EXPERIMENTAL SITE

Greater Mae Klong Irrigation Project

The Greater Mae Klong Irrigation Project is one of the larger irrigated agriculture development projects in Thailand, covering an area of approximately 480,000 ha (3 million rai). It is located in the most western part of the Central Plain of Thailand. Fig. 1 shows the map of project area. Rice and sugarcane are dominant crops, and land development work is under implementation in the area.

Pilot Project No. 1

Pilot project No.1 of the said Mae Klong project is located in Tha Muang district, Kanchanaburi province (Fig. 2). It covers 374.2 ha (2,339 rai) and irrigation water is supplied through 4 intakes of a secondary irrigation canal (1L-1R). Agriculture demonstration center is located in the pilot project.

The pilot project area received an intensive method of land consolidation during 1979 to 1981. In the design of intensive method of land consolidation (JICA, 1977), the standard size of terminal irrigation unit is 19.2 ha (Appendix 1). It consists of 12 paddy fields of 0.8 ha (5 rai) in right and left side of the terminal irrigation canal (farm ditch), respectively. Each paddy field (0.8 ha) is 50 m in width and 160 m in length, then every paddy field faces irrigation ditch (has inlet) and drainage ditch (has outlet).

Because of its limited budget, however, leveling work was not completely done and number of inlets installed to each farm ditch was less than that in design. As the result, lot of additional levees were constructed in the irrigation unit after land consolidation. It increased number of paddy fields in the irrigation unit, and reduced the average size of paddy field. Then field to field irrigation became a common practice even in the area received intensive method of land consolidation.

Fig. 1 Location map of Mae Klong Irrigation Project.

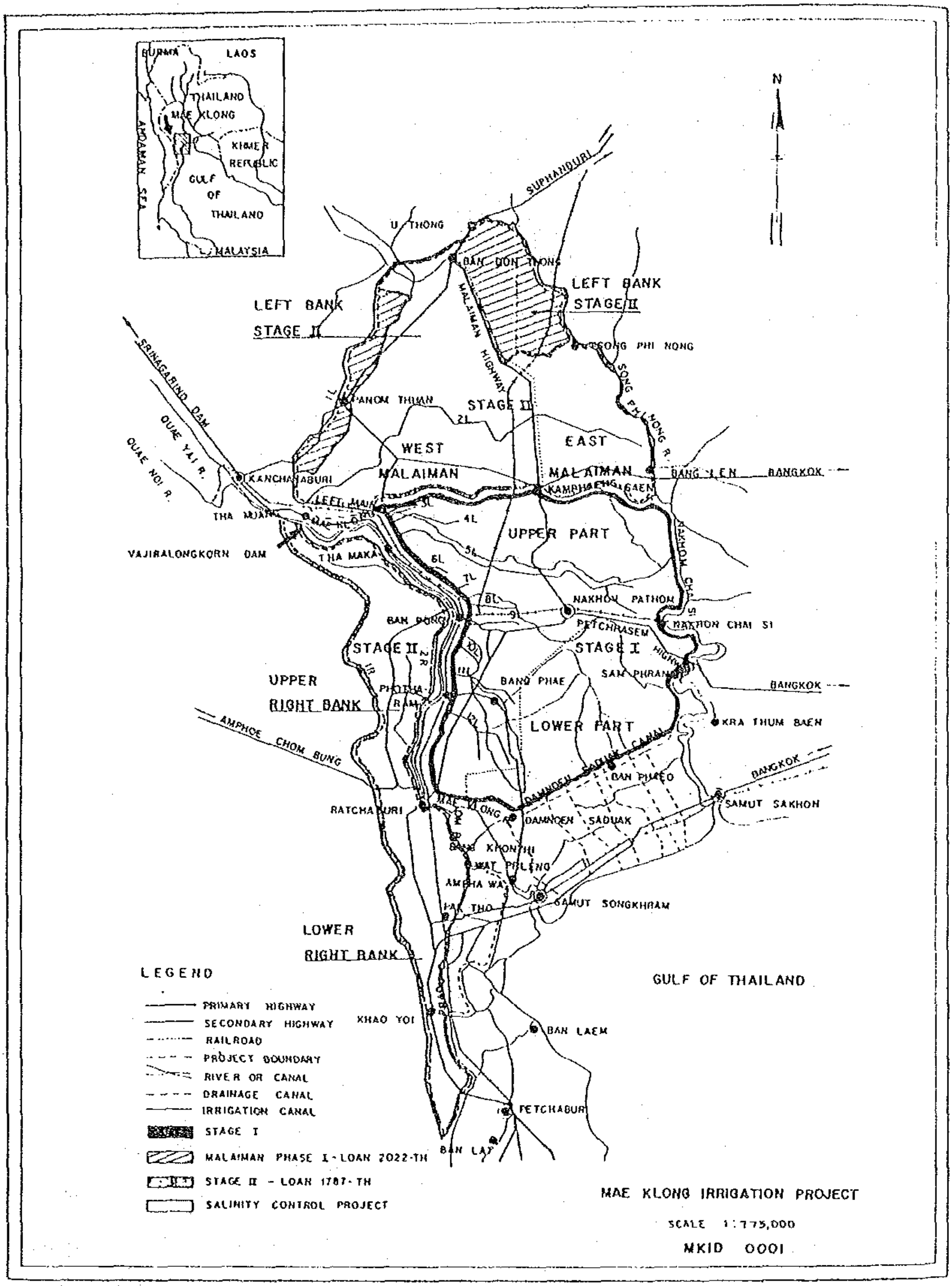
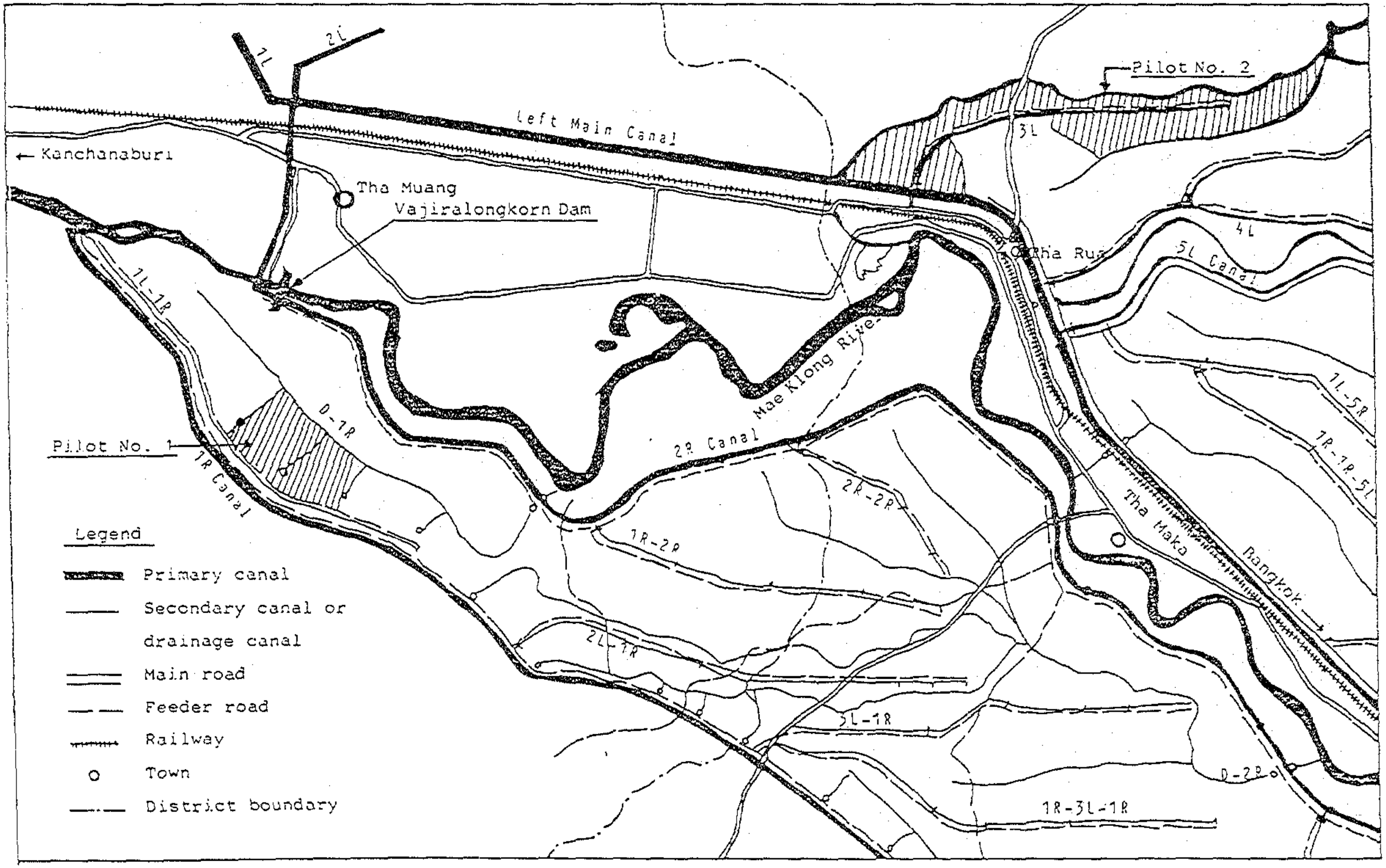


Fig. 2 Location map of Pilot Project No.1



The pilot project No. 1 and its surrounding area has rather high elevation (about 20 m above mean sea level) in the Mae Klong project, and the slope of the area is quite less in general (about 1/5,000). Irrigation water to the area is supplied by 1L-1R canal. Since elevation of the area is higher than that of surface water level of main canal (1R), irrigation water from 1R to 1L-1R canal can not be supplied by gravity. Water of 1L-1R was pumped up at the permanent pumping station at the head (about 6 km from the experimental area) and 2 temporary pumping stations along the pilot project (1 about 0.3 km upper stream and 1 about 1 km down stream of the experimental area) at the time of experiment. Two permanent pumping stations, one existing at the head and the other near the agricultural demonstration center would be operating from the following year of the experiment.

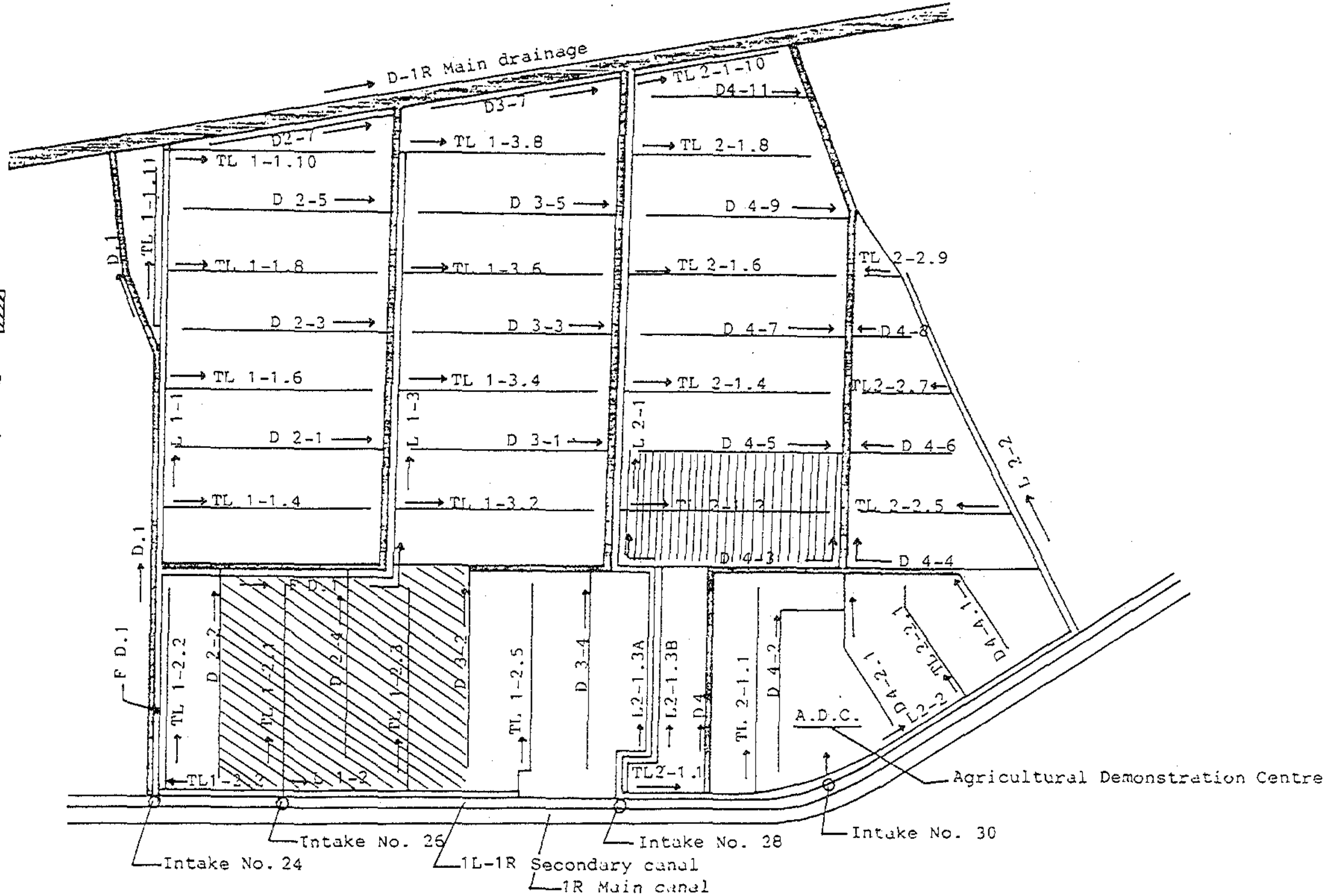
Although main and secondary canals are fully received concrete lining, part of feeder canals (tertiary) and all of farm ditches (terminal canals) are earth made. Because of quite less land slope and some long tertiary canals, it make difficult to distribute water to the downside farm ditches and to the paddy fields at the end of farm ditch.

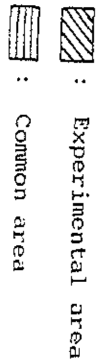
Experimental Area

The experimental area was a part of pilot project No. 1. Two terminal irrigation units, supplied water by TL 1-2,1 and TL 1-2,3 farm ditches, were used for the experiment. One irrigation unit, supplied water by TL 1-2,1, was called intensive area (intensively water controlled area), and the other unit was called semi-intensive area (semi-intensively water controlled area). Fig. 3 shows the location of experimental area in pilot project No. 1. It was just along the 1L-1R canal, and irrigation water was supplied through the intake No. 26.

Like as other areas of the pilot project, the initial paddy field (0.8 ha) was divided into small fields by additional levees in the experimental area. Prior to starting the experiment, spot height survey was conducted in the area.

Fig. 3 Location of experimental area and flow chart of irrigation water in Pilot Project No. 1





The result (Appendices 2 and 3) indicated that there were poorly irrigable fields in the area. The poorly irrigable field means that the field is higher in elevation than the field of water comes, then it hardly become flooded conditions and easily become drained conditions.

Before starting the experiment, number of inlets was 5 and 8, then number of paddy fields were 80 and 84 for intensive and semi-intensive area, respectively. It meaned that about 16 paddy fields in the intensive area and about 10 or 11 paddy fields in the semi-intensive area were supplied water by 1 inlet.

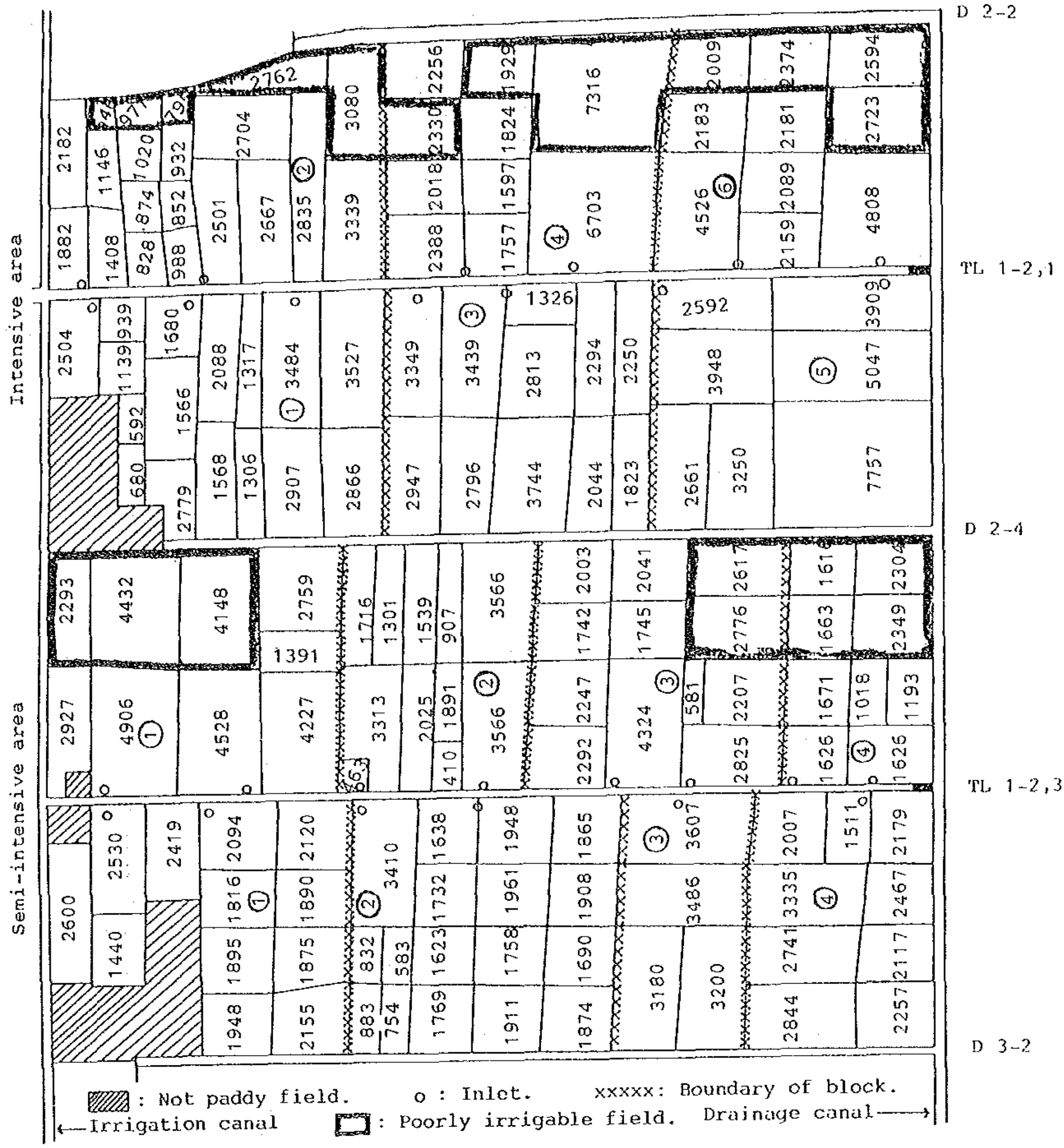
Some improvement on water distribution was done before and during early period of the experiment. Additional inlets were installed both in the intensive and semi-intensive areas. An outlet was installed to every field facing drainage ditch in the intensive area. Leveling work was done for the extremely unlevel fields in the intensive area, and some levees were removed during the leveling work. However, it could not eliminate the problem of poorly irrigable paddy field.

Details of the experimental area at the time of finishing puddling work are presented in Table 1 and Fig. 4. Parts of the area were converted into pond and housing sites, then the total paddy field area was less than the standard size of 19.2 ha either in the intensive or semi-intensive area. Paddy field area was 181,107 m^2 and 182,626 m^2, number of inlets was 13 and 14, average size of paddy field was 2,447 m^2 and 2,188 m^2 for intensive and semi-intensive area, respectively. Number of tillers were more in the intensive area (19 farmers) than in the semi-intensive area (14 farmers).

Table 1 Situations of experimental area.

	Intensive area	Semi-intensive area
Area of paddy field	181,107 m^2	181,626 m^2
Name of farm ditch	TL 1-2,1	TL 1-2,3
Number of land owners	7	8
Number of tillers	19	14
Number of paddy fields	74	83
Average size of paddy field	2,447 m^2	2,188 m^2
Number of irrigation blocks	6	4
Number of inlets	13	14
Number of outlets	21	-

Fig. 4 Area of every paddy field and location of poorly irrigable fields.



Intensive area : 181,107 m^2

Block 1	30,942
Block 2	34,412
Block 3	28,825
Block 4	30,118
Block 5	29,164
Block 6	27,646

Semi-intensive area : 182,626 m^2

Block 1	56,393
Block 2	48,836
Block 3	40,873
Block 4	36,524

EXPERIMENTAL METHODS

Prior to conducting the experiment, all farmers in the area were requested to attend the meeting, then they were oriented irrigation schedules. The initial irrigation schedule for intensive area is in Appendix 4 and that for semi-intensive area is in Appendix 5. Because of its unfamiliar irrigation schedule, fertilizer subsidy was proposed as a response to the cooperation of farmers in the intensive area. Compound fertilizer (15-15-15) at the rate of 30 kg per rai for basal and ammonium sulfate (21-0-0) at the rate of 20 kg per rai for top dressing were distributed at adequate times on the condition of returning rice at the rate of 30 kg per rai after harvesting.

Measurement of Amount of Water Supplied

A Parshall flume (locally made, 6 inch in width) and an automatic water level recorder (KWH-10, Ikeda Keiki & Co. Ltd.) were installed at the head of each farm ditch (TL 1-2,1 and TL 1-2,3) prior to conducting the experiment. A ruler was set at the Ha point of the Parshall flume. Then water level of the Ha point of Parshall flume was recorded by the automatic water level recorder after adjusting its recording point to the Ha point of Parshall flume. Quantity of water supplied was obtained from the table of Parshall flume discharge (L/sec) and converted into other forms (i.e. m^3, mm). An example of culculation of the quantity of water from the water level of Ha point is presented in Appendix 6 and 7. Measurement of the amount of water supplied was done from March 3 (starting date of irrigation water supply) and continued until July 8, 1984 (last date of irrigation water supply). Water discharge at the head of farm ditch was influenced by water level of 1L-1R canal, especially at night time. Then it was difficult to maintain water discharge at steady amount.

Distribution of Irrigation Water in Irrigation Units

1. Intensive area: Intensively water controlled area.

One irrigation unit of 181,107 m^2 was divided into 6 rotational blocks based on the existed levees in the area. It was 30,184.5 m^2 in average, and ranged from 27,646 m^2 for block 6 to 34,412 m^2 for block 2 (Fig. 4). In the intensive area, preparation water for ploughing work was supplied block by block followed by preparation water for puddling. In the schedule of irrigation water supply (Appendix 4), about 220 mm of water for ploughing and about 175 mm of water for puddling were expected, and there were 3 days for adjustment between the periods of ploughing and puddling water supply. Preparation water supply for ploughing and puddling was expected to finish in 37 days in the schedule. However, the schedule was adjusted according with the field water conditions.

After seedling establishment in the intensive area, a rotational irrigation was introduced. The schedule of rotational irrigation was 1 irrigation day for each block starting Monday (6:00 a.m.) for block 1. Sunday was reserved as a spare day in the schedule, then any field, where there was not enough water, could take water on Sunday. Because of unstable water supply to the farm ditch and different conditions of paddy field in water balance, the rotational irrigation did not strongly compel the farmers to follow. However, it ensured that the farmers, especially those who had paddy fields at the end of the farm ditch, could take water on the assigned day if their paddy fields were lack of water.

2. Semi-intensive area: Semi-intensively water controlled area.

The other irrigation unit of 182,626 m^2 was divided into 4 blocks. It was 45,656.5 m^2 in average and ranged from 36,524 m^2 for block 4 to 56,393 m^2 for block 1 (Fig. 4). In the semi-intensive area, there was no difference in water distribution between during land preparation (ploughing and puddling) and after sowing seeds. In the schedule of irrigation water supply (Appendix 5), there was no spare day. Period of water distribution in the schedule depended on the area of the block.

Same as the intensive area, the schedule of rotational irrigation did not strongly compel the farmers. However, farmers of any paddy fields were ensured that they could take water on the assigned time whenever necessary.

Measurement of Amount of Water Drained

Distribution of irrigation and drainage ditches in the pilot project No. 1 made difficult to obtain the amount of water drained from the experimental area. Since 1 drainage ditch was constructed between the 2 farm ditches, amount of water drained was influenced by the amount of water supplied to the 2 farm ditches and field conditions and management practices in the terminal irrigation units.

In the experiment, amount of water drained was obtained from D 2-4 drainage ditch which was constructed between the farm ditches for intensive and semi-intensive areas. A cut-throat flume (locally made, 4 inch in width) was installed at the end of the drainage ditch just after starting the experiment. Reading of water level was done at 6:00, 11:00, 14:30 and 18:00 hours. Amount of drainage water during night time (from 18:00 to 6:00) was estimated as 70 percent of that of day time.

Variety Used

A recommended variety of RD-23 was planted all the fields in the experimental area. It is not photo sensitive, and the growth duration is 120 days in recommendation.

Progress of Farming Work

Expansion of flooded area and progress of farming work such as ploughing, puddling, sowing (or transplanting) and harvesting were observed daily. Date of the field flooded was the date of a paddy field first flooded and it was ready to be ploughed. Date of ploughing, puddling or sowing was the date of a paddy field finished the respective work. In case of date of harvesting, the date of more than 50 percent of a paddy field harvested was taken. In direct sowing rice cultivation, due to un-uniform germination, the maturing time of rice plants sometimes range widely even within a paddy field.

Water depth at Ploughing and after Puddling

Water depth at ploughing was measured by ruler at 6 points in each of selected paddy fields immediately after starting ploughing work. Water depth after puddling was measured by ruler with base at 6 points in each of selected paddy fields 2 days after the puddling work finished.

Fractuation of Water Depth in Paddy Field after Seedling Establishment

To obtain the approximate daily water requirement in depth in farmer fields, fractuation of water depth in paddy field after seedling establishment was obtained by ruler set on a stake. Thirteen (13) and 16 stakes were installed at different paddy fields in the intensive and semi-intensive area, respectively. Reading of rulers was done every late afternoon (starting 5:40 p.m.). Measuring points of water depth are in Appendix 8.

Water Conditions of Paddy Field after Seedling Establishment

Water conditions of every paddy field was observed once a week and recorded as flooded, saturated or dried. In the recording, the saturated field meaned that more than 20 percent of the paddy field did not have surface water but the most surface soil was visually water saturated. The dried field meaned that more than 20 percent of the surface soil was visually not water saturated.

Date of Flowering

Flowering date of each field was observed at the time of observation of field water conditions. It meaned that the flowering date was only roughly obtained once a week. In the experiment, flowering date meaned that more than 50 percent of the rice plants in a field flowered at the time of observation.

Yield Survey

Yield survey was conducted in selected fields when the farmers started harvesting. A sample area of 4 m^2 in circle was harvested at each point, then the yield at 14 percent moisture content was estimated.

Water Management in Common Area during Land Preparation Period

As an example of water management in common irrigation units during land preparation period, progress of land preparation work was observed in the terminal irrigation unit supplied water by farm ditch of TL 2-1,2 (Fig. 3). No information or guidance on water distribution was given to the farmers in the area. The irrigation unit was divided into 81 paddy fields and small portions were used as field house site. Paddy field area was about 19.1 ha (119 rai) and average size of paddy field was 2,358 m^2. There were 11 inlets existed in the irrigation unit, then every inlet supplied water to about 7.4 paddy fields in average.

Data collected in the area were flooding date, ploughing date, puddling date, sowing date, water depth at ploughing, and water depth at 2 days after puddling. Procedure of obtaining respective data was same as that of the experimental area.

Water Requirement in Depth under Controlled Conditions

Because of field to field irrigation practice in farmer fields, it was difficult to obtain data on water requirement in depth. To cope with this problem, daily water requirement in depth with or without lateral seepage was obtained, using a paddy field receded depth tester (Todai N-type DIK-4300, Daiki Rika Kogyo Co. Ltd.), in a field of the agricultural demonstration center. The demonstration center was about 1.5 km far from the experimental area. The paddy field was 0.8 ha (5 rai) in size and isolated from other fields by road. It had an inlet and outlet. The farm ditch (terminal irrigation canal) was constructed with concrete.

Rice seedlings of RD-23 variety were transplanted on March 20, flowered

(50 %) on June 5, and harvested on July 3, 1984. The equipment was installed on May 22, then observation was done at 9:00 a.m. every day untill June 11, 1984.

To observe different trends of daily water requirement in depth in sunny and rainy days, a water requirement recorder (RR-20, Ikeda Keiki & Co., Ltd.) was also installed in the same paddy field. The equipment can automatically record the water level for 1 week.

Amount of Water Drained from Wide Irrigation Area

Amount of water drained from a wide irrigation area was roughly estimated. The area consisted of pilot project No. 1 (374.2 ha), its upper area (395.9 ha) supplied water by 1L-1R canal and its adjacent area (652.8 ha) supplied water by 2R canal was used for this purpose. Out of 1,422.9 ha, 944 ha was planted rice (364 ha of pilot project No. 1, 318 ha of the upper area and 262 ha of the adjacent area) in 1984 dry season. Details of the area in Appendix 9.

Water discharge in a main drainage canal (D-1R) was measured by a current meter (Hiroi eletric type current meter, Sanei Surveying Equipment Co. Ltd.) at least 2 times in every decade days from March 2 to June 29. Section of the drainage canal at the point of measuring water discharge and procedure of obtaining water discharge are in Appendix 10.

RESULTS

Limited meteorological information during the experimental period are presented in Table 2. The observation site (in the agricultural demonstration center) was about 1.5 km far from the experimental area. The highest temperature was 38.5 ^{o}C and the lowest was 18.0 ^{o}C, the mean maximum temperature of decade days was 37.2 ^{o}C and the mean minimum was 20.2 ^{o}C. The mean temperature of the decade days ranged from 25.4 ^{o}C to 30.8 ^{o}C. These data indicate that the temperature range was not harmful for rice production. Total amount of rainfall in the period from March to July was 263 mm, which was less than previous years (1983: 285.5 mm, 1982: 461 mm). Long term climatological data at the Kanchanaburi meteorological station, which is about 12 km far form the experimental area, are in Appendix 11.

Amount and Period of Water Supplied for Ploughing

Irrigation water supply to the experimental area was started on March 3, 1984. Due to the improvement work of the irrigation system in pilot project No. 1, the starting date of water supply was about 1 month later than common years. Daily amount of water supplied to the intensive and semi-intensive area is in Appendix 12.

Table 3 shows the amount and period of water supplied for ploughing. For the intensive area, irrigation period for ploughing was 382.5 hours (about 16 days). It took more for block 1. Because of the problems of pumps, quantity of water flow was less during the early period of experiment (Appendix 12). The average water discharge at the head of farm ditch was 23.0 liter per second, and it ranged from 14.2 liter per second for block 1 to 28.7 liter per second for block 5. Total quantity of water supplied was 31,626 m^3, then water supplied in depth was 174.6 mm in average which ranged from 140 mm for block 6 to 191 mm for block 5.

Table 2 Meteorological data during the experimental period[a].

Period	Temperature °c					Rainfall (mm)
	Mean	Mean Max.	Mean Min.	Ext. Max.	Ext. Min.	
March						
1st decade	26.8	33.5	20.2	36.0	18.0	0
2nd decade	29.5	36.2	22.8	38.0	19.5	0
3rd decade	28.5	33.5	23.4	36.0	22.0	8.0
April						
1st decade	30.8	37.2	24.4	38.5	21.5	4.0
2nd decade	30.8	36.9	24.8	38.0	23.0	8.5
3rd decade	28.8	33.3	24.2	37.5	23.0	11.5
May						
1st decade	28.9	34.1	23.8	36.0	22.0	0
2nd decade	28.2	33.7	22.7	35.0	20.0	44.0
3rd decade	28.8	33.6	24.3	36.0	23.0	0
June						
1st decade	28.4	33.0	23.9	34.5	23.0	22.0
2nd decade	28.3	32.6	24.1	34.0	23.5	7.5
3rd decade	25.4	28.7	22.0	32.0	21.0	18.5
July						
1st decade	28.1	32.8	23.4	34.0	22.0	65.5
2nd decade	28.0	32.0	24.0	34.5	23.5	71.5
3rd decade	28.7	32.7	24.6	34.5	23.0	2.0
					Total 263	

[a]Observation at the agricultural demonstration center.

Table 3 Amount and period of water supplied for ploughing.

Block	Intensive area					Semi-intensive area
	Area (m^2)	Irrigation hours	Amount of water supplied			(182,626 m^2)
			In L/sec	In m^3	In mm	
1	30,942	102.5	14.2	5,257	170	Irrigation hours: 382.5
2	34,412	69.0	26.1	6,484	188	Amount of water supplied:
3	28,825	50.0	27.5	4,951	172	24.0 L/sec;
4	30,118	64.0	23.7	5,455	181	33,012 m^3;
5	29,164	54.0	28.7	5,583	191	180.8 mm
6	27,646	43.0	25.2	3,896	140	
Total	181,107	382.5	-	31,626	-	
Average	30,184.5	63.75	23.0	5,270.8	174.6	

Note: Data of the semi-intensive area are based on the amount of water supplied during the irrigation hours of intensive area.

Table 4 Difference between the dates of field flooded and ploughed.

Number of paddy fields

Days	Intensive area	Semi-intensive area
0	21	27
1	27	14
2	20	6
3	7	5
4	2	3
5	2	2
6	0	7
7	0	7
8	0	5
9	0	2
10	0	2
13	0	3
18	0	1
Total	79	84

Because of its irrigation schedule, it was not actually obtained from the semi-intensive area. However, it was estimated from the quantity of water supplied during the period of ploughing water supply to the intensive area. The average water discharge was 24.0 liter per second, total quantity of water supplied was 33,012 m^3, and water supplied in depth was 180.8 mm. These values were slightly higher than those of intensive area.

