https://doi.org/10.29321/MAJ.10.A03097

Madras agric. J. 65 (7): 435—440, July, 1978.

Water Use, Components of Water Loss and Yield of Summer Rice Under Different Water and Fertility Levels*

ARVIND KUMAR[1] and PANJAB SINGH[2]

Jaya and B.C. 5 varieties of rice were grown in field under 90, 120 and 150 kg N/ha, and saturation to field capacity, 5 cm submergence to saturation and 10 cm submergence to cracking levels of soil moisture in summer seasons of 1971 and 1972, to study their yield response and water need and to quantify various components of water loss. Results revealed that between two varities, Jaya yielded significantly higher (49.2 Q/ha) than B.C. 5 (34.8 Q/ha). Varieties responsed upto 120 kg N and yielded, on an average, 45.4 Q grain/ha levels. Yield of 44.8 Q was recorded at soil moisture level of 5 cm submergence to saturation as against 44.5 Q at 10 cm submergence to soil cracking or 36.7 Q at saturation to field capacity. On an average the total amount of water applied in 10 cm submergence to cracking treatment (2828 mm) was 17.4 and 9 per cent higher than in saturation to field capacity and submergence to saturation treatments respectively. Loss through percolation amounted to nearly 61 per cent which decreased with decrease in moisture levels of the soil. On the contrary, ET loss in case of 10 cm submergence to cracking was only 31 per cent and increased with decrease in the moisture levels. Highest loss 38 per cent was recorded in saturation to field capacity treatmnt. A total of five to seven per cent of the losses could not be accounted for. Water use efficiency was higher in 5 cm submergence to saturation treatment compared to others.

Usefulness of deep submergence for higher grain yields of rice through better tillering, leaf growth and early flowering has been emphasised by Senewiratne and Mikkelson (1961), On the contrary, Ghildyal and Jana (1967) and Singh and Pande (1973) reported shallow submergence of 5 to 7.5 cm to be superior to deep submergence. Further, Mane and Dastane (1971) reported tnat varieties NP-130 and IR-8 responded similarly to 4 cm submergence and to soil moisture between 0.2 and 0.5 atm tension. Similar to that of soil moisture effect, the response of this crop to the levels of N varied at different locations. Variety TN-1 responded lineraly up to 112 kg N/ha at Chinsurah Rice Research Station (Chaudhary, 1968), upto 120 kg at Delhi (Lakhdive and Prasad, 1970)

---

* Part of Ph.D. thesis submitted to the Meerut University by the senior author.

1. Asstt. Professor (Agronomy), G.B. Pant University of Agriculture and Technology, Pantnagar.

2. Agronomist, Central Arid Zone Research Institute, Jodhpur.

and upto 160 kg at Bhubaneswar (Lenka, 1971). Thus, variation in the crop response to the management practices is not only varietal but also seasonal.

A significant quantity of water applied in rice fields is lost through various sources. A report from Japan, Amatatasn (1957) and Peterkung (1965) have indicated loss of water through percolation alone during the crop growth at various places. Crop duration and quantity of water applied are important factors to account for such losses. In India also many scientists have attempted to determine total water need of rice grown either in *kharif* or in summer but only little attempt has been made to estimate various components of water loss separately. This research project, therefore, was conducted to work out the yield response and water need of rice varieties grown in summer under different levels of soil moisture and nitrogen, besides quantifying various components of water loss.

MATERIALS AND METHODS

Field experiments were conducted at the experimental farm of Meerut University, Meerut, India during the summer seasons (April-June) of 1971 and 1972. The experimental soil was sandy loam. The experiment was laidout in a split-plot design with three replications. Two rice varieties viz. Jaya and B.C. 5 were grown in main plots while three treatments of N viz. 90, 120 and 150 kg/ha and three soil moisture viz. saturation to field capacity, 5 cm submergence to saturation and 10 cm submergence to soil cracking applied in sub-plots. These soil moisture treatments will be written hereafter as moisture stress, submergence and cyclic submergence respectively. Rice seedlings (2/hill) of 25 days age were transplanted at 15 cm x 15 cm apart. Basal application of half of N as per treatment and total of 80 kg P_2O_5 and 60 kg K_2O/ha was made through urea, diammonium phosphate and muriate of potash respectively before final puddling. Remaining N was applied through urea in two equal splits-first at tillering and second at ear emergence stage of the crop.

