G-2.3 Study on Introduction of Salt-tolerant Crops

Contact person Wasano Kikuo
Professor
Faculty of Agriculture
Saga University
1 Honjo, Saga, 8502, Japan
Tel.: +81-952-28-8723 Fax : +81-952-28-8737
E-mail : wasanok@cc.saga-u.ac.jp

Total Budget for FY1996 - FY1998 20,743,000 Yen (FY1998 : 6,803,000 Yen)

Abstract The experiment was conducted using one of the abandoned fields of Shamenov khorkhoz irrigation lands located near the lower reaches of the Syr Darya for finding some crops tolerant to saline soils and establishing a new crop rotation system or sophisticated cultivation methods. The idea is for maintaining irrigated agriculture or avoiding secondary soil salinazation and waterlogging, and reducing environment pollution due to excess use of irrigation waters. During three years of this project, in the first year 1996 collecting the informations concerning irrigated agriculture or salinized soil problems was performed by visiting some locations and institutes of Kirghizia, Uzbekistan and also Kazakstan. In the second year 1997, the whole duration was consumed for constructing the experimental field in the salt-accumulated and abandoned fields of Shamenov khorkhoz Meshet block. Other construction labors were leveling the field, constructing open drainage and boundary ditches between the treatments, reconstructing the water-gates and irrigation canals, fencing the field for guarding crops from cattle's attack, etc.

In the third year 1998, crop production in the heavily salt-accumulated field after leaching succeeded at first time in Kazakstan and lots of informations on seasonal changes of the levels and quality of groundwater in and around the fields were collected. Interrelations between the salinity of groundwater or soils and growth levels of the crops planted were analyzed.

Key Words : Kazakstan, Saline Soils, Salt-tolerant Crops

1. Introduction

About 600 ha of irrigated fields have been deserted in the 1900 ha irrigated lands in Shamenov khorkhoz irrigation lands located near the lower reaches of the Syr Darya. One of the strategies for the developing these deserted lands due to salt-accumulation will be finding the crops with increased salt-tolerance and developing new irrigated cultivation systems to facilitate reuse of saline or irrigated waters for crop production to minimize the hazardous effects of irrigation on the environment and ecology. Introduction of wild plant species which can absorb excessive salts in the soils may also be evaluated as one of the strategies for the improvement of salt-affected soils. The current crop rotation system centered on rice production should be re-evaluated in terms of salt accumulation and new irrigation or drainage systems for saving irrigation waters so as to avoid secondary salinization and reduce pollutinal effects to the environment and ecology in this area. How to maintain and develop the irrigated agriculture by avoiding secondary soil salinization due to waterlogging and excess use of irrigation waters or poor water management practices will be the most important serious problems that present and future mankind is facing with.

2. Research Objective

Finding the crops with increased salt-tolerance and superior adaptability for this salinized lands and developing new irrigated cultivation systems to facilitate reuse of saline or irrigated waters for crop production are fundamental objective in this study. Experiment on the introduction of wild plant species which can absorb excessive salts in the soils will be conducted for the purpose of the improvement of salt-affected soils. Reevaluation of the current crop rotation system centered on rice production is also important in this study for saving irrigation waters and reducing secondary salinization. Final goal in this project will be providing some detailed solutions for establishing the sustainable agriculture in this salinized lands.

3. Research Method

Crops planted were 12 species (15 cultivars); Triticum aestivum, Hordeum vulgare, Avena sativa, Carthamus tinctorius, Beta vulgaris, Sorghum bicolar, Sorghum sudanese, Zea mays, Amaranthus spp. Medicargo sativa, Melilotus spp. and Oryza sativa. These were seeded from 29 June to 2nd July after leaching. The experiment field as shown in Fig.1 is consisted of three blocks (A,B and D); two different drainage systems, i.e. a traditional type of tile drain system (A block) using perforated plastic pipes (10 cm in diameter) buried in the 1.5m depth at 10 m interval and a newly developed one (B block) using perforated sheet-pipes (5 cm in diameter) undergrounded in the 45 cm depth at 4 m interval. D block with different topography is for the experiment of screening wild plants with higher ability of absorbing excess-salts in soils or waters to reduce the salinity; D1 in arid, D3 in waterlogged and D2 in intermediate soil conditions, respectively. AC and BC blocks are treated by mole drainage in the depth 0.45m.

