The Journal of Animal & Plant Sciences, 27(4): 2017, Page: 1264-1268
ISSN: 1018-7081

GENOTYPIC DIFFERENCES AND GENOTYPE × NITROGEN INTERACTIONS FOR YIELD TRAITS IN BREAD WHEAT

F. U. Khan[1, 2], F. Mohammad[1,*], Raziuddin[1], Z. Shah[3], M. Ahmad[4] and Z. Shah[5]

[1]Department of Plant Breeding and Genetics, The University of Agriculture, Peshawar Pakistan
[2]Barani Agricultural Research Station, Kohat Khyber Pakhtunkhwa, Pakistan
[3]Department of Soil & Environmental Sciences, The University of Agriculture, Peshawar Pakistan
[4]Department of Agronomy, Bacha Khan University Charsadda, Pakistan
[5]Department of Biotechnology, University of Science and Technology Bannu, Pakistan
[*]Corresponding author: fahimbiotech@gmail.com

ABSTRACT

Efficient utilization of nitrogen by major crops has always been an aim in plant breeding research. Several economic and environmental issues urge plant breeders to develop plant varieties that could absorb and use nitrogen more efficiently. Thirty wheat varieties were grown under with (N+) and without nitrogen (N0) condition as an independent experiments at The University of Agriculture, Peshawar during 2013/14 crop season. Significant G × E interactions effects for all traits justified independent analysis of variance, which also displayed significant differences among genotypes for all the studied traits under each nitrogen level. Wheat variety Pirsabak-05 exhibited maximum values for tillers m^{-2} (131) and 1000-grain weight (51.7 g), Aas-11 for grains $spike^{-1}$ (81 grains), Shahkar-13 for biological yield (8300 kg ha^{-1}), Tatara-96 for grain yield (3570 kg ha^{-1}) and NARC-11 for harvest index (46.9%). The results of substantial variation for various yield traits across two nitrogen levels indicated that significant genetic variation exists in tested bread wheat cultivars. Thus, this germplasm can be safely used in future breeding program focused on the development of wheat cultivars well suited to low input wheat production system.

Key words: genotype-environment inetraction, germplasm, denitrification.

INTRODUCTION

Since green revolution, farmers tend to maximize N fertilization to maximize crop yield (Hirel *et al*., 2007). With the increasing demand for food, the global consumption of synthetic (commercial) fertilizers and organic (manure) compost increased sharply. Crop production is not cost-effective both with over and under-use of N fertilizers. Over-use of N fertilizers is not economical to the low-value crop producers both in terms of price of the N-fertilizer and the potential loss of yield (Ju *et al*., 2009). High consumption of N-fertilizer is also harmful to the environment, as excessive N lost by leaching into groundwater and runoff into surface water, ammonia volatilization and production of NOx gases from denitrification pollute the atmosphere (Conley *et al*., 2009). Under-use of N fertilizers results in modest crop yield, which is not financially viable. That is why, application of nitrogen fertilizer have merits (high yield) and demerits (environmental hazards) in cereal crops production. Therefore, some areas of the world needs to focus on reducing the use of N fertilizer due to environment deterioration, while developing low wheat producing areas needs to apply high levels of N fertilizers. Breeding for N use efficiency in crops is dependent on the genetic variability present in the species for the trait(s) that determine efficient N utilization and the procedures to accurately measure components that reflect N use by the plant. A key step required in breeding for high nutrient use efficiency crops is to identify and exploit variation in existing germplasm (Hirel *et al*., 2007). Keeping in view the merits of improving N use efficiency of cereals in term of environmental protection, the present experiment was thus designed to study genotypic differences among wheat germplasm for grain yield and related traits under varied level of nitrogen.