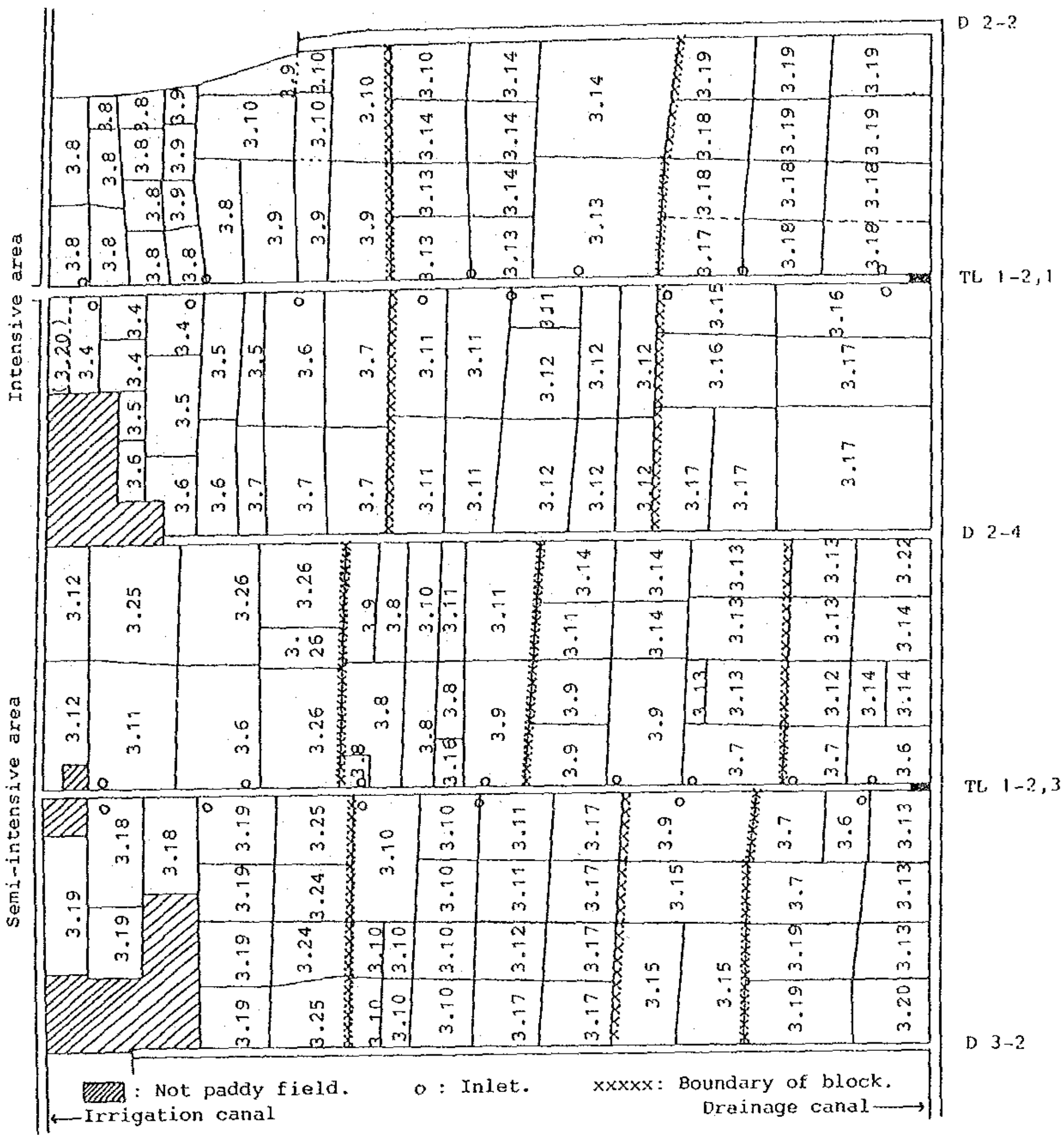
Flooded date of every field in the experimental area is in Fig. 5. Water distribution in the intensive area almost followed the order of irrigation schedule. Paddy fields in block 1 were first became flooded, then the flooded area expanded block by block. Earlier flooding of a field in block 4 was due to seepage from block 2. A small field in block 1 was initially not included in the experimental area, because it was higher in elevation and used as upland field. However, after starting the experiment, due to the request of the farmer, it was added to the experimental area with making 2 fields into 1 (removed 1 levee). As the result, preparation water for the portion was only taken in puddling water. In the semi-intensive area, all the fields in block 3 first became flooded followed by those in block 2, the date of last paddy flooded was March 19 (16 days after starting irrigation) and March 26 (23 days after starting irrigation) for intensive and semi-intensive area, respectively.

Fig. 6 shows the progress of flooded area in accumulation. The rate of flooded area accumulation was higher in the intensive area. In the semi-intensive area, some of water supplied in the later part of the period was used for puddling. Average rate of flooded area expansion was about 1.1 ha (6.9 rai) per day in intensive, and about 0.8 ha (5.0 rai) per day in semi-intensive area.

Progress of Ploughing Work

Ploughing date of each field in the experimental area is shown in Fig. 7. In the intensive area, ploughing work was started in block 1 and progressed

Fig. 5 Date of paddy field became flooded.



Note : ( ) - Portion added to the experimental area after finishing ploughing water supply.

Fig. 6 Progress of flooded area in accumulation (%).

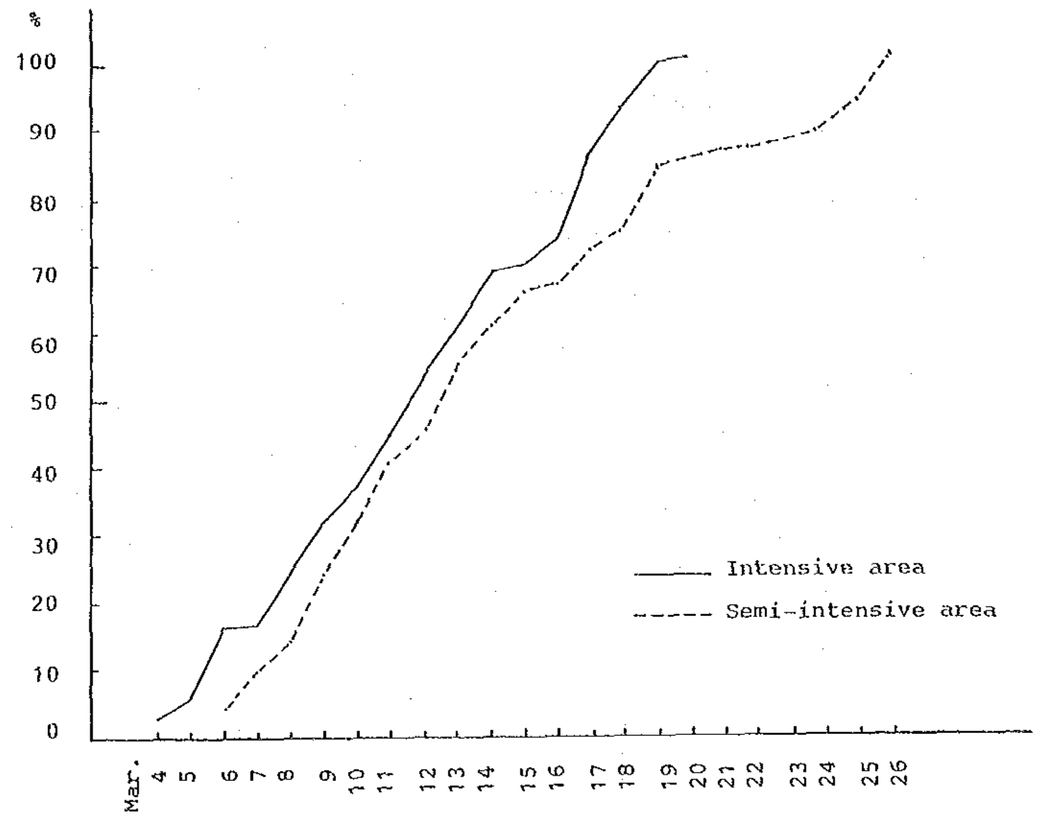


Fig. 8 Progress of ploughing work in accumulation (%).

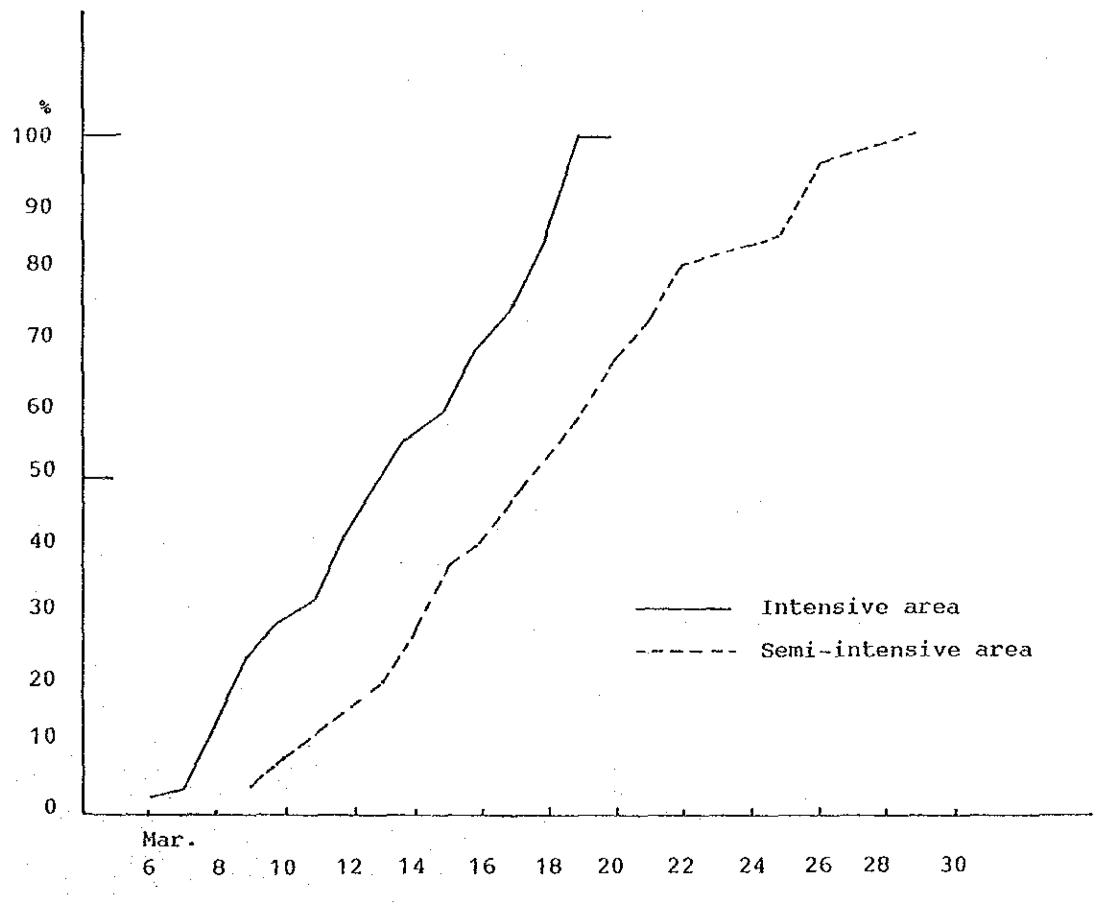
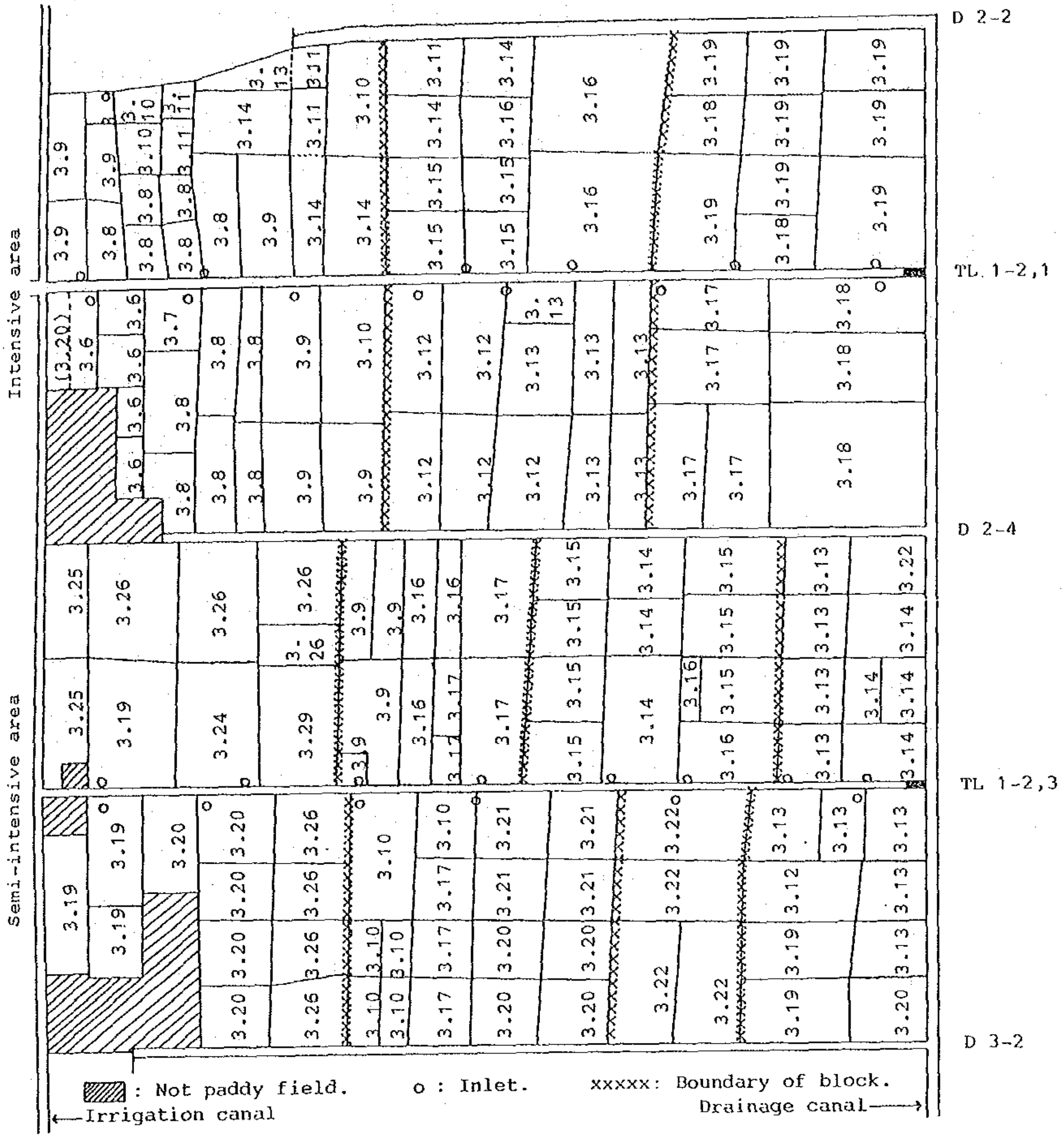


Fig. 7 Date of ploughing paddy field.



Note : ( ) - Portion added to the experimental area after finishing ploughing water supply.

almost following the order of flooded dates. The ploughing period was from March 6 to 19 in the intensive area (14 days, excluding an expectional portion in block 1). It was from March 9 to 29 in the semi-intensive area (21 days).

Table 4 shows differences in day between the field first flooded and ploughed. It ranged from 0 to 5 days in the intensive, and from 0 to 18 days in the semi-intensive area. In the intensive area, there were 2 fields which took 5 days to finish ploughing after the fields became flooded. It was due to lower elevation of the fields comparing with the surrounding fields. According to the farmers of the fields, they did not want to plough with too much water. One of the data of standing water depth at ploughing (Fig. 9) indicates that water depth was still high when the fields were ploughed 5 days after being flooded. In the semi-intensive area, although more than one half of the fields were ploughed within 3 days after being flooded, but it took more than 10 days in some fields.

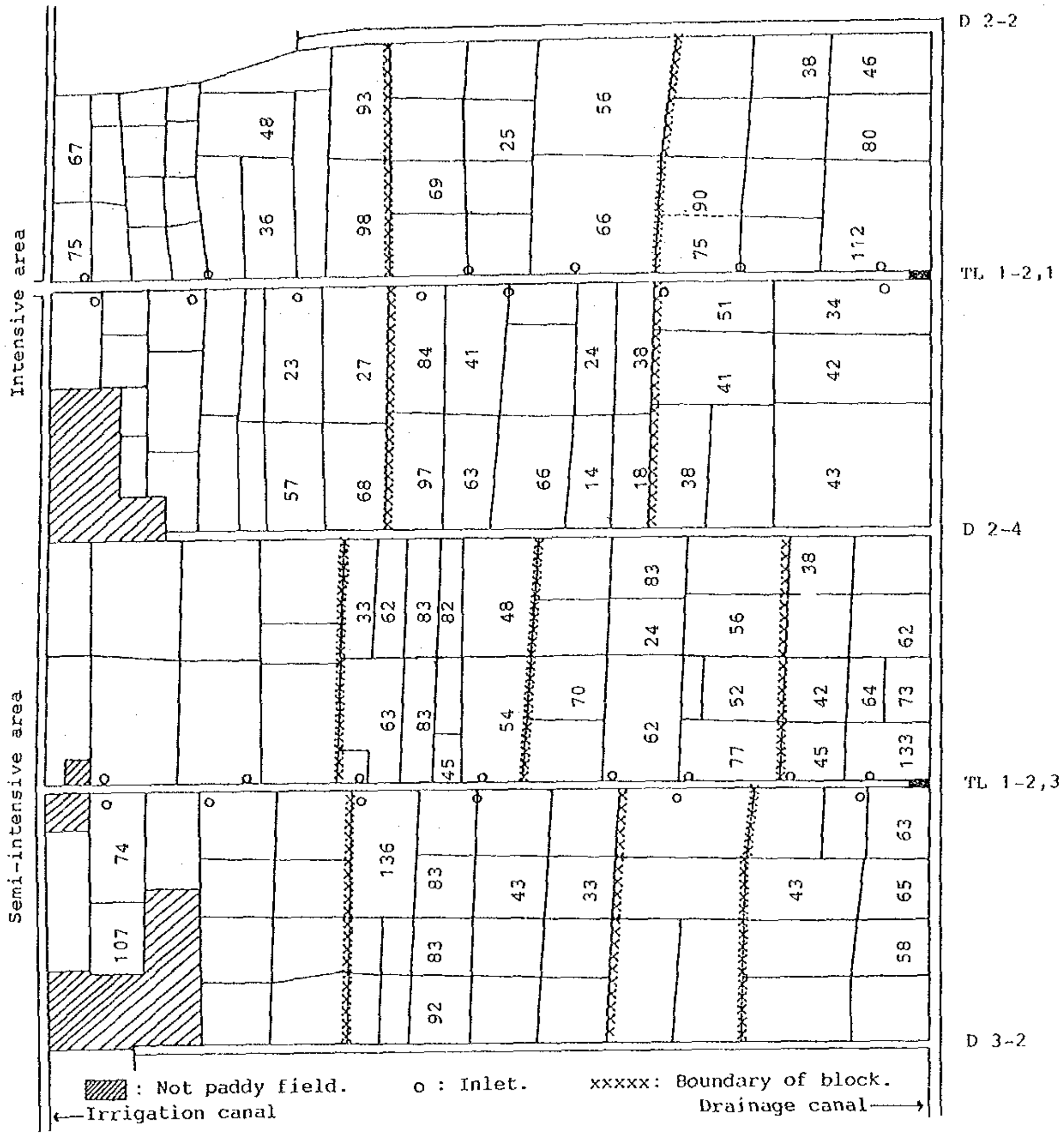
Daily progress of ploughing work in accumulation is presented in Fig. 8. The rate of ploughed area expansion was higher in the intensive area. In the semi-intensive area, most of ploughing period was overlapping with puddling period, then it took more time to finish ploughing work. Average rate of ploughed area expansion was about 1.2 ha (7.5 rai) and 0.9 ha (5.6 rai) per day for intensive and semi-intensive area, respectively.

Water Depth at Ploughing

Water depth at ploughing was taken in 35 paddy fields respectively from the intensive and semi-intensive area. Fig. 9 shows the result. It was 55.5 mm in average (ranged from 14 mm to 112 mm) for the intensive area, and 66.1 mm (24 mm to 136 mm) for the semi-intensive area.

Water depth at ploughing ranged widely. It was partly due to the slope of the area. As mentioned earlier, there were some poorly irrigable fields in the area, then to supply enough water for ploughing of the poorly irrigable

Fig. 9 Water depth at ploughing (mm).



Average of Intensive area : 55.5 mm (35 fields)

Average of Semi-intensive area : 66.1 mm (35 fields)

fields, more than necessary water had to be supplied to some other fields.

Amount of Water Supplied for Puddling

In the intensive area, after finishing the distribution of ploughing water to block 6, water supply for puddling work was started on March 19. Puddling water was rapidly distributed in the area following the order of irrigation schedule and finished on March 26.

Table 5 shows the amount and period of water supplied for puddling. For the intensive area, it took 167 hours (about 7 days) to finish the distribution of puddling water. The period was less than one half of that of ploughing water. Average water discharge for puddling was 28.8 liter per second, which was about 6 liter per second higher than that for ploughing. Total quantity of water supplied for puddling was 17,327 m^3. It was 95.7 mm in average and ranged from 41 mm for block 2 to 145 mm for block 1.

All the fields in semi-intensive area received water by March 26. Puddling water for semi-intensive area was estimated from the quantity of water supplied during the period of puddling water supply to the intensive area. The average water discharge was 30.6 liter per second, total quantity of water supplied was 18,420 m^3, and water supplied in depth was 100.9 mm in average. These valued were slightly higher than those of intensive area.

Progress of Puddling Work

Puddling work was started on March 14 in the semi-intensive area and on March 20 in the intensive area, then it was finished on March 30 in the both areas. It took 11 days for intensive and 17 days for semi-intensive area. Fig. 10 shows the puddling date of every field in the experimental area. In the intensive area, some fields in block 6 were puddled using ploughing water, and most fields in block 3 and 5 took time to be puddled after puddling water was supplied. There were some poorly drainable fields which prevented early puddling. Furthermore, it was probably affected by availability of power

Table 5 Amount and period of water supplied for puddling.

Block	Intensive area					Semi-intensive area
	Area (m^2)	Irrigation hours	Amount of water supplied			(182,626 m^2)
			In L/sec	In m^3	In mm	
1	30,942	53	23.5	4,478	145	Irrigation hours:
2	34,412	21	18.6	1,404	41	167.0
3	28,825	28	32.7	3,300	119	Amount of water
4	30,118	17	37.9	2,319	77	supplied:
5	29,164	31	33.4	3,732	128	30.6 L/sec;
6	27,646	17	34.2	2,094	76	18,420 m^3;
Total	181,107	167	-	17,327	-	100.9 mm
Average	30,184.5	27.8	28.8	2,887.8	95.7	

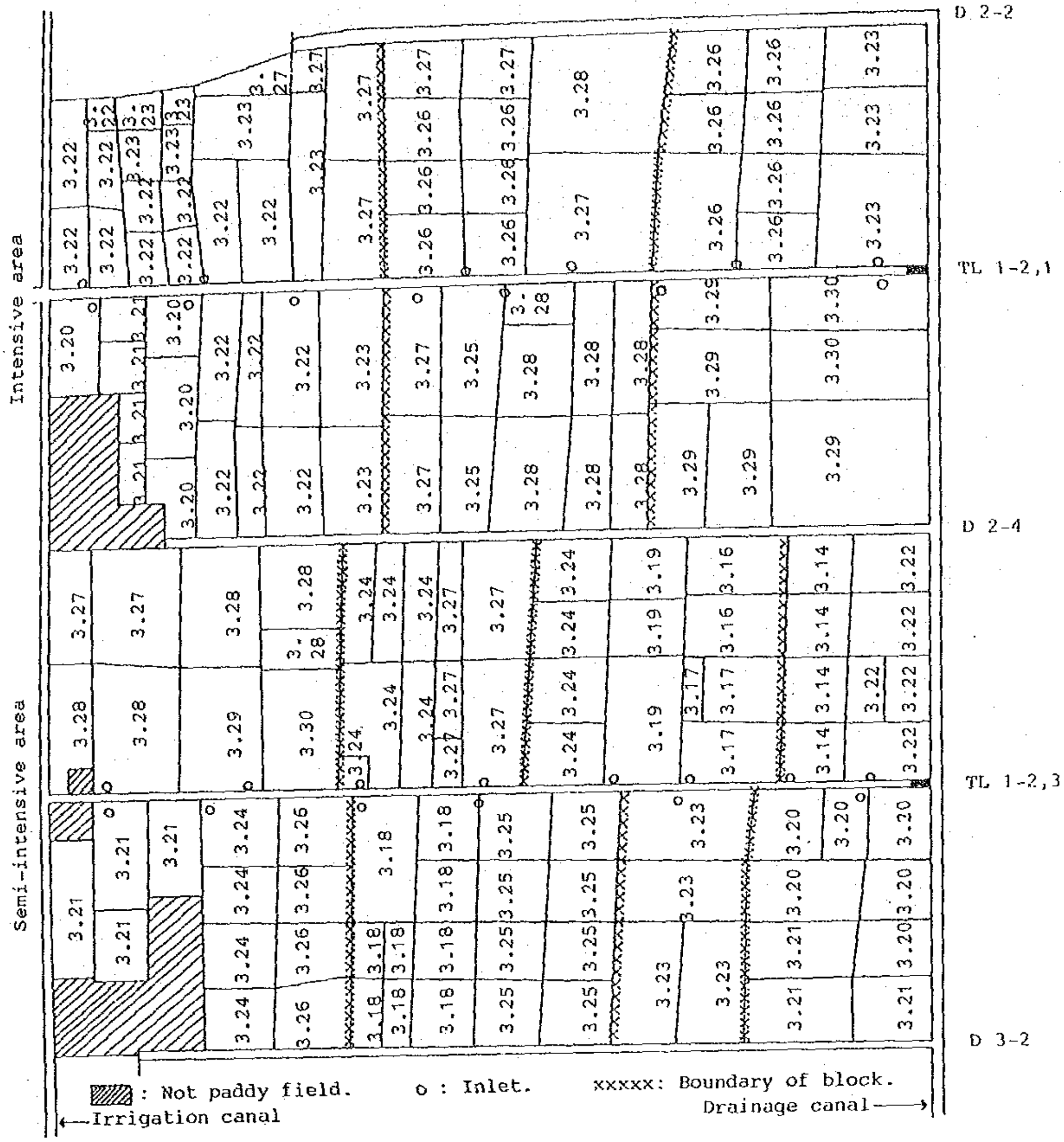
Note: Data of the semi-intensive area are based on the amount of water supplied during the irrigation hours of intensive area.

Rainfall of 8 mm (in 2 days) was not included in the calculation.

Table 6 Difference between the dates of puddling water supply and puddling in the intensive area.

Days	Number of paddy fields
-3	3
0	22
1	16
2	10
3	3
4	8
5	12
Total	74

Fig. 10 Date of puddling field.



tillers for puddling in case of those who requested the machine on the contract bases. As the result, progress of puddling work did not follow the order of irrigation schedule.

Table 6 shows the differences in day between the field received puddling water and puddled in the intensive area. Although 48 out of 74 fields were puddled within 2 days, there were 12 fields puddled on the 5th day.

Daily progress of puddling work was as Fig. 11. The rate of puddled area expansion was about 1.6 ha (10 rai) per day in the intensive area, and about 1.2 ha (6.9 rai) per day in the semi-intensive area.

Water Depth at 2 Days after Puddling

Water depth at 2 days after puddling was taken only from the limited number of fields (13 from intensive and 7 from semi-intensive area). Fig. 12 shows the result. The average water depth was 83.2 mm (43 mm to 140 mm) for intensive area, and 86.6 mm (57 mm to 113 mm) for semi-intensive area. Data taken from the several fields in block 2 of intensive area were more than the amount of puddling water supplied. It was due to water leakage through crab holes in the farm ditch when puddling water was supplied to the block 1. In addition, some fields in the block 2 were lower in elevation (Appendix 2), and water seepage from block 4 was also observed.

Progress of Direct Sowing

All farmers in the experimental area wanted to do direct sowing when they were interviewed before starting the experiment. However, two fields in the intensive area were transplanted, because it was very difficult to drain out water from the fields (according to the farmer).

Fig. 13 shows sowing (or transplanting) date of every field in the area. It was started on March 19 and ended on March 30 in the semi-intensive area (12 days), and started on March 25 and ended on April 2 in the intensive area (9 days).

Fig. 11 Progress of puddling work in accumulation (%).

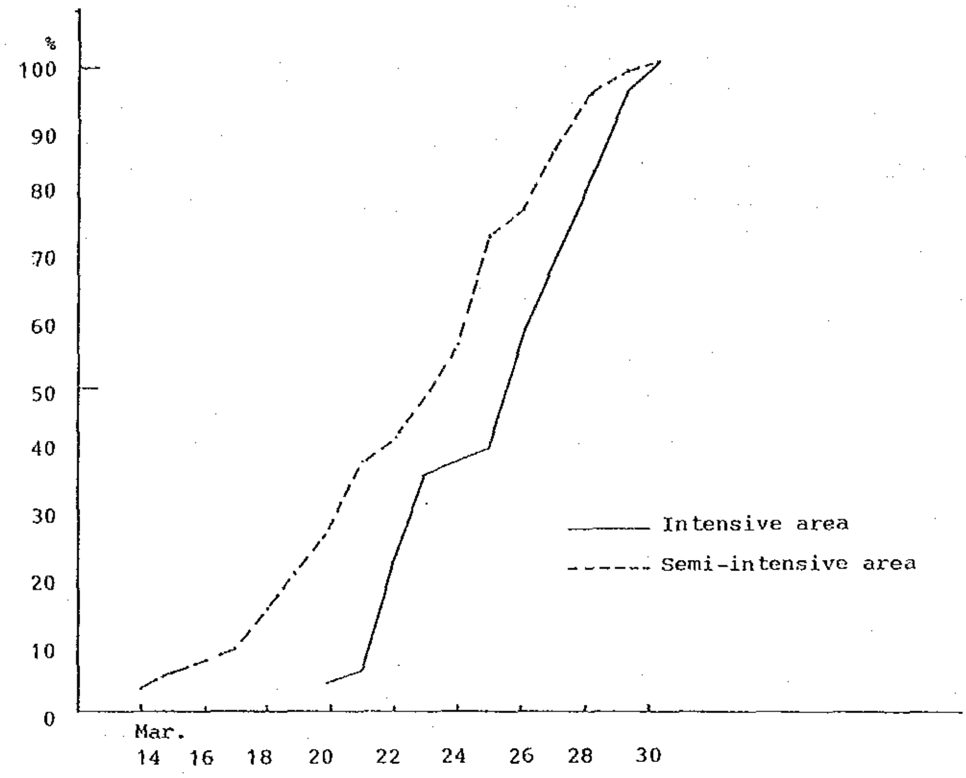


Fig. 14 Progress of sowing (and transplanting) in accumulation (%).

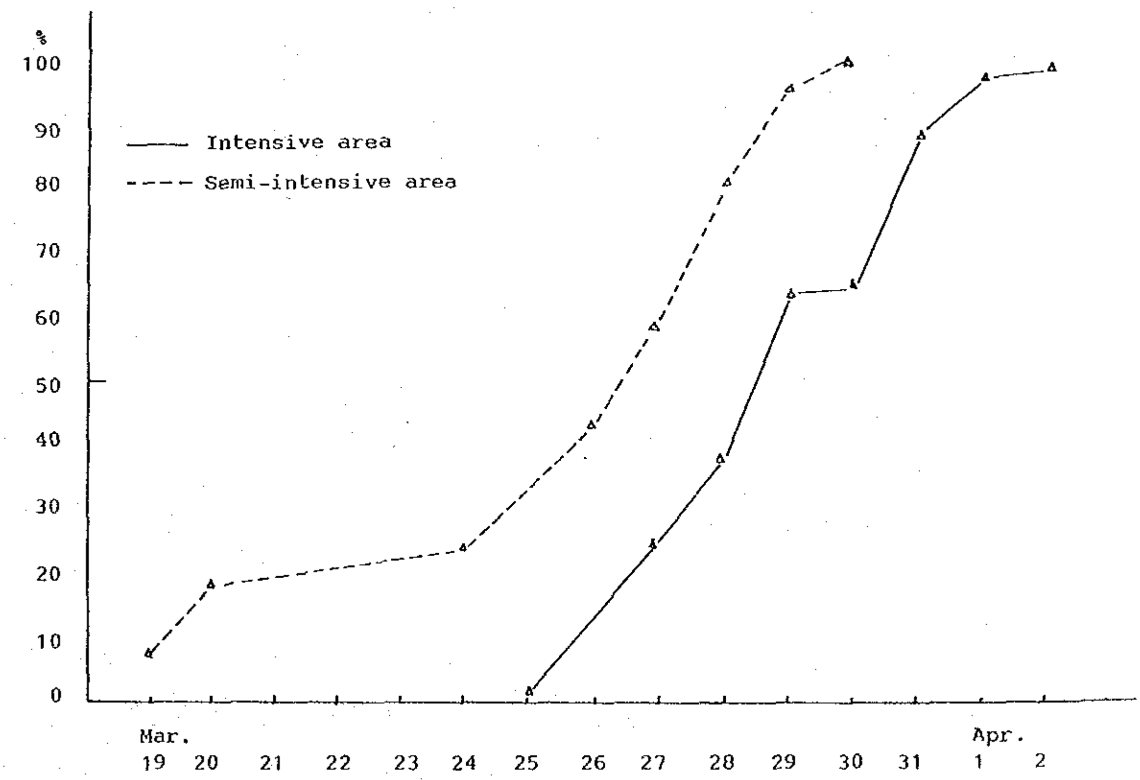
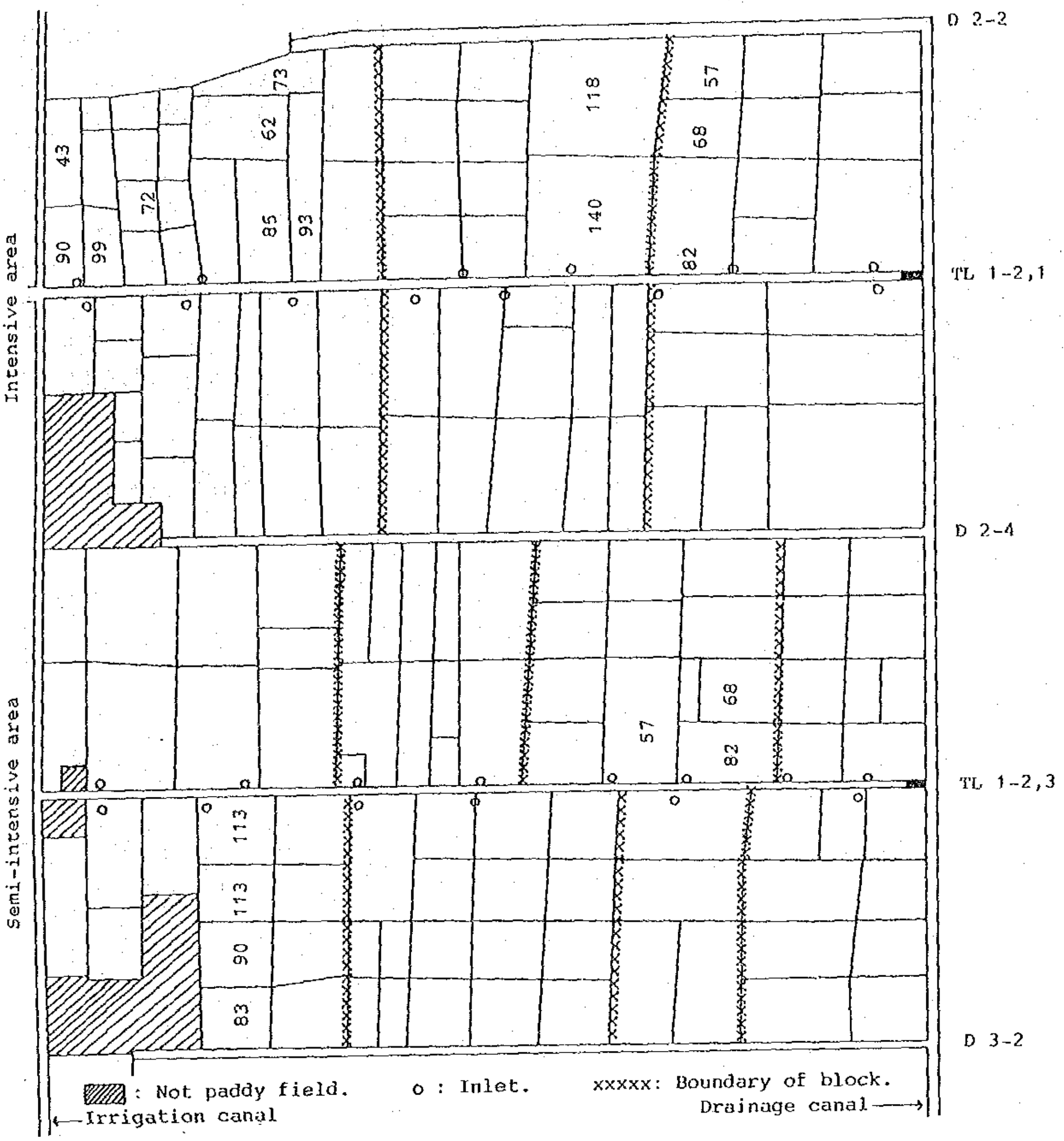


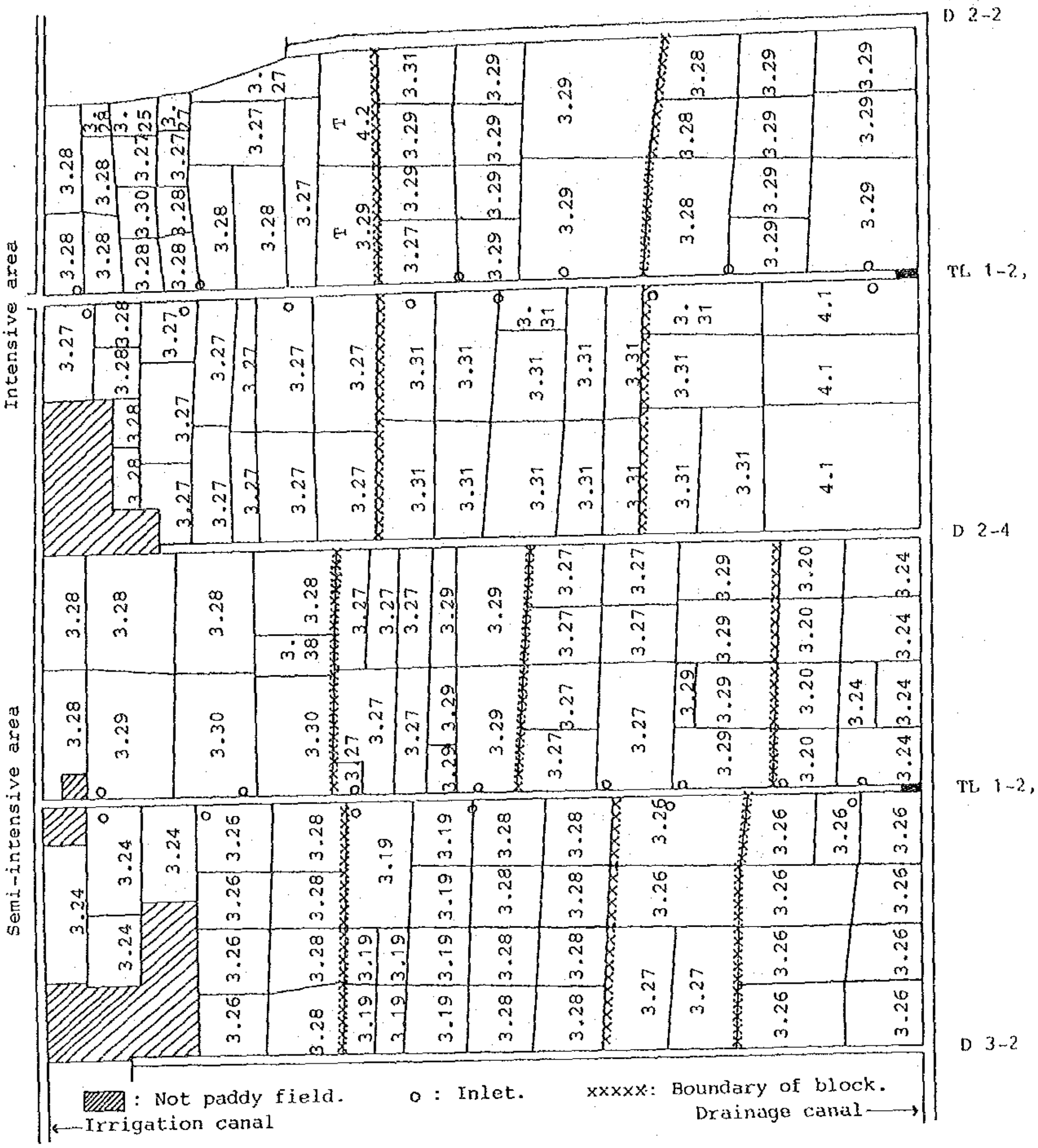
Fig. 12 Water depth at 2 days after puddling (mm).



