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Optimization of nitrogen dose for different wheat varieties under saline water irrigation conditions

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Abstract
A field experiment was conducted during the *rabi* season of 2015-16 (November, 2015 to April, 2016 at Research Farm of Chaudhary Charan Singh, Haryana Agricultural University, Hisar. Treatment combinations comprising four wheat varieties (KRL 210, WH 1105, HD 3086 and DBW 88) in the main plot and five nitrogen levels (0, 50, 100, 150 and 200 kg N ha^{-1}) in sub-plots were tested in a split-plot design with 3 replications. Results revealed that the grain yield and N uptake (grain and straw) were significantly higher in the variety WH 1105. However, N content in grain (2.08%) and straw (0.38 %) were significantly higher in DBW 88 as compared to other varieties. The incremental N levels significantly increased grain yield. Whereas, the N content and its uptake by grain and straw were also recorded higher up to 150 kg N ha^{-1} but was at par with 200 kg N ha^{-1}. The economic optimum dose of nitrogen for wheat varieties KRL 210, WH 1105, HD 3086 and DBW 88 were 182.4, 188.4, 185.9 and 181.2 kg N ha^{-1} and the agronomic optimum dose was 188.8, 194.1, 192.6, and 186.6, respectively. However, on the mean basis for wheat varieties, the economic optimum dose and agronomic optimum dose were worked out to be 184.3 and 192.6 kg ha^{-1}, respectively. On the basis of 1year results, it may be suggested that wheat variety WH 1105 should be grown with 188.4 kg N ha^{-1} under saline water irrigation conditions.

Keywords: Wheat, verities, nitrogen, saline water, AOD, EOD

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the most extensively grown crops in the world. India is the second largest producer of wheat in the world next to China. The area, production and average yield of wheat are 31.76 mha, 108.75 mt and 3424 kg ha^{-1}, respectively during 2020-21. In Haryana, it is grown over an area of 2.52 mha with a production of 12.15 mt and productivity of 4822 kg ha^{-1} during 2020-21 (Anonymous, 2020-21) [3]. The average yield of wheat is low due to climatic limitations like high temperature during the crop growth period (November-April), unsuitable irrigation water and cultivation of low-yielding varieties.

The use of available water in agriculture is a must and due to the depletion of available water, the use of saline water becomes inevitable for agriculture (Dikgwatlhe *et al*., 2008) [7]. This increased demand of more water to irrigate crops to cope with the food security issue, especially when fresh-water resources are limited, has led to a rush of interest in the use of low-quality or saline water for irrigation in agriculture Nizam *et al*. (2017) [14]. The main problem of wheat production in several parts of the state is the less availability of good quality water for irrigation. The use of saline water for irrigation has the advantage of reducing fresh water requirements for salt-tolerant crops. But salinity affects crops depending on their degree at critical growth stages and reduces the yield. So, irrigation by saline water needs to be controlled at an appropriate level for the specific crops. Accumulation of excessive salt in irrigated soils can reduce crop yields, reduce the effectiveness of irrigation, ruin soil structure, and affect other soil properties (Abedinpour, 2017) [1]. Among the alternatives for cultivation in saline environments, nitrogen fertilization has contributed to minimizing the effects of salts on plants, in addition to promoting plant growth. Nitrogen (N) is a constituent nutrient of several cellular molecules, such as chlorophyll, nucleic acids, proteins, enzymes and amino acids Taiz *et al*. (2017) [19], it can reduce the effect of salinity on plants by participating in osmoregulatory molecules present in the root region and the application of N promoted higher growth and production of plants under saline stress (Nadian *et al*., 2012) [13]. Kumar *et al.* (2017) [11] reported that variations in yield reduction of different varieties due to the capacity of variety to tolerate the higher levels of salinity in water irrigation are a genetic character.