MATERIALS AND METHODS

The present study was undertaken at New Developmental Research Farm, The University of Agriculture Peshawar, Pakistan during 2013-14 crop season. Seed of different wheat varieties was procured from various research institutes of the country (Table 1). Experimental material comprising thirty genotypes were evaluated under with (N+) and without (N0) nitrogen conditions. Before sowing, soil samples from the selected field were collected to determine various soil physio-chemical characteristic (Table 2). Recommended dose of fertilizer (P and K @ 90 and 60 kg ha^{-1}, respectively) were applied to both experiments, whereas nitrogen (@ 120 kg ha^{-1}) was applied only to with nitrogen experiment. Experimental material was planted in randomized complete block design with three replications under each level of nitrogen. Each plot consisted of 6 rows of 5 meter length each with row to row space of 30 cm, respectively. Data were recorded on tillers m^{-2}, grains spike^{-1}, 1000-grain weight (g), biological yield (kg ha^{-1}), grain yield (kg ha^{-1}) and harvest index (%). Data for all parameters was analyzed across two nitrogen levels using a mixed effects model (Annicchiarico, 2002) to quantify genotype-by-environment effects. Upon significant G x E interaction, data were also analyzed independently for each environment viz. with nitrogen (N+) and without nitrogen (N0) following the procedure of Steel *et al*. (1997).

RESULTS

Analysis of variance: Mean squares across two N levels for tillers m^{-2}, grains spike^{-1}, 1000-grain weight, biological yield, grain yield and harvest index is given in Table 3. Combined analysis of variance across two nitrogen levels showed highly significant differences among environments, genotypes and G × E interactions (GEI) for all studied traits. Significance of GEI allows to proceeds with independent analysis of variance under each level of nitrogen. Correspondingly, independent analysis of variance for each N level also showed significant differences among genotypes for all the characters studied. Significant differences among genotypes indicated that there is sufficient variability among wheat varieties of Pakistan, and thus provide an opportunity for effective selection for desired traits. Similarly, GEI effects were also significant for all the character studied, indicating differential performance of genotypes under varied level of nitrogen.

Mean Performance: Mean data for tillers m^{-2}, grain spike^{-1}, 1000-grain weight, biological yield, grain yield and harvest index of 30 wheat genotypes are given in Table 4. Tillers are an important component of wheat yield because they have the potential to develop grain-bearing heads. Number of tillers m^{-2} across two environment varied from 63 to 131. Mean number of tillers m^{-2} exhibited that wheat variety Pirsabak-05 produced maximum number of tillers m^{-2} (131), whereas, minimum number of tillers m^{-2} were recorded for wheat variety Hasham-08 and Aas-11 (63 each). Number of grains spike^{-1} varied from 49 to 81 grains across two N levels. The highest and lowest number of grains spike^{-1} were produced by wheat variety Aas-11 (81 grains) and Pirsabak-05 (47 grains), respectively across two N levels. 1000-grain weight ranged from 37.4 to 51.7 g. Maximum and minimum values of 1000-grain weight were recorded for wheat variety Pirsabak-05 (51.7 g) and Pirsabak-85 (37.4 g), respectively. Biological yield across two N levels ranged from 3950 to 8300 kg ha^{-1}. Wheat variety Shahkar-13 produced maximum above ground biomass (8300 kg ha^{-1}), followed by Tatara-96 (7819 kg ha^{-1}) and Pirsabak-05 (7492 kg ha^{-1}), whereas minimum biological yield of 3950 kg ha^{-1} were recorded for Hasham-08. Grain yield ranged from 1371 to 3570 kg ha^{-1} across two nitrogen levels. Mean over two environments, wheat variety Tatara-96 produced maximum grain yield (3570 kg ha^{-1}), followed by Shahkar-13 (3487 kg ha^{-1}) and Pirsabak-05 (3319 kg ha^{-1}), whereas minimum grain yield of 1371 kg ha^{-1} were recorded for Inqilab-91. Harvest index ranged from 26.9 to 46.9 % across two N levels. Maximum and minimum values of harvest index were recorded for wheat variety NARC-11 (46.9 %) and Inqilab-91 (26.9 %), respectively.

Table 1 List of wheat germplasm evaluated at Peshawar, 2013/14.

