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EFFECT OF IRRIGATION ON AVAILABILITY AND UPTAKE OF Zn AND Fe IN RICE (*ORYZA SATIVA* L) BASED CROP SEQUENCES

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ABSTRACT

An experiment was conducted during 1996-97 and 1997-98 at RAU Pusa to evaluate the irrigation requirements of different rice (*Oryza sativa* L.) - based crop sequences. A significant variation in yield equivalence (in terms of rice) in difference crop sequences was observed due to winter irrigation. Maximum yield equivalence (14.5 and 15.9 t/ha) was recorded in rice-potato (*Solanum tuberbsum* L.) - green gram (*Phaseolus radiata* L.) and minimum in rice-gram (*Cicer arietinum* L.) - green gram (*Phaseolus radiata* L.) (6.7 and 7.8 t/ha) sequence. A significant variation in availability and uptake of Zn and Fe was observed due to winter irrigation in all the crop sequences. Maximum available Zn and Fe was recorded in rice-wheat-green gram (0.307 & 9.53 ppm.). Among winter and summer irrigation, maximum available Zn and Fe were recorded with maximum frequency of irrigation followed by preceding lower levels. Total uptake of Zn and Fe was recorded in rice-potato-green gram (934.58 & 1040.09 and 5010.33, 5536.81 g/ha). Higher frequency of irrigation increased Zn and Fe uptake significantly followed by preceding lower levels.

Key words : Rice based crop sequences, irrigation, uptake of Zn and Fe.

In India, the deficiency of micronutrients has been observed in light textured and calcareous soils. The situation has been aggravated with the introduction of high-yielding crop varieties and intensive cropping system. Though a lot of information is a available on rice (*Oryza sativa* L.) - based crop sequence or different soil and agro-climatic conditions of the country. However information on the relative effect of irrigations on availability and uptake of Zn and Fe for individual crops under a particular sequence is very meagre. With these objectives, the present experiment was conducted with different rice-based crop sequences under varying levels of irrigation to quantify available Zn and Fe status in the soil and its uptake by different crop sequences.

MATERIALS AND METHODS

The field experiment was conducted during 1996-97 and 1997-98 at Pusa, in the sandy-loam calcareous (23% $CaCo_3$) soil having pH 8.4 (1:2 soil : water). The

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soil had electrical conductivity (0.24 ds/m) and water table of 2.0-6.1 m from soil surface during the crop season. The initial soil sample (10-30 cm) contained 0.48 ppm Zn/ha and 12.00 ppm Fe/ha. The experiment was laid out in split plot design with a combination of winter and summer irrigations in main plots and crop sequences in sub-plot with 3 replications. Rice was grown with common irrigation of 7 cm depth 3 days after disappearance of ponded water. For wheat and winter maize, IW : CPE ratios were 0.9 (I_1), 0.7 (I_2) and I_3) and for potato 1.2 (I_1), 0.9 (I_2) and 0.6 (I_3). Depth of each irrigation was 6 cm. Cumulative pan evaporation was computed as sum of the daily evaporation from standard United States Weather Bureau Class A Open Pan. In Indian mustard, irrigation levels were two irrigations at 30 and 60 days (I_1), one irrigation at 30 days after sowing (I_2) and the rainfed (I_3). In gram also I_1, I_2 and I_3 comprised two irrigations at 40 and 75 days, one irrigation at 40 days after sowing and rainfed respectively. Summer green gram and black gram were also grown at 2 irrigations with 20 and 40 days after sowing (W_1), one irrigation at 20 days after sowing (W_2), and rainfed (W_3). Five rice-based crop sequences were : rice-wheat-green gram (C_1)rice-winter maize-black gram (C_2), rice-potato-green gram (C_3), rice-mustard-green gram (C_4), and rice-gram-green gram (C_5).