Fig 2 shows the 19 observation sites designated by circled numbers for measuring the levels and quality of groundwater in and around the field. The 19 sites are classified into four groups, A, B, C and D. A group including 5 sites located near the sub-irrigation canal, B with 5 sites distributed in the north-south linear direction through the center of field, C with 4 sites located a little far from the irrigation canal in the east-west direction through the center of B block in the field, and D with 4 sites near the main irrigation canal.

4. Results and Discussion

Fig.3 shows the seasonal changes from the time just before leaching to the harvesting time of groundwater levels at 19 observation sites (B and D groups were omitted) as shown in Fig.2. Groundwater levels at the site number 1 and 2 near the irrigation canal rised within a week after leaching water supply, from 2.5 m to 0.5-1.0 m depth and those of number 3 and 6 at the center of field from 3.0 m to about 2.0 m depth, respectively. Number 8 located at the outside of field a little far from irrigation canal slowly responded to the water supply to the same level of No.1 and 2. The groundwater lowering due to water discharge adversely showed the same patterns of changes as rising except for No.8 having kept a high groundwater level (0.5 m depth) resulted from the drainage sub-canal waters near by.

Secondly, No.9 and 13 sites of C group located farthest from the irrigation canal suddenly raised the groundwater level to about 1.5 m depth which were resulted from the near shallow pool made by water leakage from the main irrigation canal. After having seeded, the levels at the three sites of C group except for No.9 (kept high level due to the leakage effects) lowered to about 2.5 m depth and gradually rised to 0.7-0.8 m depth after furrow-irrigation. These groundwater levels in the field have resulted in the lower level than those of underdrainage pipes constructed.

Fig.4 showed the iso-salinity line intuitively drawn based on the distribution of each ECw average value of 19 observation sites. Although ECw values obtained in and around the field were not evenly distributed throughout the area, the salt-accumulated area was found to have centered around the abandoned fields. On the contrary, there were two belt-shaped areas with the lowest salinity of ECw 3.3-7.9 dS/m which were running through northwestward along the both sides of the highest salinity zone. As the expectation, these situations of salinity distribution might be suggesting the causal history of salt-accumulated lands clustered in the restricted saline blocks.

Table 1 showed changes of the ECe and pH values in the different soil profiles at the sampling sites as numbered in Fig.1, which were measured before and after leaching, and at harvesting time. Salt-accumulation levels before leaching were different among the sites in field of which the site A-1 at the east corner of A block and the site BC-5 at the west corner of B block showed the lowest ECe values of less than 10 dS/m, while the site AC-2 and B-5 in the central field showed the highest ECe values (about 60 dS/m in the averages) in the field. The salinity in the different profiles (0-20 cm depth) has increased at the nearest soil surface and the clear-cut changes of the ECe values were found above or below the 5-10 cm profile. Generally, leaching treatment has reduced the salinity of the field soils to 4-6 dS/m ECe values which can be tolerable for most crops except for high salt-sensitive ones. The pH values after leaching have almost all become about 8.0 values. The soil salinity after 4 month furrow-irrigated cultivation has not so much increased as shown in the ECe values of 3.4-9.1

dS/m in the 20-25 cm profile.

