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Productivity and Nitrogen Use Efficiency of Wheat Varieties in Relation to Nitrogen Levels under *Rainfed* Conditions of North-western India

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A B S T R A C T

Although area of wheat (*Triticum aestivum* L.) under *rainfed* conditions is less in North-western India but selection of appropriate variety plays an important role in the success of crop. The experiment was conducted at the Punjab Agricultural University, Ludhiana (30^0 54' N and 75^0 48' E; 247 m ASL) during winter seasons of 2009-10 and 2010-11 on loamy sand soil with low in organic matter. The experiment was laid out in a split plot design with three nitrogen levels [N 40, 60 and 80 kg N/ha] as main plot treatment and four wheat varieties (C 306, PBW 175, PBW 396 and WH 1080) as subplot treatments with three replications. The grain yield recorded in 60 and 80 kg N/ha was 28.5 and 38.5% higher than that recorded in 40 kg N/ha, respectively. But lower dose of nitrogen (40 kg N/ha) had significantly higher nitrogen use efficiency than other doses of N application. *Rainfed* wheat variety, PBW 175 recorded the highest grain yield and nitrogen use efficiency which was significantly higher than WH 1080, PBW 175 and PBW 396.

Introduction

Wheat (*Triticum aestivum* L.) is mainly used as a staple food providing more protein than any other cereal crop. It can be consumed in different forms. Wheat straw is mainly used as animal feed. However, nutrient requirement of this cereal crop varies greatly in response to variety and environmental conditions prevailed during initial crop growth. Among the critical nutrients for plant growth, nitrogen plays a significant role. It is constituent of nucleic acids, amino acids, enzymes, and photosynthetic pigments. Use of optimum amount of nitrogen is considered as a key to obtain bumper and quality crop of wheat. Plants take up most of their nitrogen as the ammonium (NH_4^+) or nitrate (NO_3^-) form. Nitrogen is necessary for chlorophyll biosynthesis which is the main pigment involved in photosynthesis. It is also an essential component of all amino acids and protein which are considered responsible for quality of wheat (Krishankumari *et al.*, 2000). N requirement of wheat may be related to residual N in soil, differential cultivar response, microbial population in rhizosphere etc. As the soil water availability is less under *rainfed* condition, so, there are fewer chances for leaching of nitrogen. Selection of proper variety under *rainfed* conditions is an important task to get better yield. Generally, the varieties with taller plants and greater dry matter accumulation characters are considered

suitable. As the varieties respond differentially to nitrogen dose (Benin *et al.*, 2012; Kaur and Ram 2017), an experiment was planned to study the effect of nitrogen on yield attributes and yield of wheat under *rainfed* conditions in North-western (NW) India.

Materials and Methods

The field experiment was conducted at the Punjab Agricultural University, Ludhiana (30^0 54' N and 75^0 48' E; 247 m ASL) during winter seasons of 2009-10 and 2010-11. Punjab, falls in NW India, has a sub-tropical climate with hot, wet summers and cool, dry winters. The soil of experimental site was loamy sand, low in organic matter (2.9g C/kg) and slightly alkaline (pH 7.9). The experiment was laid out in a split plot design with three replications, three nitrogen levels [N @ 40, 60 and 80 kg N/ha] as main plot treatment and three wheat varieties (C 306, PBW 175, PBW 396 and WH 1080) as subplot treatments. Wheat crop was sown at the row spacing of 22.5 cm using seed rate of 100 kg/ha. The crop was raised without irrigation under *rainfed* conditions. Nitrogen was applied in the form of urea at the time of sowing. Phosphorus @ 30 kg P_2O_5/ha was applied at the time of sowing in the form of DAP. Emergence count, tiller density (both total and effective tillers) were recorded from one metre row length and data were converted to per square metre. The grains/ear were calculated from randomly selected and manually threshed five ears in each sub plot. The sample of 1000–grains was collected from each plot, and weighed to present as gram. The crop biomass and grain yield were recorded at the time of harvesting and represented as quintal/ha. Nitrogen use efficiency was calculated by dividing grain yield with nitrogen applied. All the data were analyzed using standard method of ANOVA for split plot design.

