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AGRONOMY

Productivity, agronomic efficiency and quality of bread wheat [*Triticum aestivum* (L.)] cultivars in relation to nitrogen

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Abstract

Nitrogen (N) occupies a conspicuous place in plant metabolism because adequate supply of this nutrient associated with high photosynthetic activity, vigorous vegetative growth and a dark green color among cereal crops. In view of this, the field experiments were conducted during 2011-12 and 2012-13 to evaluate the effect of nitrogen with different wheat cultivars on growth and productivity. The soil was low in organic carbon and available nitrogen. The leaf area index and photo synthetically active radiation interception was higher in variety PBW 621. The 1000-grain weight and grains per ear were significantly higher in variety PBW 550 than other varieties. The variety DBW 17 had significantly higher tiller density. The variety PBW 550 gave significantly higher grain yield but statistically on par with variety PBW 621. The yield attributes, grain yield and quality parameters were highest under 150 kg N/ha. With increase in nitrogen level upto 120 kg N/ha, there was significantly increase in grain yield which was statistically on par with 150 kg N/ha. Agronomic use efficiency was significantly similar at 120 and 150 kg N/ha than other nitrogen levels. Therefore, there is need to save nitrogen fertilizers on soils low in nitrogen availability for wheat cultivars.

Highlights

- Wheat variety PBW 550 gave the highest grain yield which was almost similar with variety PBW 621
- Nitrogen levels of 120 kg/ha increased the grain yield significantly than other levels but similar to 150 kg N/ha.

Keywords: Varieties, nitrogen levels, grain yield, quality, *Triticum aestivum* L

Wheat [*Triticum aestivum* (L)] is an important *rabi* crop which is an excellent source of nutrition in terms of carbohydrates, minerals, proteins. This crop is unique among all the cereal grains as its flour makes a cohesive mass of dough when mixed with water which can be moulded to make innumberable products. Because of genetic variation, different varieties of crop may differ in growth and development behaviour and response to different management practices (Singh *et al.* 2010). Taller varieties are generally less responsive to fertilizer application and give lesser yields than the dwarf varieties. As genotypes vary widely, nitrogen (N) has got differential response. The varieties have been found to differ in their efficiency to accumulate dry matter and yield attributing characters. Nitrogen is necessary for chlorophyll synthesis as a part of the chlorophyll molecule, involved in photosynthesis and constituent of all amino acids and protein which are considered responsible for quality of wheat (Ramesh *et al.* 2005). N is one of the most important and expensive input in wheat cultivation which very important for yield and quality of wheat. The yield response of different genotypes varies widely under different N management. However, ever increasing prices of N fertilizers and possibilities of environmental pollution and groundwater contamination warn for their judicious and efficient use. Mahajan *et al.* (2013) reported that the use of costly fertilizer inputs can be economised by using target yield equations generated from soil test based and intergrated plant nutrient management. This discrepancy regarding the fertilizer N requirement of wheat may be related to residual N in soil, differential cultivar response etc. Concerns about the N pollution of environment such as nitrate leaching into ground water and nitrous oxide emission into the atmosphere, have stimulated interest in low input strategies for N fertilization. Therefore, the present investigations were planned to study the effect of different N levels on performance of bread wheat cultivars.

Materials and methods

Experimental site

The field experiment was conducted at the Punjab Agricultural University, Ludhiana during *rabi* 2011-12 and 2012-13 representing the Indo-Gangetic alluvial plains, situated at 30^{0} $56^{/}$ N latitude and 75^{0} $52^{/}$ E longitude and at an altitude of 247 metres above mean sea level. The objective of these studies was evaluating the performance of wheat cultivars and N levels on growth and productivity of wheat cultivars. The region has a sub-tropical climate, with hot wet summers and dry cool winters for *rabi* season crop.

Experimental treatments

The field experiment comprising of 20 treatments was conducted in a split plot design with four bread wheat varieties in main plots (HD 2967, PBW 621, DBW17 and PBW 550) and five N levels in sub plots [0, 90, LCC $_{\geq 4\ 100\ kg/ha}$ (25 kg N/ha basal + 45 kg N/ha at 1st irrigation + 30 kg/ha at 2nd irrigation), 120 and 150 kg N/ha] replicated four times. The crop was sown on November, 9 in 2011 and on November 11 in 2011. The wheat was sown using seed rate of 112.5 kg/ha for variety PBW 550 and 100 kg/ha for all other varieties. N in the form of urea was applied at the rate of 0, 90, 120, 150 kg/ha (3 splits: 1/3 at sowing, 1/3 at 1st irrigation and 1/3 at 2nd irrigation) and LCC $_{\geq 4\ 100\ kg/ha}$ [25 kg N/ha basal + 45 kg N/ha at first irrigation + 30 kg N/ha (at 2nd irrigation)]. Phosphorus (P_2O_5) at the rate of 62.5 kg/ha in the form of single super phosphate (SSP-16% P_2O_5) and Potassium (K_2O) at the rate of 30 kg/ha in the form of muriate of Potash (MOP-60% K_2O) fertilizers were applied with at the time of sowing. The crop received five irrigations in 2011-2012 and 2012-13. The composite samples of 0-15 cm depth were analysed for pH, EC and available nutrients (N, phosphorous and potassium) to know the status of soil before sowing of crop in 2011-12 and 2012-13.

