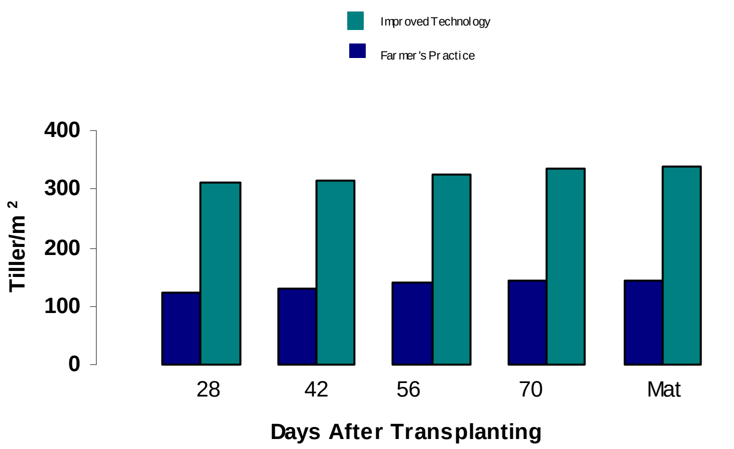

Figure 1.3-1b Effect of Technology Package on Plant Production in the IVS. Mongbeh, Robat, Kambia District 2006

Table 1.3-1 Incidence of Diseases, Pests and Iron Toxicity under Improved Technology Package and Farmers Production Practice in the Inland Valley Swamp at Mongbeh, Robat Village in the Kambia District.

Technology Package	Diseases* Insect			Pests*					Iron* Toxicity
	Brown Spot	Leaf Blast	Leaf Scald	Dead Heart	Stem Borer	Gall Midge	Case Worm	Leaf Folders	
Improved Technology	1	2	1	3	3	3	1	3	1
Farmers' Practice	5	3	7	3	3	7	5	5	3

* IRRI Standard evaluation System (SES) for rice

Brown spot and leaf scald were much more severe under farmers' production practice than under the improved technology package. Similarly, the farmers' production practice predisposed the crop to more severe incidence of gall midge, case worm and leaf folders as compared with the improved technology package. This is presumably a consequence of higher level of weeds under farmers' production practice, which serve as alternate host to pest and diseases. The incidence of weeds (figure 1.3-2) was far less in the improved technology package as compared with farmers' production practice, reflecting the weeding regime employed in the improved technology package. The incidence of iron toxicity, though not severe, was more pronounced under farmers production practice as compared with the improved technology package (Table 1.3-1), presumably because of lower soil fertility conditions in the farmer's plot.

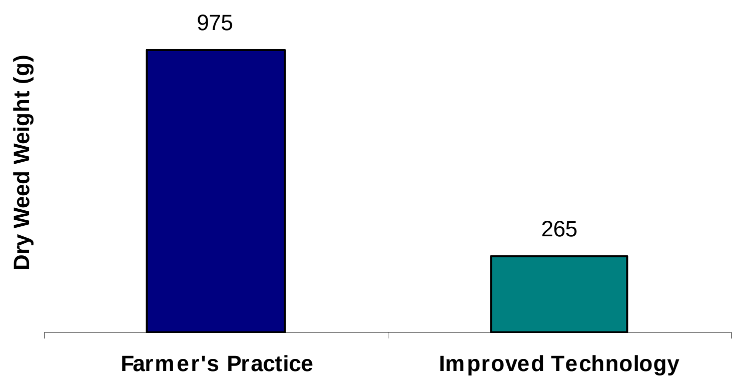

Figure 1.3-2 Effect of Technology Package on Weed Growth in the IVS. Mongbeh, Robat, Kambia District 2006

The technology packages also had marked effects on panicle production, yield components and grain yield of the crop (Table 1.3-2), reflecting strong differences in plant growth conditions between the technology packages. The improved technology package produce twice as much panicles as the farmers' practice. Yield component analysis also indicate that panicle length, number of grains per panicle and percentage filled grains were all higher under the improved technology package than farmers practice. Grain weight was also heavier with the improved technology package, resulting in 200 percent increase in grain yield over farmers' practice.

Table 1.3-2 . Grain Yield (Kg/ha) a nd Yield Com ponents showing the effect Technology Packages on Rice Production In the Inland Valley Swamp (IVS) at Mongbeh, Robat Village, Kambia District, 2006 Wet Season.

Technology Package	Tillers m^{-2} at maturity	Panicles m^{-2}	Grains per panicle	(%) Filled Grains	Grain Yield (Kg/ha)	(%) Yield increase over Farmers
Improved Technology	337	334	144	97.2	3318	200.5
Farmers' Practice	145	140	113	93.8	1104	-

Table 1.3-3 Financial benefits associated with the Improved Technology and Farmers' Practice in the Inland Valley Swamp (IVS) Robat, Kambia District, 2006 Season.

Parameter Farmer	s' Production Practice	Improved Technology
Average grain yield (Kg/ha)	1,104	3,318
Average price of paddy (Le/Kg)	1,000	1,000
Gross Benefit (Le/ha)	1,104,000	3,318,000
Variable Costs (Le/ha)		
Labour	885,625	1,059,850
Seed rice: ROK 24 @ Le 2000 / Kg	150,000	100,000
Fertilizer		
▪ 353 Kg NPK 17:17:17 @ Le 2000 / Kg	-	700,000
▪ 89 Kg Urea @ Le 2000 / Kg	-	178,000
Total variable cost (Le/ha)	1,035,625	2,037,850
Net Benefit (Le)	68,375	1,280,150

Economic Evaluation: The grain yield of paddy (Kg/ha) obtained, total variable cost (Le/ha) and net benefits are presented in Table 1.3-3. Adoption of the improved technology package gave a higher rice grain yield of 3,318 Kg/ha. as against the yield of 1,104 Kg/ha obtained with farmers production practice. A net benefit of Le 1,280,150.00 accrued from using the improved technology package as compared with Le 68,375.00 obtained from farmers' practice.

Results of marginal analysis presented in Table 1.3-4 show a positive marginal rate of return (MRR) of 120.9 %, which is in excess of the recommended minimal acceptable rate of 50% - 100%. This suggests that adoption of the improved technology package will increase farmers' grain yield output, as well as the net returns to the investments made by farm families in the new management practices.

Table 1.3-4 Marginal Rate of Return (MRR%) to Implementation of Improved Technology Package in the Inland Valley Swamp, Robat (IVS), Kambia District, 2006 Season

Parameters MRR	%
Marginal net benefit	
Marginal cost	120.9

Conclusion

Implementation of the improved technology package in IVS in the Kambia district facilitates favourable conditions for rice growth. Crop vigour was greatly enhance under the improved technology package and farmers may obtain three times as much rice yields as they would with their traditional production practices. Economic evaluation of the production methods indicate that the improved technology package will not only improved rice grain yield, but will also increase the net returns to farm families. Promotion of the improved technology package amongst farmers in the IVS will enhance rice production and facilitate food self-sufficiency and household food security.

Acknowledgement

JICA provided funds for this study. I gratefully acknowledge the valuable assistance of the following colleagues at RRS, Rokupr in the course of the study; Mr. H.M.S. Kargbo (/Extension specialist), Leonard Conteh (Senior Field Superintendent), Mr. Nazir Mahmoud (Agricultural Economist) and Mr. Alhaji Yillah (IT Specialist). I am much indebted to Drs. D.R. Taylor (Plant Pathologist) and S.D. Johnson (Agronomist/Plant Physiologist) for their useful comments on this report.

Appendix I: Components of Technology packages and Processing Methods implemented in the JICA Pre-Pilot Project undertaken in the IVS Robat in the Kambia District, 2006 Season

Technology Package	Variety	Seed Germ (%)	Plot Size (m^2)	Date of Operations			Weed Wt (g)		Production and Processing Methods						
				Sow	Maturity	Harvest	Fresh	Dry	Plowing	Harvesting	Threshing	Drying	Milling	% grain loss	% impurities
Improved	ROK 24	98	500	15/07	03/12	12/12	925	265	Hand hoe	Knives	Foot	Sun	Mortar & Pestle	3	2.5
Farmer's Practice	ROK 24	-	500	07/07	24/11	02/12	5525	975	Hand hoe	Knives	Foot	Sun	Mortar & Pestle	10	15

Appendix II: Tiller production, Panicles and Yield Components of Technology Packages implemented in the JICA Pre-Pilot Project undertaken in the IVS Robat in the Kambia District, 2006 Season.

Technology Package	Tiller Production m^{-2} Days after Transplanting						Yield Components				
	28	42	56	70	Maturity	Panicles	Panicle Length (cm)	Grains per panicle	Filled grains / panicle	Empty grains / panicle	1000 grain Wt. (g)
Improved	312	316	324	334	337	334	26.2	144	140	4	28.9
Farmer's Practice	122	131	140	144	145	140	24.8	113	106	7	21.5

1.4 Plant Traits of Selected Rice Cultivars Grown in Soil-pot Culture

1.4.1 Abstract

Nine rice cultivars (five from ROK series and four local cv.) used in the Pilot Project were grown in soil-pot culture in a net-house at Kambia, Sierra Leone. All cultivars possessed vigorous tillering habit. The harvest index of cultivars used (0.21-0.38) was smaller than that of modern high-yielding cultivars. This result implies that many cultivars in the country are inferior in genetic potential for high yield. Yet, ROK 14 likely produces high yield under the favorable cultural condition owing to its dwarf stature and high HI. Establishment of seed production system would take top priority to rice production increase in the country.

1.4.2 Introduction

JICA Agricultural Development Project carried out the Pilot Projects (PPs) in Kambia district in 2007 and 2008 to enhance rice production through the improvement of cultural practices with low cost and sustainable management (Annexes 1.1 and 1.2). The PPs were conducted in various agro-ecologies (upland, inland valley swamp, boliland, and mangrove swamp). Rice cultivars used in the PP were selected from a series of ROK varieties in 2007 and included local cultivars selected by farmers in 2008. In the present trial, all these cultivars used in the PPs were grown in soil-pot culture to find basic information on plant traits.

1.4.3 Materials and Methods

Rice cultivars, five from ROK series and four local cultivars (Table 1.4-1), were grown in a net house at a JICA house, Kambia town (9^{o}07’29” N, 12^{o}55’21” W). Seeds of ROK 3, ROK 10, ROK 14 and ROK 24 were obtained from the Rice Research Station, Rokupr (RRS-R, presently Rokupr Agricultural Research Center), those of ROK 5 from the Seed Multiplication Center at Kobia, and those of local cultivars from farmers.

Table 1.4-1 Growth Duration, Dry Matter Production, and Yield Components of Selected Rice Cultivars Grown in Soil Pots (a)

Cultivar	No. of plants	Days after sowing: 50% flowering	Days after sowing: Full maturity	Culm length (cm)	Panicle length (cm)	Air-dried weight (g/plant): Grain	Air-dried weight (g/plant): Straw (b)	Air-dried weight (g/plant): Total	Harvest index (c)	No.of panicles /plant	No.of grains /panicle	1,000-grain weight (gram) (d)
ROK 3	3	99	138	123	25	55	126	181	0.30	20	92	30
ROK 5	3	106	134	109	24	45	91	135	0.33	19	80	29
ROK 10	2	147	172	104	21	39	151	190	0.21	20	94	21
ROK 14 (e)	1	117	146	81	24	48	80	128	0.38	19	112	23
ROK 24	3	116	138	105	25	43	137	180	0.24	22	96	20
CP4 (f)	2	128	187	111	26	62	124	186	0.33	23	142	19
Kissy Fundy	3	78	98	107	21	33	56	90	0.37	22	103	15
Lansana Conteh (g)	3	122	146	110	23	47	100	147	0.32	15	118	27
Yam Gbessay	3	97	127	108	21	40	151	191	0.21	19	78	27

a) Grains signify fully-filled ones. b) Culm (internodes), leaves (sheath and blades), and the axis and branches of panicles. c) Harvest index (HI) = grain weight/total weight. d) Adjusted to 14% moisture. e) Formerly called as Mange 2. f) Locally called as Tonsor Kayrain. g) Introduced from Guenea, where it is called as Bai Junu. Sometimes called as Local Ya Gbessay.

Seeds of ROK 3 were soaked in water on July 5 and those of the others on June 21, 2008. These dates were defined as the sowing date and all growth stages were referred as days after sowing (DAS) in the text. Germinated seeds were temporarily transplanted into soil pots to raise seedlings 5 DAS, and finally transplanted into 5-liter plastics pot 14 DAS. About 4 kg of soil (taken from alluvial lowland soil of the Kolentin river tributary) was put into each pot, and water was maintained at 3-5 cm depth throughout the entire growth stages. Irrigation water was rainfall and underground water. Compound fertilizer (15-15-15) at the rate of 2 g/pot (0.3 g each of N, P_2O_5 and K_2O/pot) was applied at 29 and 49 DAS and at flowering.

The number of plants grown in a pot was one and each cultivar was replicated three times. The number of tillers and plant height at successive growth stages was recorded every two weeks. At full maturity, the aboveground portion of plants was taken, culm and panicle length were measured, panicle and straw were separately weighed after about one week air-drying, and air-dry weight of filled grains and 1,000-grains (14% moisture) were measured after threshing. The number of filled grains per panicle was calculated from air-dried weight of total grains and 1,000-grain weight.

Stalked-eye fly at the early growth stage and rice bug and plant-hopper at the late growth stage emerged. They were occasionally handpicked but the control was incomplete, but no obvious virus disease is observed. Stem borer damaged a few tillers.

Although flowering date varied a few days and culm height did 5-10 cm among three replications in many cultivars, the result was shown with their arithmetic means. However, in ROK 10, ROK 14 and CP 4, the variation was so great that 1 or 2 plants that were most feasible to the original cultivar were selected by referring the reported traits and available information: the number of plants selected is shown in Table 1.4-1.

1.4.4 Results

The total growth duration varied between 98 and 187 days, where that of Kissy Fundy was the shortest and that of CP 4 was the longest (Table 1.4-1). The total dry matter production varied between 90 and 190 g/plant: the smallest in Kissy Fundy and large in ROK 3, ROK 10, ROK 24 and Yam Gbessay. In general, straw weight was larger in cultivars of longer growth duration.

Harvest index (HI) varied 0.21-0.38, where that of Yam Gbessay and ROK 10 was the smallest and that of ROK 14 and Kissy Fundy was among the largest. The number of panicles per plant was the smallest (14 per plant) in Lansana Conteh and the largest in CP 4 (23 per plant), the number of grains per panicle was the smallest in Yam Gbessay (78/panicle) and the largest in Lansana Conteh (142/panicle), and 1,000-grain weight was the smallest in Kissy Fundy (15 g) and the largest in ROK 3 (30 g). Days from flowering to harvest were longer by cultivars with larger 1,000-grain weight except CP 4, of which full maturity was largely delayed.

The number of tillers increased rapidly about 30 DAS, reached the maximum about 60 DAS, and then gradually decreased towards full maturity (Figure 4.1-1).

Some plant traits specific to each cultivars: In many cultivars showed sturdy internodes except

Kissy Fundy, of which internodes were thin and weak and many of them was folded during grain filling period. As a result of thin internodes, HI was small, but weak internodes would not be practically appreciated. Although internodes were sturdy in ROK 10 and CP 4, many tillers were folded at the middle height during the late grain filling stage. This gets farmers into trouble in harvesting: folded straw is needed to stand up before grasping by hands for cutting. ROK 10 sometimes produced tillers at a high position of internodes.

Flowering duration was prolonged (panicles emerged successively) in CP 4 so that the proper harvesting date was hardly found because of delay in maturing with late flowered panicles. ROK 10 was susceptible to neck blast, causing unfilled grains.

1.4.5 Discussion

(1) Dry matter production and harvest index

Growth condition, especially of the light interception and mineral nutrition supply, differed between pot and field cultures, so that the growth itself differs between the two cultural conditions. Hence, dry matter production could not be compared each other, but some traits like the HI, tillering ability, *etc*. can be assessed.

The HI was generally small in the cultivars tested, including improved ROK varieties. This fact shows that genetic improvement of cultivars in the region is still far behind compared to the effort made by the International Rice Research Institute, for example, who released high yielding cultivars by pursuing the ideal plant type (*e.g*., IR 8): the HI of those cultivars is 0.45-0.5.

Otherwise, such results might be unconsciously reflected with the condition in Sierra Leone, where the maximum yield would be 5 ton/ha or so due to low solar radiation during the main rice-cropping season. An exception was ROK 14, of which plant traits were somewhat close to the ideal plant type for producing high yield: short stature with relatively high HI (0.38). Such traits would possess a high yield potential, if the cultural condition, especially nutritional condition, is favorable. In practice in the PP (2008), the cultivar was introduced at an associated mangrove swamp (Robat in Magbema chiefdom), and produced appreciable yield (nearly 4 ton/ha) with large fertilizer response (Annex 1.2). Farmers showed great interest in continuing to grow the cultivar in coming cropping season.

(2) Cultivar traits and productivity

All cultivars tested showed vigorous tillering ability. Hence, small number of tillers (or panicles) per hill often observed in farmers' fields is not owing to the cultivar's genetic backgrond, but owing to the cultural condition.

In lowlands, especially mangrove swamp, dominant cultivars like ROK 10 are photosensitive and their growth duration reaches 6 months when they are sown at the beginning of the rainy season. Because farmers are used to transplant old (sometimes 2-month old) seedlings with deep planting, those long duration cultivars are able to spare sufficient time to recover from the damage caused with unfavorable cultural practices at the beginning, and thus farmers will expect some production. In other words, farmers unconsciously avoid the risk of falling into low yield by selecting medium growth duration cultivars (120 days), which are unable to afford time to compensate a loss derived from unfavorable cultural practices.

Early maturing cultivars like Kissy Fundy is recommended to transplant in closer spacing than that the standard (*e.g.*, 20 hills/m^2). Such cultivars produce only a small vegetative growth due to short growth duration.

(3) Soil used

Total amount of nutrients in 4-liter soil in a pot is limited for sufficient growth of a rice plant. Because 0.9-1.9 gN/plant is needed in producing 90-190 g/plant of total dry matter production, assuming that nitrogen concentration of grain and straw is 10 mg/g, the total quantity of nitrogen applied is likely to be absorbed and the shortage was derived from the soil. Irrigated water might supply some amounts of nutrients too.

In the soil used in this trial, a farmer grew rice under the submerged condition during the rainy season and vegetables during the dry season. Rice growth in the pot was so vigorous that no obvious symptoms of nutrient deficiency except some major elements were observed although no fertilizer other than NPK was applied. Therefore, the soil used was considered to be fertile enough. Yet, some ferric iron film was observed during the early growth stage of rice plant.

