Technical Report No. MK-2

REPORT OF RESEARCH WORKS
on
LOWLAND RICE CULTIVATION
at
MAE KLONG PILOT PROJECT

KAZUTO MISAWA
JICA EXPERT

MARCH 1985

THAI IRRIGATED AGRICULTURE DEVELOPMENT PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

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PART A

REPORT OF DIRECT SOWING LOWLAND RICE CULTIVATION

I. YIELD AND YIELD COMPONENTS OF DIRECT SOWING RICE CULTIVATION

II. ADVANTAGES AND DISADVANTAGES OF DIRECT SOWING RICE CULTIVATION

III. IMPORTANT TECHNIQUES OF DIRECT SOWING RICE CULTIVATION

IV. MECHANIZED DIRECT SOWING RICE CULTIVATION

PART B

REPORT OF

I. COLD WEATHER DAMAGE OF LOWLAND RICE

II. MECHANIZED FARMING OF LOWLAND RICE

1. LARGE SCALE OF RAISING LOWLAND RICE SEEDLING FOR MECHANIZED TRANSPLANTING

2. MECHANIZED HARVESTING OF LOWLAND RICE

III. CROPPING PATTERN OF RICE DOUBLE CULTIVATION

PART C

SUMMARY OF AGRONOMICAL EXPERIMENTS CONDUCTED AT AGRICULTURAL DEMONSTRATION CENTRE.

CONTENTS

PART A

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

PART B

REPORT OF

TABLE OF CONTENTS

LIST OF TABLE

TABLE

LIST OF FIGURES

APPENDIX

PART C

TABLE OF CONTENTS

ANNEX

Author Shirod Prakunhungsit

Kazuto Misawa

1. Report of the Paddy Cultivation in the Dry Season, 1982.

English 51 pages

2. Report of the Paddy Cultivation in the Rainy Season, 1982.

English 84 pages

3. Report of the Paddy Cultivation in the Dry Season, 1983.

English 93 pages

4. Report of the Paddy Cultivation in the Rainy Season, 1983.

English 69 pages

5. Report of the Paddy Cultivation in the Rainy Season, 1984.

English 50 pages

REPORT

OF

DIRECT SOWING LOWLAND RICE CULTIVATION

I. YIELD AND YIELD COMPONENTS OF DIRECT SOWING RICE CULTIVATION

II. ADVANTAGES AND DISADVANTAGES OF DIRECT SOWING RICE CULTIVATION

III. IMPORTANT TECHNIQUES OF DIRECT SOWING RICE CULTIVATION

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INTRODUCTION

Since 1979, the land consolidation works on the right bank area in Mae Klong Irrigation Project have been implemented by Royal Irrigation Department and about 65,000 hectares of farmers'field will be completed by 1988. Accompanying the progress of land consolidation works, it is expected that the rice double cropping area and direct sowing rice cultivation area will be expanded rapidly.

On the other hand, AGricultural DEmosntration Centre was established in the pilot project area No. 1 by the technical cooperation between Thai and Japanese Government.

The Centre has been conducted various kind of experiments and field observations in order to improve rice farming technologies and to formulate appropriate farming techniques in the past 5 years. Useful techniques found

at the Centre have been introduced and diffused to the farmers in the pilot project areas through assisting model farmers and farmers' meeting and publishing "Mae Klong Farming News" in cooperation with agricultural extension offices and cooperative promotion office.

In 1984 dry season, Agricultural Demonstration Centre conducted the investigation on yield and yield components of direct sowing rice cultivation in the pilot areas in order to know how much these appropriate rice farming techniques have been accepted and practiced by the farmers, especially on the direct sowing rice cultivation.

According to the investigation and studies, regretably, appropriate farming techniques on the direct sowing rice cultivation have not yet been fully understood and practiced by some of farmers.

This report consists of 4 parts. The 1st part is the Yield and Yield Components of Direct Sowing Rice Cultivation in the Pilot Areas. The 2nd part is the Advantages and Disadvantages of Direct Sowing Rice Cultivation. The 3rd part is the Important Farming techniques of Direct Sowing Rice Cultivation which pays special attention to the improvement direct sowing rice cultivation, and the 4th part is the Mechanized Direct Sowing Rice Cultivation.

Although the appropriate farming techniques on the direct sowing rice cultivation have been obtained, there are still many quetions which require further studies. Seed rate, water management at the time of sowing, fertilizer amount and its application time, weed control method are some of important matters that ought to be studies further more.

The suthor eagerly hope that this report will contribute to the improvement of direct sowing rice cultivation in Mae Klong area and its similar areas in Thailand.

I. YIELD AND YIELD COMPONENTS OF DIRECT SOWING RICE CULTIVATION IN PILOT AREAS

1. Area of Direct Sowing Lowland Rice Cultivation in mae Klong Pilot Project

Land consolidation works in Mae Klong Pilot Project of Royal Irrigation Department were commenced in 1979 and conpleted in 1982.

Rice double cropping in a year has been introduced in both of the pilot area No. 1 and No. 2 after completion of the land consolidation. Consequently, yearly rice production per hectare increased form the average of 2.2 tons in 1979 to 9.0 tons in 1983. As to the rice cultuvation method, transplanting method was common practice in the project areas, but after land consolidation works have been commenced, improved direct sowing rice cultivation method has been introduced and expanded. Furthermore, the rice planting area has been expanded rapidly year by year, especially in dry season.

Table 1 shows the area planted by the direct sowing cultivation mehtod to the whole planted area in percentage classified into year and crop season. The proportion of direct sowing area to the whole rice planted area was expanded from 5% of pilot No. 1 and 2% of pilot No. 2 in 1981 dry season to 90% of pilot No. 1 and 60% of pilot No. 2 in 1984 dry season. As to the area of direct sowing rice cultivation in rainy season, it has also increased steadily but increasing rate is smaller comparing with that in dry season.

Table 1 Change of direct sowing rice cultivation area in Mae Klong Pilot Project

	Season	1981	1982	1983	1984 (%)
Pilot No. 1	Dry season	5	10	45	90
	Wet season	10	15	30	55
Pilot No. 2	Dry season	2	4	30	60
	Wet season	5	10	20	45

2. Yield of Direct Sowing and Transplanting Rice Cultivation

Table 2 shows the planted areas and rice yields in dry seasons in pilot No. 1 and No. 2.

In the pilot area No. 1, the average yield of direct sowing rice cultivation in the year of 1982, 1983 and 1984 was 3589 kg, 5444 kg and 4099 kg per ha respectively, and the highest yield was 5696 kg, 6840 kg and 7026 kg respectively. On the other hand, the average yield of transplanting rice cultivation for the above mentioned 3 years was 3660 kg, 5098 kg and 4805 kg respectively, and the highest yield was 6042 kg, 7703 kg and 5950 kg respectively. As to the pilot area No. 2, the average yield of direct sowing rice cultivation in the 3 years mentioned was 3459 kg, 3981 kg and 4637 kg respectively, and the highest yield was 4759 kg, 5859 kg and 6099 kg rsspectively. On the other hand, the average yield of transplanting rice cultivation was 3587 kg, 4734 kg and 4493 kg respectively, highest yield was 5750 kg, 6751 kg and 5798 kg respectively.

According to the results of yields, when the yields of direct sowing rice cultivation are compared with those of transplanting rice cultivation, there are not much difference. However, the results show that under the good management practices of direct sowing rice cultivation, yield level of 6 to 7 tons per hectare could be obtained.

Table 2 Planted area and yield in dry season in Mae Klong Pilot Project

1. Pilot No. 1

Year	Planted area (ha)		Yield (kg/ha) Average	Highest	Lowest
1980	17.8		4,125	6,100	1,325
1981	102.0		3,765	6,250	1,750
1982	284.7	D.	3,589	5,696	2,181
		T.	3,660	6,042	1,259
1983	347.8	D.	5,444	6,804	3,710
		T.	5,098	7,703	3,003
1984	363.7	D.	4,099	7,026	1,431
		T.	4,805	5,950	3,945

2. Pilot No. 2

Year	Planted area (ha)		Yield (kg/ha) Average	Highest	Lowest
1982	224.3	D.	3,459	4,759	2,184
		T.	3,587	5,750	2,063
1983	448.2	D.	3,981	5,859	2,079
		T.	4,734	6,751	3,423
1984	456.6	D.	4,637	6,099	1,894
		T.	4,493	5,798	3,137

Note : D. = Direct Sowing, T. = Transplanting

3. Yield and Yield Components of Direct Sowing and Transplanting Rice Cultivation

The yield of paddy is determined by many factors such as characteristics of variety, soil fertility, climate, management practices, water management, and so on. Generally, the simplified formula of the yield and yield components is shown as follows :

$$\text{Yield/ha (kg)} = \frac{\text{Panicles/m}^2 \times \text{ripened grains/panicle} \times \text{1000 grains weight (kg)}}{1{,}000 \times 10{,}000\ \text{m}^2}$$

Among the yield components, the weight of 1000 grains is almost fixed according to the characteristics of variety and the fluctuation causing from the managerial practice is small. But, the number of panicles per m^2 and ripened grains per panicle fluctuate widely resulting from many factors viz., management practices, water management, weather condition, etc., and they usually have close correlation with the yield.

Agricultural Demosntration Centre of Mae Klong Irrigation Project conducted the surveys regarding yield, yield components and growth duration of the direct sowing and transplanting rice cultivation for both of the pilot No. 1 and No. 2 areas and the paddy field in the Centre in the dry season of 1984.

3.1 Methdo of Survey

3.1.1 Yield and Yield Component Survey of Direct Sowing Rice Cultivation

In 1984 dry season, 138 plots RD-23 planted were selected randomly from the pilot No. 1 and No. 2 areas for the survey. Sample area of 4 m^2 in circle at each point, where medium growth condition in observation, was harvested in respective farm plot. In Agricultural Demonstration Centre, 5 samples each from 2 fields of mechanized driect sowing rice cultivation were selected for the survey.

The yield and weight of 1000 grains were calculated at 14 percent of moisture content by conversion. The number of ripened grains was calculated by the yield, weight of 1000 grains and number of panicles per m^2.

3.1.2 Yield and Yield Component Survey of Transplanting Rice Cultivation

In the same crop season, 55 plots were selected randomly from the pilot No. 1 and No. 2 areas and 48 plots from Agricultural Demonstration Centre, then conducted the investigation as the same method as mentioned above.

3.1.3 Growth Duration Survey

Observation of growth duration was performed for 152 plots of direct sowing rice cultivation in the pilot No. 1 area as well as 2 plots of direct sowing rice cultivation and 7 plots of transplanted rice in Agricultural Demonstration Centre.

3.2 Yield and Yield Components of Direct Sowing Rice Cultivation

Table 3 shows the summary result of investigation on the yield and yield components of direct sowing rice cultivation in the pilot No. 1 and No. 2 (the details refer to appendix).

According to the result of investigations, 49 samples out of 138 samples were between the rice yields of 4000 and 5000 kg per ha, which shared

35.5% of the whole samples. The average yield of 49 samples was 4481 kg per ha. The average number of panicles per m^2, ripened grains per panicle, weight of 1000 grains was 388 panicles, 43.6 grains, 28.1 g respectively. Further, 81 samples were yield of over 4000 kg which shared 58.7% of the whole number.

Table 3 Yield and yield components of direct sowing rice cultivation in Mae Klong Pilot Project No. 1 and No. 2, dry season, 1984.

Yield level (kg/ha)	No. of samples	Average yield (kg/ha)	Panicles / m^2	Ripened grains /panicle	Weight of 1000 grains (g)
Below 3000	14	2,555	310	32.5	27.7
3000-4000	43	3,564	370	35.6	28.1
4000-5000	49	4,481	388	43.6	28.1
5000-6000	25	5,433	428	47.1	27.6
Above 6000	7	6,392	438	55.4	27.0
The whole	138	4,269	384	41.2	27.9

Table 4 shows the result of investigation on the seed multiplication fields in Agricultiral Demonstration Centre. The sowing was conducted with mechanized direct sowing method (the details in Mechanized Direct Sowing), seed rate was 100 kg per ha, and the quantity of fertilizer applied were 86.2 kg of nitrogen, 37.5 kg of P_2O_5 per ha. According to the result, the average yield was 5245 kg per ha, the average number of panicles per m^2 was 369, the ripened grains per panicle was 52.4, and the weight of 1000 grains was 27.8 g.

Comparing the result to that of the same yield level of farmers' fields in the pilot project areas number of panicles per m^2 was lesser by

about 60 panicles, but the ripened grains per panicle was more by 5 grains.

Table 4 Yield and yield components of direct sowing rice cultivation at Agricultural Demonstration Centre, dry season, 1984.

Yield level (kg/ha)	No. of samples	Average yield (kg/ha)	Panicles / m^2	Ripened grains /panicle	Weight of 1000 grains (g)
4965-5600	5	5,245	369	52.4	27.8

Note : 1. Amount of fertilizer applied : kg/ha (A.D. Centre only)

Nitrogen : 86.25

P_2O_5 : 37.50

K_2O : 0

2. Seed rate sown : 100 kg/ha in dry condition

Table 5 shown the yield and yield components at the place where best grown paddy was observed on the same field of seed multiplication in Agricultural Demonstration Centre. The yield, number of panicle per m^2, spikelets per panicle, ripened grains per panicle, and 1000 grains weight was 7782 kg per ha, 363 panicles, 98.8 spikelets, 76.5 grains, 28.1 g respectively.

Table 5 Yield and yield component at the best growing condition at A.D. Centre

Yield kg/ha	Panicles / m^2	Spikelets / panicle	Ripened grains / panicle	Unripened grains / panicle	% of ripened grains	1000 grains weight
7782	362	98.8	76.5	22.3	77.5	28.1

3.3 Yield and Yield Components of Transplanting Rice Cultivation

Table 6 shwos the result on summary of yield and yield components of transplanted rice in the farmers' fields in the pilot No. 1 and No. 2 (the details refer to the appendix).

Out of total 55 samples, yields of 29 samples were between 4000 and 5000 kg per ha and shared 52.7% of the whole number. The average yield was 4471 kg per ha, number of hills per m^2 was 36.7, effective panicles per hill was 8.0, effective panicles per m^2 was 280, ripened grains per panicle was 60.6 grains, and the 1000 grains weight was 27.1 g. Furthermore, number of fields with the yield level of above 4000 kg were 46 plots and shared 82.6% of the whole number.

Table 6 Yield and yield components of transplanting rice cultivation in Mae Klong Pilot Project No. 1 and No. 2 dry season, 1984.

Yield level	Sample No.	Average yield (kg/ha)	Hills / m^2	Panicles / hill	Panicles / m^2	Ripened grains /panicle	weight of 1000 grains (g)
3000-4000	9	3,624	35.6	8.1	274	49.6	27.2
4000-5000	29	4,471	36.7	8.0	280	60.6	27.1
Above 5000	17	5,446	43.5	7.7	324	64.9	26.6
The whole	55	4,632	38.6	8.0	293	60.2	27.0

Note : 1. Variety : RD-23

2. Yield survey : 4 m^2/sample

3. Yield components survey : 10 hills/sample

Table 7 shows the yield and yield components of transplanted rice in Agricultural Demonstration Centre.

Out of 48 samples, 22 samples were between the yield levels of 5000 and 6000 kg per ha and shared 45.8% of the whole number and the average yield of the group was 5597 kg per ha. The yield components were 22.3 hills planted per m^2, 15.7 effective panicles per hill, 348 effective panicles per m^2, 348 panicles, 57.2 ripened grains per panicle, 57.2 grains, and 28.2 g of 1000 grain weight.

Further, the number of samples which obtained the yield of over 5000 kg per ha were 27, which shared 77% of the whole samples.

Table 7 Yield and yield components of transplanting rice cultivation at Agricultural Demonstration Centre, dry season, 1984.

Yield level	No. of samples	Average yield (kg/ha)	Hills / m^2	Panicles / hill	Panicles / m^2	Ripened grains /panicle	Weight of 1000 grains (g)
4000-5000	11	4,640	22.3	14.8	330	50.9	27.7
5000-6000	22	5,597	22.3	15.7	348	57.2	28.2
Above 6000	15	6,405	22.3	15.8	351	65.0	28.3
The whole	48	5,632	22.3	15.5	345	58.0	28.1

Note : 1. Variety : RD-23

2. Yield survey : 8 m^2/sample

3. Yield component survey : 20 hills/sample

4. Amount of fertilizer applied : kg/ha

Nitrogen : 86.25

P_2O_5 : 0, 14, 27

K_2O : 0

3.4 Growth Duration of Direct Sowing and Transplanting Rice Cultivation

Table 8 shows the growth duration, from sowing to harvesting, of the direct sowing and transplanting rice cultivation in the Agricultural Demonstration Centre. The growth duration of direct sowing rice cultivation was approximately 10 to 14 days shorter than that of transplanting cultivation.

Table 9 shows the growth duration of rice for the period from sowing to harvest obtained in Practical Water Management Experiment conducted in the pilot No. 1 area in the 1984 dry season. The growth duration of RD-23 ranged from the shortest of 111 days to the longest of 128 days. The paddy in the 81.6% of the 71 fields in total was harvested in the period of 111 to 119 days from sowing in the intensively water controled area. Furthermore, in the semi intensively water controled area, the growth duration 84.9% of the total field ranged from 112 to 123 days. The growth duration of the direct sowing rice cultivation in this area was about 10 days shorter than that of transplanting rice cultivation in Agricultural Demonstration Centre.

Table 8

Growth duration of rice,

Agricultural Demonstration Centre, Mae Klong Pilot Project

dry season, 1984.

1. Mechanized transplanting

Field No.	Sowing date	Transplanting date	Flowering date (80%)	Harvesting date	Growth duration (days)	
					Sowing to flowering	Sowing to harvesting
1	Feb. 28	Mar. 20	Jun. 11	Jul. 8	104	131
2	Feb. 28	Mar. 20	Jun. 11	Jul. 11	104	134
5	Feb. 28	Mar. 20	Jun. 11	Jul. 9	104	132
8	Mar. 6	Mar. 27	Jun. 18	Jul. 14	104	130
9	Mar. 6	Mar. 27	Jun. 18	Jul. 16	104	132
10	Mar. 6	Mar. 28	Jun. 18	Jul. 17	104	132
11	Mar. 6	Mar. 28	Jun. 17	Jul. 18	103	131

2. Mechanized direct sowing

7	Mar. 14	-	Jun. 14	Jul. 11	92	119
8	Mar. 14	-	Jun. 14	Jul. 12	92	120

Note : 1. Variety :- RD-23

2. Area planted :- transplanting 4.0 ha

Direct sowing 1.5 ha

3. Amount fertilizer applied

N = 86.25 kg/ha

P_2O_5= 37.5 kg/ha

K_2O= 0 kg.

Table 9

Growth duration of the direct sowing rice cultivation for the water management study in the Pilot Project No. 1, Mae Klong Project, dry season, 1984.

Variety : RD - 23

Growth duration (days)	Intensive area[a]				Semi intensive area[b]			
	No. of plot	Area (m^2)	%	% Accum.	No. of plot	Area (m^2)	%	% Accum.
111	4	12,531	7.2	7.2	-	-	-	-
112	-	-	-	-	1	463	0.3	0.3
113	3	10,125	5.8	13.0	1	1,891	1.0	1.3
114	1	3,250	1.9	14.9	6	17,523	9.6	10.9
115	14	30,170	17.3	22.2	4	7,531	4.1	15.0
116	3	11,455	6.5	38.7	6	13,239	7.2	22.2
117	15	36,266	20.8	59.5	14	21,714	11.9	34.1
118	11	15,978	9.1	68.6	8	20,752	11.4	45.5
119	9	22,682	13.0	81.6	7	12,189	6.7	52.2
120	6	18,357	10.5	92.1	7	14,598	8.0	60.2
121	2	5,788	3.3	95.4	6	13,047	7.1	67.3
122	2	5,307	3.0	98.4	7	18,613	10.2	77.5
123	-	-	-	-	5	13,485	7.4	84.9
124	-	-	-	-	6	21,042	11.5	96.4
125	-	-	-	-	1	2,293	1.3	97.7
126	1	2,778	1.6	100.0	1	1,716	0.9	98.6
127	-	-	-	-	-	-	-	-
128	-	-	-	-	1	2,530	1.4	100.0
Total	71				81			

Note :

a : Intensively water controled area

b : Semi intensively water controled area

3.5 Correlation of Yield and Yield Components

3.5.1 Correlation of Yield and Yield Components in Direct Sowing Rice Cultivation

Table 10 shows the correlations among yield and yield components of the direct sowing rice cultivation in the pilot No. 1 and No. 2 areas. For the total of 138 samples, highly significant correlations were observed between the yield and the panicles per m^2 and the ripened grains per panicle. At different yield levels, however, the yield was positively correlated with the panicle number only at the yield level of 4000 to 5000 kg per ha. Regardless the yield levels, the panicle number was always negatively correlated with the ripened grains per panicle. In some cases, the 1000 grain weight was negatively correlated with the panicle number or the ripened grains per panicle.

3.5.2 Correlation of Yield and Yield Component on Transplanting Rice Cultivation

Table 11-1 shows the correlations among yield and yield components of transplanted rice in the pilot No. 1 and No. 2 areas. For the total of 55 samples, significant correlation at 1% level was discernible between the yield and the ripened grains per panicle. The yield was further correlated with the number of panicles per m^2 at 5% level.

Table 11-2 shows the correlations among yield and yield components of transplanted rice in Agricultural DEmonstration Centre. For the total of 48 samples, the yield was highly significantly correlated with the ripened grains per panicle. It was also significantly correlated with the panicles per hill and the panicles per m^2. However, there was no significant correlation between the yield and any of the yield components at different yield levels.

Table 10

Correlation among yield, panicles/m^2, ripened grains/panicle and 1000 grains weight on the Direct Sowing Rice Cultivation in Pilot No. 1 and No. 2

Variety : RD - 23

Crop season : Dry , 1984.

Correlations in the yield levels and the whole

Yield level	No. of data		Correlation			
			1 (Yield)	2 (Panicles/m^2)	3 (R.grains/ panicle)	4 (1000 grains weight)
Below 3000	14	1	1.0000	0.2827	0.2391	0.4822
		2		1.0000	-0.8441**	0.2210
		3			1.0000	-0.0233
		4				1.0000
3000-4000	43	1	1.0000	0.1117	0.2644	0.0741
		2		1.0000	-0.8002**	-0.2123
		3			1.0000	-0.0665
		4				1.0000
4000-5000	49	1	1.0000	0.4299**	-0.1208	-0.1414
		2		1.0000	-0.8646**	0.0312
		3			1.0000	-0.3269*
		4				1.0000
5000-6000	25	1	1.0000	0.3751	-0.0346	-0.0170
		2		1.0000	-0.8496**	-0.0304
		3			1.0000	-0.3837*
		4				1.0000
Above 6000	5	1	1.0000	0.7705	-0.4417	-0.6636
		2		1.0000	-0.8963*	-0.9055*
		3			1.0000	0.7498
		4				1.0000
The whole	138	1	1.0000	0.4093**	0.5108**	-0.0912
		2		1.0000	-0.4950**	-0.0144
		3			1.0000	-0.2885*
		4				1.0000

Table 11

Correlation among yield, hills/m^2, panicles/m^2, ripened grains/panicle and 1000 grains weight on the Transplanting Rice Cultivation in pilot No. 1, No. 2 and Agricultiral Demonstration Centre

Variety : RD - 23

Crop season : Dry, 1984.

