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Effect of date of transplanting and water-management practices on yield of basmati rice (*Oryza sativa*)

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ABSTRACT

A field experiment was carried out during rainy seasons of 1989 and 1991 to study yield of basmati rice (*Oryza sativa* L.) as influenced by different water-management practices under 2 dates of transplanting, viz. 10 and 30 July. Water-management practices included 4 initial submergence durations of 5 days (S_5), 10 days (S_{10}), 15 days (S_{15}) and 20 days (S_{20}) and 2 subsequent irrigation levels of irrigation at 2 days (I_2) and 4 days (I_4) after infiltration of the previously ponded water.

Transplanting the crop on 10 July increased root density, N, P and K uptake and head-rice recovery along with significant increase in grain yield by 9.4 and 7.9% over 30 July 1989 and 30 July 1991 respectively. Initial submergence duration (S_{15}) significantly increased the grain yield, rooting density and N, P and K uptake over S_5 and S_{10} treatments. Subsequent irrigation level of I_2 gave significantly higher grain yield of 6.3 and 8.6% than I_4 during 1989 and 1991 respectively. The treatment I_2 also increased the root density, N, P and K uptake and head-rice recovery.

Cultivation of basmati rice (*Oryza sativa* L.) is very remunerative, as it fetches sufficiently higher price over the coarse varieties. The need for early vacation of the field for sowing the next crop has created a tendency for its early transplanting. But a very little work has been done to study the effect of early transplanting on basmati yield. In addition to time of planting, the water management is also of paramount importance. As very little work has been done on basmati rice, the present study was conducted to find out an optimum schedule of irrigation for basmati rice transplanted on different dates.

MATERIALS AND METHODS

A field experiment was conducted at Ludhiana during rainy (*kharif*) seasons of 1989 and 1991. The upper 0–30 cm soil profile was loamy sand underlined by sandy loam up to 120 cm depth. The treatments included 2 dates of transplanting, viz. 10 (D_1) and 30 July (D_2); 4 initial submergence durations, viz. 5 days (S_5), 10 days (S_{10}), 15 days (S_{15}) and 20 days (S_{20}) after transplanting; and 2 subsequent irrigation levels, viz. irrigation application 2 days (I_2) and 4 days (I_4) after infiltration of the previously ponded water. Combinations of dates of transplanting and subsequent irrigation levels were kept in main plots and initial submergence duration in subplots. Thirty-day-old seedlings were transplanted on scheduled dates of transplanting and plant popu-

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Table 1. Number of irrigations under different treatments in basmati rice

Submergence duration	1989					1991				
	10 July		30 July		Mean	10 July		30 July		Mean
	I_2	I_4	I_2	I_4		I_2	I_4	I_2	I_4	
S_5	23	17	22	18	20.0	23	18	22	19	20.5
S_{10}	25	20	27	22	23.5	26	22	26	23	24.3
S_{15}	29	24	30	25	27.0	29	25	29	26	27.3
S_{20}	31	26	34	29	30.0	33	30	33	30	31.5
Mean (dates)	24.4		25.8			25.8		26.0		
Mean (irrigation)	27.6 (I_2)		22.6 (I_4)			27.6 (I_2)		24.1 (I_4)		

Treatment details are given in text

lation was maintained at 33 hills/m^2. The crop was fertilized with 62.5 kg N/ha and 30 kg P_2O_5/ha. Number of irrigations applied to different treatments are given in Table 1.

Root samples were taken at flowering stage with a core sampler from 0–30, 30–60 and 60–90 cm soil depths. The samples were taken by keeping hill in the centre. The samples containing roots were thoroughly washed on 1-mm sieve. Root density was then calculated on dry-weight basis. Grain and straw yields were obtained from the net plot size of 6 m x 1.6 m. Uptake of N, P and K was worked out by multiplying the per-cent nutrient content in plants with their re-spective dry weight at harvest.

Water expense and water-expense efficiency for the grain yield were calculated as:

$$WE = IW + RF - SW$$

$$WEE = \frac{Y}{WE}$$

where WE, water expense; IW, amount of irrigation water applied (cm); RF, effective rainfall during the crop season (cm); SW, amount of water left in soil profile at the time of harvest (cm); WEE, water-expense efficiency (kg/ha/cm); and Y, yield (kg/ha).

