

Nutrients Content and Their Uptake in Wheat as Influenced by time and Methods of Nitrogenous Fertilizer Application under Saline Environment

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Abstract

An experiment was conducted to determine the appropriate time and methods of nitrogenous fertilizer application in wheat under saline conditions. NPK content and their uptake along with sodium content in grain and straw were studied. Generally, the increasing salinity levels decreased the NPK content and their uptake both in grain and straw of wheat. The nutrient (NPK) content and their uptake were maximum on applying 1/3 of the total nitrogen to be applied at the time of sowing as basal dressing, 1/3 after first irrigation as top dressing and remaining as foliar spray i.e. 2% after second irrigation and 2% at ear formation. In wheat straw, the values of sodium content were 9.58, 9.13, 9.86 and 9.64 times more as compared to grain at S₁ (EC 2.4 dS/m), S₂ (EC 8.0 dS/m), S₃ (EC 12 dS/m) and S₄ (EC 16 dS/m) levels of salinity respectively.

Key words : Nutrients, Uptake, Wheat, Time, Saline environment.

World population is increasing with a high rate and India alone is having a population of more than one billion people. The food grain production in India during 2003-04 was around 213 million tones, which need to be increased vigorously in the coming decades for averting starvation. Increase in food production could be made possible either by extending area under crop production or by increasing average production per unit area. Of these increase in area could not be increased because of fast industrialization, urbanization and other infrastructure developments and if at all area exceeds then it will be possible only by deforestation for which we have to pay a heavy cost. So the increase in average production per unit area offers a possibility and this can be possible only by increasing the fertility of the soil and by modifying the traditional management practices to get maximum return especially from the problem soils e.g. saline soils. The economic importance of salt problems in irrigated areas is though recognized but not adequately realized and understood and a number of such problems still remain unanswered. Various workers have reported the higher salt content in the irrigation water in considerable areas of the country under cultivation. The irrigation with saline water markedly affects soil properties, plant growth (1) and conse-

quently the crop yield. To get maximum profitable returns from the crop grown under saline water irrigated areas, various methods like use of soil amendments, selection of salt tolerant crops and their varieties, judicious use of organic manures and inorganic fertilizers, suitable nitrogenous fertilizers along with the appropriate doses of phosphorus and potassium have been suggested to the farmers under moderately saline conditions. But the use of appropriate time and methods of fertilizer application and proper management practices have been recognized as an economic and convenient solution of the problem. The maintenance of an optimum level of fertility is essential for better crop production in normal and salt affected soils. The factual information in respect of fertility status of salt affected soils and response to fertilizers is meager because of limited use of such soils for crop production. It is commonly felt by rural community that fertilizer application to these soils is likely to further aggravate the salinity problem.

Increased fertilization has sometimes been advocated to alleviate growth inhibition by salinity with some emphasis on phosphorus and potassium; but with major attention to nitrogen. In all major nutrients nitrogen is considered to be the most limiting nutrient; hence its application to the soil should find an

Table 1. Physico-chemical properties of the experimental soil.

	Soil parameter	Values
1	pH	7.6
2	EC (dS/m)	1.00
3	Saturation percentage	18.20
4	Soluble cations (me/l)	
	Ca ⁺⁺ + Mg ⁺⁺	1.50
	Na ⁺	8.20
	K ⁺	0.20
5	Soluble anions (me/l)	
	CO ₃ ⁻	0.80
	HCO ₃ ⁻	1.50
	Cl ⁻	5.60
	SO ₄ ⁻	2.82
6	Organic carbon (%)	0.30
7	Available N (kg/ha)	155
8	Available P (kg/ha)	20
9	Available K (kg/ha)	180
10	CaCO ₃ (%)	0.72
11	Sand (%)	70.20
12	Silt (%)	14.50
13	Clay (%)	15.30
14	Textural class	Sandy loam

important place. Best utilization of nitrogenous fertilizer depends on the type of fertilizer, their doses and proper time and method of their application. Thus, before using, it is essential to determine their best time and method for application under different agro-climatic conditions. Keeping these in view, an investigation was carried out to study the nutrient (NPK) content and their uptake in wheat as influenced by time and methods of nitrogenous fertilizer application under saline environment.

Methods

To study the nitrogenous fertilizer response in wheat under saline conditions, an experiment was conducted at CCR (PG) College, Muzaffarnagar, Uttar Pradesh. The experiment was conducted in micro-plots. Sixty micro-plots of size 1.5 × 1.5 meter each, lined around with polythene up to a depth of 60 cm were made. Between the micro-plots a bund of half a meter was also left. Initial composite samples before applying treatments were taken from each micro-plot. Four types of saline water S₁, S₂, S₃ and S₄ of EC 2.4, 8, 12 and 16 dS/m were prepared artificially using tube well water by mixing CaCl₂, NaCl, MgCl₂, NaHCO₃ and

Table 2. Effect of different treatments on the NPK content (%) and uptake (kg/ha) and sodium content (%) in grain of wheat.