Application of irrigation water in treatment of soil moisture stress was scheduled with Bourden gauge type soil moisture tensiometers while in submergence and cyclic submergence with graduated iron scales fixed in each plot. Quantity of water applied was workedout by Israelsen and Hansen (1962). Application of needed water was regulated with the discharge and time of run of the diesel pump installed at the head of the plot with a hose pipe attached. Evapotranspiration (ET) was measured with the help of sunken screened open pan evaporimeters designed and installed at two locations as per specifications of Sharma and Dastane (1966). These evaporimeters were provided with similar crop surroundings as those of experimental plots so as to account for the effect of advective heat, if any. The losses were measured daily at 8.00 AM and the average of the two pans was reported as daily ET. Total of each day for the full crop season added together given seasonal ET. For determining the full crop season added together gave seasonal ET. For determing the consumptive use and deep percolation of water in the crop season, two sets of empty durm (90 cm x 56 cm), one with and the other without bottom, were installed in duplicate in each of the treatment at 65 cm depth leaving a rim of 25 cm protruding above the soil. Soil dug to place the drums was replaced in the same order so as to avoid any variation caused due to drum installation, The area under each drum was also planted with rice seedlings. Water depth in each drum was maintained as per treatment. Depth of water was recorded daily with the help of iron scale fixed in the centre of each drum. The difference in depth of water between the drums with and without bottom gave the total water lost through percolation in 24 hours. Sum total of daily loss gave total seasonal percolation loss. Rain, if any, was accounted separately.

RESULTS AND DISCUSSION

The date on the yield and yield components are given in Table I. The perusal would indicate that Jaya yielded nearly 50 per cent higher than B.C. 5 in 1971 but only 34 per cent in 1972. Larger ear length, higher number of fertilespikelets and bolder grains per ear in Jaya contributed towards its yield potential. Varieties responded upto 120 kg only.

The increase under 120 and 150kg N over 90 kg was 19 per cent respectively in 1971 and 20 and 22 per cent in 1972.

The effect of N fertilization was marked on increasing the length of panicles and total number of fertile spikelets each panicle. Probably, higher application of N increased total reproductive energy available to plant which reflected on the increase in number of total fertile spikelets. When grain yields were pooled for two seasons, the interactive effect of variety and nitrogen was found significant (Table II). At each level of N, Jaya outyielded B.C.5. Both the varieties responded upto 120 kg level. A level higher than this decreased the grain yield of Jaya but not of B.C.5. Grain yield per unit of added N at 120 kg level was 46 kg/N for Jaya while only 29.7 for B.C.5.

Among different levels of soil moisture, submergence increased grain yield over soil moisture stress by 35 and 12 per cent in 1971 and 1972 respectively. Between submergence and cyclic submergence there was statistically no difference. Soil moisture stress developed in saturation to field capacity treatment had significant nagative effect on the number of shoot/plant. Lower N content in plants grown with low level of soil moisture resulted in lower production of shoots per plant (Saxena, 1974). Higher levels of soil moisture increased the number of fertile spikelets and weight of grains. Water deficit in plant affects photosynthesis through stomatal closure and thereby reduction in rate of CO_2 exchange (Singh and Pande, 1973). It does not need to be