Genotype	Parentage/Pedigree	Year of release	Breeding Centre	Province
Pak-81	KVZ/BUHO//KAL/BB	1981	CCRI, Pirsabak	Khyber Pakhtunkhwa
Pirsabak-85	KAVKAZ/(SIB)BUHO//KALYANSONA/BLUEBIRD	1986	CCRI, Pirsabak	Khyber Pakhtunkhwa
Khyber-87	KAVKAZ/TORIM-73//POTAM-70/ANAHUAC-75	1987	CCRI, Pirsabak	Khyber Pakhtunkhwa
Inqilab-91	WL-711/(SIB)CROW	1991	WRI, Faisalabad	Punjab
Watan	LU26/HD 2179	1993	WRI, Faisalabad	Punjab
Nowshehra-96	BUCKBUCK/FLICKER//MYNA/VULTURE	1996	CCRI, Pirsabak	Khyber Pakhtunkhwa
Suleman-96	F-6-74/BUNTING//SISKIN/3/VEERY-7	1996	CCRI, Pirsabak	Khyber Pakhtunkhwa
Tatara	JUPATECO-73(SIB)ALONDRA//(SIB)KINGLET/3/VEERY-S	1996	NIFA, Peshawar	Khyber Pakhtunkhwa
Ghaznavi-98	JUP/BJYY/URES	1998	AUP, Peshawar	Khyber Pakhtunkhwa
KT-2000	GEN#WHETON	2000	BARS, Kohat	Khyber Pakhtunkhwa
Saleem-2000	CHAM-6//KITE/PAPAGO-86	2000	CCRI, Pirsabak	Khyber Pakhtunkhwa
Pirsabak-04	KAUZ/STAR	2004	CCRI, Pirsabak	Khyber Pakhtunkhwa
Pirsabak-05	MUNIA/CHTO//AMSEL	2005	CCRI, Pirsabak	Khyber Pakhtunkhwa
Seher-06	CHILEROL/2*STAR/4/BOBWHITE//BUCKBUCK/PAVON-76/3/2*VEERY-10	2006	WRI, Faisalabad	Punjab
Bathoor-08	URES/JUN//KAUZ	2008	NIFA, Peshawar	Khyber Pakhtunkhwa
Faisalabad-08	PBW-65/2*PASTOR	2008	WRI, Faisalabad	Punjab
Hashim-08	JUP/ALD’S’//KLT’S’/3/VEE’S’/6/BEZ//TOB/8156/4/O	2008	ARI, D.I. Khan	Khyber Pakhtunkhwa

	N/ 3/6*TH/KF//6*			
Pirsabak-08	KAUZ / PASTOR	2008	CCRI, Pirsabak	Khyber Pakhtunkhwa
Janbaz	Gen*2//Buc/Filk/3/Buchin	2010	AUP, Peshawar	Khyber Pakhtunkhwa
Amin-08	PASTOR/OPATA	2010	ARS, S. Naurang	Khyber Pakhtunkhwa
Atta-Habib-10	INQALAB 91*2/TUKURU	2010	AUP, Peshawar	Khyber Pakhtunkhwa
Barsat-10	FRET2	2010	NIFA, Peshawar	Khyber Pakhtunkhwa
Siran-07	PBW343*2/KUKUN	2010	AUP, Peshawar	Khyber Pakhtunkhwa
AAS-11	PRL/PASTOR//2236(V.6550/Sutlej-86	2011	RARI, Bahawalpur	Punjab
AARI-11	SH-88/90A-204//MH97	2011	RARI, Bahawalpur	Punjab
Dharabi-11	CMSS97Y03676S-040Y-050M-040SY-030M-21SY-010M-0Y-0SY.	2011	BARI, Chakwal	Punjab
NARC-11	OASIS/SKAUZ//4*BCN/3/2*PASTOR	2011	NARC, Islamabad	Capital City
Punjab-11	AMSEL/ATTILA//INQ-91/PEW'S'	2011	WRI, AARI, Faisalabad	Punjab
Pirsabak-13	CS/TH.SC//3*PVN/3/MIRLO/BUC/4/MILAN/5/TILHI	2013	CCRI, Pirsabak	Khyber Pakhtunkhwa
Shahkar-13	CMH84.3379/CMH78.578//MILAN	2013	CCRI, Pirsabak	Khyber Pakhtunkhwa

CCRI: Cereal Crops Research Institute; WRI: Wheat Research Institute; NIFA: Nuclear Institute for Food and Agriculture; AUP: University of Agriculture Peshawar; BARS: Barani Agricultural. Research Station; ARI: Agriculture Research Institute; ARS: Agriculture Research Station; RARI: Regional Agricultural Research Institute; BARI: Barani Agricultural Research Institute; NARC: National Agricultural Research Centre

Table 2. Soil chemical properties of study site.

