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Nutrient Use and Uptake Efficiency in Wheat and Triticale Genotypes under Low and Optimum Input Conditions

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ABSTRACT

N, P and Zn content, harvest index and grain yield were used to evaluate diverse 32 wheat and triticale genotypes categorized in four groups i.e. *Triticum aestivum*, *Triticum durum*, synthetic wheat and triticale genotypes. The genotypes differed significantly for all the characters indicating considerable variation for improvement of these traits. The varieties LoK1 and HD2687 were having highest grain yield under low and optimum input conditions respectively, while HD 2687 showed maximum percent of increase over low input conditions. PBW343 and P7307 were having highest harvest index under low and optimum input conditions respectively, whereas Syn5 was found to show highest percent of increase over low input conditions. As nutrient use and uptake parameters are concerned, for N content triticale genotypes TL2963 and TL2967 showed highest content under low and optimum input conditions, while percent increase over low input conditions was found to be highest in HD2687 (285.96 per cent). Genotypes TL2966 and Syn36 were having highest P content under low and optimum input conditions respectively among all the four groups, while TL2969 responded better over low input conditions. Among all the four groups triticale genotype TL2963 showed trend having high content of zinc under both low and optimum input conditions, whether for percent of increase over low input conditions P7531 responded better. Path coefficient analysis revealed that harvest index followed by biological yield had the direct effect under both conditions.

Keywords: Nutrient use efficiency, wheat and triticale, N, P, Zn content in wheat, harvest index.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world. The area, production and productivity of wheat in India is approximately 28.30 million ha, 84.70 million tones, approximately 29.90 qtl/ha, respectively during the year 2010-11. The corresponding figures in Haryana are 25.15 lakh ha, 116.30 lakh tones, 46.24 qtl/ha (Anonymous, 2010-11). The increase in the use of nitrogen (N) and phosphorous (P) fertilizers between 1960 and 2000 by intensive agricultural practices has led to degradation of air and ground water quality (Tilman *et al*., 2001). Even though N is among the most abundant elements on earth, it is the critical limiting element for growth of most plants due to its unavailability (Graham and Vance, 2000). According to an estimate, about 54% soils in Haryana are deficient in zinc. Soils with extractable Zn less than 0.6% mg/ kg soil will require the application of particular nutrient to sustain production. About 50% of the soils used for cereal production in the world contain low levels of the zinc available to plants which reduces not only grain yield, but also nutritional quality of grains. Triticale is one of the synthetic amphiploid of wheat and rye which came into commercial cultivation. Synthetic wheat are produced by artificially crossing tetraploid durum wheat (*Triticum turgidum*, 2n=4x=28, AABB), donor of the A and B genomes, with *Triticum tauschii* (2n=2x=14DD). P is second only to N as the most limiting nutrient for the plant growth (Biellski, 1973, Vance *et al*., 2000). Thus, efficiency of wheat cultivars in N use has become increasingly important, because of the cost of N fertilizer and of the potential for nitrate pollution of underground water and the atmosphere. Research has shown that modern semi dwarf cultivars respond more to available nitrogen than the old, tall cultivars, which translates into higher returns to farmers (Ortiz - Monasterio *et al*., 1997). In addition, semi dwarf wheats do not necessarily require more nitrogen than older cultivars at lower levels of fertility (Ortiz - Monasterio *et al*., 1997). Graham *et al*., (2000) reported that deficiencies of zinc are well known in all cereals and cereal growing countries. From physiological evidence reported elsewhere, it would appear that a critical level for zinc is required in the soil before roots will either grow into it or function effectively (Graham *et al*., 2000). Zinc efficient genotypes absorb more zinc from deficient soils, produce more dry matter and more grain yield but do not necessarily have the highest zinc concentrations in tissue or grain. Although high grain zinc concentration also appears to be under genetic control, it is not tightly linked to agronomic zinc efficiency traits and may have to be selected for independently (Graham *et al*., 2000).

Material and methods

Experimental material: Experimental material comprised four groups of genotypes, namely, *T. aestivum*, *T. durum,* Triticale and synthetic wheat. Each group consisted of 8 genotypes, thus making a total of 32 genotypes. The detail of experimental material is given below.

