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Water Management for Lowland Rice*

S. SUBRAMANIAN[1] and K. RAJAGOPALAN[2]

Field experiments were conducted for three consecutive years (1973 through 1975) during July - November, to study the water management practices for lowland rice IR 20. Parallelism between grain yield and sunshine hours as well as diurnal air temperature was observed. Irrigating the field to 5 cm deep whenever saturation was reached during reproductive phase and an irrigation regime of saturation to field capacity (appearence of hair line crack) during vegetative and ripening phases contributed to higher production efficiency. Continuous submergences could not bring about any additional benefit. Irrigation regime of less than saturation during reproductive phase produced lesser and shorter panicles, with reduced grain number resulting in low grain yield.

Continuous submergence is invariably advocated and widely practiced, wherever rice is grown. However, recent findings from Central Rice Research Institute (CRRI). Cuttack suggest that by judicious water management, with the same quantum of water, the area under rice can almost be doubled (Pal, 1974). Though voluminous literature on irrigation research on rice is available, information on many vital aspects is rather scanty. Thus, the quantity of water required at different growth stages, effect of restricted use of water on growth and yield are some of the areas where lacunae exist. In the present paper an attempt has been made, to determine the water requirement of rice IR 20, under lowland conditions, at different growth stages and to workout the water use economy.

MATERIAL AND METHODS

Field experiments were conducted at the Agricultural College and Research Institute, Madurai situated in the Vaigai-Periyar Command area (9.54°N, 78° 50'' E and 147 m above mean sea level), during the monsoon seasons (July through November) of 1973, 1974 and 1975. The soil was of sandy loam type with a pH of 6.6, low in availability of nitrogen (220 kg/ha) and potassium (145 kg K_2O/ha) and medium in available phosphorus (21.5 kg P_2O_5/ha). The infiltration rate after puddling was 0.1 cm/hr. The water table during the cropping season fluctuated between 0.5 m to 1.0 m.

Two irrigation regimes supplied at three phases of crop growth were compared with continuous submergence of 5 cm deep (Control). The two irriga-

* Forms part and Ph. D. thesis submitted to the Tamil Nadu Agricultural University.

1 - 2 Department of Agronomy, Agricultural College and Research Institute, Madurai-625104.

tion regimes were I_1 irrigation to recoup submergence of 5 cm deep whenever saturation (glistering appearance) was noticed and I_2 maintaining moisture regime between saturation and field capacity (at 0.3 atm. tension at Field capacity the well puddled soil began to show hairline crack). The three crop growth periods were transplanting to maximum tillering (vegetative phase S_1), maximum tillering to flowering (reproductive phase S_2) and flowering to ripening (ripening phase S_3). The notations used for example $I_2I_1I_1$ represents maintaining irrigation regime I_2 during vegetative phase and I_1 during reproductive and ripening phases.

The Periyar canal water was used for irrigation and was measured through a 90° 'V' notch. Planting in the main field was done with 25 day old seedling with a spacing of 20×10 cm.

RESULTS AND DISCUSSION

Grain yield :

Summary of results of grain yield for the three years is furnished in Table I. The grain yield of rice IR 20 was the highest during 1973 followed by that during 1974. There was parallelism between yield and sunshine hours and diurnal air temperature obtained during the three years (Table I).

The variations in yield are therefore, ascribed to the differences in these weather parameters as the two are related. Accumulation of more than 200 hours of sunshine during the thirty days before harvest, combined with dry season during harvest appears to be important for higher yields (Aspiras, 1964). It is established that extremes of diurnal temperature promote dry matter accumulation. Gopalswamy (1975) from dates of sowing trial observed longer sunshine hours and minimum night temperature during ripening period contributed to higher yields in IR 20. Morachan *et al.* (1974) reported that higher or lower yield potential of rice in a particular region appears to be dicided largely by the relative temperature disparity of the respective cropping area.

TABLE I Grain yield of rice IR 20 along with sunshine hours, diurnal variation in temperature and relative temperature disparity for the last 30 days before harvest.

Years	Grain Yield (kg/ha)	Sunshine hours	Diurnel variation in temperature	Relative temperature disparity
1973	8473	284	9.6	7.12
1974	7906	244	9.0	6.64
1975	7176	211	8.3	6.03

Grain yield under continuous submergence (8046 kg/ha) did not differ significantly from the mean of rest of water management treatments (7825 kg/ha). Consisting of intermittant irrigation namely submergence to saturation (I_1) or saturation to field capacity (I_2) at different crop growth phases.

Between irrigation regimes tried at different growth phases significant yield difference was observed only at reproductive phase (Table II).

During reproductive phase the irrigation regime I_1 of irrigating to 5 cm deep whenever saturation was reached recorded significantly higher grain yield over I_2 regime of saturation to field capacity. Interaction effect between irrigation regime and crop growth stages was non significant.

The fact, that during the reproductive phase submergence to saturation recorded higher yield than maintaining moisture regime between saturation and field capacity, brings to light the need for maintaining irrigation regime of above saturation during reproductive phase. The yield reduction with I_2 regime during reproductive phase is a reflection of the impairment in the growth components; since, the plant characters leaf area index, panicles/hill, panicle length and grains per panicle which exhibited positive and significant correlation with grain yield showed reduction under this irrigation regime (Table III).