Soil properties	Units	Value
pH	-	7.92
EC	d S m-1	0.16
Organic matter	%	0.88
Lime	%	15.5
N	Ppm	34
P	Ppm	5.75
K	Ppm	124

Table 3. Mean squares for various traits of 30 wheat genotypes at The University of Agriculture, Peshawar.

SOV	df	TLR	GRNSPK	TGW	BY	GY	HI
Means squares (Pooled)							
Environments (E)	1	284215.0**	15006.6**	1225.3**	2053092067**	279519143**	612.6*
Reps(N)	4	696.7	81.2	7.9	1382054	155557	5.9
Genotypes	29	1836.6**	317.2**	89.2**	5475306**	1627700**	110.9**
G × E	29	1001.3**	94.9*	40.9**	3640431**	1000734**	146.6**
Error	116	224.7	56.6	8.6	703285	127964	40.5
CV %)	---	16.68	12.65	6.62	13.60	14.93	15.86
Means squares (N+)							
Reps	2	1216.1	133.3	11.5	2470880	269961	3.80
Genotypes	29	2536.1**	244.3**	59.6**	8579086**	2471429**	146.2**
Error	58	394.7	77.8	9.1	1211130	238360	17.6
CV (%)	---	15.33	12.86	7.25	11.53	13.40	10.96
Means squares (N0)							
Reps	2	177.2	28.5	4.25	293227	41153	8.00
Genotypes	29	301.8**	167.8**	70.5**	536650**	157005**	111.3**
Error	58	54.71	35.38	8.00	195440	17569	63.4
CV (%)	---	14.75	11.81	6.04	15.84	11.53	18.97

TLR= Tillers m^{-2}, GRSPK= Grains $spike^{-1}$, TGW= 1000-grain weight, BY= Biological yield, GY= Grain yield and HI= Harvest index
*, **= Significant at 1 and 5% level of probability, whereas NS represent non-significant

Table 4. Mean performance of 30 wheat varieties for various traits, Peshawar 2013-14.

Varieties	Tillers m^{-2}	Grains $spike^{-1}$	1000-grain weight (g)	Biological yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)
Pak-81	67	58	43.3	4917	1562	37.0
Pirsabak-85	80	70	37.4	6055	2098	36.0
Khyber-87	92	57	43.9	6053	2439	39.0
Inqilab-91	69	56	41.2	4905	1371	26.9
Watan-93	74	58	48.9	6412	2280	35.5
Nowshehra	83	74	39.1	6732	2426	40.5
Sulaiman-96	106	52	47.3	6226	2611	41.1
Tatara-96	118	61	45.1	7819	3570	45.9
Ghaznavi-98	105	63	39.8	6472	2754	43.6
KT-2000	84	59	43.7	6528	2242	41.9
Saleem-2000	96	75	38.1	6528	2737	44.7
Pirsabak-04	82	56	44.0	6989	2078	35.1
Pirsabak-05	131	49	51.7	7492	3319	45.1
Seher-06	96	60	45.8	6522	2621	42.9
Bathoor-08	70	66	45.7	4928	2126	44.0
Faisalabad-08	113	54	45.3	6858	2805	39.5
Hasham-08	63	58	37.9	3950	1397	35.1
Pirsabak-08	92	63	40.4	7233	2409	36.4
Janbaz-09	105	53	45.5	6700	2582	42.0
Amin-10	91	57	39.1	5680	2018	40.3
Atta-Habib-10	102	56	43.8	6000	2543	42.4
Barsat-10	79	54	43.1	5383	1892	36.4
Siren-10	70	55	49.7	4927	1953	41.4
Aas-11	63	81	47.0	5189	2530	43.9
ARRI-11	105	56	41.8	6010	2518	40.4
Dharabi-11	76	58	45.4	6361	2066	35.8
NARC-11	93	59	45.3	5301	2698	46.9
Punjab-11	97	49	49.4	6011	2436	44.0
Pirsabak-13	81	59	47.0	6556	2319	37.8
Shahkar-13	113	59	49.7	8300	3487	42.3
LSD for G	17.13	8.64	3.34	959.0	409.5	7.28