Data collection and analysis

The data on emergemce count was recorded from 1 m^2 quadrant. The data on plant height, leaf area index, photosynthetically active radiation interception (PARI) and soil temperature were recorded at 90 and 120 days after sowing (DAS). Number of ear bearing tillers were recorded at harvest from one metre row length and were converted to effective tillers per square metre. Randomly ten ears were taken from each plot, threshed, counted and averaged for number of grains per ear. The samples of 1000-grains were collected from the grain yield were used for recording 1000-grain weight and was expressed in gram. The crop was harvested with sickle and threshed with engine-operated thresher. Agronomic use efficiency was calculated grain yield (kg) in treated plot – grain yield in control plot /nitrogen (kg) applied. The protein content was analyzed using standard methods. The data recorded during study were analysed using SAS statistical software. The comparisons were made at 5 % level of significance.

Results and discussion

Growth attributes

Plant height was significantly affected with different varieties and N treatments. At 90 DAS, the plant height of variety PBW 550 was significantly higher than HD 2967, PBW 621 and DBW 17 (Table 1). However, PBW 621 recorded significantly higher plant height than HD 2967 and DBW 17. At 120 days after sowing and at harvest, the plant height of variety PBW 550 was significantly lower than other varieties except in 2012-13 in which it was statistically at par with DBW 17. At 90 and 120

Table 1: Periodic plant height as affected by wheat varieties and nitrogen levels

Treatment	Plant height (cm)					
	90 DAS		120 DAS		At harvest	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Varieties						
HD 2967	40.6	42.1	82.4	80.3	93.3	95.0
PBW 621	43.0	44.1	83.7	84.2	92.0	93.0
DBW 17	34.8	35.0	70.8	70.2	78.0	80.2
PBW 550	61.5	62.1	70.1	70.0	75.0	76.4
C.D. (p=0.05)	3.2	4.1	2.1	3.5	4.4	3.9
Nitrogen level (kg N/ha)						
N_0	40.4	41.3	73.7	70	81.4	81.6
N_{90}	45.3	46.3	75.7	74.5	84.7	84.1
N_{120}	46.0	47.2	78.6	79.0	87.1	90.2
N_{150}	47.6	49.5	79.0	81	85.9	90.1
$LCC_{\geq 4\ (100)}$	45.4	46.5	76.8	76.5	83.8	85.0
C.D. (p=0.05)	2.3	3.0	2.3	2.4	2.0	1.9
Interaction	NS**	NS	NS	NS	NS	NS

***DAS Days after sowing**
****NS – non-significant**

Table 2: Effect of wheat varieties and nitrogen levels on periodic leaf area index (LAI) photosynthetically active radiation interception (PARI) and soil temperature (Soil temperature) recorded at 2:30 pm

Treatment	90 DAS						120 DAS					
	LAI		PARI		Soil temperature (°C)		LAI		PARI		Soil temperature (°C)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Varieties												
HD 2967	4.83	4.96	3.90	4.10	16.4	17.0	3.90	3.90	78.88	80.1	23.1	21.3
PBW 621	4.94	5.03	4.01	4.12	16.8	17.1	4.01	3.91	83.23	82.3	23.2	21.1
DBW 17	4.73	4.95	3.80	3.94	16.5	16.7	3.80	3.94	82.04	83.1	23.6	23.5
PBW 550	4.67	4.75	3.68	3.76	16.6	17.4	3.68	3.74	77.65	79.0	23.6	22.5
C.D. (p=0.05)	0.03	0.05	0.05	0.06	-	-	0.05	0.04	NS	NS	-	-
Nitrogen level (kg N/ha)												
N_0	4.38	4.45	3.36	3.55	17.0	17.6	3.36	3.45	74.97	76.0	23.7	22.5
N_{90}	4.48	4.65	3.50	3.65	16.6	17.0	3.50	3.55	81.53	82.0	23.6	22.4
N_{120}	5.00	5.21	4.03	4.10	16.4	17.0	4.03	4.01	81.58	82.5	23.4	21.8
N_{150}	5.33	5.45	4.43	4.50	16.0	16.8	4.43	4.53	82.54	83.4	22.9	21.9
$LCC_{\geq 4\ (100)}$	4.78	4.96	3.89	4.01	16.8	16.8	3.89	3.91	81.54	81.7	23.3	21.8
C.D. (p=0.05)	0.06	0.05	0.06	0.04		-	0.06	0.04	2.64	3.57	-	-
Interaction	NS	NS	NS	NS		NS	NS	NS	NS	NS		