1. Correlation in pilot No. 1 and No. 2

Yield level (kg/ha)	No. of data		1 (Yield)	2 (Hills/m^2)	3 (Panicles /hill)	4 (Panicles / m^2)	5 (R.grains /panicle)	6 (1000 g. weight)
3000-4000	9	1	1.0000	-0.6137	0.5552	0.0913	0.3730	0.1046
		2		1.0000	-0.9394**	-0.3021	0.0517	-0.2181
		3			1.0000	0.5664	-0.3148	0.3468
		4				1.0000	-0.7912*	0.2792
		5					1.0000	-0.5763
		6						1.0000
4000-5000	29	1	1.0000	-0.0624	0.0784	-0.0007	0.2456	0.0778
		2		1.0000	-0.7559**	0.7326**	-0.6172**	-0.2833
		3			1.0000	-0.1757	0.0572	0.4018*
		4				1.0000	-0.9052**	-0.1281
		5					1.0000	-0.1094
		6						1.0000
Above 5000	17	1	1.0000	0.0662	-0.0151	0.0685	0.2347	0.3030
		2		1.0000	-0.7353**	0.7076**	-0.6500**	-0.1226
		3			1.0000	-0.0870	0.0581	0.0382
		4				1.0000	-0.9385**	-0.2080
		5					1.0000	0.2291
		6						1.0000
The whole	55	1	1.0000	0.2300	-0.0068	0.3487**	0.4782**	-0.0966
		2		1.0000	-0.7316**	0.6900**	-0.3785**	-0.2610
		3			1.0000	-0.0823	-0.0279	0.3497
		4				1.0000	-0.6081**	-0.1361
		5					1.0000	-0.1689
		6						1.0000

2. Correlation in Agricultural Demonstration Centre

Yield level (kg/ha)	No. of data		1 (Yield)	2 (Panicles / hill)	3 (Panicles / m^2)	4 (R. grains / panicle)	5 (1000 grains weight)
4000-5000	11	1	1.0000	0.3709	0.3763	0.5255	-0.0065
		2		1.0000	0.9999**	-0.5349	-0.1230
		3			1.0000	-0.5309	-0.1222
		4				1.0000	-0.2162
		5					1.0000
5000-6000	22	1	1.0000	0.0842	0.0823	0.2519	0.1151
		2		1.0000	1.0000	-0.7472**	0.1832
		3			1.0000	-0.7480**	0.1837
		4				1.0000	-0.4229
		5					1.0000
Above 6000	15	1	1.0000	0.1835	0.1793	0.3535	-0.1382
		2		1.0000	1.0000	-0.8054**	-0.1302
		3			1.0000	-0.8071**	-0.1313
		4				1.0000	-0.2397
		5					1.0000
The whole	48	1	1.0000	0.2956*	0.2938*	0.7166**	0.2812
		2		1.0000	1.0000	-0.3538	0.1216
		3			1.0000	-0.3554*	0.1212
		4				1.0000	-0.0320
		5					1.0000

Note : * Statistically significant at 5% level.

** Statistically significant at 1% level.

Table 12

Simple linear correlation coefficients, r, at the 5% and 1% levels of significance

d.f.[1]	5%	1%	d.f.	5%	1%
1	.997	1,000	26	.374	.478
2	.950	.990	27	.367	.470
3	.878	.959	28	.361	.463
4	.811	.917	29	.355	.456
5	.754	.874	30	.349	.449
6	.707	.834	32	.339	.437
7	.666	.798	34	.329	.424
8	.632	.765	36	.321	.413
9	.602	.735	38	.312	.403
10	.576	.708	40	.304	.393
11	.553	.684	45	.288	.372
12	.532	.661	50	.273	.354
13	.514	.641	55	.262	.340
14	.497	.623	60	.250	.325
15	.482	.606	70	.232	.302
16	.468	.590	80	.217	.283
17	.456	.575	90	.205	.267
18	.444	.561	100	.195	.254
19	.433	.549	125	.174	.228
20	.423	.537	150	.159	.208
21	.413	.526	175	.148	.194
22	.404	.515	200	.138	.181
23	.396	.505	300	.113	.148
24	.388	.496	400	.098	.128
25	.381	.487	500	.088	.115

[1] d.f. = n - 2, where n is the sample size

3.6 Discussion

At the present, the rice yield of RD-23 in the Centre has been expected as 5000 to 6000 kg per ha. For ensuring the yield mentioned above, the necessary numerical values of yield components of transplanting and direct sowing cultivation are as shown in table 13.

Table 13 Yield components of RD-23 at the yield level of 5-6 tons/ha

Cultivation method	Hills/m^2	Paniclas / hill	Panicles / m^2	Spikelets / panicle	% of R. grains	R.grains /panicle	1000 grains weight
Transplanting	23	15	350	95	63	60	28
Direct sowing	-	-	400	85	65	55	28

Of course, these yield components are influenced by soil fertility, management practice, climate, disease and insect control, water management, and so on. However, the number of panicles per m^2 and the ripened grains per panicle are most important yield components, and number of about 350 and 400 panicles per m^2, and about 60 and 55 ripen grains per panicle are necessary for transplanting and direct sowing cultivation respectively. Plant density, quantity of fertilizer and water management are important factors should be taken into account in order to reach to the targets.

In case of transplanting rice cultivation, the planting density of 20 to 25 hills per m^2 is necessary and the amount of nitrogen and P_2O_5 required is 80 to 100 kg per ha and 40 to 50 kg per ha respectively for the improved varieties such as RD-23. The irrigation water supply may not necessary for the period from the maximum tillering stage to 4 to 5 days after panicle initiation stage, and from about 2 weeks after flowering completed to harvest. But, sufficient irrigation water should be supplied during other growing stages.

If moisture stress occurs during the period from the reduction division stage to the completion of flowering, it will increase the unripened grains and on the contrary, 1000 grains weight will be decreased.

In case of direct sowing rice cultivation, 80 to 100 kg per ha of seed quantity is required and water supplied for the field preparation should be drained out just before sowing. Then, water supply is not required for about 7 to 14 days after sowing, because it ensures the establishment of seedlings in proper density. The amount of fertilizer and water management are same as those for transplanting rice cultivation.

Table 14 shows the yield of RD varieties obtained from the experiments of no fertilizer application conducted at Agricultural Demonstration Centre in the dry season of 1982 and 1983.

When the proper planting density of 22 to 25 hills per m^2 for RD-23 was ensured and enough amount of irrigation water was supplied, the yield of 3500 to 4000 kg per ha was obtained without fertilizer in Mae Klong area (please be refered to the Report of the Paddy Cultivation in the Dry Season, 1982 and 1983).

Table 14 Yield of no fertilizer application rice culture at Agricultural Demonstration Centre in dry season

Variety	Yield (kg/ha)	
	1982	1983
RD-7	3,075	2,519
RD-21	4,362	3,760
RD-23	4,181	3,473

Table 15 shows the variance of samples, grouped in planting type and yield level, in percentage in the pilot areas and Agricultural Demonstration Centre.

Table 15 Variance (%) of samples by planting method and yield level

(%)

Sampling plane	Planting method	Yield level (ton/ha)				
		Below 3	3-4	4-5	5-6	Above 6
Pilot No.1,No.2	Direct sowing	10.1	31.2	35.5	18.1	5.1
	Transplanting	0	16.4	52.7	30.9	0
A.D. Centre	Direct sowing	0	0	20.7	80.0	0
	Transplanting	0	0	22.9	45.8	31.3

Fig. 1 and Fig. 2 show the variance of yield, panicles per m^2, ripened grains per panicle and 1000 grains weight of direct sowing and transplanting rice cultivation.

The yield of direct sowing rice cultivation in the pilot area ranged widely, from the lowest of 1413 kg per ha to the highest of 7026 kg per ha, number of samples in below 3000 kg per ha and in 3000 to 4000 kg per ha shared 10.1% and 31.2% to the whole samples recpectively, then fluctuation of numerical value of yield components also ranged widely comparing with those of the transplanting rice cultivation in the pilot areas and Agricultural Demonstration Centre.

As mentioned above, when RD-23 was planted, it was proved that the yield of 3500 to 4000 kg per ha could be obtained even without fertilizer application. Nevertheless, for the direct sowing rice cultivation in the pilot areas, the fields obtained yield under 4000 kg per ha shared 40% of the whole fields. There must be many causes to the low yield. Those causes may be due to the followings, and there may be only one cause but sometime, there

may be two or more causes accumulated in relation to the low yield. The causes presumed were :

1) Seed rate, hastening of germination and sowing were not adequate.
2) Field preparation (leveling, puddling, planking) was not suitable.
3) Water management was not properly practiced especially the drainage at the sowing time and the irrigation water supply during the period of rice growing.
4) Weed was not properly controlled.

Fig. 1 Variance of samples in yield level

dry season, 1984.

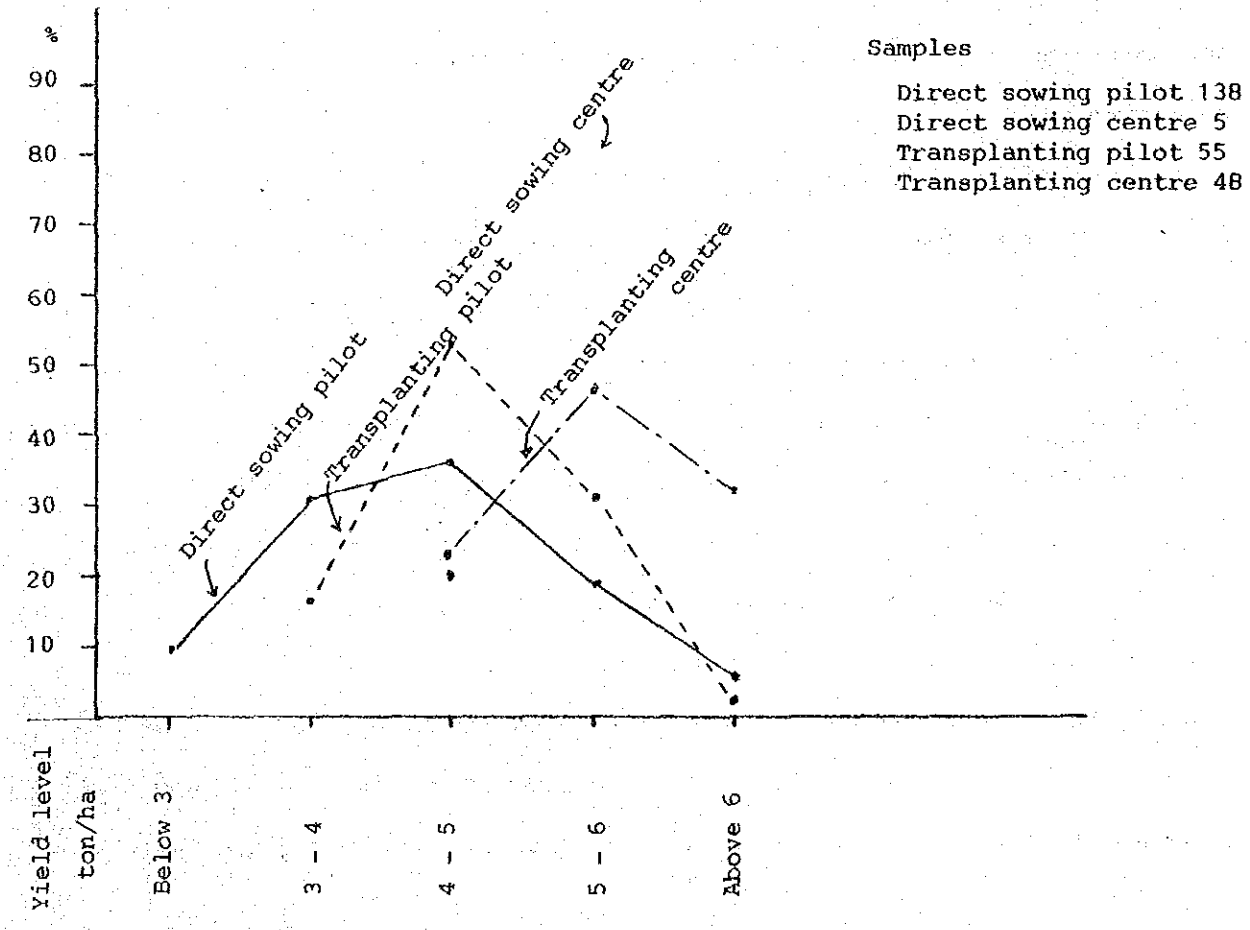
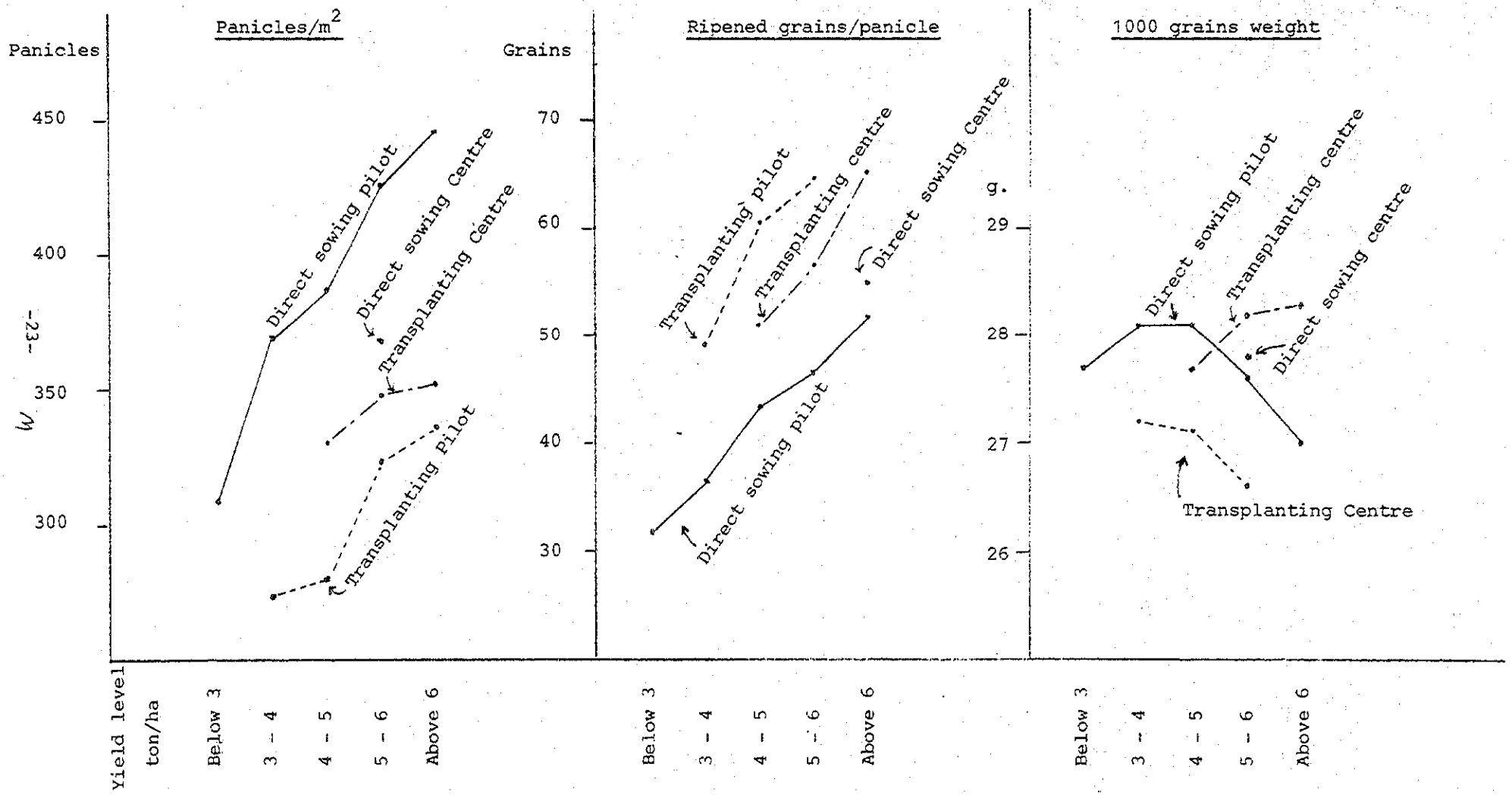


Fig 2 Variance of yield components in yield level

dry season, 1984

Samples D.sowing 138
D.sowing centre 5
Transplanting pilot 55
Transplanting centre 48



II. ADVANTAGES AND DISADVANTAGES OF DIRECT SOWING RICE CULTIVATION

1. Advantages of Direct Sowing Rice Cultivation

The advantages of direct sowing rice cultivation are as follows :

1) If apply appropriate farming techniques, the high yield of 5000 to 6000 kg per ha can be obtained, which is not inferior to the yield of transplanting mehtod.

2) Rice and sugarcane are main crops in Kanchanaburi Province. And the harvesting work of sugarcane (Deeember-April) falls on the field preparation and transplanting works of rice cultivation (February-March). It temporarily cause the shortage of labour and the wage will rise up. However, if farmers apply the direct sowing rice cultivation, the uprooting and transplanting, which require many labours in the short period, can be left out from the rice growing process. Thus, the need of labour can be saved and the competition of labour recruitment can be relieved.

3) If farmers apply the direct sowing rice cultivation in the dry season, the growth duration of rice can be shortend by about 10 days. Then, farmers can plant the wet season rice on good time without any delay of field preparation.

4) The profit can be increased because the some process such as raising of seedling, uprooting, transplanting can be left out.

Table 16 Land utilization in Kanchanaburi Province

	Farmland	Paddy	Sugarcane	Others
Area (ha)	276,400	48,606	156,465	71,329
(%)	100	17.59	56.6	25.81

Source : Agricultural Statistics of Thailand, Crop year 1981/82.

2. Disadvantages of Direct Sowing Rice Cultivation

1) For the direct sowing rice cultivation, irrigation water should be controlled freely, otherwise it is difficult to expect a steady high yield. For that reason, the direct sowing rice cultivation shall be limited to the area where the land consolidation has been completed or the field with the similar conditions. Still more, most of the fields of these conditions are suitable for the rice double croppings as well.

2) For the field leveling, it will be required higher accuracy than that for the transplanting cultivation field. The difference of undurations in a plot is prefered to be within $\pm$ 5 cm.

3) If farmers apply the direct sowing rice cultivation in rainy season, there is high possibility to be visited by the heavy rainfall with strong wind in soon after sowing, thus the establishment of seedling in uniformity and high rate will apt to be hindered. Therefore, it is recommendable to apply transplanting cultivation method as much as possible in rainy season.

4) If farmers apply the direct sowing rice cultivation thoughout both of rainy and dry seasons continuously for several years, the weed will grow thicker year by year remarkably, and it will be required high techniques in weed control.

5) More seed quantity is required compare with that of transplanting.

III. IMPORTANT TECHNIQUES OF DIRECT SOWING RICE CULTIVATION

1. Field Preparation

1.1 Working Process of Field Preparation

On the field in the area where land consolidation was completed, irrigation water is supplied according to the rotational irrigation schedule provided by Royal Irrigation Department, and the field preparation works such as ploughing, puddling and planking can be finished in 30 to 40 days.

The standard working schedule from the commencement of irrigation water supply to sowing is shown in the table 17.

Table 17 Standard field preparation schedule from commencement of irrigation water supply to sowing

Works	Totalized days from commencement of irrigation water supply		Interval between working processes (days)	
	Method I	Method II	Method I	Method II
Commencement of irrigation	1	1		
Ploughing	5	7	5	7
1st puddling and leveling	12	17	7	10
2nd puddling and planking	19	27	7	10
Herbicide application	21	29	2	2
Drainage	25	33	4	4
Making drainage furrow	26	34	1	1
Sowing	27	35	1	1

1.2 Ploughing

Generally, soil in this Mae Klong area is heavy soil, which contains about 50 percent of clay and silt. It becomes impossible conditions of ploughing by the power tiller in the dry season because of the solidified soil. The ploughing can be performed only under the flooded condition, and commonly, the field can be ploughed 2-3 days after irrigation water supply.

Ploughing is mainly conducted by the power tiller or tractor. As to their attachments, it is better to use the disc plough or reversible bottom plough than the rotavater. Because, if the disc plough or bottom plough is used as the attachment of power tiller or tractor, the rice straws and weeds are efficently ploughed in and render easiness to the later works of puddling and planking. (The high level cutting is the common practice of harvesting rice in Thailand so that 1/3 to 1/2 of straws are left in the field).

1.3 Puddling and Field Leveling

The 8 to 12 HP class power tillers have been mainly used for the works of puddling, field leveling and planking in this Mae Klong area. When using the power tiller for puddling, leveling and planking, the wheels of power tiller should be changed to cage type wheel with wide width. And as the attachment of power tiller, it is better to use the rotavator for puddling and the leveler for leveling and planking. However, most of the farmer in Mae Klong area, have been used power tiller with common type of paddy wheel and only the rake as attachment for puddling and planking. For that reason, working efficiency is poor, and it is also difficult to make nice finishing of field preparation. (Common type paddy wheel is good for ploughing)

When using the tractor, it is advisable to use the rotavator for the puddling and the drive harrow for the leveling and planking. Of course, it is

required to attach the paddy wheel suitable to the tractor size and the soil condition. If the drive harrow is not avilable drawing a log on the back of the rotavator is one of the substituting ways for the leveler.

1.4 Accuracy of Field Leveling

The accuracy of field leveling is prefered to be not exceeding ± 5 cm. In case of too great unduration in a plot and difficult to make good leveling in a short time, it is advisable to make temporary levees to divide the plot into several plots for the easement of leveling work.

1.5 Drainage Furrow

Ensuring the homogenous emergency of seedlings and uniform plant density is one of the key points to obtain the steady high yield by the direct sowing rice cultivation. For that reason, before the sowing in conducted, it is important to make drainage furrow so as to not let the puddle water ramain in the lower place of the plot and the water should be simultanously and quickly drained out. The drainage furrow should be the depth of 5 to 10 cm and the width of about 30 to 40 cm, then the suitable interval between the furrows would be about 6 to 8 m. At the time of digging the furrow, they are easily made by drawing the pottery pot in a diameter of 30 to 40 cm tightened with a rope. The drainage furrows are not only helping in draining water but also giving the good marks at the time of fertilizer and chemical applications.

1.6 Effect of Weed Control at the Field Preparation

As mentioned in the working process of the field preparation, the period of field preparation in relation to the rotational irrigation schedule is estimated about 30 to 40 days, and there are intervals of 5 to 10 days between each of working processes from commencement of irrigation water supply to 2nd puddling and planking. During the field preparation, most of weed

seeds, which have been laid on the surface of field soil, germinate and grow, but these weeds cna be ploughed in and controlled by the works of ploughing, puddling and planking.

2. Other Important Points of Direct Sowing Rice Cultivation

2.1 Variety

For the dry season crop, RD-23 is the main variety, and other nonphotosensitive varieties such as RD-7, Rd-21 can be also used. Applying the direct sowing rice cultivation in the rainy season is not adisable (The reason has been mentioned in the disadvantages of direct sowing rice cultivation). But, if apply the direct sowing rice cultivation in rainy season, the photosensitive variety such as Khao Dok Mali 105, Khao Pak Mor 148, Luang Pratew 123, etc. in addition to the RD varieties mentioned above can be also used. However, harvesting time of photosensitive varieties has no relation to the sowing time but the flowering time of each variety is decided by the response of the variety to the natural day length. Generally, the optimum growth duration from sowing to flowering has been considered about 90 days. Therefore, the sowing time should be determined by calculating back from the expective flowering date. Early sowing of photosensitive local varieties in rainy season not only causes the nutrition stagnation in the vegetative growth period but also increases the plant height, then it causes the lodging in the early ripening stage. Further, it is necessary to conduct germination test to all of the seed before sowing. The seed in germination rate of under 80% shall no be used as seed. In case of the seed of RD varieties harvested in the dry season is continuously used in the rainy season, it is necessary to conduct germination test to confirm whether the dormancy is expired or not.