TABLE I. Yield and yield components are affected by different treatments

Treatments	No. of productive tillers/plant		Ear length (cm)		No. of fruits spikelets/ear		Grain weight /ear(g)		Grain yield (q/ha)	
	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972
Varieties										
Jaya	6.40	7.90	23.40	24.65	98.31	96.54	2.31	2.36	47.92	50.46
B.C. 5	8.77	8.30	19.35	19.80	77.10	83.41	1.30	1.49	32.03	37.63
SEm±	0.33	0.10	0.35	0.18	1.37	3.63	0.07	0.06	1.86	1.62
L.S.D.(0.5)	2.01	—	2.13	1.10	8.34	—	0.43	0.37	11.32	0.86
Nitrogen (kg/ha)										
90	7.35	7.76	21.03	21.70	78.16	84.28	1.65	1.88	34.39	38.62
120	7.46	8.31	21.51	22.07	91.80	89.66	1.88	1.85	44.55	46.33
150	7.96	8.22	21.58	22.92	93.16	95.98	1.88	2.04	40.99	47.18
SEm∓	0.40	0.25	0.25	0.33	1.59	2.50	0.05	0.08	1.18	0.81
L.S.D.	—	—	—	0.95	4.59	7.22	0.14	—	3.41	2.34
Soil moisture										
Soil moisture stress	7.06	6.91	20.60	21.73	73.01	80.05	1.50	1.69	32.28	41.10
Submergence	7.73	8.88	21.56	22.45	91.45	95.70	1.86	2.06	43.56	46.03
Cyclic submergence	7.98	8.50	21.96	22.50	98.62	94.18	2.05	2.02	44.09	44.99
SEm±	0.40	0.25	0.25	0.33	1.59	2.50	0.05	0.08	1.18	0.81
L.S.D.(.05)	—	0.72	0.72	—	4.59	7.22	0.14	0.23	3.41	2.34

TABLE II. Effect of variety and nitrogen interaction on the grain yield

N (kg/ha) Varieties	90	120	150		
Jaya	42.44	55.26	49.86	SEm±	1.01
B. C. 5	30.56	35.61	38.30	L.S.D. (.05)	2.85
SEm±	2.06				
L.S.D. (.05)	6.63				

respectively. This would be more for sandy loam soil compared to other rice soils where deep per location is reduced considerably through pudding and other cultivation practices. Higher water depth or water head on soil with increase in soil moisture levels, especially in submergence and cyclic submergence, was probably the reason for higher perlocation loss. This loss was comparatively less in summer 1971 than that in 1972 which may be attributed to difference in quantum of water applied for variation in the climatic conditions in two seasons. ET loss as per cent of total applied was more at lower levels of soil moisture through the absolute quantity of total water applied was more at higher levels. In otherwords, per cent less through ET was governed by the amount of water applied in each treatment. High ET loss in summer is attributed to desiccating wind with high velocity in the season. About 5-7 per cent of water lost through other source could not be accounted for.

It may be concluded that higher yield and productivity (economic yield/unit area) of summer rice could be attained through judicious use of water and nitrogen. Growing Jaya variety with 120 kg N/ha and irrigation at 5 cm submergence to saturation soil moisture level maintained througout could produce 45 q grain/ha in the summer season. In other words, in such areas where water is not a limiting factor and land is left fallow in summer seasons, rice could be successfully cultivated. Further, to meet the high evaparative demand of the atmosphere for water in summer season, 5 cm submergence to saturation of soil moisture would be optimum. In this study soil moisture at less than 5 cm submergence to saturation level reduced the yield while higher level contributed much to percolation loss and not to the yield.

REFERENCES

AMATATSU, K. 1959. Growing Rice in Japan. Agriculture Development Series, Agriculture, forestry and fisheries. Production Conference cited by Peterkung, 1965.

CHAUDHARY, B.R. 1968. Response of paddy to fertilizer application. *Fert. News.* 13 : 29-31.

GHILDYAL, B.P. and R.K. JANA. 1967. Agrometeorological environment affecting rice yield. *Agron. J.* 59 : 786-87.

ISRAELSEN, O.W. and V. B. HANSEN. 1962. Irrigation principles and practices. John Willey and Sons, Inc. New York and London. International Ed., Toppan Co. Ltd.

LENKA, D. 1971. Response of TN-1 rice to water management practices and nitrogen fertilization in dry season. *Ind. J. Agric. Sc.* 41 : 166-72.

MANE, V.D. and N.G. DASTANE. 1971. Effect of water regimes on growth and yield of NP-130 and IR-8 rices. *Ind. J. Agric.* 16 : 1-5.

PETERKUNG. 1965. Determining water requirement of rice by field measurement in Thailand. *Intl. Rice Comm., News Letter.* 14 : 5-18.

