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RESPONSE OF UPLAND RICE CULTIVARS UNDER VARYING SOIL MOISTURE REGIMES

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SUMMARY

Three upland rice (*Oryza sativa* L.) cultivars viz. CR 143-2-2, Annada and Cauvery, were grown in the field under three irrigation regimes. There was a significant reduction in grain yield in all the three rice cultivars with the decrease in irrigation regimes. Under higher moisture stress conditions, performance was best in CR 143-2-2 and poorest in Cauvery. At IW/PET = 0.5 the cultivar Cauvery did not flower at all. Flowering was delayed in all the cultivars with the decrease of irrigation regime.

***Key words* : Irrigation regimes, leaf water potential, relative water content, stomatal resistance**

INTRODUCTION

Water is the principal factor limiting plant growth. It is an established fact that rice plant thrives well under submerged condition (Cralley and Adair 1943, Pande and Haque 1963, Jana and Ghildyal 1969 and Grontiwar and Jaggi 1972). But, under rainfed upland conditions rice plants are subjected to moisture stress because of erratic rainfall. Sometimes stress may be severe due to prolonged drought spell and most of the common upland rice cultivars give very poor yield. This information is important for plant breeders to develop varieties to improve productivity and stability of rice under rainfed condition. This study was, therefore, underktaken for evaluating the effects of different soil water stress on growth and yield of three upland rice cultivars in sandy loam soil.

MATERIALS AND METHODS

A field experiment was conducted in sandy loam soil of Central Rice Research Institute farm during 1994-95 summer season. The physical properties of soil are presented in Table 1. The experiment was conduted in split plot design assigning irrigation regimes in the main plot and cultivars in the sub-plots. The main plot included three irrigation regimes *viz.*, I_1 (IW/PET = 0.5), I_2 (IW/PET = 1.0) and I_3 (IW/PET = 2.0). The sub-plots included three upland rice (*Oryza sativa* L.) cultivars *viz.*, CR 143-2-2, Annada and Cauvery. Seeds were dry sown in the field and fertilisers were applied as basal dressing of N, P and K @ 30, 30 and 30 kg ha^{-1} and the rest 30 kg N was top

Table 1. Physical properties of soil.

Components	Value
Mechanical composition	
Clay %	17.32
Silt %	23.58
Sand %	59.10
Bulk density (Mg m^{-3})	1.51
Maximum water holding capacity %	40.27
1/3 bar moisture content %	18.33
15 bar moisutre content %	7.52

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dressed in two splits during maximum tillering and panicle initiation stages. Irrigations were given when IW/PET value reached 2.0, 1.0 and 0.5, respectively in different treatments. Soil water potential in the root-zone was estimated through mercury manometer type tensiometers placed at 10, 20, 30 and 40 cm soil depths.

Leaf water potential, relative water content and stomatal resistance of leaf were measured between 11.00 A.M. and 12.00 noon at active and maximum tillering stages. Observations were recorded on relative water content following the method described by Slatyer and Barrs (1965) and leaf water potential was measure following as the procedure of Scholander *et al.* (1964) using pressure chamber (soil moisture equipment corporation, Model 3005, Santabarbara, California, USA). Stomatal diffusive resistance was recorded with the help of porometer (Delta-T, Devices, U.K.) as adopted by Saini and Rathore (1984). All the observations were recorded in the penultimate fully developed leaf on the main culm.

Root studies were conducted during the flowering stage. A root cage (60 cm length and 20 cm diameter) was inserted into the soil keeping a plant hill at the centre. The soil core was excavated along with the cage and washed thoroughly with water jet to separate the whole root system.

Observations on plant height, total number of tillers and ear bearing tillers were recorded during the growth period. After harvesting, grain yield, straw yield and 1000-grain weight were recorded. Flowering time for each cultivar under different irrigation regimes was also recorded.

RESULTS AND DISCUSSION

Plant height and straw yield decreased remarkably in all the cultivars with the decrease of irrigation regime (Table 2). This decrease in plant height and straw yield was maximum in Cauvery and minimum in CR 143-2-2. Tiller production was maximum in Cauvery and minimum in CR 143-2-2. It increased with the decrease of irrigation regime in Annada and Cauvery but not in CR 143-2-2 (Table 2). Jana and Ghildyal (1996) also observed that the plant height and straw yield of rice progressively increased as soil water content varied from unsaturation to flooding.