Environments: The experiment was conducted in following environments

Low input: On the basis of soil test the doses of fertilizer were corrected up to 60 kg N, 30 kg P_2O_5/ha. In addition to this two irrigations were applied. First irrigation was applied on CRI stage and second irrigation was applied on flowering stage.

Optimum input: On the basis of soil test the doses of fertilizer were corrected up to 150 kg N, 60 kg P_2O_5/ha. In addition, four irrigations were applied, first irrigation was applied on CRI stage, second irrigation was applied on tillering, third on flowering stage, and fourth on dough stage.

Layout: The design was laid out in split plot design. Plot size was of single row of 3 m length. Observations were taken as 5 plants / entry / replication.

Estimation of N content and P content - 0.5 gram of finely grounded samples were taken in digestion tube and 10 ml sulfuric acid + perchloric acid in the ratio of 4:1 poured in digestion tube and left over night. The material was heated from 90 minutes at 160ºC and 30 minutes at 220ºC. After cooling, every digestion tube was filled with 30 ml distilled water and after shaking volume was made 50 ml. Then this end product was filtered into plastic bottle of 100 ml and such digests were analyzed for N content and P content.

Estimation of Zn content - 0.5 gram of finely grounded samples were taken in digestion tube and 20 ml nitric acid + perchloric acid in the ratio of 4:1 poured in digestion tube and left over night. The material was heated from 90 minutes at 160ºC and 30 minutes at 220ºC. After cooling, every digestion tube was filled with 30 ml distilled water and after shaking volume was made 50 ml. Then this end product was filtered into plastic bottle of 100 ml and such digests were analyzed for Zn content.

N content (%) - N content was estimated in plant sample following standard procedure of A.O.A.C. (1970).

N uptake (mg/plant) - N uptake was calculated by multiplying the N content in shoot by dry weight.

P content in shoot (%) - P content was measured following standard procedure of A.O.A.C. (1953)

P uptake (mg) - P uptake was calculated by multiplying the P content in shoot by dry weight.

Zn content (ppm) in shoot - Zn content was determined by Atomic Absorption Spectro-photometer, GBC 902 plus.Micronutrients uptake was calculated by multiplying content with dry yield of straw.

The N, P and Zn use efficiency were determined by the method suggested by Moll (1982).

Results

Analysis of variance

Mean squares due to genotypes were significant for all the characters except for spikelets per spike. Therefore spikelet per spike was dropped from further analysis (Table1). Significant differences due to genotypes for various traits indicated that there was considerable variation among the genotypes. Genotype × fertilizer (G × F) interaction was significant for majority of the characters in *T. aestivum, T. durum*, triticale and synthetics. This indicated that genotypes differed in their response from low to optimum input conditions for the characters under study.

Mean performance of genotypes for various traits under low and optimum input conditions

The varieties LoK1 and HD2687 were having highest grain yield under low and optimum input conditions respectively, while HD 2687 showed maximum percent of increase over low input conditions. PBW343 and P7307 were having highest harvest index under low and optimum input conditions respectively, whereas Syn5 was found to show highest percent of increase over low input conditions (Table 2). Nitrogen content in grains was found highest in triticale genotypes TL2963 (2.43%) and TL2967 (2.74%) under low and optimum input conditions, respectively, while percent of increase over low input conditions was found to be highest in HD2687 (285.96%). For phosphorous content in grains TL2966 (0.52) and Syn36 (0.42) was found to be having highest P content under low and optimum input conditions, while percent of increase over low input conditions was found to be highest in TL2969 (69.30). Triticale genotype TL2963 (97.03) and (100.64) was observed to have highest Zn content under low and optimum input conditions, respectively, while percent of increase over low input conditions was found to be highest in P7531 (63.90). Genotypes Lok1 (25.43) and PBW343 (38.95) performed better for nutrient use efficiency under low and optimum input conditions, respectively, while for percent of increase over low input conditions was found to be highest in TL2967 (141.98). Genotypes PBW343 (97.38) and Lok1 (127.15) performed better in both the field conditions i.e. low and optimum input conditions, respectively, while TL2969 (62.67) responded better upon fertilizer application. For zinc use efficiency genotypes PBW343 (233.72) and Lok1 (381.46) were best performing under low and optimum input conditions, respectively, while TL2969 (103.38) responded better over low input conditions among all the genotypes.