July, 1983.

Table 18 Characteristics of recommended rice varieties for the Mae Klong Pilot Project

I. Season free (Non photosensitive variety)

Variety	Glute-nous	G.duration or H. date	Plant height (cm)	Grain quality (mm)			Chalkiness	Cooking Quality	Diseases Resistant					Insects Resistant				Dormancy (days)	Fertilizer response	Yield Potentiality/rai (kg)	Crossing
				Length	Width	Thick			BL	BLB	GSV	YOLV	RES	GLH	BPH	SB	GM				
1. RD - 7	Non	125	115	7.3	2.3	1.8	L	S	MS	R	S	R	S	S	S	S	S	7	High	672	C4-63/GR88/Sigadis
2. RD - 9	Non	120	115	7.3	2.3	1.8	L	H	S	S	S	MS	S	R	R	R	R	35	High	657	CNT3176/EK1256/RD2
3. RD - 11	Non	135	115	7.5	2.3	1.8	L	H	MR	S	MR	S	S	MR	S	S	S	28	High	730	IR661/KDML105
4. RD - 21	Non	125	110	7.35	2.3	1.8	L	S	MR	R	S	S	R	S	R	S	S	24	High	666	KDML105/nms-4/IR26
5. RD - 23	Non	120	115	7.44	2.2	1.8	L	S	MR	R	S	S	R	S	R	S	S	32	High	715	RD7 x IR32/RD1
6. RD - 25	Non	100	100	7.36	2.26	1.79	M	H	MR	MR	S	S	R	S	MR	MR	S	28	High	538	KDML105/IR2061/KDML105/IR26

II. Rainy season only (Photo sensitive variety)

1. Khao Dok Mali 105	Non	Nov.21	138	7.5	2.1	1.8	L	S	S	S	S	S	S	S	S	S	S	56	Low	363	
2. Nang Mol S - 4	Non	Nov.26	160	7.7	2.4	1.8	L	S	S	MR	S	S	S	-	S	S	-	35	Low	436	
3. Khao Pak Mor 148	Non	Dec. 3	140	7.6	2.3	1.9	L	S	MR	S	S	S	S	-	S	S	-	42	Low	415	
4. Luang Pratew 123	Non	Dec.19	150	7.6	2.3	1.8	L	S	R	S	S	S	S	S	S	S	S	42	Low	414	
5. RD - 27	Non	Dec.15	160	7.5	2.3	1.8	L	S	S	S	S	S	MR	S	S	S	S	35	Low	517	

Note : 1. G. duration :- Growth duration, H. date :- Harvesting date

2. Cooking quality : H :- Hard, M :- Medium, S :- Soft, A :- Aroma

3. Diseases : BL :- Blast, BLB :- Bacterial leaf blight,
GSV :- Rice grassy stunt, YOLV :- Yellow orange leaf virus
RSV :- Rugged stunt virus

4. Insects : GLH :- Green rice hopper, GM :- Rice Gall Midge
BPH :- Brown plant hopper
SB :- Stem borer

5. Resistant : R :- Resistant, MR :- Medium resistant, MS :- Medium susceptable
S :- Susceptable.

Table 18 shows the charateristics of the recommended varieties in the Mae Klong area.

2.2 Quantity of Seed

Based on the experiment conducted at Agricultural Demonstration Centre (Table 19) and observation of the farmer fields, the adequate quantity of seeds required for the direct sowing rice cultivation in the Mae Klong area is 80 to 100 kg per ha. The quantity of seeds mentioned above is 2 to 3.3 times higher than the quantity required for the mechanized transplanting (30 kg/ha) or for the manual transplanting (40 kg/ha, in lowland rice nursery).

Table 19 Result of analysis on seed rate and N level for the yield of direct sowing paddy cultivation, rainy season 1982. (Variety: RD-23)

Duncan's multiple range test among seed rate

Seed rate/rai	Yield (kg/ha)	5% level
8	3,265.41	b
16	3,654.00	a
24	3,614.37	a

Duncan's multiple range test among N level

N level/rai	Yield (kg/ha)	1% level	5% level
0	2,718.05	c	c
8	3,739.41	ab	b
16	4,103.16	a	a
24	3,484.41	b	b

Note : Means followed by a common letter are not significantly different.

The following is one of the calculations regarding the seed rate and effective panicles to get the yield of 5000 to 6000 kg per ha (RD-23 as planting variety).

In order to obtain the yield of 5000 to 6000 kg per ha, the effective panicles per m^2 should be about 400 panicles in direct sowing and about 350 panicles in transplanting rice cultivation.

Assuming that the germination rate is 85%, and the seedling establishment rate is 80% for the direct sowing and manual transplanting, and 95% for mechanized transplanting rice cultivation, then the effective panicle must be obtained from a established plant is 1.65 panicles for the direct sowing, 3.6 panicles for the manual transplanting, and 4.1 panicles for the mechanized transplanting rice cultivation. Table 20 shows the calculation regarding the seed rate and effective panicles per plant. According to this calculation, if seed of 100 kg per ha is used for the direct sowing cultivation, the seedling established per m^2 is 240 seedlings and effective panicles per plant is merely almost 1.7 panicles. This is apparently due to the dense planting and most of tillers grown in the vegetative growth period become non productive tillers. The dense planting is one of the most effective measurement to suppress the weed in the early stage of rice growing. But, if seed rate exceed the level of 100 kg per ha, over abundant seedlings are established, which cause lodging of the rice plant in the early ripening stage, and the ripened grains per panicle decrease, then the increment of production can not be expected.

Table 20 Seed rate and effective panicles/plant (calculation)

Variety : RD-23

1000 grains weight : 28.0 g or 35.7 seeds/g

Germination rate : 85%

Yield target : 5000 - 6000 kg/ha

Target of panicles/m^2 : Direct Sowing : 400, Transplanting : 350

	Direct sowing	Traditional transplanting	Mechanized transplanting
Seed amount (kg/ha)	100	40	30
Seed rate (g/m^2)	20	4	3
Establishment rate (%)	80	80	95
Seedlings established/m^2	243	97	86
Planting density (hills/m^2)	-	23	23
Planting seedlings/hill	-	4.2	3.7
Effective panicles required/hill	-	15.2	15.2
Effective panicles/plant	1.7	3.6	4.1

2.3 Hastening of Germination

The proper period for the seed soaking treatment is 48 to 72 hours and another 24 to 36 hours is required for the hastening of germination. Generally, sowing the seed of the plumule shoots of about 1 mm and radicle shoots of about 2 to 3 mm is recommendable.

Some farmers soak the seeds merely one day, thus they do not uniformly germinate, because the seeds unable to absorb enough moisture for germination in a day. On the other hand, some farmers sow the seeds of the radicle grown to about 15 to 20 mm. In such a case, especially in dry season, the rate of

seedling establishment becomes lower because of withering of the germinated seeds by strong sunshine.

As to the other treatments, such as seed selection, seed disinfection, etc. are same as those for the transplanting rice cultivation.

2.4 Sowing

Draining water from the paddy field should be done in the evening of prior day of the sowing or in the early morning of the day of sowing. In order to complete the draining, the drainage furrows should be digged in the field, then drain water much as possible until no puddls are left at the lower place in the field.

In case of sowing in dry season, it is recommended to sow the seeds after 15:00 hours. This is a very effective action of protecting the growing point of radicles from the strong sunshine and increasing the emergence rate of seedlings.

In rainy season, it is apt to meet with strong shower in the time from afternoon to the night. Therefore, the drainage should be completed in the preceding day of the sowing and it is better to sow the seeds at the time of calm morning in the following day. Of course, sowing should be done as much uniformly as possible.

2.5 Gap filling

It is quite difficult to level the paddy field thoroughly. Even after the final planking, some parts of the field are still not well levelled. During the puddling and planking, the very soft mud are apt to accumalate to the lower places. Therefore, these lower places will not become the suitable soil condition for sowing though the drainage just conducted.

If the seeds are sown on these paddled places, they sink into the

muddy soil and oxygen supply is shut out. Most of the seeds will be rotten, thus will hampere the establishment of seedlings conspicuously.

For this reason, the complimentary transplanting or reseeding is required. It is advisable to do reseeding at the time of 2 to 3 days after the initial sowing, because the muddy soil in the lower places will be dried for some extent and the seed will not sink into the muddy soil anymore. Besides, the soil still contains enough moisture for rice growing.

It is better to provide the nursery on a small scale in a certain place beforehand to procure the seedlings for the complimentary transplanting. The seeding on the nursery would be performed 1 to 2 weeks before direct sowing, thus the rice will be ripen at the same time. (Refer to growth duration of direct sowing rice cultivation)

2.6 Water Management

As it was mentioned above, water should be drained just before sowing and not be supplied about 1 to 2 weeks or until the young plants are completely established. Of course, the suspension period of water supply will be varied according to the soil texture, weather and growing condition of seedlings. Same as transplanting rice cultivation, irrigation water supply is not required during the period from late vegetative growth stage to panicle initiation stage and from 2 weeks after flowering. But enough water should be supplied during the time from booting stage to the completion of flowering, in order to not let the water stress occures.

2.7 Fertilizer Application

The quantity of fertilizer to be applied varies depending on the soil fertility and the variety planted. The standard quantity of fertilizer for the RD varieties in the Mae Klong area will be about 80 to 100 kg per ha

of nitrogen and 40 to 50 kg per ha of P_2O_5. On the other hand, for the photosensitive local varieties, about 40 kg per ha each of nitrogen and P_2O_5 are adequate amount. In general, all amount of P_2O_5 should be applied as the basal fertilizer and nitrogen should be applied with a half as the basal and other half as the top dressing.

According to the result of experiments conducted at the 3 sub-projects of Irrigated Agriculture Development Project (Mae Klong, Suphanburi and Chao Phya), the application of basal fertilizer at the time of 2 to 3 weeks after sowing obtained higher yield. The top dressing at the panicle initiation stage is most effective to obtain high yield. However, there is also one of the application ways, that divides the top dressing nitrogen into two and apply at the panicle initiation and heading stages. Further, although the basal fertilizer was applied, if remarkable sympton of manurial deficiency happens in the vegetative growth period, it is advisable to apply top dressing at 4 to 5 weeks after sowing. In either case, the quantity of top dressing fertilizer and application time will be determined on the growth condition of the paddy.

2.8 Weed Control

Weed control is one of the biggest problems associated with the direct sowing rice cultivation, and finding out more effective and easier method of weed control is the important subject should be studies in the future. As mentioned above, the growing of weed can be suppresses to a certain extent by the field preparation such as ploughing, puddling, planking, etc. and the dense planting through the increment of quantity of sowing seed, but such works are not sufficient. Therefore, the application of herbicide is required. Regarding the application of herbicide, there are two application ways, viz. before sowing and after sowing. In Mae Klong Pilot Project, the application of before sowing has been recommended. To ensure the effects of herbicide,

following processes should be practiced.

1) After the final planking, supply water up to a depth of about 100 mm and. During the water supply, of course, the out let of the field should be entirely closed, and also prevent leakage of water through the holes made by crabs or rodents.

2) After enough water supplied, the inlet of the field should be entirely closed and keep the flooded condition for 1 to 2 days. The period let the soil particles, which are floating in the water, set to the bottom.

3) After most of the soil particles have settled, apply Saturn G. or Machete uniformly at the rate of 30 to 35 kg per ha and leave for 3 to 4 days.

4) After 3 to 4 days, drain water in the field and start sowing.

The daily water requirement in the Mae Klong area is about 10 mm in dry season. It means that 6 days after supplying water, there is about 30 to 40 mm of water remained in the field, provided water management was well. In case of that water leak out in 1 or 2 days after herbicide application, the effect of weed suppression will be poor. Table 21 shows the rate of seedling establishment after Saturn G. application. If the weeds are effectively controlled by herbicide at the begining of rice growing, one tiem handweeding afterward will be quite enough to control the rest of weeds.

In the direct sowing rice cultivation the application of herbicide after sowing is not recommended. Generally, water is not supplied for 1 to 2 weeks after direct sowing, then the application time of herbicide will be delayed, as the result effects of weed control will be lessened. Some farmers apply 2.4 - D to the young plant, but it should be suspened, because the crop injury is apt to occures.

Table 21 Application of Saturn G. and establishment rate of seedlings in direct sowing rice cultivation, dry season, 1980.

Unit : Established seedlings/m

Saturn G. (kg/rai)	Days before sowing	Block					Mean	% of Establishment.
		I	II	III	IV	V		
7	9	183	172	188	198	191	186.4	74.6
7	6	204	196	233	207	182	204.4	81.8
7	3	149	129	147	160	141	145.2	58.1 **
5	9	171	224	226	237	214	214.4	85.8
5	6	178	189	221	179	198	193.0	77.2
5	3	198	206	160	178	151	178.6	71.4 *
0	0	207	191	238	184	207	205.4	82.2

Note : 1. Variety = RD - 7
Weight of 1,000 grains :- 32 g
Germination rate :- 96.7 %

2. Seed rate = 8 g/m^2 or 250 grains/m^2

3. Treatment
Saturn :- amount of Saturn G. applied kg/rai
Sowing :- days after application of Saturn G.

4. ** : 1 % level of significance
* : 5 % level of significance

2.9 Crabs and Rodents Control

The control of disease and insect is performed as that in the transplanting rice cultivation.

There are heavy damages from the crabs and rodents in this Mae Klong area. The control of rodents shall be conducted by the cooperative control

before the commencement of dry season crop, because it is one of the most effective control way. At that time, the germinated seed of paddy sprinkled with zine phosphide or Fratol will be taken by the rodents at the high rate.

As to the control of crabs, it is effective to apply the solution of 500 to 1000 times of Sumithion emulsion and solution of 500 times of water dispersible Heptachlor alternatively along the levees in width of 1 m at the time before or after the puddling.

IV. MECHANIZED DIRECT SOWING RICE CULTIVATION

In case of conducting direct sowing rice cultivation on a large area, it is advisable to use the tractor (30-60 HP) attached with the broadcaster. The seeds put in the container of broadcaster, instead of fertilizer are broadcasted by the tractor. It is not only quite efficient method of sowing work but also able to obtain more uniform density than manual work, and it requires only 20 minutes for a hectare.

Between the mechanized direct sowing and manual direct sowing of rice cultivation, there are differences in hastening of germination and water management during the sowing time.

The different points are stated as follows :

1) It requires about 48 hours for the hastening of germination, because it is necessary to grow the radicles reaching about 10 to 15 mm. A great deal of seeds are handled for the hastening of germination at the same time, and it takes more time than that of the manual direct sowing. Therefore, so as to obtaining the uniform growth of plumules and radicles, it is necessary to turn over and stir the seeds 2 to 3 times a day during the treatment of hastening of germination (to avoid over heater and ununiform germination).

2) In order to prevent the breaking of plumules and radicles at the time of sowing, the seeds after the process of hastening of germination will be spreaded on the earth floor or concrete in the shed in thin layer for air-dry in about 3 to 6 hours untill the radicles turn soft and they will be nearly no broken though rough handling is given.

3) After herbicide application for 4 to 5 days, the sowing will be done on the flooded condition at a depth of over 10 cm. If the seeds are spreaded by the broadcaster loaded on the tractor, the seeds will spreaded in violent speed. However, if the field is flooded condition, the water can buffer the

shock and then the seeds will sink gently from the surface of water to the surface of the soil and, at this time, the radicles grown long will support to prevent the seeds from sinking into the muddy soil.

4) Water in the field shall be drained 2 to 3 days after sowing. At the time of drainage, the wheel track made by the running of tractor can be used as drainage furrows. Therefore, the small drainage furrows, which only join the wheel tracks and out-let, digged by hands will be sufficient.

5) According to the result of experiment conducted at Agricultural Demonatration Centre regarding the establishment rate of germinated seed sown on the flooded field, if the seed has not been sank into the muddy soil and the flooded period is within 5 days, the establishment rate of seedlings is not much different. However, if the flooded period exceed 5 days, the floating seedlings and overturned seedlings will be increased rapidly and the establishment rate will decrease accordingly.

6) Table 22 shows the specification of tractor and broadcaster used in the rainy season 1983 at Agricultural DEmonstration Centre and Table 23 shows the standard schedule of field preparation and management on the basis of sowing. Fig. 3 shows the running way of the tractor at the sowing time.

Table 22 Specification of tractor and broadcaster on operation of direct sowing (conducted wet season 1983, Agricultural Demonstration Centre)

1. Tractor : ISEKI T-35 (35 HP)

   Tractor speed : 1st gear, high position, 1.48 m/sec on the paved road

   Engine r.p.m. : 2000

2. Broadcaster : STAR GH - 250

   Form : Granule

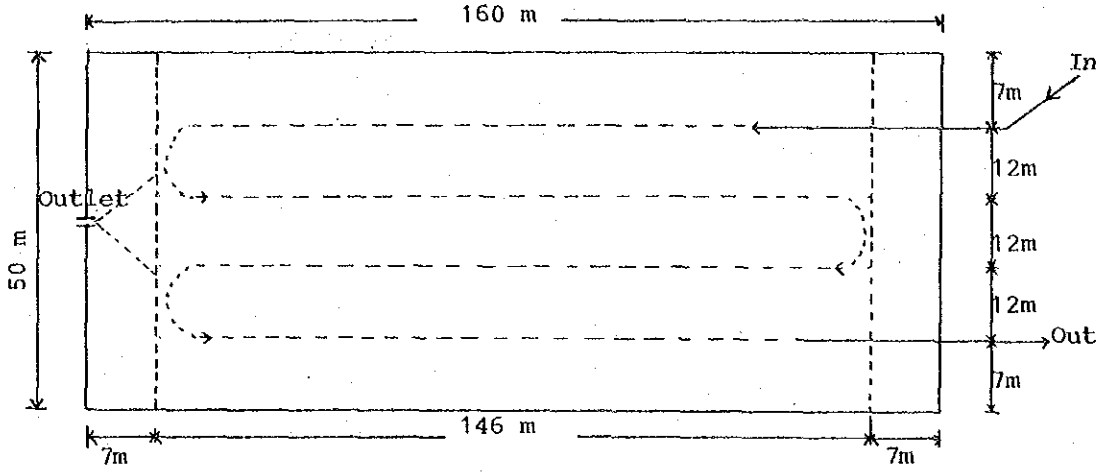
   Shutter inden : No. 7

   P.T.O. r.p.m. : Hign speed position

Table 23 Standard schedule of field preparation and managment on Mechanized Direct Sowing (Agricultural Demonstration Centre)

Work	Days from sowing
- 1st rotavating and puddling	- 10
- 2nd puddling and planking	- 5
- Herbicide application (Saturn G., 5 kg/rai)	- 4
- Sowing (Broadcasting)	0
- Drain out water	+ 2
- Insecticide application (Furadan, 5 kg/rai)	+ 7
- Basal fertilizer application (Am. Phos, 30 kg/rai)	+ 16 - 20
- Gap filling	+ 17 - 21
- Top dressing 1st (Am. Sulphate, 20 kg/rai)	Panicle formation
- Top dressing 2nd (Am. Sulphate, 20 kg/rai)	Booting - Flowering

Fig. 3 Running way of Tractor on the sowing



Appendix Datas of yield, yield component and correlation

Variety : RD - 23

Crop season : Dry season, 1984.

1. Direct sowing rice cultivation in pilot No. 1 and No. 2

1.1 The whole

Corration
DATA

	Yield	pa/m	rg/pa	1000 gw
1	2907.00	453.00	23.30	27.60
2	2793.00	426.00	23.20	28.20
3	2562.00	247.00	37.70	27.50
4	2976.00	244.00	42.80	28.50
5	2875.00	224.00	46.00	27.90
6	2084.00	245.00	31.50	27.00
7	2375.00	232.00	38.90	26.30
8	2457.00	457.00	28.80	28.60
9	2557.00	399.00	24.30	26.40
10	2781.00	306.00	33.50	27.10
11	2843.00	214.00	43.80	30.30
12	2481.00	199.00	47.40	26.30
13	1431.00	211.00	25.40	26.70
14	2653.00	484.00	19.00	28.80
15	3837.00	519.00	26.20	28.20
16	3967.00	318.00	43.30	28.80
17	3853.00	408.00	34.60	27.30
18	3832.00	330.00	39.60	29.30
19	3939.00	481.00	27.30	30.00
20	3232.00	272.00	40.70	29.20
21	3892.00	339.00	41.00	28.00
22	3250.00	364.00	32.90	27.10
23	3738.00	282.00	49.30	26.90
24	3090.00	312.00	36.30	27.30
25	3468.00	560.00	22.00	28.20

26	3737.00	442.00	30.30	27.90
27	3286.00	398.00	30.00	27.50
28	3709.00	426.00	31.50	27.60
29	3593.00	384.00	32.90	28.40
30	3132.00	300.00	37.30	28.00
31	3689.00	428.00	30.60	27.40
32	3101.00	365.00	29.00	29.30
33	3387.00	287.00	40.70	29.00
34	3000.00	346.00	30.10	28.80
35	3995.00	288.00	39.60	30.50
36	3873.00	379.00	37.00	27.60
37	3829.00	260.00	50.60	29.10
38	3636.00	369.00	32.30	30.00
39	3239.00	392.00	29.10	28.40
40	3998.00	597.00	24.20	27.70
41	3283.00	359.00	32.40	28.80
42	3044.00	292.00	38.00	27.40
43	3964.00	386.00	36.90	27.80
44	3187.00	357.00	22.20	27.70
45	3701.00	385.00	34.30	28.00
46	3442.00	329.00	33.70	31.00
47	3791.00	313.00	44.20	27.40
48	3705.00	382.00	33.70	28.80
49	3675.00	329.00	41.28	27.10
50	3987.00	298.00	50.30	26.60
51	3084.00	358.00	29.00	29.70
52	3940.00	371.00	37.30	28.50
53	3456.00	385.00	34.40	26.10
54	3943.00	410.00	34.80	27.60
55	3084.00	250.00	45.20	27.30
56	3128.00	666.00	18.60	25.30
57	3617.00	202.00	65.80	27.20
58	4755.00	657.00	26.10	27.70
59	4723.00	447.00	38.80	27.20
60	4467.00	302.00	48.10	29.00
61	4112.00	372.00	38.50	28.70

62	4590.00	299.00	53.90	28.50
63	4963.00	416.00	45.70	26.10
64	4546.00	304.00	50.20	29.80
65	4963.00	362.00	45.50	30.10
66	4827.00	325.00	52.10	28.50
67	4133.00	281.00	51.20	28.70
68	4257.00	391.00	35.00	31.10
69	4217.00	400.00	33.50	31.50
70	4292.00	280.00	51.10	30.00
71	4238.00	311.00	47.50	28.70
72	4761.00	573.00	26.10	31.80
73	4214.00	497.00	28.20	30.00
74	4577.00	414.00	40.20	27.50
75	4217.00	250.00	60.70	27.80
76	4457.00	398.00	37.70	29.70
77	4418.00	369.00	41.60	28.80
78	4138.00	274.00	51.50	29.30
79	4207.00	325.00	47.10	27.50
80	4290.00	271.00	65.20	26.10
81	4266.00	377.00	42.00	27.60
82	4134.00	345.00	43.90	27.30
83	4040.00	412.00	33.20	29.50
84	4592.00	352.00	46.10	28.30
85	4390.00	360.00	43.10	28.30
86	4832.00	447.00	38.30	28.20
87	4951.00	602.00	28.20	28.60
88	4457.00	449.00	38.60	25.70
89	4114.00	474.00	32.30	26.90
90	4209.00	373.00	43.40	26.00
91	4297.00	432.00	34.70	28.70
92	4933.00	381.00	45.80	28.30
93	4494.00	386.00	43.40	26.80
94	4339.00	435.00	34.90	28.60
95	4337.00	287.00	53.80	28.10
96	4875.00	499.00	37.10	26.30
97	4748.00	306.00	56.20	27.60