Table 2. Growth attributes of rice cultivars under different irrigation regimes.

Cultivars	**Plant height (cm plant^{-1})**				**Tiller No./sq m***				**Straw yield (t ha^{-1})**			
	I_1	**I_2**	**I_3**	**Mean**	**I_1**	**I_2**	**I_3**	**Mean**	**I_1**	**I_2**	**I_3**	**Mean**
CR 143-2-2	39.90	45.37	49.53	44.93	6.80	6.81	6.80	6.80	2.84	3.26	3.99	3.37
Annada	36.70	45.03	50.43	44.06	6.89	6.86	6.81	6.85	2.91	4.65	5.15	4.24
Cauvery	30.03	41.77	47.33	39.71	7.12	7.04	7.00	7.05	1.47	2.11	4.53	2.70
Mean	35.54	44.06	49.10		6.93	6.90	6.87		2.41	3.35	4.56	
CD at 5% P												
Irrigation regimes				2.82				0.20				0.10
Cultivars				2.82				0.16				0.34
Cultivars at the same irrigation regime				4.48				0.28				0.59
Irrigation regime at same cultivar				4.56				0.28				0.50
CV (%)												
Irrigation				5.02				2.18				2.89
Cultivar and interaction				6.04				2.32				9.72

* Transformed into logarithm scale.

Among the three cultivars, Cauvery showed the loswest leaf water potential and CR 142-2-2 showed the highest. With the increase of irrigation regimes leaf water potential increased in all the cultivars (Table 3). Similarly, there was a significant increase of relative water content with the increase of irrigation regimes (Table 4). Lowest relative water content was recorded in Cauvery and the highest in CR 143-2-2 under all the irrigation regimes. Maximum stomatal resistance was exhibited by CR 143-2-2 and minimum by Cauvery (Table 5). The resistance was the lowest in the highest irrigation regime (IW/PET; 2.0) and the highest in the lowest irrigation regime (IW/PET; 0.5). John and Rolando (1980) reported that when two rice cultivars are exposed to the same initial soil and atmospheric condition, they differed markedly in their ability to maintain high leaf water potential. This was reflected in stomatal resistance and leaf rolling.

Table 3. Leaf water potential (bars) of rice cultivars under different irrigation regime (negative values).

Cultivars	Active tillering stage				Maximum tillering stage			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
CR 143-2-2	16.67	14.77	12.20	14.54	18.27	16.17	14.60	16.34
Annada	19.13	16.70	14.93	16.92	20.67	16.97	16.30	17.98
Cauvery	24.47	19.50	17.30	20.42	25.30	22.00	19.20	22.17
Mean	20.09	16.99	14.81		21.41	18.38	16.70	
C.D. at 5% P								
Irrigation regimes				2.24				0.78
Cultivars				1.42				1.49
Cultivars at the same irrigation regime				2.47				2.58
Irrigation regime at same cultivar				2.67				2.19
C.V. (%)								
Irrigation				9.90				3.15
Cultivar and interaction				8.02				7.70

Table 4. Relative turgidity (%) of rice cultivars under different irrigation regimes.

Cultivars	Active tillering stage				Maximum tillering stage			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
CR 143-2-2	84.89	89.21	93.95	89.35	81.12	85.70	92.17	86.33
Annada	80.59	86.60	91.62	86.27	77.00	84.28	90.66	83.98
Cauvery	69.16	82.55	88.01	79.90	65.06	79.18	84.29	76.18
Mean	78.21	86.12	91.19		74.39	83.05	89.04	
C.D. at 5% P								
Irrigation regimes				3.40				2.67
Cultivars				1.92				2.47
Cultivars at the same irrigation regime				3.33				4.27
Irrigation regime at same cultivar				3.81				4.07
C.V. (%)								
Irrigation				3.05				2.49
Cultivar and interaction				2.20				2.92

Table 5. Stomatal resistance (Scm^{-1}) of rice cultivars under different irrigation regimes.