TABLE II Effect of irrigation regimes on grain yield (kg/ha) of rice IR 2C

Year	Growth Phase	Irrigation regimes I_1	I_2	SE_D	$CD_{(0.05)}$
1973	S_1	8509	8413		
	S_2	8937	7985	256	541
	S_3	8639	8283		
1974	S_1	7830	7914		
	S_2	8235	7509	196	410
	S_3	7938	7806		
1975	S_1	7152	7140		
	S_2	7465	6827	184	387
	S_3	7176	7116		
Mean	S_1	7849	7802		
	S_2	8212	7440	208	444
	S_3	7917	7735		

TABLE III Effect of irrigation regimes during reproductive phase on the growth characters.

Plant growth character	I_1	I_2	SE_D	CD at 0.05	Correlation coefficient with grain yield
Leaf area index	10.5	9.7	0.14	0.3	0.83**
Panicles/hill	8.3	7.6	0.2	0.4	0.67**
Grains/panicle	105.1	100.5	0.7	1.4	0.84**
Panicle length	24.2	23.7	0.1	0.2	0.69**

Reproductive phase has been considered critical period for rice by several workers. Kramer (1969) considered the period when reproductive organs are formed, pollination and fertilization occur as the vulnerable period in crop growth. Moreover, reproductive phase also coincides with the maximum water requirement period (Nair *et al.*, 1973). Thomar and Ghildyal (1975) observed resistance to water transport in non-flooded rice plant (0.3 Atom) was nearly twice as high as in flooded plants. Evidently, in this study, the irrigation regime of saturation to field capacity during reproductive phase was not able to fully meet the water need necessitated during the critical period for primordial initiation and developlemt, leading to reduced panicles/hill, shorter panicles and lesser number of grains/panicle culminating in reduced grain yield.

Under similar conditions Lenka (1974) reported better results with shallow submergence during maximum tillering to flowering and saturation to field capacity during rest of the period. Shanmugasundaram and Morachan (1974) and Kaliappa *et al.* (1974) under Coimbatore conditions found shallow submergence during reproductive phase to be conducive for higher yields. Findings of this study that submergence to saturation during reproductive phase is better than saturation to field capacity for higher yield in rice is in confirmity with the observations of above workers.

Continuous submergence compared to rest of the treatments betowed no beneficial effect on grain yield. The facts that the rest of the treatments included submergence to saturation; that saturation to field capacity during vegetative and ripening phases was as good as maintaining submergence to saturation; and that the water table in the experimental area was shallow (0.5 to 1.0 m) during the cropping period explains the lack of response of grain yield to continuous submergence.

Water used :

The water used under different water management practices differed significantly as seen in Table IV.

TABLE IV Water used by rice IR 20 under varied water management practices and production efficiency (kg grain/ha cm)

Water Management	Water used (cm)	Production efficiency
I_1 I_1 I_1	104.2	79.3
I_1 I_1 I_2	96.3	84.5
I_1 I_2 I_1	100.3	75.0
I_1 I_2 I_2	92.1	80.9
I_2 I_1 I_1	98.2	86.5
I_2 I_1 I_2	90.2	87.1
I_2 I_2 I_1	93.8	78.6
I_2 I_2 I_2	86.9	86.0
Submergence	120.7	66.0
SE_D	0.193	4.3
CD ($P = 0.05$)	0.42	9.3

The total water used under continuous submergence (120 7 cm) was 21 per cent higher than that used under other treatments (95.3 cm). In as much as continuous submergence always had standing water the constant head of water on the soil surface results in greater downward percolation than in a well drained soil (Patrick and Mahapatra, 1968). Besides loss through evaporation is likely to be higher. Hence the water used under continuous submergence was higher than that consumed under the other treatments. Similar water use from 900 mm when irrigation was given at appearance of soil crack to 2266 mm under continuous flooding was observed at CRRI, Cuttack (Chaudhury and Pandey, 1965).

In all the three phases of crop growth water used under I_2 regime was markedly lower than that used under I_1 regime (Table V.)

TABLE V Water used (cm) by rice IR 20 under the irrigation regimes during different phases of crop growth.

Irrigation regime	Water used under growth phases		
	S_1	S_2	S_3
I_1	98.2	97.2	99.1
I_2	92.2	93.3	91.4
SE_D	0.098	0.098	0.098
CD (P=0.05)	0.2	0.2	0.2

Production efficiency : The production efficiency was maximum under the water management practice of I_2 I_1 I_2 and least under continuous submergence (Table IV). Production efficiency was higher under I_2 irrigation regime during vegetative and ripening phases; whereas, during reproductive phase it was better under I_1 regime (Table VI).

TABLE VI Production efficiency (kg/grain/ha/cm) under the two irrigation regimes at the growth phases.

Irrigation regime	Production efficiency under growth phases		
	S_1	S_2	S_3
I_1	79.9	84.4	79.8
I_2	84.5	80.0	84.6
SE_D	2.2	2.2	2.2
CD (P=0.05)	4.6	4 6	4.6

The low production efficiency under continuous submergence observed in this study can be attributed to the increased water use under continuous submergence without any additional production than in the other treatments. At the International Rice Research Institute, Philippines the average efficiency was reported to be the highest at seven day irrigation interval and lowest under continuous submergence (Anon, 1973).

The increased water use under I_1 treatment over I_2 during vegetative phase and ripening phases could not bring about any additional benefit on grain yield and therefore the I_2 regime which used lesser delta was more efficient in production during the vegetative and ripening phases. During reproductive phase under I_1 regime the increase in yield was relatively higher than the increased water used. Evidently the I_1 regime was more efficient in grain yield production per unit of water used than I_2 regime.

To sum up water management practice of submergence to saturation during reproductive phase and saturation to field capacity during vegetative and ripening phases contributed to higher yield and efficient production per unit of water used in rice IR 20 under low land conditions.

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