98	4850.00	608.00	29.80	26.80
99	4255.00	299.00	51.40	27.70
100	4577.00	545.00	31.30	26.80
101	4579.00	209.00	84.90	25.80
102	4397.00	392.00	30.50	27.70
103	4865.00	423.00	41.10	28.00
104	4111.00	280.00	56.00	26.20
105	4630.00	326.00	55.70	25.50
106	4829.00	497.00	36.70	26.50
107	5696.00	464.00	43.40	28.30
108	5555.00	419.00	47.50	27.90
109	5092.00	448.00	39.90	28.50
110	5428.00	491.00	39.30	28.10
111	5087.00	327.00	54.60	28.50
112	5265.00	417.00	45.40	27.80
113	5018.00	338.00	48.80	30.40
114	5491.00	350.00	59.20	26.50
115	5300.00	450.00	40.80	28.90
116	5858.00	370.00	53.90	29.40
117	5831.00	541.00	38.00	28.40
118	5131.00	395.00	51.80	25.10
119	5686.00	499.00	39.40	28.90
120	5043.00	375.00	50.40	26.70
121	5475.00	424.00	46.40	27.80
122	5841.00	463.00	47.60	26.50
123	5725.00	386.00	54.70	27.10
124	5363.00	422.00	42.40	30.00
125	5913.00	455.00	48.30	26.90
126	5176.00	431.00	41.60	28.90
127	5452.00	355.00	60.00	25.60
128	5298.00	360.00	57.90	25.40
129	5334.00	486.00	41.40	26.50
130	5313.00	455.00	47.50	25.50
131	5460.00	572.00	36.90	25.90
132	7026.00	477.00	54.40	27.10
133	6889.00	584.00	39.30	30.00

134	6562.00	422.00	55.10	28.20
135	6050.00	448.00	49.60	27.20
136	6086.00	400.00	59.40	25.60
137	6034.00	361.00	65.80	25.40
138	6099.00	372.00	64.00	25.60

No. of Data = 138

No. of Variables = 4

	Mean
1	4269.19
2	384.27
3	41.22
4	27.91

	Varianc	S.D
1	1047010.00	1023.23
2	9119.19	95.49
3	123.62	11.12
4	1.92	1.38

Covariance

	1	2	3	4
1	1047010.0	39990.6	5811.4	-129.2
2	39990.6	9119.2	-525.6	-1.9
3	5811.4	-525.6	123.6	-4.4
4	-129.2	-1.9	-4.4	1.9

Correlation

	1	2	3	4
1	1.0000	0.4093**	0.5108**	-0.0912
2	0.4093	1.0000	-0.4959**	-0.0144
3	0.5108	-0.4950	1.0000	-0.2885*
4	-0.0912	-0.0144	-0.2885	1.0000

1.2 Yield levels

Cooration

DATA

	Yield	pa/m	rg/pa	1000 gw
1	2907.00	453.00	23.30	27.60
2	2793.00	426.00	23.20	28.20
3	2562.00	247.00	37.70	27.50
4	2976.00	244.00	42.80	28.50
5	2875.00	224.00	46.00	27.90
6	2084.00	245.00	31.50	27.00
7	2375.00	232.00	38.90	26.30
8	2457.00	457.00	18.80	28.60
9	2557.00	399.00	24.30	26.40
10	2781.00	306.00	33.50	27.10
11	2843.00	214.00	43.80	30.30
12	2481.00	199.00	47.40	26.30
13	1431.00	211.00	25.40	26.70
14	2653.00	484.00	19.00	28.80

No. of Data = 14

No. of Variables = 4

	Mean
1	2555.36
2	310.07
3	32.54
4	27.66

	Variance	S.D
1	164351.00	405.40
2	11622.70	107.81
3	105.13	10.25
4	1.32	1.15

Coveriance

	1	2	3	4
1	164351.0	12354.9	993.9	224.8
2	12354.9	11622.7	-933.0	27.4
3	993.9	-933.0	105.1	-0.3
4	224.8	27.4	-0.3	1.3

Correlation

	1	2	3	4
1	1.0000	0.2827	0.2391	0.4822
2	0.2827	1.0000	-0.8441**	0.2210
3	0.2391	-0.8441	1.0000	-0.0233
4	0.4822	0.2210	-0.0233	1.0000

Corration

DATA

	Yield	pa/m	rg/pa	1000 gw
1	3837.00	519.00	26.20	28.20
2	3967.00	318.00	43.30	28.80
3	3853.00	408.00	34.60	27.30
4	3832.00	330.00	39.60	29.30
5	3939.00	481.00	27.30	30.00
6	3232.00	272.00	40.70	29.20
7	3892.00	339.00	41.00	28.00
8	3250.00	364.00	32.90	27.10
9	3738.00	282.00	49.30	26.90
10	3090.00	312.00	36.30	27.30
11	3468.00	560.00	22.00	28.20
12	3737.00	442.00	30.30	27.90
13	3286.00	398.00	30.00	27.50
14	3709.00	426.00	31.50	27.60
15	3593.00	384.00	32.90	28.40
16	3132.00	300.00	37.30	28.00
17	3589.00	428.00	30.60	27.40
18	3181.00	365.00	29.00	29.30
19	3387.00	287.00	40.70	29.00
20	3000.00	346.00	30.10	28.80
21	3995.00	288.00	39.60	30.50
22	3873.00	379.00	37.00	27.60
23	3829.00	260.00	50.60	29.10
24	3636.00	368.00	32.30	30.00
25	3239.00	392.00	29.10	28.40
26	3998.00	597.00	24.20	27.70
27	3283.00	359.00	32.40	28.80

28	3044.00	292.00	38.00	27.40
29	3964.00	386.00	36.90	27.80
30	3187.00	357.00	22.20	27.70
31	3701.00	385.00	34.30	28.00
32	3442.00	329.00	33.70	31.00
33	3792.00	313.00	44.20	27.40
34	3705.00	382.00	33.70	28.80
35	3675.00	329.00	41.20	27.10
36	3987.00	298.00	50.30	26.60
37	3084.00	358.00	29.00	29.70
38	3940.00	371.00	37.30	28.50
39	3456.00	385.00	34.40	26.10
40	3943.00	410.00	34.80	27.60
41	3084.00	258.00	45.20	27.30
42	3128.00	666.00	18.60	25.30
43	3617.00	202.00	65.80	27.20

No. of Data = 43

No. of Variables = 4

	Mean
1	3563.56
2	370.16
3	35.59
4	28.13

	Varianc	S.D
1	108153.00	328.87
2	8215.66	90.64
3	75.61	8.70
4	1.32	1.15

Covariance

	1	2	3	4
1	108153.0	3329.0	756.0	28.0
2	3329.0	8215.7	-638.7	-22.1
3	756.0	-630.7	75.6	-0.7
4	28.0	-22.1	-0.7	1.3

Correlation

	1	2	3	4
1	1.0000	0.1117	0.2644	0.0741
2	0.1117	1.0000	-0.8002**	-0.2123
3	0.2644	-0.8002	1.0000	-0.0665
4	0.0741	-0.2123	-0.0665	1.0000

Corration

DATA

	Yield	pa/m	rg/pa	1000 gw
1	4755.00	657.00	26.10	27.70
2	4723.00	447.00	38.80	27.20
3	4467.00	302.00	48.10	29.00
4	4112.00	372.00	38.50	28.70
5	4590.00	299.00	53.90	28.50
6	4963.00	416.00	45.70	26.10
7	4546.00	304.00	50.20	29.80
8	4963.00	362.00	45.50	30.10
9	4827.00	325.00	52.10	28.50
10	4133.00	281.00	51.20	28.70
11	4257.00	391.00	35.00	31.10
12	4217.00	400.00	33.50	31.50
13	4292.00	280.00	51.10	30.00
14	4238.00	311.00	47.50	28.70
15	4761.00	573.00	26.10	31.80
16	4214.00	497.00	28.20	30.00
17	4577.00	414.00	40.20	27.50
18	4217.00	250.00	60.70	27.80
19	4457.00	398.00	37.70	29.70
20	4418.00	369.00	41.60	28.80
21	4138.00	274.00	51.50	29.30
22	4207.00	325.00	47.10	27.50
23	4290.00	271.00	65.20	26.10
24	4366.00	377.00	42.00	27.60
25	4134.00	345.00	43.90	27.30
26	4040.00	412.00	33.20	29.50

27	4592.00	352.00	46.10	28.30
28	4390.00	360.00	43.10	28.30
29	4832.00	447.00	38.30	28.20
30	4951.00	602.00	28.20	28.60
31	4457.00	449.00	38.60	25.70
32	4114.00	474.00	32.30	26.90
33	4209.00	373.00	43.40	26.00
34	4297.00	432.00	34.70	28.70
35	4933.00	381.00	45.80	28.30
36	4494.00	386.00	43.40	26.80
37	4339.00	435.00	34.90	28.60
38	4337.00	287.00	53.80	28.10
39	4875.00	499.00	37.10	26.30
40	4748.00	306.00	56.20	27.60
41	4850.00	608.00	29.80	26.80
42	4255.00	299.00	51.40	27.70
43	4577.00	545.00	31.30	26.80
44	4579.00	209.00	84.90	25.80
45	4397.00	392.00	40.50	27.70
46	4865.00	423.00	41.10	28.00
47	4111.00	280.00	56.00	26.20
48	4630.00	326.00	55.70	25.50
49	4829.00	497.00	36.70	26.50

No. of Data = 49

No. of Variables = 4

	Mean
1	4480.88
2	388.04
3	43.63
4	28.08

	Varianc	S.D
1	77440.80	278.28
2	9799.29	98.99
3	121.04	11.00
	2.24	1.50

Covariance

	1	2	3	4
1	77440.8	11841.9	-369.8	-58.9
2	11841.9	9799.3	-941.6	4.6
3	-369.8	-941.6	121.0	-5.4
4	58.9	4.6	5.4	2.2

Correlation

	1	2	3	4
1	1.0000	0.4299**	-0.1200	-0.1414
2	0.4299	1.0000	-0.8646**	0.0312
3	-0.1208	-0.8646	1.0000	-0.3269 *
4	-0.1414	0.0312	-0.3269	1.0000

Corration

DATA

	Yield	pa/m	rg/pa	1000 gw
1	5696.00	464.00	43.40	28.30
2	5555.00	419.00	47.50	27.90
3	5092.00	448.00	39.90	28.50
4	5428.00	491.00	39.30	28.10
5	5087.00	327.00	54.60	28.50
6	5265.00	417.00	45.40	27.80
7	5018.00	338.00	48.80	30.40
8	5491.00	350.00	59.20	26.50
9	5300.00	450.00	40.80	28.90
10	5858.00	370.00	53.90	29.40
11	5831.00	541.00	38.00	28.40
12	5131.00	395.00	51.80	25.10
13	5686.00	499.00	39.40	28.90
14	5043.00	375.00	50.40	26.70
15	5475.00	424.00	46.40	27.80
16	5841.00	463.00	47.60	26.50
17	5725.00	386.00	54.70	27.10
18	5363.00	422.00	42.40	30.00
19	5913.00	455.00	48.30	26.90
20	5176.00	431.00	41.60	28.90

21	5452.00	355.00	60.00	25.60
22	5298.00	360.00	57.90	25.40
23	5334.00	486.00	41.40	26.50
24	5313.00	455.00	47.50	25.50
25	5460.00	572.00	36.90	25.90

No. of Data = 25

No. of Variables = 4

	Mean
1	5433.24
2	427.72
3	47.08
4	27.58

	Varianc	S.D.
1	74428.10	272.82
2	3931.96	62.71
3	47.00	6.86
4	2.19	1.48

Covariance

	1	2	3	4
1	74428.1	6417.1	-64.6	-6.9
2	6417.1	3932.0	-365.2	-2.8
3	-64.6	-365.2	47.0	-3.9
4	-6.9	-2.8	-3.9	2.2

Correlation

	1	2	3	4
1	1.0000	0.3751	-0.0346	-0.0178
2	0.3751	1.0000	-0.8496**	-0.0304*
3	-0.0346	-0.8496	1.0000	-0.3837
4	-0.0178	-0.0304	-0.3837	1.0000

Corration

DATA

	Yield	pa/m	rg/pa	1000 gw
1	5600.00	431.00	48.10	27.00
2	5099.00	399.00	46.60	27.40
3	5187.00	353.00	51.40	28.60
4	4965.00	313.00	55.90	28.40
5	5372.00	369.00	52.40	27.80

No. of Data = 5

No. of Variables = 4

	Mean
1	5244.60
2	373.00
3	50.88
4	27.84

	Varianc	S.D
1	61308.30	247.61
2	2014.00	44.88
3	13.46	3.67
4	0.45	0.67

Covariance

	1	2	3	4
1	61308.3	8561.5	-401.2	-110.0
2	8561.5	2014.0	-147.6	-27.2
3	-401.2	-147.6	13.5	1.8
4	-110.0	-27.2	1.8	0.4

Correlation

	1	2	3	4
1	1.0000	0.7705	-0.4417	-0.6636
2	0.7705	1.0000	-0.8963*	-0.9055*
3	-0.4417	-0.8963	1.0000	0.7498
4	-0.6636	-0.9055	0.7498	1.0000

Direct sowing at Agricultural Demonstration Centre

Corration

DATA

	Yield	pa/m	rg/pa	1000 gw
1	7026.00	477.00	54.40	27.10
2	6889.00	584.00	39.30	30.00
3	6562.00	422.00	55.10	28.20
4	6050.00	448.00	49.60	27.20
5	6086.00	400.00	59.40	25.60
6	6034.00	361.00	65.80	25.40
7	6099.00	372.00	64.00	25.60

No. of Data = 7

No. of Variables = 4

	Mean
1	6392.29
2	437.71
3	55.37
4	26.01

	Varianc	S.D
1	183746.00	428.66
2	5820.24	76.29
3	82.01	9.06
4	2.83	1.68

Corvariance

	1	2	3	4
1	183746.0	24946.8	-2361.7	516.9
2	24946.8	5820.2	-660.5	115.6
3	-2361.7	-660.5	82.0	-14.0
4	516.9	115.6	-14.0	2.8

Correlation

	1	2	3	4
1	1.0000	0.7628*	-0.6084	0.7170*
2	0.7628	1.0000	-0.9561**	0.9009**
3	-0.6084	-0.9561	1.0000	0.9214 **
4	0.7178	0.9009	-0.9214	1.0000

2. Transplanting rice cultivation in pilot No. 1 and No. 2

2.1 The whole

Corration
DATA

	Yield	hill/m	pa/hill	pa/m	rg/pa	1000 gw
1	3945.00	24.00	11.90	286.00	52.20	26.40
2	3675.00	36.00	6.90	248.00	59.80	24.80
3	3339.00	43.00	7.40	318.00	39.50	26.60
4	3499.00	45.00	4.78	212.00	60.20	27.40
5	3978.00	33.00	8.20	271.00	58.70	25.00
6	3840.00	39.00	7.70	300.00	44.00	29.10
7	3912.00	25.00	11.50	288.00	43.30	31.00
8	3137.00	35.00	8.20	287.00	40.00	27.50
9	3287.00	40.00	6.30	252.00	48.90	26.70
10	4269.00	28.00	9.00	252.00	65.80	27.90
11	4637.00	27.00	12.10	327.00	48.70	29.10
12	4700.00	26.00	8.40	218.00	71.40	30.20
13	4678.00	23.00	10.80	248.00	63.10	29.90
14	4370.00	15.00	14.80	222.00	66.50	29.60
15	4075.00	29.00	10.00	290.00	55.30	25.40
16	4701.00	26.00	9.60	250.00	71.50	26.30
17	4699.00	30.00	8.60	258.00	70.10	26.00
18	4660.00	26.00	10.20	265.00	64.40	27.30
19	5414.00	51.00	5.90	301.00	48.40	31.00
20	4154.00	35.00	8.10	284.00	52.10	28.10
21	4458.00	38.00	5.70	217.00	75.30	27.30
22	4739.00	42.00	6.90	290.00	64.60	25.30
23	4915.00	55.00	6.10	336.00	55.40	26.40
24	4356.00	38.00	7.10	270.00	60.00	26.90
25	4329.00	38.00	7.20	274.00	60.00	26.50
26	4904.00	44.00	7.90	348.00	53.80	26.20
27	4280.00	34.00	6.30	214.00	77.50	25.80
28	4085.00	50.00	6.50	325.00	49.50	25.40
29	4112.00	46.00	6.30	290.00	55.20	25.70
30	4943.00	43.00	7.60	327.00	55.80	27.10

31	4434.00	39.00	7.30	295.00	57.40	27.10
32	4092.00	39.00	7.00	273.00	55.50	27.00
33	4398.00	35.00	8.20	287.00	59.60	25.70
34	4538.00	47.00	7.00	329.00	53.60	26.30
35	4003.00	59.00	7.30	431.00	33.20	28.00
36	4535.00	34.00	7.40	252.00	67.70	26.60
37	4255.00	27.00	7.40	200.00	77.90	27.30
38	4734.00	41.00	6.50	267.00	68.70	25.80
39	5950.00	33.00	9.20	304.00	71.20	27.50
40	5249.00	30.00	7.60	228.00	85.00	27.10
41	5811.00	36.00	7.90	284.00	75.80	27.00
42	5168.00	61.00	5.90	360.00	54.20	26.50
43	5220.00	24.00	11.20	269.00	71.60	27.10
44	5471.00	46.00	7.60	350.00	56.20	27.80
45	5309.00	50.00	8.20	410.00	49.00	26.40
46	5469.00	51.00	7.80	398.00	51.30	26.80
47	5798.00	40.00	9.00	360.00	62.90	25.60
48	5208.00	49.00	5.40	265.00	74.70	26.30
49	5236.00	67.00	6.40	429.00	45.90	26.60
50	5478.00	34.00	7.80	265.00	77.70	26.80
51	6551.00	58.00	5.80	336.00	72.50	26.90
52	5106.00	38.00	7.70	293.00	66.00	26.40
53	5015.00	45.00	6.40	288.00	67.00	26.00
54	5255.00	39.00	9.30	363.00	57.00	25.40
55	5289.00	38.00	8.10	309.00	65.80	26.00

No. of Data = 55

No. of Variables = 6

	Mean
1	4632.04
2	38.62
3	7.95
4	292.78
5	60.15
6	26.98

	Varianc	S.D
1	490480.00	700.34
2	112.72	10.62
3	3.57	1.89
4	2813.62	53.04
5	125.36	11.20
6	1.97	1.40

Covariance

	1	2	3	4	5	6
1	490480.0	1710.2	-9.0	12954.4	3749.8	-94.8
2	1710.2	112.7	-14.7	388.6	-45.0	-3.9
3	-9.0	-14.7	3.6	-8.2	-0.6	0.9
4	12954.4	388.6	-8.2	2813.6	-361.2	-10.1
5	3749.8	-45.0	-0.6	-361.2	125.4	-2.7
6	-94.8	-3.9	0.9	10.1	-2.7	2.0

Correlation

	1	2	3	4	5	6
1	1.0000	0.2300	-0.0068	0.3487**	0.4782**	-0.0966
2	0.2300	1.0000	-0.7316**	0.6900**	-0.3785*	-0.2610
3	-0.0068	-0.7316	1.0000	-0.0823	-0.0279	0.3497
4	0.3487	0.6900	-0.0823	1.0000	-0.6081**	-0.1361
5	0.4782	-0.3785	-0.0279	-0.6081	1.0000	-0.1689
6	-0.0966	-0.2618	0.3497	-0.1361	-0.1689	1.0000

2.2 Yield levels

Corration
DATA

	Yield	hill/m	pa/hill	pa/m	rg/pa	1000 gw
1	3945.00	24.00	11.90	286.00	52.20	26.40
2	3675.00	36.00	6.90	248.00	59.80	24.80
3	3339.00	43.00	7.40	318.00	39.50	26.60
4	3499.00	45.00	4.70	212.00	60.20	27.40
5	3978.00	33.00	8.20	271.00	58.70	25.00
6	3840.00	39.00	7.70	300.00	44.00	29.10
7	3912.00	25.00	11.50	288.00	43.30	31.00
8	3137.00	35.00	8.20	287.00	40.00	27.50
9	3287.00	40.00	6.30	252.00	48.90	26.70

No. of Data = 9

No. of Variables = 6

	Mean
1	3623.56
2	35.56
3	8.09
4	273.56
5	49.62
6	27.17

	Varianc	S.D
1	101018.00	317.83
2	53.53	7.32
3	5.36	2.32
4	1016.53	31.88
5	71.46	8.45
6	3.75	1.94

Covariance

	2	2	3	4	5	6
1	101018.0	-1427.1	408.6	925.4	1002.1	64.4
2	-1427.1	53.5	-15.9	-70.5	3.2	-3.1
3	408.6	-15.9	5.4	41.8	-6.2	1.6
4	925.4	-70.5	41.8	1016.5	-213.3	17.2
5	1002.1	3.2	-6.2	-213.3	71.5	-9.4
6	64.4	-3.1	1.6	17.2	-9.4	3.8

Correlation

	1	2	3	4	5	6
1	1.0000	-0.6137	0.5552	0.0913	0.3730	0.1046
2	-0.6137	1.0000	-0.9394**	0.3021	0.0517	-0.2181
3	0.5552	-0.9394	1.0000	0.5664	-0.3148	0.3468
4	0.0913	-0.3021	0.5664	1.0000	-0.7912*	0.2792
5	0.3730	0.0517	-0.3148	-0.7912	1.0000	-0.5763
6	0.1046	-0.2181	0.3468	0.2792	-0.5763	1.0000

Corration
DATA

	Yield	hill/m	pa/hill	pa/m	rg/pa	1000 gw
1	4269.00	28.00	9.00	252.00	65.80	27.90
2	4637.00	27.00	12.10	327.00	48.70	29.10
3	4700.00	26.00	8.40	218.00	71.40	30.20
4	4678.00	23.00	10.80	248.00	63.10	29.90
5	4370.00	15.00	14.80	222.00	66.50	29.60
6	4075.00	29.00	10.00	290.00	55.30	25.40
7	4701.00	26.00	9.60	250.00	71.50	26.30
8	4699.00	30.00	8.60	258.00	70.10	26.00
9	4660.00	26.00	10.20	265.00	64.40	27.30
10	4514.00	51.00	5.90	301.00	48.40	31.00
11	4154.00	35.00	8.10	284.00	52.10	28.10
12	4458.00	38.00	5.70	217.00	75.30	27.30
13	4739.00	42.00	6.90	290.00	64.60	25.30
14	4915.00	55.00	6.10	336.00	55.40	26.40
15	4356.00	38.00	7.10	270.00	60.00	26.90
16	4329.00	38.00	7.20	274.00	60.00	26.50
17	4904.00	44.00	7.90	348.00	53.80	26.20
18	4280.00	34.00	6.30	214.00	77.50	25.80
19	4085.00	50.00	6.50	325.00	49.50	25.40
20	4112.00	46.00	6.30	290.00	55.20	25.70
21	4943.00	43.00	7.60	327.00	55.80	27.10
22	4434.00	39.00	7.30	285.00	57.40	27.10
23	4092.00	39.00	7.00	273.00	55.50	27.00
24	4398.00	35.00	8.20	287.00	59.60	25.70
25	4538.00	47.00	7.00	329.00	53.60	26.30
26	4003.00	59.00	7.30	431.00	33.28	28.00
27	4535.00	34.00	7.40	252.00	67.70	26.60
28	4255.00	27.00	7.40	200.00	77.90	27.30
29	4734.00	41.00	6.50	267.00	68.70	25.80