SAXENA, A.K. 1974. Water and nitrogen requirement of rice. Unpub. Ph.D. Thesis submitted to Meerut University.

SENWIRATNE, S. T. and D. S. MIKKELSON. 1961. Physiological factors limiting growth and yield of *Oryza sativa* under unflooded condition. Plant and Soil 14 : 127-45.

SHARMA, R. G. and N. G. DASTANE. 1966. Use of screened evaporimeters in evapotranspirametry. Proc. Symp. Water Management, Udaipur.

SINGH, PANJAB and H. K. PANDE. 1973. Physiological response of rice (Cult-calrose) to soil moisture stress and nitrogen levels. 43rd session. *Natl. Aca. Sci. Univ.* of Jodhpur, India.

respectively. This would be more for sandy loam soil compared to other rice soils where deep per location is reduced considerably through pudding and other cultivation practices. Higher water depth or water head on soil with increase in soil moisture levels, especially in submergence and cyclic submergence, was probably the reason for higher perlocation loss. This loss was comparatively less in summer 1971 than that in 1972 which may be attributed to difference in quantum of water applied for variation in the climatic conditions in two seasons. ET loss as per cent of total applied was more at lower levels of soil moisture through the absolute quantity of total water applied was more at higher levels. In otherwords, per cent less through ET was governed by the amount of water applied in each treatment. High ET loss in summer is attributed to desiccating wind with high velocity in the season. About 5-7 per cent of water lost through other source could not be accounted for.

It may be concluded that higher yield and productivity (economic yield/unit area) of summer rice could be attained through judicious use of water and nitrogen. Growing Jaya variety with 120 kg N/ha and irrigation at 5 cm submergence to saturation soil moisture level maintained throughout could produce 45 q grain/ha in the summer season. In other words, in such areas where water is not a limiting factor and land is left fallow in summer seasons, rice could be successfully cultivated. Further, to meet the high evaparative demand of the atmosphere for water in summer season, 5 cm submergence to saturation of soil moisture would be optimum. In this study soil moisture at less than 5 cm submergence to saturation level reduced the yield while higher level contributed much to percolation loss and not to the yield.

REFERENCES

AMATATSU, K. 1959. Growing Rice in Japan. Agriculture Development Series, Agriculture, forestry and fisheries. Production Conference cited by Peterkung, 1965.

CHAUDHARY. B.R. 1968. Response of paddy to fertilizer application. *Fert. News.* 13 : 29-31.

GHILDYAL, B.P. and R.K. JANA. 1967. Agrometeorological environment affecting rice yield. *Agron. J.* 59 : 786-87.

ISRAELSEN, O.W. and V. B. HANSEN. 1962. Irrigation principles and practices. John Willey and Sons, Inc. New York and London. International Ed., Toppan Co. Ltd.

LENKA, D. 1971. Response of TN-1 rice to water management practices and nitrogen fertilization in dry season. *Ind. J. Agric. Sc.* 41 : 166-72.

MANE, V.D. and N.G. DASTANE. 1971. Effect of water regimes on growth and yield of NP-130 and IR-8 rices. *Ind. J. Agric.* 16 : 1-5.

PETERKUNG. 1965. Determining water requirement of rice by field measurement in Thailand. *Intl. Rice Comm., News Letter.* 14 : 5-18.

SAXENA, A.K. 1974. Water and nitrogen requirement of rice. Unpub. Ph.D. Thesis submitted to Meerut University.

SENWIRATNE, S. T. and D. S. MIKKELSON. 1961. Physiological factors limiting growth and yield of *Oryza sativa* under unflooded condition. Plant and Soil 14 : 127-45.

SHARMA, R. G. and N. G. DASTANE. 1966. Use of screened evaporimeters in evapotranspirametry. Proc. Symp. Water Management, Udaipur.

SINGH, PANJAB and H. K. PANDE. 1973. Physiological response of rice (Cult-calrose) to soil moisture stress and nitrogen levels. 43rd session. *Natl. Aca. Sci. Univ.* of Jodhpur, India.