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Nitrogen uptake, recovery and N-use efficiency in wheat (*Triticum aestivum*) as influenced by nitrogen and irrigation levels in semi-reclaimed sodic soils

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ABSTRACT

A 2-year field experiment was conducted with wheat (*Triticum aestivum* L. emend. Fiori & Paol.) variety 'HD 2285' in semi-reclaimed sodic soil of Karnal, comprising 4 levels each of nitrogen and irrigation. Scheduling irrigation at 1.2 irrigation water : cumulative pan evaporation (IW : CPE) ratio was better than other irrigation schedules in terms of grain yield. With each increment of N level from 60 to 180 kg/ha, there was a significant increase in the grain yield as well as N uptake. Response to N of grain production at 1.2 IW : CPE ratio was significantly more than that at 0.6 and 0.9 IW : CPE ratios. The N content in shoot at spike-initiation stage was higher in irrigated than in unirrigated treatment, but reverse was true for N content in grain and straw at maturity. The N uptake through grain and straw was higher when irrigation was given at 1.2 IW : CPE ratio. Recovery of applied N and N-use efficiency were maximum when irrigation was given at 1.2 IW : CPE ratio along with 60 kg N/ha.

Salt-affected soils are mainly confined to arid and semi-arid areas of the country (Bhargava *et al.*, 1981). Presence of low amount of organic matter, apart from high exchangeable sodium percentage (ESP) coupled with high pH, causes deficiency of available nitrogen in these soils. Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) crop responds remarkably well to high levels of N fertilizer. The N-use efficiency (NUE) is considerably reduced due to N loss in sodic soils. Nitrogen deficiency in these soils is further accentuated by low urease enzymic activities (Beri and Brar, 1978). The magnitude of N-use efficiency further depends on the degree of available soil water, which controls the movement of N in the active root zone. In the present experiment effect of N on yield, uptake, recovery and N-use efficiency of wheat was studied under different irrigation schedules in semi-reclaimed sodic soils.

MATERIALS AND METHODS

The field experiment was conducted during the winter seasons of 1990–91 and 1991–92 at the institute farm, Karnal. The soil of the experimental field was Aquic Natrustalf with loamy texture (51.9% sand, silt 30.5% and clay 17.6%) at surface (0–15 cm) and sandy clay-loam in the lower depths. The bulk density varied from 1.46 to 1.62 g/cm^3. The organic carbon and available N were 0.21% and 198.1 kg/ha

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respectively. The water content at 0.3 and 1.5 MPa was 22.3 and 12.1% respectively. The experiment was laid out in split-plot design taking 4 irrigation schedules, viz. no irrigation (I_1), 0.6 (I_2), 0.9 (I_3) and 1.2 (I_4) irrigation water · cumulative pan evaporation (IW : CPE) ratios in main plots and 4 levels of nitrogen (0, 60, 120 and 180 kg/ha) in subplot with 4 replications.

'HD 2285' wheat was sown on 11 December 1990 and 2 December 1991 during respective seasons. Full dose of phosphorus @ 60 kg/ha, 25 kg/ha zinc sulphate and half dose of N (according to treatments) were applied at time of sowing and the remaining N was given at crown-root-initiation (CRI) stage (30 days after sowing). One common irrigation was given at the CRI stage to all the treatments. In each irrigation, 7 cm water was applied with the help of Parshall flume. The crop was harvested on 15 April and 13 April during 1990–91 and 1991–92 respectively. The N content in grain and straw was determined by micro-Kjeldahl's procedure and N-use efficiency was calculated as per formula given by Yoshida (1978).

RESULTS AND DISCUSSION

Grain yield

In both the years, irrigation at 1.2 IW : CPE ratio gave significantly higher grain yield than the treatments of 0.6 and 0.9 IW : CPE ratios and unirrigated condition (Table 1). It could be due to higher plant water status as a consequence of stomatal conductance, which might have resulted in higher rate of cell-division and cell-elongation and higher mobilization of photosynthates from various plant parts for development of grains (Evans and Wardlaw, 1976). The response to N in grain yield was significant with each increment of N from 60 to 180 kg/ha (Table 1). The grain yield increased with 120 kg N/ha over the lower dose (60 kg/ha) by 26.7%. The corresponding increase in grain yield at 180 kg N/ha was 12.1%. In pooled data, the interaction effect between irrigation and N was significant. The response of N was higher at 1.2 IW : CPE ra-