RESULTS AND DISCUSSION

Effect of transplanting date

Earlier transplanting (10 July) of basmati rice increased both the grain and straw yields over late transplanting (30 July). Transplanting on 10 July gave higher grain yields of 5.0 and 8.6% in 1989 and 1991 respectively, as compared with 30 July transplanting (Table 2). Earlier transplanting due to better root density (Fig. 1) favoured the uptake of N, P (Table 3) and K (Table 4) and thereby increased the grain yield. Uptake of N, P and K at panicle-initiation and flowering stages was higher in 10 July over 30 July transplanting in both the years. At harvest the N uptake in earlier transplanting was higher by 12.0 and 12.8 kg/ha over the late transplanting during 1989 and 1991 respectively. In 10 July transplanting uptake (at harvest) of P remained higher by 2.6 and 3.5 kg/ha and of K by 26.9 and 28.2 kg/ha over 30 July transplanting in 1989 and 1991 respectively. Rice yields reduced with the

Table 2. Grain yield, straw yield, water expense and water-expense efficiency (WEE) for grain yield and head-rice recovery under different treatments of basmati rice

Treatment	Grain yield (q/ha)		Straw yield (q/ha)		Water expense (cm)		WEE (kg/ha-cm)		Head-rice recovery (%)	
	1989	1991	1989	1991	1989	1991	1989	1991	1989	1991
Transplanting date										
D_1	27.7	29.1	99.0	96.8	131.0	132.2	21.4	22.7	56.8	56.6
D_2	25.4	27.0	83.7	81.9	138.1	134.7	18.8	20.3	54.6	54.1
CD (P = 0.05)	0.6	0.7	1.6	1.9					0.6	0.5
Submergence duration										
S_5	24.7	25.9	86.0	82.9	110.5	109.2	22.5	23.9	55.9	55.2
S_{10}	26.3	27.9	90.2	88.5	126.5	124.3	20.9	22.5	55.7	55.5
S_{15}	27.4	29.1	94.2	92.6	143.1	139.5	19.2	20.8	55.4	55.1
S_{20}	27.7	29.4	95.1	93.4	158.3	160.8	17.9	18.7	55.8	55.6
CD (P = 0.05)	0.3	0.4	0.8	1.0					NS	NS
Irrigation schedule										
I_2	27.3	29.1	96.2	93.6	145.5	141.7	19.0	20.6	58.0	57.4
I_4	25.7	27.0	86.5	85.1	123.7	125.2	21.3	22.2	53.4	53.3
CD (P = 0.05)	0.6	0.7	1.6	1.9					0.6	0.5

Treatment details are given in text

Table 3. Nitrogen and phosphorus uptake (kg/ha) by basmati rice under various transplanting dates and irrigation schedules

Treatment	Nitrogen uptake						Phosphorus uptake					
	1989			1991			1989			1991		
	Straw	Grain	Total	Straw	Grain	Total	Straw	Grain	Total	Straw	Grain	Total
Transplanting date												
D_1	61.7	33.6	95.3	62.2	36.4	98.6	16.3	7.8	24.1	16.9	8.1	25.0
D_2	52.7	30.6	83.3	52.5	33.3	85.8	14.5	7.0	21.5	14.2	7.2	21.5
CD (P = 0.05)	1.5	0.8		1.7	1.0		0.5	0.3		0.3	0.2	
Initial submergence duration												
S_5	55.6	29.5	85.1	53.2	32.1	85.3	14.1	6.4	20.5	14.4	7.2	21.6
S_{10}	56.4	32.1	88.5	56.5	34.6	91.1	15.7	7.3	23.0	15.4	7.6	23.0
S_{15}	59.7	32.9	92.6	59.7	36.4	91.1	16.0	7.6	23.6	16.1	8.0	24.1
S_{20}	60.6	33.9	94.4	60.1	36.3	96.4	16.6	7.8	24.4	16.3	8.0	24.3
CD (P = 0.05)	1.9	0.7		1.9	0.6		0.4	0.2		0.2	0.2	
Subsequent irrigation level												
I_2	62.6	34.4	96.9	62.1	37.9	100.0	17.4	8.1	25.5	17.1	8.5	25.6
I_4	51.8	29.8	81.6	52.8	31.8	84.6	13.5	6.7	20.1	14.0	6.9	20.9
CD (P = 0.05)	1.5	0.8		1.7	1.0		0.5	0.3		0.3	0.2	