Discussion

The increase in mean performance of grain yield from low to optimum input conditions was up to 75.30% in *T. durum* group followed by triticale group (68.3%), Synthetic wheat group (67.1%) and *T. aestivum* group (56.80%). The higher increase under optimum input conditions indicated the potential for fertilizer responsiveness of the genotypes which can be used in breeding programme for improvement of the trait under consideration. With regard to responsive genotypes in various groups the genotypes HD2687 in *T. aestivum* group, P7531 in *T. durum* group and TL2967 in triticale group and Syn 5 in synthetic wheat group were highly fertilizer responsive for grain yield. Singh and Prasad (1998) indicated that N application (0-80 kg N /ha) significantly increased the grain yield of wheat. Azad *et al*., (1998) found significant increase in yield of wheat due to increase in rate of fertilizer application from 100 percent recommended dose of NPK to 150 percent. Genotypes for harvest index responded from low to optimum input conditions upto 32.57% in *T. durum* group followed by 32.320% in synthetic wheat group, 29.50 % in triticale group and 22.41 % in *T. aestivum* group. Responsiveness of WH 1021 in *T. aestivum* group, HI8498 in *T. durum* group, TL 2968 in triticale group and Syn 36 in synthetic wheat group was high for biological yield, while for harvest index, DBW 17 in *T. aestivum* group, P7531 in *T. durum* group, TL 2967 in triticale group were highly responsive genotypes from low to optimum input conditions. Similarly Torabi and Malakuti (1997) found that the application of N (0-80 kg N/ha) increased grain yield but decreased harvest index of wheat.

The increase in mean performance of genotypes for N content in grams in various groups from low to optimum input conditions was upto 121.96% in *T. aestivum* group followed by 33.81% in *T. durum* group followed by 30.36% in triticale group followed 26.62% in synthetic wheat group. Similarly the mean performance of the genotypes for P content in grams from low to optimum input conditions in various groups was upto 20.48% in *T. aestivum* group followed by 8.39% in synthetic wheat group followed by 5.26% in *T. durum* group followed by 3.12% in triticale group. With regard to responsiveness the genotypes HD 2687 in *T. aestivum* group, HI 8498 in *T. durum* group, TL 2968 in triticale group and Syn 5 in synthetic wheat group were highly responsive for N content in grains. For P content in grains the genotypes WH 1021 in *T. aestivum* group, WHD 943 in *T. durum* group, TL 2969 in triticale group, Syn 27 in synthetic wheat group were highly responsive. The mean performance of the genotypes for Zn content in grains showed high response from low to optimum input conditions in various groups. The genotypes Lok1 in *T. aestivum* group, P 7531 in *T. durum* group, TL 2968 in triticale group and Syn 24 in synthetic wheat group were highly responsive. Rengel and Graham (1995) observed that zinc may be important for an early establishment of crops on low fertility soil and also for high grain yield and concluded that crops grown from seed containing higher Zn content have distinct advantages which culminate in grater yield when grown in soil of low Zn status.

Table 1. Mean squares for various characters of wheat genotypes evaluated under Low and optimum input conditions