2. Material and Methods

The experiment was conducted during *rabi* season of 2015-16 at Research Farm of the Department of Soil Science, CCSHAU, Hisar, Haryana, India. Laboratory analyses were carried out at the Department of Agronomy and Department of Soil Science. The experiment was laid out in a split-plot design with three replicates and the treatments consisting of four varieties viz., KRL 210 (V_1), WH 1105 (V_2), HD 3086 (V_3) and DBW 88 (V_4) in main plots and five levels of nitrogen viz., 0 (N_0), 50 (N_1), 100 (N_2), 150 (N_3) and 200 (N_4) kg N ha^{-1} in sub-plots. Four irrigations were applied with saline water (EC 7.0 d Sm^{-1}) at 21, 45, 85, 122 DAS. The crop was sown in line at 20 cm apart with hand plough on November 06, 2015, with a seed rate of 125 kg ha^{-1}. The full dose of Phosphorus and potassium at rates of 60 and 40 kg ha^{-1} respectively and half dose of nitrogen as per treatment were applied at sowing time as basal. The remaining half dose of nitrogen was applied as a top dressing at 1st irrigation i.e. at crown root initiation stage as per treatment. The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. After harvesting of the wheat crop, grains were separated with a mini-plot thresher. The grain yield from the net plot area was weight and converted into kg ha^{-1}. Nitrogen content in grain and straw at harvest was determined. For analysis of N, oven-dried plant material (grain and straw at harvest) from each plot was grinded separately with grinder. Nitrogen (Nessler's reagent method (Lindner, 1944) contents in the samples were analyzed.

The response of wheat yield to nitrogen was studied as per the procedure explained by (Anonymous, 1966) [2]. Quadratic response to nitrogen application was observed and the following quadratic model was used to compute the optimum dose of nitrogen:

$$Y = a + bx + cx2 \qquad \ldots (1)$$

Where,
Y=Grain yield of wheat kg ha^{-1} for a given level of x.
X=Unit of nitrogen kg ha^{-1}.
a, b and c are constants of the model.

To work out the Agronomic Optimum Nitrogen Rate (AONR), the below-mentioned equation was used:

$$AONR = \frac{b}{2c} \qquad \ldots (2)$$

The Economic Optimum Nitrogen Rate (EONR) was computed with the help of the following equation:

$$EONR = \frac{1}{-2c}\left(\frac{q}{p} - b\right) \qquad \ldots (3)$$

Where,
q=Price of N $unit^{-1}$.
p=Price kg^{-1} of wheat grain.

AOD=Agronomic optimum dose of nitrogen is the nitrogen rate that will produce maximum grain yield regardless of cost.
EOD=Economic optimum dose of nitrogen is the nitrogen rate that will result from the maximum financial return to nitrogen it's usually less than the agronomic optimum dose of nitrogen.
Data collected during the study were statistically analyzed by using the technique of analysis of variance (ANOVA) described by Cochran and Cox (1992) [6].

3. Results and Discussion

The data pertaining to grain yield are given in (Table 1), revealed that the grain yield was significantly influenced by different varieties and levels of nitrogen. Among the varieties, WH 1105 recorded significantly higher grain yield of 4250 kg ha^{-1} as compared to all other varieties, whereas, the lowest grain yield (3397 kg ha^{-1}) was recorded in KRL 210. The characteristics which contributed to the yields are specific and depend upon the genetic potential of genotypes. Genetic variation among different wheat cultivars was also reported by Panwar *et al*. (2013) [15] and Baloch *et al*. (2014) [4]. There was a significant increase in grain yield with an increase in nitrogen level from 0-150 kg N ha^{-1}. Crop fertilized with 200 kg N ha^{-1} resulted in maximum grain yield (4739 kg ha^{-1}), however, it was statistically at par with 150 kg N ha^{-1} (4585 kg ha^{-1}). Whereas, minimum grain yield (2369 kg ha^{-1}) was obtained in the control. These findings were in accordance with those of Iqtidar *et al*. (2006) [9].

The differences in nitrogen content in grain were significantly influenced by different varieties and levels of nitrogen. Among the varieties, DBW 88 recorded significantly higher nitrogen content (2.08%) in grain, being statistically at par with WH 1105 (2.04%) and HD 3086 (1.99%) whereas, KRL 210 contained significantly lower nitrogen content (1.86%). The data on the nitrogen content of straw as given in (Table 1) revealed that it was significantly influenced by different varieties and levels of nitrogen. Among the varieties, DBW 88 recorded significantly higher nitrogen content (0.38%) being at par with WH 1105 (0.37%) whereas, KRL 210 had significantly lower nitrogen content in straw (0.29%). This may be due to the better root development and absorption of nutrients from the soil. Similar results were also reported by Singh *et al.* (2011) [17] and Rawal and Kuligod (2014) [16]. In general, nitrogen content in grain and straw increased with the increase in nitrogen levels up to 150 kg N ha^{-1} and declined thereafter. The maximum nitrogen content (2.17%) in grain was estimated in 150 kg N ha^{-1} being significantly higher than 0, 50, 100 and 200 kg N ha^{-1}. Whereas, minimum nitrogen content (1.73%) was recorded with the control. The maximum nitrogen content in straw (0.40%) was estimated at 150 kg N ha^{-1}, being significantly higher than 0, 50, and 100 kg N ha^{-1}. However, it was at par with 200 kg N ha^{-1}. The minimum nitrogen content in straw (0.26%) was recorded with the control. Adequate nitrogen availability to the plants and better translocation of assimilated nitrogen towards the grain with 150 kg N ha^{-1} resulted in higher biomass yield and straw nitrogen content with 150 kg N ha^{-1}. Similar results were also reported by Fisher (1993) [8]. Nitrogen uptake was significantly influenced by different varieties and levels of nitrogen.