Table 2 shows the quantitative differences of some agronomic characters among the plots of crops (alfalfa, sweet clover and rice were not listed here) planted in the field. The characters measured were culm length, panicle length, number of panicles per hill, number of hills survived in a plot, leaf blade length, leaf blade width, length/width ratio, and plant height. The numbers of plant or hills per plot were different between those of A-field and B-field (30% more plants than A-field). The numbers of hills per plot in A-field were 150 in wheat, barley and oats, 20 in sorghum and maize, 300 in amaranth, 60 in safflower and beet. Differences of salinity tolerance among crops can be evaluated by comparing these data measured. Relationships between different performances of crops planted and different salinity and soil properties in the field are now under analysis.

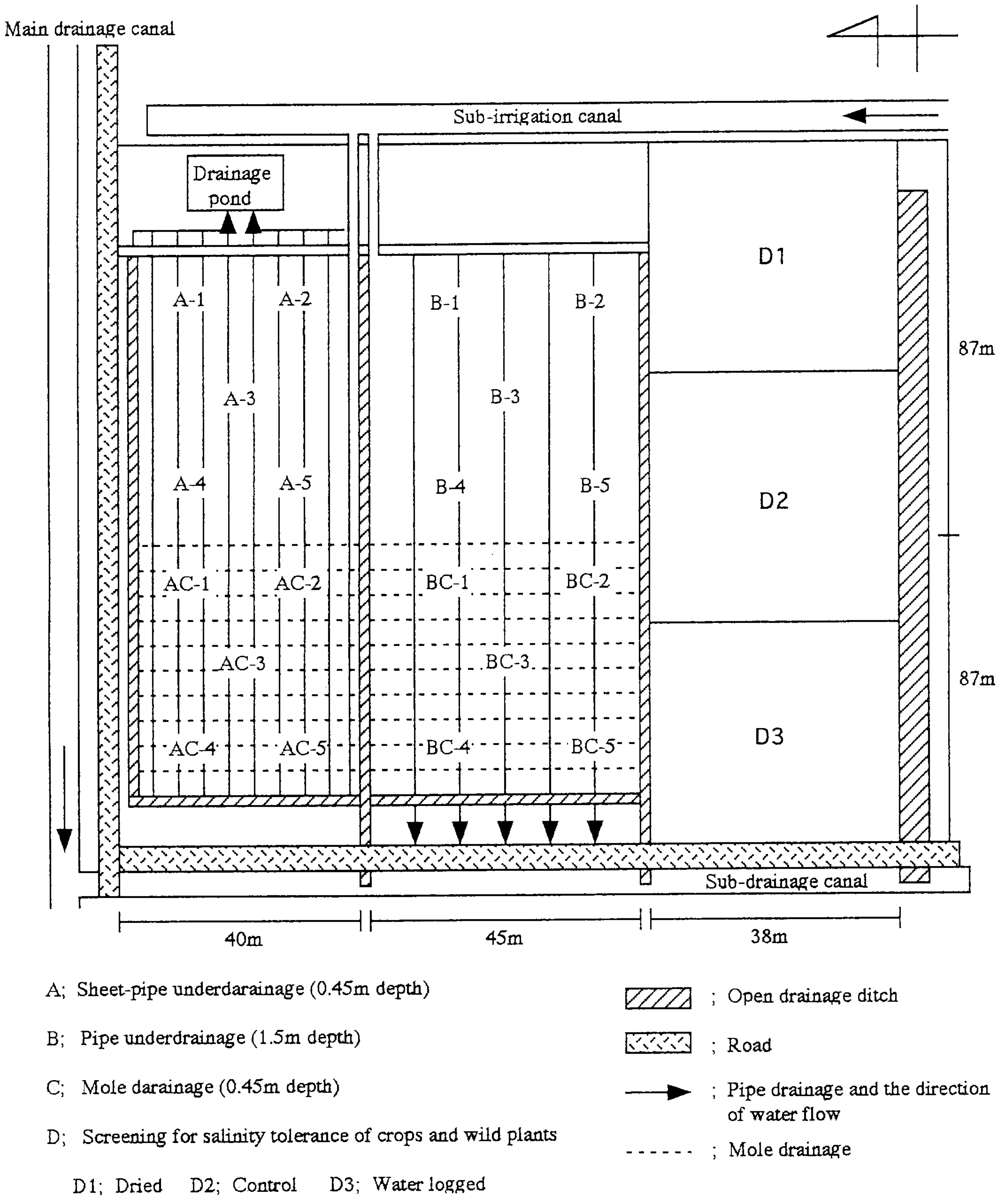


Fig. 1 Field layout of drainage treatments and soil sampling sites

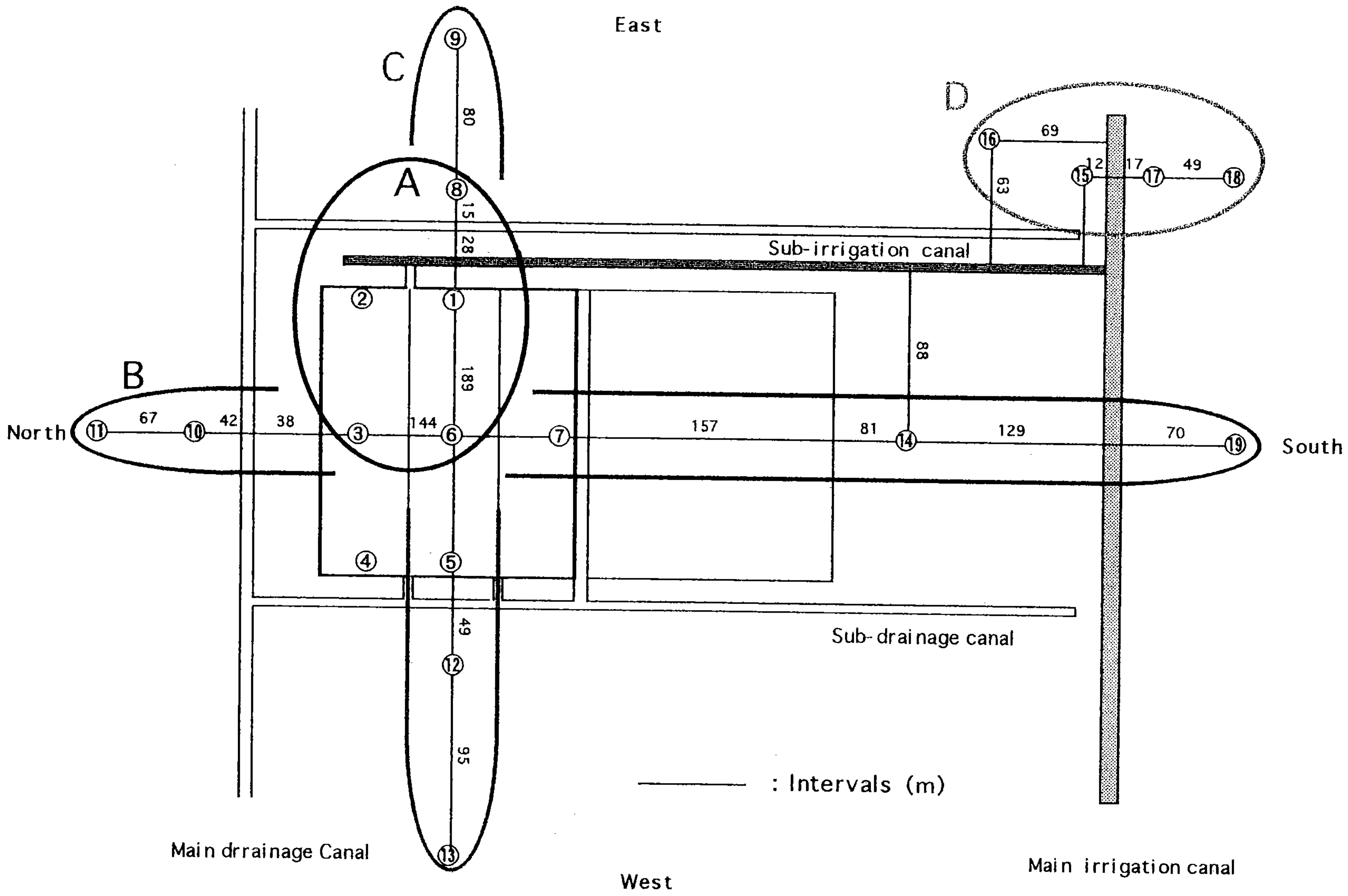
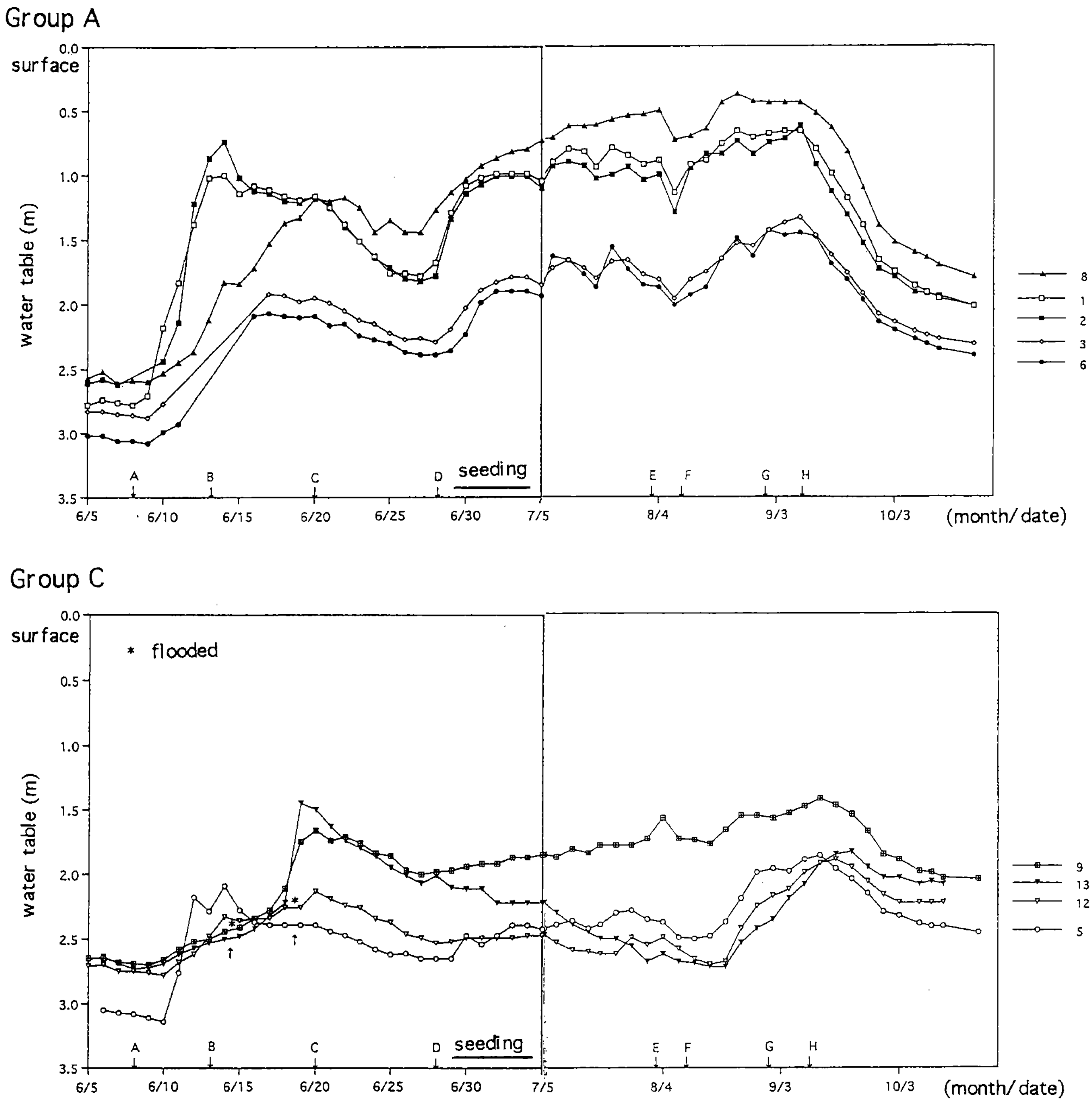