Table 1. Effect of nitrogen and irrigation levels on grain yield of wheat (pooled data of 1990–91 and 1991–92)

Irrigation level	N (kg/ha)				
	0	60	120	180	Mean
I_1	825	1,216	1,518	1,607	1,291
I_2	1,093	1,907	2,426	2,727	2,038
I_3	1,303	2,328	2,996	3,319	2,486
I_4	1,513	2,506	3,151	3,651	2,705
Mean	1,183	1,989	2,522	2,826	
CD (P = 0.05)					
For I			134.5		
For N			60.5		
For 2 N levels at same I			161.0		
For 2 I levels at same or different N			192.5		

Details of irrigation are given in text

Table 2. Effect of nitrogen and irrigation on N content at various stages of crop growth

Treatment	N content (%) at					
	Spike initiation		Maturity			
	Shoot		Grain		Straw	
	1990–91	1991–92	1990–91	1991–92	1990–91	1991–92
Irrigation						
I_1	1.51	1.44	2.17	2.12	0.47	0.44
I_2	1.79	1.54	2.14	2.10	0.45	0.40
I_3	1.91	1.69	2.04	2.00	0.42	0.35
I_4	1.96	1.74	2.03	1.99	0.39	0.33
CD (P = 0.05)	0.13	0.12	0.10	0.10	0.01	0.01
N (kg/ha)						
0	1.39	1.40	1.94	1.91	0.38	0.31
60	1.67	1.63	1.99	1.98	0.42	0.33
120	1.88	1.75	2.05	2.00	0.43	0.38
180	2.02	1.80	2.10	2.07	0.45	0.42
CD (P = 0.05)	0.08	0.05	0.03	0.06	0.003	0.004

Details of irrigation treatments are given in text

tio than that at 0.9 and 0.6 IW : CPE ratios.

Nitrogen content

During both the years N content in shoot at spike-initiation stage in 0.9 and 1.2 IW : CPE ratios was at par, but further decrease in IW : CPE ratio significantly declined N content from 1.9 to 1.79 and 1.63 to 1.54% in the respective seasons (Table 2). The N content in shoot was significantly lower under unirrigated conditions during both the years. The N content in grain was higher in unirrigated treatment, but the difference between unirrigated and 0.6 IW : CPE ratio was not significant in both the years. The N content in straw decreased significantly with increasing IW : CPE ratio in both the years. The decrease in N content due to increasing IW : CPE ratio might be attributed to higher amount of dry-matter production, resulting in dilution with under more frequent irrigation (Mehta *et al.*, 1982).

The increasing levels of N increased the N content in shoot at spike initiation as well as in grain and straw during both the years (Table 2). This increase can be explained on the basis that application of N increases the N availability and root cation-exchange capacity, which enhances absorption of nutrients (Elgabaly, 1962). Our results confirm the findings of Singh and Anderson (1973) and Singh *et al.* (1979).

Nitrogen uptake

Due to high mobility of inorganic N in soil solution, N uptake through grain was the highest at 1.2 IW : CPE ratio during both the years (Fig. 1). Decreasing IW : CPE ratio from 1.2 to 0.6 reduced the N mobility and consequently the N uptake