Treat-	Nitrogen		Phosphorus		Potassium		Sodium
	Con-	Uptake	Con-	Uptake	Con-	Uptake	Con-
	(%)	(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)
Salinity Levels							
S ₁	1.47	52.25	0.48	17.40	0.40	14.20	0.12
S ₂	1.64	55.17	0.47	15.65	0.37	14.09	0.15
S ₃	1.93	57.91	0.44	13.24	0.31	09.31	0.22
S ₄	2.02	48.93	0.38	08.98	0.27	06.55	0.25
SE ±	0.013	0.381	0.010	0.202	0.006	0.518	0.004
CD at							
5%	0.037	1.095	0.029	0.581	0.017	1.487	0.013
Time and Methods							
T ₁	1.53	45.63	0.42	13.20	0.34	10.08	0.18
T ₂	1.69	50.12	0.43	13.18	0.34	10.44	0.19
T ₃	1.76	52.69	0.44	13.61	0.33	10.14	0.17
T ₄	1.96	61.91	0.47	15.07	0.36	11.85	0.20
T ₅	1.89	57.48	0.45	14.04	0.34	10.43	0.20
SE ±	0.014	0.426	0.011	0.226	0.006	0.579	0.005
CD at							
5%	0.041	1.225	0.032	0.649	0.019	1.633	0.015

Na₂SO₄ salts. The ratio of cations as Na:Mg:Ca was kept 12:5:3 and anions Cl:SO₄:HCO₃ as 2:1:1 up to electrical conductivity (EC) 8 dS/m and beyond that 6:1:1 up to EC 16 dS/m. Pre-sowing irrigation with these saline waters were given according to lay out plan of the experiment. The plots were prepared well and recommended doses of P₂O₅ and K₂O (60 and 40 kg/ha) were given. The split doses of 120 kg/ha nitrogen were adjusted in various micro-plots based on following details: T₁—1/2 at the time of sowing-basal dressing + 1/2 after first irrigation-top dressing, T₂—1/3 at the time of sowing-basal dressing + 1/3 after first irrigation-top dressing + 1/3 after second irrigation-top dressing, T₃—1/3 at the time of sowing-basal dressing + 1/3 after first irrigation-top dressing + 1/3 at the time of ear formation-top dressing, T₄—1/3 at the time of sowing-basal dressing + 1/3 after first irrigation-top dressing + 2% foliar spray after second irrigation + 2% spray at ear formation, T₅—1/3 at the time of sowing-basal dressing + 1/3 after first irrigation-top dressing + 2% spray at ear formation.

The treatments were randomly given to each plot replicating thrice in randomized block design. The

Table 3. Effect of interaction of salinity of irrigation water and time and methods of fertilizer application on the nitrogen and potassium content (%) of grain of wheat.

Treatments	Time and methods				
	T ₁	T ₂	T ₃	T ₄	T ₅
Salinity Levels					
Nitrogen					
S ₁	1.43	1.43	1.47	1.52	1.51
S ₂	1.51	1.54	1.56	1.83	1.77
S ₃	1.73	1.80	1.90	2.18	2.05
S ₄	1.46	2.01	2.10	2.32	2.21
SE ±	0.029				
CD at 5%	0.083				
Potassium					
S ₁	0.40	0.39	0.40	0.41	0.42
S ₂	0.35	0.36	0.37	0.41	0.37
S ₃	0.30	0.31	0.26	0.37	0.32
S ₄	0.29	0.28	0.27	0.27	0.26
SE ±	0.013				
CD at 5%	0.039				

wheat variety HD-2329 was sown. Soil samples taken before sowing were analyzed for physico-chemical properties following the standard procedures and are given in Table 1.

Chemical constituents in grain and straw after harvest were estimated by various methods. The details of the methods are as follows. Nitrogen content : Calorimetric method, phosphorus content : Ammonium vanadate molybdate yellow color method, potassium content : Flame photometer method, Sodium content : Flame photometer method.

The uptake values of N, P and K in grain and straw were calculated using the content (%) of nutrient and its corresponding yield values.

Results and Discussion

Irrigation with saline water upsets the physiological and metabolic activities of the plant (1). Increasing levels of salt decreases the plant growth (2), size of leaf, plant height, nutrient uptake and amount of nutrient content in grain and straw.

Nitrogen Content and Its Uptake in Grain and Straw of Wheat

Increasing levels of salinity enhanced the nitro-

Table 4. Effect of different treatments on the NPK content (%) and uptake (kg/ha) and sodium content (%) in straw of wheat.