Average of Intensive area : 83.2 mm (13 fields)

Average of Semi-intensive area : 86.6 mm (7 fields)

Fig. 13 Date of direct sowing or transplanting.



Note : T - Transplanting

Table 7 shows the difference in day between puddling and sowing (or transplanting). Although number of fields seeded was most on 3rd day either intensive or semi-intensive area, it ranged from 0 to 8 days in intensive and 0 to 13 days in semi-intensive area.

Draining water from paddy field before and after sowing seeds is quite important in direct sowing rice cultivation. Excess water of some paddy fields in the intensive area was drained out by pumps. Some farmers applied herbicide before sowing seeds. These circumstances affected the sowing time.

Fig. 14 shows the expansion of seeded area in accumulation. The rate of seeded area expansion was about 2.0 ha (12.5 rai) per day for intensive and about 1.5 ha (9.4 rai) per day for semi-intensive area.

Amount of Water Supplied after Preparation Water

After puddling water, irrigation water was supplied for 104.625 days and stopped on July 8, 1984. Table 8 shows the amount of water distributed and rainfall in the period.

Based on the progress of sowing (and transplanting) in the intensive area, the period from March 26 to April 5 was called adjusting period for sowing. As mentioned earlier, draining water after puddling is important in direct sowing rice cultivation. Amount of water supplied during the period was 2.40 mm per day and 4.86 mm per day for intensive and semi-intensive area, respectively. The period from April 6 to 15 was called pre-rotational period. Due to the differences in field water conditions of different fields, water distribution for intensive area was depending on the field conditions in the period.

Starting 2 weeks after the last paddy field was transplanted, weekly rotational irrigation was introduced to the intensive area, then it continued 12 weeks. Due to the fractuation of water supply to 1L-1R canal, amount of water distributed was not constant either for the intensive or semi-intensive area (Appendix 12). It ranged from 3.37 mm per day to 15.86 mm

Table 7 Number of paddy fields seeded at different days after finishing puddling work.

Days	Intensive area	Semi-intensive area
0	1	5
1	2	13
2	12 (1)	18
3	19	24
4	8	2
5	6	3
6	15 (1)	10
7	8	0
8	1	3
12	0	3
13	0	2
Total	72 (2)	83

Note : ( ) is paddy field transplanted.

Table 9 Amount of water drained at different periods.

Period		Amount of water drained		
Date	Days	In m^3	In m^3/day	In L/sec
Mar.12-22	11	3,722	338	3.92
Apr. 3-22	20	7,575	379	4.38
Apr.23-26	4	840	280	3.24
May. 9	1	1,129	1,129	13.07
May.21-25	5	7,905	1,581	18.30
Jun.25-Jul.1	7	2,829	404	4.68
Jul.2-6	5	195	39	0.45
Total	53	24,195	457	5.28

Table 8 Amount of water supplied after puddling water.

	Period		Intensive area : 181,107 m^2				Semi-intensive area: 182,626 m^2				Rainfall
			Ammount of water supplied				Ammount of water supplied				
	Date	Days	In m^3	In L/sec	In mm	In mm/day	In m^3	In L/sec	In mm	In mm/day	mm
Adjustment for sowing	Mar.26-Apr.5	10.625	4,614	5.0	25.5	2.40	9,418	10.3	51.6	4.86	3.0
Pre-rotation	Apr. 6-15	10	16,790	19.4	92.7	9.27	21,189	24.5	119.5	11.95	12.0
1st rotation	Apr. 16-22	7	10,257	17.0	56.6	8.09	14,893	24.6	81.5	11.64	1.5
2nd rotation	Apr. 23-29	7	7,456	12.3	41.2	5.89	11,863	19.6	65.0	9.29	11.5
3rd rotation	Apr.30-May 6	7	13,377	22.1	73.9	10.54	13,500	22.3	73.9	10.56	0
4th rotation	May 7-13	7	20,094	33.2	111.0	15.86	15,340	25.4	84.0	12.00	6.0
5th rotation	May 14-20	7	14,812	24.5	81.8	11.69	15,604	25.8	85.4	12.20	35.5
6th rotation	May 21-27	7	13,703	22.7	75.7	10.81	14,865	24.6	81.4	11.63	0
7th rotation	May28-Jun.3	7	7,726	12.8	42.7	6.10	7,830	12.9	42.9	6.13	4.0
8th rotation	Jun. 4-10	7	6,171	10.2	34.1	4.87	7,351	12.2	40.3	5.76	18.0
9th rotation	Jun. 11-17	7	10,509	17.4	58.0	8.29	12,046	19.9	66.0	9.43	3.0
10th rotation	Jun. 18-24	7	9,011	14.9	49.8	7.11	9,969	16.5	54.6	7.80	14.0
11th rotation	Jun.25-Jul.1	7	7,391	12.2	40.8	5.83	9,930	16.4	54.4	7.77	9.0
12th rotation	Jul. 2-8	7	4,279	7.1	23.6	3.37	5,387	8.9	29.5	4.21	27.0
Total or mean		104.625	146,190	16.2	800.5	7.65	169,185	18.7	926.4	8.85	144.5
Include rainfall					945.0	9.03			1070.9	10.24	

per day for intensive area, and 4.21 mm per day to 12.20 mm per day for semi-intensive area.

After puddling water supply, a total amount of 146,190 m^3 and 169,185 m^3 of irrigation water was supplied to intensive and semi-intensive area, respectively. It was 16.2 liter per second of average water discharge, 800.5 mm in total depth or 7.65 mm per day in average daily water supply to the intensive area, then it was 18.7 liter per second, 926.4 mm in total depth, or 8.85 mm per day for semi-intensive area.

Rainfall was 144.5 mm in the period from March 26 to July 8. Including the rainfall to the amount of irrigation water supplied, it becomes 945.0 mm in total depth (9.03 mm/day) and 1,070.9 mm (10.24 mm/day) for intensive and semi-intensive area, respectively.

Amount of Water Drained to Drainage Ditch

Due to the collapse of cut-throat flume, influence of back water from the succeeding drainage canal and time conflict with other work, data on the amount of water drained to the drainage ditch (D 2-4) were obtained from the limitted number of observation days (53 days). Table 9 shows the result. It was 5.28 liter per second or 465 m^3 per day in average of limited observation, and ranged from 10 m^3 per day to 2,050 m^3 per day (Appendix 13).

Water Management in Common Area during Land Preparation Period

In the irrigation unit of not receiving any guidances on water distribution, the last paddy field became flooded on March 30 (Fig. 15). It was 27th day since irrigation water supply was started. The period of irrigation water supply for flooding field (for ploughing) was 8 days and 4 days longer than that obtained in the intensive and semi-intensive area, respectively. Although there were some exceptions, the flooded area expanded from the head to the end of the farm ditch. There also observed water leakage from the farm ditch to paddy fields. It was due to additional inlets made by farmers and crab holes.

Fig. 15 Date of paddy field became flooded in common area.

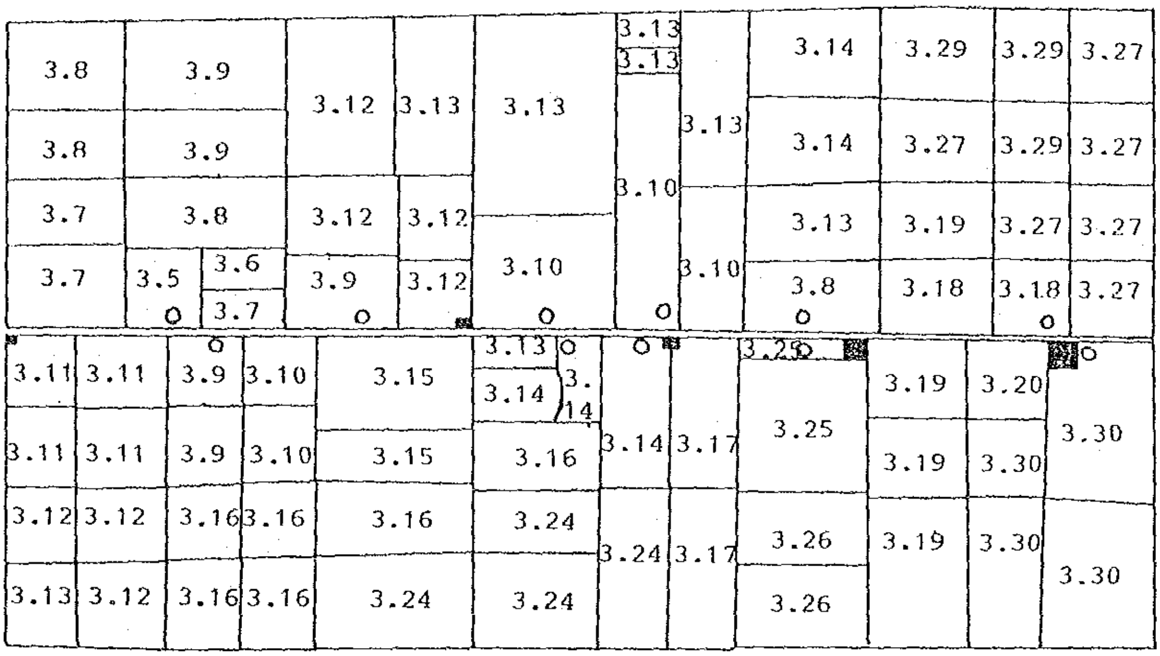
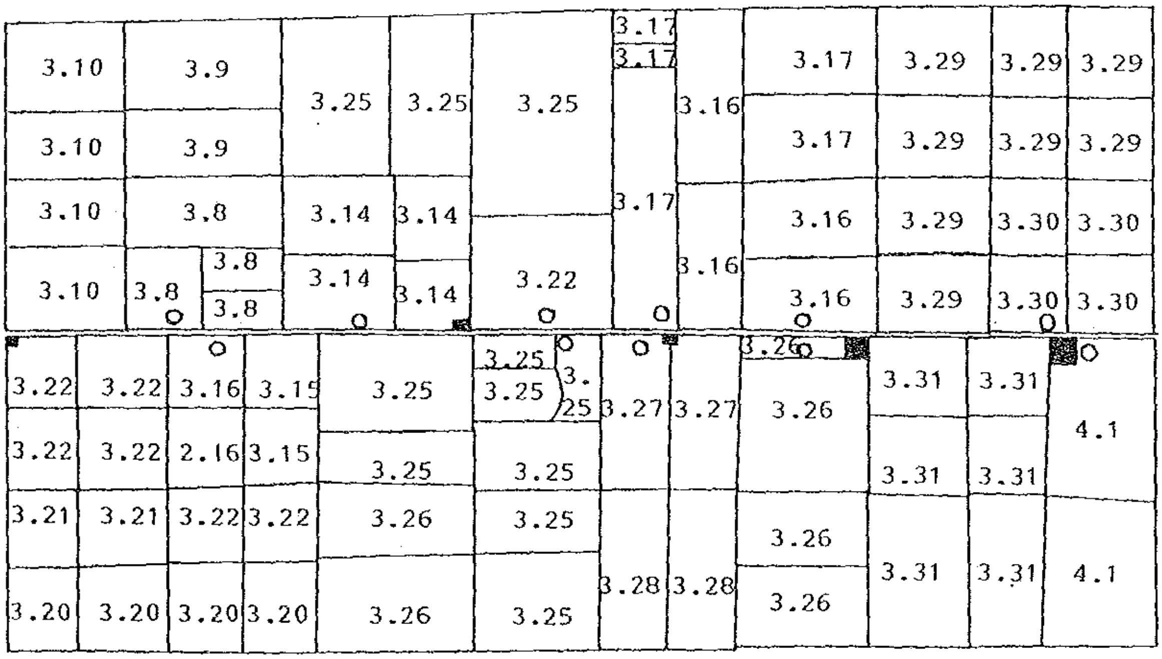


Fig. 16 Date of ploughing paddy field in common area.



In the irrigation unit, all fields were direct seeded. Ploughing work started March 8 and finished April 2 (26 days, Fig. 16), puddling work started March 9 and finished April 2 (25 days, Fig. 17), then sowing work started March 13 and finished April 3 (22 days, Fig. 18). The last day of puddling was 3 days later than that obtained in the experimental area.

Table 10 shows the differences in day between dates of flooded and ploughed. It took 0 to 13 days to be ploughed after the field became flooded. It was similar to the result of semi-intensive area. Table 11 shows the differences in day between dates of puddling and sowing. It took 1 to 7 days from puddling to sowing, which was similar to the result of intensive area.

Water depth at ploughing and 2 days after puddling in different fields is in Fig. 19 and Fig. 20, respectively. Water depth at ploughing was obtained from 45 fields. It was 72.7 mm in average and ranged from 23 mm to 129 mm. Water depth at 2 days after puddling was taken in 23 fields. It was 104.0 mm in average and ranged from 35 mm to 195 mm. These values were higher than those obtained in the experimental area.

Although amount of water supplied for land preparation in the irrigation unit was not measured, water depths at ploughing and 2 days after puddling indicated that it was more than that supplied to each of the irrigation units in the experimental area. Prolonged land preparation period in the irrigation unit was probably due to the practice that farmers got more than necessary water for land preparation, then they drained out excess water.

Field Water Conditions after Seedling Establishment

Through visual observation, water condition of each field after seedling establishment was obtained every week during the period from April 20 to July 7, 1984. Table 12 shows field water condition at different time in growth duration. Out of 12 observation dates, 7 and 8 dates were at least water saturated conditions in the intensive and semi-intensive area, respectively. The field water condition was sometimes influenced by rainfall. At most about

Fig. 17 Date of puddling paddy field in common area.

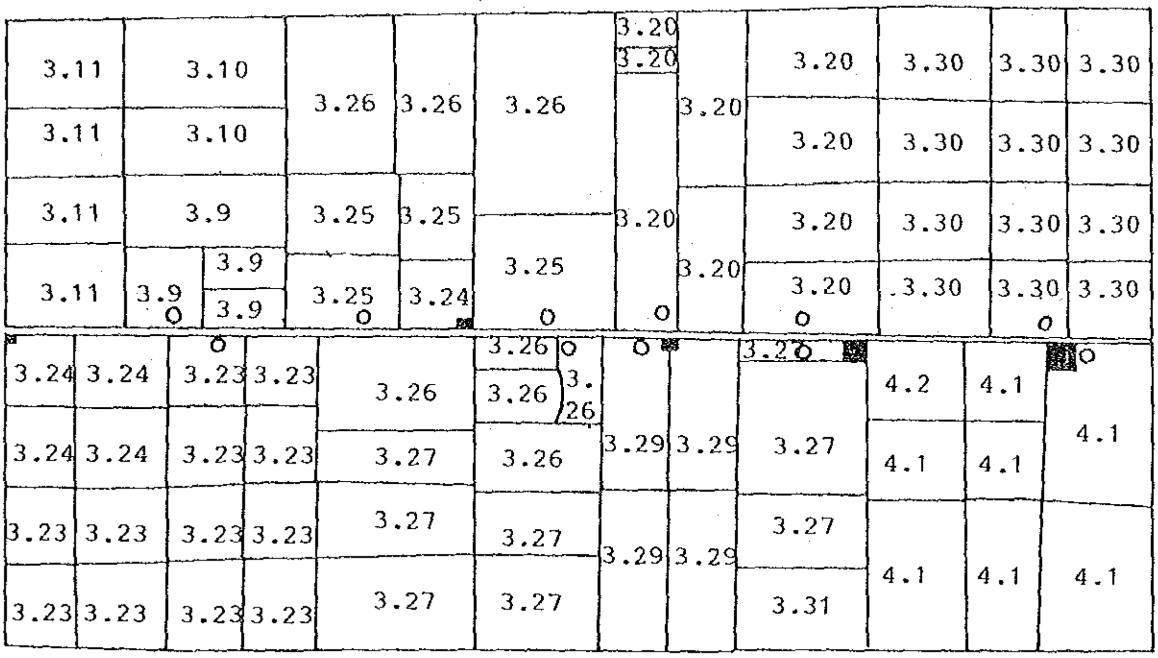


Fig. 18 Date of sowing in common area.

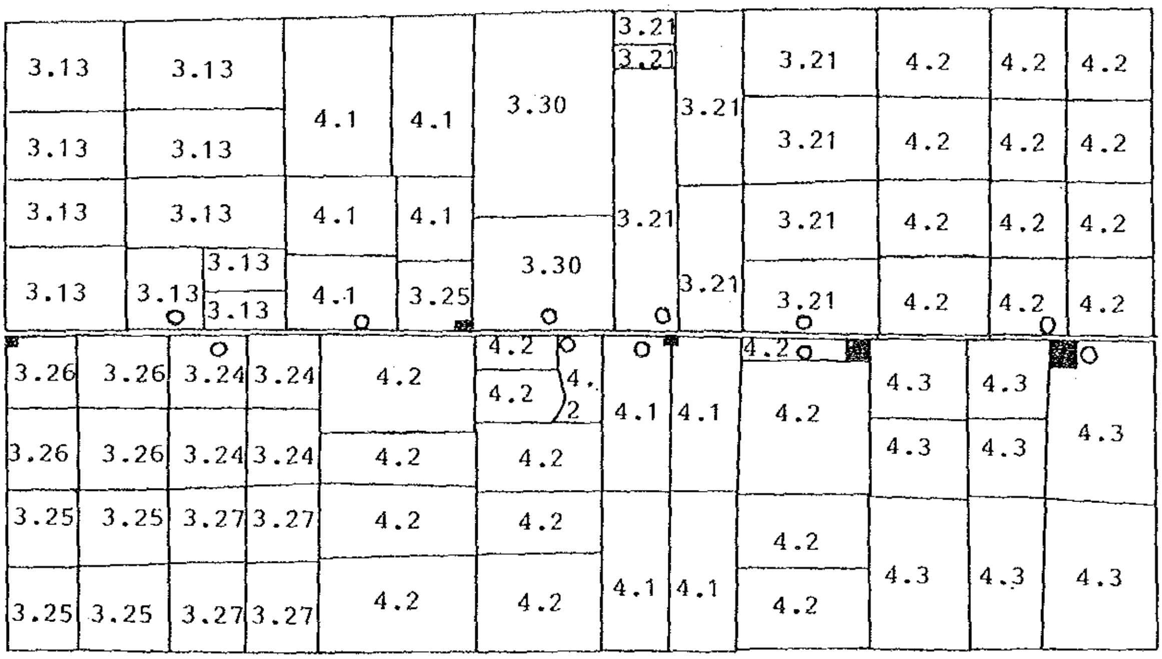


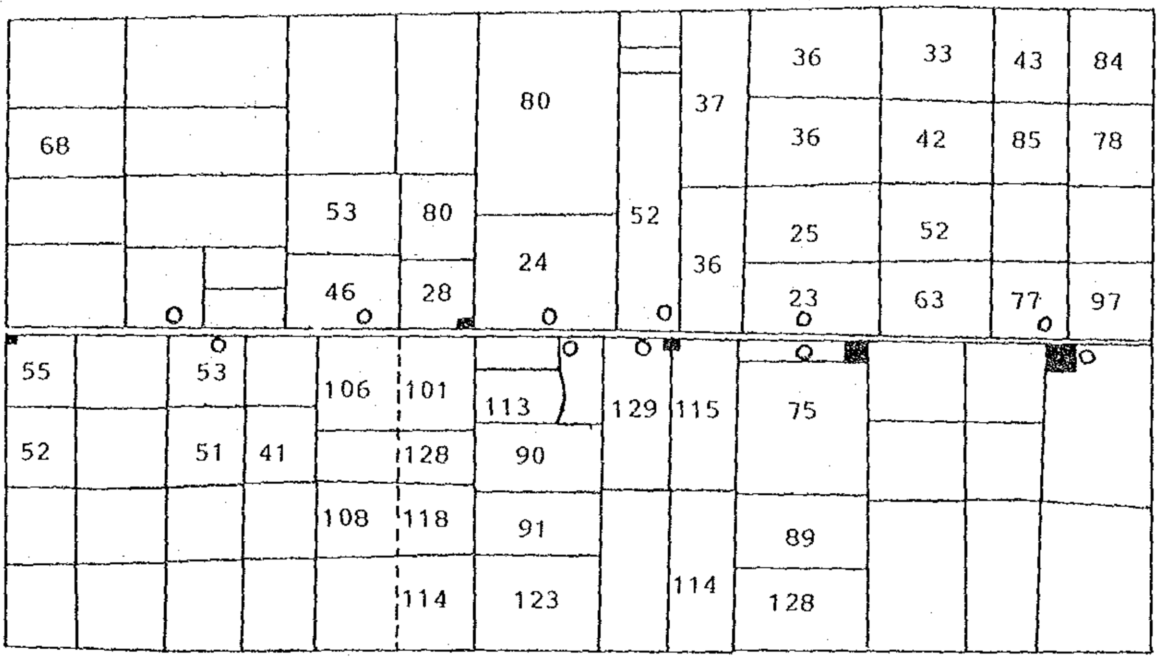
Table 10 Number of paddy fields ploughed at different days after flooded in common area.

Days	Number of fields
0	8
1	7
2	12
3	10
4	5
5	3
6	3
7	4
8	2
9	3
10	5
11	9
12	8
13	2
Total	81

Table 11 Number of paddy fields seeded at different days after puddled in common area.

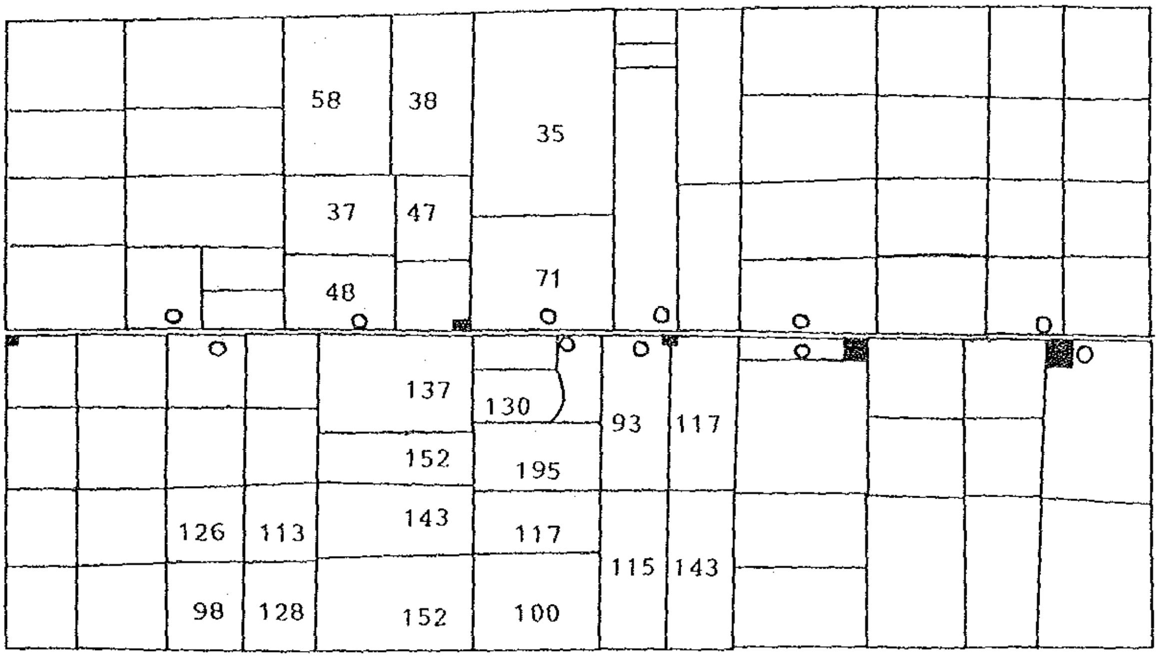
Days	Number of fields
1	15
2	20
3	18
4	9
5	1
6	10
7	8
Total	81

Fig. 19 Water depth at ploughing in common area.



Mean : 72.7 mm

Fig. 20 Water depth at 2 days after puddling in common area.



Mean : 104.0 mm

Table 12 Field water conditions at different time of growth duration.

Date	Experimental Area: 181,107 m^2						Comparative Area: 182,626 m^2					
	Flooded		Saturated[a]		Dried[b]		Flooded		Satueated[a]		Dried[b]	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Apr. 20	161,401	89.12	18,138	10.01	1,568	0.87	155,117	84.84	19,598	10.73	7,911	4.33
27	153,866	84.96	27,241	14.54	0	0	154,183	84.43	22,455	11.78	5,988	3.28
May. 6	159,795	88.23	18,808	10.38	2,504	1.38	148,130	81.11	27,642	15.14	6,854	3.75
11	179,267	98.98	1,840	1.02	0	0	167,329	91.62	15,297	8.38	0	0
19	175,485	96.90	5,622	3.10	0	0	178,893	97.96	3,733	2.04	0	0
25	171,046	94.44	10,061	5.56	0	0	174,003	95.28	8,623	4.76	0	0
Jun. 2	134,192	74.10	41,544	22.94	5,371	2.97	164,983	90.34	17,643	9.66	0	0
10	144,551	79.82	36,556	20.18	0	0	142,665	78.12	39,961	21.88	0	0
15	147,726	81.57	23,952	13.23	9,429	5.21	146,614	80.28	27,430	15.02	8,582	4.70
24	175,824	97.08	5,283	2.92	0	0	180.096	98.61	2,530	1.39	0	0
30	102,306	56.49	76,297	42.13	2,504	1.38	153,058	83.81	29,568	16.19	0	0
Jul. 7	158,343	87.43	22,764	12.57	0	0	141,225	77.33	41,401	22.67	0	0
Mean	155,316	85.76	24,008	13.22	1,781	0.98	158,858	86.98	21,323	11.64	2,444	1.34

[a]Saturated - More than 20% of the surface is not flooded but most surface soil is water saturated.

[b]Dried - More than 20% of the surface soil is not water saturated.

5 percent of the experimental area was dried condition on June 15. Although there were some differences between the intensive and semi-intensive area, the field water condition showed a similar trend. Field water conditions of each observation date are in Appendix 14.

Although there were few fields which easily faced water shortage, most fields were at least water saturated conditions. The data support that the amount of water supplied was enough, and its distribution was satisfactory either in the intensive or semi-intensive area. The paddy fields which easily subjected to dry conditions were poorly irrigable fields. Elevation of those fields were higher than adjacent fields, then water hardly came in and easily went out from the fields. In addition to water conditions, the poorly irrigable fields faced more weed problems than others.

Fractuation of Water Depth in Farmer Fields after Seedling Establishment

Water depth at different fields was observed daily from April 19 to July 8. Due to rain or time conflict with other work, it was not observed sometimes in the period. Approximate water requirement in depth in farmer fields was obtained from the accumulated increment of water depth divided by number of observation days. Table 13 shows the result. It was 9.26 mm per day in average and ranged from 5.31 mm to 15.02 mm for the intensive area. It was 11.31 mm per day in average and ranged from 6.00 mm to 19.33 mm for the semi-intensive area. Records of daily water depth at different points are in Appendix 15.

The data only indicate water depth in the field at the observation time. Water flew from field to field in the experimental area where 1 inlet supplied water for about 6 paddy fields in average. The approximate water requirement in depth of the intensive area was 0.23 mm higher than that of the amount of water supplied in mm per day (irrigation water and rainfall). It was 1.07 mm higher in the semi-intensive area.

Some of the measuring points were rather high portion in the field. Then the percent of not flooded days or the maximum continously not flooded

Table 13 Approximate water requirement in depth at different fields.

Measuring Point No.	Intensive area					Semi-intensive area				
	A.W.R.D.[a] (mm/day)	Flooded days	Not-flooded days	% Not-flooded days	M.C.N.F. days[b]	A.W.R.D.[a] (mm/day)	Flooded days	Not-flooded days	% Not-flooded days	M.C.N.F. days[b]
1	8.91	27	38	58.46	5	7.92	64	2	3.0	2
2	8.22	64	1	1.54	1	8.17	66	0	0	0
3	5.61	40	25	38.46	6	12.68	65	1	1.5	1
4	12.76	60	5	7.69	2	19.33	52	14	21.1	4
5	15.02	51	14	21.54	3	15.86	64	2	3.0	2
6	6.64	42	23	35.38	4	7.90	49	17	25.8	5
7	11.70	53	12	18.46	3	9.79	50	16	24.2	10
8	10.52	60	5	7.69	3	11.15	66	0	0	0
9	6.60	62	3	4.62	1	7.48	66	0	0	0
10	5.31	31	34	52.31	12	15.47	66	0	0	0
11	9.97	59	6	9.23	3	11.27[d]	17	0	0	0
12	9.83	64	1	1.54	1	13.62	66	0	0	0
13	c					6.00	64	2	3.0	2
14	-					13.77	64	2	3.0	0
15	-					8.53	57	9	13.6	8
16	-					12.05	58	8	12.1	6
Mean	9.26					11.31				

a: Approximate water requirement in depth.

b: Maximum continiously not-flooded days.

c: Stake was lost, and not enough observation times.

d: Obtained from the data of 17 days.

days of the points were not same as the trend of field water conditions (Table 1[illegible]

Flowering Period

Flowering period was from June 10 to July 7 and June 10 to July 14 in the intensive and semi-intensive area, respectively. However, it was from June 15 to July 7 for direct seeded paddy fields in the intensive area. Percent of flowered area in accumulation is presented in Fig. 21. It shows that paddy fields of about 85 percent in the intensive and 65 percent in the semi-intensive area flowered by June 23. Flowering date of each field in the area is in Appendix 16.

Progress of Harvesting Work

Harvesting work was first started in a transplanted field in the intensive area. Fig. 22 shows the harvesting date of each field in the experimental area. Two transplanted fields in the intensive area were harvested on July 9 and July 18. In paddy fields of direct sowing, the period of harvesting was for 12 days (from July 20 to July 31) in the intensive area, and it was for 19 days (from July 14 to August 1) in the semi-intensive area.

Daily progress of harvesting work was as Fig. 23. The rate of harvested area expansion was about 0.78 ha (4.9 rai) per day and about 1.0 ha (6.3 rai) per day for intensive and semi-intensive area, respectively. However, the rate was about 1.5 ha (9.4 rai) per day in direct sowing paddy fields in the intensive area.

Growth Duration

Growth duration in this report means the difference in day between sowing and harvested dates. Table 14 shows the distribution of growth duration in direct sowing paddy fields. It indicates that 60 percent of the direct sowing fields in the intensive area was harvested in the period from 116 days to 120 days after sowing. On the other hand, about 60 percent of the semi-intensive area was harvested in the period from 121 days to 128 days after sowing. Growth duration of each field in the experimental area is in Appendix 17.

Fig. 21 Flowered area in accumulation (%).