Table 3: Emergence count, yield attributes and yield of wheat as influenced by varieties and nitrogen levels

Treatment	Emergence count/m²		Effective tiller/m²		Grains/ear		1000-grain weight (g)		Grain yield (q/ha)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Varieties										
HD 2967	192	180	327	332	39.8	38.5	35.8	38.8	48.45	50.21
PBW 621	192	185	340	346	42.8	41.3	36.4	35.1	49.90	50.20
DBW 17	192	186	352	362	41.8	40.3	35.8	31.7	47.31	46.26
PBW 550	187	185	314	315	47.2	48.2	40.9	39.3	51.69	51.78
C.D. (p=0.05)	NS	NS	13	11	0.3	0.5	3.8	3.1	2.12	2.51
Nitrogen level (kg N/ha)										
N_0	191	182	275	271	39.8	37.3	36.2	31.5	41.41	42.12
N_{90}	191	183	323	355	42.3	41.0	37.4	32.7	46.53	45.81
N_{120}	191	184	361	359	43.6	43.8	37.5	33.9	54.03	53.23
N_{150}	191	185	365	365	45.8	46.1	37.9	41.7	54.97	54.95
$LCC_{\geq 4\ (100)}$	191	184	342	346	42.9	44.1	37.4	34.1	49.75	52.1
C.D. (p=0.05)	NS	NS	15	13	0.9	0.8	NS	7.5	1.52	1.73
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Quality characters and agronomic efficiency of wheat as influenced by varieties and nitrogen levels

Treatment	Protein content (%)		Hectolitre weight (kg)		Grain hardness (kg)		Agronomic use efficiency (kg grain/kg N applied)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Varieties								
HD 2967	11.06	11.51	72.87	73.12	7.65	7.61	7.74	7.83
PBW 621	11.14	11.23	75.32	76.51	9.99	10.12	7.96	8.47
DBW 17	10.89	11.01	75.11	75.00	9.91	10.24	10.06	7.37
PBW 550	11.34	11.5	76.69	75.63	10.44	10.66	7.85	8.09
C.D. (p=0.05)	NS	NS	1.56	1.23	1.28	1.35	NS	NS
Nitrogen level (kg N/ha)								
N_0	10.19	10.51	74.19	75.0	8.20	8.31	-	-
N_{90}	10.97	11.24	75.23	75.2	9.15	9.26	5.69	4.08
N_{120}	11.41	11.65	75.37	75.91	9.95	10.12	10.52	9.23
N_{150}	11.78	11.70	75.84	75.79	10.83	11.21	9.05	8.50
$LCC_{\geq 4\ (100)}$	11.19	11.46	74.38	73.39	9.36	9.35	8.34	9.95
C.D. (p=0.05)	0.28	0.24	0.59	0.61	0.41	0.39	1.52	1.60
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

DAS, plants were significantly taller in 150 kg N/ha than control but was statistically at par with 90, 120 kg N/ha and $LCC_{\geq 4\ (100\ kg\ /ha)}$ treatment except in 2011-12 where it was significantly better than 90 kg N/ha also. At harvest, plant height recorded was the highest with N level of 120 kg N/ha and statistically at par with 150 kg N/ha in both years. The wheat variety PBW 621 resulted in significantly higher leaf area index at 90 and 120 DAS in both years except in 2012-13 however it was higher in variety PBW 550 at 120 DAS (Table 2). Hussain *et al*. (2012) also reported higher LAI in variety TD 1 at 75 DAS than other varieties. At 90 and 120 days after sowing, 150 kg N/ha had significantly more leaf area index than all other N levels (Table 2). At 90 days after sowing, the highest PAR interception was recorded in variety PBW 621 which was significantly higher than variety HD 2967, PBW 550 and DBW 17 varieties in 2011-12 however; this variety recorded significantly higher PARI than PBW 550 and DBW 17 only but was statistically at par with HD 2967 in 2012-13. At 90 days after sowing, PAR interception recorded was the highest in 150 kg N/ha which was significantly higher all other treatments. At 120 days after sowing, PAR interception was recorded highest at 150 kg N/ha which was significantly higher than control but was statistically on par with 90 kg N/ha, $LCC_{\geq 4\ (100\ kg/ha)}$ and 120 kg N/ha in both years. N limitation affected wheat growth by reduction of the intercepted PAR (Dreccer *et al.* 2000). The soil temperature recorded was the highest in variety PBW 550 at 90 and 120 DAS except in 2011-12 where it was the higher in variety PBW 621 (Table 2). It might be due to lower LAI and PARI in the variety PBW 550. Among N treatments, the highest soil temperature was recorded in control (No N) treatment it might be due to less LAI and PARI and more of the radiations strikes the ground surface so the soil temperature was more. Ram *et al.* (2013) also recorded higher soil temperature in the treatments where the LAI and PARI was the less. All the interactions were found to be non-significant.

