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ALLEVIATION OF SALT EFFECTS ON FLOODED RICE (*ORYZA SATIVA* L.) BY NITROGEN FERTILIZATION

F. Azam, M. Ashraf and A. Lodhi
Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan

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Rice (*Oryza sativa* L. var. IR-6) was grown in pots treated with varying levels of salts and ammonium nitrogen (N). Salinization of soil caused a significant decrease in different yield components of rice while N application alleviated adverse effects of salts to a greater extent. All yield components showed a significant improvement due to applied N. The root biomass showed a close correlation with the above ground plant components indicating a direct bearing of root biomass on the overall plant performance.

Key words: Rice, Salinity, Root Biomass, N use efficiency.

Introduction

Nitrogen (N) is the most common nutrient element required for crop production [1]. The problem of low N availability is aggravated in salt affected soils where organic matter and N content are low [2] and mineralization of N is partially or completely inhibited [2-4]. Since organic matter is a predominant source of plant available N [1,5-7] retardation of its mineralization is bound to exert a negative effect on the availability of N to plants. Therefore, in addition to negative effects of high salts on plant physiology, reduced availability of N may be an important factor inhibiting the growth of plants on saline soils. This assumption is supported by the observation that plants grown on salt-affected soils derived only 20% or less of their N from the soil [8] whereas those growing on normal soil obtained 80% or more of their N from soil [5-7]. Although positive effects of N application on different yield components of crop plants are well documented for normal agriculture soils similar information for salt-affected soils is meagre.

The objectives of this investigation were to study: (i) the effects of different levels of applied N on yield and yield components of flooded rice grown in soil at 3 salt levels, (ii) the relationship of root biomass with above-ground plant components, and (iii) the efficiency of N use from salinized and non-salinized soil.

Materials and Methods

The experimental soil collected from the top 15 cm layer of a field at the Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan, was air-dried, crushed and passed through a 2 mm sieve. Physico-chemical properties of the soil were: pH (1:1), 7.4; electrical conductivity (EC), 1.3 mmhos/cm; organic C, 0.6%; total N, 0.06% (598 $\mu g\ g^{-1}$ soil); NH_4-N, 7 $\mu g\ g^{-1}$ soil; NO_3- N, 26 $\mu g\ g^{-1}$ soil; sand, 31%; silt, 41% clay, 28%.

Five kilograms of the air dried soil were packed in 36 plastic pots (6 kg capacity; height, 22 cm; diameter, 18 cm). One set of 12 pots was irrigated with 1600 ml of water, a second set with 1600 ml of a salt solution containing 3840 $\mu g\ ml^{-1}$ salts (NaCl, $CaCl_2$, $MgCl_2$ and Na_2SO_4 mixed in ratio of 4:5:1:10) and the third set with double the concentration of salts as that in the second set. Total salts added per pot amounted to either 6 or 12 gm (untreated soil contained 200 ppm soluble salts or 1 gm salts per pot). Each pot also received P and K as KH_2PO_4 at the rate of 100 and 126 mg pot^{-1}. Triplicate pots in each set received N at the rate of 0, 300, 450 and 750 mg per pot through $(NH_4)_2SO_4$ in three splits at the time of transplanting, at tillering and before panicle initiation. After soil treatment, three 4 week old rice (*Oryza sativa* L.; var. IR-6) seedlings were transplanted to each pot in July 1990. The plants were grown to maturity under flooded conditions using deionized water and harvested in Nov. 1990. Data on various growth and attributory characters and N recovery were collected at harvesting time and presented in Tables 1-4.

Results and Discussion

Increasing levels of salinity tended to cause a progressive decrease in growth and development of paddy roots and shoots as reflected by various attributes under consideration (Table 1). Application of fertilizer N caused a significant improvement in all agronomic parameters, both in the presence and the absence of salts and alleviated the adverse effects of salts to a significant extent. Recovery of N and its distribution in different plant parts (Table 2) in relation to different treatments followed the trend similar to that of dry matter yield and significant linear correlation (r = 0.98) was observed between N uptake and dry matter yield.