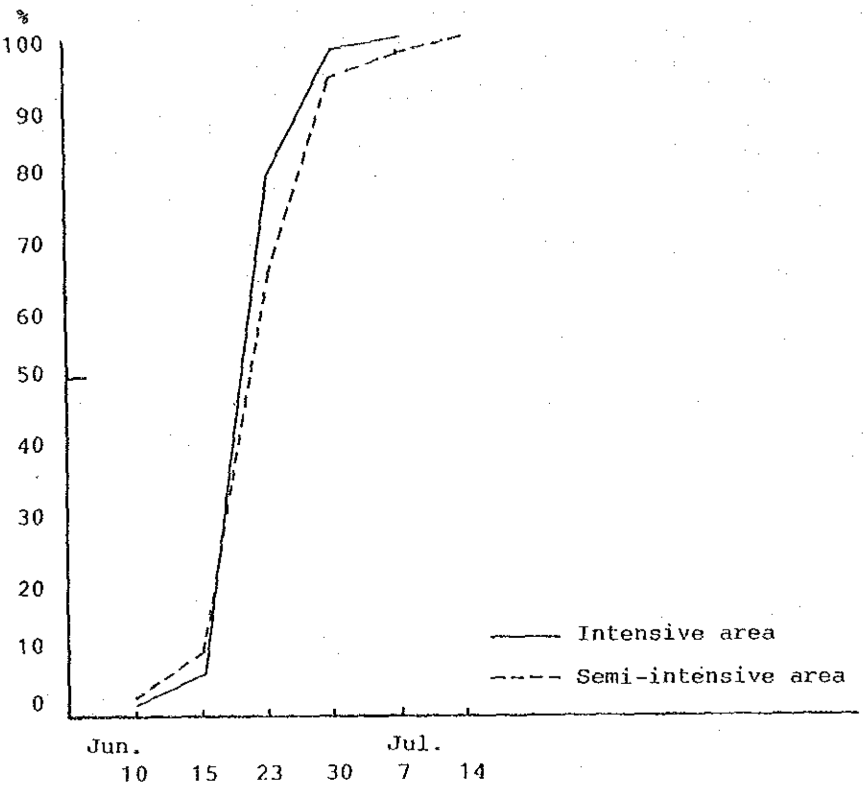


Fig. 23 Progress of harvesting work in accumulation (%).

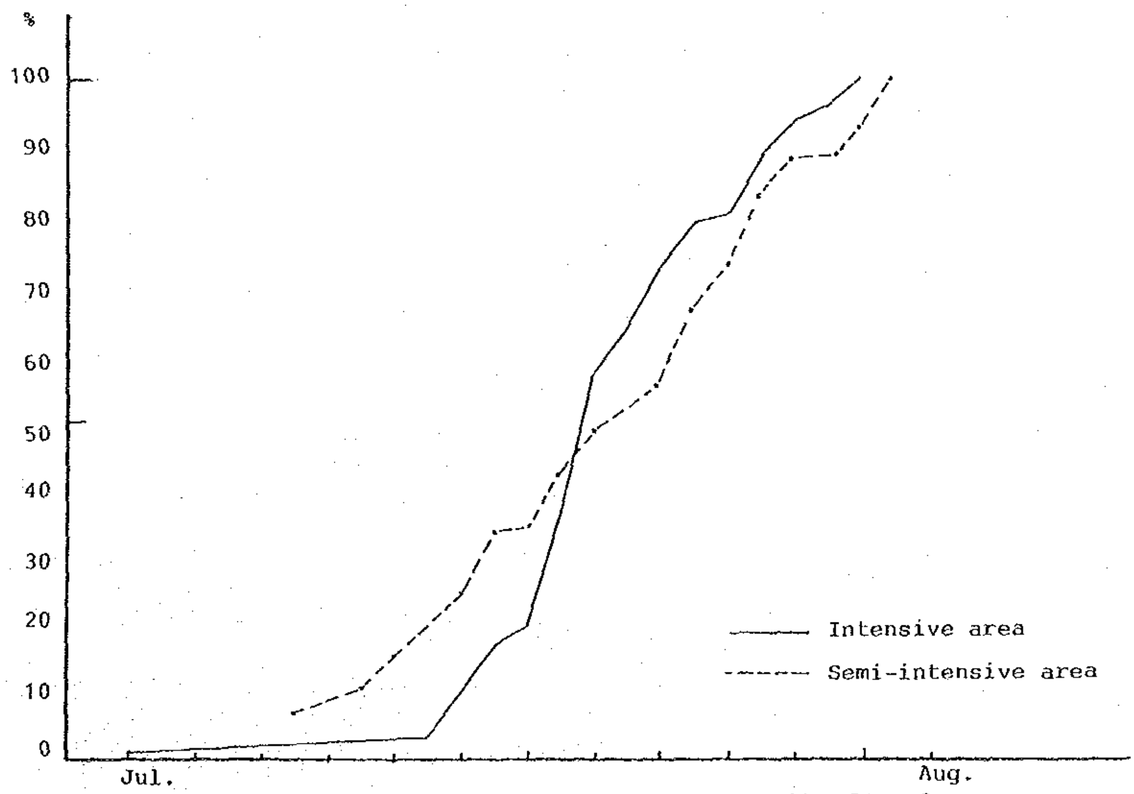


Fig. 22 Date of harvesting.

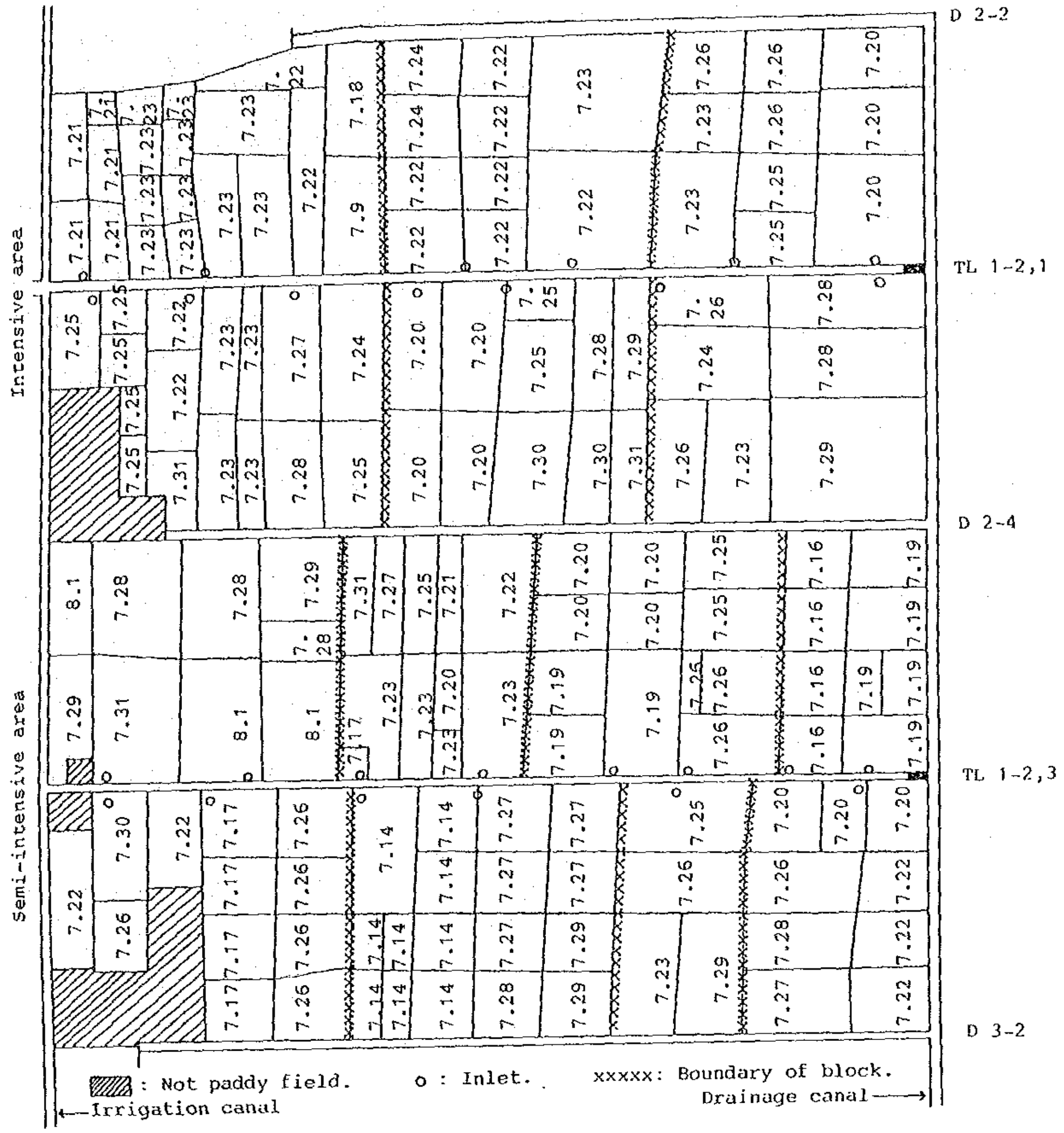


Table 14 Distribution of growth duration in direct sowing fields.

Growth duration	Intensive area	Semi-intensive area
111 - 115 days	32 %	15 %
116 - 120 days	60	45
121 - 125 days	6	37
126 - 128 days	2	23

Table 15 Rice yield at different spots.

Sample Number	Yield (kg/ha)	
	Intensive area	Semi-intensive area
1	5,397	5,286
2	5,255	4,776
3	5,199	4,591
4	5,151	4,102
5	4,862	4,090
6	4,859	4,037
7	4,828	3,931
8	4,751	3,844
9	4,701	3,716
10	4,491	3,514
11	4,009	-
12	3,669	-
13	3,617	-
14	3,491	-
15	2,995	-
16	2,676	-
Total	69,951	41,887
Average yield	4,372	4,189
Standard deviation	849	537
Average yield P/P No.1 (from 130 plots)	4,184	-

Table 16 Analysis of variance of Table 15[a].

Source of variation	Degrees of freedom	Some of squares	Mean square	Observed F
Treatments	1	206,622	206,622	0.37^{ns}
Experimental error	24	13,431,989	559,666	

[a] cv = 10.5 %

About 60 percent of the direct sowing fields in the intensive area was harveste by 117th day, it was 120th day in case of the semi-intensive area (Appendix 18).

Several factors might contribute to the differences of growth duration. In the intensive area, there was a field harvested on 126th day. The field usually faced water shortage, and also adversely affected by herbicide. Except this one field, difference in growth duration in the intensive area was 10 days (from 113 days to 122 days). Some fields were harvested late because of labor shortage. However, a uniform rate of fertilizer application to the intensive area would be the main reason of rather short difference in growth duration.

Yield

Rice yields were estimated from the yield survey of 16 spots (4 m^2 each) in the intensive area and 10 spots in the semi-intensive area. Table 15 shows the result. The average yield of intensive area was 4,372 kg per rai (700 kg/rai), and ranged from 2,676 kg per ha to 5,397 kg per ha. It was 4,189 kg per ha (670 kg/rai), and ranged from 3,514 kg per ha to 5,286 kg per ha in the semi-intensive area. Standard deviation was higher for the intensive area. In the intensive area, there were 5 samples which exceeded 5 ton per ha, but 2 samples were less than 3 ton per ha. On the other hand, all of the samples from the semi-intensive area were more than 3.5 ton per ha. The average yields were not statistically different (Table 16).

Furthermore, the yield level of the experimental area was similar to the average yield of other areas in the pilot project No. 1 (4,184 kg/rai). It means that the amount of water supplied and its distribution was at least satisfactory to obtain the average yield in the area.

Water Requirement in Depth in Controlled Conditions

Water requirement in depth under controlled conditions was measured in an isolated paddy field by road. Table 17 shows the result. At most 10 mm per day of water in depth was lost by evaporation, transpiration, vertical

Table 17 Water requirement in depth in controlled field.

Date	With seepage (mm)		Without seepage (mm)		Temperature (°C)			Rainfall
	Water depth	Daily requirement	Water depth	Daily requirement	Max.	Min.	Mean	(mm)
5.22	94		-		35	24	29.5	-
23	86	8	88	-	33	24.5	28.8	-
24	78	8	80	8	35	25	30.0	-
25	70	8	73	7	36	26	31.0	-
26	62	8	65	8	33	25	29.0	-
27	52	10	55	10	33	23	28.0	-
28	42	10	45	10	32.5	23	27.8	-
29	32	10	35	10	32	25	28.5	-
30	81	-	-	-	29.5	24	26.8	-
31	75	6	77	-	33	24	28.5	-
6. 1	69	6	71	6	32.5	24.5	28.5	-
2	62	7	64	7	34	24	29.0	4.0
3	65	-3	66	-2	34.5	24	29.3	-
4	61	4	63	3	34	23.5	28.8	10.5
5	66	-5	68	-5	34	24	29.0	-
6	60	6	62	6	32	24.5	28.3	3.0
7	58	2	60	2	31.5	23.5	27.5	2.5
8	56	2	59	1	32	24	28.0	0.5
9	48	8	51	8	32.5	23	27.8	1.5
10	41	7	45	6	32.5	24	28.3	-
11	31	10	35	10	31	25	28.0	-

1. Water requirement in depth (May 22 - June 11)
   1) Evapotranspiration + percolation + seepage + rainfall (22 mm): 6.70 mm/day
   2) Evapotranspiration + percolation + rainfall (22 mm): 6.45 mm/day
2. Water requirement in depth in sunny days (May 22-29)
   1) Evapotranspiration + percolation + seepage: 8.86 mm/day
   2) Evapotranspiration + percolation: 8.43 mm/day
3. Water requirement in depth in rainy days (June 6-10)
   1) Evapotranspiration + percolation + seepage + rainfall (7.5 mm): 6.63 mm/day
   2) Evapotranspiration + percolation + rainfall (7.5 mm): 6.13 mm/day

percolation and lateral seepage. Because of its minimal water seepage from the field, there observed only slight differences between total field water requirement (including seepage) and actual field water requirement (excluding seepage). Amount of seepage water was rather high just after irrigation water supply (2 mm in a day), but it was quite less afterward (0-1 mm in a day).

Including total rainfall during the observation period (May 22 - June 11), average daily water requirement in depth was 6.70 mm and 6.45 mm for water requirement with seepage and without seepage, respectively. The daily water requirement in depth was influenced by rainfall. In sunny days (May 22-29), it was 8.86 mm per day as water requirement with seepage and 8.43 mm per day as water requirement without seepage. In rainy days (June 6-10), it was 6.63 mm per day as water requirement with seepage and 6.13 mm per day as water requirement without seepage (including rainfall in the period of 7.5 mm).

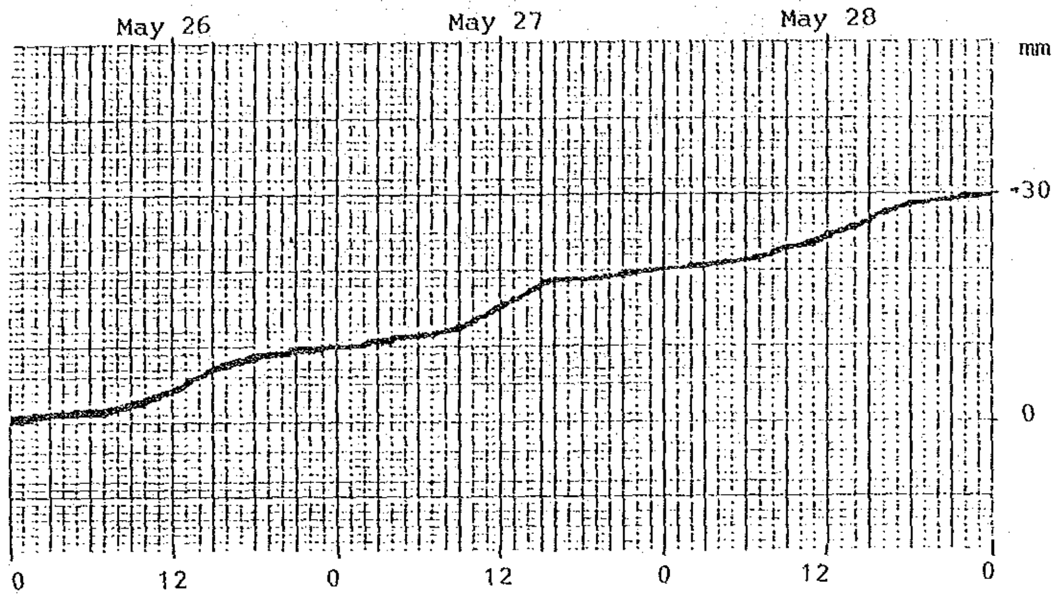
Fig. 24 shows the difference in change of field water levels between sunny days and rainy days (only light rain). In this 3 sunny days, field water requirement was 10.0 mm every day. On the other hand, it was 5.67 mm per day in average (including rainfall of 6 mm) in 3 rainy days. The data indicate that rainfall not only increased the field water level but also reduced the amount of evapotranspiration water.

Water discharge in a Main Drainage Canal

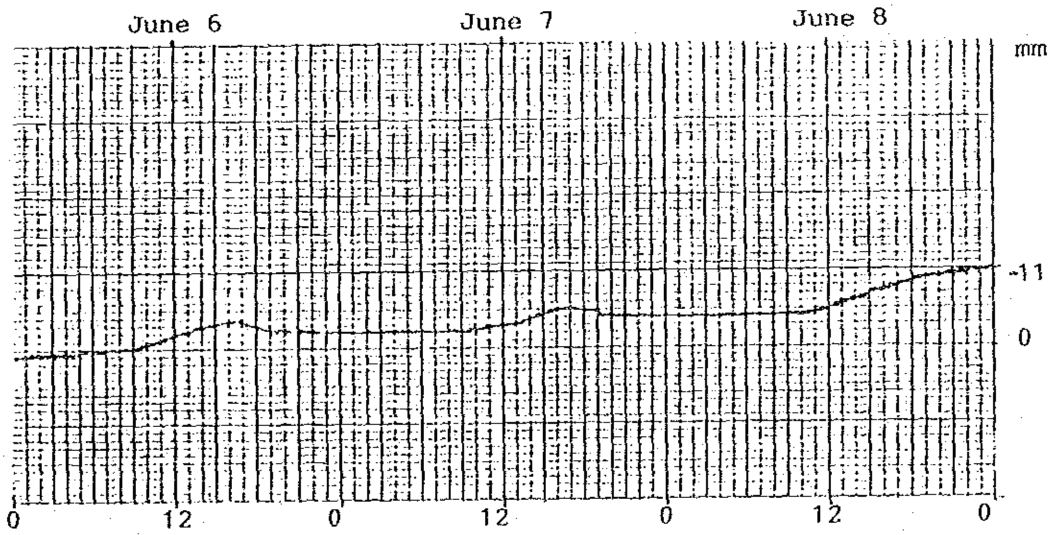
Water discharge in a main drainage canal (D-1R) fractuated as Fig. 25. The average quantity of water flow during the period from March to June was 536 liter per second. It rapidly increased after starting irrigation water supply, and reached to about 750 liter per second in late March and early April. It decreased to about 400 liter per second in late April, and farmers complains water shortage. The quantity of water again increased up to about 900 liter per second in late May, then decreased to about 350 liter per second in late June. Water discharge at the measuring time is in Appendix 19.

Fig. 24 Fractuations of field water levels in sunny days and rainy days (only light rain).

1. Sunny days



2. Rainy days

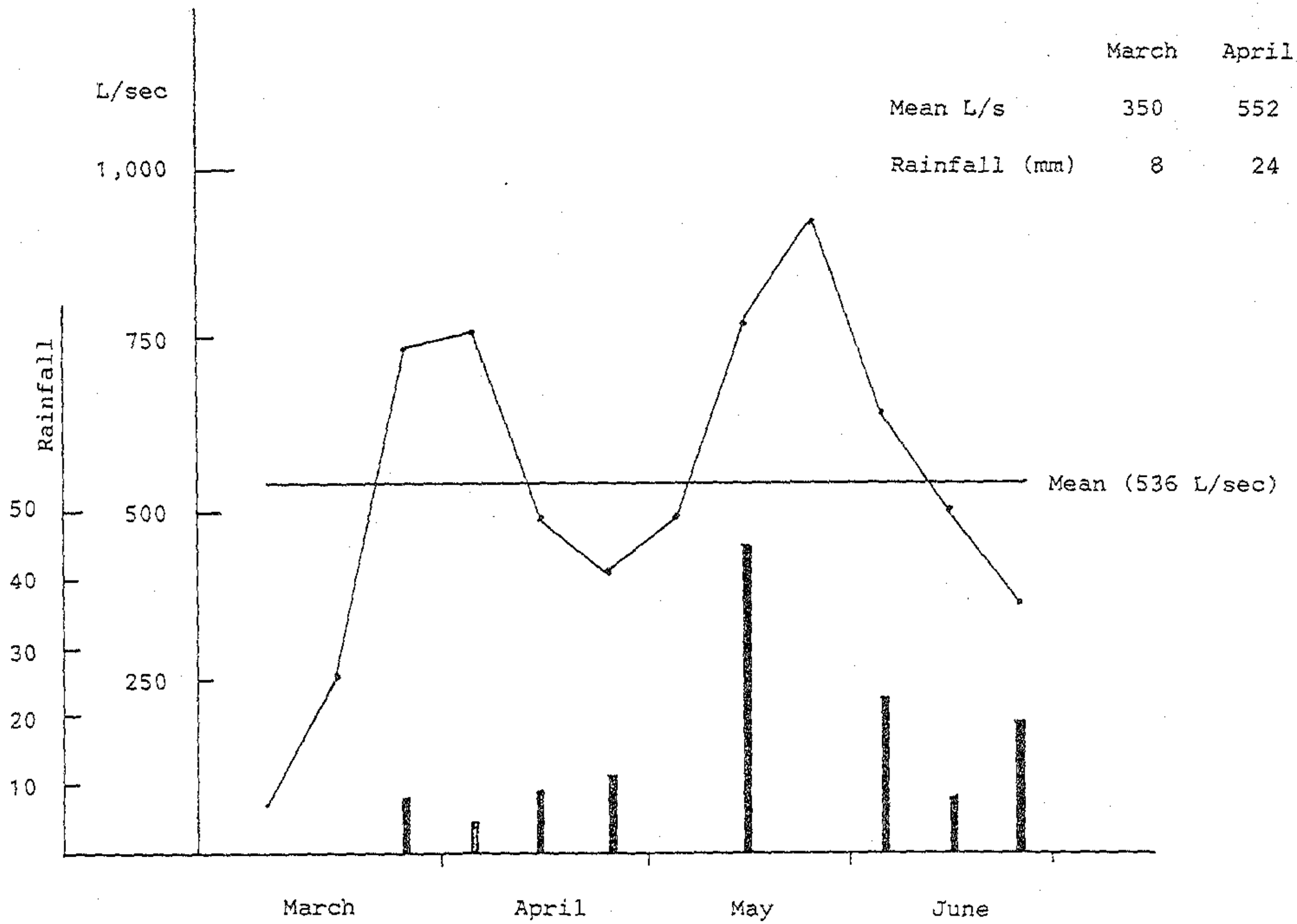


Rainfall: June 6-3.0 mm
June 7-2.5 mm
June 8-0.5 mm

Note: Rainfall was recorded about 300 m from the observation point.

Fig. 25 Water discharge in a main drainage canal.

	March	April	May	June
Mean L/s	350	552	729	501
Rainfall (mm)	8	24	44	48



The quantity of water flow was probably influenced by rainfall in some extent. The total rainfall during the period was 124 mm. However, it was more due to poor management of irrigation water. There observed at least 3 problems in water management. Firstly, farm ditches near the intake took more water than those far from the intake. Secondary, paddy fields near the head of farm ditch took more than necessary water and drained out excess water. Thirdly, there were lots of crab holes along the ditch facing drainage canal and water was continiously leaked out.

Amount of water supplied to 1L-1R canal is in Appendix 20. Part of water supplied to 1L-1R canal was distributed to the area (237.3 ha of paddy planted area and 73.2 ha of sugarcane land) down stream of the pilot project No. 1, but it was difficult to separate from the total amount of water supplied to 1L-1R canal. Irrigation water supplied to the adjacent area by 2R canal was not obtained. These situation made difficult to estimate the amount of water supplied to the upper stream of draining water measuring point, although 0.23 liter per second per rai and 0.17 liter per second per rai was used as a peak water supply of paddy field and sugarcane land, respectively, in this area.

Based on the paddy planted area of 944 ha, the average draining water discharge of 536 liter per second became 4.91 mm per day. It ranged from almost 0 mm per day in early March to 8.44 mm per day in late May. Since rainfall of surrounding area did not affect the drainage water discharge in the dry season, the average value of 4.91 mm per day indicated poor water management in the wide irrigation area.

DISCUSSIONS

Irrigation water and rainfall supplied to the paddy field is lost through (1) evaporation from soil surface, (2) transpiration from the rice plant (and weeds), (3) vertical percolation, and (4) lateral seepage. Amount of water necessary for rice cultivation is usually divided into 2 periods such as for land preparation and for growth duration (after direct sowing or transplanting).

Preparation Water

Amount of water for ploughing and puddling work mostly depend on the practice of land preparation. In the experimental area or Mae Klong area, ploughing work is usually done after the paddy field becomes flooded. Because of its heavy soil type, it is difficult to plough the field by power tiller or small tractors in dry conditions. In this practice, more amount of preparation water is necessary than ploughing paddy field in dry conditions.

Preparation water obtained in the intensive area was 270.3 mm (174.6 mm for ploughing and 95.7 mm for puddling). It was 281.7mm (180.8 mm for ploughing and 100.9 mm for puddling in estimation) in the semi-intensive area.

Nakajima and Misawa (1983) obtained the amount of preparation water in different field conditions at the agricultural demonstration center. In 1983 dry season, 137.6 mm of preparation water (only for puddling) was required to the field (7,850 m^2) where rotavated twice after harvesting 1982 wet season rice and 165.1 mm of preparation water (137.6 mm for ploughing and 27.5 mm for puddling) was necessary to another field (7,850 m^2) where rice straw was spread on the field after harvesting.

Murao (1984) derived 103 mm of soaking water from 3 phase distribution of the soil (Appendix 21). Based on the amount of water supplied (174.6 mm), water depth at ploughing (55.5 mm) and the amount of water necessary for soaking soil (103 mm), field efficiency (Ef) of preparation water for ploughing of the intensive area was obtained as follows:

$$\text{Ef for ploughing} = \frac{\text{Water required}}{\text{Water supplied}}$$

$$= \frac{(55.5 \text{ mm} + 103 \text{ mm})}{174.6 \text{ mm}}$$

$$= 0.91$$

Evaporation was not taken into account in this calculation. Due to its irrigation schedule, Ef for ploughing was not obtained from the semi-intensive area.

In similar procedure, Ef of preparation water (ploughing and puddling) became 0.69 and 0.67 for intensive and semi-intensive area, respectively. Amount of water supplied for adjustment was not included in this calculation. The lesser Ef in preparation water was mostly due to water loss through evaporation.

Although amount of preparation water supplied to the common area was not measured, it was estimated as 304.4 mm based on water depth at 2 days after puddling (104 mm), soaking water (103 mm) and the coefficient obtained from the experimental area (0.68 as mean). However, actual amount of water supplied was probably more than this value. Because puddling work was finished 3 days later than experimental area, and apparently more water was drained from the irrigation unit during the land preparation period.

Longer land preparation period in farmer fields was probably the main reason of more preparation water. Longer field preparation period requires more water for evaporation, percolation and seepage. Preparation water was saved if the field was ploughed after harvesting.

Because of its proper water management during land preparation period, preparation water obtained from the intensive area (270.3 mm in 23 days) is probably the minimum value in farmer fields in Mae Klong area in dry season. Preparation water of 300 to 330 mm in 30 days would be the resonable amount for farmer fields in the area. It becomes 1.16 to 1.27 liter per second per ha of water duty (0.19-0.20 L/sec/rai) or 22.2 to 24.4 liter per second of water discharge at the head of farm ditch (terminal irrigation canal) of standard irrigation unit (19.2 ha) in the pilot project No. 1.

Based on the water requirement in depth of 7.72 mm per day (JICA, 1977) and estimated field efficiency of 0.70, Hisamoto (1984) proposed the peak water requirement of 11.03 mm per day at the head of farm ditch. It becomes 330.9 mm in 30 days. It is quite a reasonable amount of preparation water for farmer fields. The value obtained in the experiment (270-280 mm of preparation water) would be the target in the future.

Land Preparation Period

Land preparation period is mostly influenced by availability of water, ability of farm machine (or draft animal) and management practices. In Mae Klong area, power tillers are mostly used for land preparation. Germinated seed direct sowing method of rice cultivation becomes popular recently, especially for dry season rice. About 90 percent of paddy planted area in the pilot project No. 1 was direct seeded in 1984 dry season.

Period of preparation water supply was 23 days in the experimental area and 27 days in the common area. Period from starting irrigation to finishing puddling was 27 days in the experimental area and 29 days in the common area. Period from starting irrigation to finishing sowing was 27 days in the semi-intensive area, 30 days in the intensive area (including transplanting field), and 31 days in the common area. More than 90 percent of paddy field in the pilot project area finished land preparation when the common irrigation unit finished land preparation. It means that about 30 days of preparation period is enough for farmers to finish land preparation in dry season, if they apply direct sowing and there is enough water. Due to more labor necessary for uprooting and transplanting work, the period would be prolonged if they apply transplanting method.

In the Mae Klong area, irrigation water supply usually stop for 2 months (December and January) for maintenance work of irrigation system. The rice plant faces the risk of cold weather damage, if it flowers later than November 20. Under these circumstances, farmers can start land preparation for dry season rice in February, and they should harvest wet season rice at last within the year.

Because of sunny weather in dry season and harvesting work of sugarcane (December to April), farmers prefer direct sowing method for dry season rice. Improved varieties (mostly RD-23 at present) are planted in dry season, and their growth duration is about 120 days. If farmers can finish land preparation for dry season rice within February or by early March, they can harvest in June or early July.

Farmers should sow rice seeds (either directly to the main field or to the nursery) by August 20 for the safety of wet season rice. After the above practices for dry season rice, farmers have 1 to 2 months of land preparation period for wet season rice depending on the sowing date of respective field in dry season. Longer land preparation period is necessary for wet season rice, because rice farming in more diversified in wet season. Farmers plant more number of varieties including photo sensitive traditional ones which have different harvesting dates. Since direct sowing fields face the risk of poor seedling establishment if heavy rain falls within 10 days after sowing, transplanting method is still popular for wet season rice (about 45 % of the paddy fields in pilot project No. 1 in 1984).

Field Efficiency of Water

Roughly estimated drainage water discharge was about 465 m^3 per day at the end of the drainage ditch (D 2-4). However, it became 487 m^3 per day if the data from April 3 to July 6 were used. The drainage ditch was constructed just between the intensive and semi-intensive area, and approximately one half of water drained from the respective area went to the drainage ditch. Based on the assumptions that irrigation water was equally distributed within the intensive or semi-intensive area and evapotranspiration and percolation rates were same over the experimental area, 487 m^3 per day became 2.68 mm per day, then water requirement in depth excluding seepage was 6.96 mm per day [(9.03 + 10.24) / 2 - 2.68]. It means that seepage water was 2.07 mm per day and 3.28 mm per day for intensive and semi-intensive area, respectively. In other words, about 77 percent and 68 percent of supplied water (including rainfall) was used for evapotranspiration and percolation in the intensive area and semi-intensive area, respectively.

The daily amount of seepage water obtained in the experiment area was less than that estimated for the wide irrigation area (4.91 mm per day). Under field to field irrigation practice and earth made levees along the drainage ditch, the field efficiency of water obtained from the intensive area was quite high, and that obtained from the semi-intensive area was satisfactory. The data indicate that the field efficiency of 70 percent can be obtained if farmers are properly oriented and water is properly supplied. Development of mutual understandings among farmers about the importance of water and its effective utilization is necessary to improve the field efficiency of water.

Water Requirement in Depth

Water requirement in depth is influenced by evaporation, transpiration, vertical percolation and lateral seepage. In farmer fields, seepage is usually the biggest factor which affects the water requirement in depth, because other factors are not easily controlled.

Amount of irrigation water supplied for 104.625 days after puddling was 800.5 mm for intensive and 926.4 mm for semi-intensive area. There was 144.5 mm of rainfall in the period. As the result, average daily water supply was 9.03 mm for intensive and 10.24 mm for semi-intensive area including rainfall (Table 8). Approximate water requirement in depth obtained at the different points was 9.26 mm per day and 11.31 mm per day in average for intensive and semi-intensive area, respectively. The difference of the values obtained from the amount of water supplied and from field observation was quite small. However, the approximate water requirement in depth ranged quite widely (Table 13) due to field to field irrigation practice and different field water conditions. Fig. 26 shows the fractuation of water depth at different fields in the intensive area. It indicates that water depth decreased more than 40 mm in one day in some fields (Appendix 15).

Water requirement in depth excluding seepage obtained in the controlled field was 6.45 mm per day as an average of 20 days from May 22 to June 11 (Table 17). It was 8.43 mm per day as an average of sunny days and 6.13 mm per day as an average of slight rainy days (including rainfall). Although percolation rate was not obtained in the experiment, it was reported as about 1 mm per day (JICA, 1977).

Fig. 27 shows water requirement in depth obtained in experimental area, controlled field, and some water requirement research stations in 1980 dry season. It was 7.39 mm per day at Mae Taeng (March to June), 7.55 mm per day at Sam Chuk (February to May), and 8.02 mm per day at Petchaburi (January to May). Although it is difficult to compare the values obtained at different places at different years, rather late measuring time of the controlled field (late May to early June) is probably the main reason of lower water requirement in depth. Because rainfall greatly affect evapotranspiration. Higher water requirement in depth in farmer fields was due to seepage.

Rotational Irrigation

Two kind of rotational irrigation schedules were introduced in the experimental area. The intensive area had different rotational irrigations for land preparation and rice growth duration. The semi-intensive area had weekly rotational irrigation throughout the experimental period. However,

Fig. 26 Fractuation of water depth at different fields in intensive area.