(4) Fertilizer applied

Fertilizer application was suppressed during the mid growth stage to imitate the potted plant close to plants grown in the main field. If an additional fertilizer was supplied, the maximum number of tillers would have easily reached 100 or more per plant. Note that the fertilizer timing could affect differently to cultivars, of which growth duration varied greatly, because the dates of the first and second top-dressing were fixed with DAS over the cultivars.

(5) Seed mixture

Various plant traits of local cultivars somewhat differed among three replicates. Yet, the difference was smaller than that of ROK 10 and ROK 14. Farmers' effort is worthwhile to maintain seed purity. On the contrary, for instance in ROK 14, flowering date was 127, 117 and 100 DAS and culm length was 80, 81 and 69 cm by the plant number 1, 2 and 3, respectively.

Seed mixture would not affect greatly the productivity in the aspect of photosynthesis of the rice population under the present yield level: *e.g.*, about 1 ton/ha. The main problem of seed mixture is the difficulty in finding the proper harvesting time. The total production is surely reduced whichever farmers adjust the harvesting time to the early or late cultivar. The loss is caused by (1) shattering of over-ripened grains when harvesting is late or (2) harvesting un-matured grains when it is early. Seed supply system should be first established to promote rice production in this country.

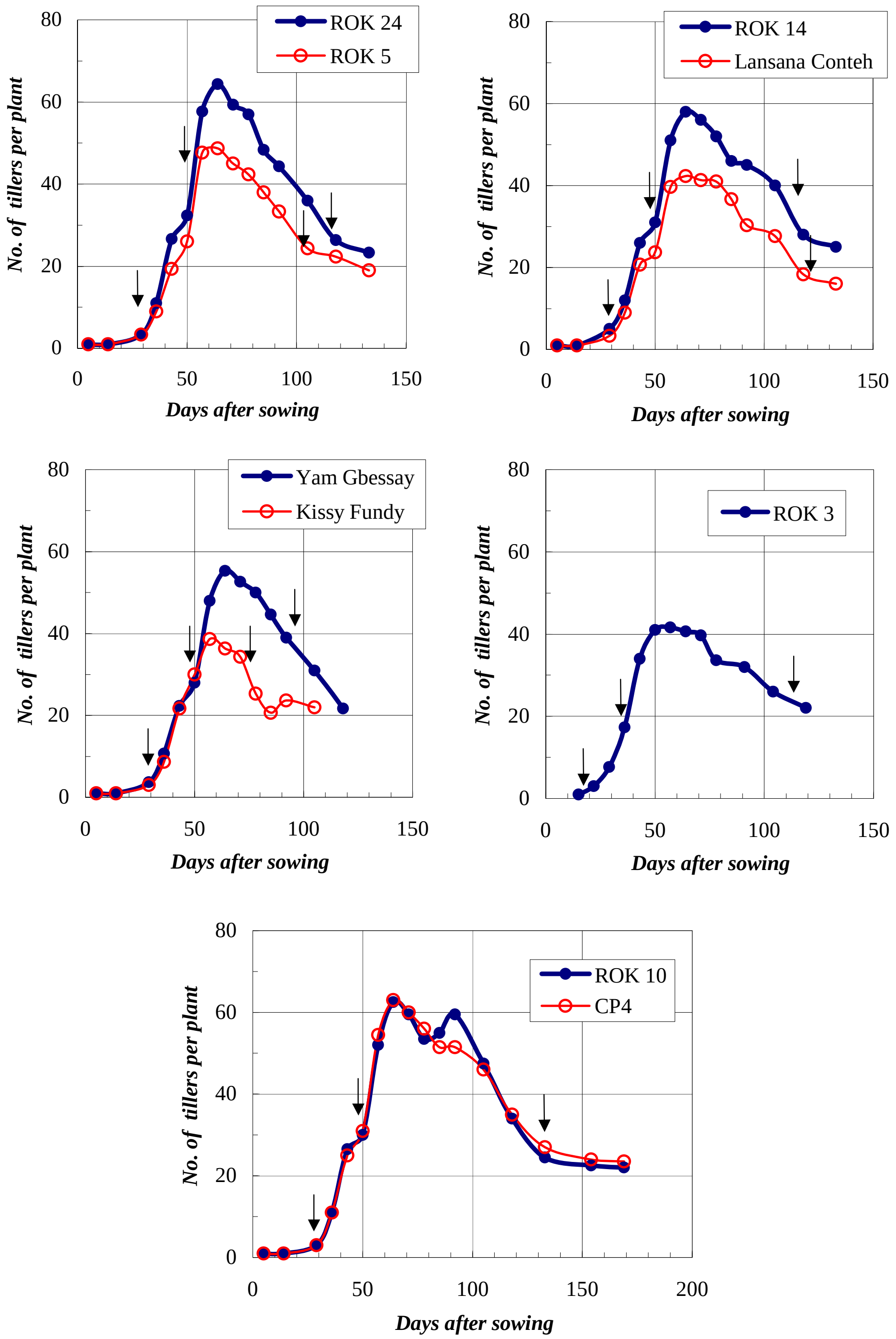

Figure 1.4-1 Number of Tillers at Successive Growth Stages of Rice Plants (from germination to late grain filling period)

*The data at full maturity were excluded. Arrows shows the date of top-dressing.

Annex 2

Pilot Trial of Vegetable Production for the Support of Women's Group

Annex 2 Pilot Trial of Vegetable Production for the Support of Women's Groups

2.1 Pilot Trial in 2007 (dry season)

2.1.1 Background

A Pilot Trial (PT) of vegetable production for the support of women's group was implemented during the dry season of October 2007 through February 2008, in two villages (Makatick and Mathon), based on the policies of low cost and the effective utilization of local resources.

At each site, a traditional vegetable crop (i.e., eggplant for Makatick and pepper for Mathon) and a newly introduced crop (watermelon) were selected for the trial. One women's group was targeted at each site. The women's groups were expected to participate actively in the trial and experience the newly introduced cultivation techniques.

Prior to the commencement of the PT, farming tools such as watering cans, shovels and head pans were provided by the JPT to the women's group at each site.

The trial started with sowing in mid November 2007. The schematic farming calendar is shown in Figure 1.

Village	Crop	2007			2008		
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Makatick	Eggplant		S	T		H	→
	Watermelon		S	T		H	→
Mathon	Pepper		S	T			H →
	Watermelon		S	T		H	→

S: Sowing, T: Transplanting, H: Harvesting

Figure 2.1-1 Schematics of the Farming Calendar of the Pilot Trial of Vegetable Production

2.1.2 Methods

Under the present situation and issues indicated in the target villages, the improved techniques introduced in the pilot trial are listed below in contrast to traditional cultivation methods. This trial was comprised of 3 plots as follows,

Plot A: Fertilizer application (basal $N:P_2O_5:K_2O$=5:5:5 kg/10a) + field management

Plot B: Fertilizer application (basal $N:P_2O_5:K_2O$=5:5:5 kg/10a + top dressing) + field management

Plot C: Traditional methods

The main improved techniques introduced for pepper and eggplant included: (i) seed drilling in the nursery bed followed by inter-row cutting with a knife before transplanting, (ii) transplanting in rows, (iii) wide intra-row spacing, (iv) fertilizer application in liquid form, (v) thinning out and (vi) the utilization of local resources for controlling pests. As for watermelon, (i) the use of pots for nursing and (ii) fruit and vine thinning were introduced.

Details of the PT methods at both sites are presented below.

Table 2.1-1 Methods of the Trial of Pepper Production (Mathon)

	Traditional cultivation (Plot C)	Improved techniques (Plot A,B)
Sowing time	15th November	15th November
Transplanting time	20th December	20th December Cutting inter-row spaces using a knife to stimulate new root growing prior to transplanting.
First harvesting	Nil	3rd March
Variety	Nenekoroh	Nenekoroh
Area of the plots	Unmeasured	1a (Plot A 0.5 a, Plot B 0.5 a)
Sowing amount	Unmeasured	ca. 20 cc
Area of the nursery	Unmeasured	1m×4m
Planting density	ca. 20 cm intra-row spacing	1.6 m furrow× 0.45 m intra-row spacing
Planting system	Random	2 row, row planting
No. of plants	46 plants	276 plants
Nursery	The nursery is heaped up 10 to 20 cm high and the top is shaded with palm leaves	The nursery is heaped up 10 to 20 cm high and the top is shaded with a thin layer of palm leaves and these are then removed immediately at a certain stage of growth to prevent elongation of the seedlings.
Nursery soil	Mixture of compost and top soil	Utilize carbonized rice husks together with a mixture of compost, topsoil and chemical fertilizer.
Sowing	Broadcasting	Stripe sowing
Nursing	Watering twice a day	Watering once or twice a day
Fertilizer application	Nil	Application of NPK 15:15:15 ($N:P_2O_5:K_2O$=5:5:5 kg/10a) around the plants in both plots. After transplanting, liquid fertilizer treated by dissolving the same fertilizer in water is applied in plot B, if necessary.
Transplanting	Water substantially before uprooting and uproot from the bottom of the root.	Cut an inter-row space using a knife to stimulate new root growth 3 days before transplanting. Water substantially before uprooting and uproot from the bottom of the root.
Thinning	Nil	The primary stem and two of the vigorous secondary stems are trained at the primary stage only
Top dressing	Nil	Liquid fertilizer is applied around the plants in plot B, if necessary
Intertillage	Nil	Intertillage is carried out if weeds disturb the plant growth
Control of diseases and insects	Broadcast rice husk ash	Control using local resources. Spray with neem.
Harvesting	Once a week	Depending on the situation

Table 2.1-2 Methods of the Trial of Eggplant Production (Makatick)

	Traditional cultivation (Plot C)	Improved techniques (Plot A,B)
Sowing time	13th November	13th November
Transplanting time	24th December	24th December
First harvesting	26th February	19th February
Variety	—	—
Area of the plots	0.5a	1a (Plot A 0.33 a, Plot B 0.33 a)
Sowing amount	—	ca. 16 cc
Area of the nursery	—	1m×3m
Planting density	ca. 25cm intra-row spacing	1.6m furrow × 0.6m intra-row spacing
Planting system	2 row planting	2 row, row planting
No. of plants	102 plants	136 plants
Nursery	The nursery is heaped up 10 to 20 cm high and the top is shaded with palm leaves	The nursery is heaped up 10 to 20 cm high and the top is shaded with a thin layer of palm leaves and these are removed immediately at a certain stage of growth to prevent elongation of the seedlings.
Nursery soil	Mixture of compost and top soil	Utilize carbonized rice husks together with a mixture of compost, topsoil and chemical fertilizer.
Sowing	Broadcasting	Stripe sowing
Nursing	Watering twice a day	Watering once or twice a day
Fertilizer application	Nil	Application of NPK 15:15:15 ($N:P_2O_5:K_2O$=5:5:5kg/10a) around the plants in both plots. After transplanting, a liquid fertilizer treated by dissolving the same fertilizer in water is applied in Plot B, if necessary.
Transplanting	Water substantially before uprooting and uproot from the bottom of the root. Transplant almost in a straight line and at uniform intervals.	Cut an inter-row space using a knife to stimulate new root growth 3 days before transplanting. Water substantially before uprooting and uproot from the bottom of the root.
Thinning	Nil	The primary stem and two of the vigorous secondary stems are trained at the primary stage only
Top dressing	Nil	Liquid fertilizer is applied around the plants in Plot B, if necessary
Intertillage	Nil	Intertillage is done if weed disturb the plant growth
Control of disease and insect	Broadcast rice husk ash	Control using local resources. Spray with neem.
Harvest	Once a week	Depending on the situation

Table 2.1-3 Methods of the Trial of Watermelon Production (Mathon, Makatick)

	Traditional cultivation (Plot C)	Improved techniques (Plot A, B)
Sowing time	—	Mathon: 29th November, Makatick: 29th November,
Transplanting time	—	Mathon: 15th December Makatick: 14th and 17th December

First harvesting	－	Mathon: 20th February, Makatick: 19th February
Variety	Sugar baby	Sugar baby
Area of the plots	1a	2a (Plot A 1a, Plot B 1a)
Sowing amount	－	70 cc
Area of the nursery	Nil	1m×5-6m
Planting density	－	1.8 m furrow × 1.5 m intra-row spacing
Planting system	Random	1 row planting
No. of plants	Mathon: 7 plants Makatick:24 plants	Mathon: 70 plants Makatick: 64 plants
Nursery	After sowing, the top is shaded with palm leaves.	Raise plug seedlings using plastic cups or the leaves of a palm or banana. Alternatively, raise soil block seedlings using a wooden box. The top is shaded using palm leaves.
Nursery soil	Mixture of compost and top soil	Utilize carbonized rice husks together with a mixture of compost, topsoil and chemical fertilizer.
Sowing	Direct sowing	1 to 2 seeds are sown for each pot, depending on the germination ratio
Nursing	Watering once or twice a day	Watering once or twice a day
Field preparation	Plowing and preparing the field with the assistance of some men	Plowing and preparing the field with the assistance of some men
Fertilizer application	Nil	Application of NPK 15:15:15 ($N:P_2O_5:K_2O$=5:5:5 kg/10a) around the plants in both plots. After transplanting, liquid fertilizer treated by dissolving the same fertilizer in water is applied in Plot B, if necessary.
Transplanting	－	Hardening of the seedlings 5 days before transplanting by reducing the watering and removal of the shading structure. If palm leaves are used as planting pots, the seedlings are transplanted as they are together with the pots. If plastic cups are used, the seedlings are transplanted by just taking out the soil block from the pots.
Mulching	Rice straw mulch	Rice straw mulch
Thinning of the plants	Nil	The primary vine is pinched off leaving 6 leaves and 4 of the vigorous secondary vines are selected and grown in the same direction. The tertiary vines are pinched off up to the fruit set node and then all the vines are left as they grow after the fruit set
Watering	Watering once or twice a day	Watering once or twice a day
Fruit thinning	Nil	The first female flowers on each vine are removed and the set fruits after the 8th node on each vine. The total number of fruits on each plant should be limited to 2 to 3 only.
Weeding	Mulching with rice straw and removal of weeds 3 times during the planting period	Mulching with rice straw and the removal weeds 3 times during the planting period
Top dressing	Nil	Liquid fertilizer is applied around the

		plants in Plot B, if necessary
Intertillage	Nil	Intertillage is carried out if the weeds disturb the plant growth
Control of diseases and insects	Nil	Control using local resources. Spray with neem and tobacco extract solution.
Harvesting	Depending on the situation	Harvest 35 to 40 days after flowering. Determine the optimum time for harvesting according to the fruit size and by making a knocking sound on the fruit.
Seed production	—	Wash well and eliminate any mucus. Preserve only the seeds that sink in water
Preservation of the seeds	—	Preserve the dried seeds in a sealed paper bag in a cool place

2.1.3 Results and discussion

Monitoring of the results of the yield is shown in Figures 2, 3 and 4. Note that pepper is excluded from the results because there is no record of time-dependent changes.

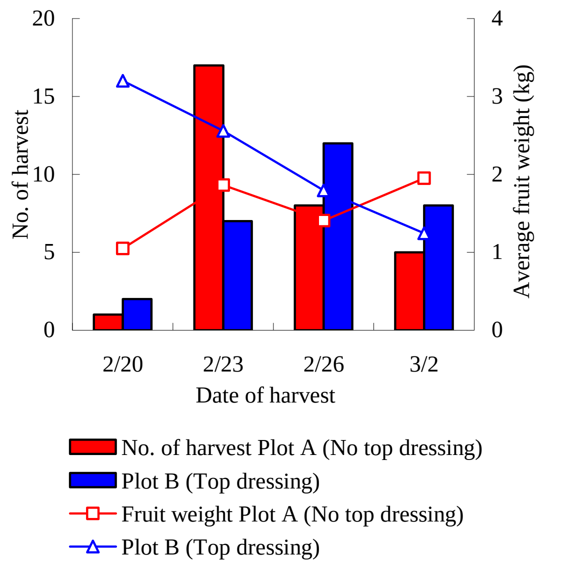

Figure 2.1 -2 Harvest of the Watermelon in Mathon

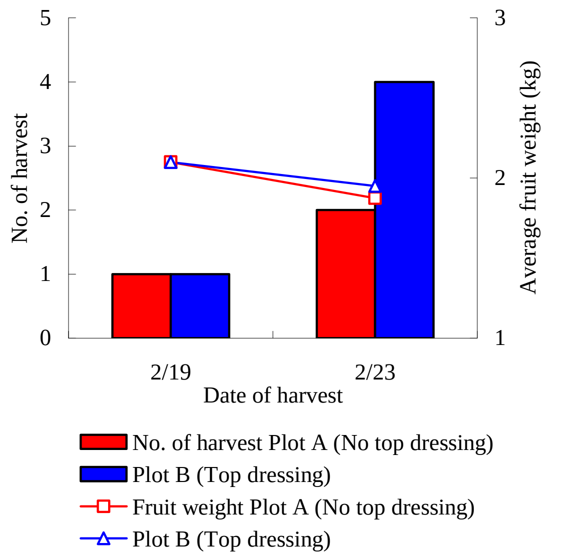

Figure 2.1-3 Harvest of the W atermelon in Makatick

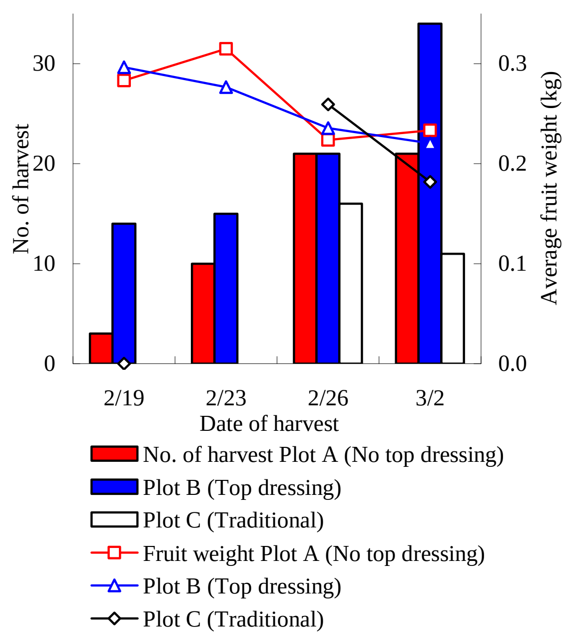

Figure 2.1-4 Harvest of Eggplant in Makatick

The results of the yield survey and sales are shown in the table below. There are obvious differences among three plots, particularly for the eggplant. However for the watermelon, the effects of disease have made no differences to the yield.