No. of Data = 29

NO. of Variables = 6

	Mean
1	4467.83
2	36.72
3	8.04
4	280.34
5	60.62
6	27.14

	Varianc	S.D
1	74794.30	273.49
2	105.42	10.27
3	4.07	2.02
4	2382.88	48.81
5	100.66	10.03
6	2.36	1.54

Covariance

	1	2	3	4	5	6
1	74794.3	-175.2	43.3	-9.7	673.9	32.7
2	-175.2	105.4	-15.7	367.2	-63.6	-4.5
3	43.3	-15.7	4.1	-17.3	1.2	1.2
4	-9.7	367.2	-17.3	2382.9	-443.3	-9.6
5	673.9	-63.6	1.2	-443.3	100.7	-1.7
6	32.7	-4.5	1.2	-9.6	-1.7	2.4

Correlation

	1	2	3	4	5	6
1	1.0000	-0.0624	0.0784	-0.0007	0.2456	0.0778
2	-0.0624	1.0000	-0.7559**	0.7326**	-0.6172 **	-0.2833
3	0.0784	-0.7559	1.0000	-0.1757	0.0572	0.4018*
4	-0.0007	0.7326	-0.1757	1.0000	-0.9052 **	-0.1281
5	0.2456	-0.6172	-0.0572	-0.9052	1.0000	-0.1094
6	0.0778	-0.2833	0.4018	-0.1281	-0.1094	1.0000

Corration
Data

	Yield	hill/m	pa/hill	pa/m	rg/pa	1000 gw
1	5950.00	33.00	9.20	304.00	71.20	27.50
2	5249.00	30.00	7.60	228.00	85.00	27.10

3	5811.00	36.00	7.90	284.00	75.80	27.00
4	5168.00	61.00	5.90	360.00	54.20	26.50
5	5220.00	24.00	11.20	269.00	71.60	27.10
6	5471.00	46.00	7.60	350.00	56.20	27.80
7	5309.00	50.00	8.20	410.00	49.00	26.40
8	5469.00	51.00	7.80	398.00	51.30	26.80
9	5798.00	40.00	9.00	360.00	62.90	25.60
10	5208.00	49.00	5.40	265.00	74.70	26.30
11	5236.00	67.00	6.40	429.00	45.90	26.60
12	5478.00	34.00	7.80	265.00	77.70	26.80
13	6551.00	58.00	5.80	336.00	72.50	26.90
14	5106.00	38.00	7.70	293.00	66.00	26.40
15	5015.00	45.00	6.40	288.00	67.00	26.00
16	5255.00	39.00	9.30	363.00	57.00	25.40
17	5289.00	38.00	8.10	309.00	65.80	26.00

No. of Data = 17

No. of Variables = 6

	Mean
1	5446.06
2	43.47
3	7.72
4	324.18
5	64.93
6	26.60

	Varianc	S.D
1	148970.00	385.97
2	132.39	11.51
3	2.17	1.47
4	3282.15	57.29
5	124.18	11.14
6	0.40	0.63

Covariance

	1	2	3	4	5	6
1	148970.0	294.1	-8.6	1513.9	1009.5	74.1
2	294.1	132.4	-12.5	466.4	-83.3	-0.9
3	-8.6	-12.5	2.2	-7.3	1.0	0.0
4	1513.9	466.4	-7.3	3282.2	-599.1	-7.6
5	1009.5	-83.3	1.0	-599.1	124.2	1.6
6	74.1	-0.9	0.0	-7.6	1.6	0.4

Correlation

	1	2	3	4	5	6
1	1.0000	0.0662	-0.0151	0.0685	0.2347	0.3030
2	0.0662	1.0000	-0.7353**	0.7076**	-0.6500**	-0.1226
3	-0.0151	-0.7353	1.0000	-0.0870	0.0581	0.0382
4	0.0685	0.7076	-0.0870	1.0000	-0.9385**	-0.2080
5	0.2347	-0.6500	0.0581	-0.9385	1.0000	0.2291
6	0.3030	-0.1226	0.0382	-0.2080	0.2291	1.0000

3. Transplanting rice cultivation in Agricultural Demonstration Centre

3.1 The whole

Corration
Data

	Yield	hill/m	pa/hill	pa/m	ra/pa	1000 gw
1	4949.00	22.30	15.10	336.00	52.60	28.00
2	4970.00	22.30	15.00	334.00	51.50	28.90
3	4500.00	22.30	15.20	338.00	47.50	28.00
4	4918.00	22.30	14.20	316.00	57.20	27.20
5	4610.00	22.30	15.60	347.00	48.70	27.30
6	4606.00	22.30	16.60	369.00	45.90	27.20
7	4050.00	22.30	13.80	307.00	46.00	28.70
8	4882.00	22.30	15.80	352.00	50.60	27.40
9	4531.00	22.30	12.90	287.00	57.60	27.40
10	4845.00	22.30	14.90	332.00	53.10	27.50
11	4181.00	22.30	14.20	316.00	49.00	27.00
12	5323.00	22.30	17.30	385.00	48.70	28.40
13	5873.00	22.30	15.70	349.00	57.80	29.10
14	5410.00	22.30	15.30	340.00	60.50	26.30
15	5971.00	22.30	14.60	325.00	65.40	28.10
16	5059.00	22.30	15.40	343.00	52.30	28.20
17	5957.00	22.30	17.40	387.00	55.00	28.00
18	5233.00	22.30	13.80	307.00	61.10	27.80
19	5634.00	22.30	17.20	383.00	51.30	28.70
20	5987.00	22.30	14.40	328.00	65.20	28.70
21	5926.00	22.30	17.70	394.00	52.60	28.60
22	5596.00	22.30	15.60	347.00	56.90	28.40
23	5510.00	22.30	16.40	365.00	52.40	28.80
24	5505.00	22.30	17.20	383.00	51.60	27.80
25	5992.00	22.30	13.90	309.00	51.80	28.70
26	5643.00	22.30	15.70	349.00	58.40	27.70
27	5427.00	22.30	16.20	360.00	52.30	28.80
28	5973.00	22.30	17.30	385.00	55.60	27.90
29	5657.00	22.30	12.20	271.00	76.50	27.30
30	5535.00	22.30	15.90	354.00	56.50	27.70

31	5050.00	22.30	14.80	329.00	53.60	28.70
32	5513.00	22.30	14.20	316.00	61.00	28.60
33	5361.00	22.30	16.30	363.00	51.60	28.60
34	6168.00	22.30	15.80	352.00	62.80	27.90
35	6326.00	22.30	13.40	298.00	76.60	27.70
36	6261.00	22.30	16.10	358.00	61.80	28.30
37	6012.00	22.30	13.80	307.00	68.20	28.70
38	6717.00	22.30	15.10	336.00	70.10	28.50
39	6455.00	22.30	14.80	329.00	67.90	28.90
40	6363.00	22.30	16.80	374.00	64.70	26.30
41	6384.00	22.30	17.00	378.00	59.10	28.60
42	6079.00	22.30	14.70	327.00	64.80	28.70
43	6691.00	22.30	16.50	367.00	63.10	28.90
44	6116.00	22.30	16.70	372.00	57.50	28.60
45	6823.00	22.30	16.10	358.00	67.60	28.20
46	6835.00	22.30	17.00	378.00	66.00	27.40
47	6187.00	22.30	17.70	394.00	54.30	28.90
48	6717.00	22.30	15.10	336.00	70.10	28.50

No. of Data = 48

No. of Variables = 6

	Mean
1	5631.71
2	22.30
3	15.51
4	345.04
5	57.97
6	28.12

	Varianc	S.D
1	507121.00	712.12
2	0.00	0.00
3	1.74	1.32
4	864.68	29.41
5	59.03	7.68
6	0.74	0.68

Covariance

	1	2	3	4	5	6
1	507121.0	-0.0	277.6	6152.1	3920.9	137.2
2	-0.0	0.0	0.0	0.0	-0.0	-0.0
3	277.6	0.0	1.7	38.8	-3.6	0.1
4	6152.1	0.0	38.8	864.7	80.3	2.4
5	3920.9	-0.0	-3.6	-80.3	59.0	-0.2
6	137.2	-0.0	0.1	2.4	-0.2	0.5

Correlation

	1	2	3	4	5	6
1	1.0000	0.0000	0.2956**	0.2938*	0.7166**	0.2812
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.2956	0.0000	1.0000	1.0000	-0.3538	0.1216
4	0.2938	0.0000	1.0000	1.0000	-0.3554*	0.1212
5	0.7166	0.0000	-0.3538	-0.3554	1.0000	-0.0320
6	0.2812	0.0000	0.1216	0.1212	-0.0320	1.0000

3.2 Yield levels

Corration
Data

	Yield	hill/m	pa/hill	pa/m	rg/pa	1000/gw
1	4949.00	22.30	15.10	336.00	52.60	28.00
2	4970.00	22.30	15.10	334.00	51.50	28.90
3	4500.00	22.30	15.20	338.00	47.50	28.00
4	4918.00	22.30	14.20	316.00	57.20	27.28
5	4610.00	22.30	15.60	347.00	48.70	27.30
6	4606.00	22.30	16.60	369.00	45.90	27.28
7	4050.00	22.30	13.80	307.00	46.00	28.70
8	4882.00	22.30	15.80	352.00	50.60	27.40
9	4531.00	22.30	12.90	287.00	57.60	27.40
10	4845.00	22.30	14.90	332.00	53.10	27.50
11	4181.00	22.30	14.20	316.00	49.00	27.0(

No. of Data = 11

No. of Variables = 6

	Mean
1	4640.18
2	22.30
3	14.85
4	330.36
5	50.88
6	27.69

	Varianc	S.D
1	97457.20	312.18
2	0.00	0.00
3	1.05	1.02
4	518.25	22.77
5	16.18	4.02
6	0.40	0.63

Covariance

	1	2	3	4	5	6
1	97457.2	-0.0	118.6	2674.2	659.8	-1.3
2	-0.0	0.0	-0.0	0.0	0.0	0.0
3	118.6	-0.0	1.0	23.3	-2.2	-0.1
4	2674.2	0.0	23.3	518.3	-48.6	-1.8
5	659.8	0.0	-2.2	-48.6	16.2	-0.5
6	-1.3	0.0	-0.1	-1.8	-0.5	0.4

Correlation

	1	2	3	4	5	6
1	1.0000	0.0000	0.3709	0.3763	0.5244	-0.0065
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.3709	0.0000	1.0000	0.9999**	-0.5349	-0.1230
4	0.3763	0.0000	0.9999	1.0000	0.5309	0.1222
5	0.5255	0.0000	-0.5349	-0.5309	1.0000	-0.2162
6	-0.0065	0.0000	-0.1230	-0.1222	-0.2162	1.0000

Corration
Data

	Yield	hill/m	pa/hill	pa/m	rg/pa	1000 gw
1	5323.00	22.30	17.30	385.00	48.70	28.40
2	5873.00	22.30	15.70	349.00	57.80	29.10
3	5410.00	22.30	15.30	340.00	60.50	26.30
4	5971.00	22.30	14.60	325.00	65.40	28.10
5	5059.00	22.30	15.40	343.00	52.30	28.20
6	5957.00	22.30	17.40	387.00	55.00	28.00
7	5233.00	22.30	13.80	307.00	61.10	27.80
8	5634.00	22.30	17.20	383.00	51.30	28.70
9	5987.00	22.30	14.40	320.00	65.20	28.70
10	5926.00	22.30	17.70	394.00	52.60	28.60
11	5596.00	22.30	15.60	347.00	56.90	28.40
12	5510.00	22.30	16.40	365.00	52.40	28.80
13	5505.00	22.30	17.20	383.00	51.60	27.80
14	5992.00	22.30	13.90	309.00	51.80	28.70
15	5643.00	22.30	15.70	349.00	58.40	27.70
16	5427.00	22.30	16.20	360.00	52.30	28.80
17	5973.00	22.30	17.30	385.00	55.60	27.90
18	5657.00	22.30	12.20	271.00	76.50	27.30
19	5535.00	22.30	15.90	354.00	56.50	27.70
20	5060.00	22.30	14.80	329.00	53.60	28.70
21	5513.00	22.30	14.20	316.00	61.00	28.60
22	5361.00	22.30	16.30	363.00	51.60	28.60

No. of Data = 22

No. of Variables = 6

	Mean
1	5597.50
2	22.30
3	15.66
4	348.36
5	56.73
6	28.22

	Varianc	S.D
1	87731.30	296.19
2	0.00	0.00
3	2.04	1.43
4	1020.81	31.95
5	40.64	6.37
6	0.40	0.63

Covariance

	1	2	3	4	5	6
1	87731.3	0.0	35.7	779.3	475.5	21.6
2	0.0	0.0	0.0	-0.0	0.0	0.0
3	35.7	0.0	2.0	45.7	-6.8	0.2
4	779.3	-0.0	45.7	1020.8	-152.4	3.7
5	475.5	0.0	-6.8	-152.4	40.6	-1.7
6	21.6	0.0	0.2	3.7	-1.7	0.4

Correlation

	1	2	3	4	5	6
1	1.0000	0.0000	0.0842	0.0823	0.2519	0.1151
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0842	0.0000	1.0000	1.0000	-0.7472**	0.1832
4	0.0823	0.0000	1.0000	1.0000	-0.7480**	0.1837
5	0.2519	0.0000	-0.7472	-0.7480	1.0000	-0.4229
6	0.1151	0.0000	0.1832	0.1837	-0.4229	1.0000

Corration
Data

	Yield	hill/m	pa/hill	pa/m	rg/pa	1000 gw
1	6168.00	22.30	15.80	352.00	62.80	27.90
2	6326.00	22.30	13.40	298.00	76.60	27.70
3	6261.00	22.30	16.10	358.00	61.80	28.30
4	6012.00	22.30	13.80	307.00	68.20	28.70
5	6717.00	22.30	15.10	336.00	70.10	28.50
6	6455.00	22.30	14.80	329.00	67.90	28.90
7	6363.00	22.30	16.80	374.00	64.70	26.30
8	6384.00	22.30	17.00	378.00	59.10	28.60

9	6079.00	22.30	14.70	327.00	64.80	28.70
10	6691.00	22.30	16.50	367.00	63.10	28.90
11	6117.00	22.30	16.70	372.00	57.50	28.60
12	6823.00	22.30	16.10	358.00	67.60	28.20
13	6835.00	22.30	17.00	378.00	66.00	27.40
14	6187.00	22.30	17.70	394.00	54.30	28.90
15	6717.00	22.30	15.10	336.00	70.10	28.50

No. of Data = 15

No. of Variables = 6

	Mean
1	6409.00
2	22.30
3	15.77
4	350.93
5	64.97
6	28.27

	Varianc	S.D
1	79636.60	282.20
2	0.00	0.00
3	1.56	1.25
4	777.64	27.89
5	31.24	5.59
6	0.50	0.71

Covariance

	1	2	3	4	5	6
1	79636.6	0.0	64.8	1411.4	557.5	-27.6
2	0.0	0.0	-0.0	0.0	0.0	-0.0
3	64.8	-0.0	1.6	34.9	-5.6	-0.1
4	1411.4	0.0	34.9	777.6	-125.8	-2.6
5	557.5	0.0	-5.6	-125.8	31.2	-0.9
6	-27.6	-0.0	-0.1	-2.6	-0.9	0.5

Correlation

	1	2	3	4	5	6
1	1.0000	0.0000	0.1835	0.1793	0.3535	-0.138
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.1835	0.0000	1.0000	1.0000	-0.8054 **	-0.1302
4	0.1793	0.0000	1.0000	1.0000	-0.8071 **	-0.1313
5	0.3535	0.0000	-0.8054	-0.8071	1.0000	-0.2397
6	-0.1382	0.0000	-0.1302	-0.1313	-0.2397	1.0000

Simple linear correlation coefficients, r, at the 5% and 1% levels of significance

d.f.[1]	5%	1%	d.f.	5%	1%
1	.997	1,000	26	.374	.478
2	.950	.990	27	.367	.470
3	.878	.959	28	.361	.463
4	.811	.917	29	.355	.456
5	.754	.874	30	.349	.449
6	.707	.834	32	.339	.437
7	.666	.798	34	.329	.424
8	.632	.765	36	.321	.413
9	.602	.735	38	.312	.403
10	.576	.708	40	.304	.393
11	.553	.684	45	.288	.372
12	.532	.661	50	.273	.354
13	.514	.641	55	.262	.340
14	.497	.623	60	.250	.325
15	.482	.606	70	.232	.302
16	.468	.590	80	.217	.283
17	.456	.575	90	.205	.267
18	.444	.561	100	.195	.254
19	.433	.549	125	.174	.228
20	.423	.537	150	.159	.208
21	.413	.526	175	.148	.194
22	.404	.515	200	.138	.181
23	.396	.505	300	.113	.148
24	.388	.496	400	.098	.128
25	.381	.487	500	.088	.115

[1] d.f. = n - 2, where n is the sample size

I. COLD WEATHER DAMAGE OF LOWLAND RICE

The sterility of lowland rice caused by the high temperature in the central plain of Thailand is well known but the cold weather damage of lowland rice is almost not known. However, the rate of occurrence of cold weather damage of lowland rice will be high in the case of late planting in rainy season on the rice double cropping area. Because, accompanying the delay of harvesting of dry season rice crop, the planting of wet season rice will be also delayed. For that reason, late planting rice in the wet season will has a chance to meet with low temperature in December or January in high possibility. Thus cold weather damage of rice will be occured.

As for the Agricultural Demonstration Centre, the late planting of rice in 1982 and 1983 suffered cold weather damage heavily.

1. Cold Weather Damage in 1982

The rice plant is susceptible to cold weather in the period from the reduction division stage until the completion of flowering. If the rice plant meets with cold weather in this period, the productive function will be obstructed and causes low production.

In 1982, the rice plant (RD-23) was transplanted on the 25th of October met with cold weather during the period mentioned above and suffered heavy damage. The table 1 shows the result of growth investigation at the heading stage of RD-23 which suffered the cold weather damage and table 2 shows result of investigation of the yield, spikelets/panicle, ripened grains/panicle and weight of 1000 grains.

According to these results of investigation, the plant height, panicles/hill, spikelets/panicle looked almost no difference to the rice which was normally grown but the rate of ripened grain was only 11.68% and weight of

1000 grains was 23.6 g which is quite less comparing with normal weight of 27-28 grams thus the yield was 307 kg/ha in extremely low. Table 3 shows the details of temperature in the period of 20 days from December 12th to 31st in which the cold weather occured.

According to this data, the totalized hours in which the temperature droped below 18°c was 201 hours and below 15°c was 95 hours respectively. Furthermore, the trough of low temperature occured twice, in the former on 22nd-23rd and the latter on 29th-30th and during those period, the hours in which temperature droped below 15°c was 20 hours and 19 hours respectively.

The former trough of low temperature met with the period from pollen mother cell differentation stage to reduction division stage and the latter trough fell on the time of just before the heading, for that reason, it was supposed that these low temperature were main causes to induce the physiological injury such as unmaturing of pollen and unopening of anther thus the sterility of rice occured and obtained abnormal low production.

Further, the mean of daily lowest temperature in December was 17°c and the extreme minimum temperature was 9°c.

2. Cold Weather Damage in 1983

In 1983, the rice (RD-23) sown on September 10th and transplanted on 30th on the same month suffered heavy cold weather damage. Table 4 shows the rice planted area and the yield in 2 plots at Agricultural Demonstration Centre which suffered the cold weather damage. The yield obtained at the 2 plots were only 505 kg/ha and 412 kg/ha respectively. Table 5 shows the details of temperature in the period of 20 days from November 21st to December 12th in which the low temperature happened.

According to these datas, the totalized hours in which the temperature dropped below 16°c and 14°c during the period of 20 days mentioned above were

99 hours and 28hours respectively. The trouph of low temperature occured on 2 days on November 29th and 30th and total hours in below 16°c and 14°c were 24 hours and 17 hours respectively. The low temperature happened in 1983 were similar to that of 1982 and the rice plant on the growing was just in the time of from the pollen mother cell differentation stage to the reduction division stage. For that reason, the rice planted suffered very heavy damage.

3. Frequency of Occurrence of Cold Weather in Mae Klong Pilot Ptoject Area

Table 6 shows the frequency of occurrence of low temperature below 18°c classified into month and temperature degree in the basis of the datas recorded at Kanchanaburi Meteorological Station (Latitude 14° 01', Longitude 99° 32' E, MSL 28 m) in the period of 29 years from 1951-1980.

Generally, the resistance of rice plant against low temperature is more or less different among the varieties and the degree of injury is also different according the stage of growth.

However, if it suppose that the minimum temperature of the monthly mean in which the rice will be suffered any injury such as the growth stagnation, occurrence of the lesion and the sterility etc. to be 18°c, the low temperature happened 16 times in the month of December and 18 times in January in the past 29 years.

Furthermore, if it suppose that the critical minimum temperature of monthly mean which the rice plant will be suffered from low temperature injury to be 17°c, the low temperature of that occured 7 times during the month of December and 11 times during the month of January. Consequently, the frequency of occurrence of cold weather damange is high in this Mae Klong area. Of course. the fluctuation of daily minimum temperature in the month will be varied according to each year, it is unable to decide that whether damage will be happened or not.

Table 1 Result of plant investigation at the heading time

(Jan. 4, 1982; 70 days after transplanting)

Block	I	II	III	IV	V	Mean
G. height (cm)	94.7	88.3	80.5	82.0	78.5	84.8
E. tiller	35.8	25.2	25.7	29.6	20.9	27.4
Heading	30.2	20.5	15.1	19.1	17.2	20.4
%, Heading	84.4	81.4	58.8	64.5	82.2	74.4

. Note : Block area = 5 m x 8 m = 40 m^2

Plant sample/block = 10 hills

Table 2 Yield and Yield Components, 1982 rainy season rice crop

Yield

Block	I	II	III	IV	V	Mean
Yield (kg/ha)	579.5	173.7	52.8	179.0	552.5	306.9

Yield components (mean by 297 panicles)

Panicles/hill	21.36
Spikelets/panicle	77.05
Ripened grains/panicle	9.00
Unripened grains/panicle	68.05
% of ripened grains	11.68
1,000 grains weight	23.60 g.