Application of fertilizer N caused a reduction in the per cent dry matter yield attributable to root and straw while an increase was observed in case of grain, both in the presence and in the absence of salts (Table 3). Relatively higher proportion of N yield than that of dry matter yield (57% vs. 37%, average for all treatments) was attributable to grain portion in different treatments. The level of salts had no bearing on the partitioning although N application caused a significant increase in partitioning of dry matter and N yield to grain as compared to control. Similarly, partitioning of dry matter and N yield to grain was also not affected by salinity. Dry matter and N yield of roots exhibited significant correlation with both dry matter and N yield of above-ground plant parts (Table 4).

Excessive salts inhibit the mineralization of organic N in soil [2-4] thereby leading to N starvation of plants. Under salt affected conditions, therefore, availability of N may be one of the important determinants of plant growth and productivity. In the present study, applied N caused a significant improvement in growth and yield of rice, the relative improvement being better in salinized than in non-salinized soil suggesting that N application may considerably alleviate the negative effects of salinity on plant growth. The ratio of extra dry matter production to N uptake due to applied N was similar in both salinized and non-salinized soil. Therefore, the reduction in dry matter yield under salinized conditions could be due in part to the retarded availability of N from native soil organic matter. However, once taken by the plants, utilization of N for grain production was similar since harvest index and N harvest index increased with increasing amounts of added N but did not exhibit significant differences in salinized or non-salinized soil.

The relative improvement in different plant parameters due to applied N was higher under salinized than that under non-salinized conditions. This could possibly be due to the increased availability of native N to plants grown in salinized soil receiving NH_4-N where inhibition of nitrification [4] will lead to accumulation of NH_4-N. The interchange of NH_4-N with native soil N, the so-called "pool substitution" [9] will release additional amounts of N from soil organic matter and its uptake by plants. Azam *et al.* [10] reported a significant increase in the uptake of native soil N by rice following application ^{15}N-labelled NH_4-N under both salinized and

TABLE 1. AGRONOMIC CHARACTERISTICS OF RICE GROWN UNDER DIFFERENT CONDITIONS.

Salts added (gm pot^{-1})	N added (mg pot^{-1})	Dry matter yield (gm pot^{-1}) Root	Straw	Grain	Total	Harvest index	No. of spikes pot^{-1}	No. of filled grains	%Seed set	100-Grain weight
0	0	10.6	24.4	15.7	50.7	0.39	11.3	715	70.4	2.19
	300	13.8	33.5	32.0	79.3	0.49	14.0	1413	80.5	2.26
		(31)	(37)	(104)	(57)	–	(24)	(98)	–	–
	450	16.0	39.6	42.2	97.8	0.52	16.0	1771	89.2	2.38
		(52)	(62)	(169)	(93)	–	(42)	(148)	–	–
	750	23.0	52.9	65.1	132.0	0.51	22.0	2562	88.6	2.19
		(118)	(117)	(258)	(161)	–	(95)	(258)	–	–
6	0	8.1	20.7	12.3	41.1	0.37	11.0	625	74.5	1.97
	300	11.5	29.3	27.5	68.4	0.48	14.0	1061	81.9	2.59
		(43)	(42)	(123)	(66)	–	(27)	(70)	–	–
	450	11.8	33.1	30.9	75.7	0.48	15.0	1585	83.0	1.95
		(45)	(60)	(151)	(84)	–	(36)	(154)	–	–
	750	18.5	48.9	50.8	118.1	0.51	27.0	2323	87.1	2.19
		(128)	(137)	(312)	(188)	–	(146)	(272)	–	–
12	0	4.9	15.8	7.2	27.9	0.31	8.0	386	68.2	1.88
	300	5.8	22.3	18.8	46.9	0.46	14.0	875	77.2	2.15
		(19)	(41)	(160)	(68)	–	(75)	(146)	–	–
	450	9.5	30.8	26.8	67.1	0.47	18.0	1246	80.6	2.15
		(74)	(95)	(271)	(140)	–	(125)	(223)	–	–
	750	10.8	37.4	38.4	86.5	0.51	25.0	1780	85.7	2.16
		(120)	(137)	(430)	(210)	–	(213)	(361)	–	–
LSD (P=0.05)		1.2	2.1	3.4	3.1	0.03	1.8	101	6.8	0.12
		(8)	(11)	(21)	(22)	–	(11)	(25)	–	–

Table 2. Nitorgen Yield and its Distribution (Italicized Figures Pertain to Per Cent Increase Over Control Due to Applied N).