Table 2.1-4. Results of the yield survey

Village	Item	Plot ※1	Sowing date	Trans-planting date	Number of Trans-planted	Harvested from	Target yield ※2 Standard yield	Actual yield (until 3/2) Number of fruit	Weight (kg)
Makatick	Eggplant	A	11/13	12/24	68	2/19	100kg	55	13.6
		B	11/13	12/24	68	2/19	100kg	84	20.8
		C	11/13	12/28	102	2/26	150kg	27	6.2
	Water-melon	A	11/29	12/15	32	2/19	64 fruits	3	5.9
		B	11/29	12/15	32	2/19	64 fruits	5	9.9
		C	11/29	1/10	24	-	48 fruits	0	0
Mathon	Pepper	A	11/15	12/20	138	-	150kg	12,558 ※3	20.6
		B	11/15	12/20	138	-	150kg	13,800	22.6
		C	11/15	12/20	138	-	150kg	0	0
	Water-melon	A	11/29	12/15	35	2/20	70 fruits	31	53.7
		B	11/29	12/15	35	2/20	70 fruits	29	55.8
		C	12/15	direct	7	-	14 fruits	0	0

※1 A: basal fertilizer application, B: basal+ top dressing、C: traditional

※2 watermelon: planned amout of bearing per fruit 2.5×0.8, pepper, eggplant: calculated by plot area from standard yield, i.e., 30t/ha

※3 Pepper yield was estimated from counting bloomed flower.

The following points, however, can be derived from the results.

(1) In general, the yields of all three crops are low and are less than the standard yield.

(2) In particular, the watermelon produced a low yield due to a severe attack of Melonfly (*Dacus cucurbitae*) that completely destroyed the fruit pulp by feeding on it. Spraying with chemical controls as an urgent countermeasure was not effective. Especially in Makatick, only 8 fruits were harvested from 88 plants, which represents annihilation in comparison with the 60 fruits in Mathon. As a result, it was clarified that infestation with the Melonfly is the most crucial factor in watermelon production. Such incidents must be avoided to achieve stable production by means of the application of chemical controls.. However, raising seedlings in pots produced faster and healthier growth than direct sowing.

(3) The pepper also produced a very low yield in Mathon due to weak growth derived from the severe transplanting shock and the occurrence of a virus infection. The first fruit harvest was delayed to March although it was scheduled to start in January in the original plan. Almost 4 months passed after the date of sowing. A severe infestation by a virus also contributed to the short duration of the harvest and the low yield.

(4) The eggplant production showed a comparatively high yield compared with that of the watermelon and pepper. Although slight damage due to diseases and insects were observed during the planting period, it did not become so serious as to give crucial damage to the production. A clear difference could be observed between the 3 plots, and in particular the effects of thinning out on the growth and yield were obviously confirmed. Plot B showed the highest yield (20.8 kg) while Plots A and C produced 13.6 kg and 6.2 kg, respectively.

(5) Neem leaves and pepper extract almost controlled the aphids on the pepper and eggplant, which led to a higher yield, especially with the eggplant.

(6) The women's groups appreciated the PT in terms of crop selection, the techniques introduced (the use of pots for nursing the watermelon seedlings, fertilizer application in liquid form, and thinning out) and the frequent visit by experts. On the other hand, there were some complaints from them about the increased workload and the unavoidable employment of men for certain activities in the PT. Gaps were also apparent in the understanding of the purpose and contents of the PT among the concerned groups, probably due to insufficient communication. An attitude of dependence was observed in the women's groups.

2.2 Pilot Trial in 2008 (rainy season)

2.1.1 Backgr ound

Following to the dry season trial in 2007, a PT of vegetable production was implemented in 2008 in the same villages and groups, i.e., Mathon and Makatick. The basic concepts of the PT included low cost and the effective utilization of local resources, as in 2007. The pilot trial for 2008 was carried out in the rainy season based on the results and experience gained in the previous trial, and emphasized verification of the proposed techniques to be practically applied. The tested crops were switched between the two villages, i.e., pepper in Makatick and eggplant in Mathon according to the requirements of both groups. In addition, watermelon was tested again in both villages.

This trial was expected to contribute to the eventual promotion of its implementation by women's groups not only in the two villages, but also in neighboring villages through extension of the applicable techniques verified in the pilot trial.

The trial started with sowing in mid May 2008. The schematic farming calendar is shown in Figure 2.2-1.

		2008					
Villages	**Crops**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct**
Mathon	Eggplant	S	T	H →			
	Watermelon	S T		H →			
Makatick	Pepper		S	T		H →	
	Watermelon	S T		H →			

S: Sowing, T: Transplanting, H: Harvesting

Figure 2.2-1 Schematics of the Farming Calendar for the Pilot Trial of Vegetable Production

2.1.2 Methods

Based on the results of the pilot trial conducted in the year 2007, the following plan was carried out as shown in Tables 1, 2 and 3.

The main improved techniques introduced for eggplant and pepper production include: (i) seed drilling in the nursery bed followed by inter-row cutting using a knife before transplanting, (ii) wider intra-row spacing, (iii) fertilizer application in liquid form, (iv) thinning out, and (v) the utilization of local resources such as the neem for controlling pests. As for the watermelons, techniques such as (i) the use of pots for nursing and (ii) thinning of the fruit and vines were introduced.

As for the pepper and eggplant, the effects of thinning out were again tested in 2008 since the thinning out of the eggplant had proved effective for increasing yields in the previous trial. Similarly, the dose of the basal fertilizer application was reduced from $N:P_2O_5:K_2O$= 5:5:5 kg/10a to $N:P_2O_5:K_2O$= 4:4:4 kg/10a. Moreover, the effects of the neem in controlling pests was carefully monitored in 2008, since the neem seeds, which contain a highly active element, were obtained in April 2008.

Based on the lessons learnt from the previous year, a memorandum of understanding (MOU) was concluded between the women's groups and the Project on the 2008 trial in order to ensure a thorough understanding of the purpose and policies of the PT and to clarify the roles of each party.

Table 2.2-1 Methods of the Trial of Pepper Production (Makatick)

	Plot A	Plot B
Sowing time	2nd June	
Transplanting time	1st July	
First harvesting	29th September	
Variety	Nenekoroh	
Area of the plots	0.5 a	0.5 a
Sowing amount	ca. 20 cc	
Area of the nursery	1m×4 m	
Planting density	1.6 m furrow× 0.45 m intra-row spacing	
Planting system	2 rows, row planting	
No. of plants	120 plants	120 plants
Nursery	The nursery is heaped up 10 to 20 cm high and the top is shaded with a thin layer of palm leaves and these are removed immediately at certain stage of growth to prevent elongation of the seedlings.	
Nursery soil	Use of top soil mixed with NPK compound fertilizer in the amount of 0.1 g/10L.	
Sowing	Stripe sowing	
Nursing	Watering once a day	
Fertilizer application	Application of NPK 15:15:15 ($N:P_2O_5:K_2O$=4:4:4 kg/10a) around the plants in both plots. After transplanting, liquid fertilizer treated by dissolving the same fertilizer in water is applied in Plot B, if necessary.	
Transplanting	Cutting an inter-row space using a knife to stimulate new root growth 3 days before transplanting. Water substantially before uprooting and uproot from the bottom of the root.	Cutting an inter-row space every two days to make it three times using a knife to stimulate new root growth starting from one week before transplanting. Water substantially before uprooting and uproot from the bottom of the root.
Thinning	Nil	The primary stem and three of the vigorous secondary stems are pruned at the primary stage only
Top dressing	Nil	The fertilizer is applied around the plants in Plot B in the amount of NPK 15:15:15 ($N:P_2O_5:K_2O$=6:6:6kg/10a) at the maximum, if necessary
Intertillage	Nil	Intertillage is carried out if weeds disturb the plant growth
Control of diseases and insects	Nil	Spraying with insecticide for prevention at the nursery stage by providing 2 to 3 different types of chemicals. Control using local resources. Spray neem liquid or scatter neem powder.
Seed production	Contaminated with many varieties.	Separate by variety
Preservation of the seeds	Pan	Preserve in a sealed paper bag in a cool place

Table 2.2-2 Methods for the Trial of Eggplant Production (Mathon)

	Plot A	Plot B
Sowing time	13th May	
Transplanting time	10th June	

Harvesting time	22nd July	
Variety	—	
Area of the plots	0.5 a	0.5 a
Sowing amount	ca. 16 cc	
Area of the nursery	1m×3 m	
Planting density	1.6 m furrow× 0.6 m intra-row spacing	
Planting system	2 rows, row planting	
No. of plants	98 plants	98 plants
Nursery	The nursery is heaped up 10 to 20 cm high and the top is shaded with a thin layer of palm leaves and these are removed immediately at a certain stage of growth to prevent elongation of the seedlings.	
Nursery soil	Use top soil mixed with NPK compound fertilizer in the amount of 0.1g/10L.	
Sowing	Stripe sowing	
Nursing	Watering once a day	
Fertilizer application	Application of NPK 15:15:15 ($N:P_2O_5:K_2O$=4:4:4 kg/10a) around the plants in both plots. After transplanting, liquid fertilizer treated by dissolving the same fertilizer in water is applied in plot B, if necessary.	
Transplanting	Cutting an inter-row space using a knife to stimulate new root growth 3 days before transplanting. Water substantially before uprooting and uproot from the bottom of the root.	Cutting an inter-row space every two days to make it three times using a knife to stimulate new root growth starting from one week before transplanting. Water substantially before uprooting and uproot from the bottom of the root.
Thinning	Nil	The primary stem and three of the vigorous secondary stems are pruned at the primary stage only
Top dressing	Nil	Fertilizer is applied around the plants in Plot B in the amount of NPK 15:15:15 ($N:P_2O_5:K_2O$=6:6:6 kg/10a) at a maximum, if necessary
Intertillage	Nil	Intertillage is carried out if weeds disturb the plant growth
Control of diseases and insects	Nil	Spraying insecticide for prevention at the nursery stage by providing 2 to 3 different types of chemicals. Control using local resources. Spray with neem liquid or scatter neem powder.
Harvest		The first fruit is removed to maintain the vigor of the plant before growing 5 cm in size.
Fruit classification	Nil	As many kinds and varieties of fruits are contaminated, fruit classification is carried out before shipping.
Seed production	Contaminated with many varieties.	Separate by variety
Preservation of the seeds	Pan	Preserve in a sealed paper bag in a cool place

Table 2.2-3 Methods of the Trial of Watermelon Production (Mathon, Makatick)

	Improved techniques
Sowing time	Mathon: 13th May Makatick: 12th May
Transplanting time	Mathon: 31st May Makatick: 30th May
Harvesting time	Mathon: 26th July

	Makatick: 25th July
Variety	Sugar baby
Area of the plots	2a
Sowing amount	300 seeds
Area of the nursery	1m×3 m
Planting density	1.8 m furrow× 1.5 m intra-row spacing
Planting system	1 row planting
No. of plants	70 plants for each site
Nursery	Raise plug seedlings using plastic cups or the leaves of a palm or banana. Alternatively, raise soil block seedlings using a wooden box. The top is shaded using palm leaves.
Nursery soil	Use of top soil mixes with NPK compound fertilizer in the amount of 0.1 g/10L.
Sowing	1 seed is sown for each pot depending on germination ratio
Nursing	Watering once a day
Field preparation	Plowing and preparing the field with assistance of some men
Fertilizer application	Application of NPK 15:15:15 ($N:P_2O_5:K_2O$=4:4:4 kg/10a) around the plants in both plots. After transplanting, liquid fertilizer treated by dissolving the same fertilizer in water is applied in Plot B, if necessary.
Transplanting	Hardening of the seedlings 5 days before transplanting by reducing watering and removal of the shading structure. The seedlings are transplanted with the complete soil block taken out from the pots.
Mulching	Rice straw mulch
Thinning of the plants	The primary vine is pinched off leaving 6 leaves and 4 of the vigorous secondary vines are selected and grown in the same direction. The tertiary vines are pinched off up to the fruit set node and then all the vines are left as they are to grow after the fruit set
Watering	Watering once a day
Fruit thinning	The first female flowers on each vine are removed and set the fruits after the 8th node on each vine. The total number of fruits on each plant should be limited to 2 to 3 only.
Weeding	Removal of weeds 3 times during the planting period
Top dressing	Fertilizer is applied around the plants in the amount of NPK 15:15:15 ($N:P_2O_5:K_2O$=6:6:6 kg/10 a) at a maximum, if necessary
Intertillage	Intertillage is carried out if weeds disturb the plant growth
Control of diseases and insects	Spraying insecticide for prevention at the nursery stage providing 2 to 3 different types of chemicals. Control using local resources. Spray neem and tobacco extract solutions. For Melonfly, spread a solution of Furadan on the surface of the fruit.
Harvesting	Starting from August. Harvesting is carried out 40 to 45 days after flowering or 10 to 14 days after the disappearance of the stripes on the fruit surface. Determine the optimum time of harvesting according to the fruit size and by making a knocking sound on the fruit.
Seed production	Wash well and eliminate the mucus. Preserve only the seeds that sink in water
Preservation of seeds	Preserve in a sealed paper bag in a cool place

1. Results and discussion

The monitoring results of the yield are shown in Figures 2.2-2, 2.2-3, 2.2-4 and 2.2-5

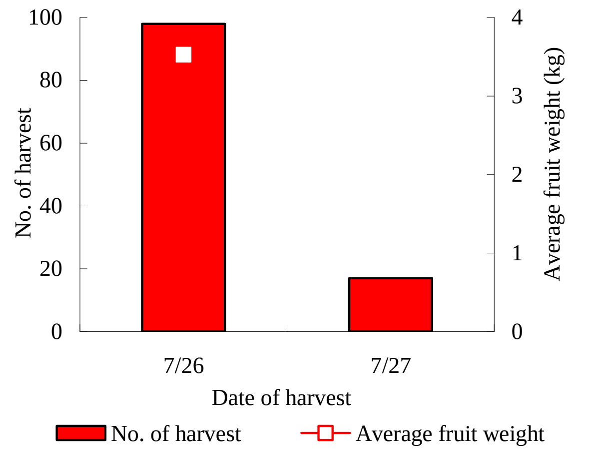

Figure 2.2-2 Harvest of Watermelon in Mathon

* Deficit data for average fruit weight on 7/27

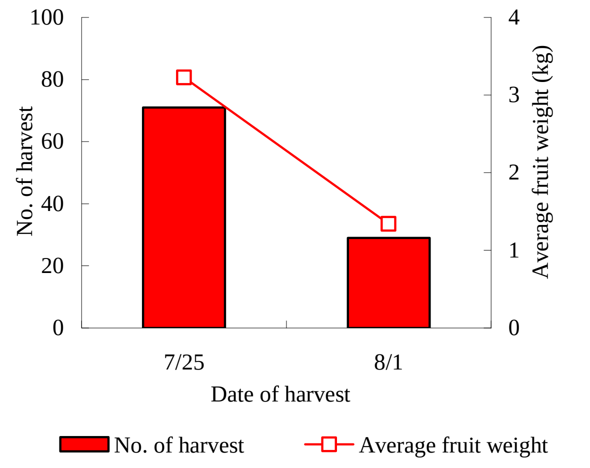

Figure 2.2-3 Harvest of Watermelon in Makatick

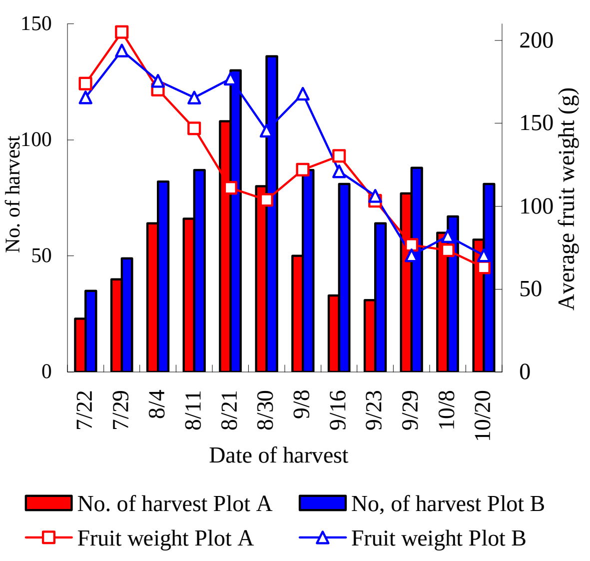

Figure 2.2-4 Harvest of Eggplant in Mathon

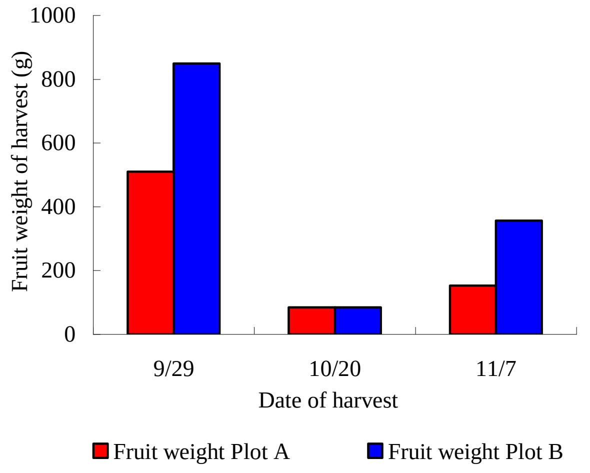

Figure 2.2-5 Harvest of Pepper in Makatick

Results of the yield survey are shown in Table 2.2-4.

Table 2.2-4 Results of the yield survey

Village	Item	Plot ※1	Sowing date	Trans-planting date	No. of Trans-planted	Harvested from	Target yield ※2 Standard yield	Actual yield Number of fruit	Weight (kg)
Makatick	Pepper	A	6/2	7/1	120	9/29	150kg	457	0.8
		B	6/2	7/1	120	9/29	150kg	786	1.3
	Watermelon		5/12	5/30	70	7/25	140 fruits	100	268.1
Mathon	Eggplant	A	5/13	6/10	98	7/22	150kg	689	81
		B	5/13	6/10	98	7/22	150kg	987	136
	Watermelon		5/13	5/31	70	7/26	140 fruits	115	345.5

※1 A: basal fertilizer application, B: basal＋ top dressing+field management

※2 watermelon: planned amout of bearing per fruit 2.5×0.8, pepper, eggplant: calculated by plot area from standard yield, i.e., 30t/ha

The following points, however, can be derived from the results.