DISCUSSION

Breeding wheat for high N uptake and N use efficiency under minimal nitrogen conditions is a key to reduce nitrogen application in wheat production systems. The results of the current studies revealed significant differences among genotypes for all the characters studied, indicating considerable genetic variation existed in bread wheat cultivars of Pakistan. As the amount of nitrogen applied was same for all the genotypes in a given N treatment, varied response of genotypes simply reflects the differences among tested genotypes. The results of current study proposed that the extent of the available genetic variability in efficiency of N use, uptake and utilization provide room for selecting genotypes for hybridization program aimed at the development of nitrogen efficient bread wheat cultivars. Calculation of component traits of NUE showed that, most of variation in this character was due to nitrogen uptake efficiency. Previous studies also reported genetic variation for yield and yield component at high and low N input in wheat (Chardon *et al*., 2010; Gallais and Hirel, 2004; Sinebo *et al*., 2004; Le Gouis *et al*., 2000; Sahu *et al*., 1997; Tirol-Padre, 1996; Feil, 1992; Cox *et al*., 1988; Austin *et al*., 1980).

Genotype × nitrogen interactions was found significant for grain yield, N use efficiency and its components, which indicated that genotypes reacted differently under varied N level. The level of varieties × nitrogen interaction could be somewhat due to the superiority of the modern cultivars (more suitable and responsive to increased N input), and as result of their decreased plant height. The significant varieties × nitrogen interaction for grain yield and other related traits is evidence for varying responses of these cultivars at varied N levels (Austin *et al*., 1980). However, Ceccarelli (1996) suggested an optimum condition to select genotypes for low-input environments. Significant positive association between nitrogen levels and the grain yield has already been reported in many studies (Austin *et al*., 1980). On the other hand, negative correlation between grain yield and grain nitrogen concentration has also been documented in bread wheat (Cox *et al*., 1985).

Numerous studies validated that modern wheat semi dwarf varieties with improved harvest index and NUE are predominant due to their high yield but not by their increased N concentrations in the plant. Different studies conducted on modern UK wheat varieties showed an increase in NUE from 14% to 18%, subject to N level (Sylvester-Bradley and Kindred, 2009). The maximum increase of 24% to 29% in NUE was observed in modern Spanish wheat varieties (Acreche *et al*., 2008). Furthermore, Ceccarelli (1996) emphasized that genotypes selected for high yield in favorable environments yield more in medium to high yielding conditions than lines selected in less favorable conditions. Among yield components, the 1000-grain weight was significantly reduced in most of the genotypes by N fertilization from N0 to N+ treatment. Khalilzadeh *et al*. (2013) reported that the contribution of 1000-grain weight was 15% more at N0 compared to N+ conditions in grain yield variation. To sustain high crop production under limited nitrogen fertilization, it is pre requisite to select genotypes/lines that perform well under low or high N fertilization or under both N fertilization levels. Furthermore, regardless of reduction in yield, direct selection under limited N supply would be more fruitful than an indirect selection under high N conditions (Presterl *et al*., 2003).

Acknowledgements: This research work is the part of Ph.D. dissertation research of Mr. Fahim Ullah Khan, Ph.D. scholar Department of Plant Breeding and Genetics, The University of Agriculture, Peshawar-Pakistan.

REFERENCES

Acreche, M. M., G. Briceno-Felix, J. A. M. Sanchez and G. A. Slafer (2008). Physiological bases of genetic gains in Mediterranean bread wheat yield in Spain. Eur. J. Agron. 28:162-170

Annicchiarico, O. P. (2002). Genotype x Environment Interaction: challenges and opportunities for plant breeding and cultivation recommendations. FAO Plant Prod. Prot. Paper., 174.