Grain yield	Replication (2)†	Fertilizer(F) (1)	Error(a) (2)	Genotype(G) (7)	G X F (7)	Error (b) (28)
T. aestivum	1.44	1062.58*	5.28	58.75*	17.82*	3.18
T. durum	3.06	1543.15*	4.85	47.82*	16.03	5.42
Triticale	19.89	740.49*	7.36	22.71	24.45*	5.60
Synthetic wheat	3.64	322.51*	0.71	15.85*	4.02	1.85
Biological yield per plant						
T. aestivum	20.33	2898.92*	10.05	307.36*	177.70*	12.58
T. durum	17.37	3584.53*	22.86	259.10*	162.54*	11.42
Triticale	148.61	1699.37*	77.85	190.23*	164.38*	41.45
Synthetic wheat	59.26	938.99*	4.82	168.57*	35.58	20.52
Nitrogen content in grain						
T.aestivum	>0.01	13.38*	0.01	0.14*	0.10*	0.06
T.durum	0.01	2.72*	0.05	0.34*	0.18*	0.03
Triticale	0.01	4.09*	0.02	0.55*	0.20*	0.01
Synthetic wheat	0.01	1.94*	>0.01	0.22*	0.33*	>0.01
Phosphorous content in grain						
T.aestivum	>0.01	0.09*	>0.01	0.03*	0.01*	>0.01
T.durum	>0.01	0.02*	>0.01	0.01*	0.02*	>0.01
Triticale	>0.01	>0.01	>0.01	0.03*	0.01*	>0.01
Synthetic wheat	>0.01	0.03*	>0.01	0.03*	0.01*	>0.01
Zinc content in grain						
T.aestivum	34.31	1914.85*	64.31	98.45*	24.46*	>0.01
T.durum	34.31	2167.72*	64.31	67.23*	22.52*	>0.01
Triticale	34.31	1040.06*	3.99	31.89*	34.35*	5.67
Synthetic wheat	1.94	381.10*	7.92	533.49*	5.65*	>0.01
Nitrogen use efficiency						
T.aestivum	473.74	533314.77*	2035.30	27680.89*	8937.17*	1631
T.durum	1512.79	762110.91*	2398.31	23633.10*	7917.26*	2674.92
Triticale	9811.03	365640.71*	3639.32	11211.18*	12074.28*	2764.71
Synthetic wheat	34.50	450.80*	64.10	22.13*	1985.73	915.07
Phosphorous use efficiency						
T.aestivum	9.19	3665.73*	79.13	1289.16*	364.13*	>0.01
T.durum	9.16	1453.10*	78.76	811.17*	253.92*	>0.01
Triticale	9.20	1381.38*	79.40	383.61*	413.95*	>0.01
Synthetic wheat	9.19	679.51*	79.19	298.33*	89.35*	>0.01
Zinc use efficiency						
T.aestivum	31.44	121962.46*	>0.01	10002.86*	3343.72*	>0.01
T.durum	31.28	76632.09*	120.70	6169.46*	2147.48*	>0.01
Triticale	31.44	53243.10*	120.54	3017.97*	3238.95*	>0.01
Synthetic wheat	31.15	24838.45*	120.99	2325.27*	827.47*	>0.01

*, **: significant at 5% and 1% level of significance respectively.

Table 2. Mean performance of genotypes for various traits under low and optimum input conditions

Sr. no.	Trait	Input conditions	Genotype	Mean	% of increase over low input conditions
1	Grain yield per plant (g)	Low input	Lok1	21.45*	HD2687 (143.20)
		Optimum Input	HD2687	31.49*	
2	Biological yield (g)	Low input	WH147	75.30*	WH1021 (72.10)
		Optimum Input	PBW343	91.10*	
3	Harvest index	Low input	PBW343	32.50*	Syn5 (94.30)
		Optimum Input	P7307	38.60*	
4	N content	Low input	TL2963	2.43*	HD2687 (285.96)
		Optimum Input	TL2967	2.74*	
5	P content	Low input	TL2966	0.52*	TL2969 (69.30)
		Optimum Input	Syn36	0.42*	
6	Zn content	Low input	TL2963	97.03*	P7531 (63.90)
		Optimum Input	TL2963	100.64*	
7	Nutrient use efficiency	Low input	Lok1	25.43*	TL2967 (141.98)
		Optimum Input	PBW343	38.95*	
8	Phosphorous use efficiency	Low input	PBW343	97.38*	TL2969 (62.67)
		Optimum Input	Lok1	127.15*	
9	Zinc use efficiency	Low input	PBW343	233.72*	TL2969 (103.38)
		Optimum Input	Lok1	381.46*	

*, **: Significant at 5% and 1% level of significance respectively.

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