(1) Pepper showed a low yield since it was annihilated by a severe attack of virus as well as a slow recovery from transplanting shock, which prolonged the start of harvesting despite all measures being taken such as the control of vector insects at the nursery stage, top dressing, thinning and so on. There was no difference between Plots A and B.

(2) Although the watermelons were exposed to a severe attack of Melonfly, further damage could be controlled since dissolved Furadan was spread all over the surface of the ovaries during flowering or 3 to 5 days after that at the latest. Through this means the lowest level of yield was obtained. Fruit rotting due to sunburn occurred at both sites, especially in Makatick where almost 1/3 of the total number of fruits were disposed of due to this physiological damage. Control of Melonfly is the key issue in watermelon cultivation in Kambia district. 100 fruits were harvested in Makatick, where it was possible to get rid of either the Melonfly attack or fruit rotting caused by sunburn while a few more fruits (115 fruits) were produced in Mathon. This difference is presumed to be due to the difference in the occurrence of fruit rotting caused by the difference in weather conditions, especially the difference in precipitation and fluctuations in the temperature after rain between the two sites.

(3) Eggplant production also gave a stable yield in this trial following from the previous trial. Although slight damage due to diseases and insects was observed during the planting period, these did not become so serious as to cause crucial damage to production. The most serious incident occurred at the nursery stage in which grasshoppers fed on and completely damaged whole seedlings. In the very short time of a few hours, almost half of the seedlings were missing from the nursery in Mathon. This problem was overcome by immediate spraying with insecticide.

There is a clear difference between Plot A and B in terms of the yield. Plot B showed a higher yield (135.5 kg), while Plot A produced only 80.6 kg and the difference is presumed to be derived from the effects of the neem insecticide, thinning out and top dressing. A very clear difference could be observed even in the growth as well as the yield. The effects of thinning out and top dressing were also confirmed on the eggplant in the previous trial.

(4) Neem water (liquid extract of the neem kernel using lukewarm water), neem seed husk chips (ground neem seed husks) and neem powder (ground neem kernel) were applied to the pepper and eggplant. Neem water was found to be unsuitable in the rainy season since neem is easily washed away by the rain. However, the effects of pest control using neem powder were obvious in that aphids and grasshoppers were not found in Plot B while they were observed in Plot A. Although, the use of neem was not able to exterminate insects to the same extent as the use of chemical pesticides, a certain effect was confirmed.

(5) From the lessons learnt from first trial, a memorandum of understanding (MOU) was concluded between the women's group and the Project for 2008 in order to thoroughly understand the purpose and policy of the PT and to clarify the roles of each party. Many women thus participated in the activities without difficulty.

The results of the sales are shown in Table 2.2-5, Figure 2.2-5, and 2.2-6.

Table 2.2-5 Sales of the Watermelon

		Makatick	Mathon
Total yield		100	115
Fruit size	6kg class	0	2
	5kg class	4	6
	4kg class	9	4
	3kg class	60	79
	1-2kg class	27	7
	Unknown	0	17
Consumed or discarded		25	15
Target of sales		75	100
Total sales		Le 129,000	Le 120,700
Unit price	4-5kg	Le 2,500-3,000	Le 2,000-2500
	3kg	Le1,500-2,000	Le 1,500
	< 3kg	Le 700-1,000	Le 700-1,000
	in pieces	Le 100	Le 100

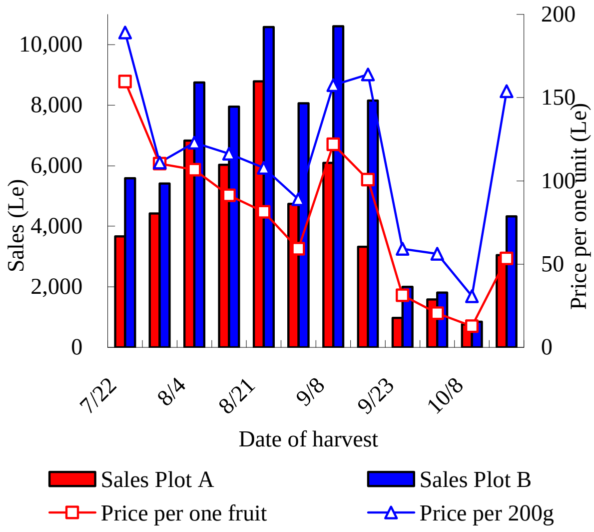

Figure 2.2-5 Sales of Eggplant in Mathon

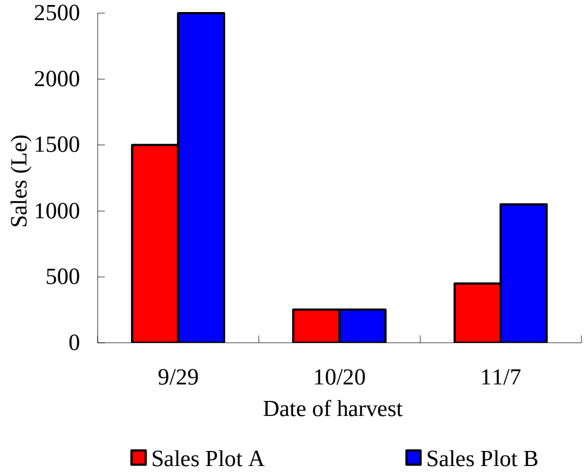

Figure 2.2-6 Sales of Pepper in Makatick

(1) Regarding the watermelon, the total yield was 100 fruits in Makatick and 115 fruits in Mathon. Out of these, 75 fruits in Makatick and 100 fruits in Mathon were sold in the Barmoi Luma market. Prior information was obtained that the unit price in Mange was Le 50,000 for 12 fruits in the beginning of December, i.e., the primary stage of shipping, and less than Le10,000 in the peak season. However, the unit price was lower than expected, such as Le129,000 for 75 fruits in Makatick and Le 120,700 for 100 fruits, due to a lack of demand. It was clear that the unit price in Mathon was lower than that in Makatick in spite of achieving the same price in marketing. Due to the damage to water-soaked fruit, the yield and sales of watermelon decreased by 20-30 %.

(2) The sales activity for the eggplant was conducted in the Pamalap market where they were sold to Guinean traders at 12 fruits each. The unit price varied from Le 13 to 160 for 1 fruit and Le 31 to 189 for 200 g (high quality size in Sierra Leone), but this was 3 to 40 times lower than the market in Kambia or Rokupr.

(3) The sales activity for the pepper was conducted in the Rokupr market at 1 buttercup each. 1 buttercup is about 170 g and the unit price was Le 500. Therefore, only Le 2,200 for Plot A and Le 3,800 for Plot B were gained, which cannot cover the production costs, such as for farming tools, seeds, fertilizer and insecticide.

Annex 3

Field Survey Report

Annex 3 Field Survey Report

3.1 Baseline Survey

3.1.1 Intr oduction

MAFFS Kambia District Office (MAFFS-K, hereafter), Rice Research Station at Rokupr (RRS-R, hereafter) and JICA jointly administered the Farm Management and Rural Socioeconomic Surveys (the Baseline Survey, hereafter). The Baseline Survey was executed over a one-month period from 12 July through 15 August, 2006 to elucidate the existing conditions of the agriculture and the rural areas in Kambia district and collect basic data by which to determine the sites and details of the pilot projects.

The Baseline Survey comprised two surveys that were conducted separately: the Village Information Survey and the Farm Household Survey. For the former 134 villages were selected in the seven chiefdoms, and the latter was carried out for 1995 farm households selected from those villages.

The focus of the Village Information Survey was to reveal the existing conditions of rural populations, socioeconomic infrastructure, farmers' organizations, and agricultural and livestock industries. On the other hand, the Farm Household Survey is mainly concerned with clarifying the existing conditions of crop production, farm management, post harvest, farm output utilization, marketing, credit, and livelihood activities.

The village information survey and household survey report are composed of the following categories.

Village information	Household survey
(1) Demographic information	(1) General information on household
(2) Economy and infrastructure	(2) Crop cultivation
(3) Social aspect	(3) Crop husbandry - Lowland rice
(4) Health	(4) Crop husbandry - Upland crops
(5) Education	(5) Post harvest activities
(6) Environment protection	(6) Farm output utilization (2005)
(7) Agriculture	(7) Marketing - Rice
(8) Livestock	(8) Marketing - Upland crops (except rice)
	(9) Credit
	(10) Livelihood activity

3.1.2 Selection of Villages and Households

The number of households (HHs) in each chiefdom and that of villages in 7 chiefdoms had been set to 15 and 133, respectively: 1995 HHs in total in Kambia district. Villages were allocated into 7 chiefdoms proportionally to the total number of villages in each chiefdom: about 20% of the total number of villages in chiefdoms (Table 3.1-1). Villages were selected from all sections more or less proportionally to their size. However, when the survey proceeded, the total number of HHs in a village was less than 15 so that one village was added to supplement the shortage. Eventually, the total number of villages selected was 134. Refer Appendix 1 for the list of villages selected. The number of villages surveyed varied 12-29 per chiefdom.

Table 3.1-1 Number of villages surveyed a nd some d emographic information on Kambia

Chiefdom	(abbr.)	No. of villages surveyed	Total number of villages (a)	farms (b)	population (c)	Total area (km^2)	Population density (head/km^2)
Mambolo	Mam	12	64	4,792	33,825	261	130
Samu	Samu	29	145	7,267	56,857	515	110
Gbinleh Dixing	G.D.	18	95	2,174	19,569	186	105
Magbema	Mag	17	91	8,586	67,125	424	158
Masungbala	Mas	18	92	3,725	28,502	175	163
Tonko Limba	T.L.	25	131	4,970	39,106	847	46
Bramaia	Bram	15	79	3,585	25,392	606	42
Total or mean		134	697	35,099	270,376	3,013	90

a) Survey by the Farmers' Field School in 2004.
b) 2004 census: Agricultural Activities by Household.xls.
c) Sierra Leone 2004 Population, Housing Census - Statistics Sierra Leone.

Village Information was collected by interviewing several representative persons in villages. Major informants were village (or town) chiefs, elders and religious leaders: a sizable number of farmers provided information too (Table 3.1-2).

Table 3.1-2 Title and the number of informants in the survey o f village information

Title	no.
Town or village chief (b)	126
Section chief (b)	29
Councilor and chairman	15
Elder and tribal authority	124
Chair lady	21
Youth leader	15
Imam (c)	53
Pastor	9
Teacher	26
Others (d)	90
sum	508

a) Average number of informants = 3.8 person/village
b) Included assistant chief, etc.
c) Included 2nd and assistant imam
d) Farmers, care taker, speaker, etc.

3.2 Preliminary observation on nutrient status of soils and crops in various agro-ecologies of Kambia district, Sierra Leone

To evaluate soil fertility in Kambia district, soils and plants were collected from crop fields in various agro-ecologies. Chemical analyses show that many nutrients were widely low, being even below the critical deficiency level in several soils. General nutrient status was better in uplands than in inland valley swamps (IVSs) and bolilands, although soil fertility in the latter two varied greatly. The relationship opposes the observation in other regions of the world, probably due to high rainfall and continuous leaching of nutrients in IVSs by high rainfall and relatively short, steep rivers in the Kambia district. Rice plants likely suffered from salinity injury in some mangrove swamps. Yet, no single, common nutrient responsible for low rice yield was identified: i.e., nutrient status was site-specific. Further detailed analyses are prerequisite to find the real cause of prevailing low yield in the area.

3.2.1 Introduction (background information)

West Africa stands on the basement complex formed in Precambrian era and the landscape is shield-shaped owing to alternate erosion and sedimentation for millions of years. Climate of Sierra Leone belongs to wet tropics (annual rainfall: 2,000-3,500 mm). The soils are mainly Ferralsols (Oxisols), which are highly weathered and are poor in soil nutrients as a result of continuous leaching. Tropical rain forest once covered the whole country, but the remaining virgin forest is few at present: man-made secondary forest caused mainly by a slash-and-burn shifting agriculture prevails.

Farmers in Sierra Leone grow rice, their staple food, for several-hundred years, in various agro-ecologies: i.e., mangrove swamp, boliland, riverain, inland valley swamp (IVS) and upland. A hinterland of mangrove swamp is categorized as associated mangrove swamp. In Kambia district, all agro-ecologies except riverain exist, and are widely used for subsistence agriculture.

The baseline survey (information collected by interviewing farmers) shows that the average grain yield of rice (rough or husk rice) in Kambia district is extremely low: 0.4 ton/ha on average, ranging from 0.1 to 1.0 ton/ha. What factor will be most responsible for it? Temperature and water supply will not be a limiting factor to plant growth owing to the wet tropical climate. Solar radiation is low due to high rainfall and prolonged cloudy days during the rainy season, the main rice growing period. It is, however, high (i.e., 180-220 cal cm^{-2} d^{-1} from July to November) (Ojo, 1977) enough to produce 5-6 ton/ha of rice yield based on our experiences in other parts of West Africa, Asia and South America. From our observation in farmers' fields, the number of plants for each unit field area is kept fairly sufficient (i.e., 20-25 hill/m^2), weeds are relatively well controlled, and infestation or damages by diseases, insect pests, birds and animals are unlikely to contribute to the substantial yield loss. Farmers grow various traditional and improved modern cultivars (varieties), often depending upon seed availability. Cultivar selection is crucial to produce a yield level of 5-6 ton/ha or higher, but it holds less importance at a yield level of 1-2 ton/ha or lower. In other words, any cultivar would produce such yields as far as crop management is proper. In respect to cultivar, an exception will be a selection of suitable cultivars of which culm elongation trait fits to the flooding depth (e.g., floating rice).

Based on these information and observations, soil fertility might be one of the important factors responsible for the present low yields. To ascertain this assumption, soil and plant samples were collected and their chemical properties were analyzed.

3.2.2 Collection of soil and plant samples

Soil samples (0-15 cm) were collected in various agro-ecologies from all over the Kambia district from May to December, 2006 (Table 3.2-1 and Figure 3.2-1). The number of samples was 37 in total: 7 from mangrove swamps, 4 from associated mangrove swamps, 10 from bolilands, 9 from IVSs, and 7 from uplands.

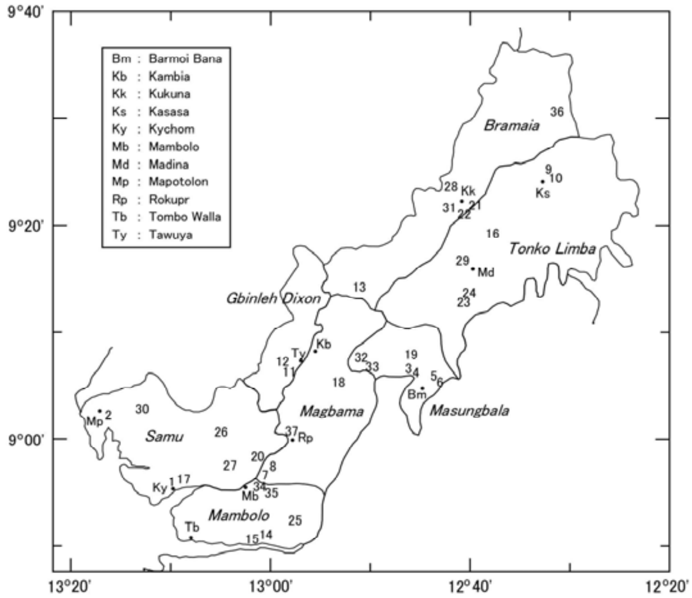

Figure 3.2-1 Sampling sites of soils in Kambia district

Total number of 13 plant samples was collected (Table 3.2-2): 9 from rice (3 from mangrove swamps and associated mangrove swamps, 1 from boliland and 5 from IVSs during ripening stage), 2 from cassava, 1 from fonio (funde millet), and 1 from pepper. Leaf-blades of upper 2-3 leaves in rice, upper 4-5 leaves in cassava and pepper, and the above-ground plant parts in fonio were taken.

Note that agro-ecologies are according to the identification made by the staff of MAFS-K and villgers. An agro-ecology at Robat (No. 37) had been defined as riverain, but it was corrected to associated mangrove swamp based on our observation of physio-graphical characteristics and vegetation.

3.2.3 Results of routine chemical analyses

(1) Soil

1) Concentrations of various cations, total C, total N, etc. were larger in uplands than in IVSs and bolilands (Table 3.2-3 and Figure 3.2-2) (Note 1). Great amount of organic matter was accumulated (being larger in total C and total N) (Note 2) in many mangrove swamps (Figure 3.2-2) (Note 3). Available P, and concentrations of Zn and Mn too, were low, being nearly to induce deficiency symptoms, in many soils of various agro-ecologies.

   As for bolilands and IVSs, nutrient status varied greatly among locations, probably due to the difference in soil texture (e.g., sandy, clayey and peaty) and geographical features. Exchangeable cations and the cation saturation percentage were low, and their levels were as low as inducing K deficiency in several soils. Although the dimensional size of boliland and IVS largely differs (e.g., several tens to thousands ha in the former and several to tens ha in the latter), their chemical properties were similar to each other.