Treatments	Nitrogen		Phosphorus		Potassium		Sodium
	Con-tent (%)	Uptake (kg/ha)	Con-tent (%)	Uptake (kg/ha)	Con-tent (%)	Uptake (kg/ha)	Con-tent (%)
Salinity Levels							
S ₁	0.74	50.87	0.30	20.44	1.41	97.32	1.15
S ₂	0.75	51.46	0.28	18.85	1.33	89.98	1.37
S ₃	0.78	47.65	0.17	10.27	1.24	74.60	2.17
S ₄	0.83	49.27	0.14	6.96	1.10	66.31	2.41
SE ±	0.007	0.466	0.017	0.322	0.040	1.104	0.011
CD at 5%	0.020	1.339	0.050	0.926	0.117	3.171	0.031
Time and Methods							
T ₁	0.74	47.01	0.19	12.34	1.27	80.05	1.78
T ₂	0.75	48.11	0.21	13.23	1.27	81.80	1.76
T ₃	0.78	49.40	0.22	13.98	1.28	80.96	1.79
T ₄	0.81	54.16	0.24	16.26	1.27	85.40	1.78
T ₅	0.79	50.40	0.23	14.98	1.27	82.05	1.76
SE ±	0.008	0.521	0.009	0.360	0.018	1.235	0.124
CD at 5%	0.023	1.448	0.026	1.035	NS	3.545	NS

gen content in grain of wheat as compared to each preceding lower level of salinity (Table 2). In nitrogen uptake, it increased up to S₃ level, however at S₄ level of salinity N uptake reduced significantly compared to any lower level of salinity. Compared to T₁ treatment, T₂, T₃, T₄ and T₅ treatments enhanced the N content and N uptake significantly.

In straw also, each higher level of salinity increased the N content as compared to any lower level of salinity, except a non-significant difference, which was noticed between S₂ and S₁ levels of salinity. Nitrogen uptake was significantly decreased with S₃ as compared to S₁ level of salinity. Reduction in N uptake was also observed with S₄ level of salinity as compared to S₁ and S₂ levels but S₄ was significantly higher when compared to S₃ level. With regard to treatments, T₄ proved to be better than T₁, T₂, T₃ and T₅ treatments in both N uptake and content in straw.

Increased nitrogen content in grain and straw has also been confirmed by Bhatnagar and Yadav (3) and Bangal et al. (4). The increased nitrogen content may be the consequence of stunted growth and low dry matter production due to salinity. Regarding the

Table 5. Effect of interaction of salinity of irrigation water and time and methods of fertilizer application on uptake of nitrogen, and phosphorus (kg/ha) in grain of wheat.

Treatments	Time and methods				
	T ₁	T ₂	T ₃	T ₄	T ₅
Salinity Levels					
	Nitrogen				
S ₁	50.20	50.64	52.33	54.74	53.34
S ₂	49.74	50.98	52.18	63.12	59.83
S ₃	48.65	51.37	55.71	71.19	62.63
S ₄	33.92	47.50	50.55	58.59	54.11
SE ±	0.853				
CD at 5%	2.450				
	Phosphorus				
S ₁	18.23	16.82	17.09	17.66	17.19
S ₂	14.67	15.13	15.45	17.11	15.90
S ₃	11.68	12.32	13.08	15.51	13.60
S ₄	08.20	08.45	08.83	09.99	09.45
SE ±	0.452				
CD at 5%	1.229				

uptake of nitrogen in grain and straw, it has been confirmed by various workers that reduced N uptake is apparently due to reduction in growth and grain and straw production as a result of salinity (3, 5—7).

The interaction effect of salinity and split doses on N content in grain was noticed (Table 3) and was observed that each increasing level of salinity enhanced the N content and as compared to S₁ level of salinity with each type of split doses except with T₁ where differences between S₂ and S₁, S₄ and S₁ were non-significant. With regard to N uptake effect of treatments was different from each other. At treatment T₄ each increasing level of salinity enhanced the N uptake as compared to S₁, while in treatment T₅, the uptake was enhanced at S₂ and S₃ levels compared to S₁ level. All the nitrogen treatments enhanced N uptake by grain at all levels of salinity compared to T₁ treatment.

Phosphorus Content and Its Uptake in Grain and Straw of Wheat

Salinity level S₄ significantly decreased the P content and uptake in grain as compared to S₁, S₂ and S₃ levels of salinity (Table 2). Phosphorus uptake was reduced with each higher level of salinity. The highest P content was recorded with T₄ treatment com-

Table 6. Effect of salinity of irrigation water on EC and pH of experimental soil after crop harvest.