Among the varieties, WH 1105 recorded significantly higher nitrogen uptake (88.0 kg ha^{-1}) in grain compared to all other varieties except DBW 88. The variety KRL 210 recorded significantly lower nitrogen uptake (65.7 kg ha^{-1}) by grain than all other varieties. The data on nitrogen uptake by straw revealed that the differences in nitrogen uptake were significantly influenced by different varieties and levels of nitrogen. Among the varieties, WH 1105 recorded significantly higher nitrogen uptake (23.77 kg ha^{-1}) by straw than all other varieties, whereas, KRL 210 (15.85 kg ha^{-1}) had significantly lower nitrogen uptake, which may be due to the better root development and absorption of nutrients from the soil by WH 1105. Similar results were also reported by Singh *et al.* (2008) [18]. Nitrogen uptake in grain increased with the increase in nitrogen levels from 0 to 200 kg N ha^{-1}. The maximum nitrogen uptake (100.05 kg ha^{-1}) in grain was estimated at 200 kg N ha^{-1}, being significantly higher than 0, 50, and 100 kg N ha^{-1}, however, it was at par with 150 kg N ha^{-1} (99.54 kg ha^{-1}). Whereas, minimum nitrogen uptake (41.46 kg ha^{-1}) in grain was recorded in control. In general, nitrogen uptake by straw increased with the increase in nitrogen levels up to 150 kg N ha^{-1}. The maximum nitrogen uptake (25.71 kg ha^{-1}) by straw was estimated at 150 kg N ha^{-1} being significantly higher than 0, 50, and 100 kg N ha^{-1} whereas, it was at par with 200 kg N ha^{-1} (25.14 kg ha^{-1}). Minimum nitrogen uptake (10.25 kg ha^{-1}) by straw was recorded in the control. This was mainly due to the fact that nutrient uptake followed the yield pattern which increased with increasing levels of nitrogen. Singh *et al*. (2008) [18] reported that the increment in N uptake was probably due to improvement in soil conditions, which promoted the proliferation of roots and plant demand, which in turn drew more nutrients from larger areas and greater depth. The data on total nitrogen uptake as presented in (Table 1) revealed that among the varieties, WH 1105 recorded significantly higher total nitrogen uptake (111.7 kg ha^{-1}) than all other varieties, whereas, KRL 210 (81.5 kg ha^{-1}) had significantly lower total nitrogen uptake.

In general, total N uptake increased with the increase in nitrogen levels up to 150 kg N ha^{-1}. The maximum nitrogen uptake (125.3 kg ha^{-1}) was estimated at 150 kg N ha^{-1} being significantly higher than 0, 50, and 100 kg N ha^{-1} whereas, it was at par with 200 kg N ha^{-1} (125.2 kg ha^{-1}). Minimum total N uptake (51.7 kg ha^{-1}) was recorded in the control economic optimum does of Nitrogen.

The response curve of the economic optimum dose of N for different levels of nitrogen is depicted in (Figure 1). The regression equations, regression coefficient, economic optimum dose, agronomic optimum dose, and yield are presented in (Table 2). Economic optimum doses for varieties, KRL 210, WH 1105, HD 3086 and DBW 88 were 182.4, 188.4, 185.9 and 181.2 kg N ha^{-1} and agronomic optimum doses were 188.8, 194.1, 192.6 and 186.6 kg N ha^{-1}, respectively. However, on the mean basis of varieties, the economic optimum dose and agronomic optimum dose were worked out to be 184.3 and 192.6 kg ha^{-1}, respectively. Results presented in (Table 2 and Figure 1) showed that the agronomic optimum dose, as well as economic optimum dose (EOD) of nitrogen, increased with increasing nitrogen levels. The agronomic optimum dose of variety WH 1105 was computed using yield data and the N dose applied is higher than other varieties. Agronomic optimum dose (AOD) is the nitrogen rate that will produce maximum grain yield regardless of cost and the economic optimum dose is the nitrogen rate that will result in maximum financial returns to nitrogen. EOD is usually less than AOD and will usually decrease as nitrogen prices increase. These results are in line with those obtained by Clark *et al*. (1991) [5], and Kulekci *et al*. (2009) [10].