Table 3.2-1 Brief description of sampling sites of soils

Soil no.	Date (2007)	Place	Ecology class	Note	Plot (crops, etc.)
01	6/01	Kychom	Mangrv-ass		
02	6/01	Mopotolon	Mangrv-ass		
03	6/02	Mafari	Upland	nearby west end of village	low fertility
04	6/02	Mafari	Upland	nearby west end of village	high fertility
05	6/02	Rolal Beneh	Boliland	near to Roobeneh village	Upper site
06	6/02	Rolal Beneh	Boliland	near to Roobeneh village	Lower site
07	6/05	Gbonko Maria	Mangrv. sw.	W of village	
08	6/05	Katakira	Mangrv. sw.	a part of 100 ha nursery	higher portion
09	6/06	Banekeh Boli	Boliland	Lower site	glassland (1 m tall)
10	6/06	Banekeh Boli	Boliland	Upper site	glassland (20 cm)
11	6/06	Matenbe boli	Boliland	Lower site	
12	6/06	Matenbe boli	Boliland	Upper site	
13	7/13	Laminaia	IVS	Konia swamp	
14	7/15	Rotenbana	Mangrv. sw.		Rice
15	7/16	Robali	Mangrv. sw.	not blackish	Rice
16	7/19	Kolonkuray	Boliland	Kondo boli	
17	7/23	Kassire	Mangrv. sw.		kireh-kireh
18	7/26	Mayainkain	Upland	hilly slope	upland rice
19	7/29	Ro-Nonko	Upland	hilly slope	upland rice
20	7/30	Rosinor	Boliland	Yampumorie boli	early rice
21	7/31	Karawani	IVS		rice
22	7/31	Karawani	Upland	hilly slope	upland rice
23	8/02	Bassia	IVS		
24	8/02	Bassia	Upland	hilly slope (5-10 deg.)	Funde
25	8/03	Masira	IVS	Upper site	
26	8/06	Makaliso, E	IVS	Makoti swamp	cassava mound
27	8/06	Koya	Mangrv-ass		
28	11/16	Teneba Bramaia	Boliland		Rice
29	11/16	Kamathorthor	IVS	Badina IVS	Rice
30	11/30	Surobulomia	IVS	dry swamp	Pepper
31	12/01	Sabuya	IVS	Kraigiri swamp (IVS)	Rice
32	12/02	Kawula	IVS	Bairo area (upper site)	Cassava
33	12/02	Kawula	IVS	Kumandi-Gbanker	Rice
34	12/11	Makhot	Mangrv. sw.	no fertilizer)	Rice
35	12/11	Makhot	Mangrv. sw.	+Fertilizer by Kobia	Rice
36	12/14	Kufuru	Boliland		Rice
37	12/15	Robat	Mangrv-ass		Rice

Mangrv. sw.; mangrove swamp: Mangrv-ass: associated mangrove swamp;
IVS: inland valley swamp;

Table 3.2-2 Element concentration of plant samples

Plant no.	Corres. soil no.	Crop	Ecology class	Growth stage	N (g/kg)	P (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	cr.Si (g/kg)	Na (mg/kg)
04	14	Rice	Mangrv. sw.	Havesting	8	0.7	11	2.7	0.3	282	143	10	1.4	82	26
17	34	Rice	Mangrv. sw.	Late ripening	17	1.4	11	1.7	2.0	141	168	17	1.4	45	186
20	37	Rice	Mangrv-ass	Harvesting	9	0.4	7	7.2	0.9	146	474	17	1.3	60	24
11	28	Rice	Boliland	Early ripening	30	1.2	17	2.2	1.2	86	244	15	3.7	46	9
12	29	Rice	IVS	Late ripening	17	0.9	44	5.9	2.3	93	113	20	1.4	37	289
14	31	Rice	IVS	Shortly after flow.	13	0.6	9	9.3	1.1	87	230	19	2.0	28	15
16	33	Rice	IVS	Mid ripening	9	0.5	11	4.5	0.9	121	222	16	1.5	65	21
21	-	Rice	IVS	Mid ripening	16	0.8	4	13.6	3.0	296	384	26	2.2	63	407
22	13	Rice	IVS	Late ripening	11	0.8	8	4.7	0.4	435	341	18	3.2	47	44
10	26	Cassava	IVS	10-month old	42	2.1	17	2.5	2.7	76	125	27	5.0	1	25
15	32	Cassava	Upland	1-year old	36	2.2	12	3.9	4.0	146	207	43	4.4	1	18
09	24	Fonio	Upland	Mid ripening	8	1.2	24	3.6	2.3	50	140	16	3.3	7	46
13	30	Pepper	IVS	Veget. growth st.	64	3.6	6	3.7	2.6	196	397	131	6.4	5	53

Corres. soil no.: corresponding soil number; flow: flowering; Veget. growth st.: vegetative growth stage; Cr.Si: crude silica; Mangrv. sw.; mangrove swamp: Mangrv-ass: associated mangrove swamp; IVS: inland valley swamp;

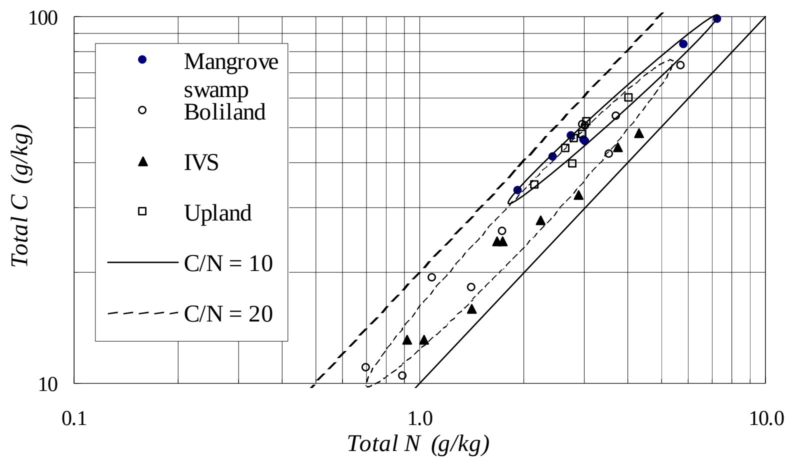

Figure 3.2-2 Relationship between total C and total N in various agro-ecologies

In many upland soils, gravels (the diameter larger than 2 mm) were so large in quantity (note 4) that the concentration of nutrients would be practically a half or less of the value presented in Table 3.2-3 (the data based on pure soils, being 2 mm or smaller particles).

In IVSs, iron toxicity was said to be widely distributed (RRSR Annual Report). Yet, it was not confirmed how serious it was (except plant nos. 04, 21 and 22), because the analytical items made so far were not sufficient to do it. Nevertheless, the result shows that the toxicity would be possible in the soils of low reducible Mn and CEC and of high total C (e.g., nos. 13, 23, 33, etc.), because these traits are commonly associated with the Fe toxicity.

2) As for mangrove swamps, the samples were taken while rice was growing: the time of least sea water intrusion. Yet, some soils (i.e., nos. 07, 15, 17 and 27) were high in cation concentration and electrical conductivity (EC, 1:5), which would induce salt damage to rice. All soils high in salt concentration were found along the Great Scarcies River and west of

Robali (soil no. 15) along the Little Scarcies River, even though the latter are said to be free from brackish water.

EC, carbon concentration, exchangeable cations, etc. were lower in associated mangrove swamps than in mangrove swamps, as an average value. It will be, however, practically hard to distinguish each other, because the maximum value was similar among them and rainfall would differ year to year.

Note 1)

Concentrations of organic matter and cations were larger in many soils in uplands than in IVSs in Kambia, Sierra Leone. This relationship opposes the observations in many other regions of the world, including other West African countries (i.e., Ghana, Cote d'Ivoire, Burkina Faso, etc). In general, nutrients in uplands leach out, and thus, soil fertility is higher in lower side than in the upper side. Reasons for such a discrepancy could be that (i) nutrients are leaching even in lowlands, because water are constantly flowing due to abundant rainfall and relatively short, steep rivers in Kambia, without water control, and (ii) fairly favorable condition of nutrient status in uplands is anyhow maintained with 7-10 years fallow period; yet, the sustainability of the latter is unknown.

Possibility of continuous water flow in the lowlands (IVSs) contradicts the fact that Fe toxicity is common in IVSs: the toxicity is often accompanied with ill-drainage. Therefore, we should find what is happening there and what the real cause is.

Note 2)

Organic-C concentration (measured with the Tyurin method) was about 90% (82-113%) of the total-C concentration (measured with the combustion method). Hence, the majority of total-C can be considered to be an organic matter.

Note 3)

Organic matter (or total C) is high in mangrove swamp, because the soils are kept under submerged condition for a prolonged period. Its concentration in Kambia district (total C: 30-100 mg/kg) is yet far higher than that in continental-type deltas (e.g., Mekong delta, 20-40 g/kg organic C). The situation in Kambia could be reflected with small rate of sedimentation owing to relatively short river.

Note 4)

Soil sampling itself was difficult especially when the amount of gravels was large: being hard in digging and in taking a proportional mixture of soils and gravels; besides, uneven distribution of gravelly patches in fields. At the same time, it was impressive to see a relatively good growth of crops on such gravelly soils.

Table 3.2-3 Some chemical and physical properties of soils in Kambia district

		pH (H_2O)			ΔpH			EC (mS/m)		
	n	mean	min	max	mean	min	max	mean	min	max
Mangrv. sw.	7	4.8	3.5	6.0	-0.3	-0.5	-0.1	310	21	719
Mangrv-ass	4	4.4	3.3	5.1	-0.7	-1.5	-0.2	139	3	537
Boliland	10	5.1	4.2	5.7	-0.9	-1.4	-0.5	6	1	24
IVS	9	4.9	4.2	5.6	-0.8	-1.5	-0.3	4	1	7
Upland	7	5.6	5.2	5.9	-1.1	-1.2	-1.0	3	2	5

		Exch. Ca ($cmol_c$/kg)			Exch. Mg ($cmol_c$/kg)			Exch. Na ($cmol_c$/kg)		
	n	mean	min	max	mean	min	max	mean	min	max
Mangrv. sw.	7	4.9	0.7	7.9	8.5	0.2	19.4	10.6	0.2	28.6
Mangrv-ass	4	2.5	0.4	6.1	4.7	0.1	14.8	4.3	0.1	16.6
Boliland	10	1.5	0.4	5.4	0.6	0.1	2.1	0.1	0.0	0.3
IVS	9	1.1	0.3	2.4	0.3	0.1	0.7	0.1	0.0	0.3
Upland	7	4.6	2.2	8.2	1.2	0.6	1.8	0.0	0.0	0.1

		CEC ($cmol_c$/kg)			Base saturation (%)			PAC (g P/kg)		
	n	mean	min	max	mean	min	max	mean	min	max
Mangrv. sw.	7	25	9	37	104	6	160	6.7	3.3	12.8
Mangrv-ass	4	21	10	28	49	3	134	4.5	1.7	5.8
Boliland	10	19	5	35	15	7	33	3.6	0.4	9.1
IVS	9	13	4	34	16	3	34	1.8	0.6	3.8
Upland	7	14	11	18	43	18	58	3.6	2.5	4.1

		Hot wat. NH_4-N (mg/kg)			Hot wat. B (mg/kg)			Gravel (g/kg)		
	n	mean	min	max	mean	min	max	mean	min	max
Mangrv. sw.	7	106	63	162	7.7	2.4	13.2	3	0	19
Mangrv-ass	4	81	38	118	7.2	1.7	22.2	2	0	8
Boliland	10	71	47	100	1.8	1.2	3.0	6	0	22
IVS	9	78	47	103	1.5	1.2	2.3	8	0	16
Upland	7	83	68	111	1.9	1.7	2.3	1567	45	3936

Mangrv. sw.; mangrove swamp: Mangrv-ass: associated mangrove swamp; IVS: inland valley swamp;
ΔpH = pH(KCl) - pH(H_2O); EC: electro conductivity; CEC: cation exchange capacity;
PAC: phosphorus adsorption coefficient.; Exch.: exchageable; Hot wat.: hot water extractable.

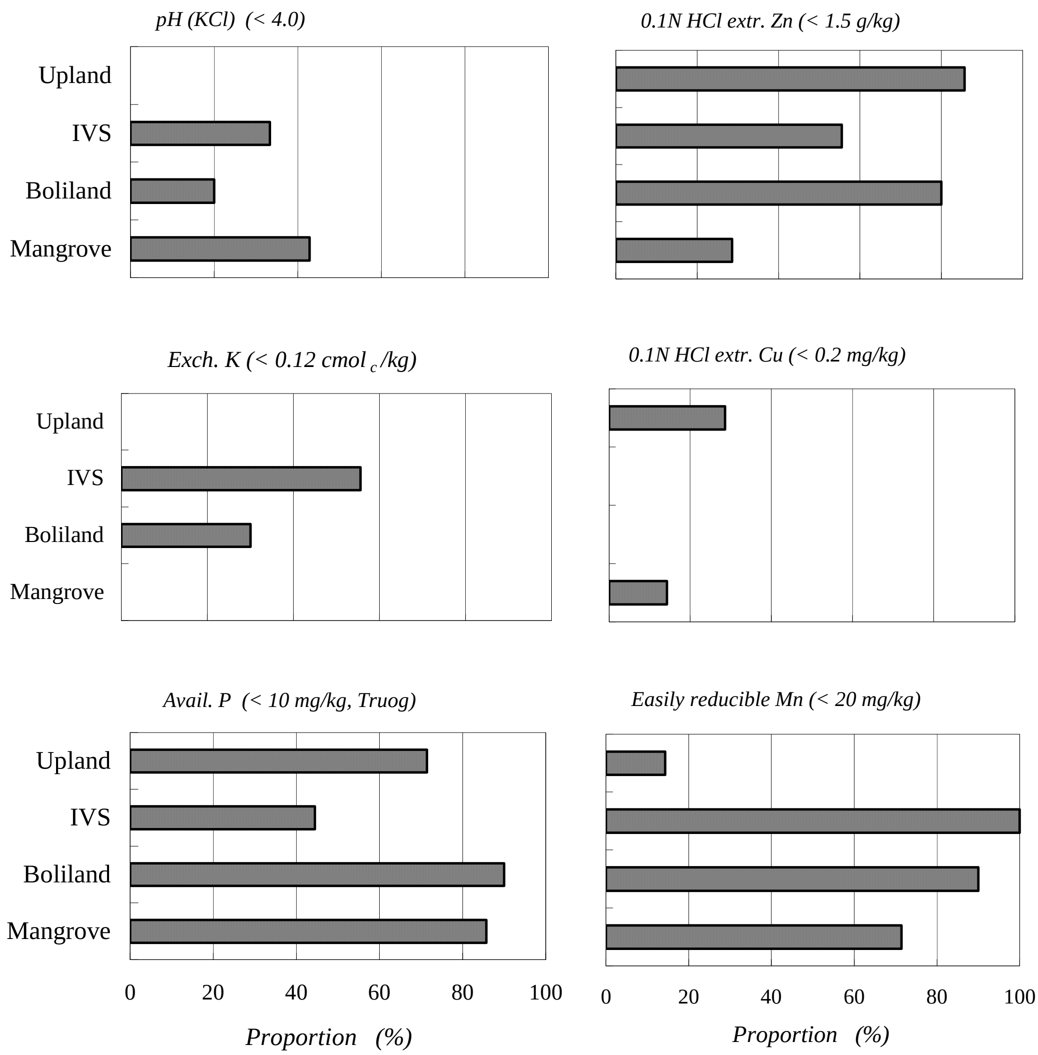

Figure 3.2-3 Proportion of soils of which nutrient concentration is lower than the critical level

(2) Plant

As for rice plants, N, P and K concentrations in many samples were below critical levels (e.g., about 10, 1 and 10 g/kg, respectively) (note 5), being similarly low in Mg, Zn, Cu and Si (the critical level is about 1 g/kg, 20 mg/kg, 2 mg/kg, and 50 g/kg, respectively) (Table 3.2-2). The low nutrient concentration in plants was derived from low soil fertility common in Kambia district and less fertilizer application under subsistence agricultural system.

No close relationship between corresponding soils and plants was found in any element (i.e., macro- and micro-nutrients). The result would be rooted on the general phenomenon that plants primarily adjust their growth (dry matter production) against poor nutrient availability so as to maintain element concentration to be constant as much as possible.

Fe concentration in rice plants was beyond the critical level (about 300 mg/kg) in some mangrove swamps, so that such plants would suffer from Fe excess. Those plants were found in soils with low level of easily reducible Mn.

Note 5)
For convenience (to make easier in understanding the analytical result for general readers), the critical concentrations for deficiency or excess level are presented in the text. Yet, readers should bear in mind that they are guidelines and such concentrations might vary with growth stages of plants, interaction between elements and environmental conditions.

3.2.4 Summary and tentative planning

(1) The project aims at building-up a technical package with which sustainable and reasonably high yield of rice could be obtained. The package is planned to extend to farmers through the extension system, and thus, input level should be low, being affordable to farmers. The low level of input helps also making high return of the cost by the law of diminishing returns to fertilizers.

Rice yield is now low as 0.4 ton/ha, far below the potential yield (i.e., 5-6 ton/ha) estimated from climatic conditions in Sierra Leone. Improvement of crop management solely would not enhance yields. An input of chemical fertilizers is inevitable to increase production, because soil fertility is low in general. Input levels vary depending upon social and economic conditions and also upon farmers' knowledge. The most economical quantity of chemical fertilizers and their efficient ways of application should be determined. To quantify them, routine chemical analyses of soils and plants were made. As mentioned above, many nutrients lack in soils, but no single nutrient that is responsible for low yield has been identified.

(2) The pilot project is now on-going. We are planning to analyze chemical properties of soils and plants there, and eventually we will establish a technical package by finding the limiting factor and by interpreting environmental and socio-economic conditions.

Additional chemical properties of the collected soils will be analyzed to find a limiting factor in each agro-ecology if time is spared. They are:

1) Soil

(a) Total S to identify acid sulfate soils in mangrove swamps (note 6)
(b) Al^{3+} and H^{+} to evaluate the effect of low pH
(c) Water soluble (1:5) cations and S concentration (SO_4-S and total S) to evaluate fertility levels
(d) Bray-2 P as available P for lowlands
(e) NaOAc Si
(f) Free Fe oxide and EDTA-Fe
(g) $CaCO_3$ to signify a quantitative relationship between total C and organic C
(g) Particle size distribution as a physical property

Note 6)

pH(H_2O_2) is widely and effectively adopted to identify possible acid sulfate soils at an initial stage. However, its value was low in several soils in uplands and bolilands, which are unlikely acid sulfate soils: such soils could be acid sulfate soils too. Potentially acid sulfate soils (mud clay) are defined to contain sulfidic materials; 7.5 g/kg or larger of S in the form of sulfides and $CaCO_3$ equivalent less than one-third of S concentration (Soil Taxonomy, USDA 1975).

2) Plant: Al and S

3.2.5 Future perspectives

A problem of Fe toxicity is presented as an example.

The additional analyses mentioned above can be made without technical difficulty because an analysis works on the dried soils; yet, time is definitely a problem.

Measurements of acidity (pH) and of free iron oxides (extraction with hydrosulfide-EDTA by the method of Asada and Kumada) on dried soils will help finding a part of causes. We face, however, some difficulties of identifying the real cause. First of all, no typical bronzing symptom (usual to Fe toxicity) has been found in fields. Hence, the occurrence is likely to interact with other factors. The approach to quantify such factors will be measurements of changes in Eh and ferrous iron in the fields plausible to Fe excess, and so on. These measurements request a suitable analytical facility nearby; at present, it could be RRSR.

Such a work is a sort of research matter, and the activity will conflict with the objectives of the current project: the extension or transfer of improved technology. In turn, the project would not fulfill the final goal if the real cause of prevailing low yields were not identified.

3.2.6 References

Ojo, O., The Climates of West Africa, Heinemann, London. pp.218, 1977

3.3 Agricultural machinery Survey

JPT-MAFFS-K conducted the survey to get the basic information on the agricultural machinery in Kambia district on December 2006.