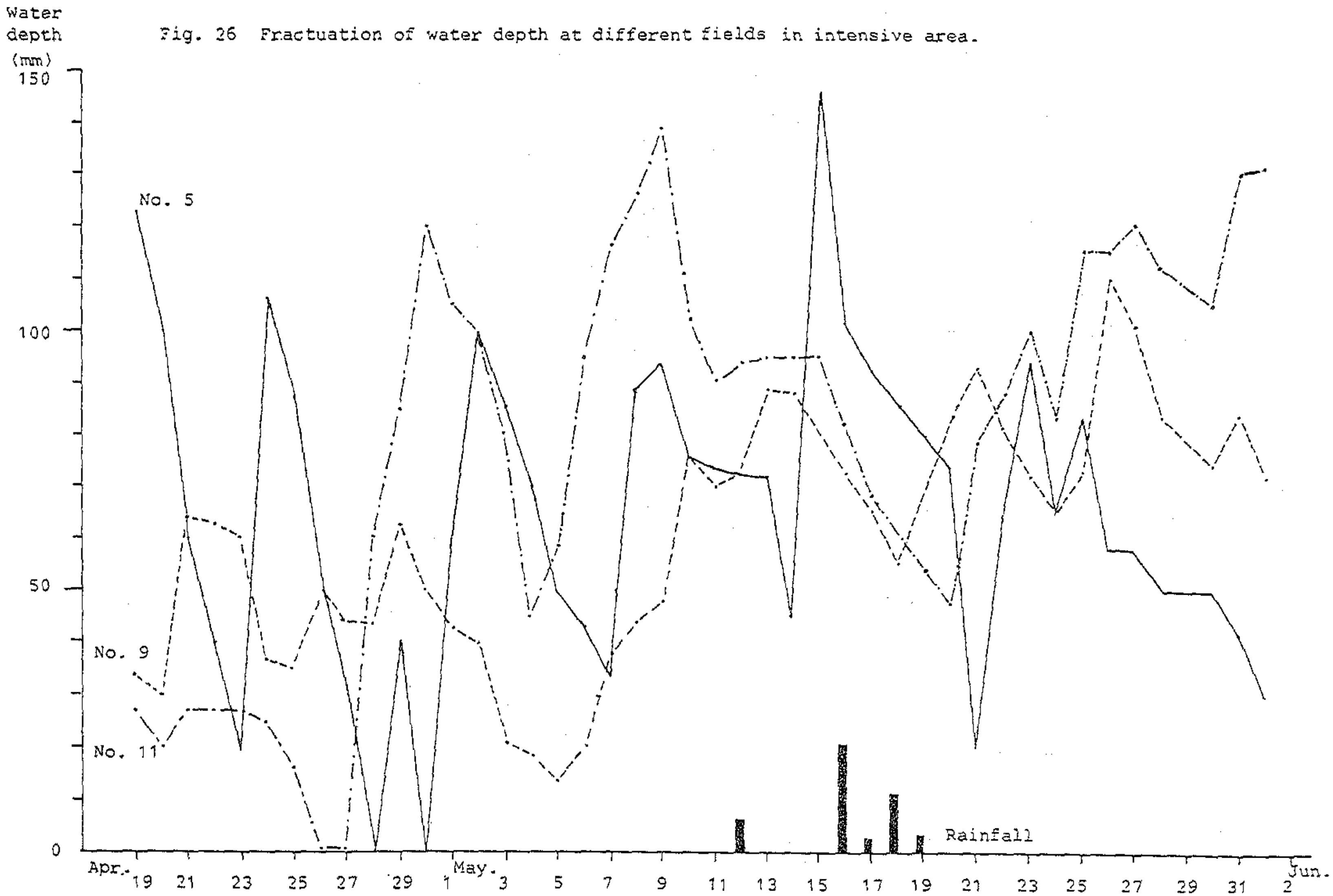
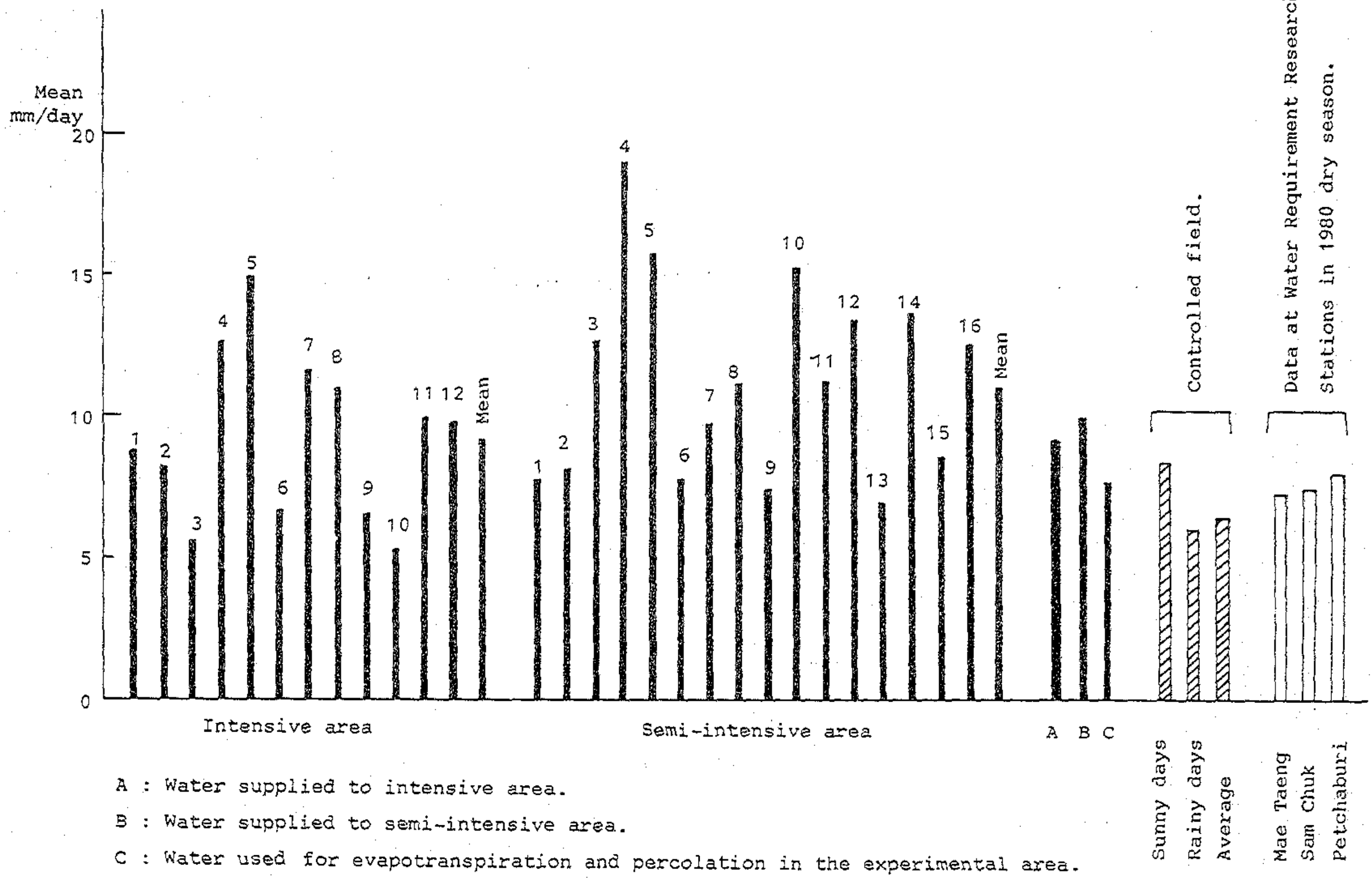


Fig. 27 Water requirement in depth in different paddy fields.



A : Water supplied to intensive area.

B : Water supplied to semi-intensive area.

C : Water used for evapotranspiration and percolation in the experimental area.

except the one for land preparation of the intensive area, they did not strongly compel the farmers to follow. Diversified field conditions in water balance in the experimental area made difficult to persist the scheduled rotational irrigations. But, at least, farmers had benefits from the irrigation schedules, because they could take water on assigned days, if their fields were lack of water. Field water conditions after seedling establishment (Table 12) shows that the water distribution was satisfactory.

Table 18 shows number of paddy fields seeded (or transplanted) at different days after flooding. It was 17.6 days in average for intensive area (ranged 9-24 days), 12.0 days for semi-intensive area (ranged 2-24 days), and 9.5 days for common area (ranged 2-23 days). It means that in 30 days of total land preparation period in the intensive area, every field finished sowing (or transplanting) in 17.6 days in average. The longer land preparation period of respective field in the intensive area was the result of separating preparation water for ploughing and puddling. This practice has an advantage in weed control, because weed seeds germinate after flooding (or ploughing) and weed seedlings are later puddled into the soil.

However, it is difficult to introduce this kind of rotational irrigation to wider area at present. There are at least 2 pre-requisites for rotational irrigation, such as (1) provision of terminal irrigation facilities and (2) mutual cooperation among farmers. Even pilot project No. 1, which received an intensive method of land consolidation, field to field irrigation is still a common practice because of lesser number of inlets and more number of paddy fields. In Mae Klong area, Operation and Maintenance Office of RID has responsibility for primary and secondary canal maintenance and water distribution to tertiary canals. Then farmers have responsibility for tertiary canals or farm ditches. Water user groups are being organized in the area where land consolidation work is completed. Farmers are oriented about water management, and water fee for repair and maintenance of respective canal is collected

Table 18 Number of paddy fields seeded (or transplanted) at different days after first flooding.

Days	Intensive area[a]	Semi-intensive area	Common area
2	0	4	2
3	0	2	6
4	0	3	7
5	0	2	5
6	0	3	9
7	0	8	7
8	0	1	11
9	1	9	1
10	6	3	0
11	5	6	6
12	0	2	1
13	0	9	5
14	3	0	3
15	8	0	8
16	5	8	0
17	4	5	2
18	4	7	2
19	9	6	1
20	18	2	4
21	4	1	0
22	5	1	0
23	4	0	1
24	2	1	0
Mean	17.6	12.0	9.5
S.D.	4.0	5.6	5.2

[a]Excluding a small portion later added to the experimental area.

from 1 year after the completion of land consolidation. It is 40 baht per rai per year for extensive land consolidation area, and 70 baht per rai per year for intensive land consolidation area.

It will take some more years for farmers to understand the importance of water management. It is the common practice at present that farmers who have paddy fields at the head of farm ditch take more water and drain out excess water, then farmers who have paddy fields at the end of farm ditch have less water and they sometimes pump up water from drainage canal. This situation makes difficult to collect water fee for maintenance.

To cope with this problem, Hisamoto (1984) proposed a practical rotational irrigation schedule for each farm ditch (20 in total) in the pilot project No. 1. Based on the existing inlets and boundaries of land owners in each irrigation unit, he divided the area into 3 rotational blocks as standard. Example of the proposed rotational schedule is in Appendix 22. In the schedule, changing irrigation block is either 6:00, 12:00 or 18:00 hours, and the rotational block of the middle and the end receives 1.2 and 1.4 times of water of the head of the farm ditch, respectively. The schedule ensures the farmers that they can get water on assigned days if their fields are lack of water.

The rotational irrigation schedule of 3 blocks in standard is a quite a practical method at present. It will improve water distribution within the farm ditch. More precise irrigation schedule, such as that of intensive area, can be introduced after the farmers become familiar with rotational irrigation and installing additional inlets at appropriate points.

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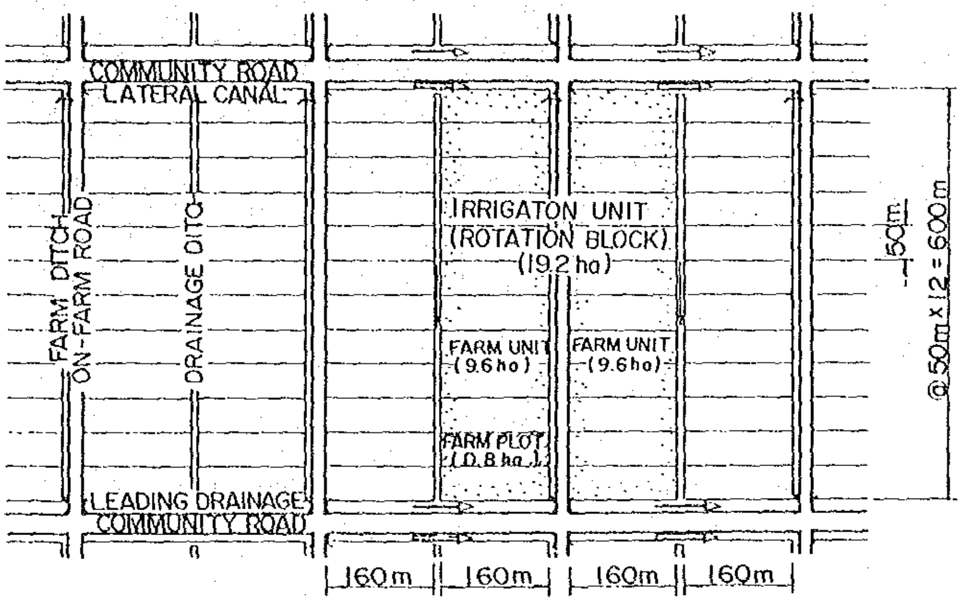
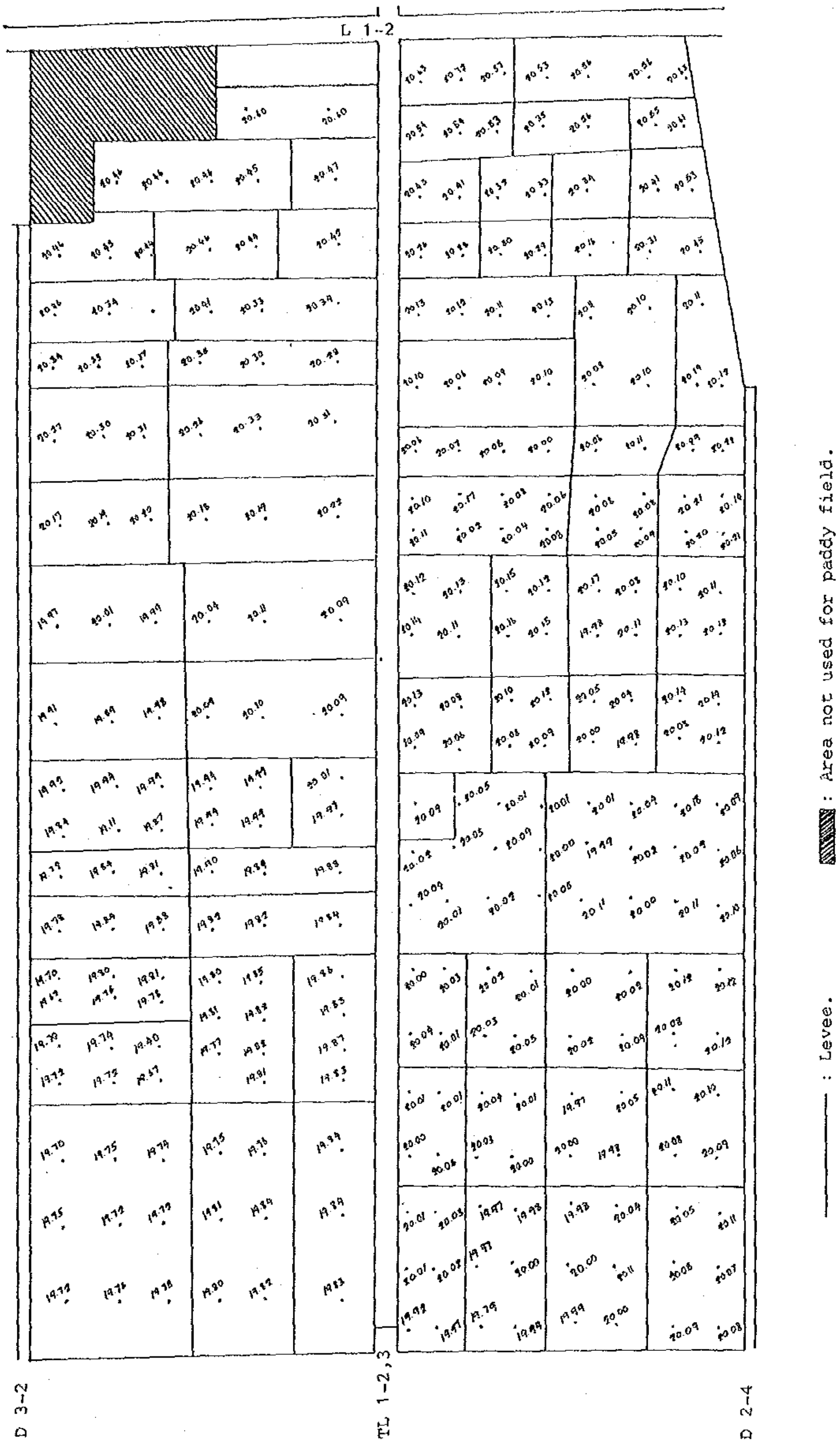
Appendix 1 Standard size of terminal irrigation unit[a].

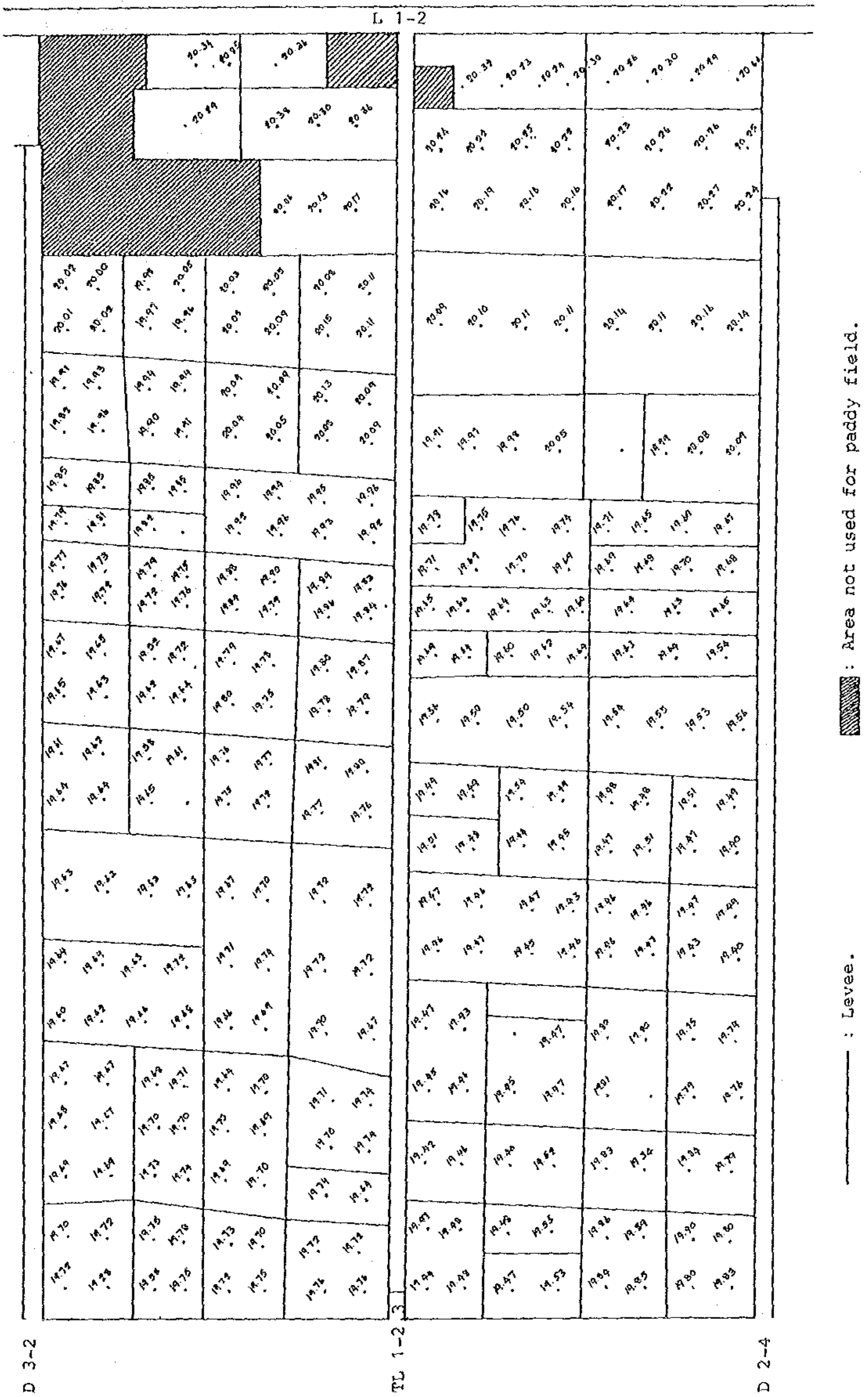


[a]From " Design report, Mae Klong pilot project in the technical cooperation on the irrigated agriculture development in Thailand ", p. 3 - 22, JICA, 1977.

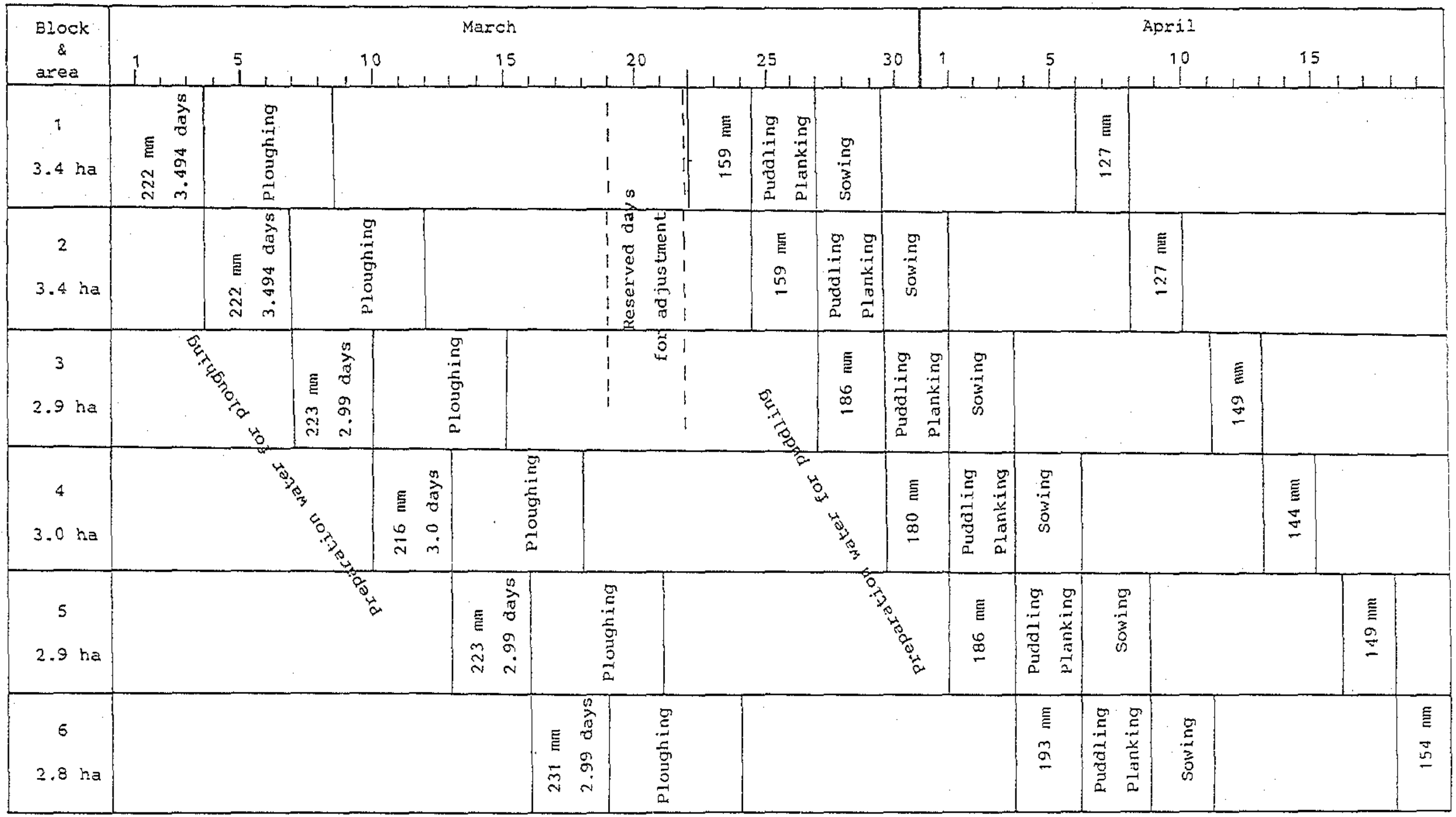
Appendix 2 Elevation of the spots in intensive area (m above MSL).



Appendix 3 Elevation of the spots in semi-intensive area (m above MSL).



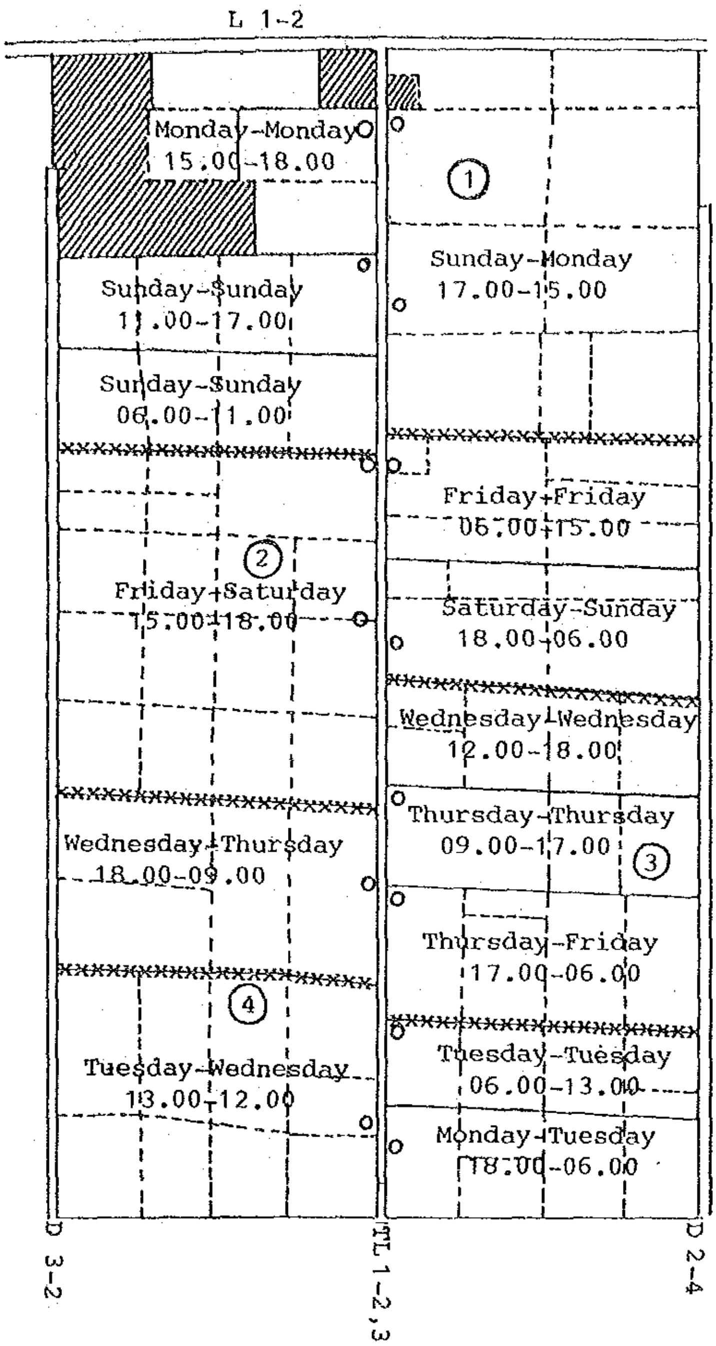
Appendix 4-1 Irrigation and farming schdule for intensive area.



4-2 ตารางการส่งน้ำ และ การเพาะปลูก (intensive area).

บลอค หมายเลข	มีนาคม (1–31) / เมษายน (1–18): ลำดับกิจกรรม						
1 3.4 (เฮคแตร์)	222 มม 3.494 วัน	ไถ		159 มม	เทือก คราด - หวาน	127 มม	
2 3.4 (เฮกแตร์)	222 มม 3.494 วัน	ไถ	วันสำรองน้ำ	159 มม	เทือก คราด - หวาน	127 มม	
3 2.9 (เฮกแตร์)	223 มม 2.99 วัน	ไถ		186 มม	เทือก คราด - หวาน	149 มม	
4 3.0 (เฮกแตร์)	ขังน้ำไว้ใช้ในการไถ	216 มม 3.0 วัน	ไถ	ขังน้ำไว้ใช้ในการเทือก	180 มม	เทือก คราด - หวาน	144 มม
5 2.9 (เฮกแตร์)	ขังน้ำไว้ใช้ในการไถ	223 มม 2.99 วัน	ไถ	ขังน้ำไว้ใช้ในการเทือก	186 มม	เทือก คราด - หวาน	149 มม
6 2.8 (เฮกแตร์)	231 มม 2.99 วัน	ไถ		193 มม	เทือก คราด - หวาน	154 มม	

Appendix 5 Irrigation schdule for semi-intensive area.



①

06.00 น. วันอาทิตย์
ถึง
18.00 น. วันจันทร์

06.00 Sunday
to
18.00 Monday

②

06.00 น. วันศุกร์
ถึง
06.00 น. วันอาทิตย์

06.00 Friday
to
06.00 Sunday

③

12.00 น. วันพุธ
ถึง
06.00 น. วันศุกร์

12.00 Wednesday
to
06.00 Friday

④

18.00 น. วันจันทร์
ถึง
12.00 น. วันพุธ

18.00 Monday
to
12.00 Wednesday

O : Inlet

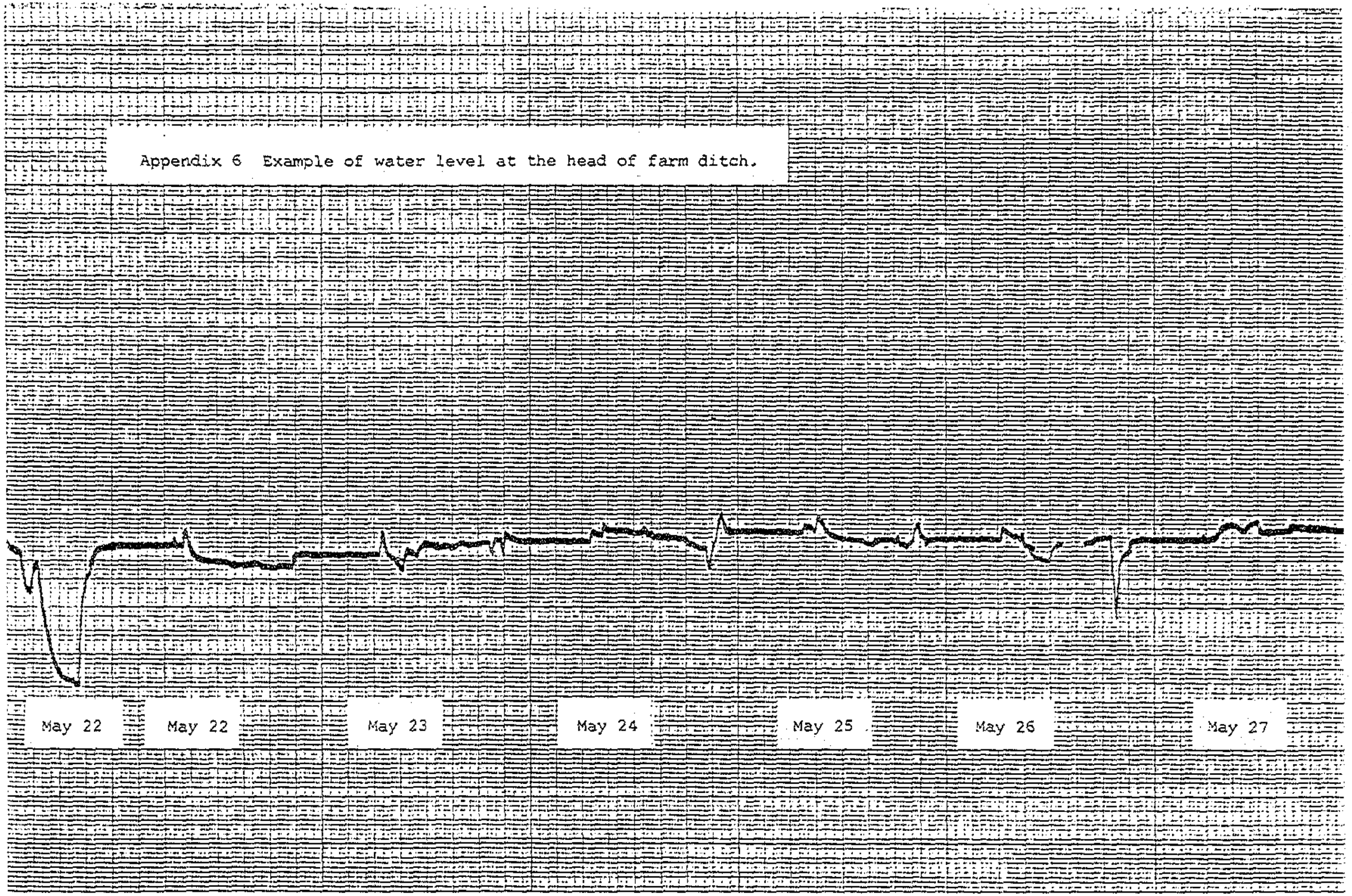
— : Boundary of cultivater.

xxx : Boundary of irrigation block.

▨ : Not paddy field.

◯ : Irrigation block.

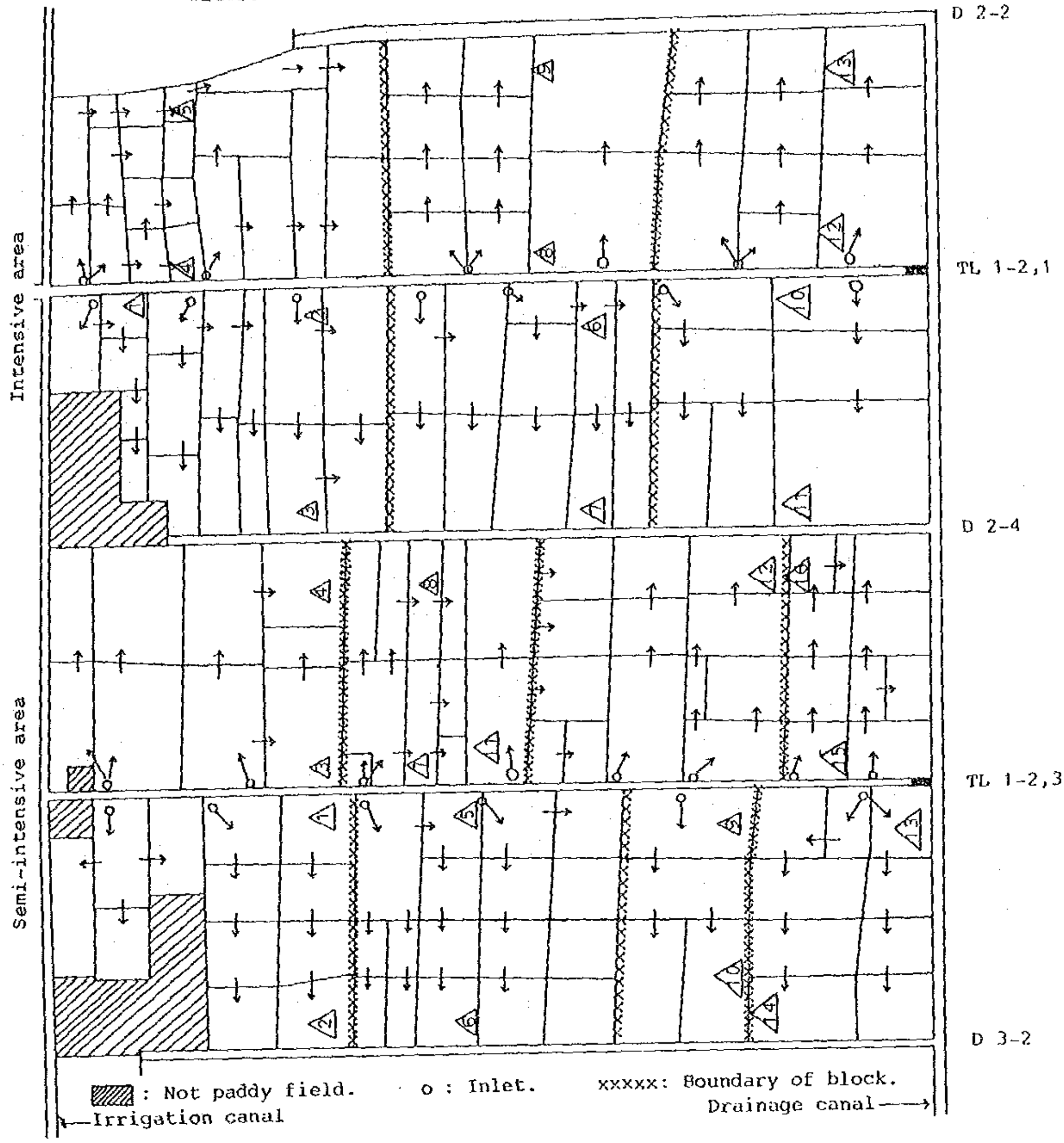
Appendix 6 Example of water level at the head of farm ditch.



Appendix 7 Example of calculating water discharge at the head of farm ditch.