Austin, R.B., J. Bingham, R.D. Blackwell, L.T. Evans, R.A. Ford, C.L. Morgan and M. Taylor (1980). Genetic improvement in winter wheat yield since 1900 and associated physiological changes. J. Agric. Sci., 94: 675–689.

Ceccarelli, S. (1996). Adaptation to low/high input cultivation. Euphytica. 92:203-214

Chardon, F, J. Barthélémy, F. D. Vedele and C.M. Daubresse (2010). Natural variation of nitrate uptake and nitrogen use efficiency in *Arabidopsis thaliana* cultivated with limiting and ample nitrogen supply. J. Exp. Bot., 61(9): 2293-2302.

Conley, D. J., H.W. Paerl and R.W. Howarth (2009). Controlling eutrophication: nitrogen and phosphorus. Sci. 323: 1014-1015.

Cox, M.C., C.O. Qualset and D.W. Rains (1985). Genetic variation for nitrogen assimilation and translocation in wheat. I. Dry matter and nitrogen accumulation. Crop Sci. 25:430-435

Cox, T.S., J. P. Shroyer, B. H. Liu, R. G. Sears and T. J. Martin (1988). Genetic improvement in agronomic traits of hard red winter wheat cultivars from 1919 to 1987. Crop Sci. 28:756-760

Earl, C.D., and F.M. Ausubel (1983). The genetic engineering of nitrogen fixation. Nutritional review. 41:1-6

Feil, B. (1992). Breeding progress in small grain cereals-A comparison of old and modern cultivars. Plant Breed. 108:1-11

Gallais, A., and B. Hirel. 2004. An approach to the genetics of nitrogen use efficiency in Maize. J. Exp. Bot., 55(396): 295-306.

Hirel, B., J. Le Gouis, B. Ney, and A. Gallais (2007). The challenge of improving nitrogen use efficiency in crop plants: towards a more central role for genetic variability and quantitative genetics within integrated approaches. J. Exp. Bot. 58: 2369–2387.

Ju, X-T., G-X. Xing, and X-P. Chen. 2009. Reducing environmental risk by improving N management in intensive Chinese agricultural systems. Proceedings of the National Academy of Sci., 106: 3041-3046.

Khalilzadeh, G., E. Azizov and A. Eivazi (2013). Genetic differences for nitrogen uptake and nitrogen use efficiency in some Azerbijani bread wheat landraces (*Triticum aestivum* L.). Global Adv. Res. J. Agric. Sci. 1(3): 048-055

Le Gouis, J., D. Beghin, E. Heumez, and P. Pluchard (2000). Genetic differences for nitrogen uptake and nitrogen utilisation efficiencies in winter wheat. Europ. J. Agron., 12: 163–173.

Presterl, T., G. Seitz, M. Landbeck, W. Thiemt, W. Schmidt and H. H. Geiger (2003). Improving nitrogen use efficiency in European maize: estimation of quantitative parameters. Crop Sci. 43: 1259-1265

Sahu, R. K., A. Tirol-Padre, J. K. Ladha, U. Singh, S. S. Baghel and M. N. Shrivastava (1997). Screening genotypes for nitrogen use efficiency on a nitrogen deficient soil. Oryza. 34:350-357

Sinebo, W., R. Gretzmacher, and A. Edelbauer (2004). Genotypic variation for nitrogen use efficiency in Ethiopian barley. Field Crop Res., 85: 43-60.

Steel, R. G. D., J. H. Torrie and D.A. Dickey (1997). Principles and procedures of statistics, a biological approach, 3rd edition. McGraw Hill, Inc. New York, Toronto, London.

Sylvester-Bradley R. and D. R. Kindred (2009). Analyzing nitrogen responses of cereals to prioritize routes to the improvement of nitrogen use efficiency. J. Exp. Bot. 60: 1939-1951

Tirol-Padre, A., J. K. Ladha, U. Singh, E. Laureles, G. Punzalan and S. Akita. (1996). Grain yield performance of rice genotypes at sub-optimal levels of soil N as affected by N uptake and utilization efficiency. Field Crops Res. 46:127-142.