3.3.1 Total number of agricultural machine in Kambia District

Total number of agricultural machine was 220 machines (Table 3.3-1). Number of rice huller at Mambolo, Samu and Masungbala where main rice production chiefdom in Kambia are, have 137 rice huller which is 87 % of total of 158 machine. Work oxen only worked at Mambolo.

Table 3.3-1 Type and Number of Agricultural Machine and Work Oxen

Chiefdom	Type of agricultural machine					
	Rice huller	Cassava grater	Power tiller	Rice thresher	Work oxen	Total
Mambolo	68	1	4		3	76
Samu	45		9			54
Giblet Dixon	4	4	5			13
Magbema	24	18	3			45
Masungbala	2	2				4
Tonko Limba	6	7	2	1		16
Bramaia	9	1	1	1		12
Total number	158	33	24	2	3	220
Mambolo	43	3	17	0	100	35
Samu	28	0	38	0	0	25
Gbinleh Dixon	3	12	21	0	0	6
Magbema	15	55	13	0	0	20
Masungbala	1	6	0	0	0	2
Tonko Limba	4	21	8	50	0	7
Bramaia	6	3	4	50	0	5
Total number	100	100	100	100	100	100

3.3.2 Introduced year of the surveyed machinery and work oxen

After 2002 when the civil war was ended, 92% of the rice hullers, 86 of the power tillers and 97 % of cassava grater were introduced (Table 3.2-2). The stability of the public peace after civil war and losses during the civil war were reflected at the time of the introduction of the machine.

Table 3.3-2 Year of Introduction of Agricultural Machinery and Work Oxen

Introduced year	Type of agricultural machine						
	Rice huller	Cassava grater	Power tiller	Rice thresher	Work oxen	Total	(%)
Before 2000	6		2			8	4
2001	7	1	1			9	4
2002	8	1	2	2		13	6
2003	25	4	1		2	32	15
2004	27	9	2			38	18
2005	67	17	13		1	98	45
2006	17	1				18	8
Total	157	33	21	2	3	216	100

3.3.3 M ode of introduction

Purchased machinery totals 134, accounting for 61% of the surveyed total, followed by donated machinery with 55, and loaned with 22 (Table 3.3-3). Out of 152 rice hullers surveyed, purchased number was 113, 74% of the total. On the other hand, half of the introduced rice thresher, power tiller and cassava grater were by donation.

Table 3.3-3 Mode of Introduction of Agricultural Machinery Surveyed

Type	Mode of introduction						
	Donation	Loan	Cost sharing	Lease	Purchase	Exchange	Total
Rice huller	23	15	0	0	113	1	152
Cassava grater	16	3	0	0	14	0	33
Power tiller	12	1	2	1	3	5	24
Rice thresher	4	1	0	0	3	0	8
Work oxen	0	2	0	0	1	0	3
Grand total	55	22	2	1	134	6	220

3.3.4 Owner of the Machine and Work Oxen

Out of 220 surveyed, 68% or 149 were privately owned, while 34% or 71 were group or community owned. Some 78% of rice hullers surveyed are privately owned. All of the work oxen are privately owned. On the contrary, majority of surveyed thresher, power tiller and cassava graters are group/community owned.

Table 3.3-4 Owner of the Machine and Work Oxen

Type of machinery/oxen	Owner		Total
	Private	Group/community	
Rice huller	118	34	152
Cassava grater	12	21	33
Power tiller	5	19	24
Thresher	2	6	8
Work oxen	3	0	3
Grand total	149	71	220
Percentage (%)			
Rice huller	78	22	100
Cassava grater	36	64	100
Power tiller	21	79	100
Thresher	25	75	100
Work oxen	100	0	100
Grand total	68	32	100

3.3.5 Operation Condition of Agricultural Machinery by Owner and Type

Of the total surveyed, 74% or 162 are operational, and remaining 26% or 58 are not operational. Over 80% of the privately owned machinery surveyed is operational, while less than 60% of the communally owned machinery is operational. It should be noted that more than half of the power tiller surveyed were not operational.

Table 3.3-5 Operation Condition of Agricultural Machinery by Owner and Type

Type	Owner						Total		
	Private			Group/community					
	Operational	Not operational	Total	Operational	Not operational	Total	Operational	Not operational	Total
Rice huller	104	23	127	14	11	25	118	34	152
Cassava grater	11	1	12	15	6	21	26	7	33
Power tiller	2	3	5	8	11	19	10	14	24
Thresher	1	1	2	4	2	6	5	3	8
Work oxen	3	0	3	0	0	0	3	0	3
Grand total	121	28	149	41	30	71	162	58	220

3.3.6 Operation Period of Not Operational Agricultural Machinery

Average operation period of not operational agricultural machinery is: 11 months for thresher, 29 months for rice huller, 34 months for power tiller, and 24 months for cassava grater, respectively. Operation period is generally longer in privately owned machinery than in communally owned ones. While more than half of the privately owned machinery was operated more than two years, while more than 70% of the communally owned not operational machinery was operated for less than two years. Major constraints to repair and maintenance of the machinery include lack of spare parts and lack of technical know-how.

Table 3.3-6 Operation Period of Not Operational Agricultural Machinery

Type	Private					Group/community					Total				
	<1yr	1-2yr	2-3yr	>3yr	Ave. (m)	<1 yr	1-2 yr	2-3 yr	> 3yr	Ave. (m)	<1 yr	1-2 yr	2-3 yr	> 3yr	Ave. (m)
Rice huller	3	3	6	5	36	3	6	1	1	17	6	9	7	6	29
Cassava grater	0	0	1	0	32	1	1	0	1	21	1	1	1	1	24
Power tiller	0	0	0	3	87	2	6	1	2	19	2	6	1	5	34
Thresher	1	0	0	0	7	1	0	1	0	13	2	0	1	0	11
Total	4	3	7	8	-	7	13	3	4	-	11	16	10	12	-

Note: (m): Month

3.3.7 Agricultural Machinery to Which Training Has Been Conducted at Introduction

More than 70% of the machinery to which training has been done is operational (Table 3.3-5). Some 78% of the communally owned operational machinery were got trained, suggesting the particular importance of the training for those group.

Table 3.3-7 Agricultural Machinery to Which Training Has Been Conducted at Introduction

Type	Private			Group/community			Total		
	Opera-tional	Not opera-tional	Total	Opera-tional	Not opera-tional	Total	Opera-tional	Not opera-tional	Total
Rice huller	54	14	68	10	9	19	64	23	87
Cassava grater	6	1	7	11	3	14	17	4	21
Cassava grater	6	1	7	11	3	14	17	4	21
Thresher	0	1	1	4	0	4	4	1	5
Work oxen	3	0	3	0	0	0	3	0	3
Grand total	64	17	81	32	18	50	96	35	131
Rice huller	79	21	100	53	47	100	74	26	100
Cassava grater	86	14	100	79	21	100	81	19	100
Power tiller	50	50	100	54	46	100	53	47	100
Thresher	0	100	100	100	0	100	80	20	100
Work oxen	100	0	100				100	0	100
Grand total	79	21	100	64	36	100	73	27	100

3.3.8 Problems in Repairing and Maintenance of Rice Huller

The problems in repairing and maintenance of rice huller are lack of parts both for operational and not-operational machines. In addition, it seems that the machine was broken down by lack of information and techniques for maintenance and can not be repaired by lack of found to buy parts.

Table 3.3-8 Problems in repairing and maintenance of rice huller

Problems	Numbers		Total	Ratio (%)	
	Operational machines (117)	non-operational machine (37)		Operational	non-operational
Lack of parts	104	33	137	89	89
Lack of knowledge on machine repairing	61	26	87	52	70
Lack of fund for machine repairing and maintenance	26	18	44	22	49
Lack of knowledge on operation and maintenance	0	2	2	0	5
Others	8	7	15	7	19
Total	199	86	285	22	49

3.4 Post Harvest and Handling Survey

3.4.1 Survey on the current situation of post harvest and handling

The current situation of post harvest and handling in the pilot project villages were surveyed through interview with the model farmers and the chief of PP villages from 16 through 19 November, 2007. The interview was conducted by staff of PEMSD of MAFFS-K, using the questionnaire which had been prepared for the survey. The collected answers were inputted into computer for analysis. The results of the survey are summarized in the following.

(1) Harvesting

Harvesting period is identified mainly by grain color, except by leaf color at Macoth.

Harvesting knife is used to cut at about one third of the stem length from ground level.

Making small bundle with a part of cut stems and gathering as a small mount to dry in or surrounding rice field for two to seven days were common except sixty days at Robat.

(2) Threshing

After drying stems, they are commonly beaten by wood stick or treading and tramping on spread panicles over the leveled and cleaned ground, and beaten against a drum or broken mortar (Robennah) besides above two threshing method.

Threshed rice (with husk) is winnowed after drying for one to three hours in the field.

After winnowing, rice (with husk) is dried if necessary on the ground at their home.

(3) Rice hulling and milling

Hulling and milling of rice is done by two ways: by hand and by machine. Hulling and milling for self consumption is carried out by hand using pestle and mortar and for selling is mainly by machine.

Eighty percent of the rice brought to machine for hulling and milling are parboiled.

<u>Drying rice before hulling</u>

Rough rice or parboiled rice was dried by all farmers on the ground at their house, before hulling and milling by machine or by hand.

Drying duration was for one or two days and six to eight hours per day.

<u>Present situation on the utilization of machine for hulling and milling</u>

Three out of seven pilot project villages have a rice hulling-milling machine in their village. But these machines are not functioning well. Farmers living in the villages which do not have rice hulling-milling machine used to bring their rice to the nearest village which have the machine on foot, by bicycle, or by boat (Kunthai).

Table 3.4-1 Availability of a Rice Huller in the Pilot Project Village, its Working Condition, and the Nearest Village with the Machine

Pilot project village	Presence of rice hulling and milling machine in the village	Working condition of the machine	The nearest village with rice hulling-milling machine and its distance from the village	
			Name of village	Distance (km)
Macoth	Yes	Not functioning well	-	
Rosinor	Yes	Not functioning well	-	
Kunthai	No	-	Rokupr	24
Robat	Yes	Not functioning well		1
Robennah	No	-	Kawula	4
Kalintin	No	-	Kalintin	2
Sabuya	No	-	Kukuna	1

Rough rice or parboiled rice is used to pass through the machine twice, because husks are not able to be removed well after one pass as the machine is not running well.

The selling price of head rice is higher than that of broken rice.

More broken rice is produced from rough rice compared with parboiled rice.

Dryness of parboiled rice (with husk) is judged by a) biting the grain, b) by beating the grain using mortar and pestle, c) stepping the knee on the top of the grain.

Farmers understand the reasons why broken rice was produced through hulling-milling process. The reasons are in the following.

a) Caused by over drying (7 villages)

b) Caused by poor parboiling of rice (6 villages)

c) Caused by failure of drying before hulling-milling (6 villages)

d) Caused by inferior performance of the machine (2 villages)

(4) Storage

Dried rough rice (milled), parboiled rice (with husk) and parboiled rice (milled) are usually stored in bags and wooden box and they keep at the farmer’s bed room.

(5) Post-harvest Losses Estimated by Farmers in the Pilot Project Villages

According to the results of an interview survey, farmers estimate that most losses occur during the process of handling: from harvest to cleaning, as shown in Table 3.4-2. The table also shows main causes of the losses in each operation stage.

Table 3.4-2 Post-harvest Losses Estimated by Farmers in the Pilot Project Villages

Operation	Losses (%)	Main causes
(1) Handling of rice	**19.2**	
1) Cutting	3.2-16.7 (9.7)	Over dry, variety, and poor harvesting method
2) Drying of sheaves	0.8-6.8 (3.6)	Variety, poor harvesting method, pests, transportation, and lack of tarpaulin
3) Threshing	1.3-6.2 (3.0)	Variety, lack of tarpaulin
4) Cleaning	1.5-5.4 (2.9)	Lack of tarpaulin
(2) Processing of rice	**2.6**	
5) Parboiling	0	-
6) Milling	0.2-2.6 (1.5)	Over dry, transportation, rice huller operation
7) Cleaning	0.1-2.8 (1.1)	Lack of tarpaulin
(3) Storage	**0.7**	
8) Storage	0.1-1.3 (0.7)	Pests and poor storage facilities
Total losses	**22.5**	

Note: Losses are range of seven villages.

Calculation method of assumed post-harvest losses: The answers when farmers obtained the harvest of 10 bushels, how many bushels, tripence pan or cups were lost by each processing, was assumed to be a value of the harvest loss in their village. Then when loss at a work is calculating, that is, calculate losses at the previous losses are subtracted from a weight of the working at calculating. These values assumed to be the extent of losses of individual harvesting activities to the total losses.

From the above-mentioned results of the survey, the characteristics of post-harvest and handling in the pilot villages were as follows:

a. All post harvest practices except milling process were carried out by manpower.

b. Handling of rice was carried on the ground not on the tarpaulin, woven bamboo or palm leaf mats, except for cleaning after threshing and drying parboild rice, which were carried out on the tarpaulin.

c. It seems that farmers cannot buy the tarpaulin for drying by lack of found.

3.4.2 Present condition of the Rice huller survey

(1) Installation of Rice Huller and Initial Training

1) Initial training

Prior to the installation of rice huller, a two-days-training on operation and maintenance (O&M) of rice huller was conducted by FINIC at MAFFS-K on 29 and 30 November 2007 (Table 3.4-3). Objective of the training was to learn the technical basics on how to operate and maintain a rice huller properly. Participants were two model farmers from each of seven pilot project villages (14 farmers in total), the extension workers assigned to the pilot projects (FEWs, BESs and SMSs; 15 in total), and several engineers of the workshop at MAFFS-K.

Table 3.4-3 Date of Initial Training, Completion of the Shed Construction and Installation of the Rice Huller

Pilot Village	Training before installation	Completion of the shed construction	Installation of the rice huller
Macoth	29/11/07	17/12/07	21/02/08
Rosinor	29/11/07	02/02/08	19/02/08
Kunthai	29/11/07	26/01/08	18/02/08
Robat	29/11/07	24/12/07	20/02/08
Robennah	29/11/07	07/02/08	17/02/08
Kalintin	29/11/07	21/01/08	16/02/08
Sabuya	29/11/07	05/01/08	15/02/08

2) Follow up training

A follow up training was conducted from 15 to 21 February 2008 in each pilot village at the time of installation of rice huller. The objectives of the follow up training were to refresh the memory of farmers who participated in the initial training on O&M of rice huller, to get used to the milling operation, and to assess the talent of farmers on milling operation.

Training was conducted by Mr. Foday Kamara, president of FINIC and his two staff, focusing on more practical operation and regular maintenance of the machine.

(2) Some problems of the rice huller identified by the survey

After two times training, operators can operate the rice huller by themselves and farmers group is earning money by the machine. But, following problems observed by the survey (Table 3.4-4). All machine had problems had two problems or more.

All farmers groups have strongly requested to JPT to repair the machine properly and to train the operators for repairing method.

Table 3.4-4 Problems Observed Connected with the Operation of Engine and Rice Huller and their Cause

Problems identified	Cause
1) Problems on engine	
Roller does not discharge the rice at normal speed	a) Auger welded on roller worn out due to sustained use. b) Cylindrical Roller burst due to wear c) Belt slipping due to slackness d) Pulley spinning around the shaft due to broken key or key way e) Rice Discharge valve not accordingly opened f) Paper or plastic stuck in the neck of the hopper g) Rice leaking along the protrusion of the roller shaft
Rice escapes from sieve	a) Sieve Burst due to stone/metal in rice b) Wear due to sustained use c) Sieve not properly seated on its seat d) Wrong size of sieve fitted

Engine not aligned properly to the frame	a) Bolts holding machine to frame and engine slackened b) Milling machine pulley not in the correct position
The engine emitting too much black smoke	a) Engine overloaded b) Piston rings worn out c) Air cleaner blocked by either dirt or over tightening of cover d) Engine main bearings worn out and seizing the crankshaft e) Fuel filter stuck with dirt f) Injector nozzle worn out
Engine consumes engine oil	a) Piston rings worn out b) Sleeve worn out c) Leakage
Engine cannot start	a) Air in the fuel system b) Filter is dirty c) Water in the fuel system d) Engine governor faulty e) Injector clogged with carbon f) Engine lacks compression g) Fuel tap closed

2) Problems on Huller

Roller worn out	
Hulling blades worn out	
Bearings worn out	
Rice discharging through the shaft bushing	Space between shaft and cover for chamber
Rice coming out without being milled properly	a) Milling blade worn out b) Milling blade wrongly adjusted making gap between auger and blade too big c) Auger worn out d) Discharge and feed valve not opened correctly accordingly e) Rice does not fully fill the milling chamber
Too much rice broken while milling	a) Rice too dry b) Rice too soak/wet c) Adjustable Milling blade too close to milling auger
Rice too difficult to mill	a) Rice is rubber like due to more moisture content particularly for parboil rice
Unusual noise in the milling chamber while milling	a) A piece of metal or stone in the milling chamber b) Milling auger too close to the milling blade which makes the two to rub and cause noise c) Rice sieves not properly sited d) Milling machine bearings worn out
Engine lazy while milling	a) Fuel finishing in the tank b) Fuel filter clog with dirt c) Water in the fuel d) Piston rings worn out e) Sleeve worn out f) Fuel tap not fully opened

Based on the diagnosis of the above problems, the final training to the operators was carried out from 6 December to 12 December, 2008.

(3) Management of the Rice Huller Operation

Rice hullers have been operated since installation except that at Kalintin where the basement for rice huller was broken because of poor mixture of cement.

Days operated of rice huller are 10 day at Rosinor to 75 day at Kunthai (Table 3.4-5).   The Difference in the days operated of rice huller is du to difference in the breakage of the machine and the amount of rice for hulling by overlapping the installation period and harvesting period.

Farmers groups use the income for purchasing the fuel, repair parts lubricant for maintenance of the machine.

Table 3.4-5 Summary of the Operation of Rice Huller

Pilot village	Days operated	Account book	Service charge (Le)		Usage of Service Charge					Amount of saving * (Le)
			Kind (cups/bushel)	Le/Bushel	Fuel	Repair	Lubricant	Saving	Others	
Macoth	50	yes	-	2,500	X	X	X	X	Hire labor in farming	235,100
Rosinor	10	yes		2,000	X		X	X	-	100,000
Kunthai IVS	52	yes	5	2,500	X	X	X	X	-	900,000 700,000
Kunthai Upland										200,000 300,000
Robat	75	yes	-	2,000	X	X	X	X	-	200,000
Robennah	14	yes	8	4,000	X	X	X	X	-	100,000
Kalintin	Nil	No	-	-	-	-	-	-	-	-
Sabuya	47	yes	-	4,400	X		X	X	-	100,000

Note: Since the installation to Middle of October, 2009

* Column above is cash at hand and column below is bank deposit at Kunthai.