Cultivars	Active tillering stage				Maximum tillering stage			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
CR 143-2-2	4.89	4.57	3.36	4.27	5.34	4.88	4.06	4.76
Annada	5.45	4.84	3.97	4.75	6.25	5.33	4.59	5.39
Cauvery	6.94	5.70	4.67	5.77	7.56	6.22	5.28	6.35
Mean	5.76	5.04	4.00		6.38	5.48	4.64	
C.D. at 5% P								
Irrigation regimes				0.35				0.44
Cultivars				0.37				0.42
Cultivars at the same irrigation regime				0.63				0.74
Irrigation regime at same cultivar				0.58				0.69
C.V. (%)								
Irrigation				5.36				6.10
Cultivar and interaction				7.23				7.51

As a whole the cultivar Cauvery showed very poor root growth under all the irrigation regimes (Table 6). The root lenght, depth of ramification and the volume were significantly more in CR 143-2-2 as compared to Annada and Cauvery. Length and depth of ramification of roots increased and the volume of roots decreased with the decrease of irrigation regime. Jana and Ghildyal (1969) reported progressive increase in the dry weight of roots as the soil water content varied from unsaturation to flooding.

Flowering was delayed in all the cultivars with the decrease of irrigation regime. The delay was maximum in Cauvery and minimum in CR 143-2-2 (Table 7). At IW/PET; 0.5 (lowest irrigation regime) the cultivar Cauvery did not flower at all. There was a significant decrease in ear bearing tiller, grain yield and 1000-grain weight in all the three cultivars with the decrease of irrigation regimes (Table 8). Jana and Ghildyal (1969) also reported that percentage of ear bearing tillers increased from 61 to 97 with the variation of soil water content from unsaturation

Table 6. Root growth characteristics of rice cultivars under different irrigation regimes.

Cultivars	Root length (cm)				Depth of remification of roots (cm)				Volume of roots $hill^{-1}$ (cm^3)			
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
CR 143-2-2	55.03	51.27	47.67	51.32	27.03	25.27	21.57	24.62	18.97	22.43	26.37	22.59
Annada	50.50	47.67	43.70	47.29	23.13	21.57	18.80	21.17	15.53	17.20	19.23	17.32
Cauvery	40.33	35.68	30.77	35.59	15.67	12.37	10.30	12.78	10.53	12.97	14.50	12.67
Mean	48.62	44.87	40.71		21.94	19.73	16.89		15.01	17.53	20.03	
C.D. at 5% P												
Irrigation regimes				2.39				0.50				1.18
Cultivars				3.06				1.44				1.56
Cultivars at the same irrigation regime				5.30				2.50				2.70
Irrigation regime at same cultivar				4.72				2.08				2.39
C.V. (%)												
Irrigation				4.08				1.97				5.14
Cultivar and interaction				6.66				7.19				8.67

Table 7. Flowering in rice cultivars under different irrigation regimes.

Cultivars	Days for 50% flowering		
	I_1	I_2	I_3
CR 143-2-2	82	77	73
Annada	96	88	82
Cauvery	N.F.	100	91

N.F. = Not flowered

Table 8. Mean yield and yield attributes of rice cultivars under different irrigation regimes.

Cultivars	Ear bearing tiller m^{-2}			Grain yield ($t\ h^{-1}$)			1000-grain weight (g)		
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3
CR 143-2-2	544	625	666	0.85	1.69	2.14	17.52	18.28	21.34
Annada	196	603	651	0.38	1.20	2.09	19.68	20.21	22.72
Cauvery	N.F.	278	416	N.F.	0.15	1.26	N.F.	17.48	20.63

N.F. = Not flowered

to flooding. Under higher moisture stress conditions (lower irrigation regime) performance was best in CR 143-2-2 and poorest in Cauvery. By the decrease in irrigation regime from I_3 to I_2, yield reduction in CR 143-2-2 was 21%, in Annada it was 43% and in Cauvery it was 85% (Table 8).

This study indicate that drought tolerant rice cultivar possesses less number of tillers. On the contrary, the cultivars like Cauvery and Annada which are less tolerant to drought, produced more number of tillers with the decrease of irrigation regime. This increase in tiller production was most probably due to the restriction of reproductive growth under higher stress conditions.

Better performance of the cultivar CR 143-2-2 at higher moisture stress was due to its drought tolerance as compared to the other two cultivars. This cultivar showed a better water absorption system in the higher moisture stress condition as observed by its maintenance of higher leaf water potential and lower stomatal resistance in comparison with other two cultivars. Longer root system in the cultivar CR 143-2-2 as compared to Annada and Cauvery contributed to its ability to tolerate moisture stress.

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