Fig. 2 Observation sites shown in circled number for measuring grondwater levels and water quality in and around the experiment field



A ; water supplies to irrigation canal
A-B; leaching
C ; water discharge from irrigation canal
D ; water supplies to irrigation canal
E ; water discharge from irrigation canal
F ; water supplies to irrigation canal
G ; irrigated
H ; water discharge from irrigation canal

Fig. 3 Time-course changes of water table in and around the experiment fields under irrigated conditions

(number ; observation site number shown in Fig. 2)

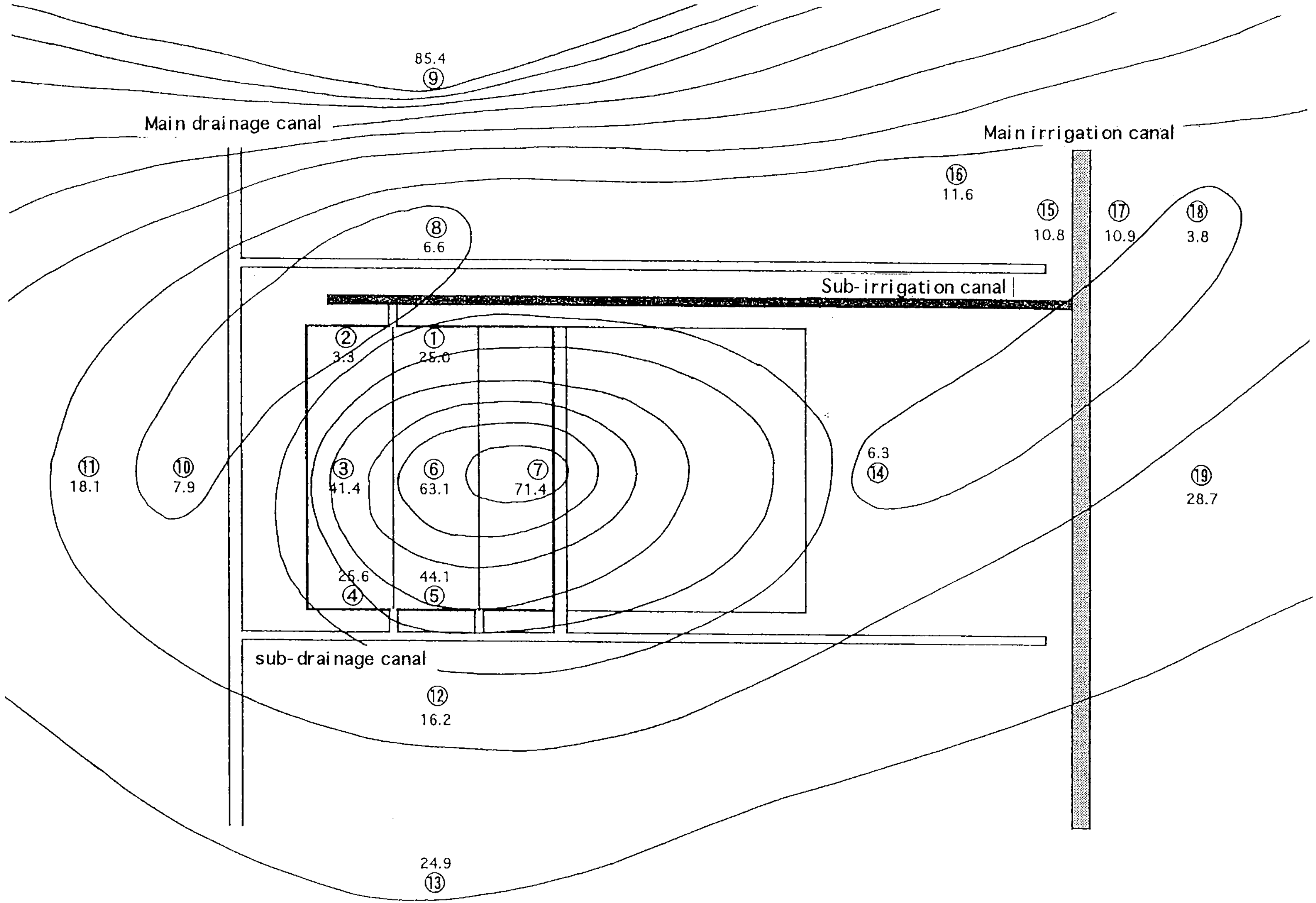


Fig. 4 Distribution of isosalinity-line EC(dS/m) in the field and around the experimental site

Table 1. Changes of soil salinity(ECe),pH before(6 Jun),after(20 Jun) leaching and of harvesting(8 Oct)

Plot No.	ECe(dS/m)		pH			ECe	pH
(depth)[a]	6 Jun	20 Jun	6 Jun	20 Jun		8 Oct	8 Oct
A -1(0)	15.7	3.3	8.0	7.9	A -1(20)	6.9	7.8
A -1(2)	10.4	3.5	8.0	7.9	A -1(60)	4.3	7.9
A -1(5)	7.4	6.7	8.0	7.9			
A -1(10)	4.2	3.2	7.9	7.9			
A -1(15)	4.2	3.1	7.9	7.8			
A -5(0)	48.8	10.1	8.2	7.9	A -5(20)	8.3	7.9
A -5(2)	21.6	5.9	7.9	7.9	A -5(60)	4.7	7.7