Treatment details are given in text

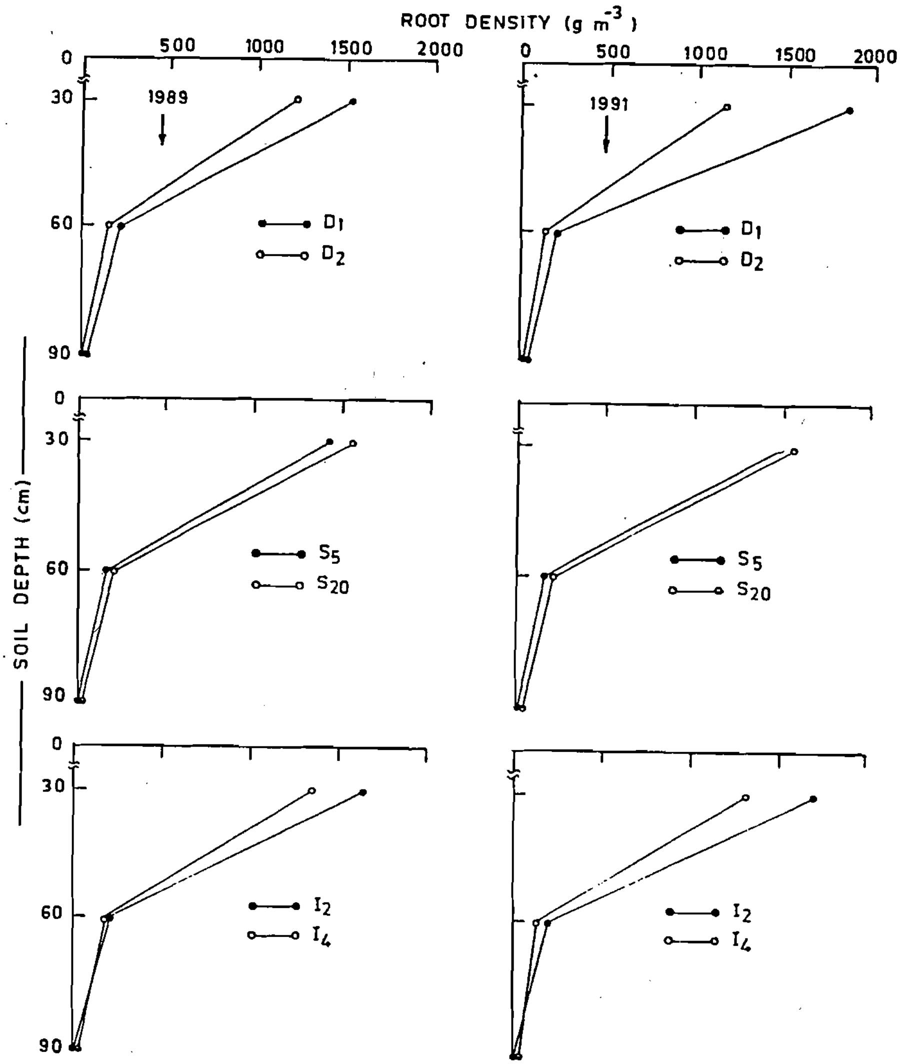

Fig. 1. Root density (g/m^3) of basmati rice at flowering stge when transplanted on different dates, initial submergence duration and irrigation intervals (treatment details are given in text)

delayed transplanting by way of negative growth and lower photosynthetic rate, resulting in empty grains and ineffective tillers (Ding and Chai, 1982). Akram *et al.* (1985) also obtained higher grain yield of basmati with earlier sowing. Water-expense efficiency was higher by 2.6 and 2.4 kg grain/ha-cm when transplanted on 10 July than on 30 July. Kumar and Subramanium (1989) also obtained higher water-expense efficiency in earlier transplanted crop. The head-rice recovery was significantly higher under 10 July than 30 July transplanting. The decrease in head-rice recovery under late transplanting appeared due to high amount of chalky kernels (Dhaliwal *et al.*, 1986).