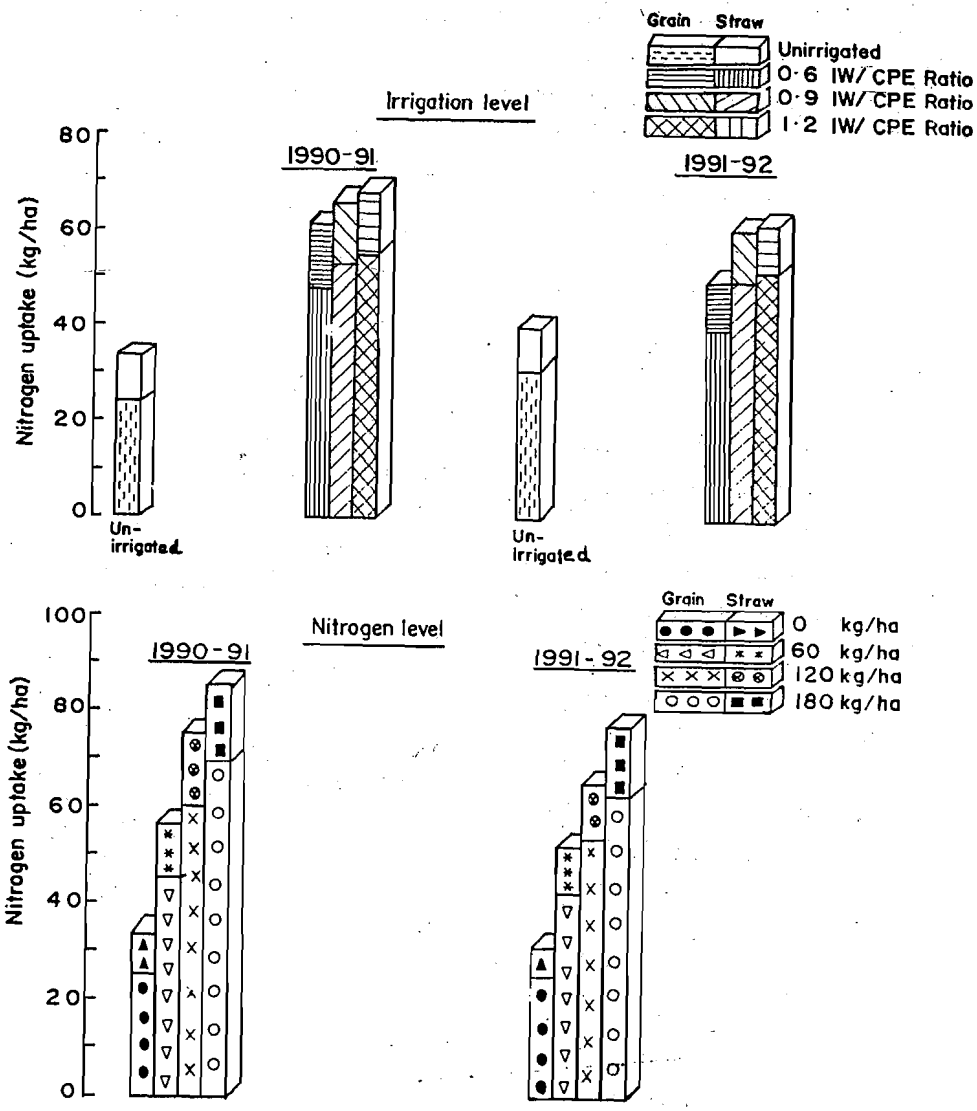

Fig. 1. Nitrogen uptake as influenced by irrigation and N levels in wheat

through grain and straw in each year. It could be due to more reduction in yield under 0.6 IW : CPE ratio than at higher ratio. Similar observations were also made by Rao (1981) and Sharma *et al.* (1990). Application of N increased the N uptake through grain as well as straw with each increment of fertilizer N, but the magnitude of increase was more between 0 and 60 kg N/ha.

Table 3. Nitrogen recovery (%) and N-use efficiency (kg grain/kg N applied) of wheat as influenced by irrigation and N

Irrigation	N (kg/ha)					
	1990–91			1991–92		
	60	120	180	60	120	180
	Apparent recovery (%)					
I_1	14.7	13.1	11.3	23.5	19.1	11.9
I_2	28.1	34.6	28.3	29.4	29.9	23.2
I_3	38.7	39.5	30.7	37.8	32.5	28.7
I_4	43.9	37.3	33.5	41.1	35.9	31.5
	N-use efficiency					
I_1	4.0	3.9	3.4	9.0	7.3	5.2
I_2	12.5	13.9	10.6	10.9	8.2	7.3
I_3	15.5	16.4	12.6	12.0	11.8	10.7
I_4	18.0	17.5	13.0	16.2	12.5	10.7

Details of irrigation treatments are given in text

Apparent N recovery

When irrigation was given at 1.2 IW : CPE ratio, maximum recovery of applied N (43.9% during 1990–91 and 41.1% during 1991–92) was obtained with the application of 60 kg N/ha (Table 3). Recovery of applied N was higher with 120 kg N/ha compared with 180 kg N/ha at all the levels of irrigation. Lowest recovery of applied N was recorded under unirrigated condition at 180 kg N/ha during both the years.

Nitrogen-use efficiency

Efficiency of applied N was higher (18.0 and 16.2 kg grain/kg applied N during 1990–91 and 1991–92 respectively) when irrigation was given at 1.2 IW : CPE ratio along with 60 kg N/ha (Table 3). Nitrogen-use efficiency decreased with each successive increase in N level under unirrigated conditions during both the years. When irrigation was given at 0.6 or 0.9 IW : CPE ratio, N-use efficiency increased with increasing N level up to 120 kg/ha, thereafter decreasing trend was recorded in both the seasons.

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