Table 1: Effect of varieties to nitrogen under saline water irrigation on grain yield, nitrogen content and its uptake by grain and straw of wheat

Treatments	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		Total uptake (kg ha^{-1})	Grain yield (kg ha^{-1})
Varieties	**Grain**	**Straw**	**Grain**	**Straw**	**Grain + Straw**	
KRL 210	1.86	0.29	65.68	15.85	81.5	3,397
WH 1105	2.04	0.37	88.0	23.77	111.7	4,250
HD 3086	1.99	0.32	79.15	18.87	98.0	3,920
DBW 88	2.08	0.38	82.10	21.77	103.8	3,898
SEm±	0.03	0.01	2.00	0.43	2.1	65
CD at 5%	0.10	0.03	7.37	1.53	7.5	229
Nitrogen levels (kg ha^{-1})						
0	1.73	0.26	41.46	10.25	51.7	2,369
50	1.91	0.31	63.84	16.44	80.3	3,323
100	2.05	0.36	88.74	22.80	111.5	4,315
150	2.17	0.40	99.54	25.71	125.3	4,585
200	2.11	0.38	100.05	25.14	125.2	4,739
SEm±	0.02	0.01	1.99	0.73	2.1	89
CD at 5%	0.06	0.03	5.78	2.11	6.1	258

Table 2: Regression equations, regression coefficients (R^2), economic optimum dose (EOD) of nitrogen, the agronomic optimum dose of nitrogen (AOD) and grain yield (kg ha^{-1}) for different levels of nitrogen

Varieties	Regression equations	Regression coefficient (R^2)	EOD (kg ha^{-1})	Grain yield (kg ha^{-1})	AOD (kg ha^{-1})	Grain yield (kg ha^{-1})
KRL 210	$-0.0628x^2+23.713x+1967.7$	0.99	182.4	4203	188.8	4206
WH 1105	$-0.0696x^2+27.019x+2591.3$	0.96	188.4	5211	194.1	5214
HD 3086	$-0.0599x^2+23.069x+2512$	0.96	185.9	4731	192.6	4733
DBW 88	$-0.0731x^2+27.288x+2265.8$	0.99	181.2	4810	186.6	4812
Mean	$-0.0664x^2+25.277x+2334.2$	0.99	184.3	4700	190.3	4740

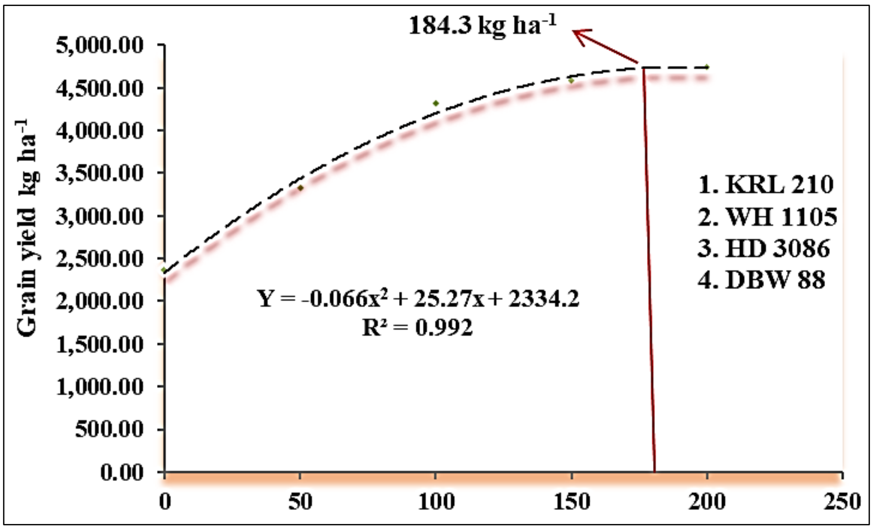

Fig 1: Effect of varieties to nitrogen under saline water irrigation on the economic optimum dose of nitrogen of wheat

4. Conclusion

Wheat variety WH 1105 performs better under saline water irrigation. On the mean basis for wheat varieties, the economic optimum dose and agronomic optimum dose were worked out to be 184.3 and 192.6 kg ha^{-1}, respectively.

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