Date	Time	Ha (cm)	Q (L/sec)	v (m^3)	V (m^3/day)
May 22	0.00	16.50			
	8.00	16.75	22.38	644.69	
	8.25	18.00	24.00	36.00	
	9.40	15.30	22.44	100.97	
	13.15	14.70	19.03	245.45	
	14.00	14.50	18.23	49.23	
	16.15	14.60	18.13	146.88	
	18.00	14.20	17.84	112.38	
	20.50	14.40	17.64	179.96	
	21.00	15.60	19.03	11.42	
	24.00	15.60	20.24	218.63	
					1746
May 23	0.00	15.60			
	6.40	15.70	20.35	488.31	
	7.00	17.70	22.54	27.05	
	7.35	15.90	22.76	47.79	
	9.10	14.00	18.93	107.88	
	10.00	16.00	19.03	57.08	
	11.00	15.60	20.66	74.36	
	12.00	16.80	21.49	77.36	
	15.00	16.50	22.44	242.33	
	16.00	16.90	22.54	81.16	
	17.00	16.70	22.76	81.93	
	19.10	16.80	22.65	176.68	
	19.40	16.00	21.91	39.43	
	20.00	17.20	22.33	26.80	
	20.40	17.30	23.73	56.95	
	20.57	16.00	22.44	22.89	
	21.05	17.70	22.87	10.98	
	23.00	17.10	24.06	165.99	
	24.00	17.10	23.40	84.25	
					1869
May 24	0.00	17.10			
	7.00	17.10	23.40	589.78	
	7.05	18.00	24.38	7.32	
	8.15	17.70	25.05	105.19	
	8.30	18.50	25.60	23.04	
	13.20	18.10	26.05	453.29	
	18.00	17.30	24.71	415.20	
	20.15	16.80	23.30	188.70	
	20.50	14.20	20.04	42.08	
	21.30	17.20	20.45	49.08	
	22.03	19.80	26.50	52.47	
	22.40	18.20	27.64	61.37	
	24.00	18.30	25.94	124.51	
					2112

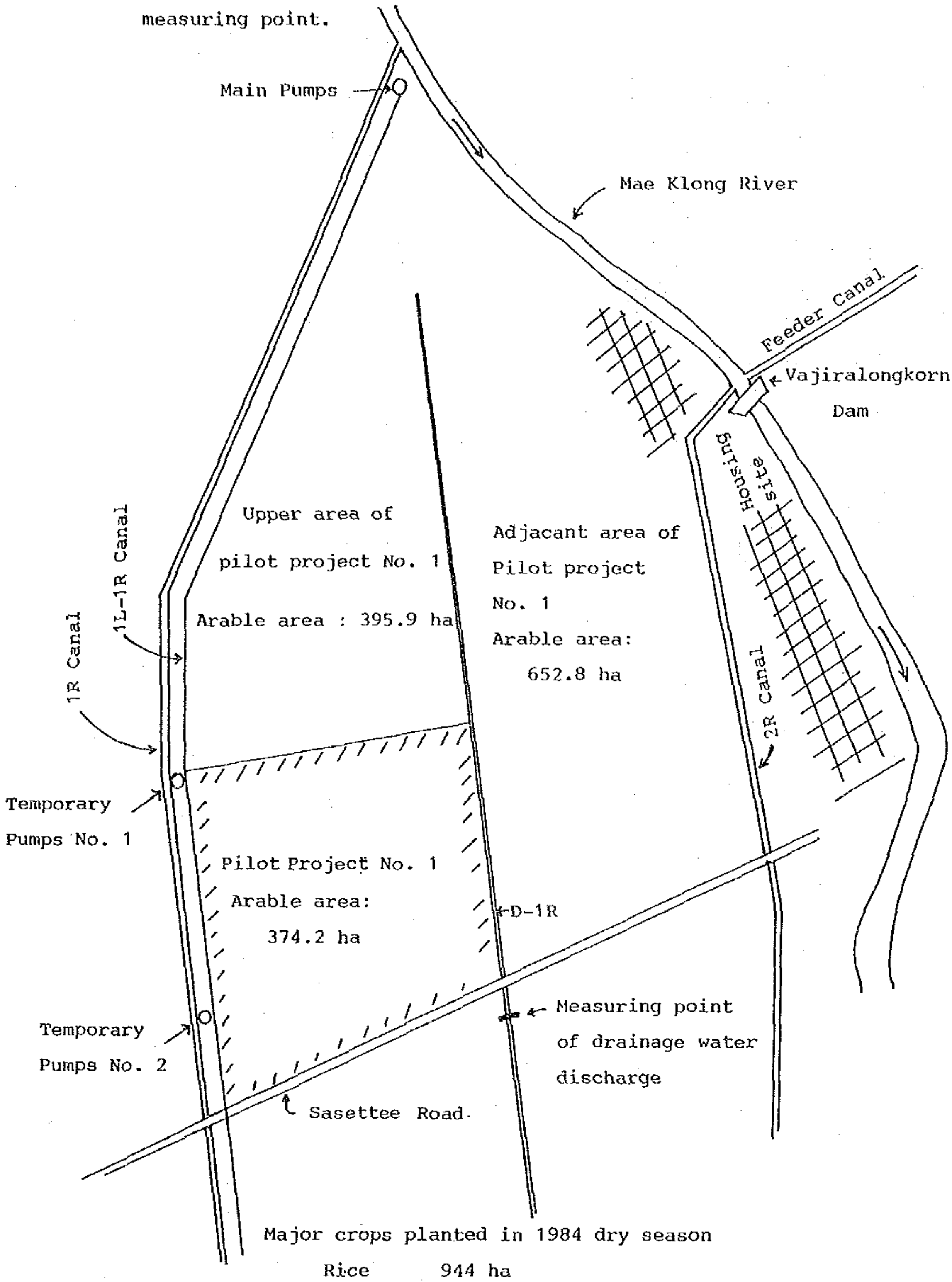
Appendix 8 Measuring points of water depth and flowing way of irrigation water.



△ Measuring point of water depth.

→ Flowing way of water after inlet.

Appendix 9 Profile of land use in the upper stream of draining water measuring point.

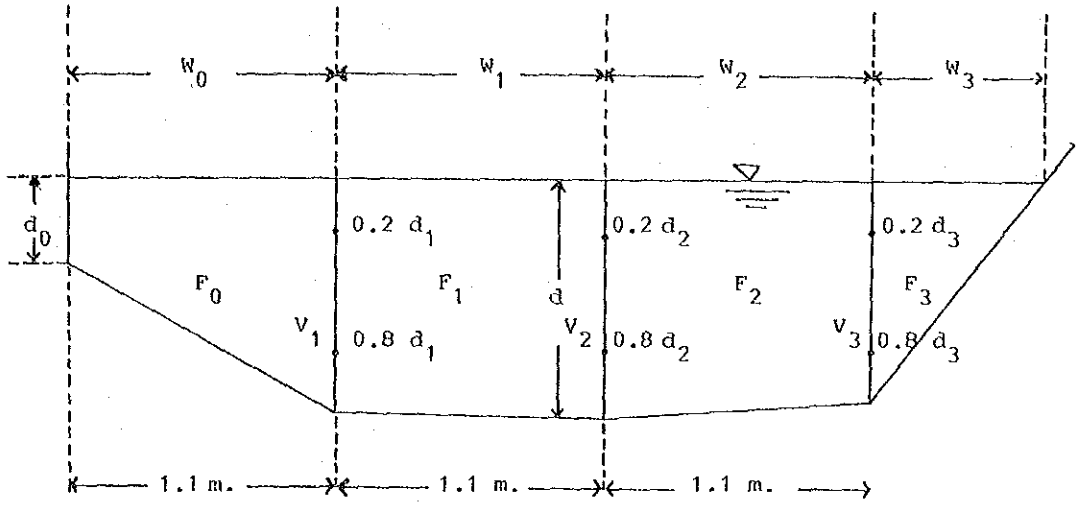


Major crops planted in 1984 dry season

Rice 944 ha

Sugarcane 370 ha

Appendix 10 Section of drainage canal at the point of measuring water discharge and procedure of obtaining water discharge.



1. Calculation F:

$$F_0 = \frac{(d_0 + d_1) \times W_0}{2}$$

$$F_1 = \frac{(d_1 + d_2) \times W_1}{2}$$

$$F_2 = \frac{(d_2 + d_3) \times W_2}{2}$$

$$F_3 = \frac{d_3 \times W_3}{2}$$

2. Calibrated velocity:

$$V_c = 0.118\ V + 0.014$$

$$V_{c\ 0} = \frac{2\ V_0}{3}$$

$$V_{c\ 1} = \frac{V_1 + V_2}{2}$$

$$V_{c\ 2} = \frac{V_2 + V_3}{2}$$

$$V_{c\ 3} = \frac{2\ V_3}{3}$$

3. $q = F \times Vc$

4. $Q = q_0 + q_1 + q_2 + q_3$

Appendix 11 Climatological data for the period 1951-1980[a].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	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 maximum	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 minimum	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
Extreme maximum	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
Extreme minimum	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
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 hrs	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
Pan evaporation (mm)	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
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 maximum	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 minimum	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
Extreme minimum	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

[a]From "Climatological data of Thailand 30-year period (1951-1980)", p. 30, Meteorological Department, Ministry of Communications, 1982.

Appendix 12 Amount of irrigation water supplied.

Date	Intensive area	Semi-intensive area
Mar. 3	561	475
4	1,056	710
5	1,064	1,044
6	1,394	1,456
7	1,907	1,900
8	2,109	2,266
9	2,235	2,172
10	2,536	2,693
11	2,356	2,635
12	2,194	2,504
13	2,419	2,607
14	2,141	2,295
15	1,920	1,785
16	2,512	2,386
17	2,228	2,523
18	2,289	2,598
19	705	963
sub-total (Ploughing)	31,626 m^3 174.6 mm 10.96 mm/day 23.0 L/sec	33,012 m^3 180.8 mm 11.34 mm/day 24.0 L/sec
Mar 19	1,781	1,533
20	1,886	2,114
21	1,780	2,036
22	1,803	2,563
23	2,971	2,392
24	3,017	3,202
25	2,952	3,090
26	1,131	1,490
Sub-total (Puddling)	17,327 m^3 95.7 mm 13.75 mm/day 28.8 L/sec	18,420 m^3 100.9 mm 14.50 mm/day 30.6 L/sec
Mar. 26	543	1,490
27	1,121	2,265
28	2,015	1,392
29	659	396
30	26	27
31	19	628
Apr. 1	0	123
2	75	1,125
3	116	1,429
4	11	47

Date	Intensive area	Semi-intensive area
5	29	496
Sub-total (Adjustment)	4,614 m^3 25.5 mm 2.40 mm/day 5.0 L/sec	9,418 m^3 51.6 mm 4.86 mm/day 10.3 L/sec
Apr. 6	210	1,850
7	1,722	2,249
8	2,221	2,299
9	1,564	1,477
10	2,009	2,527
11	1,830	2,221
12	1,254	1,934
13	1,067	1,532
14	2,446	2,552
15	2,467	2,546
Sub-total (Pre-rotation)	16,790 m^3 92.7 mm 9.27 mm/day 19.4 L/sec	21,189 m^3 119.5 mm 11.95 mm/day 24.5 L/sec
Apr. 16	1,120	2,007
17	1,014	1,983
18	1,772	2,265
19	1,816	2,234
20	1,765	2,337
21	1,517	2,088
22	1,253	1,989
Sub-total (Rotation1)	10,257 m^3 56.6 mm 8.09 mm/day 17.0 L/sec	14,893 m^3 81.5 mm 11.64 mm/day 24.6 L/sec
Apr. 23	907	1,668
24	1,164	1,984
25	1,144	1,845
26	1,061	1,774
27	1,467	1,988
28	788	1,411
29	925	1,323
Sub-total (Rotation2)	7,456 m^3 41.2 mm 5.89 mm/day 12.3 L/sec	11,863 m^3 65.0 mm 9.29 mm/day 19.6 L/sec

Date	Intensive area	Simi-intensive area
Apr. 30	918	1,307
May 1	802	1,315
2	1,867	1,734
3	1,980	1,843
4	2,803	2,358
5	2,564	2,581
6	2,443	2,363
Sub-total (Rotation3)	13,377 m^3 73.9 mm 10.54 mm/day 22.1 L/sec	13,500 m^3 73.9 mm 10.56 mm/day 22.3 L/sec
May 7	2,288	2,253
8	2,916	2,209
9	2,872	2,204
10	2,866	2,264
11	3,006	2,215
12	3,086	2,106
13	3,060	2,089
Sub-total (Rotation4)	20,094 m^3 111.0 mm 15.86 mm/day 33.2 L/sec	15,340 m^3 84.0 mm 12.0 mm/day 25.4 L/sec
May 14	2,556	2,373
15	2,140	2,253
16	2,065	2,200
17	1,912	2,104
18	2,075	2,180
19	1,881	2,136
20	2,183	2,358
Sub-total (Rotation5)	14,812 m^3 81.8 mm 11.69 mm/day 24.5 L/sec	15,604 m^3 85.4 mm 12.20 mm/day 25.8 L/sec
May 21	1,671	2,328
22	1,746	2,088
23	1,869	2,049
24	2,112	2,084
25	2,154	2,100
26	1,946	2,051
27	2,205	2,165
Sub-total	13,703 m^3	14,865 m^3

Date	Intensive area	Semi-intensive area
(Rotation6)	75.7 mm 10.81 mm/day 22.7 L/sec	81.4 mm 11.63 mm/day 24.6 L/sec
May 28	1,922	1,891
29	1,859	1,708
30	1,619	1,723
31	1,689	1,912
June 1	637	587
2	0	7
3	0	0
Sub-total (Rotation7)	7,726 m^3 42.7 mm 6.10 mm/day 12.8 L/sec	7,830 m^3 42.9 mm 6.13 mm/day 12.9 L/sec
June 4	0	0
5	0	0
6	949	716
7	1,841	1,750
8	1,753	2,004
9	1,466	1,985
10	162	896
Sub-total (Rotation8)	6,171 m^3 34.1 mm 4.87 mm/day 10.2 L/sec	7,351 m^3 40.3 mm 5.76 mm/day 12.2 L/sec
June 11	1,117	1,393
12	1,528	1,595
13	1,106	1,557
14	1,360	1,862
15	1,808	1,962
16	1,836	1,898
17	1,750	1,779
Sub-total (Rotation9)	10,509 m^3 58.0 mm 8.29 mm/day 17.4 L/sec	12,046 m^3 66.0 mm 9.43 mm/day 19.9 L/sec

Date	Intensive area	Semi-intensive area
June 18	1,215	1,347
19	897	996
20	978	1,085
21	1,403	1,560
22	1,524	1,642
23	1,525	1,654
24	1,469	1,685
Sub-total (Rotation10)	9,011 m^3 49.8 mm 7.11 mm/day 14.9 L/sec	9,969 m^3 54.6 mm 7.80 mm/day 16.5 L/sec
June 25	1,556	1,722
26	1,267	1,583
27	971	1,376
28	1,181	1,639
29	797	1,125
30	378	593
Jul. 1	1,241	1,888
Sub-total (Rotation11)	7,391 m^3 40.8 mm 5.83 mm/day 12.2 L/sec	9,930 m^3 54.4 mm 7.77 mm/day 16.4 L/sec
Jul. 2	1,219	1,371
3	1,129	1,289
4	991	1,348
5	899	1,337
6	0	13
7	37	22
8	0	7
Sub-total (Rotation12)	4,279 m^3 23.6 mm 3.37 mm/day 7.1 L/sec	5,387 m^3 29.5 mm 4.21 mm/day 8.9 L/sec

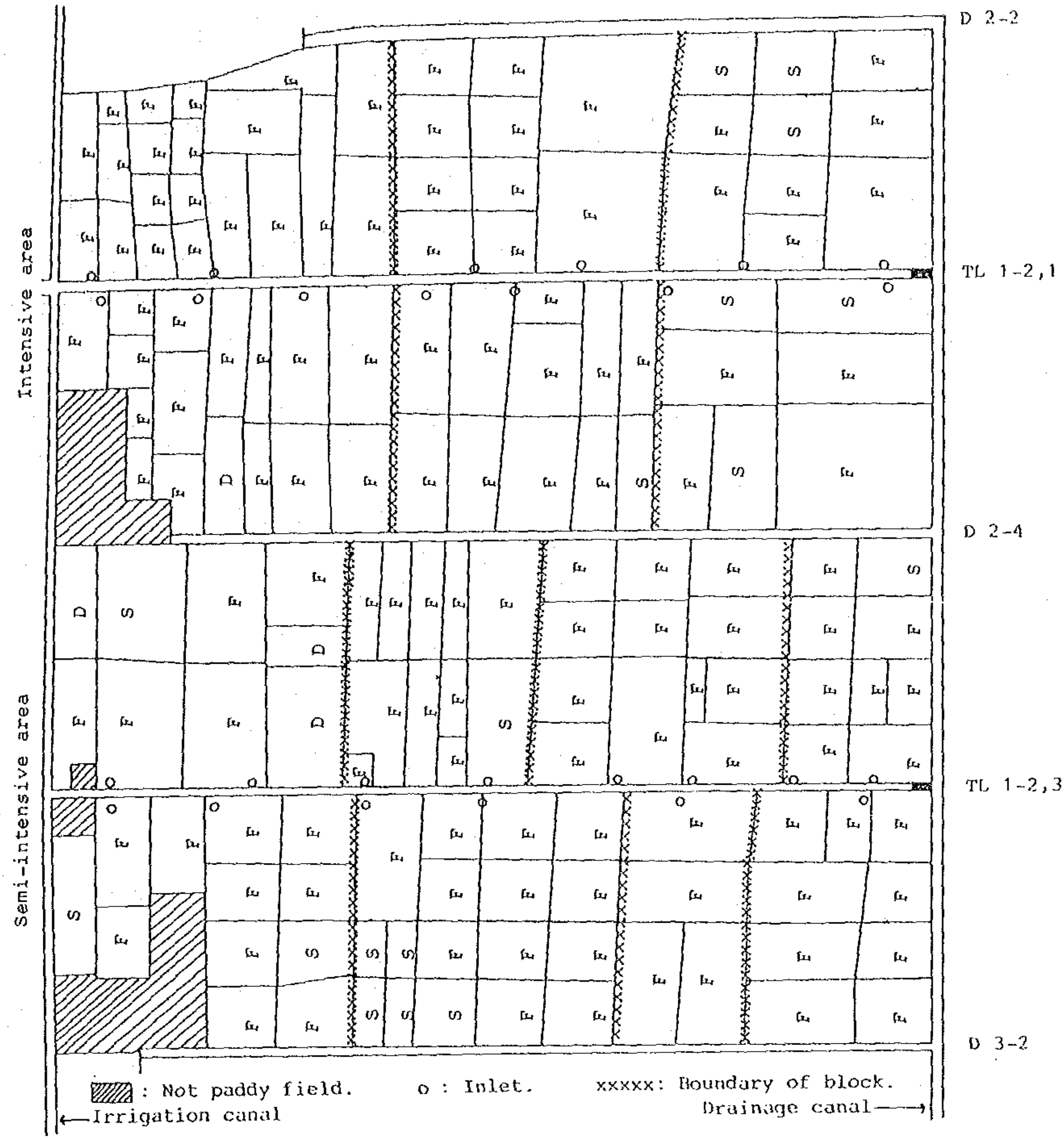
Appendix 13 Amount of water drained.

Date	Water discharge	
	m^3/day	L/sec
Mar. 12	40	
13	40	
14	33	
15	22	
16	61	
17	636	
18	1,069	
19	598	
20	170	
21	522	
22	531	
S.total	3,722	(11 days)
Mean (1)	338	3.92
Mar. 23 - Apr. 2 Missing		
Apr. 3	131	
4	184	
5	44	
6	17	
7	22	
8	138	
9	169	
10	456	
11	595	
12	937	
13	1,111	
14	541	
15	498	
16	565	
17	524	
18	381	
19	522	
20	308	

Date	Water discharge	
	m^3/day	L/sec
Apr. 21	224	
22	208	
S.total	7,575	(20 days)
Mean (2)	379	4.38
Apr. 23		
24	375	
25	251	
26	214	
S.total	840	(3 days)
Mean (3)	280	3.24
Apr. 27 - May 8 Missing		
May 9	1,129	
Mean (4)	1,129	13.07
May 10 - 20 Missing		
May 21	806	
22	1,830	
23	2,050	
24	1,676	
25	1,543	
S.total	7,905	(5 days)
Mean (5)	1,581	18.30
May 26 - Jun. 24 Missing		
Jun. 25	653	
26	760	
27	492	
28	348	
29	303	
30	166	
Jul. 1	107	
S.total	2,829	(7 days)
Mean (6)	404	4.68

Date	Water discharge	
	m^3/day	L/sec
Jul. 2	87	
3	59	
4	25	
5	14	
6	10	
S.total	195	(5 days)
Mean (7)	39	0.45
G. total	24,195	(53 days)
Mean	457	5.28

Appendix 14-1 Water condition of paddy field (April 20).

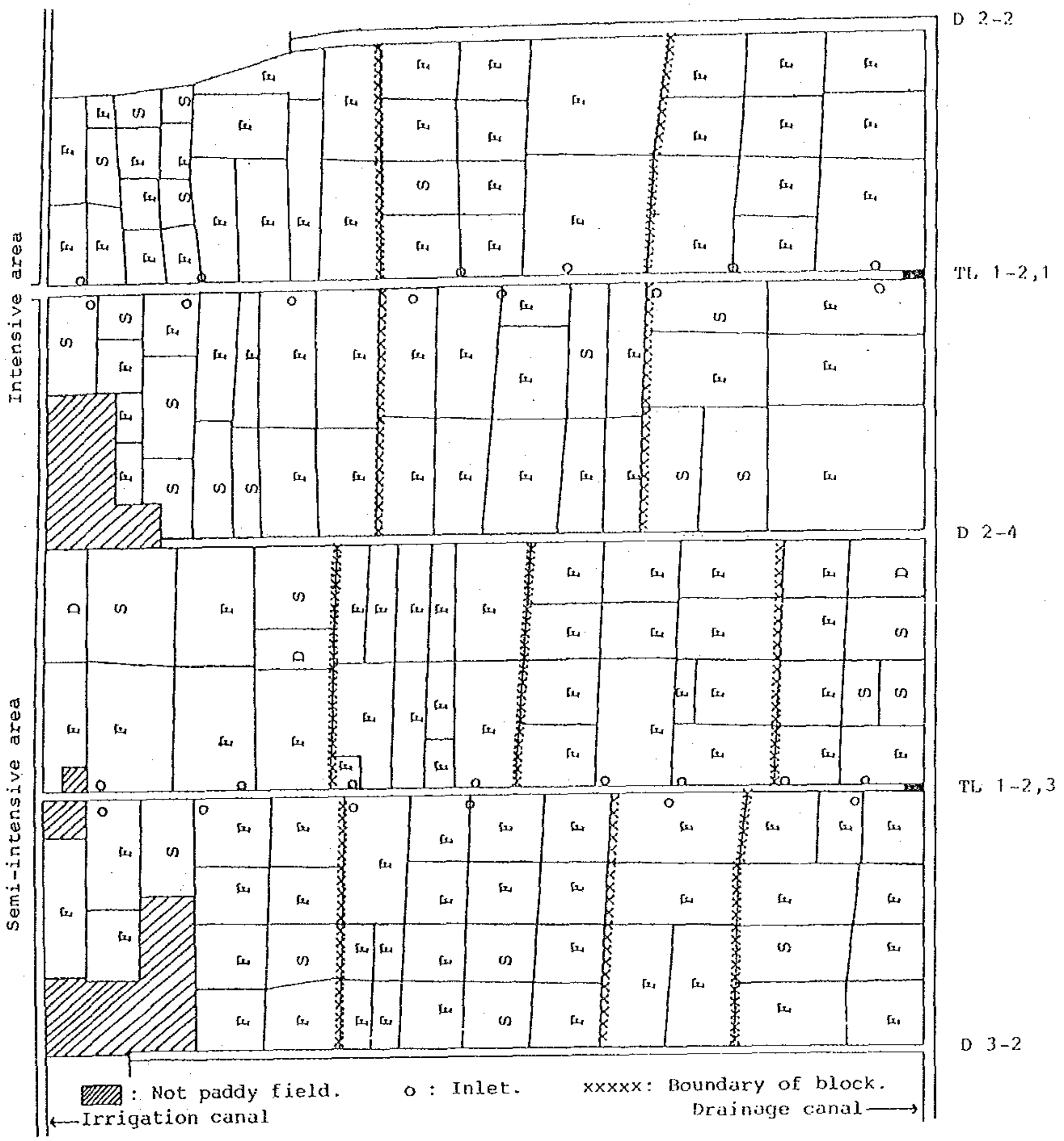


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-2 Water condition of paddy field (April 27).

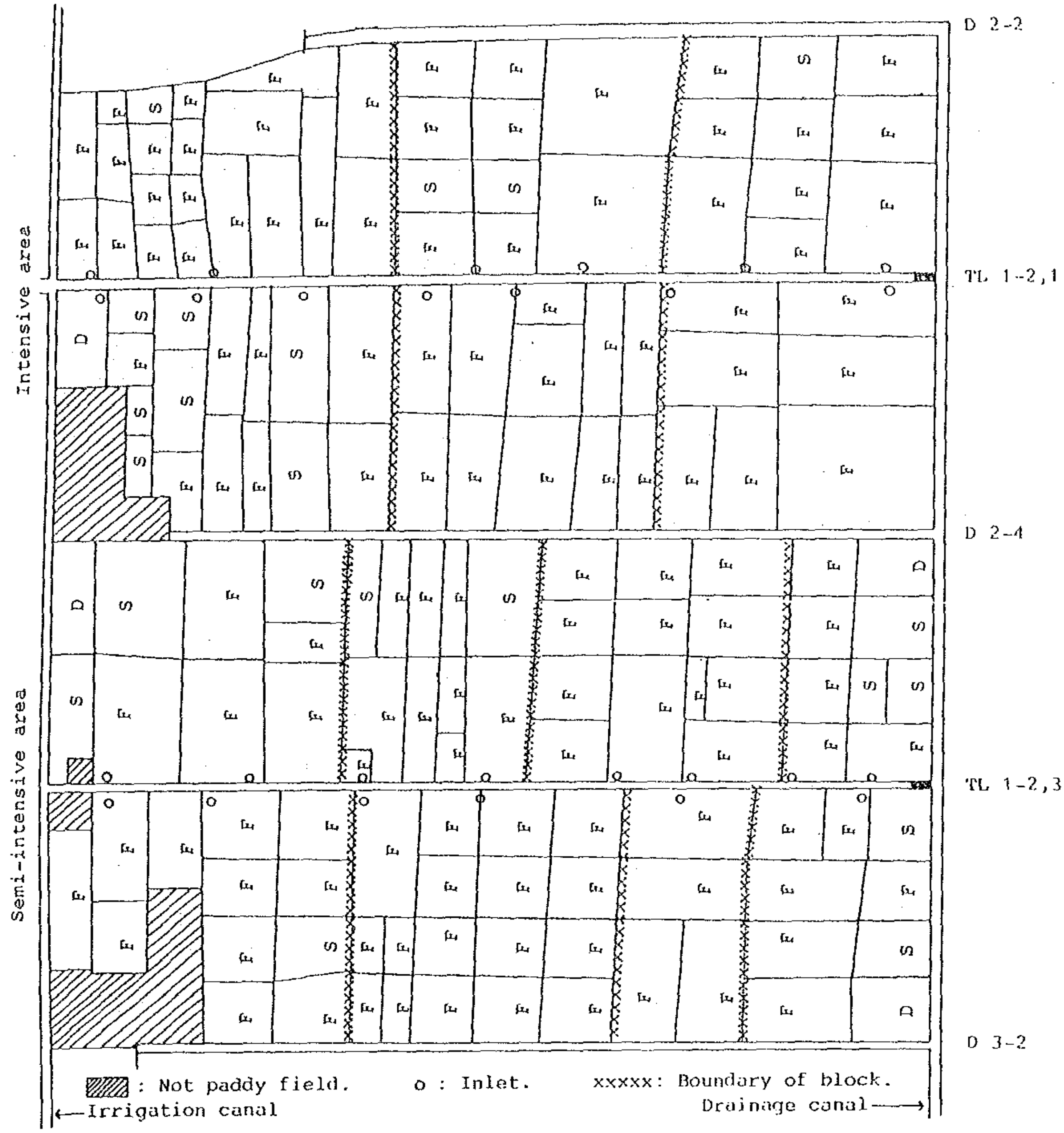


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-3 Water condition of paddy field (May 6).

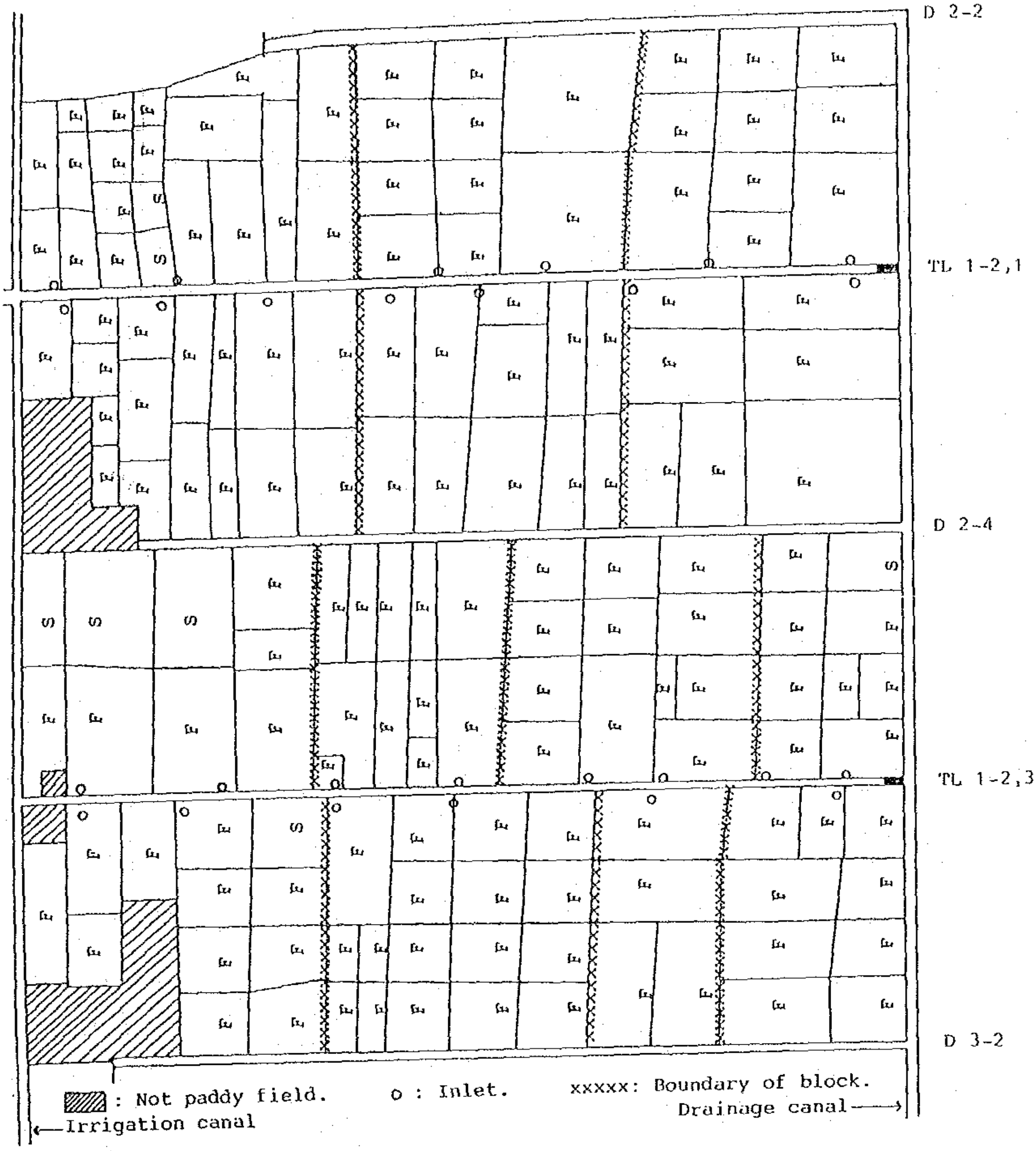


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-4 Water condition of paddy field (May 11).

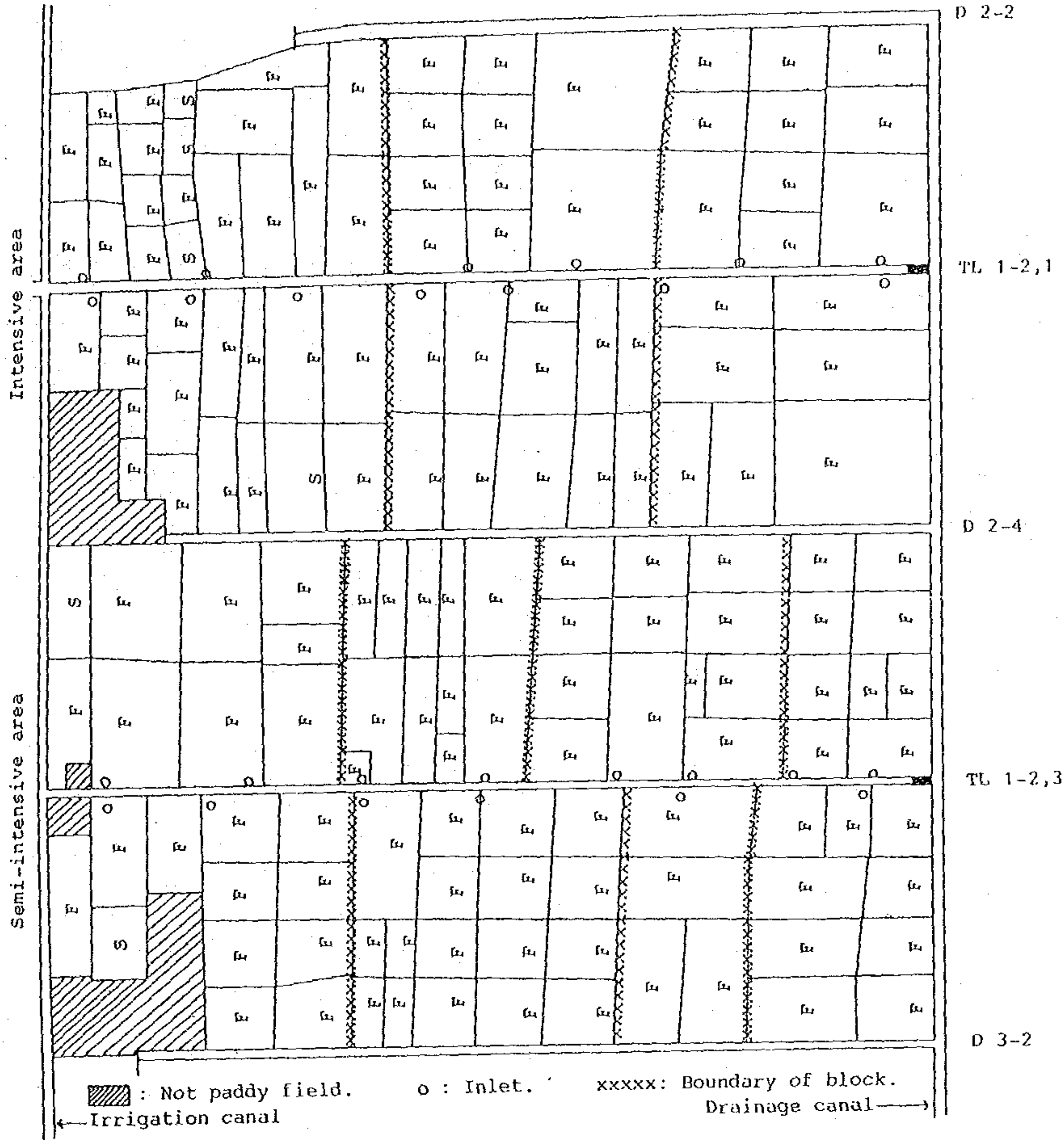


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-5 Water condition of paddy field (May 19).