Results and Discussion

Emergence, yield attributes, biological yield and phenology of rainfed wheat

Performance in different years

The highest emergence count, total tillers, effective tillers and biological yield recorded in 2010-11 was significantly higher than 2009-10 (Table 1). Although grains per earhead recorded were non-significant but test weight was significantly higher in 2009-10. Higher test weight in 2009-10 might be due to lower effective tillers which resulted in more assimilate translocation towards developing grain. The highest biological yield was recorded in 2010-11, which might be due to more number of total and effective tillers.

Effect of nitrogen levels

The emergence count was not significantly influenced with nitrogen levels. The highest total tillers, effective tillers, grains per earhead, test weight and biological yield was recorded in 80 kg N/ha. Grains per earhead recorded in 80 kg N/ha was statistically similar to 60 kg N/ha. However, grains per earhead recorded in 60 kg N/ha was statistically at par with 40 kg N/ha. Although, total tillers recorded in different nitrogen treatments were statistically at par with each other but total and effective tillers recorded in 80 kg N/ha were 6.9 and 7.6% higher than 40 kg N/ha and 2.6 and 1.1% higher than 60 kg N /ha, respectively. The test weight recorded in 80 kg N/ha was the highest which was statistically at par with 60 kg N/ha but significantly higher than that recorded on 40 kg N/ha. The test weight recorded in 60 kg N/ha was also significantly higher than 40 kg N/ha. Higher yield attributes in higher nitrogen treatment was due to increased availability of nitrogen for the growth and development of the crop plants. The

biological yield recorded in 80 kg N/ha was significantly higher than 60 and 40 kg N/ha. A significant increase of 14.9 and 23.5% in biological yield was recorded in 60 and 80 kg N/ha over 40 kg N/ha application. Higher biological yield at higher nitrogen levels was due to increased rates of carbon assimilation resulting in higher yield attributing characters in this treatment. The phenology of wheat crop was not influenced by nitrogen levels.

Effect of varieties

The emergence count recorded in different varieties was statistically similar (Table 1). Tiller density and effective tillers recorded in variety PBW 175 were significantly higher than WH 1080, PBW 396 and C 306. However, the total and the effective tillers recorded in WH 1080, PBW 396 and C 306 were statistically similar. The grains per earhead recorded in WH 1080 were at par to PBW 396 and C 306 but significantly higher than PBW 175. It might be due the genotypic potential of the variety. Similar finding with different grains per erahead were also recorded by other scientists (Kaur and Ram, 2017). All the varieties differ among each other for 1000-grain weight but WH 1080 and PBW 396 were statistically similar. The wheat variety PBW 175 recorded the highest 1000-grain weight which was significantly higher than WH 1080, PBW 396 and C 306.

If the grains per earhead are less then generally such varieties have higher 1000-grain weight (Benin *et al.*, 2012). The highest biological yield was recorded in PBW 175 which was statistically similar to C 306 and WH 1080 but significantly higher than PBW 396. The variety PBW 175, C 306 and WH 1080 recorded 15.0, 14.8 and 9.2% higher biological yield than that recorded in PBW 396. It might be due higher yield attributing characters. The hearing was 4-6 days was late in PBW 396 but maturity was almost similar as compared to other varieties. So this character is also responsible for higher biological yield in these varieties.

Grain yield

The grain yield recorded in nitrogen level of 80 kg/ha was the highest, which was significantly higher than 40 kg N/ha but statistically at par with the 60 kg N/ha (Table 2). The grain yield recorded in 60 kg N/ha was also significantly higher than 40 kg N/ha. The magnitude of yield increase was recorded 28.5 and 38.5% higher in 60 and 80 kg N/ha than 40 kg N/ha respectively. The higher grain yield at higher dose of nitrogen might be due to high nitrogen availablility for chlorophyll and Rubisco biosynthesis, ultimately resulting in higher net assimilation rates for the growth and development which increased the yield attributes. Bawar *et al.*, (2016) also reported wheat grain yield was similar at 50 and 75 kg N/ha.