Farmers groups except at Kalintin have some amount of cash at hand and have bank deposit at Kunthai.   Micro-credit has been started for the SMS's guidance by framers group of upland rice at Kunthai.

3.5 Market Survey

3.5.1 Overview

The Market Survey was conceived for lack of available data and information on crops' distribution and market prices. The purposes of the survey are twofold:

1) To record seasonal changes in crops market prices through observation of the annual price fluctuations of crops produced in Kambia district including cereals and vegetables focusing on rice
2) To examine the possibility and ramifications of shipping crops by the farmers themselves taking into account their retail prices between the times when crops' supply is high after harvest and when it is lower.

As planned, the survey has been conducted at the four main markets in Kambia district, namely, Barmori Luma Market, Rokupr Market, Kambia I and II Market, and Madina Market as well as at nearby farmers. The main subjects for observation in the survey are agro-products, cereals and vegetables in particular, including rice (both imported and local), maize, millet (fundi), sorghum, beans, groundnuts, cassava (tuber and gari), potatoes, ginger, tomatoes, onions, palm oil, etc. Further, production materials such as seed rice and fertilizer have also been investigated.

The initial phase of the survey commenced in February and ended in April 2007. Based on the preliminary analysis of the data and information obtained in the phase, the survey schedule for the second phase was slightly modified. The second phase that started in May 2007 is currently underway.

As of September 2007, the fluctuations of not only retail prices but also wholesale prices started to be investigated in the Market Survey. Moreover, it is planned to start an additional distribution survey, which encompasses producer prices and sales destinations, in November when harvest starts in earnest.

3.5.2 Trend of retail price of rice

The Market Survey was conducted from February 2007 through January 2008. The characteristics of the retail price fluctuations of those crops are described below. The data by crop are presented from Tables 3.4-1 to 3.4-6. There are those months for which no data is presented. It is because the respective crops were not supplied to the markets in the months and thus their retail prices could not be recorded. Also, the prices for April are estimated values.

3.5.3 Fluctuation of retail price

(1) Rice

In Kambia district, rice is distributed mainly in three forms: parboiled rice, imported rice and milled rice (rough rice). Parboiled rice and imported rice are supplied to the markets all through the year. Rough rice appears at the markets right after harvest but almost none is distributed during the rainy season. The retail price of rice increases during the changeover period from July through October and decreases from November through March. For popular parboiled rice, the retail price is in the range of Le 1,350-1,500/kg at the lowest to Le 2,400-2,800/kg at the highest with about Le 2,000/kg at the middle.

Table 3.5-1 Fluctuation of retail price: Rice

Madina (Le/kg)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Imported	2,000	1,603	1,600	1,700	1,800	1,600	2,000	2,000	2,000	2,000	2,000	2,000
Parboiled	1,800	1,688	1,817	1,900	2,000	1,800	2,000	2,300	2,200	2,000	1,600	1,700
Milled rough	2,100	1,600	-	-	-	-	-	-	-	-	1,800	1,800

Kambia II (Le/kg)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Imported	2,000	1,571	1,600	1,600	1,600	1,700	1,800	1,800	2,000	2,000	1,900	2,000
Parboiled	1,800	1,571	1,600	1,550	1,500	2,000	2,400	2,400	2,400	2,400	1,800	1,800
Milled rough	2,200	2,000	2,000	-	2,000	-	-	-	-	2,400	2,200	2,200

Rokupr (Le/kg)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Imported	1,900	1,400	1,400	1,500	1,600	1,400	1,700	2,000	2,000	2,000	2,100	2,050
Parboiled	1,600	1,367	1,333	1,500	1,800	1,333	2,400	2,600	2,800	2,400	1,700	2,000
Milled rough	2,100	1,800	1,800	-	2,000	1,800	-	-	-	-	2,000	2,000

Barmoi Luma (Le/kg)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Imported	2,000	1,477	927	-	-	-	1,800	1,800	2,000	1,900	1,900	1,900
Parboiled	1,800	1,477	1,756	1,700	1,600	1,467	1,400	2,400	2,400	2,400	1,800	1,800
Milled rough	2,200	833	739	-	1,800	1,900	-	-	-	-	2,000	1,900

(2) Cassava, potato, foofoo (cassava paste), and cassava gari

Cassava, potato, foofoo, and cassava gari are generally regarded as substitute food for rice, which is the staple food. The retail price of cassava is Le 400-600/kg on average per year and it tends to increase from August to October when the supply of rice becomes scant. The price of potato, on the other hand, is several times as much with much greater fluctuation over time. Cassava gari, a processed product of cassava, sells at higher retail prices for Le 1,200-1,500/kg on average throughout the year.

Table 3.5-2 Fluctuation of Retail Price: Tuber crops and their processed products

Madina Le/kg

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Cassava	402	-	-	-	-	-	314	769	774	499	227	402
Cassava gari	1,273	1,111	1,320	-	1,250	1,250	1,625	1,500	1,500	1,500	1,500	1,273
Foofoo	716	200	400	-	-	400	834	700	833	333	292	716
Potato	-	-	2,396	-	2,000	1,538	-	-	-	-	-	-

Kambia II Le/kg

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Cassava	507	473	498	-	-	-	501	488	1,000	470	478	507
Cassava gari	1,125	1,036	1,000	-	1,000	1,250	1,500	1,500	1,500	1,500	1,250	1,125
Foofoo	1,000	1,000	1,000	-	-	1,000	600	1,000	1,000	1,000	1,000	1,000
Potato	2,857	4,444	3,204	-	1,735	1,909	8,000	5,278	4,000	-	3,095	2,857

Rokupr Le/kg

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Cassava	1,071	-	-	-	-	-	556	556	643	591	952	1,071
Cassava gari	1,000	700	758	-	1,000	758	1,950	1,500	1,250	1,250	1,125	1,000
Foofoo	500	773	1,006	-	500	1,006	1,917	500	667	500	417	500
Potato	1,667	-	-	-	2,500	-	-	-	2,084	1,834	1,667	1,667

Barmoi Luma Le/kg

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Cassava	238	405	551	-	-	298	375	413	1,000	488	480	238
Cassava gari	1,000	-	-	-	-	-	1,250	1,485	1,250	1,250	1,250	1,000
Foofoo	1,603	-	-	-	-	-	541	3,200	-	3,333	3,333	1,548
Potato	2857	-	-	-	-	-	7,143	3,846	3,333	3,333	4,229	2857

(3) Leaf vegetables

Of the leaf vegetables, cassava leaves, potato leaves and krainkrain, krainkrain has the highest retail price at Le 1,000/kg on average a year except at Madina Market. Since Madina Market is distinctively a producers' market, the retail prices of leaf vegetables tend to be relatively low compared to markets located within a city area such as Kambia II.

Table 3.5-3 Fluctuation of Retail Price: Leaf vegetables and ginger

Madina — Le/kg

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ginger	2,023	1,267	800	-	-	-	1,111	-	-	-	-	-
Cassava leaves	333	357	400	-	392	411	278	310	286	286	254	309
Potato leaves	309	1,745	384	-	392	433	365	268	333	292	309	309
Krainkrain	500	662	475	-	448	400	278	333	400	310	367	366

Kambia II — Le/kg

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ginger	1,429	1,892	1,110	-	1,250	2,104	1,429	1,429	1,667	1,429	1,548	1,429
Cassava leaves	667	2,048	812	-	794	701	667	718	769	667	667	667
Potato leaves	310	409	282	-	683	286	263	298	263	275	275	286
Krainkrain	700	742	950	-	1,172	1,000	1,000	885	769	1,000	834	1,000

Rokupr — Le/kg

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ginger	1,000	1,500	1,665	-	1,250	1,665	-	-	1,750	1,429	-	1,250
Cassava leaves	500	403	792	-	735	792	-	-	172	667	333	500
Potato leaves	500	470	639	-	333	639	-	-	150	286	250	333
Krainkrain	1,667	836	810	-	833	810	-	-	1,000	1,000	833	903

Barmoi Luma — Le/kg

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ginger	1,181	-	-	-	-	-	-	-	1,429	1,429	1,429	1,250
Cassava leaves	667	606	601	-	250	418	-	-	667	667	667	667
Potato leaves	310	267	280	-	411	236	-	-	1,595	286	295	400
Krainkrain	1,000	-	-	-	-	-	-	-	1,000	1,000	885	1,000

(4) Groundnut oil, palm oil and groundnut

Groundnut oil and palm oil, both primary process products, maintain stable retail prices throughout the year. The price of groundnut oil is the highest of the three commodities at over Le 5,000/kg on overage per year at any market

Table 3.5-4 Fluctuation of Retail Price: Groundnut oil, palm oil and groundnut

Madina												Le/kg
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Groundnut oil	5,333	4,929	4,500	-	4,444	-	6,667	4,333	4,500	5,000	5,000	5,000
Palm oil	4,666	4,333	3,333	-	3,333	3,333	3,333	3,333	3,667	3,333	4,167	4,333
Groundnut	3,200	-	-	-	-	-	-	-	1,250	1,667	2,167	2,667

Kambia II												Le/kg
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Groundnut oil	5,667	4,292	5,292	-	-	5,000	5,333	5,667	5,333	5,333	5,667	5,500
Palm oil	4,667	3,308	2,667	-	3,000	3,333	3,333	3,167	3,500	3,667	4,333	4,667
Groundnut	3,542	-	-	-	-	-	-	4,546	1,538	2,400	2,600	2,859

Rokupr												Le/kg
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Groundnut oil	6,000	-	-	-	-	-	5,000	5,000	5,000	5,167	5,333	5,000
Palm oil	5,000	3,528	2,333	-	3,111	2,333	3,333	3,167	3,167	3,000	4,333	4,667
Groundnut	-	-	-	-	-	-	-	-	1,471	2,500	-	3,125

Barmoi Luma												Le/kg
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Groundnut oil	5,333	-	-	-	-	-	6,250	4,667	5,333	5,333	5,333	5,333
Palm oil	4,667	2,433	1,942	-	2,667	2,556	3,834	2,556	3,333	3,667	4,167	4,500
Groundnut	3,200	3,969	-	-	3,000	2,981	3,220	4,000	1,538	2,400	3,018	2,800

(5) Okra, onion and pepper

As for pepper, a crop introduced in the PT of the present project, its retail price (dried) almost reaches over Le 10,000/kg. This clearly indicates that pepper is a highly cashable crop.

(6) Fertilizer (NPK and urea)

The prices of NPK and urea per kg are presented in the table below. These fertilizers are generally sold by buttercup (220g) at every market, and their distribution is unstable all through the year. Since fertilizers are imported goods, it is difficult to purchase them in a large quantity at a time.

Table 3.5-5 Fluctuation of Retail Price: Okra, onion and pepper

Madina (Le/kg)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Okra	-	4,106	3,400	-	-	-	-	1,200	2,167	1,333	757	-
Cucumber	-	-	-	-	-	-	-	555	418	375	-	-
Onion impor.	3,166	7,437	8,333	-	-	4,000	9,750	10,000	8,000	5,000	4,500	3,000
Pepper dried	15,000	18,333	16,300	-	20,000	12,000	24,000	26,000	20,000	10,000	13,000	15,000

Kambia II (Le/kg)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Okra	2,000	2,750	4,000	-	933	2,000	1,667	6,000	2,000	1,000	1,000	1,500
Cucumber	-	-	-	-	-	-	-	-	1,634	4,000	3,334	-
Onion impor.	2,500	9,589	4,042	-	6,000	8,167	10,000	8,000	5,000	4,000	4,000	2,500
Pepper dried	10,000	16,442	7,167	-	10,000	12,000	9,500	18,750	24,000	18,750	15,625	10,000

Rokupr (Le/kg)

Okra	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Okra	-	-	-	-	-	533	-	1,459	2,000	1,667	1,667	500
Cucumber	-	-	-	-	-	-	-	625	469	750	-	-
Onion impor.	3,500	7,750	2,850		3,333	2,850	-	4,000	-	3,334	4,000	1,520
Pepper dried	12,000	8,333	3,722		12,667	13,722	-	4,000	15,000	24,000	15,000	16,000

Barmoi Luma (Le/kg)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Okra	2,000	2,008	-	-	-	1,414	490	800	2,000	1,034	1,333	2,000
Cucumber	-	-	-	-	-	-	-	-	1,634	4,000	4,000	-
Onion impor.	3,500	2,000	-	-	3,513	1,389	4,200	4,000	5,000	2,667	2,667	4,000
Pepper dried	10,000	-	13,667	-	13,333	10,583	8,715	16,000	30,000	12,500	11,250	10,000

Table 3.5-6 Fluctuation of Retail Price: Fertilizers

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep	Oct.	Nov.	Dec.
Madina												
NPK	3,333	6,000	8,009	-	-	-	3,590	3,333	4,167	3,333	3,333	3,333
Urea	3,333	-	-	-	-	-	4,423	4,167	4,167	3,333	3,333	3,333
Kambia II												
NPK	-	-	-	-	-	-	2,839	3,846	3,846	3,846	3,846	3,846
Urea	-	-	-	-	-	-	2,839	-	3,846	3,846	3,846	3,846
Rokupr												
NPK	3,333	-	-	-	-	-	-	-	5,000	4,500	3,334	3,333
Urea	3,333	-	-	-	-	-	-	-	5,000	5,000	4,167	3,333
B. Luma												
NPK	3,846	-	-	-	-	-	2,600	2,826	3,846	3,846	3,846	-
Urea	3,846	-	-	-	-	-	2,600	2,600	-	3,846	3,846	-

3.6 Measurement Unit of Rice Grains in Kambia District, Sierra Leone

3.6.1 Abstract

Agricultural commodities are exclusively measured by volume in Sierra Leone, although the unit of measurement is not standardized. To know the extent of variation, volumetric weight of rice grains was appreciated with containers currently used by farmers at seven villages (chiefdoms) in the Kambia district.

Wooden boxes (Box) were used in the central and southern chiefdoms (Mambolo, Samu, Gbinleh Dixing), where the volumetric weight of grains (rough rice) was 32-33 kg/Box irrespective of box size. Bath-pan (BP) was adopted in the central and northern chiefdoms (Gbinleh Dixing, Magbema, Bramaia), where the grain weight was about 33 kg/BP. Farmers reckon the grain volume measured either with Box or BP as 1 bushel (bu).

In contrast, the grain weight measured with a tripence-pan (TP), which was widely used in the district, varied greatly as 2.2-3.5 kg/TP, and also the number of TPs equivalent to1 bu varied 10-22, among locations. Yet, because of the reversal relationship of the two factors among locations, the variation of volumetric weight was reduced though it was still large: 30-34 kg/bu in the central and southern chiefdoms (Samu, Gbinleh Dixing and Magbema) and 48-52 kg/bu in the central and northern chiefdoms (Bramaia, Tonko Limba, Masungbala). Rice price for each bu was higher in the northern chiefdoms than in the southern chiefdoms, so that rice price per unit weight showed less variation: Le610-640/kg shortly after harvest.

The only two types of measuring cups (often called as butter cup) for milled (polished) rice were used, and their volumes were apparently similar (net volume: about 340 cm^3). The volumetric weight of parboiled, milled rice was 0.29 kg/Cup by the dominantly used one [FAPLAST].

Because not only the quantity of rice production but also cultivated area was measured by grain (seed) volume in the country, one should bear in mind that the container volume and the volumetric unit (bu) itself vary greatly among locations. Further survey is prerequisite to estimate rice production itself, to protect farmers' fair profit, and to make plans for agricultural development.

3.6.2 Back ground

Rice, a staple food, is extensively grown and is the most important crop in Sierra Leone. Nevertheless, its volumetric measurement system is not standardized, and the present situation on the conversion rate from volume to weight and the quantitative relationship between measuring containers remains unknown. Such situation is applicable to all districts in the country and to the other crops too.

Agricultural products are quantified by volume in Sierra Leone. Quantification by filling and heaping up containers is widely practiced in many agricultural products, including rice, pepper, *etc*., and cooking items like sugar and salt. As for rough rice (paddy), the official volumetric weight is defined as 25 kg/bu. Farmers estimate cropped area by the quantity of seeds sown for rice too: the planted field area sown with 1 bu seeds is considered to be 1 acre equivalent in both planting methods with direct sowing and transplanting.

JICA/MAFFS-K carried out the Pilot Project (PP) at the seven villages, one each in 7 chiefdoms of Kambia district in 2007-2008, to develop agricultural technical packages for contributing to the increase in rice productivity. In the process of yield analyses, the JICA Project Team (JPT) confronted an ambiguous traditional measuring system, especially in the analysis of yield data. During the PP implementation, the JPT tried to understand the measuring system by gathering relevant information from MAFFS-K staff and farmers, but the collected information was not systematic and insufficient.

3.6.3 Surve y Methods

A survey on the volumetric measuring system of rice was conducted February 9-13, 2008. The JPT inspected all the available containers (or vessels) that farmers used to volumetrically quantify rice in all PP villages, and weighed the rice grains that were measured with those containers. At the same time, the JPT collected relevant information like the common name, the number of containers existed in the village, milling (hulling and polishing) recovery, *etc*., and analyzed the quantitative relationship among containers and their difference among locations.

Rough rice of three cultivars (ROK 3, ROK 5 and ROK 10) that was produced in the PP (2007-2008) and used for yield and yield component analysis was used for measurements. Unfortunately, seeds obtained from the Seed Multiplication Project at Kobia for the PP were considerably contaminated with exotic cultivars: 10-30%. Grains were harvested, threshed, winnowed with local fans, dried sufficiently, and kept in air for more than one month to equilibrate with air moisture. One-thousand-grain weight was 27, 29 and 21 g in ROK 3, ROK 5 and ROK 10, respectively.

Because heaping-up grains on containers is a delicate procedure, farmers themselves practiced it. First, a container was horizontally placed on the ground: second, rice grains were filled into a container by dropping them freely and dropping was continued until grains were falled out of the container: third, heaping was carefully completed with gentle and repeated dropping of grains by hands, so that heaped shape formed a conical cone or a rectangular pyramid. To cram grains, practices such as pressing the content by hands or shaking the container are not allowed.

Rice grains filled and heaped up were transferred on a plastics sheet or into a bigger container, and were weighed with a spring balance (maximum capacity of 10 kg). Measurements were repeated 3-4 times for sample weight less than 10 kg, and twice for that larger than 10 kg. Whenever the weight was determined, its moisture amount was measured with a moisture meter (Shizuoke Seiki Ltd., Comet CD-5). The average moisture amount was 15.0%, 14.9% and 15.4% for ROK 3, ROK 5 and ROK 10, respectively, and the coefficient variation in each cultivar was about 3%. Grain weight adjusted to 14% moisture, the standard value in Sierra Leone, is shown in the text.

