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Mixed Ammonium and Nitrate Nutrition of Wheat Under Different Soil Salinity Regimes

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Abstract

Effect of varying NH_4^+ -N: NO_3-N ratios on wheat yield and N utilization on artificially salinized soil with salinity regimes of 0, 6 and 12 dS m^{-1} under pot culture conditions revealed that productive tillers, grain, straw and total biomass were the highest with NH_4^+ -N: NO_3-N ratio of 50:50. These growth parameters were the lowest where either NH_4^+ -N or NO_3-N was used alone. Similarly N uptake and N recovery in wheat was significantly higher at optimum NH_4^+ -N: NO_3-N ratio of 50:50 than where NH_4^+ -N or NO_3-N alone was used. Increasing salinity levels significantly reduced the wheat yield and N utilization. However, balanced N nutrition was helpful to ameliorate the harmful affect of salinity to some extent.

Introduction

Out of total 80 percent fertilizers are nitrogenous used for crop production in Pakistan (NFDC, 1997). The nitrogen utilization by grain crops has been low being only 42-63 percent in Montana (USA) for spring wheat (Christensen and Killorn, 1981) and under the calcareous alkaline soil conditions of Pakistan it is presumed to he still lower. The applied fertilizer is thus lost from soil plant system through denitrification, volatilization, leaching and run off.

Efficient fertilizers practice maximize the utilization of applied fertilizers by the crop in a most economical way for optimum crop production. Grain yield increase is closely related with the increased application of fertilizer or more truly the increased uptake of nitrogen (Olsen, 1986; Li *et al*., 1982). Therefore, numerous strategies such as use of N sources, slow release fertilizer, placement techniques and nitrification inhibitors have been devised to reduce nitrogen losses and improve fertilizer use efficiency (Freney *et al*., 1992; Slangen and Kerkhoff, 1984). In Pakistan nitrogenous fertilizer used for crop production are mainly urea, ammonium sulphate and calcium ammonium nitrate. Urea and ammonium sulphate are ammonium forming and ammonium containing fertilizers. Whereas, calcium ammonium nitrate contains 50 percent NH_4^+-N and 50 percent NO_3 -N.

Studies have revealed that higher crop yields may be obtained with a mixture of nitrate and ammonium than either source alone (Bock, 1986; Hageman, 1984; Olsen, 1986). Mixed ammonium and nitrate nutrition has an energy saving effect/or minimizes pH changes and/or optimizes ATP synthesis (Cox and Reisenauer, 1973). In hydroponic studies beneficial effects of mixed nitrogen nutrition (NH_4^+ and NO_3) have been reported on the yield of wheat (Ali *et al*., 1995) and Oat (Ali, 1993).

In Pakistan 5.73 million hectares of land are affected by salinity and sodicity (Muhammad, 1983). On salt affected soil a substantial reduction in cereal crop yield has been reported (Naeem *et al*., 1998). Ahmed *et al*. (1997) reported marked reduction in straw and grain yield of wheat at a ECe of 15 dsm^{-1}. A 50 percent reduction in wheat yield occurred at Ec 8.5 dsm^{-1}. The extent of salinity inhibition of growth however may affected by the nutritional status of plant (Bernstein *et al*., 1974). Increasing NH_4 proportion in the total of 6 mM in nutrient solution increased wheat shoot dry weight, did not change N concentration in the dry mass but increased percentage either with or without 60 mM NaCl (Silberbush and Lips, 1991). Shaviv *et al*. (1990) reported larger wheat dry matter and protein yield with ammonium and nitrate than nitrate alone on sandy or clay soils. The relative increased in yield and N and P accumulation due to mixed N nutrition were significantly higher in the salinized soil. However, such information regarding the effect of mixed ammonium and nitrate nutrition on nitrogen utilization by wheat under different soil salinity regimes is still meaged and all together lacking in Pakistani soil conditions. Present investigations are an endeavour in this direction.