Table 3 Temperature in December 1982

Period	Mean Max.°c	Mean Min.°c	Ext. Max.°c	Ext. Min.°c	Totalized hours below 18°c	Totalized hours below 15°c
Dec. 12-21	26.5	15.7	29.5	14.5	81	17
Dec. 22-31	28.5	11.6	31.5	9.0	120	78
				Total	201	95
Dec. 22-23	27.3	10.0	28.0	9.5	26	20
Dec. 29-30	29.0	9.5	30.0	9.0	22	19
December	28.1	17.2	33.5	9.0		

Table 4 Area planted and yield, 1983 rainy season rice crop

Field No.	6	7
Area (ha)	0.76	0.75
Yield (kg/ha)	505	412

Table 5 Temperature in November and December in 1983

Period	Mean Max.°c	Mean Min.°c	Ext. Max.°c	Ext. Min.°c	Totalized hours below 18° c	below 16° c	below 14° c	below 12° c
Nov. 21-30	25.0	14.7	28.0	10.5	88	50	12	11
Dec. 1-10	25.1	14.8	27.0	12.0	91	49	16	0
				Total	179	99	28	11
Nov. 29-30	24.0	10.5			30	24	17	7
November	26.9	19.6	32.0	10.5				
December	27.5	17.4	30.5	12.0				

Table 6 Frequency of low temperature occurrence for past 29 years (from 1951 - 1980)

Month	Monthly mean min. temperature Below 19° c	Below 18° c	Below 17° c	Below 16° c	Below 15° c	Below 14° c	Average °c	Ext. Min.°c
November	3	0	0	0	0	0	20.7	11.6
December	20	16	7	3	0	0	18.0	6.8
January	22	18	11	7	2	1	17.7	5.5
February	4	2	0	0	0	0	20.5	12.1
Total	49	36	18	10	2	1		

4. Time Limit of Sowing for Avoiding Cold Weather Damage

If suitable temperature and irrigation water supply are ensured, nonphotosensitive high yielding varieties such as RD-23 can be cultivated throughout the year. That is the advantage of these varieties and is also disadvantage of them because if the sowing time is delayed in the rainy season in Mae Klong area, the possibility to meet with cold weather on the late growth period of rice is high and the damage will be occured in high frequency. For the rainy season rice crop in the Mae Klong Project, the sowing should be finished before 20th of August of year in order to avoid cold weather damage. Generally, the growth durations of nonphotosensitive RD varieties are estimated around 90-100 days from sowing to flowering and 120-130 days from sowing to harvest. Therefore, if the sowing conduct on about 20th of August and the appropriate management practice is performed, the flowering will be expected around on 20th - 30th of November and can be harvested before the end of December thus, it is very rare that the rice plant which is growing in the stages of reduction division to flowering will meet with cold weather so that, the steady and high yield will be ensured.

As to the photosensitive local varieties, the fluctuations of their flowering time resulting from the time of early or late sowing are extremely small. The Luang Pratew is one of the most late maturing variety in the Mae Klong Project area and its' flowering time is about 20th of November. For that reason, most of photosensitive varieties planting in Mae Klong area are almost free from the cold weather damage.

5. Rice Double Cropping Area and Improved High Yielding Variety in Thailand

The rice double cropping area in the 1981/82 crop year was only in six hundred thousand hectares which only shared about 6% of all the lowland rice planted area in Thailand. However, accompanying the construction of irrigation

facilities accelerated by Thai Government, it is expected that the rice double cropping area will be expanded rapidly and steadly year by year.

The other hand, the area planted of improved high yielding varieties such as RD-23, 21 etc. is estimated as about 20% on the total planted area of rainy season rice crop in Thailand. But, accompanying the expansion of rice double cropping area, the planting area of nonphotosensitive RD varieties will be also increased quickly.

Accordingly, the special attention shall be paid to that the sowing time of rainy season crop in the rice double cropping area, especially, in the low temperature occuring area such as outskirts of Chao Phya river delta, Northern and Northeastern Thailand, shall not be conducted too late.

II. MECHANIZED FARMING OF LOWLAND RICE

The mechanized lowland rice cultivation in the Mae Klong area has been progressed rapidly and the fields of ploughing, puddling and threshing have nearly been all mechanized but the transplanting and harvesting works which require many labors in concentration for the short period and hardest work in the process of rice cultivation are not yet been mechanized.

However, accompanying the expansion of rice double cropping area as well as diffusion of intensive rice cultivation, it is no doubtful that these field of works will be mechanized in the near future.

In prognostication these coming, the Agricultural Demonstration Centre has been introduced many kind of agricultural machineries and conducted lots of trials and observations since 1981 in order to find out what are the appropriate machineries and operational techniques for the lowland rice cultivation in the Mae Klong Project area, consequently, the consistent working system by the machineries including seed sowing, transplanting, insect and disease control, harvesting and paddy drying has been established.

Large scale of seeding machinery and raising of seedling of lowland rice for mechanized transplanting have been popularized in Japan nowadays. However, the seeding plant and large scale of raising of rice seedling for the mechanized transplanting are not yet known widely in Thailand.

1. LARGE SCALE OF RAISING LOWLAND RICE SEEDLING FOR MECHANIZED TRANSPLANTING

Generally, the processing of raising of seedling are different according to climate whether tropical or temperate zone, variety whether Japonica or Indica, Soil texture whether clay or sandy soil etc. In the tropical zone, some works on the process of raising of seedling can be left off comparing with the works of the temperate zone.

Therefore, the Centre will report regarding important points shall be paid attention specially on the process of raising of seedling because some point of the proceeding are different to that in Japan.

1.1 Materials

1.1.1 Seedling Box

The number of seedling box will be changed according to plant density (hills/m^2), seedlings/hill but around 180-200 boxes for a hectare is required in general. The standard planting density in Mae Klong area is 20-25 hills/m^2 and seedlings/hill is 4-5 seedlings.

1.1.2 Quantity of Seed for Sowing

The seed of 150 grams in dry condition for 1 box is proper quantity. Although, the quantity of seed in 150 gms/box is thought as dense sowing, this seed quantity is necessary in order to grow healthy seeding in the short period and make the missing plant happening in the time of transplanting as small as possible.

1.1.3 Bed Soil

The bed soil of 5 litters for 1 box is necessary. Because of the soil of paddy field in the Mae Klong area contains clay and silt exceeding 50%, if

permeability and aeration are not so good and in the case that the high speed automatic seeding machine (about 500 boxes/hour) is used, the water supplied into the box will be delayed to percorate and makes it difficult of sow. According, in order to highten water permeability and aeration of the bed soil, the bed soil shall be made by crashing and sieving material soil and to be sieved soil in proportion of 3 mixed with carbonized rice husk in proportion of 2.

1.1.4 Quantity of Fertilizer to be Applied per One Box

It is necessary to apply Am. Sulphate of 2 grams, T.S. Phosphate of 3 grams as the basal for the nonphotosensitive RD varieties and it will be required to apply Am. Sulphate of 1 gram, T.S. Phosphate of 2 grams as the basal for the photosensitive local varieties. If the basal fertilizer put in the mixer when the soil for bed soil is mixed with the carbonized rice husk by the mixer, it can be equally mixed with the bed soil.

The top dressing for the RD varieties will be Am. Sulphate in 2 grams applying at the time about 2 weeks after sowing. As to the photosensitive local varieties, the top dressing is not required in general. If the exceeding nitrogen is applied, it will not only cause the spindly growth of seedling and difficulty of transplanting but also the establishment rate of seedlings will be decreased.

1.2 Seedling Age and Plant Height of Seedling

The growing speed of seedling will be varied according to the varieties and weather condition. The suitable plant height of seedling for mechanized transplanting shall be 18-25 cm and the suitable seedling age shall be 18-24 days from sowing or 3-3.5 leaves.

Table 7 and Fig. 1 show the result of investigation on the relation of grass height of seedling and number of day after sowing among the RD varieties in the rainy season 1982. Also, table 8 shows the temperature, humidity, and precipitation during the raising of seedling period.

1.3 Standard Works of Sowing and Raising of Seedling and Cautions on Works

1.3.1 Soaking hours of Seed

Generally, the soaking time of seed needs 72 hours. If the soaking time be less than 48 hours, it may be caused ununiformed germination.

1.3.2 Hastening of Germination

It needs about 24-36 hours for the management of hastening of germination. In case of seed over 50 kgs at a time, the seed must be turned over and stired 2-3 times at least during the time of hastening management in order to make uniform germination.

1.3.3 Emergence of Seedling

The seedling boxes,sown seed,shall be piled up to 15-20 stories indoors and covered with canvas sheets or gunny bags so as to let them germinate It will be required about 24-36 hours for the management of emergence of seedling. If the management time is too short, uniform emergence of seedling may be obstructed after transfering of the seedling boxes from indoor to outdoor nursery. On the contrary, if management time is too long, the emerged plumules in the seedling box situated in the lower story will thrust into the small draining holes of the seedling box situated upper stage so that when the seedling boxes are taken off and moved to outdoor nursery, the growing point of young seedling may be damaged. For that reason, the emergence condition of seedling must be observed carefully and the timing to move the seedling boxes to the outdoor nursery must be judged without mistake.

Table 7 Plant height of seedling in the rainy season 1982 (sowing : Jul. 25, 1982)

Variety	Days after sowing (cm)						
	5	10	13	16	19	21	24
RD - 7	7.8	13.3	15.5	19.5	21.9	23.7	27.6
RD - 21	7.4	13.5	14.2	15.0	16.6	19.6	22.6
RD - 23	8.0	14.4	16.4	18.1	19.4	22.4	23.9

Fig. 1 Plant height of seedlings for mechanized rice transplanting.

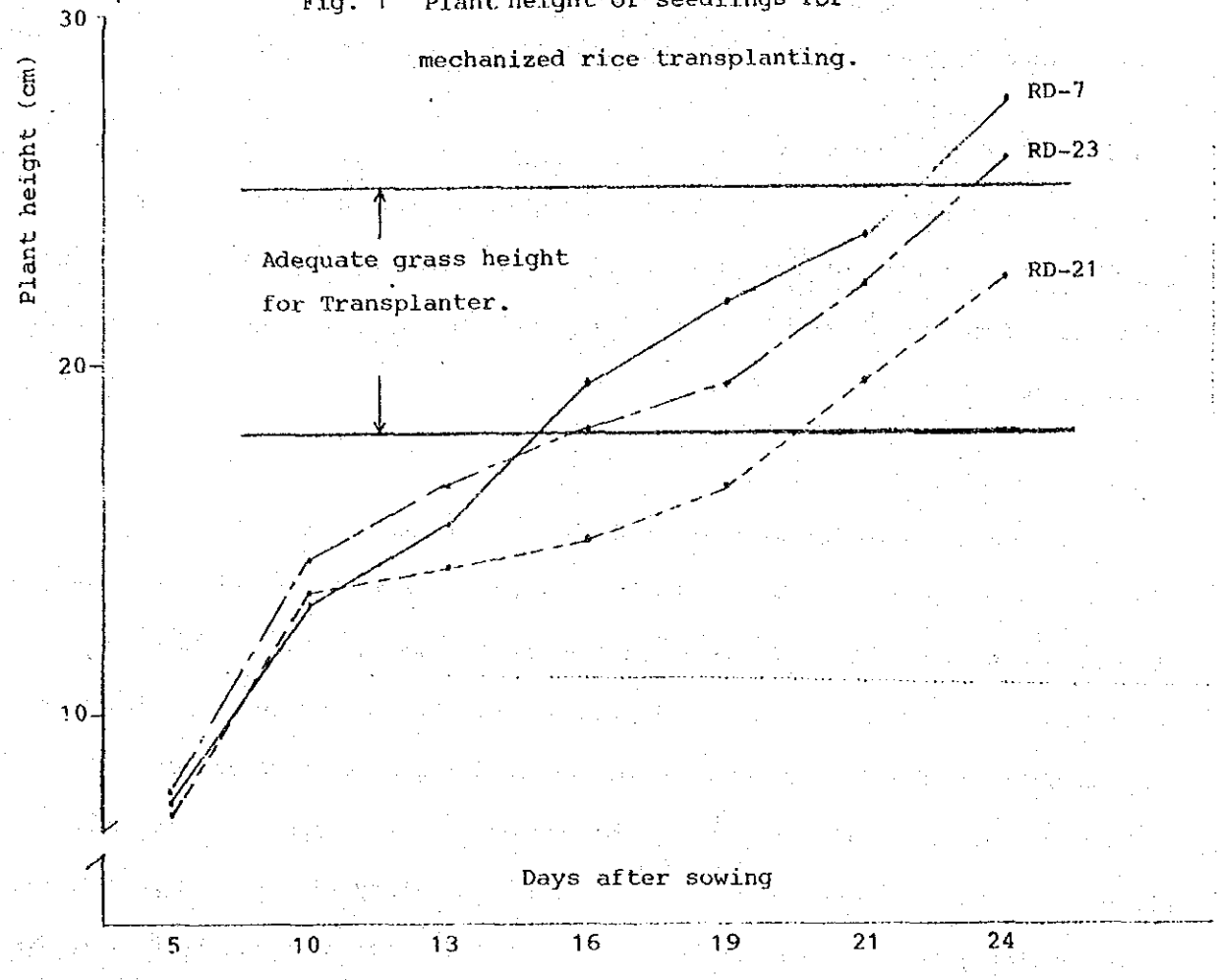


Table 8 Climatological data (from Aug. 30 - Sept. 19, 1982 for 21 days)

Rainfall	:	76 mm.	
Temperature	:	Mean	26.7°c
		Mean Max.	30.2°c
		Mean Min.	23.2°c
Humidity	:	Mean Max.	97.7 %
		Mean Min.	63.8 %

1.3.4 Greening and Hardning

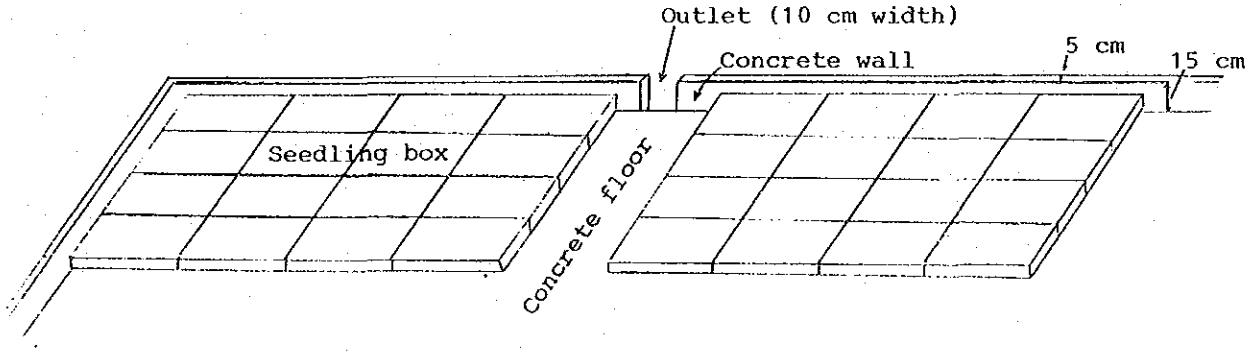
The seedling boxes of the completion of emergence shall be moved from indoor to the nursery outdoor to conduct greening and hardning of seedlings. It is advisable to begin to move the seedling boxes from about 3 o'clock in the afternoon. In the case of the plumules grown indoors are exposed under the strong sunshine suddenly, the chlorosis of the plumules may occur.

1.3.5 Nursery made of Concrete

Agricultural Demonstration Centre improved the paddy drying court made of concrete and has been used both as nursery and drying court. The drying court of paddy has been in the size of 15.5 meters by 25 meters which was divided into 3 blocks and the concrete frame of 12 cm in height and 5 cm in width was made around the blocks and an outlet of width of 10 cm was provided in each block. Of course, the concrete floor of nursery is in level.

The each block can be arranged 600 seedling boxes though 2 managerial passages each in width of about 50 cm would be left. So that a total of 1800 seedling boxes, it means that the seedlings for about 9 hectares can be provided in a time. Furthermore, the water management is quite easy and also the growth of seedlings is more uniform comparing with the seedlings which are grown in the nursery provided in the paddy field. Especially, although the transplanting is delayed for certain reason, the seedlings can be preserved for long time of 30-50 days in good condition.

Fig. 2 Concrete nursery cum paddy drying court



1.3.6 Water management in Nursery

It is not necessary supplying water into the concrete nursery on the day of the seedling boxes are moved to the nursery from indoors because the bed soil still keep sufficient water for the growth of seedling. And it is required to supply water in the depth of 1-2 cm into the nursery on the following morning and then drain out the water as quickly as possible after the bed soil absorbed enough water. (The flooding time shall be 30 minutes to 1 hour) Such water management shall be repeated for 2-3 days and then the water shall be supplied in the depth of 2-3 cm all the time until the day of transplanting. If the water is kept in the flooded condition from morning till night on the day and following day of moving the seedling boxes to the nursery , the growth of seedlings will be remarkably hindered. For that reason, special attention shall be paid for the water management in the initial period of the raising of seedling.

1.4 Machineries for Mechanized Transplanting at Agricultural Demonstration Centre

The machineries for mechanized transplanting have been used by the Centre are specified in the Table 9.

The centre has 2 units of riding type transplanter and 4 units of walking type transplanter. The riding type transplanter can be operated stably and easily comparing with the walking type under the condition that the cultivated soil is deep and the subsoil is soft.

Table 9 Machinery for mechanized transplanting at Agricultural Demonstration Centre

Name of machinery	Model or capacity	unit
Automatic seeding machine	ISEKI EM-50, 500 boxes/hr.	1 set
Soil pulverizer and siever	ISEKI SF-2, 6.5 HP	1 set
Soil and fertilizer mixer	ISEKI IMM-8, 5.0 HP	1 set
Belt conveyer for bed soil conditioning	ISEKI KM-4m	2 units
Seedling box	Plastic made, 60x30 cm	2500 boxes
Transplanter		
Riding 5 raws type	ISEKI PL-500	2 units
Walking 4 raws type	ISEKI PF 451-80 RW	2 units
Walking 4 raws type	KUBOTA S-402	2 units

2. MECHANIZED HARVESTING OF LOWLAND RICE

2.1 Mechanized Harvesting and Lost paddy

The appendix is the detailed information showing the investigation for which 2 (two) kinds of Japanese made combine harvester were operated at Agricultural Demonstration Centre in the rainy season rice crop in 1982 and the operational speed of harvesters were converted by shifting of the gear position and investigated the paddy grains dropped on the field.

According to the investigation, the more the operational speed of combine harvester, the lesser the rate of grains lost. It is the quite contrary result to that in Japan. This is considered basing on that the shattering habit between Japonica rice and Indica is different. As the shattering habit of Indica rice is higher than that of Japonica, for that reason, it is presumed that some of the paddy grains will be shed from panicles by the pysical shock and friction which will be caused during the work process of from mowering to shoving into the thresher. However, if the combine harvester will be operated by high speed, the paddy grains shattered will be shoved together with rice straw into the thresher before the paddy grains will drop on the ground thus the rate of lost paddy is low.

2.2 Defect of Japanese Made Combine Harvester

The Japanese made Combine Harvester has been developed for the small scale of rice farming and Japanese farmers who have high standard knowledge and techniques on agricultural machinery. Accordingly, the most of Combine Harvester have been manufactured in Japan are high efficient on the work and nice in appearance but too complex in the mechanism and too delicate in the operation. For that reason, Japanese made Combine Harvester is not suitable for the large scale of rice farming and farmer whose technical level is still

low in Thailand. Although, in the Agricultural Demonstration Centre, many mechanical trouble occured in only a year of 1982.

If Japanese manufacturing Co. try to export Combine Harvester to Thailand in the future shall be developed to simplicity in mechanism and durableness for use.

2.3 Suitable Rice Farming Area for Mechanized Harvesting

At the present, the suitable rice farming area for mechanized harvesting is quite limited. The reasons are as follows :

1.) The area planted RD varieties resistant to lodging in the ripening stage is small.

2.) The rice farming area with irrigation facility able to control water freely is in only five hundred thousand hectares to six hundred thousand in the whole Thailand.

3.) Considering from the respect of efficiency and durability, the price of Combine Harvester is too expensive for rice farming in Thailand.

However, as the Thai Government has promoted the construction of irrigation facilities as well as the diffusion of RD varieties at the present, it is expected that the suitable rice farming area for the mechanized harvesting will be increased rapidly in the near future.

Appendix Mechanized harvesting and paddy lost

1. Specification of combine harvester used

1.) Iseki Combine Harvester, 3500-HL

32 PS/2600 rpm, reaping width, 1400 mm.

2.) Iseki Combine Harvester, 1800-HL

16 PS/3000 rpm, reaping width, 1050 mm.

2. Details of rice cultivation

1.) Variety :- RD - 23

2.) field :- No. 5, 6 and 7

3.) Area :- 16.83 Rai (2.7 ha)

4.) Sowing :- Aug. 10, 1982 (mechanized)

5.) Transplanting :- Aug. 30 and 31 (mechanized)

6.) Seedling age :- 20 days

7.) Fertilizer application

Basal :- LF (GML) 300 L/rai (N = 86.25 kg/ha)

Top dressing : Amm. Sulphate 0-40 kg/rai (0-52.5 kg/ha)

Total Nitrogen :- 13.8 - 22.2 kg/rai (86.25 - 138.75 kg/ha)

8.) Flowering :- Nov. 9, 1982.

9.) Drain water :- Nov. 26, 1982.

17 days after flowering

17 days before harvesting

10.) Harvesting :- Dec. 13, 1982.

34 days after flowering

104 days after transplanting

124 days after sowing

11.) Condition of the standing crop at the harvesting time

Lodged slightly

Grass height

Top of panicle mean 129 cm

Bottom of panicle mean 89 cm

Moisture content of the paddy

Max. 19.9 %

Min. 15.6 %

Mean 16.9 %

1000 paddy grains weight 28.2 g (in 14 % moisture content)

12.) Yield (by crop cutting survey)

Field No. 5	mean	5,619	kg/ha
Field No. 6	mean	5,916	
Field No. 7	mean	6,479	

3. Field condition

1.) Rain fall after draining

1st	Dec. 1982	8.5 mm
3rd	Dec. 1982	4.0 mm
	Total	12.5 mm

2.) Bearing capacity of the soil

Soil resistance for the combine harvester operation was satisfactory in general

4. Survey date :- Dec. 13, 1982.

5. Result of the operation

1.) Time required for harvesting

Harvester	Field No.	Area (rai)	Time required (min)	Efficiency (min/rai)	Operation speed
3500-HL	5.1	2.81	130	46.26	#6 and #8
3500-HL	6.1	3.18	123	38.68	#8 and #6
1800-HL	7-1	3.18	341	107.23	#3
1800-HL	7-2	1.50	105	70.00	#3

Note : Skillfulness of operator

3500-HL well trained

1800-HL quite bigin

Disposal of straw

Cutting 5 - 6 cm and droped

2.) Practical operational time required in 50 m

unit:second/50 m

Speed position	#1	#2	#3	#4	#6	#8
3500-HL	-	215.3	-	96.4	70.0	50.4
1800-Hl	288.0	188.8	156.0	-	-	-

3.) Lost paddy

unit:grains/m^2

Speed position	#2	#4	#6	#8
3500-Hl	1495	1140	987	670

4.) Lost paddy assumed in kg/ha and % against the yield

Speed position	3500-HL #2	#4	#6	#8
Lost paddy (kg/ha)	421.6	321.5	278.3	188.9
%, lost paddy	6.5 - 7.5	4.9 - 5.7	4.3 - 4.9	2.9 - 3.4

6. 2nd investigation of the lost paddy

1.) Field :- No. 11 area 2.06 rai

2.) Variety :- RD - 23

3.) Condition of the standing crop :- lodged completely 1 week before harvesting

4.) Harvesting and investigation date :- Dec. 23, 1982.

Ref. - Sowing :- Aug. 19

Transplanting :- Sept. 10

- 126 days after sowing

5.) Field condition

17 days after drain out water

Soil resistance for machine operation was quite satisfactory

6.) Yield : 6655 kg/ha (by crop cutting survey)

7.) Result

Mechinery	Speed	Lost grains (g/m^2) I	II	III	IV	V	mean	kg/ha	%, loss
1800-HL	#3	78.26	100.7	120.35	197.50	96.78	118.72	1187.2	17.84
3500-HL	#6	64.56	97.67	54.48	40.63	43.13	60.09	600.9	9.03

III. CROPPING PATTERN OF RICE CULTIVATION IN MAE KLOGN PILOT PROJECT

1. Factors Determining Cropping Pattern

The cropping pattern of rice double cultivation in mae Klong Pilot Project No. 1 is determined by following factors :

1.1 Schedule of Irrigation Water Supply

The irrigation water supply to the 1L-1R canal is generally started on the beginning of February and stopped on the end of November of year.