A -5(5)	6.2	9.3	8.0	7.9			
A -5(10)	6.5	14.6	8.0	7.9			
A -5(15)	4.4	18.9	7.9	7.7			
AC-2(0)	110.1	23.7	8.6	8.1	AC-2(20)	9.1	8.0
AC-2(2)	86.3	5.7	8.3	8.1	AC-2(60)	17.8	7.7
AC-2(5)	14.9	5.9	8.0	8.0			
AC-2(10)	16.9	7.1	8.0	8.0			
AC-2(15)	21.8	8.0	8.1	7.8			
AC-4(0)	11.5	7.3	8.1	8.1	AC-4(20)	3.8	7.7
AC-4(2)	24.0	4.3	8.2	8.1	AC-4(60)	4.7	7.8
AC-4(5)	11.6	5.3	8.1	8.1			
AC-4(10)	10.3	9.2	8.1	8.1			
AC-4(15)	10.3	6.8	8.1	8.1			
B -1(0)	34.4	8.2	8.3	7.8	B -1(20)	8.8	7.9
B -1(2)	18.5	4.0	8.1	7.9	B -1(60)	10.5	7.8
B -1(5)	5.4	4.2	8.1	7.9			
B -1(10)	4.6	4.3	7.9	7.9			
B -1(15)	5.6	5.2	7.7	7.9			
B -5(0)	144.1	97.4	8.3	7.9	B -5(20)	22.9	7.7
B -5(2)	104.7	44.7	8.2	7.8	B -5(60)	65.5	7.6
B -5(5)	54.2	56.2	8.0	7.9			
B -5(10)	37.2	58.3	8.0	7.8			
B -5(15)	38.1	48.6	8.0	7.7			
BC-2(0)	24.4	8.3	8.0	7.9	BC-2(20)	3.4	7.9
BC-2(2)	10.3	3.7	8.0	8.0	BC-2(60)	4.2	7.8
BC-2(5)	9.5	3.8	8.0	8.0			
BC-2(10)	7.5	4.9	7.9	7.9			
BC-2(15)	7.1	5.1	7.9	7.8			
BC-5(0)	8.6	9.9	8.1	8.0	BC-5(20)	6.2	8.0
BC-5(2)	11.3	4.1	8.1	8.1	BC-5(60)	23.2	7.5
BC-5(5)	5.7	4.5	8.1	8.1			
BC-5(10)	6.4	4.6	8.1	8.0			
BC-5(15)	6.9	4.6	8.0	7.9			