Effect of initial submergence duration

Both the grain and straw yields of basmati were significantly increased with the increase in initial submergence duration from 5 to 15 days (Table 2). The increase in yield occurred primarily due to more water availability for proper development of seedlings which favoured root development (Fig. 1) and uptake of nutrients. Khera *et al.* (1991) obtained higher yield with submergence duration of 3 weeks. The increase in initial submergence duration increased the values of water expense which caused a decrease in water-expense efficiency. However, the lower grain yields obtained under S_5 and S_{10} than S_{15} may not permit to keep initial submergence duration only for 5 or 10 days. Head-rice recovery was not differentially affected.

Effect of subsequent irrigation levels

Irrigation treatment I_2 gave significantly higher grain and straw yields of basmati rice than I_4 during both the years. During 1989 and 1991 the increase in grain yield with I_2 over I_4 was 6.3 and 9.6% respectively. Treatment I_2 ensured uninterrupted growth followed by full expression of yield-contributing characters and their proper development made possible probably by sizeable mobilization of reserve and current photosynthates to the sink. Significant and positive correlations were observed between grain yield and water expense for both the years of study ($Y = 18.99 + 0.56\ x$; $r = 0.64$ for 1989 and $Y = 18.39 + 0.072\ x$; $r = 0.73$ for 1991), showing high dependence of yield on water expense. Favourable effect of I_2 on grain yield was also due to positive effect (Fig. 1) on root density (Hasegawa *et al.*,

Table 4. Potassium uptake (kg/ha) by basmati rice under different transplanting dates and irrigation schedules

Treatment	1989			1991		
	Straw	Grain	Total	Straw	Grain	Total
Transplanting date						
D_1	173.3	10.8	184.1	170.4	11.1	181.5
D_2	147.3	9.9	157.2	143.3	10.0	153.3
CD (P = 0.05)	3.8	0.3		4.8	0.4	
Initial submergence duration						
S_5	151.4	9.6	161.0	145.9	10.1	156.0
S_{10}	157.9	10.2	168.1	153.1	10.6	163.7
S_{15}	164.9	10.7	175.6	151.1	10.7	171.8
S_{20}	166.4	10.8	177.2	164.4	10.9	175.3
CD (P = 0.05)	6.7	0.3		4.7	0.3	
Subsequent irrigation level						
I_2	170.3	11.2	181.5	166.7	11.6	178.3
I_4	150.5	9.5	160.0	148.1	9.4	157.5
CD (P = 0.05)	3.8	0.3		4.8	0.4	

Treatment details are given in text

Table 5. Canopy temperature and leaf-water potential of crop at different stages under levels of subsequent irrigations in basmati rice

Treatment	1989			1991		
	Maximum tillering	Panicle initiation	Flowering	Maximum tillering	Panicle initiation	Flowering
			Canopy temperature (°C)			
I_2	30.04	28.75	27.22	28.89	28.46	27.41
I_4	31.04	29.87	28.36	30.45	29.71	28.70
			Leaf-water potential (bars)			
I_2	—11.81	—13.28	—14.43	—12.12	—12.89	—14.47
I_4	–16.41	–18.22	–19.99	–16.29	–18.01	–20.80

Treatment details are given in text

1985), which caused better uptake of nutrients (Tables 3, 4) and thereby helped in growth and development of crop. The canopies under I_2 at different stages of growth also resulted in lower temperature and higher leaf-xylem potential (Table 5) which improved micro-environments and might have helped to sustain higher rates of photosynthesis and hence higher yield realization in well-irrigated plots. Prihar and Grewal (1988) and Uppal *et al.* (1991) also recorded decrease in yield of coarse rice with increase in the interval between disappearance of ponded water and irrigation application. Head-rice recovery also increased under I_2 and I_4 treatments.

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