Irrigation water for supplying to the paddy fields in the pilot project No. 1 is taken in from the 1L-1R canal which is the 1st lateral canal of the 1R main canal which is flowing over the right bank area of Mae Klong river basin.

There are 2 pumping stations to get the irrigation water from the 1R canal at the head of the 1L-1R lateral canal and on about 7 km downstream. There is the period of 2 month of suspension of water supply, from the later half of harvest time of rainy season rice crop to the begining of February of the following year and during the period of water suspension, the pumps will be checked and repaired if necessary and the canals (lateral and farm ditch) will be dredged and patched.

1.2 Duty of Irrigation Water Supplied to the Farm Ditches, and Period for Field Preparation

According to the investigation on the practical water management experiment conducted in the dry season 1984, the amount of water for ploughing and puddling required about 300 mm. On the other hand, the duty of water supplied to the farm ditch for watering on the irrigation unit of 19.2 hectares is 24 L/sec at the turnout. Therefore, in case of watering for an irrigation unit which is divided into 4-6 blocks by rotational irrigation schedule, about

30 days is needed for ploughing and puddling.

Note : As for the basis for the water requirement, you are kindly refered to the " REPORT OF PRACTICAL WATER MANAGEMENT EXPERIMENT ON RICE CULTIVATION AT THE MAE KLONG PILOT PROJECT IN 1984 DRY SEASON ".

1.3 Variety planted

The varieties cultivated in dry season are entirely non photosensitive variety. The most popular variety at the present is the RD-23 which shared 90% of the total planted area and the remaining of 10% are other RD varieties. These non photosensitive varieties are not concerned with the day length and the growth duration from seeding to harvesting have been defined and the growth duration of RD-23, RD-7 are about 120-130 days in general.

As to the varieties for the rainy season rice crop, the majority has been changed to RD-23 and also some number of local varieties have been still cultivated. These local varieties are mostly photosensitivity and are not concerned to the seeding time and the flowering time of them are almost fixed respectively so that the growth duration of them are fluctuated depend on the seeding time and to let each variety display its yield potentiality, a period of 120-130 days for growing is required. For that reason, if seeding time too delay, it is hard to ensure the sufficient growth duration thus the yield will be decreased.

Khao Dok Mali 105, Khao Pak Mor 148 and Luang Pratew 124 are representative photosensitive local varieties in the Mae Klong area and the planting area of these varieties to the whole area planted is showing decrease for year by year but, owing to that the eating quality is good and it can be expected a yield of 2500-3500 kg/ha even cultivate with small fertilization as well as it is easy to manage on the field etc.. For that reason, the planting rate of them can be considered as will be remained for about 30% hereafter.

Table 10 shows area planted RD varieties in percent classified into year and seasons.

Table 10 Area planted RD varieties in Mae Klong Irrigation Project

	Pilot Project No. 1		Pilot Project No. 2	
	Dry season	Wet season	Dry season	Wet season
1981	99 %	25 %	99 %	10 %
1982	99	49	99	35
1983	99	70	99	60
1984	99	-	99	-

1.4 Cultivation Method

The rice cultivation method in dry season has been changed rapidly from the transplanting method to the direct sowing. For the dry season crop in 1984, the cultivation area by the direct sowing method shared about 90% of the total planted area. As a forecast in the future, it is considered as that the direct sowing rice cultivation will be expanded to whole area in the Mae Klong Project except some of fields in the drainage difficulty. The main reason is that for the paddy fields of land consolidation completed and enabling to control the irrigation water freely :

- Although the direct sowing method is applied, the high yield of 4-6 tons/ha not different from that applied with transplanting method can be expected.
- Transplanting and harvesting works require the most labours in concentration for the short period and they are hardest work in the process of rice cultivation. If the direct sowing rice cultivation method is adopted, the raising of seedling, uprooting and transplanting work can be saved.

And, the period of field preparation and transplanting for the rice

cultivation in dry season meet together with the period of harvesting of sugar cane and the problem of labour shortage occurs. If the direct sowing rice cultivation method is applied, the seeding works can be finished in merely short time thus labour shortage problem will be relieved.

However, if adopt the direct sowing rice cultivation in the rainy season, there is high possibility to be visited by the heavy rain with strong wind in soon after sowing thus uniformed establishment of seedling in high rate will be obstructed. Furthermore, in case of applying the direct sowing rice cultivation throughout in both rainy and dry season continuously, the weed will grow thick remarkably.

Table 11 shows the direct sowing rice cultivation area (%) in Mae Klong Pilot Project classified years and crop seasons.

Table 11 Direct sowing cultivation area in Mae Klong Pilot Project

	Pilot Project No. 1		Pilot Project No. 2	
	Dry season	Wet season	Dry season	Wet season
1981	5 %	10 %	2 %	5 %
1982	10	15	4	10
1983	45	30	30	20
1984	90	55	60	45

1.5 Weather condition

For the rainy season crop, the seeding period of seasonal bound varieties is limited and in case of non photosensitive variety such as RD-23, it has the advantage of unlimited seeding time but, if the seeding time be latened to the time on after 20th of August, the rice plant on the growing in the period from reduction division stage to flowering is apt to be suffered from the low temperature in December of year. Thus it may occur

cold weather damage in the frequency of once in some year.

Table 12 shows the characteristics of recommended rice varieties for the Mae Klong Pilot Project.

Table 13 shows appropriate seeding time and growth duration of recommended photosensitive variety in Mae Klong Pilot Project.

Table 14 shows climatological data for the period of 29 years from 1951 to 1980 at Kanchanaburi Meteorological Station and Fig. 3 shows Monthly Mean Meteorological Data for the period from 1951 - 1980 at Kanchanaburi.

July, 1983.

Table 12 Characteristics of recommended rice varieties for Mae Klong Pilot Project

I. Season free (Non photosensitive variety)

Variety	Glute-nous	G.duration or H. date	Plant height (cm)	Grain quality (mm) Length	Width	Thick	Chalkiness	Cooking Quality	Diseases Resistant BL	BLB	GSV	YOLV	RES	Insects Resistant GLH	BPH	SB	GM	Dormancy (days)	Fertilizer response	Yield Potentiality/rai (kg)	Crossing
1. RD - 7	Non	125	115	7.3	2.3	1.8	L	S	MS	R	S	R	S	S	S	S	S	7	High	672	C4-63/GR88/Sigadis
2. RD - 9	Non	120	115	7.3	2.3	1.8	L	H	S	S	S	MS	S	R	R	R	R	35	High	657	CNT3176/EK1256/RD2
3. RD - 11	Non	135	115	7.5	2.3	1.8	L	H	MR	S	MR	S	S	MR	S	S	S	28	High	730	IR661/KDML105
4. RD - 21	Non	125	110	7.35	2.3	1.8	L	S	MR	R	S	S	R	S	R	S	S	24	High	666	KDML105/rms-4/IR26
5. RD - 23	Non	120	115	7.44	2.2	1.8	L	S	MR	R	S	S	R	S	R	S	S	32	High	715	RD7 x IR32/RD1
6. RD - 25	Non	100	100	7.36	2.26	1.79	M	H	MR	MR	S	S	R	S	MR	MR	S	28	High	538	KDML105/IR2061/KDML105/IR26

II. Rainy season only (Photo sensitive variety)

1. Khao Dok Mali 105	Non	Nov.21	138	7.5	2.1	1.8	L	S	S	S	S	S	S	S	S	S	S	56	Low	363	
2. Nang Mol S - 4	Non	Nov.26	160	7.7	2.4	1.8	L	S	S	MR	S	S	S	-	S	S	-	35	Low	436	
3. Khao Pak Mor 148	Non	Dec. 3	140	7.6	2.3	1.9	L	S	MR	S	S	S	S	-	S	S	-	42	Low	415	
4. Luang Pratew 123	Non	Dec.19	150	7.6	2.3	1.8	L	S	R	S	S	S	S	S	S	S	S	42	Low	414	
5. RD - 27	Non	Dec.15	160	7.5	2.3	1.8	L	S	S	S	S	S	MR	S	S	S	S	35	Low	517	

Note : 1. G. duration :- Growth duration, H. date :- Harvesting date

2. Cooking quality : H :- Hard, M :- Medium, S :- Soft, A :- Aroma

3. Diseases : BL :- Blast, BLB :- Bacterial leaf blight,
GSV :- Rice grassy stunt, YOLV :- Yellow orange leaf virus
RSV :- Rugged stunt virus

4. Insects : GLH :- Green rice hopper, GM :- Rice Gall Midge
BPH :- Brown plant hopper
SB :- Stem borer

5. Resistant : R :- Resistant, MR :- Medium resistant, MS :- Medium susceptable
S :- Susceptable.

Table 13 Appropriate seeding time and growth duration of

Recommended photosensitive variety in Mae Klong Pilot Project

Variety \ Date or days	Seeding	Trans-planting	Panicle initiation	Flowering	Harvesting	Growth duration
Khao Dok Mali 105	Jul.17-Jul.24	Aug. 13	Sept. 22	Oct. 22	Nov. 21	120-125
Nang Mon S-4	Jul.22-Jul.29	Aug. 18	Sept. 27	Oct. 27	Nov. 26	120-125
Khao Pak Mor 148	Jul.24-Jul.31	Aug. 20	Oct. 4	Nov. 3	Dec. 3	125-130
RD - 27	Jul.31-Aug.7	Aug. 27	Oct. 16	Nov. 15	Dec. 15	130-135
Luang Pratew 123	Aug.4-Aug.11	Aug. 31	Oct. 20	Nov. 19	Dec. 19	130-135
ref.						
RD - 23 (in wet season)	Jul.1-Aug.20	Jul.20 - Sept.10	Sept.1 - Oct.20	Sept.30 - Nov.20	Oct.30 - Dec.20	120-130

Note : 1. Nursery period : 18 - 25 days

2. Vegetative growth period from transplanting to Panicle initiation :

Khao Dok Mali 105 and Nang Mon S-4 :- 40 days

Khao Pak Mor 148 :- 45 days

RD - 27 and Luang Pratew 123 :- 50 days

Table 14 Climatological data for the period of 29 years from 1951-1980 at Kanchanaburi Meteorological Station

Latitude 14° 01' N MSL 28 m

Longitude 99° 32' E

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature (°c)													
Mean	25.6	28.1	30.3	31.4	29.9	28.9	28.3	28.2	27.8	27.2	26.1	25.0	28.1
Mean Max.	32.3	34.9	37.2	37.9	35.4	33.7	33.1	32.9	32.6	31.5	30.7	30.8	33.6
Mean Min.	17.7	20.6	23.0	24.9	25.0	24.6	24.2	24.0	23.8	23.0	20.8	18.2	22.5
Ext. Max.	38.1	40.3	41.9	43.5	41.6	38.4	37.8	37.8	37.6	37.3	37.5	37.2	43.5
Ext. Min.	5.5	12.1	11.2	17.2	21.5	22.0	20.8	21.5	20.8	16.2	11.6	6.8	5.5
Relative Humidity (%)													
Mean	62.0	60.0	57.0	59.0	69.0	72.0	73.0	74.0	76.0	79.0	73.0	67.0	68.0
Mean Max.	87.1	85.0	81.9	81.6	86.6	87.8	88.4	88.9	91.5	93.0	90.9	88.5	87.6
Mean Min.	41.3	39.0	35.8	38.8	52.1	57.3	58.0	58.5	61.3	64.2	57.4	48.4	51.0
Ext. Min.	11.0	15.0	14.0	15.0	22.0	32.0	34.0	35.0	36.0	31.0	27.0	21.0	11.0
Evaporation (mm.)													
Mean-Pan	141.0	153.1	211.2	235.9	207.3	158.9	164.7	148.9	127.6	127.7	129.5	140.1	1945.9
Sunshine Duration (hr/day)													
Mean (Bangkok)	9.1	9.0	8.8	8.7	8.2	6.3	5.5	5.3	5.2	6.8	8.3	8.7	7.5
Rainfall (mm.)													
Mean	5.5	17.2	36.2	71.3	158.9	92.5	106.3	107.9	232.2	222.9	56.3	7.8	1115.0
Mean rainy days	1.1	2.0	3.4	6.4	14.2	13.5	16.1	17.2	18.7	15.1	5.4	1.6	114.7
Greatest in 24 hr.	54.4	82.0	133.9	75.8	95.4	74.1	65.8	99.5	165.5	162.8	117.6	45.6	165.5

Fig. 3 Monthly mean meteorological data for the period of from 1951 to 1980

at Kanchanaburi

Station : Kanchanaburi

Index station :- 48450

Latitude :- 14° 01'

Longitude :- 99° 32' E

MSL :- 28 m.

Note : Sunshine data at Khamphaeng saen

Year

mean or total

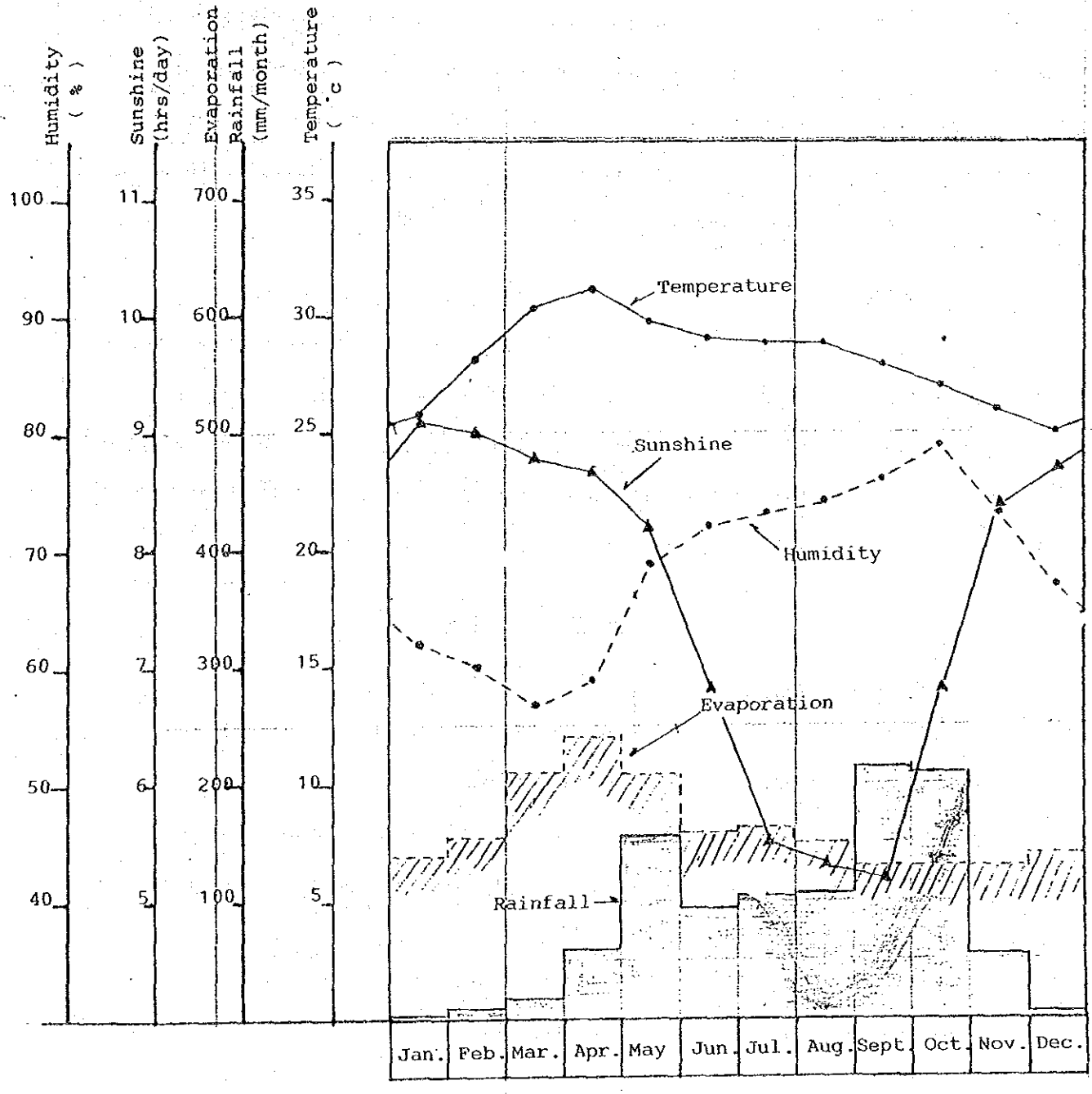
Temperature :- 28.1° c

Relative humidity :- 68.0 %

Evaporation :- 194.9 mm.

Rainfall :- 1115.0 mm.

Rainy days :- 114.7 days



2. Rice Double Cropping Calendar and Recommendation of Appropriate Rice Farming Practice

In consideration of the factors viz., irrigation system and water supply schedule, variety, farming method, climate etc. mentioned previously, the following rice double cropping calendar and appropriate farming practices are recommended. Furthermore, it is recommendable that these rice double cropping calendar and appropriate farming practices for mae Klong area shall be adopted widely on the areas in which the land consolidation (on-farm development) has been completed and enabled to conduct rice double cropping such as Phitsanulok Project and many similar conditioned areas in Northern and North-eastern Thailand.

Fig. 4 shows Rice Double Cropping Calendar for Mae Klong area.

2.1 Recommendation of appropriate Rice Farming for Dry Season Crop

Generally, the direct sowing rice cultivation method is recommendable for the dry season crop except the fields which are difficult to control irrigation water freely. (as to the detailed information for the direct sowing rice cultivation refer to " DIRECT SOWING LOWLAND RICE CULTIVATION AT MAE KLONG PROJECT "

Dry Season Rice Crop

Farming practice	Recommendation
1.) Yield target	Above 800 kg/rai (above 5000 kg/ha)
2.) Cultivation method	Direct sowing
3.) Variety	RD-23 and other nonphotosensitive varieties
4.) Seed rate	13-15 kg/rai (80-100 kg/ha) in dry condition
5.) Preparation of seed	
- Soaking	About 3 days
- Hastening of germination	24-36 hours

6.) Field leveling	Good leveling is required. Difference of underation in a plot should be within ± 5 cm.
7.) Fertilizer application	
- Basal	30-40 kg/rai of Ammophos (16:20:0 or 20:20:0) to be applied at about 2 weeks after sowing.
- Top dressing	Apply 20-40 kg/rai of Am. Sulphate (21:0:0) at about 60-70 days after sowing (in the time of young panicle formation stage).
8.) Herbicide application	Apply about 5 kg/rai of Saturn G. or Machete at 4-5 days before sowing.
9.) Water management	Before conducting ploughing and puddling check and close holes digged by crabs and rodents in levee to prevent leakage of water.
- Herbicide application time	Supply water in a depth of about10 cm then apply herbicide. Standing water should be kept for 3-4 days in stationary condition.
- Before sowing time	Drainage furrow shall be made every 8-10 m interval in order to complete the drainage.
- Sowing and after sowing	Drainage shall be conducted just before sowing then conduct sowing as uniform as possible and irrigation water shall not be supplied until the young plants are completely established in about 1-2 weeks. Rice plants require much of water in the period from the booting stage to completion of the flowering, on the contrary, the irrigation water supply shall be refrained

	during the period from maximum tillering stage to 4-5 days after panicle initiation atage. And then, the water supply will not be required any more from 2 weeks after completion of flowering to harvest.
10.) Gap filling	Providing small scale of nursery to procure seedling for complimentary transplanting shall be required at about 10 days before direct sowing or additional seeding is necessary at 2-3 days after sowing to the lower puddled places (after surface soil dried to a certain extent).
11.) Rodent and crab control	Adequate control is required for prevention of water loss. Zine phosphide, Warfarin or Fratol for rodents and Sumithion or Heptachlor for crabs are recommendable. Rodents control shall be conducted by the cooperative works before commencement of dry season rice cultivation.
12.) Insect control	It is better to apply 5 kg/rai of Furadan or Padan Mipcin at about 2 weeks after sowing.

2.2 Recommendation of Appropriate Rice Farming for Rainy Season Crop

The transplanting rice cultivation method is recommended in the rainy season. Because, if apply the direct sowing method, there is high possibility to be visited by the heavy rain with strong wind soon after sowing thus uniform establishment of seedling in the high rate will be apt to hindered.

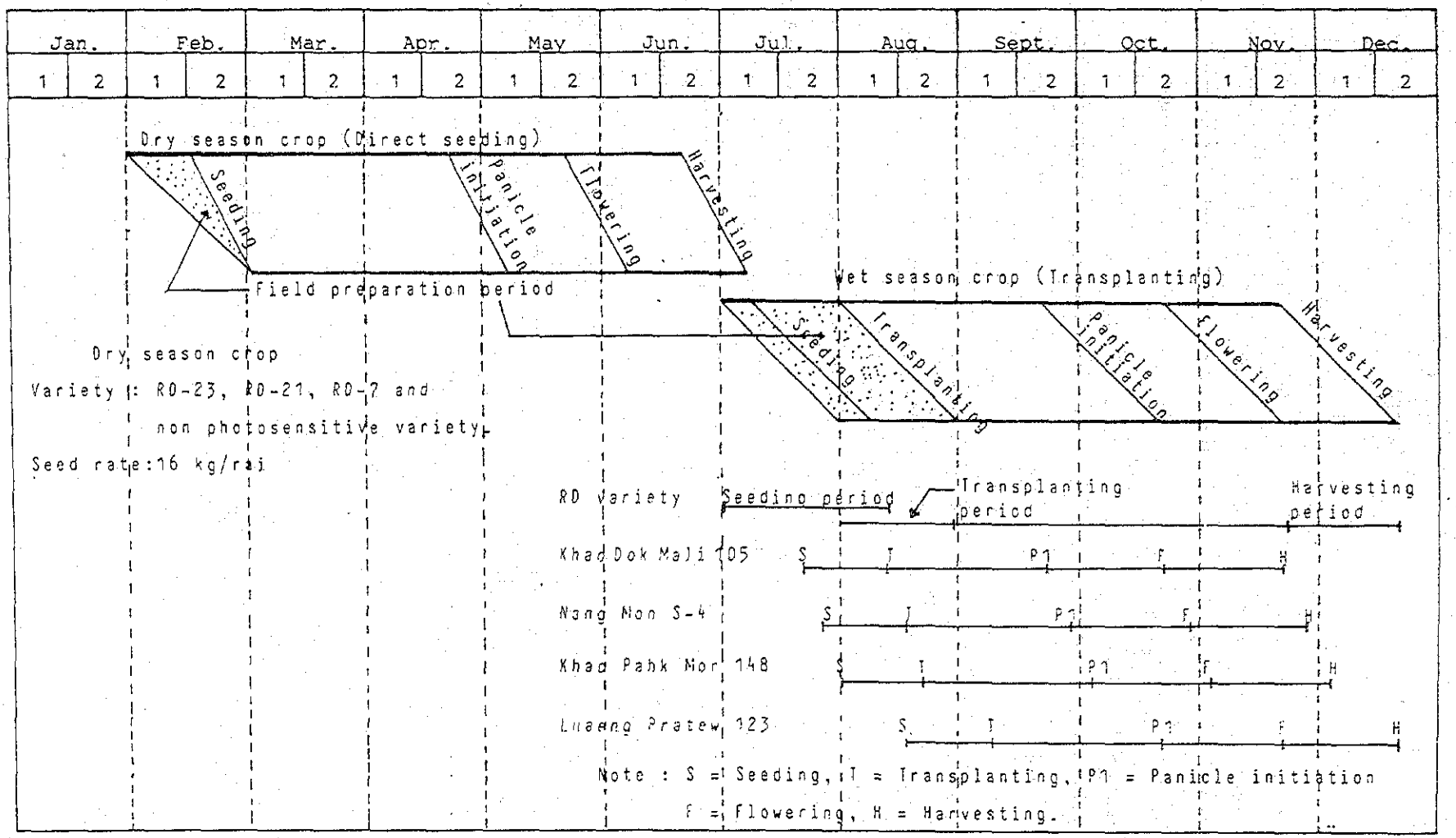
Rainy Season Rice Crop

Farming practice	Recommendation
1.) Yield target	700 kg/rai (4400 kg/ha)
2.) Cultivation method	Transplanting in general
3.) Variety	RD-23, other RD varieties (will be shared about 70%) and photosensitive local varieties viz. Khao Dok Mali 105, Nang Mol S-4, Khao Pak Mor 148, Luang Pratew 123.
4.) Nursery size	20 wa^2/rai (500 m^2/ha)
5.) Seed rate	6 kg/rai (37.5 kg/ha)
6.) Preparation of seed	Soaking and hastening of germination are same as direct sowing.
7.) Seedling age at transplanting	18-25 days
8.) Planting density and seedlings/hill	100 hills/wa^2 (25 hills/m^2), about 30 cm x 13 cm or 20 cm x 20 cm and 3-4 seedlings/hill.
9.) Root depth at transplanting	As shallow as possible
10.) Fertilizer application	
- Basal	30-40 kg/rai of Ammophos (16:20:0 or 20:20:0) for RD varieties and 20 kg/rai for photosensitive local varieties. Apply at puddling time or 1 week after transplanting.
- top dressing	20-30 kg/rai of Am. Sulphate (21:0:0) for RD varieties and 10-20 kg/rai for local varieties. Apply at young panicle formation stage about 45-50 days after transplanting.
11.) Herbicide application	apply 5 kg/rai of Saturn G. or Machete at 4-5 days after transplanting.