[a] (0);0-2cm, (2);2-5cm, (5);5-10cm, (10);10-15cm, (15);15-20cm, (20);20-25cm, (60);60-65cm

Table 2 Means for some agronomic characters in the soil surveyed plots of the crops planted

Plot	Wheat				Oat				Barley			
No.	CL	PL	NP	NH	CL	PL	NP	NH	CL	PL	NP	NH
A -1	80	8.6	9.6	102	59	18.5	7.6	74	43	8.0	7.1	71
A -5	67	8.2	8.0	84	53	18.3	6.7	65	44	8.9	7.0	42
AC-2	51	8.3	6.0	66	32	13.0	4.5	10	38	7.2	4.7	19
AC-4	69	8.9	8.6	71	51	17.7	6.6	68	41	8.7	7.3	24
B -1	62	8.0	5.8	81	48	16.6	5.7	89	40	7.6	7.0	58
B -5	51	11.0	7.1	26	49	19.1	4.1	35	33	7.7	5.3	16
BC-2	50	8.2	4.8	41	44	16.0	5.5	63	38	8.2	4.9	26
BC-5	68	9.8	7.3	101	47	19.0	6.9	40	41	8.7	6.3	28

	Grain sorghum				Sweat sorghum				Sudangrass			
	CL	PL	NP	NH	CL	PL	NP	NH	CL	PL	NP	NH
A -1	218	19.8	4.4	15	97	27.6	3.9	4	240	36	10.8	4
A -5	162	19.8	3.5	10	86	24.3	3.6	4	166	34	5.5	3
AC-2	155	17.4	2.5	9	81	21.9	2.6	2	133	31	4.2	5
AC-4	182	19.5	3.6	8	87	24.7	2.7	3	206	32	8.2	3
B -1	177	18.7	2.5	23	98	25.3	3.2	7	184	33	3.8	10
B -5	130	18.3	2.4	3	77	41.7	4.3	1	45	24	1.0	1
BC-2	147	19.8	2.1	12	71	23.7	1.8	2	141	32	1.6	3
BC-5	170	19.8	2.6	11	85	25.2	2.5	4	182	33	4.0	3

Plot	Beet				Maize				Amaranth			Safflower	
No.	BL	WL	R	NH	CL	PL	NP	NH	CL	PL	NH	PH	NH
A -1	39	13.3	2.9	14	135	41	1.6	4	57	30	178	74	71
A -5	40	14.2	2.8	17	128	29	1.5	2	51	25	159	51	53
AC-2	28	11.2	2.5	7	89	29	1.0	1	36	26	42	36	19
AC-4	46	15.4	3.0	20	104	33	1.3	5	55	37	71	58	26
B -1	40	14.6	2.7	11	96	34	1.2	5	49	23	280	51	82
B -5	45	19.2	2.3	1	116	43	1.0	1	49	24	19	22	42
BC-2	36	15.6	2.4	5	80	28	1.0	3	45	26	32	29	40
BC-5	30	10.9	2.6	3	85	30	1.0	2	70	39	80	39	31

CL;culm length(cm), PL;panicle length(cm), NP;number of panicles per hill,
NH;number of hills per plot, PH;plant height,BL;leaf blade length(cm),
WL;leaf blade width(cm), R;length/width ratio