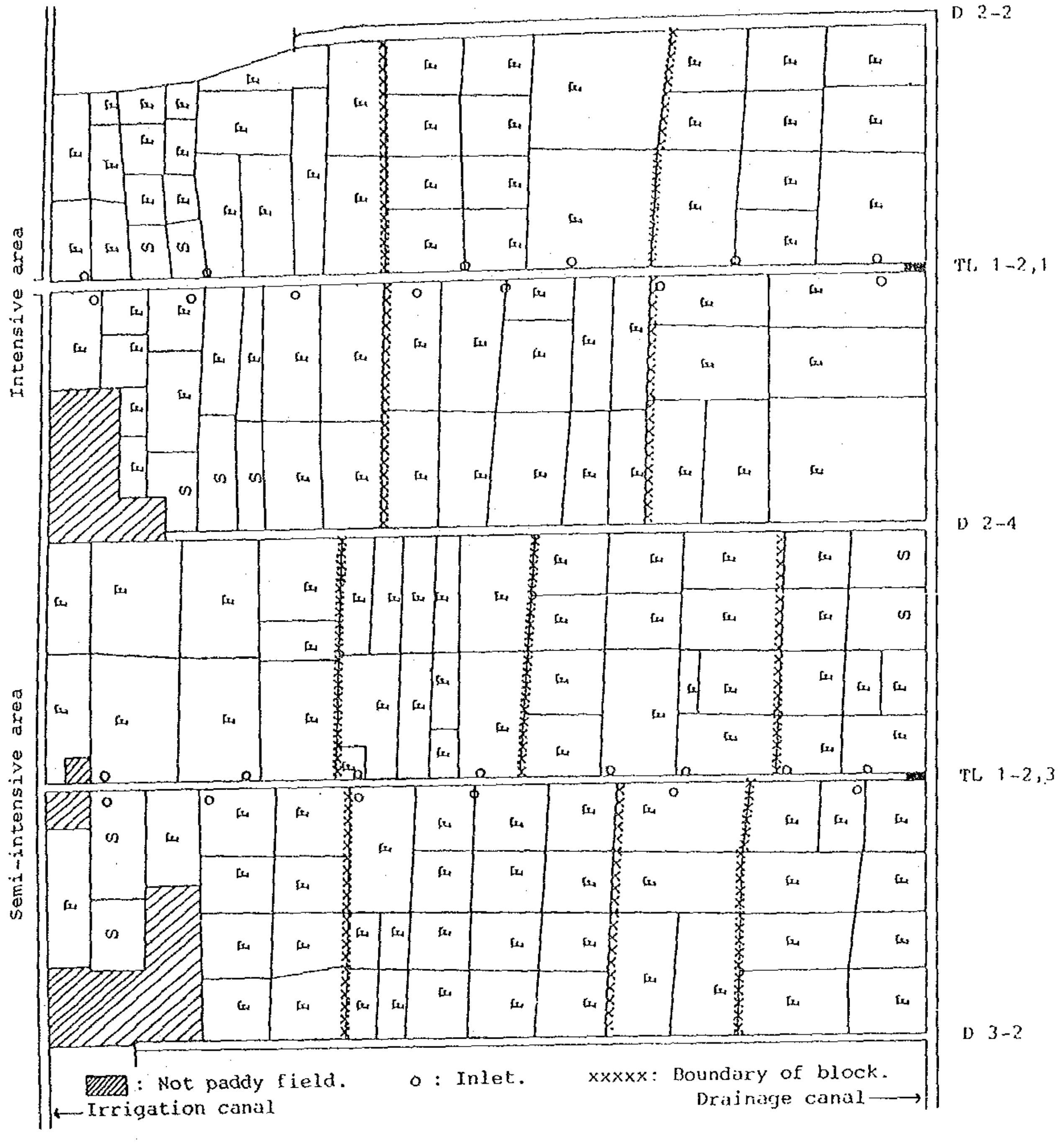


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-6 Water condition of paddy field (May 25).

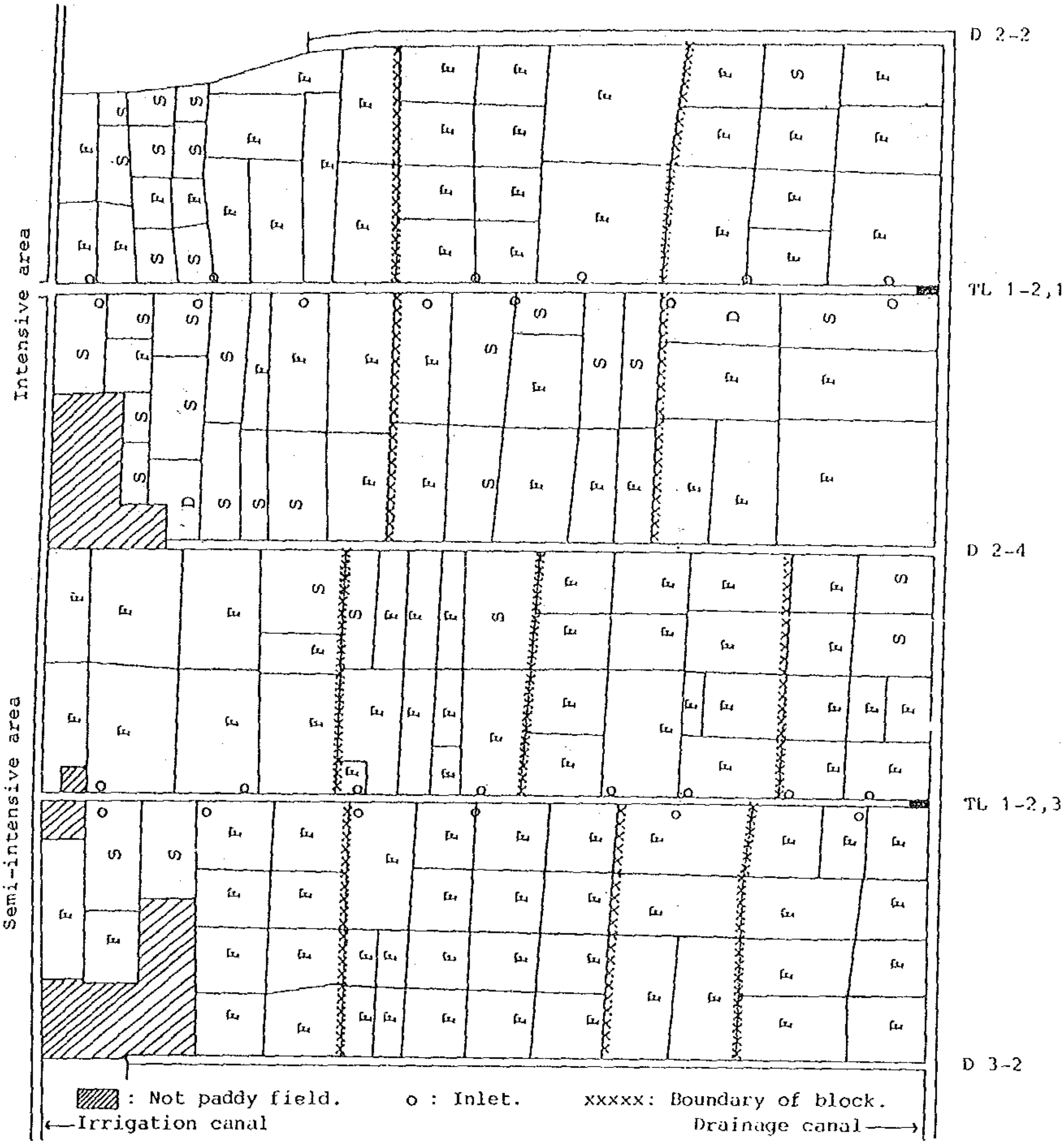


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-7 Water condition of paddy field (June 2).

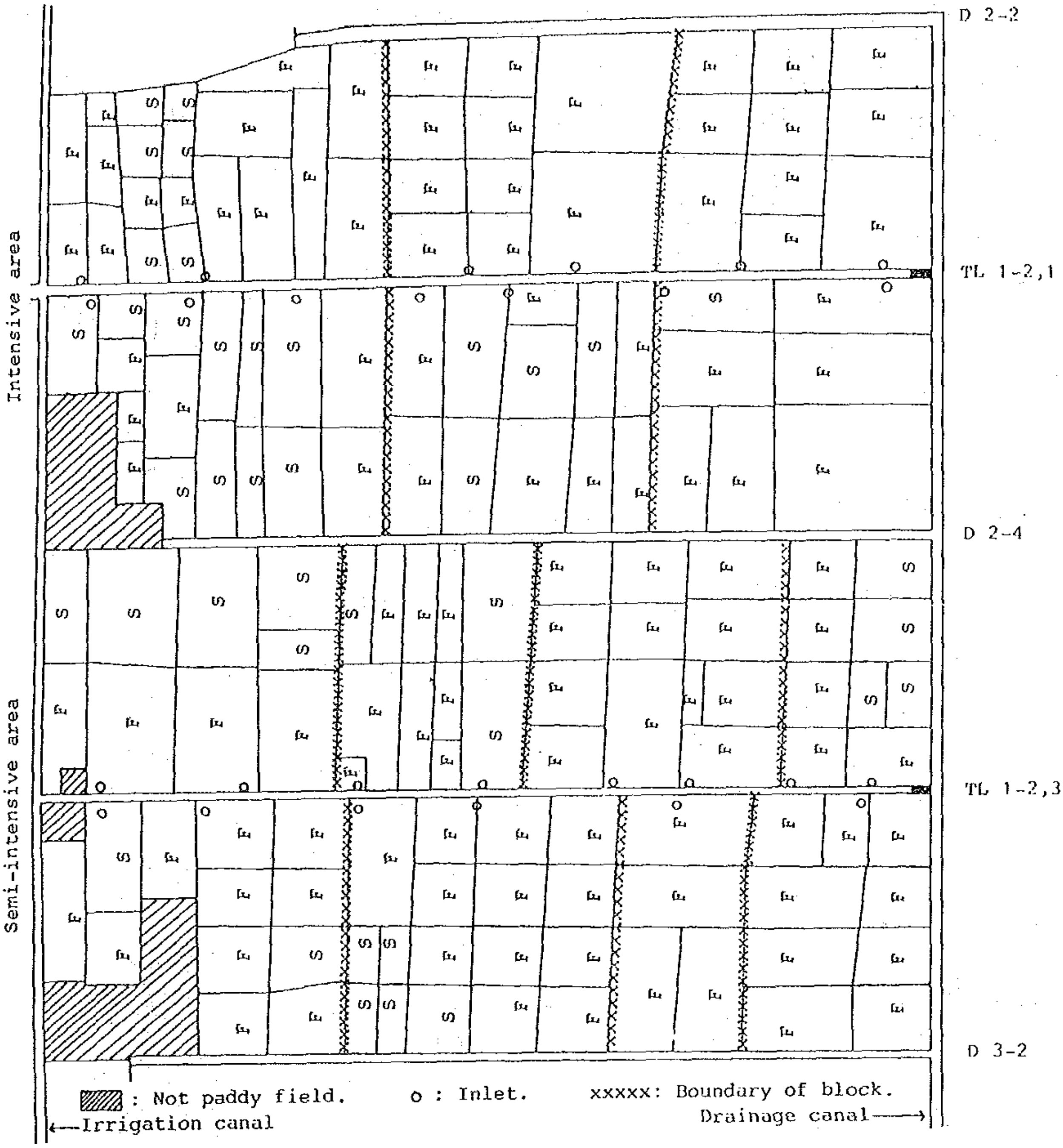


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-8 Water condition of paddy field (June 10).

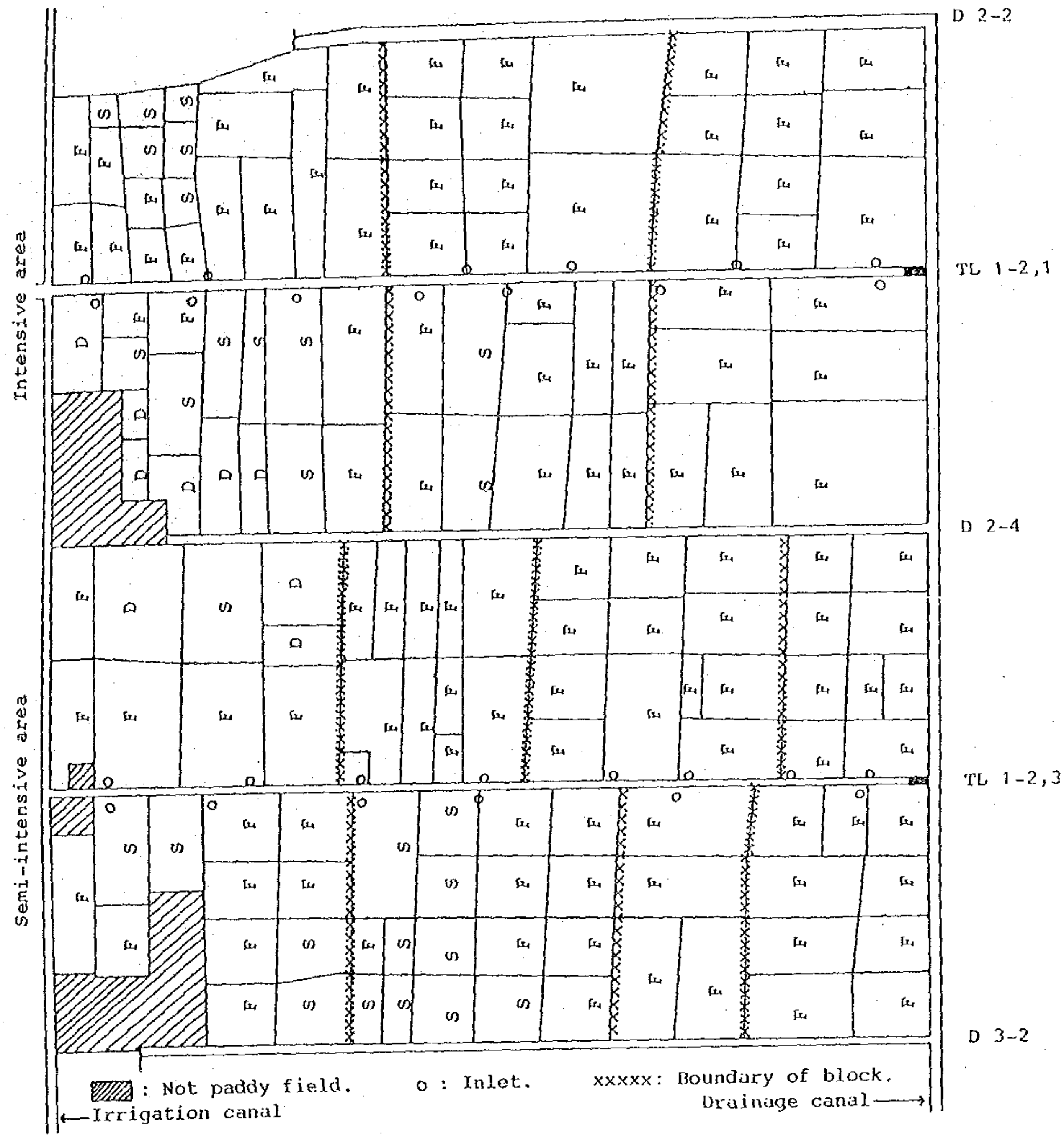


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-9 Water condition of paddy field (June 15).

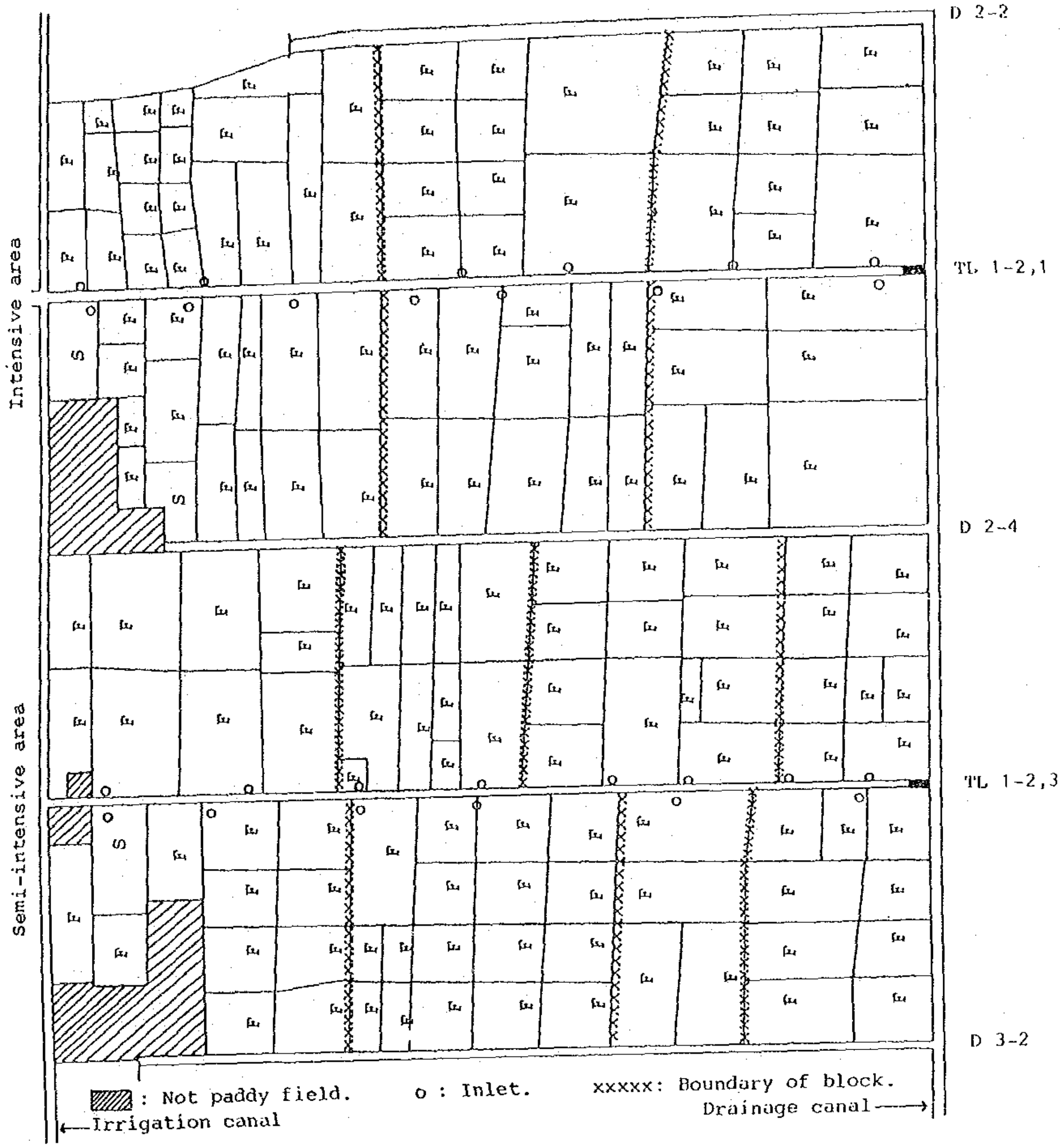


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-10 Water condition of paddy field (June 24).

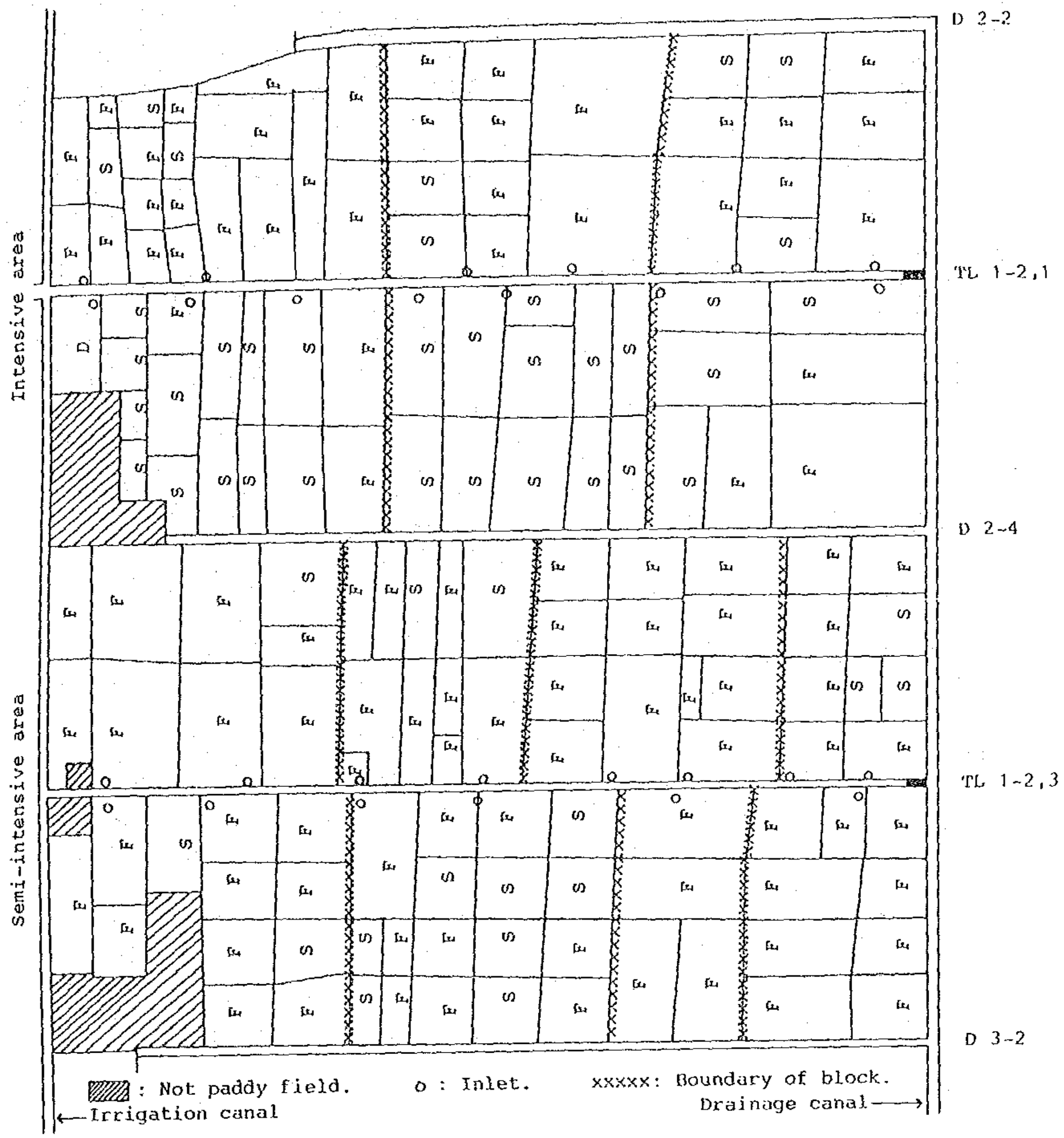


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-11 Water condition of paddy field (June 30).

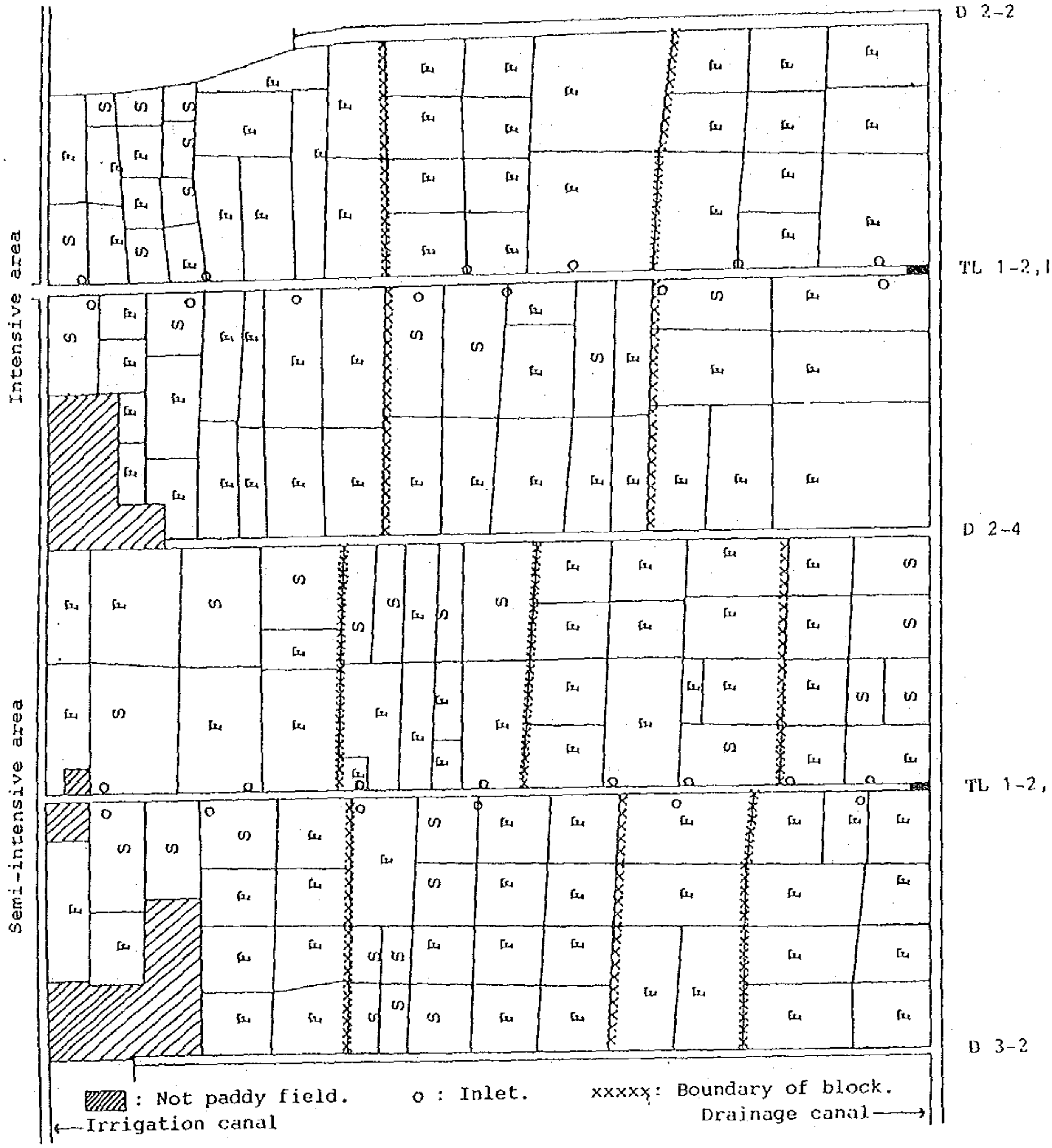


F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D : Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 14-12 Water condition of paddy field (July 7).



F : Flooded.

S : Saturated - More than 20 % of the surface soil has no standing water, but the most surface soil is visually water saturated.

D.: Dried - More than 20 % of the surface soil is visually not water saturated.

Appendix 15-1 Daily water depth at different points in intensive area (mm).

Date	B 1, P1		B 1, P 2		B 1, P 3		B 2, P 4		B 2, P 5		B 3, P 6		B 3, P 7		B 4, P 8		B 4, P 9		B 5, P 10		B 5, P 11		B 6, P 12	
	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.
Apr. 19	0		24		43		59		122		25		88		0		34		0		27		24	
20	22	-22	34	-10	32	11	59	0	100	22	44	-19	100	-22	40	-40	30	4	0	0	20	7	12	12
21	0	22	29	5	43	-11	58	1	60	40	44	0	68	32	50	-10	64	-34	0	0	27	-7	0	12
22	0	0	28	1	29	14	67	-9	40	20	35	9	55	13	31	19	63	1	0	0	27	0	0	0
23	0	0	20	8	23	6	65	2	20	20	25	10	42	13	24	7	60	-3	0	0	27	0	0	0
24	38	-38	20	0	20	3	50	15	106	-86	4	21	0	42	2	22	37	23	0	0	25	2	0	0
25	20	18	29	-9	18	2	62	-12	87	19	0	4	0	0	1	1	35	2	0	0	16	9	40	-40
26	2	18	20	9	16	2	36	26	52	35	0	0	0	0	60	-59	50	-15	0	0	0	16	55	-15
27	1	1	20	0	1	15	20	16	30	22	0	0	63	-63	75	-15	44	6	20	-20	0	0	60	-5
28	0	1	43	-23	0	1	10	10	0	30	0	0	62	1	50	25	44	0	10	10	60	-60	65	-5
29	0	0	22	21	32	-32	30	-20	40	-40	23	-23	85	-23	60	-10	63	-19	0	10	85	-25	85	-20
30	68	-68	10	12	5	27	20	10	0	40	0	23	74	11	40	20	50	13	0	0	120	-35	57	28
May 1	20	48	0	10	0	5	0	20	60	-60	0	0	11	63	27	13	43	7	0	0	105	15	60	-3
2	0	20	2	-2	0	0	89	-89	100	-40	0	0	0	11	0	27	40	3	0	0	100	5	60	0
3	0	0	20	-18	0	0	62	27	85	15	0	0	0	0	40	-40	21	19	0	0	80	20	50	10
4	0	0	22	-2	23	-23	41	21	70	15	61	-61	118	-118	23	17	19	2	0	0	45	45	52	-2
5	0	0	20	2	21	2	37	4	50	20	60	1	125	-7	17	6	13	6	0	0	59	-14	47	5
6	0	0	14	6	15	16	42	-5	43	7	52	8	134	-9	52	-35	20	-7	0	0	95	-36	45	2
7	61	-61	38	-24	29	-14	31	11	34	9	45	7	124	10	32	20	38	-18	0	0	117	-22	45	0
8	34	27	25	13	55	-26	56	-25	89	-55	19	26	107	17	30	2	43	-5	0	0	126	-9	67	-22
9	3	31	25	0	31	24	120	-64	94	-5	30	-11	68	39	53	-23	48	-5	0	0	129	-3	52	15
10	0	3	28	-3	28	3	93	27	76	18	56	-26	97	-29	84	-31	72	-24	0	0	102	7	64	-12
11	0	0	28	0	43	-15	52	41	74	2	52	4	96	1	70	14	70	2	37	-37	90	12	62	2
12	0	0	26	2	42	1	39	-37	73	1	51	1	95	1	63	7	73	-3	25	12	94	-4	54	8

Note. B : Block No., P : Measuring point No., W.L. : Water level, R.D. : Water requirement in depth.

Date	B 1, P 1		B 1, P 2		B 1, P 3		B 2, P 4		B 2, P 5,		B 3, P 6		B 3, P 7		B 4, P 8		B 4, P 9		B 5, P 10		B 5, P 11		B 6, P 12	
	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.
May 13	0	0	25	1	54	-12	30	9	72	1	49	2	130	-35	59	4	89	- 4	23	2	95	- 1	115	-61
14	0	0	20	5	50	4	20	10	45	27	63	-14	130	0	50	9	88	1	45	-22	95	0	110	5
15	30	-30	30	-10	34	16	60	-40	145	-100	20	43	130	0	40	10	80	8	40	5	95	0	107	3
16	35	- 5	30	0	35	- 1	80	-20	102	43	50	-30	100	30	32	8	72	8	50	-10	82	13	140	-33
17	32	3	29	1	35	0	78	2	92	10	49	1	96	4	95	-63	65	7	47	3	68	14	123	17
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	48	-	97	-	33	-	0	-	74	-	82	-	20	-	65	-	75	-	130	-	47	-	20	-
21	32	16	41	56	50	-17	17	-17	20	54	50	32	63	-43	78	-13	93	-18	12	118	78	-31	89	-69
22	20	12	30	11	25	25	25	- 8	64	-44	44	6	57	6	53	25	81	12	0	12	88	-10	72	17
23	9	11	28	2	30	- 5	0	25	94	-30	60	-16	30	27	40	13	72	9	0	0	100	-12	57	15
24	0	9	28	0	43	-13	82	-82	65	29	40	-20	77	-47	79	-39	65	7	10	-10	83	17	78	-21
25	0	0	26	2	26	17	40	42	83	-18	30	10	44	33	78	1	73	- 8	36	-26	115	-32	100	-22
26	0	0	30	- 4	10	16	12	28	58	25	39	- 9	74	-30	93	-15	110	-47	31	5	115	0	119	-19
27	62	-62	10	-20	22	-12	5	7	58	0	30	9	36	38	82	11	101	9	28	3	120	- 5	80	39
28	52	10	32	-22	44	-22	49	-44	50	8	25	5	29	7	76	6	83	18	25	3	112	8	69	11
29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	0	-	25	-	32	-	13	-	50	-	29	-	59	-	87	-	74	-	20	-	105	-	54	-
31	0	0	20	5	26	6	10	3	42	8	27	2	58	1	92	- 5	84	-10	13	7	130	-25	54	0
June 1	0	0	17	3	20	6	3	7	30	12	22	5	48	10	81	11	72	12	40	-27	131	- 1	47	7
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	21	-	110	-	12	-	19	-	7	-	5	-	36	-	87	-	65	-	10	-	79	-	92	-
10	85	-64	103	7	0	12	0	19	0	7	0	5	8	28	75	12	53	12	0	10	110	-31	110	-18
11	0	85	20	83	0	0	0	0	0	0	0	0	0	8	50	25	45	8	0	0	107	3	80	30
12	0	0	30	-10	0	0	10	-10	0	0	0	0	0	0	45	5	40	5	0	0	98	9	70	10

Date	B 1, P 1		B 1, P 2		B 1, P 3		B 2, P 4		B 2, P 5		B 3, P 6		B 3, P 7		B 4, P 8		B 4, P 9		B 5, P 10		B 5, P 11		B 6, P 12	
	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.
June 13	0	0	28	2	0	0	32	-22	0	0	0	0	0	0	37	8	13	10	0	0	89	9	62	8
14	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	0	0	20	-	0	-	27	-	0	-	20	-	65	-	70	-	28	-	20	-	87	-	115	-
16	0	0	20	0	0	0	20	7	0	0	20	0	61	4	68	2	21	7	32	-12	86	1	117	- 2
17	10	-10	23	- 3	0	0	15	5	0	0	15	5	60	1	63	5	20	1	30	2	86	0	116	1
18	0	10	37	-14	0	0	51	-36	13	-13	0	15	56	4	60	3	17	3	30	0	90	- 4	76	40
19	0	0	45	- 8	0	0	60	- 9	18	- 5	0	0	53	3	52	8	10	7	34	- 4	123	-33	71	5
20	0	0	32	13	0	0	62	- 2	40	-22	0	0	48	5	61	- 9	10	0	41	- 7	138	-15	70	1
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	0	-	30	-	0	-	58	-	37	-	0	-	42	-	60	-	9	-	41	-	132	-	68	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	0	-	12	-	0	-	44	-	25	-	0	-	35	-	51	-	0	-	29	-	121	-	69	-
25	0	0	24	-12	0	0	51	-47	12	13	0	0	60	-25	35	16	15	-19	13	16	113	8	43	26
26	0	0	37	-13	15	-15	54	- 3	7	5	0	0	54	6	30	5	18	1	0	13	104	9	37	6
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	5	-	18	-	2	-	31	-	3	-	1	-	46	-	19	-	3	-	0	-	80	-	15	-
30	5	0	14	4	0	2	11	20	0	0	0	1	38	8	10	9	5	- 2	0	0	75	5	5	10
July 1	75	-70	20	- 6	0	0	46	-35	0	0	0	0	22	16	0	10	2	3	0	0	68	7	2	3
2	52	23	20	0	0	0	41	5	17	-17	23	-23	16	6	0	0	0	2	0	0	51	17	0	2
3	31	21	16	4	0	0	40	1	20	- 3	28	- 5	10	6	0	0	11	-11	0	0	23	28	9	- 9
4	0	31	24	- 8	0	0	39	1	34	-14	26	2	0	10	40	-40	29	-18	0	0	0	23	17	- 8
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	0	-	18	-	0	-	37	-	24	-	22	-	0	-	37	-	18	-	0	-	0	-	38	-
7	0	0	13	5	0	0	36	1	0	24	0	22	0	0	35	2	12	6	20	-20	0	0	60	-22
8	0	0	10	3	0	0	25	11	0	0	0	0	0	0	22	13	7	5	12	8	0	0	56	4

Table 15-2 Daily water depth at different points in semi-intensive area (mm).