Materials and Methods

A pot culture experiment was conducted in the glass house of National Agricultural Research Centre, Islamabad to investigate the effect of mixed ammoniacal (NH_4^+) and nitrate (NO_3^-) nitrogen nutrition on wheat under different salinity regimes. The study was conducted on normal Gujranwala loam soil collected from farm land of the center. The soil was collected from 0-15 cm soil depth. The soil was dried and passed through 2 mm sieve before use. Physico-chemical characteristics of soil are given in Table 1. Five kg of the sieved soil was used in plastic pots.

The soil was artificially salinized to three salinity levels i.e., 0, 6 and 12 dSm^{-1} using sodium chloride. Salinity regime were created one week before sowing of wheat and soil

moistened to field capacity. NH_4^+–N treatments and tabulated as under:

Mixed NH_4^+ –N and NO_3–N treatments.

Treatment	NH_4^+ –N (%)	NO_3–N (%)	N-sources
T_1	0	0	
T_2	100	0	Urea
T_3	75	25	$(NH_4)_2SO_4$, NH_4NO_3
T_4	50	50	NH_4NO_3
T_5	25	75	HNO_3, NH_4NO_3
T_6	0	100	HNO_3

The same H ion concentration was maintain in all treatments using HCI in treatments where HNO_3 was not used. Nitrogen was applied at I50 mg kg^{-1} in solution form and well mixed in the pots before sowing of wheat. Dicyandiamide was used as a nitrification inhibitor at 2.5 mg kg^{-1} in all treatments to maintained above mentioned NH_4^+–N: NO_3–N ratios. The experiment was organized in completely randomized design. Phosphorus and Potassium were applied at 50 and 100 mg kg^{-1} respectively. The seed of wheat cultivar Ingelab 91 were sown in moist soil and covered with plastic sheet to avoid moisture loss through evaporation and to facilitate the germination. Experimental treatments were replicated thrice. After germination and establishment 5 plants per pot were kept. Crop was grown to maturity and watered as and when required. Grain and straw yield were recorded at the time of harvesting and nitrogen concentration determined in the plant material. N uptake and recovery were calculated. All the data were subjected to statistical analysis and treatment differences determined using LSD.

Results and Discussion

The investigations were carried out on originally normal non saline, non sodic) soil, which was alkaline in reaction pH 7.8). The soil was low in organic matter, total and mineral N. It was medium in available P and K (Table 1) the oil was artificially salinized at 0, 6 and 12 dSm^{-1}.

Table 1: Physico-chemical characteristics of the soil

Characteristics	Unit	Gujranwala Loam series
pH (1:1)	-	7.80
EC	(dS m^{-1})	0.25
$CaCO_3$	%	3.50
Organic matter	%	0.95
Available P	Mg kg^{-1}	0.76
Available K	Mg kg^{-1}	0.04
Total N	%	0.04
NH_4^+ –N	Mg kg^{-1}	10.00
NO_3–N	Mg kg^{-1}	13.00

Physical crop responses: Data relating to tillers, grain and raw yield total biomass and harvest index is given in Table 2. Productive tillers were significantly affected by N fertilizer treatments and the salinity regimes. Highest tillers are recorded in zero salinity treatment. Increasing levels salinity significantly reduced the tillers. Lowest-tillers were recorded at the highest salinity level (12 dS m^{-1}) Mixed NH_4^+ –N: NO_3 salinity level. Differences in tillers due to 75:25 and 25:75 NH_4^+–N: NO_3–N ratio were nonsignificant. However, application of either 100 percent NH_4^+–N or NO_3 –N gave lower tillers than the ideal NH_4^+–N: NO_3 –N ratio.

Harvest index was not significantly affected by mixed NH_4^+–N: NO_3–N nutrition treatments. Salinity levels had some effect on harvest index. It was significantly reduced at the highest salinity. Wheat yield reduction at higher salinity levels could be attributed to increased hydrostatic and osmotic pressures. Similar results were reported earlier, who recorded marked reduction in wheat at ECe 12 dSm^{-1}. 50 percent reduction in yield at ECe 8.5 dSm^{-1} has been reported.