Only one example of respective container was selected and measured its volumetric weight in each PP site, but the size of another containers was measured when they were obtained. Containers for polished rice were also collected and their trademark was recorded: the volumetric weight of polished rice had already been measured with the one of them.

3.6.4 Surve y Results

(1) Container

Three types of containers for quantifying rough rice were found: a wooden box (Box. 'kume' in Temne), a bath-pan (BP, 'baf-pan' in Krio) and a tripence-pan (TP). The use of the former two was confined to a few locations (chiefdoms), whereas the latter was widely used in all the chiefdoms (Table 3.6-1).

The Box was found in the central and southern chiefdoms (Mambolo, Samu, and Gbinleh Dixing) and the BP in the central and northern chiefdoms (Gbinleh Dixing, Magbema and Bramaia). The Box was a rectangular parallelepiped with 500-570, 260-290, 310-370 mm of length, width and depth, respectively, and the net volume was 0.042-0.051 m^3 (=42-51 liter) (Table 3.6-2). Number of Boxes available in a village was one in Kunthai, four with different sizes in Rosinor and several in Macoth. All BPs were made of porcelain enamel (vitreous enamel) and their size was similar: about 610 and 540 mm of the upper and lower diameter, respectively, with about 200 mm in depth and 0.015 m^3 of the net volume (Table 3.6-3). All TPs were bowl-like and the majority of them were made of porcelain enamel: exception was found at Robat, being made of aluminum (brought from Guinea). The size was 231-262 and 139-152 mm in upper and lower diameter, respectively, with 65-122 mm depth and about 0.0013 m^3 net volume (Table 4). The TP is called as either pan, local TP, shariah pan (or simply 'Shariah', meaning Muslim law) or rubber, and several names were often used in villages.

Table 3.6-1 Unit weight of rough rice (a) by various cultivars (b) and measuring containers at the seven pilot project sites in Kambia district, Sierra Leone

Chiefdom	Village	Grain weight (kg) per box				Grain weight (kg) per BP				Grain weight (kg) per TP			
		ROK 3	ROK 5	ROK10	mean	ROK 3	ROK 5	ROK10	mean	ROK 3	ROK 5	ROK10	mean
Mambolo	Macoth	32.4	33.7	33.1	33.1	-	-	-	-	3.36	3.51	3.47	3.45
Samu	Rosinor	31.5	31.9	31.9	31.8	-	-	-	-	2.63	2.63	2.68	2.65
Gbinleh Dixing	Kunthai	31.8	32.0	32.1	32.0	32.7	33.5	33.9	33.4	2.63	2.67	2.75	2.68
Magbema	Robat	-	-	-	-	32.1	33.0	33.3	32.8	2.81	2.83	2.82	2.82
Masungbala	Robennah	-	-	-	-	-	-	-	-	2.08	2.32	2.17	2.19
Tonko Limba	Kalintin	-	-	-	-	-	-	-	-	2.19	2.44	2.42	2.35
Bramaia	Sabuya (c)	-	-	-	-	-	-	-	-	2.19	2.39	2.39	2.32
Relative weight (d)		99	101	100	-	98	100	102	-	97	102	101	-

a) Moisture amount of grains was adjusted to 14%.

b) One-thousand (1,000)-grain weight was 26.9, 28.9 and 21.1 g in ROK 3, ROK 5 and ROK 10, respectively.

c) Baf-pan was available.

d) Relative weight averaged over entire villages.

Table 3.6-2 Size of wooden boxes

Village		Note	Inner size (mm)			Net volume (m^3)
			Length	Width	Depth	
Macoth		a	514	267	309	0.042
Mambolo			501	258	370	0.048
Rosinor	1	a, b	487	273	364	0.048
	2		567	287	312	0.051
Kunthai		a	484	276	374	0.050

a) The box used for measuring the weight of rough rice at the survey.
b) A side board was got out of position about 9 mm in one side.

Table 3.6-3 Size (mm) of bath-pan (BP) (a)

Village	Diam. of upper brim		Diam. of bottom	Depth
	Outer	Inner		
Robat	605	540	300	203
Kalintin	610	550	305	201
Sabuya	606	530	315	201

a) BP is locally calld as a baf-pan and is made of porcelain enamel (vitreous enamel).

Table 3.6-4 Size of tripence pan (TP) (a)

Village	Common name	Size (mm)			
		Diam. of upper brim		Diam. of bottom	Depth (center)
		Outer	Inner		
Macoth	Pan	254	235	-	121
Rosinor (b)	TP	231	215	-	122
Kunthai	TP	235	-	-	105
Robat	TP	242	227	-	113
Robennah	Pan	262	-	145	65
Kalintin	TP	252	224	139	82
Sabuya	Rubber	250	225	152	81

a) All made of porcelain enamel (vitreous enamel) except the one at Robat that was made of alminium and made in Guinea.
b) The center bottom was deformed (swollen).

Only two types of a container (plastics cups, often called as butter cup: Cup) for quantification of polished rice were found (see the footnote in Table 3.6-5). Out of 7 villages surveyed, the one marked with FAPLAST, Lebanon 001 (FL) was used in 5 villages, whereas the other marked with Super Plastics, C.Mug - 371 (SP) was in two villages. The net volume was slightly larger in the latter than in the former.

Table 3.6-5 Price (a) of rough rice and milled rice, type of the cup for measuring milled rice

Village	Price (Leone) of rough rice for each		Price (Leone) of rough rice in unit weight (Leone/kg) by		Price of milled rice (Leone/cup)		Type of cup	Number of cups per bag
	bu	TP	bu	TP	Rough rice	Par-boiled	(d)	
Macoth	20,000	-	605	-	c	-	FL	-
Rosinor	20,000	-	629	-	450	400	FL	240
Kunthai	30,000	-	939	-	600	500	FL	240
Robat	b	b	b	b	c	-	SP	240
Robennah	30,000	2,000	623	913	c	450	SP	240
Kalintin	-	1,500	-	638	c	400	FL	-
Sabuya	-	2,000	-	862	c	400	FL	200

a) Price during the survey (shortly after harvesting season: the cheapest price).
Exchange rate: Le2,950/US$1.00 in January-February, 2008.
b) Farmers seldom sell rough rice.
c) Farmers rarely mill rough rice because of producing a large quantity of broken rice.
d) FL: FAPLAST, Lebanon 001 (inner diameter: 74 mm, height: 80 mm). SP: Super Plastics, C.Mug - 371, Made in Sierra Leone (upper and lower outer diameter: 80 and 64 mm, height: 85 mm). About 290 g (parboiled, milled rice)/cup [FL].

(2) Volumetric weight of rough rice

Volumetric weight of rough rice was similar between the two large containers: 32-33 kg/Box and about 33 kg/BP as an average of three cultivars used (Table 3.6-1).

The volume measured with the large containers (Box or BP) is commonly reckoned 1 bu equivalent. However, the volumetric weight of rough rice measured with the small container, TP, varied greatly among locations. The volumetric weight by TP can be classified into 3 groups: it was smallest as 2.2-2.3 kg/TP in the central and northern chiefdoms (Masungbala, Tonko Limba and Bramaia), intermediate as 2.7-2.8 kg/TP in the central and southern chiefdoms (Samu, Gbinleh Dixing and Magbema), and largest as 3.5 kg/TP in Mambolo.

The volumetric weight of ROK 3 was 1-3% smaller and that of ROK 5 and ROK 10 was 0-2% larger than the average in all containers. The error caused with replicated samples was about 1% with the Box and BP, and 2-3% with the TP.

(3) Conversion of TP measurement to bushel

Conversion rate of grain volume measured with the TP to bu is defined in every village. Farmers account 10-22 TP for 1 bu (Table 3.6-6). The variation of the conversion rate is large, being more than twice. However, the volumetric weight per TP held was a reversal relationship with the number of TPs, and thus, the variation among villages (chiefdoms) become small as 30-52 kg/bu. Nevertheless, the difference of the volumetric weight per bu based on TP was obviously large among locations: 48-52 kg/bu in the central and northern chiefdoms vs. 30-34 kg/bu in the central and southern chiefdoms.

In Macoth, farmers adopted two different conversion rates (10 or 12 TP/bu) depending on the occasion, where the detail was unknown.

Table 3.6-6 Number of tripence (TP) per bushel and weight of rough rice per bushel (a)

Village	No. of TP/bu	Weight (kg/bu)
Macoth	10 or 12	34 or 41
Rosinor	11	29.1
Kunthai	12	32.2
Robat	12	33.9
Robennah	22	48.2
Kalintin	22	51.7
Sabuya	22	51.1

a) An average of three cultivars based on the number of TP per bushel.

(4) Price of rough and polished rice

Price of rough rice was Le 20,000-30,000/bu and Le 1,500-2,000/TP (Table 3.6-5). The price per unit weight was calculated as Le600-940/kg when the grain volume was measured by bu, and was as Le640-910/kg when the volume was measured by TP. Variation of the price per unit weight was smaller than that per volume.

Price of polished rice (parboiled) was Le 400-450/Cup. JPT had previously measured the volumetric weight of polished (parboiled) ROK 3 as 0.29 kg/Cup with the FL. Thus, price per weight was calculated to be Le 1,550-1,700/kg.

Some information on rice polishing; Farmers traditionally hull and polish rice by beating grains (both rough and parboiled rice) with a wooden mortar and pestle, and this practice is dominated even at present. Commercial milling machines (rice huller and polisher) are available, especially in the southern chiefdoms, where they are exclusively an Engelberg type. When rough rice is polished, it produce a larger quantity of broken rice compared to parboiled rice both with manual beating and machines, so that farmers are used to hull and polish parboiled rice, and even never do rough rice in some villages: *e.g.*, Kalintin and Robat. Farmers usually keep rough rice in stock, parboil a certain quantity of it (20-30 kg) at once, hull and polish it after drying, and consume it for home or sale.

Farmers at Robennah reported that 5 cups of polished rice was obtained from 1 TP of rough rice: *i.e.*, hulling and polishing recovery was 87%. At Rosinor, 48 and 66 cups of polished rice were from 1 bu of rough and parboiled rice, respectively: the recovery was 57% and 78%, respectively. Large difference of the recovery between locations was likely derived from the degree of polishing and separation of broken rice.

Polished rice is often stored in bags, and bagging unit is mostly at 240 Cup/bag (= 20 dozen of Cup/bag) (Table 3.6-5). Yet, buying-and-selling is based on the number of cups in all villages surveyed.

3.6.5 Implication of Survey Results

(1) Rough rice weight in respective container

Contrary to the difference of the size (Table 3.6-2), the volumetric weight of grains was similar among boxes (Table 3.6-1). This fact implies that those boxes were carefully made to function as a measurement standard. Yet, we should further investigate another Boxes existed in the surveyed villages and in another locations. Volumetric weight for each bu based on the TP was generally similar with that based on the Box or BP as far as they were used. An exception was at Rosinor; the volumetric weight by TP was about 10% less than that based on the Box or BP. The result might imply that farmers would not carefully estimate their production or they would totally depend on traders' measurement boxes when they sold rice.

Use of the Box or BP is, however, confined to certain locations, mostly in the central and southern chiefdoms. Instead, the TP is most commonly used across all chiefdoms. Unfortunately, its size and the volumetric weight of grains varied greatly (Tables 3.6-1 and 3.6-4). Needless to mention, anyone should carefully identify a container whenever he of she quantifies rice grains.

Grain size determined with 1,000-grain weight did not affect greatly to the volumetric weight (Table 3.6-1), although it varied considerably among cultivars used: 21-29 g. The fact shows that the volumetric weight is likely controlled with multiple factors: *e.g.*, grain size, moisture amount, winnowing degree, glume (husk or hull) surface texture, grain shape (length, width and thickness), awn length, dropping height of grains during filling process to the containers, *etc*. In addition, materials used in this study were unfortunately consisted of mixed cultivars at a certain rate and the winnowing degree varied among cultivars. As for polished rice, the proportion of broken rice affects the volumetric weight: it varies greatly among products because all processes, especially final step of broken rice separation, were manually controlled. Besides, the width of brim (rim) for bowl-shaped containers (BP and TP) and the board thickness for wooden boxes at upper side surely affects the volumetric weight, because rice grains are measured with heaping up grains on the containers.

Farmers and extension workers said that the Box was commonly used in mangrove swamp area. As reported in Macoth, the reason why the number of TP equivalent to 1 bu varies as 10 or 12 depending on an occasion is unknown. When 1 bu is estimated with 12 TP, the volumetric weight reaches 41 kg/bu. Farmers will lose their profit for sale as much as 25% compared with the weight measured by Box (33 kg/bu). Besides, farmers are used to mention that traders use their own Box, which is 1-2 TP larger than the one used by farmers. Therefore, many farmers regretfully express their TP as 'Work for nothing' ('Blok tin' in Temne and 'Gleh bra' in Susu). Farmers should cooperate each other to take some measures to cope with traders, at least in an aspect of rice quantification. Otherwise, they are continuously losing their fair profit: the loss by cooperation can be easily compensated with the real profit.

Note that the seed multiplication center at Kobia, only the official seed distributor in the country, purchases seeds from farmers by weight (source from a Kobia staff met during the survey). They purchase rice at the rate of 27 kg/bu and process it to 25 kg/bu for sale.

(2) Grain weight based on rice price

Substantial difference of the price per bu (Table 3.6-5) and the weight per bu (Table 3.6-1) was found among locations, but the difference in the volumetric weight among chiefdoms was reduced when the price per weight was compared. This result suggests that rice market at least stands rationally among locations, although the discrepancy of the volumetric weight among chiefdoms affects production estimate.

Yet, some difference among locations remains even in the price per weight. Readers should bear in mind that all data on price presented above was obtained with interviews: some of them might be biased. Taking of the general situation, Le610-640/kg would be the most appropriate value shortly after harvesting season in Kambia district. For instance, Le940/kg at Kunthai might hold some expectation by villagers.

(3) Container shape and sampling error

The sampling error of volumetric weight measurements by repetition was about 1% by Box and BP and 2-3% by TP. The error is likely caused with the heaping procedure on containers to form a conical cone or a rectangular pyramid, even though it was formed by sufficient care.

(4) Further examination of presented information

a) The result of the baseline survey conducted in 2006 was analyzed with the official conversion rate as 1 bu = 25 kg for rice production and the cropped acreage (1 bu seeds being equivalent to 1 acre). However, no village adopting such conversion rate was found and the unit of bu itself varied greatly among locations. Several compiled data like rice yield per unit field area possessed no validity, and thus, all items relevant to crop acreage and production should be revised by re-calculation.

Further examination might be similarly requested in the market and post-harvest surveys.

b) The present result affects the seed rate in the technical package. In a draft, it was based on the traditional estimate as one-bushel seed to one acre in all ecologies. In the interpretation of one bushel, we adopted the official conversion rate (25 kg/bu), and thus the recommended seed rate was 62.5 kg/ha (= 1 bu/acre).

Being based on this interpretation, the number of emerged plants in direct sowing is calculated as about 190 m^{-2} (= 62.5x1,000x1,000x0.9/(30x10,000)) at the best, assuming that 1,000-grain weight is 30g and germination proportion is 90%. The number of plants is likely small for establishment of favorable stands: e.g., seeding rate for direct sowing in irrigated lowlands is commonly 80-120 kg/ha. The wrong interpretation resulted in an incomplete sowing at Kalintin boliland by the PP (2007): the projected area was not filled with the recommended seed quantity, which was not due to farmers' fault.

(5) Information to be collected

a) Net volume of BP, TP and Cup. Lateral side of those containers is frequently curvilinear, so that net volume can be measured only by filling water. In addition, some missing data on container shape are to be collected.

b) Volumetric weight was larger in the northern chiefdoms, smaller in the southern chiefdoms, and various or intermediate in the central chiefdoms (Magbema, Masungbala, Gbinleh Dixing). The boundary lies unlikely on the chiefdom border, and thus, we have to find it somewhere in the central chiefdoms by surveying the situation in additional villages.

c) Quantification of traders' containers and find a difference from those used by farmers.

d) Volume change of rice by parboiling process.

e) Additional data on current price of rough and polished rice should be collected on the basis of real weight. The information can be supplemented with that obtained in the baseline survey (2006) and the market survey.

f) Actual cropped acreage and production at farmers' fields should be assessed and compared with the information obtained from farmers.

g) The present activities by the Ministry of Trade for measurement unification (Newspaper?).

3.6.6 Perspectives and Recommendation

JICA Agricultural Project is undertaking to enhance rice production through the improvement of crop management. To verify such technologies, the PP was set up by designing various treatments. Proper assessment of crop yield is prerequisite, where two key factors, cropped area and production, should be most appropriately determined both at farmers' field and at the PP site. The actual status on the two factors was found to be ambiguous, however. We should have had surveyed much earlier.

The official conversion rate like 25 kg/bu was not practically adopted in the Kambia district. JPT wonders what was the intension of it: unfortunately we failed to find any effort to extend the information by the authority. At the same time, JPT doubt what type of conversion rate they applied in many agricultural surveys carried out in the past, including those by FAO, UN, *etc*.

MAFFS would have had surveyed the prevailing measurement system, if the organization were really serve for farmers. Because they allocate a large number of staff all over the districts in the country and the cost for such survey is minimal, they can easily deal with the survey. At the same time, it will provide a good opportunity to collect necessary information for future plan.

Unfortunately, today, no positive attitude towards promotion of agricultural development is found by such a huge organization. They ought not to depend on outsiders for ever. They should strive hard to raise their own position by full efforts. Otherwise, no prosperous future will come to the country.

Notes:

a) bu: imperial bushel, being 8 gallons or about 0.036 m^3.

b) 1 acre = ca. 0.4 ha.

c) The official source of the conversion rate as 25 kg/bu of rough rice is MAFFS-K.

Photo 3.6-1 Grain heap on a wooden box
broken (Macoth, 2008/02/12)

Photo 3.6-2 Wooden box partially
(Rosinor, 2008/02/13)

Photo 3.6-3 Grain heap on a bath pan
(Robat, 2008/02/12)

Photo 3.6-4 Grain heap on a tripence pan
(Macoth, 2008/02/12)

Photo 3.6-5 Tripence pan of which bottom was swollen
(Rosinor, 2008/02/13)

Photo 3.6-6 Tripence pan under a critical condition
(Kunthai, 2008/02/13)