Soil samples were collected from each plot in the beginning and the end of the experiment. In the processed soil sample available micronutrients were extracted with DTPA (Diethylene traiamine penta acetic acid) in extracting solution (0.005 M DTPA:0, 01 M triethanol amine (TEA) : 0.01 M ($CaCl_2$) adjusted at pH 7.3) in a soil : solution ratio of 1:2 and shaken for two hours (Lindsay and Norvell, 1978). The available Zn and Fe were determined in a clear aliquote with the help of Atomic Absorption Spectrophotometer Varian Tectron (AA 120). Oven dried ground and sieved samples were digested in tri-acid, mixture of HNO_3, $HClO_4$ and H_2SO_4 in 10:4:1 ratio. In the aliquote Zn and Fe were determined with the help of Atomic Spectrophotometer and the concentraiton in the sample were estimated from the calibration curve. Yield equivalence was calculated in terms of rough rice on the basis of the prevailing market price of different crops.

Results and Discussion

Yield equivalence

There were significant differences among the crop sequence with respect to yield equivalence. During both the years, maximum yield equivalence in terms of rice was recorded in rice-potato-green gram (14.57 and 15.95 t/ha), followed by rice-maize-black gram (10.39 and 11.55 t/ha). Winter crops mostly governed the variation in yield equivalence because rice was grown at the same level of irrigation in each case and variation in yields of summer crop was marginal. The highest yield equivalence in potato was due to much higher yield of potato than maize or wheat in spite of low selling price of potato as compared to these 2 crops. Suitability of potato as one of the crops in 3-crop rotation was also reported by Sharma *et. al.* (1988).

Winter irrigation also had a significant effect on yield equivalence. The yield equivalence at maximum frequency of irrigation (I_1) resulted in significantly maximum value (10.67 and 11.67 t/ha) followed by preceding lower levels. The interaction between winter irrigation and crop sequences turned out to be significant during both the years. Maximum yield equivalence (16.82 and 18.33 t/ha) was recorded in sequence having potato with maximum frequency of irrigation and minimum with lowest frequency of irrigation in the sequence having gram. This was because of the fact that optimum moisture helped in proper utilization of nutrients and maintaining the required hydration of protoplasm. The proper maintenance of hydration of protoplasm might have reduced the viscosity and increased the permeability of both water and nutrients (Stocker, 1960).

Available

There was marked reduction in available Zn status in the soil as compared to its initial value and showed a marked variation due to different sequences. The DTPA-Zn ranged between 0.298-0.308 ppm at the completion of first year of crop sequence and 0.298-0.309 ppm after completion of second year cycle as compared to the initial available Zn of 0.48 ppm. The reduction in Zn was due to adoption of intensive crop rotation, which has been observed by Singh and Sandhu (1980). Moisture might have imposed restrictions on the movement of Zn to reach the functional.

Winter irrigation had a significant effect on the available Zn content of the soil. The left over Zn in the soil was higher, when the frequency of irrigation was higher. In case of minimum frequency of irrigation, the value was lowest because of the fact that paucity of site for final assimilation while in case of higher frequency diffusion as well as availability was higher due to increase in temperature by frequent irrigation water.

Available Iron

There was significant effect of crop sequence on available Fe content of soil after completion of both the crop cycle. In both the years, the left over available Fe was higher in maize and potato dominating sequence (9.59 and 9.53 ppm). This might have been due to less utilization of Fe by maize, which is a C_4 plant requiring higher temperature for uptake of nutrients as compared to wheat, gram and mustard, which are primarily winter crops. The value in case of potato was lesser (80-90 ppm) in the haulms of potato against 420 ppm in case of gram, 200-205 ppm in the case of wheat (Thind *et. al.*, 1979).

Irrigation had a significant role on available Fe content of soil. In case of higher frequency of irrigation, the availability of Fe was higher because more frequency of irrigation led to reduce for relatively more period than lesser frequency of irrigation. The reduced situation might have increased the availability of Fe^{++} in the soil and ultimately the left over value was higher.