Emergence, yield attributes and yield

The wheat varieties had no significant effect on emergence count but emergence of seedlings in variety PBW 550 was numerically less than other varieties in both years (Table 3). The effective tillers/m^2 were the lowest in the variety PBW 550 which were significantly less than HD 2967, PBW 621 and DBW 17 varieties. Ram *et al*. (2012) also reported significantly lower tillering in variety PBW 550 than DBW 17. The N level of 150 kg/ha had the highest effective tillers and no. of grains than all other N levels. The highest effective tillers in 150 kg/ha were statistically same with nitrogen level of 120 kg/ha in 2011-12 and with 120 kg N/ha and 90 kg N/ha in 2012-13.The variety PBW 550 had significantly higher number of grains per ear and 1000-grain weight over all other varieties in both years. Rahman *et al.* (2002), who reported that N application, have tremendous effect on tiller formation and survival of tillers. The grains per earhead and 1000-grain weight were significantly higher in the variety PBW 550 which was significantly higher than all other varieties. Ram *et al*. (2012) also reported also reported higher 1000-grain weight in variety PBW 550. Among the N treatments, the highest grains per earhead and 1000-grain weight was recorded in 150 kg N/ha which was significantly higher than all other treatments but the data on 1000-grain weight recorded in 150 kg N/ha were significantly higher than all other treatments except in 2012-13 where it was non-significant. The highest grain yield was obtained in variety PBW 550 which was statistically on par with variety PBW 621 but significantly higher that HD 2967 and DBW 17 varieties in 2011-12 but in 2012-13, the variety PBW 550 recorded significantly higher grain yield than DBW 17 but statistically at par with PBW 621 and HD 2967 varieties. The higher grain yield in these varieties might be due to higher yield attributing characters. The wheat variety PBW 502 out yielded the varieties PBW 343, WH 542, PDW 274, PBW 509 and PBW 373 (Gill *et al*. 2011). N level of 150 kg/ha gave significantly higher grain yield than control, 90 kg N/ha and $LCC_{\geq 4\ (100\ kg/ha)}$ treatment however, it was statistically on par with N level of 120 kg/ha in both years. Increased grain yield from 15.75 to 17.09 q/ha with increase in N level from 0 to 75 kg/ha, showing a linear trend was also reported by Khan *et al*. 2011). All the interactions were found to be non-significant.

Quality characters and agronomic use efficiency

The protein content was not significantly different in the varieties. The highest protein content was recorded in 150 kg N/ha which was significantly higher than all other N levels except in 2012-13 where it was statistically at par with 120 kg N/ha. The variety PBW 550 had significantly higher hectolitre weight over HD 2967 and DBW 17 however it was statistically on par with PBW 621 (Table 4) in both the years. The variety PBW 621 recorded similar hectolitre weight as in variety DBW 17 but significantly higher than HD 2967. Among N treatments, in 2011-12 the highest hectolitre was recorded on 150 kg N/ha which was statistically at par with $LCC_{\geq 4\ (100\ kg/ha)}$ and 120 kg N/ha treatments. However, in 2012-13 the highest hectolitre was recorded on 120 kg N/ha which was statistically at par with LCC $_{\geq 4\ (100\ kg/ha)}$ and 150 kg N/ha treatments. The variety PBW 550 had significantly highest grain hardness than PBW 621, DBW 17 and HD 2967 in 2011-12. The highest grain hardness was recorded in 150 kg N/ha which was significantly higher than all other N levels. Wheat varieties had non-significant effects on agronomic use efficiency. Agronomic efficiency was found significantly higher at 120 kg N/ha than 90 kg N/ha and LCC ≥ 4 (100 kg/ha) treatment but statistically on par with 150 kg N/ha. Also LCC $_{\geq 4\ (100\ kg/ha)}$ treatment and 150 kg N/ha was found statistically on par with each other in 2011-12. In second year LCC ≥ 4 (100 kg/ha) treatment recorded the highest agronomic efficiency which was statistically at par with 120 and 150 kg N/ha. All the interactions were found to be non-significant. It is concluded from the present studies that the variety PBW 550 gave highest grain yield which was almost similar with variety PBW 621 and N levels of 120 kg/ha increased the grain yield significantly than other levels but similar to that recorded with 150 kg N/ha.

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