Higher wheat yields with mixed NH_4^+–N: NO_3–N nutrition than NH_4^+–N or NO_3–N can be attributed to balanced uptake of the soil nutrients (Ali, 1993). Similar results were reported by Shaviv *et al*. (1990), Ali *et al*. (1995) and Ali (1993).

Ammonium N alone reduced the uptake of K, Ca and Mg. Nitrate -N alone reduced the uptake of sulphate, phosphate and some micronutrient. Mixed NH_4^+–N: NO_3–N favoured the balanced uptake of anions and cations therefore, gave higher yields than other treatments.

Nitrogen utilization by wheat: Nitrogen concentration in wheat grain was much higher than in straw (Table 3). Nitrogen concentration was significantly affected by salinity levels and mixed NH_4^+–N: NO_3–N nutrition treatments. Nitrogen concentration decreased with increasing salinity levels. Thus lowest concentration were recorded at the highest salinity level (12 dSm^{-1}), Similar results have been reported by Ali (1993). Nitrogen concentration was the highest with mixed NH_4^+–N: NO_3–N ratio of 75-25 and it was significantly lower with either NH_4^+–N or NO_3–N than the mixed NH_4^+–N: NO_3–N nutrition.

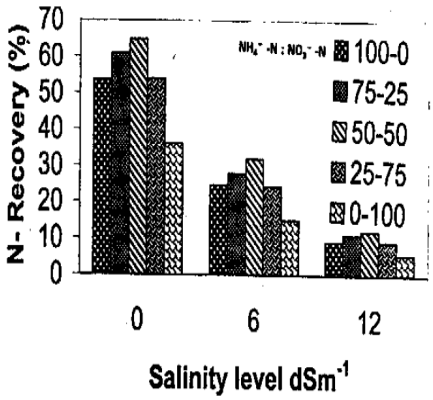

Fig. 1: Effect of salinity and mixed ammonium and nitrate nutrition on nitrogen utilization by wheat

Table 2: Effect of salinity and mixed NH_4^+–N and NO_3^-–N nutrition on wheat

Treatments		Productive tillers (No./pot)	Grain yield (g pot^{-1})	Straw yield (g pot^{-1})	Biomass (g pot^{-1})	Harvest index
Nitrogen NH_4^+–N:NO_3–N	Salinity Regimes (dS m^{-1})					
Non	0	3.33 ghi	3.21l	3.47l	6.67n	0.481ab
100-0	0	9.00c	25.08c	27.66d	52.71d	0.475ab
75-25	0	10.67b	29.54b	33.43b	62.95b	0.469ab
50-50	0	12.00a	32.97a	36.82a	69.78c	0.472ab
25-75	0	9.67bc	29.08b	31.13c	60.08c	0.484ab
0-100	0	7.67d	23.96d	26.83e	50.79e	0.472ab
Non	6	2.67hi	1.66m	1.77m	3.430	0.484ab
100-0	6	3.33ghi	13.209	14.90f	27.431	0.481ab
75-25	6	4.33fg	14.90	17.25	32.13g	0.463abc
50-50	6	6.33e	17.87e	18.42f	36.28f	0.492a
25-75	6	4.67f	14.39f	16.77g	31.16fi	0.1462abc
0-100	6	3.33ghi	11.84h	13.87h	25.72j	0.461abcd
Non	12	2.33i	0.72n	1.01m	1.73p	0.412f
100-0	12	3.00hi	6.08k	8.08k	14.15m	0.43ef
75-25	12	3.67fgh	7.16j	9.25j	16.4l	0.436cdef
50-50	12	4.67f	8.05i	10.67i	18.73k	0.431def
25-75	12	3.33ghi	7.18j	8.48jk	15.66l	0.459bcde
0-100	12	30.00hi	6.01k	7.74k	13.75m	0.438cdef