12.) Water management	Maintain 4-5 cm depth of water or irrigate about 8 cm depth every week until 2 weeks after flowering. However, the paddy fields may be dried after maximum tillering stage for about 10 days.
13.) Rodents, crabs and insect control	Same management as direct sowing.

Fig. 4 Rice Double Cropping Calendar

for Mae Klong area



SUMMARY OF AGRONOMICAL EXPERIMENTS CONDUCTED AT AGRICULTURAL DEMONSTRATION CENTRE

1. Introduction

Agricultural Demonstration Centre conducted lots of agronomical experiments, collection existed technical datas and their analysis and field observations in order to improve farming technologies on the transplanting and direct sowing rice cultivation in both of dry and rainy seasons.

Appropriate rice farming practices on the basis of the result of experiments have been established and diffused to the farmers in the project through the extension activities in close cooperation with government agencies concerned and farmers organization.

Furthermore, the Centre multiplied purified paddy seed of recommended high yielding varieties and distributed those seed to the farmers in order to realize rice double cropping and increase yield per unit acerage.

Consequently, the yearly rice production has been greatly increased from single cropping of 2.2 tons per hectare before commencement of the cooperation project to double cropping of 8-9 tons per hectare on the average.

Although appropriate farming techniques of the rice double cropping have been established, there are still many quetions ought to be studied regarding looking for promising veriety in addition to RD-23, maintaining and increasing of soil fertility, minimizing of water amount to be supplied for rice cultivation, seeking for efficient weed control method and et cetra have been left for further works.

2. Agronomical Experiment and Investigation

During the technical cooperation period, Agricultural Demonstration Centre conducted a lot of agronomical experiments water management experiments and investigations.

Unfortunately, the Centre couldn't conduct experiments in the former half cooperation period from April 1977 to the rainy season crop of 1981.

The reasons were as follows :

1.) Japanese agronomist was assigned on December of 1979 about 3 years after the commencement of project cooperation.

2.) Reconstruction of on-farm development was required in 1980 and 1981, because miss constructions of irrigation facilities, farming roads and very poor field leveling were made by Sanyu Consultant Co.

3.) Soil fertility was not uniform for conducting of experiment due to poor land consolidation work.

4.) Necessary farming machinery and equipment were not procured until the year end of 1981.

5.) Permanent field workers and technical assistants were not assigned.

Accordingly, the Centre commenced regular experiments from in dry season of 1982.

2.1 Agronomical Experiment Conducted

Method of experiment and investigation

- Design : Mostly, Randaomized Completed Block and 4 Replication
- Plot size : 40 m^2 (8 m x 5 m)
- Yield survey : 8 m^2 (4 m x 2 m) in each plot
- Yield components survey : 20 hills/plot
- Moisture content : Converted into 14 %

	Year	Crop season
1.) Effect of Application Rate of Nitrogen and RD Varieties for Rice Yield	1980	Wet
	1981	Dry and Wet
- Nitrogen rate : 6, 8 10 and 12 kg/rai		
- Variety : RD-7, RD-9 and RD-11		
2.) Effect of Application Rate of Nitrogen and RD Varieties Released Newly	1982	Dry and Wet
	1983	Dry
- Nitrogen rate : 0, 8, 16 and 24 kg/rai		
- Variety : RD-21, RD-23 and RD-7 (control)		
3.) Effect of Application Rate of Nitrogen and Photosensitive Local Varieties and RD Varieties for Rice Yield	1983	Wet

	Year	Crop season
- Nitrogen rate : 0, 6 and 12 kg/rai		
- Variety : Khao Dok Mali 105, Khao Pak Mor 148 Luang Pratew 123, Nang Mon S-4 RD-7, RD-23 and RD-27		
4.) Effect of Plant Density and Application Rate of Nitrogen for Rice Yield	1982	Dry and Wet
- Planting density: 11.4, 16.0, 22.2 and 40 hills/m^2 (35x25, 25x25, 30x15, 25x10 cm)		
- Application rate of Nitrogen : 0 and 16 kg/rai		
5.) Effect of Preceding Upland Crops as Green Manure for Rice Yield	1980	Wet
- Upland Crop : Muang bean, Sesbania and Crotoloria (Hemp)		
6.) Effect of Application Rate and Time of Saturn G. for Establishment Rate of Seedling on Direct Sowing Rice Cultivation	1980	Wet
- Application rate : 5 and 7 kg/rai		
- Application time : 3, 5 and 7 days before Sowing		
7.) Effect of Sowing Seed Rate and Application Rate of Nitrogen for Rice Yield on Direct Sowing Rice Cultivation	1982 1983	Dry and Wet Dry
- Seed rate : 8, 16 and 24 kg/rai		
- Nitrogen rate : 0, 8, 16 and 24 kg/rai		
8.) Effect of Sowing Seed rate and Application Rate of Nitrogen (cooperation Experiment with Chao Phya and Suphanburi Sub Project)	1983 1984	Wet Dry

	Year	Crop season
- Variety : RD-23		
- Seed rate : 4, 8 and 16 kg/rai		
- Nitrogen : 12 kg/rai (Basal 6, T. Dressing 6 kg/rai)		
9. Effect of P_2O_5 and K_2O for Rice Yield	1982	Dry and Wet
	1983	Dry
- P_2O_5 rate : 0, 8 and 16 kg/rai		
- K_2O rate : 0, 6 and 12 kg/rai		
10.) Effect of Application Method and Time of Basal Fertilizer for Rice Yield	1983	Dry and Wet
	1984	Dry
- Basal fertilizer : N=10, P_2O_5=6, K_2O=6 kg/rai		
- Application method : Puddling time (deep placement) and 1, 7, 14 and 21 days after transplanting (broadcasting on the surface soil)		
11.) Fertilizer Effect of Ami-Ami (by product of Ajinomoto) as Basal Comparing with Chemical Fertilizer	1982	Wet
	1983	Dry
- Basal : Ami Ami (N=4.6%) 300 L and 210 L/rai Ammophos (16:20:0) 60 kg/rai		
- Top dressing : Am. Sulphate 0 or 20 kg/rai		
- Total Nitrogen = 13.8 kg/rai, P_2O_5 = 12 kg/rai		
12.) Effect of Application Time of Ami Ami and Triple Super Phosphate	1983	Wet
	1984	Dry

		Year	Crop season
	- Application time of Ami Ami : 1 week and 1 month before transplanting		
	- $P_2 O_5$ rate : 0, 6 and 12 kg/rai		
13.)	Effect of Ami Ami, Urea and T.S. Phosphate for Rice Yield	1984	Dry
	- Basal : GML 200 L + TSP 27 kg, GML 200 L + TSP 14 kg, GML 200 L, Urea 20 kg + TSP 27 kg, Urea 20 kg + TSP 14 kg, Urea 20 kg/rai		
	- Top dressing : Urea 10 kg/rai respectively		
14.)	Effect of Seedling Age for Growth Duration and Yield	1984	Dry
	- Seedling age : 20, 30, 40 and 50 days		
15.)	Effect of Unirrigated Period for Growth Duration and Yield	1984	Dry
	- Unirrigated period : 3, 5, 7, 9 days after disapearance of water		
16.)	Effect of Moisture Stress for Rice Yield	1984	Dry
	- Moisture stress : at rooting, primodial, booting and flowering stage		
	- Dry up period : for 10 days in respective growing stage		
17.)	Effect of Sowing Time of Photosensitive Local Variety for Growth Duration and Yield	1984	Wet
	- Variety : Khao Pak Mor 148, Luang Pratew 123 and RD-27		
	- Nitrogen rate : 0, 6 and 12 kg/rai		

		Year	Crop season
18.)	Effect of Application Time of Fertilizer for Rice Yield	1984	Wet

- Variety : RD-23 and RD-27
- Nitrogen : Basal = 0, 6, 6, 6 kg/rai
  1st T.D. = 0, 3, 0, 6 kg/rai
  at 2 weeks after transplanting
  2nd T.D. = 6, 3, 3, 3 kg/rai
  at young panicle formation stage
  3rd T.D. = 0, 0, 3, 3 kg/rai
  at flowering stage
- Total NPK : N = 12 kg/rai, P_2O_5 and K_2O = 6 kg/rai

2.2 Experiment and Investigation for Water Management

1.)	Water Requirement for Ploughing and Puddling (at Agricultural Demonstration Centre)	1983	Dry
2.)	Water Requirement in Depth (at Agricultural Demonstration Centre)	1984	Dry
3.)	Practical Water Management Experiment at Mae Klong Pilot Project (Cooperation Experiment with Extension and Water Management Section, RID.)	1984	Dry

- Area investigated : 3 terminal irrigation units
  i Intensively controled area (18.1 ha)
  ii Semi-intensively controled area (18.3 ha)
  iii Common area (19.1 ha)
- Main item of investigation
  i Water requirement for field preparation
  ii Water requirement for the period of paddy growing

iii Water discharg of drainage ditch and
main drainage canal

- Progress of farming work
- Rice production

4.) Baring Capacity in Paddy Field 1983 Dry

- For using of combine harvester

3. Summary of Result of Major Experiments

3.1 Effect of Application Rate of Nitrogen and RD Varieties Newly Released

RD-7, RD-21 and RD-23 are the typical recommended paddy varieties at the present in the Mae Klong river basin. For these varieties, application quantity of nitrogen changed from 0-24 kg/rai and investigated the yield and yield components respectively. The results obtained were as follows :

1.) As to the yield, among the varieties and nitrogen levels, the significant difference was noticiable in 1% level respectively. It denotes that selection of variety and application of appropriate quantity of nitrogen are most important factors for getting high and steady yield of paddy. In comparison of the yield among the varieties in the last 2 experiments (dry season 1982, 1983) were as follows :

RD-21 > RD-23 > RD-7

According to the investigation, between RD-21 and RD-23, there was not much difference but between these 2 varieties and RD-7, considerable difference was shown.

2.) If consider RD-21 variety on its yield only it seems as a most excellent variety but should be judged it by adding the result of growth investigation, it is not quite preferable because it needed about 20 days from commencement

of sprouting out head to completion of heading. It is considered that RD-21 as a variety has not entirely fixed and it is still continue segregation.

3.) Further, RD-7 variety has not only smaller yield potentiality compared with RD-21 and RD-23 but also with the defect of susceptibility to the Rugged Stunt Virus.

Judging from the reasons mentioned above, RD-23 is the most excellent variety for the Mae Klong Irrigation Project area at the present time.

4.) According to the result of analysis of experiments and data obtained from seed multiplication of paddy cultivation, 90-120 kg of nitrogen quantity per hectare is considered as appropriate in the pilot areas.

5.) Further, in the case of that the irrigation water is sufficiently supplied during rice cultivation period, a paddy production of approximatlly 2,500-4,300 kg/ha can be obtained though no fertilizer is applied. This yield is far more than average yield of 1,800 kg/ha in whole Thailand. Thus it denotes that how an important factor the irrigation water supply be for the paddy cultivation. Table mentioned below shows the yield obtained by no fertilizer application rice cultivation in the dry season, 1982 and 1983.

Variety	Yield (kg/ha)	
	1982	1983
RD-7	3,075	2,519
RD-21	4,362	3,760
RD-23	4,181	3,473

3.2 Effect of Planting Density and Application Rate of Nitrogen for Rice Yield

The experiments conducted in order to find out proper planting density on the transplanting cultivation.

According to the result of experiments, in the case of nitrogen quantity of more or less 100 kg/ha (16 kg/rai) applied, the planting density of 22.2 hills/m^2 (30 cm x 15 cm) is considered as most practical. If the hills/m^2 is made to over 40 hills, it will not only waste labour for trnasplanting but also causes lodging in the early stage of maturing thus it will relate to decrease of yield.

Further, when the paddy is cultivated without fertilizer application or small quantity of fertilizer with density of under 16 hills/m^2, it is hard to ensure the necessary panicles for obtaining high yield and this is another cause of yield decrease

3.3 Effect of Sowing Seed Rate and Application Rate of Nitrogen for Rice Yield on Direct Sowing Rice Cultivation

The experiment conducted by RCB in 3 seed rate (8, 16, 24 kg/rai) and 4 levels of nitrogen application (0, 8, 16 and 24 kg/rai)

according to the result of analysis, for the increasing of quantity of nitrogen application and seed quantity, the yield was increasing but when the quantity of nitrogen application reached to 24 kg/rai, the yield of the treatment using the seed quantity of 24 kg/rai was decreased. In the case of seed rate of 16 kg/rai, the yield was higher than that of seed rate of 8 kg/rai and 24 kg/rai but yield in between seed rate 16 kg/rai and 24 kg/rai was not significant difference in statistic. As the conclusion, the optimum quantity of sowing seed and nitrogen for the germinated seed direct sowing rice cultivation in Mae Klong pilot areas are judged to be about 16 kg/rai (100 kg/ha) respectively.

3.4 Effect of P_2O_5 and K_2O Application for Rice Yield

The experiments were conducted by RCB method and 4 replication in the 3 levels of application quantity of P_2O_5 (0, 8 and 16 kg/rai) and K_2O (0, 6 and 12 kg/rai).

In the experiment conducted in dry season 1983, significant difference among the yield was unnoticiable respectively but for the spikelets/panicle and 1,000 grains weight, the significant difference is noticiable. Further, on the experiment of rainy season crop 1982, in both of yield and yield components, the significant difference was noticiable. Summarizing, for the fertilization effect of P_2O_5 and K_2O are judged as follows :

On the Mae klong river basin, when conduct continuously rice double cropping in a year and obtain the yield of more than 4,000 kg/ha/crop, it is considered that from the 3rd year after commencement of rice double cropping, in another words, from the 5th crop, to apply the P_2O_5 and K_2O is recommendable.

3.5 Effect of Application Method and Time of Basal Fertilizer for Rice Yield

The test variety was RD-23 and the basal fertilizer applied per rai were N=10 kg, P_2O_5=6 kg, K_2O=6 kg and the time for application of basal fertilizer were divided into 5, that is to say, at the time of puddling, 1 day, 7 days, 14 days and 21 days after transplanting. The method of basal fertilizer application were that deep placement of fertilizer was made at the puddling time and the others were broadcasted on the soil surface. The yields were investigated on respective application time of basal fertilizer.

According to the result of yield investigation, there were no significant difference among the treatments but the yields in the treatments of fertilizer application at the time of puddling and 1-2 weeks after transplanting were higher than the others.

3.6 Fertilizer Effect of Ami-Ami as Basal Comparing with Chemical Fertilizer (Ami-Ami : By product of Ajinomoto; Nitrogen Content 4.6 %)

The experiments were conducted in the rainy season, 1982 and dry season, 1983.

According to the result of experiments, the effect of Ami Ami was proved as not inferior to chemical fertilizer in comparison. It was executed additional experiment in dry season 1983. The result was similar to the experiment of last time. Among the different of fertilizer, the significant difference was unnoticiable but the yield in between Ami Ami application and without fertilizer, the significant difference of 1% was found. As it was mentioned in the report of Seed Production Rice Culture in the dry season 1983, the cost of using Ami Ami is cheaper about ฿ 800 /ha than that of using the chemical fertilizer.

3.7 Effect of Application Rate of Nitrogen and Photosensitive Local and RD Varieties for Rice Yield

4 Typical local varieties of Khao Dok Mali 105, Nang Mon S-4, Khao Pak Mor 148 and 3 RD Varieties of RD-27, RD-7 and RD-23 (RD-7 and RD-23 are non photosensitive variety) were used as test variety. Amount of N application per rai were varied in 3 levels of 0, 6, 12 kg for each variety and, then investigated the yield and yield components respectively.

The result appeared that in the case of N application amount in 0 kg per rai, the yields of varieties per hectare were that the 2 varieties of RD-23 and Nang Mon S-4 was about 3,600 kg, the 3 varieties of Khao Dok Mali 105, Khao Pak Mor 148 and was in the level of 3,300 kg and, then Luang Pratew 123 in 3,000 kg and RD-7 was in 2,600 kg thus the difference of yield per ha between highest and lowest was 1,000 kg.

In the case of N application amount with 12 kg/rai, the yield/ha ranged that the RD-23 in highest of 4,650 kg, next, Nang Mon S-4 in 4,200 kg, RD-27 and RD-7 in the level of 3,800 kg, Khao Dok Mali 105 in 3,600 kg, Khao Pak Mor 148 in 3,500 kg and Luang Pratew 123 in lowest of 3,000 kg.

Further, in the case of N was applied in 12 kg/rai, the rate of yield increase in percentage on the basis of the yield which nitrogen was not applied at all, RD-7 was highest rate in increase of 46%, and next was RD-23 in 30%, Nang Mon S-4 in 17%, RD-27 in 15%, Khao Dok Mali 105 in 10%, Khao Pak Mor 148 in 5% and Luang Pratew 123 in 3% in comparison. The rate of yield increase of non photosensitive varieties was higher than that of photosensitive varieties. Besides, when nitrogen was applied in 12 kg/rai, rice plant of photosensitive varieties lodged completely during the period of flowering and early ripening stage, while plants of RD-7 and RD-23 lodged only partialy.

Concluding from the result of experiments regarding varieties and application quantity of nitrogen, it can be said as follows :

- RD-23 Variety is not only able to get higher production, though it is cultivated without fertilization comparing with other varieties but also the efficiency of fertilization is high and, also, it is able to be cultivated in both rainy and dry season so that this variety is considered at the present time as most execellent one for this Mae Klong Project area.

- Most of the photosensitive varieties show low efficiency of fertilization, in the case of cultivation without fertilization or with small amount of fertilizer applied, considerable high yield could be expected. The limitation of nitrogen amount applied is considerated as under 12 kg/rai.

- As to the RD-7 variety, the yield in the case of cultivation without fertilization is inferior to the local varieties in comparison and the yield potentiality is also low. In addition, RD-7 is one of the msot susceptible

variety to Rugged Stunt Virus. So that it ought to be ruled out as a recommended variety for this Mae Klong Pilot Project area.

3.8 Effect of Application Time of Ami-Ami and Triple Super Phosphate

As the variety for experiment, the RD-23 was used and GML of 300 liters (N=13.8 kg/rai) applied as basal manure. The time of application of Ami Ami were divided to 1 week and 1 month before transplanting. The triple super phosphate application were varied in 0 kg, 6 kg, 12 kg/rai and all quantity of fertilizer was applied for the basal manure and nothing was applied as additional fertilizer.

According to the result of analysis, the significant difference was noticeable between treatments for the application time of Ami Ami. The yield in the treatment of Ami Ami application on 1 month before transplanting reached 4,000 kg/ha and exceeded that of the treatment of Ami Ami on 1 week before transplanting. The response of P_2O_5 in between treatments, the significant difference was not noticeable.

3.9 Effect of Ami Ami, Urea and T.S. Phosphate for Rice Yield

The variety for experiment was RD-23 and the method of fertilizer application were made to the following 6 kinds and, then the investigation of yield were performed respectively.

Treatment			
Fertilizer	Basal/rai	Top dressing Urea (kg/rai)	NPK (kg/rai)
1. GML	200 L	10	13.8-12-0
TSP	27 kg		
2. GML	200 L	10	13.8-6-0
TSP	14 kg		

3.	GML	200 L	10	13.8-0-0
4.	Urea	20 kg	10	13.8-12-0
	TSP	27 kg		
5.	Urea	20 kg	10	13.8-6-0
	TSP	14 kg		
6.	Urea	20 kg	10	13.8-0-0

According to the result of yield investigation, significant difference was not noticeable in among the treatments.

In considering the result of a series of experiment regarding Ami Ami fertilizer, it will be concluded as follows :

1. The Ami Ami possess the fertilization effect not inferior to that of Urea, Ammonium Sulphate or Ammonium Phosphate.
2. The fertilization effect of Ami Ami is high durability in comparison with chemical fertilizer.
3. The production cost using of Ami Ami is cheaper than that of using chemical fertilizer.
4. However, the effect of $P_2 O_5$ is not comfirmed yet until the present time.

3.10 Detailed Information and Result of Other Experiment and Investigation

As to the detailed information and result of other experiments and investigations conducted at the Agricultural Demonstration Centre and in the pilot area, you are kindly refered to the reports which are separatly bound.

List of technical reports is given as below.

1) Report of the Paddy Cultivation in the Dry Season, 1982.

2) Report of the Paddy Cultivation in the Rainy Season, 1982.

3) Report of the Paddy Cultivation in the Dry Season, 1983.

4) Report of the Paddy Cultivation in the Wet Season, 1983.

5) Report of the Paddy Cultivation in the Rainy Season, 1984.

4. Recommendation

Appropriate rice farming practices based on the result of experiments diffused to the farmers in the project. As the result, yearly rice production was grately increased in comparison with that of before commencement of the project.

However, still many quetions ought to be studied have been left for futher work.

They are :

4.1 Variety

The most popular variety at the present in the project is the RD-23 which shared about 90% of the total planted area in the dry season and about 60% in the rainy season.

Planting one variety in wide area should be avoided because it causes the risk of crop failure due to insects, diseases and natural calamities. So as to minimize the risk some other promising varieties should be selected.

4.2 Soil fertility

Soil fertility of paddy field will be decreased owing to the continuation of rice double cropping for many years. Countermeasure to prevent the decrease of soil fertility is the important matter to be considered. Returning rice straw without burning is recommended in addition to the application of adequate amount of chemical fertilizer. Agronomical experiments should also be conducted

on applying some organic fertilizer, i.e. green manure, city compost, cow dung, chicken manure.

4.3 Practical experiments

Conducting following practical experiment regarding rice cultivation should be continued

- Effect of moisture stress at main growing stages for rice yield
- Effect of unirrigated period for growth duration and yield
- Effect of sowing time of photosensitive local variety for growth duration and yield.