Zinc uptake

The total uptake of Zn by different crop

Table 1. Effect of irrigation on yield equivalence (in term of rice) and available Zn and Fe

Treatments	Yield equivalence (t/ha)		Available Zn (ppm)		Available Fe (ppm)	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
A) Winter irrigation						
I_1	10.7	11.7	0.321	0.309	10.24	9.97
I_2	9.7	10.7	0.305	0.307	9.32	9.10
I_3	8.4	9.2	0.289	0.289	0.893	8.26
C.D. (0.05)	0.07	0.5	0.011	0.007	0.204	0.131
B) Summer irrigation						
W_1	9.5	10.6	0.311	0.307	9.54	9.03
W_2	9.7	10.5	0.306	0.297	9.60	9.07
W_3	9.5	10.4	0.298	0.301	9.36	8.62
C.D. (0.05)	N.S.	N.S.	N.S.	0.007	N.S	0.131
C) Crop sequence						
C_1	8.3	8.9	0.307	0.309	9.07	8.91
C_2	10.4	11.3	0.301	0.303	9.78	9.34
C_3	14.6	15.9	0.298	0.300	9.59	9.53
C_4	8.0	8.8	0.311	0.298	9.53	8.91
C_5	6.7	7.8	0.308	0.299	9.50	8.85
C.D. (0.05)	0.27	0.45	0.008	0.007	0.160	0.22

sequences varied between 607-1040 g/ha in both the years. Among sequences, the uptake was higher in case of the sequence containing potato due to higher yield and a medium range of concentration. Though, the concentration of Zn was higher in mustard, the total uptake was relatively lesser as compared to cereals and potato due to low yield of mustard. Higher uptake of Zn under potato containing sequence has been reported by Singh and Sandhu (1980) as well.

Difference in the uptake of Zn was found to be non-significant due to summer irrigation indicating that uptake is mediated through temperature controlled diffusion, which is not greatly influenced by higher moisture content of soils in summer, but irrigation in winter significantly influenced Zn uptake. Maximum uptake was observed with higher frequency of irrigation, which decreased with decreasing number of irrigation in both the years of experimentation. This revealed that the effect of irrigation was mostly due to temperature-controlled diffusion to roots. As different sequences had different nature of crops during winter, whose concentraiton varied differently under different irrigations, no unidirectional trend was observed. Due to this diversity, the interaction between crop sequence and winter irrigation was found to be significant.

Table 2.: Effect of irrigation and crop sequence on Zn and Fe uptake

Treatments	Zn uptake (g/ha)		Fe uptake (g/ha)	
	1996-97	1997-98	1996-97	1997-98
A) Winter irrigation				
I_1	820.07	915.69	4877.75	5406.08
I_2	732.70	801.73	3992.35	4402.00
I_3	642.63	716.67	3352.82	3719.82
C.D. (0.05)	28.20	57.67	165.98	301.59
B) Summer irrigation				
W_1	729.22	816.41	4074.11	4572.86
W_2	740.24	814.76	4120.40	4510.56
W_3	725.95	802.91	4029.42	4444.57
C.D. (0.05)	N.S.	N.S.	N.S.	N.S.
C) Crop sequence				
C_1	681.28	730.00	4002.44	4314.25
C_2	791.00	849.04	4006.74	4295.62
C_3	934.58	1024.09	5010.33	5536.81
C_4	645.29	710.23	3686.62	4118.74
C_5	606.85	727.45	3667.07	4281.07
C.D. (0.05)	18.10	43.42	113.44	206.11

Iron uptake

The total Fe uptake in various crops sequences generally ranged between 3.7-5.5 kg/ha per crop sequence. Initial available Fe in the soil was around 24 kg/ha. Though soil Fe may be higher, Fe management becomes highly imperative because in the calcareous soil, where pH is high, Fe is precipitated as :

$$Fe(OH)_2\text{---}Fe_2(OH)_3\text{---}Fe_2(CO_3)\text{---}Fe_2CO_3$$

Which is highly insoluble. Hence, high pH and high carbonate content resulted in the precipitation and unavailability of Fe. Fe uptake was significantly influenced by different crops sequences. Though the uptake was highest in case of sequence containing potato. Similar results were also observed by Singh and Sandhu, 1980. The magnitude of increase was relatively low due to lower concentration of Fe in potato tuber and haulm. The uptake was almost equal in case of sequence containing gram and mustard because in the mustard the concentration was higher in grain, while in case of gram in straw, which balanced each other and equalized the total uptake.

As iron is a redox element, its availability is generally governed by application of water and organic matter, which help in creating reduced condition. Winter irrigation significantly influenced the Fe uptake indicating that irrigation could produce environment to increase Fe availability. But the same level of irrigation could not control the redox situation in summer because of high rate of evapotranspiration and therefore, could not produce significant difference in uptake.

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