Values followed by same letters are not significantly different from each other at 5 percent level of significant

Table 3: Effect of salinity and mixed ammonium and nitrate nutrition on nitrogen utilization by wheat

Treatments		N. Concentration (%)		Nitrogen uptake mg/pot			R-recovery (%)
Nitrogen NH_4^+–N:NO_3–N	Salinity Regimes (dS m^{-1})	Grains	Straw	Grains	Straw	Total	
Non	0	0.26l	0.11l	8.36m	3.92k	12.27m	-
100-0	0	1.25a	0.36a	314.3d	99.54b	41 3.8c	53.54c
75-25	0	1.2b	0.34a	354.2b	114.8a	469.0b	60.9b
50-50	0	1.16c	0.31c	382.4a	115.3a	497.8a	64.74a
25-75	0	1.11d	0.30c	322.8c	94.4ac	417.2c	53.99c
0-100	0	0.92h	0.23g	220.4e	62.6d	283.0d	36.10d
Non	6	0.17m	0.077n	2.81mn	1.35kl	4.16n	-
100-0	6	1.13d	0.287d	149.1h	40.80f	189.9g	24.779
75-25	6	1.12d	0.267e	166.9g	46.02e	212.9f	27.83f
50-50	6	1.11d	0.247f	198.3f	45.46e	243.7e	31.94e
25-75	6	1.04e	0.217h	150.2h	36.369	186.6g	24.339
0-100	6	0.79j	0.183i	93.891	25.42h	117.9h	15.17h
Non	12	0.10n	0.037o	0.71n	0.38l	1.08n	
100-0	12	0.92h	0.177i	56.15k	14.28i	70.43k	9.25j
75-25	12	0.98f	0.159j	70.44J	14.51i	84.95j	11.18i
50-50	12	0.96g	0.137k	77.29j	14.55i	91.85i	12.1i
25-75	12	0.85i	0.113l	60.79k	9.6j	70.39	9.24j
0-100	12	0.61k	0.097m	36.68l	7.46j	44.07l	5.73k

Values followed by same letters are not significantly different from each other at 5 percent level of significant.

Nitrogen uptake in the grain, straw and grain straw (total) was significantly affected by salinity levels and mixed NH_4^+ –N and NO_3^- –N nutrition. Increasing levels of salinity significantly reduced the nitrogen uptake. Thus lowest uptake was recorded at the highest salinity level (12 dSm^{-1}). In general N recovery in wheat was the highest in N treatment without salinity. Increasing salinity levels significantly reduced N recovery. Thus lowest N recovery was recorded at the highest salinity levels (Table 3). N- recovery was significantly affected by different N treatments. N recovery was the highest with mixed NH_4^+–N; NO_3–N ratio of 50:50. Recovery was significantly lower with either NH_4^+ –N or NO_3^- alone (Fig. 1). Highest N recovery NH_4^+ –N and NO_3^- –N of 50:50 is attributed to

highest biomass production in this treatment due to balanced uptake of anions and cations. For greater biomass production more nitrogen was utilized by wheat. As a result N recovery was significantly improved with ideal NH_4^+–N; NO_3–N ratio. With either NH_4^+–N or NO_3–N alone wheat biomass production was significantly reduced due to hampered uptake of anion, cation and nitrogen. Increasing salinity levels caused significant reduction in N utilization and recovery due to increasing hydrostatic and osmotic pressures resulting in reduced uptake of water and nutrients included nitrogen. Therefore, increasing salinity levels caused a progressive decrease in N recovery by wheat. In view of the forgoing results/findings it is concluded that wheat production on salt affected areas of Pakistan can be, enhanced and N use efficiency improved by using fertilizers which contain NH_4^+–N and NO_3–N in equal proportion such as calcium ammonium nitrate (CAN). Therefore, CAN could be more efficient nitrogen source as compared to urea (NH4 forming fertilizer) and ammonium sulphate (ammonium containing fertilizer) for growing wheat.

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