Among the varieties, PBW 175 recorded the highest grain yield which was significantly higher than WH 1080, C306 and PBW 396. The grain yield recorded in C 306 and WH 1080 was statistically similar. The higher grain yield in PBW 175 was due to more number of total tillers, effective tillers and higher 1000-grain weight. Bawar *et al.*, (2016) reported that grain yield of Shirvan was significantly higher than that in Bojnoord variety under *rainfed* conditions. Benin *et al.*, (2012) also reported different grain yield in different varieties.

Nitrogen use efficiency

The highest nitrogen use efficiency was recorded in 40 kg N/ha which was significantly higher than 60 ad 80 kg N/ha (Table 3). Again 60 kg N/ha recorded significantly higher nitrogen use efficiency than 80 kg N/ha.

Table.1 Effect of different years, levels of nitrogen and varieties on yield attributes of wheat under *rainfed* conditions (Pooled mean of two years)

Treatment	Emergence count (m^{-2})	Total tillers (m^{-2})	Effective tillers (m^{-2})	Grain per earhead	Test weight (g)	Biological yield (q ha^{-1})	Days to earing	Days to maturity
Year's effect								
2009-10	184.9	257.7	230.0	38.5	30.8	48.11	111	160
2010-11	226.8	343.2	320.9	38.5	29.1	52.44	111	159
LSD (P=0.05)	10.6	43.8	44.9	NS	1.5	4.00	NS	NS
Nitrogen levels								
40 kg N/ha	209.0	290	263	36.6	28.80	44.57	111	160
60 kg N/ha	210.3	302	280	38.9	30.22	51.23	111	160
80 kg N/ha	198.2	310	283	40.0	30.88	55.03	111	160
CD (0.05)	NS	NS	NS	2.4	1.40	3.92	NS	NS
Varieties								
C 306	200.3	295	271	38.3	27.81	52.57	110	160
PBW 175	203.1	320	292	36.3	32.63	52.69	111	160
PBW 396	215.4	292	269	38.7	29.37	45.81	115	159
WH 1080	204.5	294	270	40.6	30.06	50.04	109	160
LSD (P=0.05)	NS	12.9	12.4	2.4	1.36	2.74	0.48	0.28

Table.2 Grain yield (q ha^{-1}) under *rainfed* conditions as influenced by levels of nitrogen and wheat varieties (pooled mean of two years)

Variety	Nitrogen levels (kg/ha)			
	40	60	80	Mean
C 306	16.05	21.84	23.00	20.30
PBW 175	18.97	23.15	23.54	21.89
PBW 396	14.85	19.93	21.33	18.70
WH 1080	16.55	20.48	24.15	20.40
Mean	16.61	21.35	23.01	

LSD (P=0.05) Nitrogen levels: 1.66
Varieties: 1.21
Interaction: NS

Table.3 Nitrogen use efficiency (kg grain kg N $applied^{-1}$) as influenced by different levels of nitrogen and wheat varieties under *rainfed* conditions (pooled mean of two years)

Variety	Nitrogen levels (kg/ha)			
	40	60	80	Mean
C 306	40.13	36.40	28.75	35.09
PBW 175	47.43	38.58	29.43	38.48
PBW 396	37.13	33.22	26.66	32.33
WH 1080	41.38	34.13	30.19	35.23
Mean	41.51	35.58	28.76	

LSD (P=0.05) Nitrogen levels: 3.00
Varieties: 2.00
Interaction: NS

Higher nitrogen use efficiency in 40 kg N/ha might be due to lower nitrogen dose used in this treatment. Among the wheat varieties, PBW 175 recorded the highest nitrogen use efficiency. Kaur and Ram (2017) also recorded higher nitrogen use efficiency in lower dose of the nitrogen. Wheat varieties C 306 and WH 1080 were statistically similar in nitrogen use efficiency. The higher nitrogen use efficiency recorded in variety PBW 175 was due to higher grain yield. Kaur and Ram (2017) also reported variability in nitrogen use efficiency in different varieties. It can be concluded that, the nitrogen dose of 60 kg N/ha can used under *rainfed* conditions in NW Indian conditions using variety PBW 175.

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