	EC (dS/m)	pH
Initial sample	1.0	7.60
Salinity Levels		
S ₁	1.0	7.61
S ₂	2.1	7.72
S ₃	4.8	7.75
S ₄	8.6	7.78

pared to any other treatment. Also T₄ treatment increased the P uptake values compared to other treatments.

Table 4 shows that in wheat straw also the increasing level of salinity significantly decreased the P content and its uptake. T₃, T₄ and T₅ showed their superiority over T₁ and T₄ over T₂ for both P content and uptake. Interaction effect of salinity of irrigation water and time and methods of fertilizer application on uptake of P in grain indicated (Table 5) that each increasing level of salinity decreased the uptake of P in grain with each type of split dose, except that with T₄ and T₅ treatments at S₂ level where responses were of non-significant order. Again T₄ showed its superiority over T₁ at S₂ and S₄ levels of salinity.

Reduced phosphorus content in grain and straw has also been recorded by Mahajan and Sonar (7) and Hewitt (8), who found low phosphorus content in salt stressed plant due to decrease in ATP concentration and adenylate energy change. As regard to phosphorus uptake in grain and straw similar results have been obtained by Gandhi and Paliwal (6), and Mahajan and Sonar (7). The reduction in dry matter due to salinity may be the possible cause of low uptake of P in grain and straw as uptake is the combined function of content and yield of dry matter or grain.

Potassium Content and Its Uptake in Grain and Straw of Wheat

The present investigation revealed that each higher level of salinity depressed potassium content and its uptake in grain (Table 2) and straw (Table 4) of wheat as compared to any lower level of salinity. However, the difference between S₂ and S₁ on potassium uptake in grain was of non-significant order. Treatment T₄ showed significant beneficial effect on po-

potassium content in grain over other treatments. With regard to potassium uptake, T_4 treatment significantly enhanced the uptake in grain as compared to T_1 and T_3 treatments, whereas trend was not of any definite order for others. In wheat straw, the effect of splitting doses of nitrogen on potassium content was of non-significant order, but for potassium uptake treatment T_4 enhanced its values significantly compared to T_1 , T_2 and T_3 .

The effect of interaction of salinity of irrigation water and time and methods of fertilizer application on the potassium content in grain was found to be significant (Table 3). The potassium content was found to be increased with nitrogen treatments T_4 and T_5 up to S_3 level of salinity as compared to T_1 treatment and beyond that the same was decreased. However, the effect of statistically significant order was noticed with T_4 treatment and S_2 and S_3 levels only. Decreased potassium content in grain and straw has also been confirmed by Torres (9) and Ansari et al. (10). Regarding potassium uptake in grain and straw the findings have been confirmed by Shimose (11), Das and Mehrotra (12).

Sodium Content in Grain and Straw of Wheat

Sodium content in grain indicated that each higher level of salinity enhanced the sodium content significantly as compared to any lower level of salinity. In wheat straw, the values of sodium content were 9.58, 9.13, 9.86 and 9.64 times more as compared to grain at S_1 , S_2 , S_3 and S_4 levels of salinity respectively. There was no significant difference among the various treatments with regard to sodium content in straw of wheat. Increased sodium content in grain and straw, when irrigated with saline water was also observed by Deo and Kumar (13) and Hira and Singh (14).

Change in EC and pH of Experimental Soil after Harvest

The EC and pH of each salinity level treated plots were recorded after harvest to assess the effect of saline water irrigation on soil EC and pH (Table 6). The EC values of S_1 , S_2 , S_3 and S_4 salinity treatments were recorded as 1.0, 2.1, 4.8 and 8.6 dS/m respectively. This indicated 2 to 8 times more salt build up in

the soil due to saline water irrigation with the given treatments. The pH value raised from 7.60 to 7.78 with increasing salinity levels from S_1 to S_4 which indicated that there was not much variation in the pH value as affected by irrigation water of given salinity.

Conclusion

Thus nutrient content and their uptake were maximum with T_4 nitrogen treatment at all salinity levels. In this regard treatment T_5 occupied second place. This beneficial response of these treatments may be due to split doses of nitrogen as the other conditions and level of nutrient supply was constant. Earlier also better response with split and foliar application of nitrogen was reported (15). Split application helps in maintaining a regular supply of available nitrogen and also reduces the leaching losses, moreover gaseous losses are also more in single dose than split doses. Foliar application enhances the nutrient uptake. Ray Choudhary et al. (16) confirmed that urea solution (1 to 3%) can be applied to wheat as foliar spray with beneficial results. They further confirmed that with foliar application of urea plants use nitrogen better than when urea is put in as soil application. Thereby, treatment T_4 proved to be better than other split application in the present investigation due to inclusion of two foliar applications.

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