Date	B 1,P 1		B 1,P 2		B 1, P 3		B 1, P 4		B 2, P 5		B 2,P 6		B 2,P 7		B 2,P 8	
	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.
Apr. 19	21		68		103		0		25		44		21		98	
20	20	1	66	2	82	21	15	-15	25	0	24	20	40	-19	85	13
21	21	1	57	9	90	-8	62	-47	90	-65	64	-40	52	-12	92	-7
22	28	-7	70	-13	92	-2	39	23	66	24	63	1	52	0	96	-4
23	52	-24	81	-9	92	0	0	39	50	16	58	5	55	-3	92	4
24	32	20	78	3	79	13	59	-59	30	20	46	12	48	7	101	-9
25	20	12	65	13	79	0	50	9	13	17	40	6	38	10	78	23
26	14	6	65	0	67	12	29	21	10	3	35	5	60	-22	64	14
27	3	11	61	4	36	31	0	29	50	-40	28	7	21	39	58	5
28	3	0	50	11	30	6	29	-29	100	-50	50	-22	27	-6	63	-5
29	45	-42	60	-10	45	-15	45	-16	62	38	65	-15	72	-45	109	-46
30	29	16	55	5	43	2	0	45	30	32	49	16	60	12	95	14
May 1	2	27	45	10	38	5	0	0	20	10	22	27	30	30	66	29
2	0	2	41	4	22	16	45	-45	0	20	0	22	29	1	58	8
3	0	0	44	-3	30	-8	85	-40	0	0	27	-27	21	8	32	26
4	35	-35	41	3	41	-11	87	-2	87	-87	21	6	19	2	15	17
5	28	7	53	-12	32	9	62	25	69	18	15	6	15	4	0	15
6	25	3	47	-6	45	13	50	12	50	19	14	1	0	15	58	-58
7	69	-44	80	-33	2	43	155	-105	25	25	18	-4	0	0	53	5
8	34	35	83	-3	10	-8	98	57	24	1	14	4	97	-97	109	-56
9	20	14	66	17	50	-40	43	55	10	14	14	0	73	24	123	-14
10	20	0	65	1	38	12	38	5	8	8	11	3	56	17	89	34
11	20	0	64	1	21	17	30	8	45	-37	26	-15	40	16	77	12
12	25	-5	70	-6	12	9	18	12	42	3	45	-19	23	17	46	31
13	48	-23	84	-14	10	2	0	18	39	3	42	3	0	23	20	26

Date	B 3,P 9		B 3,P 10		B 3,P 11		B 3,P 12		B 4, P13		B 4, P 14		B 4, P 15		B 4, P 16	
	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.	W.L.	R.D.
Apr. 19	60		112		42		40		45		80		39		26	
20	72	-12	110	2	39	3	30	10	48	-3	83	-3	30	9	10	16
21	64	8	100	10	30	9	17	13	38	10	72	10	15	15	0	10
22	45	19	94	6	25	5	15	2	30	8	67	5	10	5	0	0
23	40	5	72	22	20	5	15	0	20	10	44	23	1	9	2	-2
24	40	0	40	32	32	-12	10	5	20	0	34	10	28	-27	15	-13
25	33	7	24	16	50	-18	53	-43	20	0	0	34	27	1	38	-23
26	65	-32	55	-31	65	-15	41	12	20	0	8	-8	26	1	22	16
27	64	1	80	-35	53	12	55	-14	20	0	27	-15	18	8	28	-6
28	54	10	80	0	41	12	54	1	15	5	48	-21	16	2	21	7
29	64	-10	115	-35	63	22	75	-21	31	-16	82	-34	27	-11	45	-24
30	60	4	130	-15	69	-6	109	-34	46	-15	100	-18	27	0	77	-32
May 1	64	-4	127	3	69	0	87	22	50	-4	100	0	46	-19	59	18
2	60	4	74	53	76	-7	95	-8	49	1	80	20	60	-14	65	-6
3	45	15	51	23	57	19	86	9	37	12	68	12	41	19	58	7
4	32	13	24	27	52	5	72	14	29	8	41	27	20	21	37	21
5	39	-7	3	21	20	32	53	19	20	9	0	41	2	18	24	13
6	37	2	78	-75	61	-41	85	-32	20	0	46	-46	0	2	66	-42
7	77	-40	85	-7	-	-	109	-24	-	-	56	-10	13	-	81	-
8	36	41	91	-6	-	-	130	-21	75	-	62	-14	36	-23	10	71
9	77	-41	100	-9	-	-	120	10	70	5	70	-8	80	-44	85	-75
10	76	1	103	-3	-	-	87	33	68	2	90	-20	47	33	36	49
11	75	1	116	-13	-	-	62	25	64	4	92	-2	43	4	30	6
12	70	5	113	3	-	-	50	12	59	5	93	-1	38	5	23	7
13	69	1	120	-7	-	-	50	0	57	2	100	-7	35	3	20	3

Note. B : Block No., P : Measuring point No., W.L. : Water level, R.D. : Water requirement in depth.

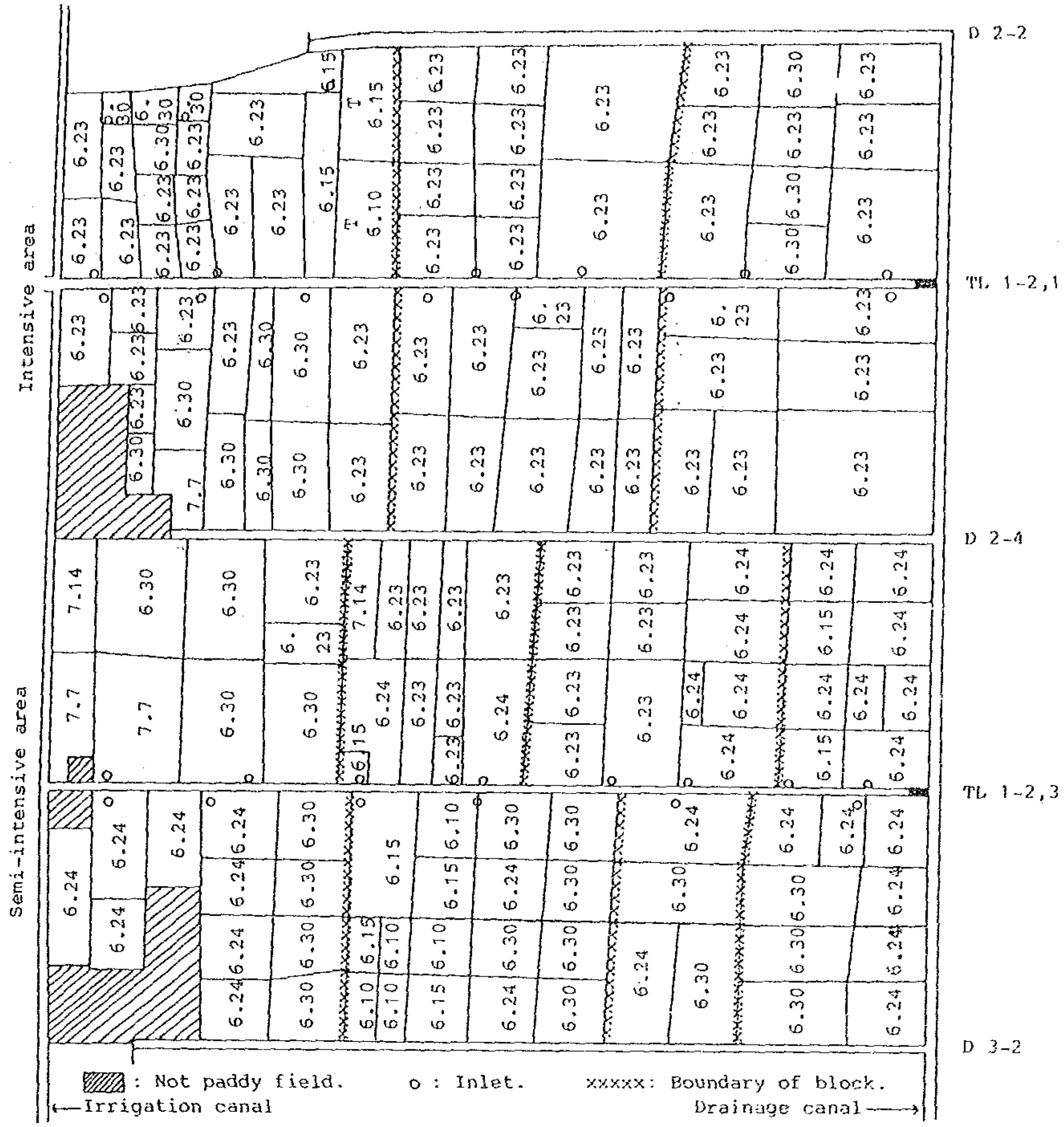
Date		B 1,P 1 W.L.	B 1,P 1 R.D.	B 1,P 2 W.L.	B 1,P 2 R.D.	B 1,P 3 W.L.	B 1,P 3 R.D.	B 1,P 4 W.L.	B 1,P 4 R.D.	B 2,P 5 W.L.	B 2,P 5 R.D.	B2, P 6 W.L.	B2, P 6 R.D.	B 2,P 7 W.L.	B 2,P 7 R.D.	B 2,P 8 W.L.	B 2,P 8 R.D.
May	14	59	-11	106	-22	28	-18	0	0	31	8	48	- 6	30	-30	49	-29
	15	50	9	96	10	17	11	137	-137	35	- 4	52	- 4	27	3	42	7
	16	56	- 6	104	- 8	60	-43	102	35	50	-15	43	9	27	0	40	2
	17	52	4	93	11	54	6	97	5	45	5	37	6	20	7	32	8
	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	20	48	-	97	-	33	-	0	-	74	-	82	-	20	-	65	-
	21	52	- 4	95	2	93	-60	150	-150	70	4	56	26	0	20	64	1
	22	45	7	92	3	63	30	78	72	60	10	55	1	47	-47	70	- 6
	23	36	9	74	18	62	1	61	17	45	15	30	25	69	-22	62	8
	24	35	1	70	4	37	25	48	13	28	17	24	6	40	29	83	-21
	25	42	- 7	70	0	50	-13	82	-34	10	18	16	8	25	15	76	7
	26	34	8	61	9	74	-24	68	14	70	-60	76	-60	72	-47	89	-13
	27	57	-23	75	-14	100	-26	73	- 5	39	31	47	29	44	28	72	17
	28	57	0	90	-15	107	- 7	150	-77	37	2	43	4	26	18	63	9
	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30	90	-	130	-	93	-	91	-	36	-	60	-	6	-	54	-
	31	102	-12	147	-17	96	- 3	60	31	32	4	47	13	2	4	50	4
June	1	94	8	128	19	84	12	51	9	48	-16	50	- 3	57	-55	50	0
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9	42	-	51	-	39	-	18	-	67	-	17	-	23	-	67	-
	10	55	-13	84	-33	51	-12	0	18	44	23	0	17	0	23	55	12
	11	65	-10	95	-11	44	7	0	0	40	4	0	0	0	0	60	- 5
	12	58	7	89	6	37	7	0	0	38	2	0	0	13	-13	60	0
	13	51	7	85	4	32	5	0	0	35	3	0	0	32	-19	65	- 5

Date		B 3, P 9 W.L.	B 3, P 9 R.D.	B 3,P 10 W.L.	B 3,P 10 R.D.	B 3,P 11 W.L.	B 3,P 11 R.D.	B 3,P 12 W.L.	B 3,P 12 R.D.	B 4,P 13 W.L.	B 4,P 13 R.D.	B 4,P 14 W.L.	B 4,P 14 R.D.	B 4,P 15 W.L.	B 4,P 15 R.D.	B 4,P 16 W.L.	B 4,P 16 R.D.
May	14	56	13	75	45	-	-	36	14	45	12	60	40	20	15	10	10
	15	55	1	80	- 5	-	-	25	11	89	-44	47	13	47	-27	10	0
	16	70	-15	80	0	-	-	23	2	85	4	47	0	56	- 9	11	- 1
	17	69	1	77	3	-	-	42	-19	73	12	42	5	48	8	7	4
	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	20	75	-	130	-	-	-	20	-	3	-	92	-	46	-	20	-
	21	62	13	78	52	-	-	52	-32	1	2	53	39	37	9	12	8
	22	50	12	50	28	-	-	87	-35	50	-49	38	15	52	-15	65	-53
	23	45	5	49	1	-	-	90	- 3	66	-16	28	10	52	0	62	3
	24	89	-44	97	-48	-	-	65	25	49	17	62	-34	41	11	41	21
	25	66	23	116	-19	-	-	62	3	45	4	85	-23	23	18	11	30
	26	58	8	120	- 4	-	-	98	-36	44	1	90	- 5	16	7	88	-77
	27	63	- 5	130	-10	-	-	135	37	50	- 6	100	-10	68	-52	110	-22
	28	72	- 9	118	12	-	-	150	15	45	5	105	- 5	80	-12	125	-15
	29	78	- 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	30	73	5	104	-	-	-	135	-	70	-	104	-	80	-	110	-
	31	68	5	94	10	-	-	120	15	65	5	98	6	72	8	130	-20
June	1	61	7	84	10	-	-	103	17	47	18	93	5	61	11	112	18
	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	9	68	-	117	-	-	-	95	-	51	-	65	-	14	-	60	-
	10	60	8	109	8	-	-	110	-15	57	- 6	77	-12	43	-29	78	-18
	11	48	12	80	29	-	-	105	5	46	11	52	25	40	3	75	3
	12	50	- 2	90	-10	-	-	100	5	54	- 8	73	-21	69	29	100	-25
	13	52	- 2	100	-10	-	-	130	-30	52	2	72	1	65	4	100	0

Date	B 1,P 1 W.L.	B 1,P 1 R.D.	B 1,P 2 W.L.	B 1,P 2 R.D.	B 1,P 3 W.L.	B 1,P 3 R.D.	B 1,P 4 W.L.	B 1,P 4 R.D.	B 2,P 5 W.L.	B 2,P 5 R.D.	B 2,P 6 W.L.	B 2,P 6 R.D.	B 2,P 7 W.L.	B 2,P 7 R.D.	B 2,P 8 W.L.	B 2,P 8 R.D.
June 14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	51	-	88	-	30	-	0	-	26	-	0	-	31	-	70	-
16	46	5	81	7	32	-2	0	0	90	-64	29	-29	5	26	57	13
17	62	-16	87	-6	40	-8	10	-10	87	3	26	3	3	2	49	8
18	50	12	78	9	67	-27	97	-87	60	27	0	26	28	-25	71	-22
19	65	15	106	-28	46	21	90	7	60	0	0	0	20	8	65	6
20	71	-6	105	1	33	13	80	10	65	-5	0	0	19	1	62	3
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	70	-	102	-	30	-	73	-	62	-	0	-	17	-	60	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	57	-	89	-	15	-	50	-	48	-	0	-	12	-	37	-
25	53	4	78	11	0	15	41	9	32	16	7	-7	10	2	60	-23
26	68	-15	85	-7	128	-128	35	6	47	-15	-	7	18	-8	55	5
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	44	-	63	-	127	-	75	-	140	-	1	-	0	-	42	-
30	40	4	61	2	113	14	63	12	168	-28	0	1	0	0	38	4
July 1	62	-22	91	-30	131	-18	57	6	187	-19	0	0	0	0	24	14
2	32	30	47	44	123	8	50	7	180	7	0	0	0	0	18	6
3	21	11	29	18	110	13	41	9	173	7	0	0	0	0	9	9
4	19	2	18	11	104	6	91	-50	165	8	0	0	0	0	58	-49
5	20	-1	24	-6	87	17	66	25	92	73	10	-10	0	0	47	11
6	19	1	36	-12	78	9	47	19	33	59	20	-10	0	0	32	15
7	19	0	36	0	50	28	37	10	10	23	22	-2	0	0	32	0
8	17	2	22	14	40	10	22	15	2	8	15	7	0	0	21	11

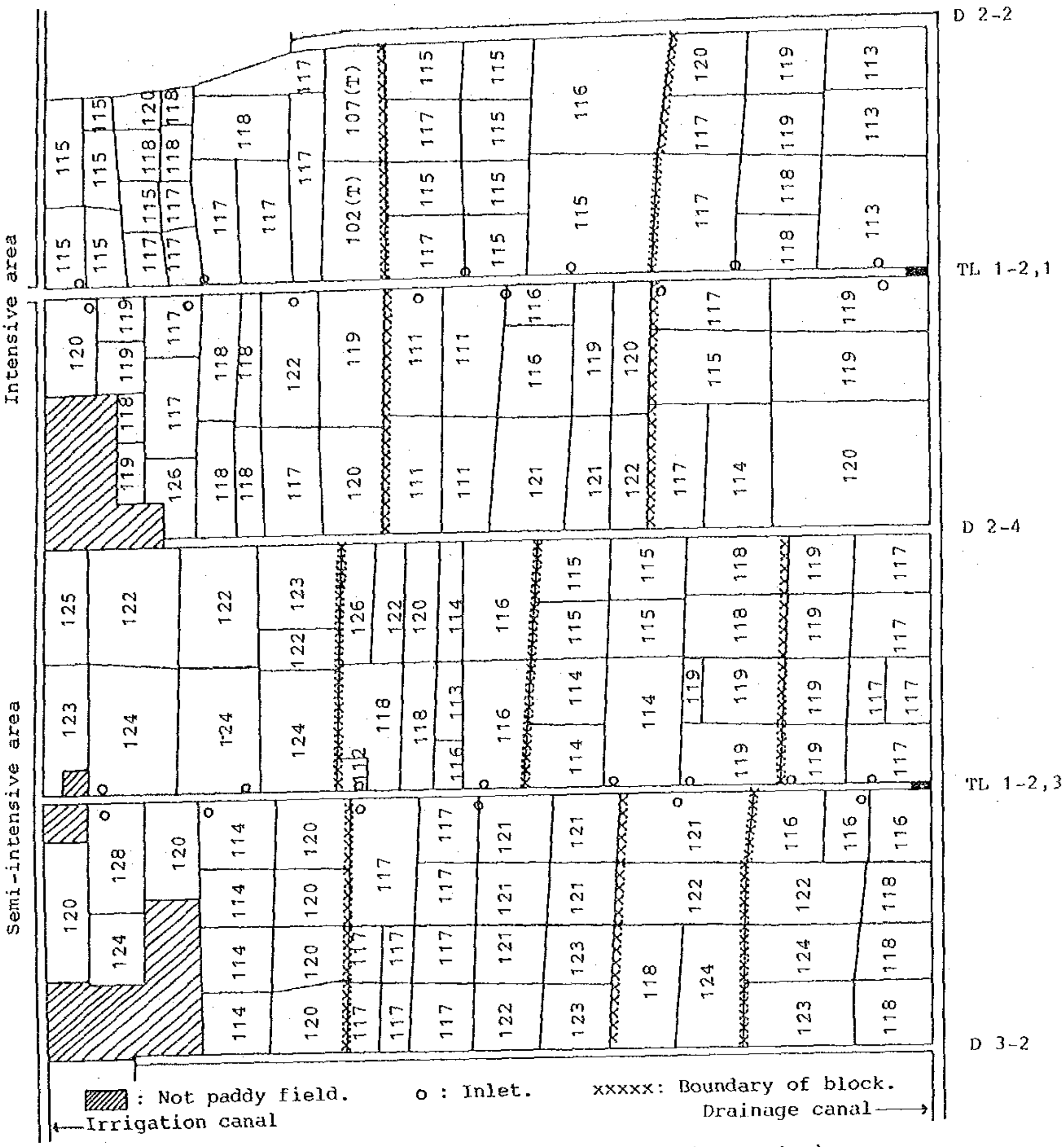
Date	B 3,P 9 W.L.	B 3,P 9 R.D.	B 3,P 10 W.L.	B 3,P 10 R.D.	B 3,P 11 W.L.	B 3,P 11 R.D.	B 3,P 12 W.L.	B 3,P 12 R.D.	B 4,P 13 W.L.	B 4,P 13 R.D.	B 4,P 14 W.L.	B 4,P 14 R.D.	B 4,P 15 W.L.	B 4,P 15 R.D.	B 4,P 16 W.L.	B 4,P 16 R.D.
June 14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	67	-	98	-	-	-	120	-	65	-	68	-	61	-	92	-
16	75	-8	114	-16	-	-	155	-35	65	0	81	-13	87	-26	120	-28
17	67	8	100	14	-	-	150	5	63	2	80	1	80	7	118	2
18	67	0	110	-10	-	-	142	8	72	-9	85	-5	94	-14	120	-2
19	95	-28	115	-5	-	-	165	-23	70	2	82	3	95	1	135	-15
20	82	13	100	15	-	-	157	8	80	-10	106	-24	93	2	130	5
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	78	-	102	-	-	-	155	-	78	-	106	-	92	-	131	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	71	-	80	-	-	-	163	-	72	-	126	-	110	-	122	-
25	69	2	101	-21	-	-	151	12	70	2	108	18	105	5	118	4
26	66	3	100	1	-	-	144	7	77	-7	80	28	92	13	108	10
27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	57	-	80	-	-	-	138	-	46	-	51	-	61	-	94	-
30	51	6	61	19	-	-	120	18	51	-5	60	-9	35	26	77	17
July 1	44	7	52	9	-	-	112	8	43	8	61	-1	0	35	50	27
2	41	3	47	5	-	-	71	41	19	24	50	11	0	0	41	[illegible]
3	43	-2	53	-6	-	-	37	34	0	19	47	3	0	0	0	41
4	44	-1	65	-12	-	-	2	35	0	0	35	12	0	0	0	[illegible]
5	42	2	47	18	-	-	10	-8	22	-22	36	-1	0	0	0	0
6	41	1	33	14	-	-	22	-12	30	-8	36	0	0	0	0	0
7	40	1	32	1	-	-	21	1	30	0	36	0	0	0	0	0
8	22	18	18	14	-	-	3	18	21	9	18	18	0	0	0	0

Appendix 16 Date of flowering.



T : Transplanted field

Appendix 17 Growth duration (from sowing to harvesting)at different fields.



Note: T-transplanted field (from transplanting to harvesting).

Appendix 18 Distribution of growth duration.

Growth duration	Experimental area				Comparative area		
	Area (m^2)	%[a]	%	% Accum.	Area (m^2)	%	% Accum.
102	3,339	1.8 T	-	-	-	-	-
107	3,080	1.7 T	-	-	-	-	-
111	12,531	6.9	7.2	7.2	-	-	-
112	-	-	-	-	463	0.3	0.3
113	10,125	5.6	5.8	13.0	1,891	1.0	1.3
114	3,250	1.8	1.9	14.9	17,523	9.6	10.9
115	30,170	16.7	17.3	32.3	7,531	4.1	15.0
116	11,455	6.3	6.6	38.8	13,239	7.2	22.2
117	36,266	20.0	20.8	59.6	21,714	11.9	34.1
118	16,570	9.1	9.5	69.1	20,752	11.4	45.5
119	22,090	12.2	12.6	81.7	12,189	6.7	52.2
120	18,357	10.1	10.5	92.2	14,598	8.0	60.2
121	5,788	3.2	3.3	95.5	13,047	7.1	67.3
122	5,307	2.9	3.0	98.5	18,613	10.2	77.5
123	-	-	-	-	13,485	7.4	84.9
124	-	-	-	-	21,042	11.5	96.4
125	-	-	-	-	2,293	1.3	97.7
126	2,779	1.5	1.6	100.0	1,716	0.9	98.6
127	-	-	-	-	-	-	-
128	-	-	-	-	2,530	1.4	100.0
Total	181,107				182,626		

a : Including transplanted area.

Appendix 19 Water discharge in a main drainage canal.

Date		Quantity (m^3/sec)	Period mean (m^3/sec)	Quantity (m^3/day)	Period (days)	Total amount (m^3)
March	2	0.040	-	-	-	-
	6	0.080	0.060	5184	4	20736
	12	0.180	0.130	11232	6	67392
	16	0.250	0.215	18576	4	74304
	19	0.345	0.298	25747	3	77241
	20	0.445	0.395	34128	1	34128
	21	0.621	0.533	46051	1	46051
	23	0.737	0.679	58666	2	117332
	26	0.819	0.778	67219	3	201657
	27	0.837	0.828	71539	1	71539
	30	0.839	0.838	72403	3	217209
April	4	0.820	0.830	71712	5	358560
	9	0.568	0.693	59875	5	299375
	11	0.454	0.511	44150	2	88300
	15	0.475	0.465	40176	4	160704
	19	0.491	0.483	41731	4	166924
	22	0.411	0.451	38966	3	116898
	24	0.333	0.372	32141	2	64282
	27	0.464	0.399	34474	3	103422
May	2	0.574	0.519	44842	5	224210
	8	0.347	0.461	39830	6	238980
	15	0.636	0.492	42509	7	297563
	17	0.752	0.694	59962	2	119924
	18	1.517	1.135	98064	1	98064
	21	1.403	1.460	126144	3	378432
	28	0.351	0.877	75773	7	530411
	31	0.505	0.428	36979	3	110937
June	4	0.550	0.528	45619	4	182476
	5	0.958	0.754	65146	1	65146
	11	0.689	0.824	71194	6	427164
	15	0.185	0.437	37757	4	151028
	19	0.313	0.249	21514	4	86056
	22	0.345	0.329	28426	3	85278
	26	0.412	0.379	32746	4	130984
	29	0.330	0.371	32054	3	96162
Total or Mean			0.536	46293	119	5508869

Appendix 20 Amount of water supplied to 1L-1R canal in 1984 dry season.

Month		Permanent Pump Ø 24 inch		Temporary Pump						Total Quantity (M^3)
				Ø 12 inch		Ø 10 inch		Ø 8 inch		
		hr	Wq	hr	Wq	hr	Wq	hr	Wq	
Feb.	1	-	-	-	-	-	-	-	-	-
	2	199	360986	11	9900	-	-	-	-	370886
	3	317	575038	419	377100	-	-	-	-	952138
Mar.	1	414	750996	729	656100	-	-	-	-	1407096
	2	466	845324	678	610200	15	8640	-	-	1464164
	3	486	881604	741	666900	204	117504	-	-	1666008
Apr.	1	444	805416	653	587700	162	93312	-	-	1486428
	2	383	694762	492	442800	197	113472	14	5544	1256578
	3	242	438988	454	408600	409	235584	220	87120	1170292
May	1	230	417220	982	883800	402	231552	38	15048	1547620
	2	260	471640	1046	941400	333	191808	-	-	1604848
	3	286	518804	1113	1001700	423	243648	-	-	1764152
June	1	74	134236	1046	941400	410	236160	-	-	1311796
	2	72	130608	731	657900	213	122688	-	-	911196
	3	225	408150	788	709200	145	83520	-	-	1200870
Jul.	1	139	252146	-	-	-	-	-	-	252146
	2	-	-	-	-	-	-	-	-	-
	3	-	-	-	-	-	-	-	-	-
Total		4237	7685918	9883	8894700	2913	1677888	272	107712	18366218

Note : Formular of the Calculation

Permanent Pump : Ø 24 ( ) hr x 0.504 m^3/s x 3600 s/hr = ( ) hr x 1814 m^3/hr

Temporary Pump : Ø 12 ( ) hr x 0.250 m^3/s x 3600 s/hr = ( ) hr x 900 m^3/hr

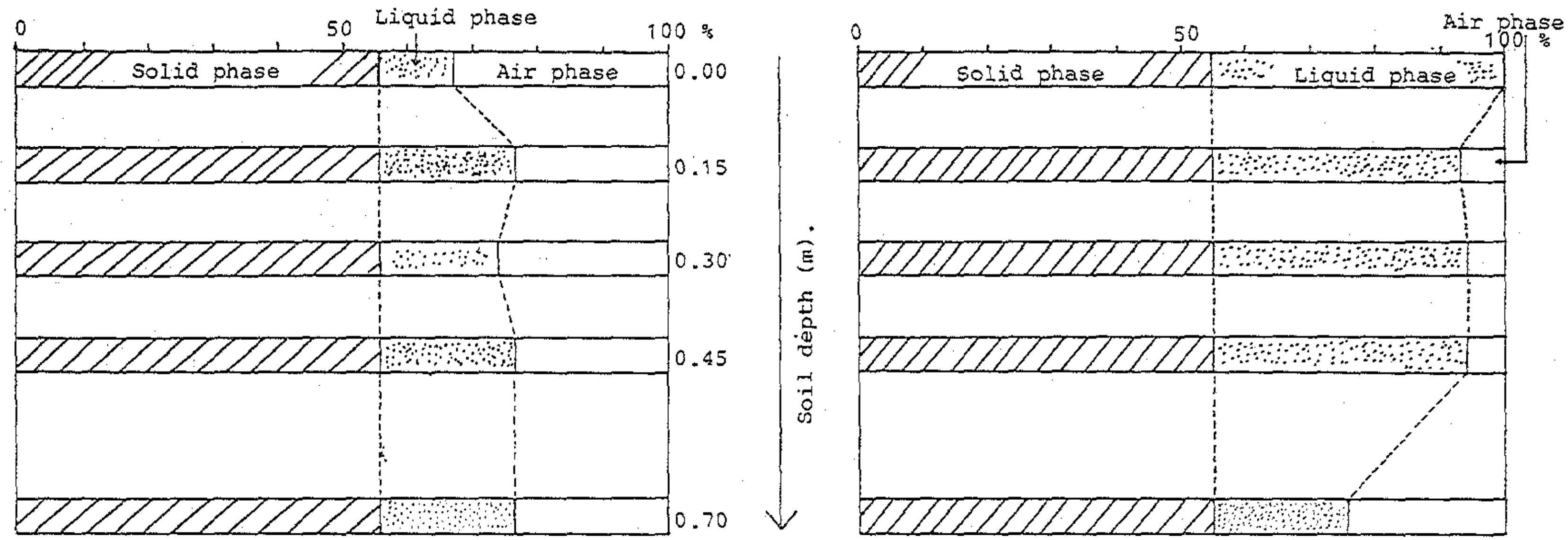
: Ø 10 ( ) hr x 0.160 m^3/s x 3600 x hr = ( ) hr x 576 m^3/hr

: Ø 8 ( ) hr x 0.110 m^3/s x 3600 x hr = ( ) hr x 396 m^3/hr

Appendix 21 Three phases of the soil and amount of soaking water[a].

1. Volume percentage before irrigation.

2. Volume percentage after 3 days irrigation.



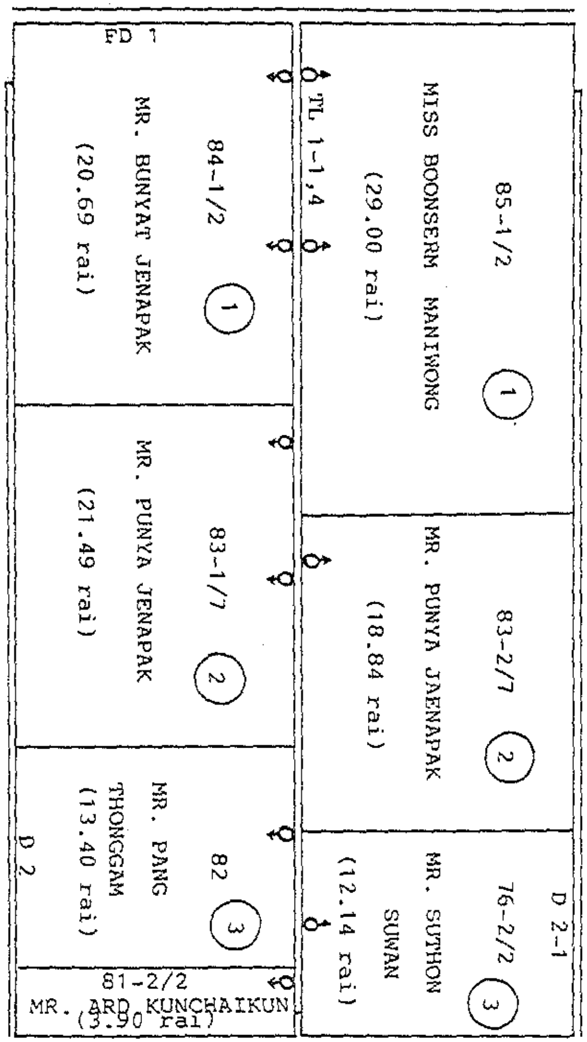
Water depth = Soil depth x Average Liquid phase

Soil depth (m)	Liquid phase (%)				Water depth (mm)
	Before	After	Water increased	Average	
Surface	11.9	44.7	32.8	-	-
0.02	22.1	38.6	16.5	24.7	5.0
0.15	22.1	38.6	16.5	16.5	21.0
0.30	19.3	38.9	19.6	18.1	27.0
0.45	22.0	39.3	17.3	18.5	28.0
0.70	22.0	22.0	0	8.7	22.0
Total					103.0

[a]From " Progress report on water management study ", p. 6, Murao, S., IADP, 1984.

Basic data were from " Fundamental survey for water management ", Nakajima, J. and K. Misawa, IADP, 1983.

Appendix 22 Example of proposed rotational irrigation schedule in pilot project No. 1[a].



Rotation unit	Plot No.	No. of Inlet	Name	a (rai)	a' (rai)	E.I.T. (hr)	Irrigation Time (hr)
1	84-1/2	2	Mr. Bunyat	20.69	a x 1.0	$\frac{a'}{A'}$ x 156	Mon 6.00
	85-1/2	2	Miss Boon-serm	29.00			Wed 18.00
Total		4		49.69	49.69	56	60
2	83-1/7	1	Mr. Punya	21.49	a x 1.2	$\frac{a'}{A'}$ x 156	Wed 18.00
	83-2/7	2	Mr. Punya	18.84			Sat 6.00
Total		3		40.33	48.40	55	60
3	82	1	Mr. Pang	13.40	a x 1.4	$\frac{a'}{A'}$ x 156	Sat 6.00
	81-2/2	1	Mr. Ard	3.90			
	76-2/2	1	Mr. Suthon	12.14			Mon 6.00
Total		3		29.44	41.22	46	48
Grand Total		10		A = 119.46	A' = 139.31	156	168

Irrigation time : 7 days x 24 hr = 168 hr.

E.I.T. (Effective Irrigation Time) : 168 hr - (3 unit - 1) x 6 hr = 156 hr.

[a]From " Rotational irrigation schedule in Mae Klong pilot project No. 1 ", Hisamoto, K., IADP, 1984.

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