Salts added (gm pot^{-1})	N added (mg pot^{-1})	N yield (mg pot^{-1})				Nitrogen harvest index
		Root	Straw	Grain	Total	
0	0	57.7	99.0	140.9	297.6	0.59
	300	71.0	135.6	310.1	516.6	0.70
		(23)	(37)	(120)	(74)	–
	450	90.1	156.9	461.6	708.3	0.75
		(56)	(59)	(228)	(138)	–
	750	144.3	238.0	694.3	1076.6	0.74
		(150)	(140)	(393)	(262)	–
6	0	42.7	86.0	132.9	261.5	0.61
	300	59.9	114.0	280.0	453.8	0.71
		(40)	(33)	(111)	(74)	–
	450	73.1	148.2	344.8	566.1	0.70
		(71)	(73)	(160)	(117)	–
	750	111.6	236.6	648.6	996.8	0.73
		(162)	(175)	(388)	(281)	–
12	0	24.5	70.6	72.8	167.9	0.51
	300	29.8	106.4	201.1	337.4	0.65
		(22)	(51)	(176)	(101)	–
	450	56.4	140.1	301.1	497.7	0.68
		(131)	(99)	(314)	(197)	–
	750	61.7	192.8	504.9	759.4	0.72
		(152)	(173)	(593)	(352)	–
LSD (P=0.05)		6.7	20.2	24.6	56.5	5.3
		(21)	(18)	(33)	(38)	–

Table 3. Percent Distribution of Dry Matter and N Yield in Different Plant Parts.

Salts added (gm pot^{-1})	N added (mg pot^{-1})	% of dry matter yield			% of N yield		
		Root	Straw	Grain	Root	Straw	Grain
0	0	20.8	48.2	31.0	19.4	33.3	47.3
	300	17.4	42.2	40.4	13.7	26.2	60.1
	450	16.4	40.5	43.1	12.7	22.2	65.1
	750	17.4	40.1	42.5	13.4	22.1	64.5
6	0	19.7	50.3	30.0	16.3	32.9	40.9
	300	16.9	42.9	40.3	13.2	25.1	51.7
	450	15.5	43.7	40.8	12.9	26.2	60.9
	750	15.6	41.4	43.0	11.2	23.7	65.1
12	0	17.6	56.5	25.9	14.6	42.1	43.3
	300	12.4	47.4	45.8	8.8	31.5	59.7
	450	14.2	45.8	40.0	11.3	28.2	60.5
	750	12.5	43.2	44.3	8.1	25.4	65.5
LSD (P=0.05)		1.1	3.7	2.6	1.3	3.2	3.1

Table 4. Correlation (r)* of Root Dry Matter and Root N with Dry Matter and N Yield of Above-ground Plant Parts (Values from All Treatments were Used).

Root parameters	Dry matter yield			N yield		
	Straw	Grain	Total	Straw	Grain	Total
Dry matter yield	0.95	0.92	0.95	0.86	0.88	0.90
N yield	0.95	0.92	0.96	0.95	0.92	0.96

* All correlations are significant at 1% level of significance.

non-salinized conditions. They attributed this increased to added nitrogen interaction through pool substitution or enhanced mineralization of N from the native soil organic matter [9]. Since pool substitution is closely related with immobilization of N in soil [9] and the later is essentially root-driven [9,11], increased root biomass at increased levels of added N (Table 1) would lead to higher pool substitution.

One of the attributes of N application is the increase in root biomass [12-14]. The enhancement in soil N uptake following NH_4 addition is sometimes attributed to increased root growth resulting in increased soil volume being explored by the plant for nutrients including N[9]. In the present study, root growth was significantly improved due to N application both in the presence and in the absence of salts; the improvement being more in salinized soil. This could lead to added nitrogen interaction with consequent increase in uptake of N from both soil and fertilizer. Added nitrogen interaction under such conditions has been reported previously [10]. In addition, a well developed root system will presumably support higher microbial activity in the rhizosphere with concomitant benefits to the plants in terms of enhanced supply of N through N_2 fixation and production of growth hormones [15,16]. Highly significant correlations (Table 4) observed between root parameters (dry matter and N yield) and dry matter and N yield of above-ground plant components suggests that considerable increase in crop yields may be possible by improving the root system through agronomic or biotechnological means.

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