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Full Length Research Paper

Genetic differences for nitrogen uptake and nitrogen use efficiency in some Azerbijani bread wheat landraces (*TRITICUM AESTIVUM* L.)

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Genotypic differences in major components of the nitrogen uptake and use efficiency between bread wheat (*Triticum aestivum* L.) landraces was evaluated in field conditions under varied N fertilization levels (0, 200 kg N ha^{-1}) based on RCB design with three replications. All characters showed significant genotypic diffrences. Results showed that high variation between genotypes in almost trials by reducing nitrogen. The interaction of G × N for all characters was significant, except harvest index (HI). The highest grain yields belong to Girmizigul, Bc-5, Bc-7 and Bc-17 and the lowest sensibility to N reduction belong to Bc-13 and Bc-14. Landraces of Bc-12, Bc-14 and Bc-16 for grain N concentration and Bc-4, Bc-7 and Bc-14 for straw N concentration showed the lowest reaction to N reduction. Among of N use efficiency components, Nitrogen uptake efficiency was contribution for about 95% of variation at both levels of N. The best landraces for N uptake efficiency were Bc-5, Bc-11 and Bc-15. Grain yield at all N0, N+ and G×N interaction was the best explained by the Grain N concentration than grain N yield. Results indicated that both nitrogen uptake efficiency and grain yield had been more importance criteria for selection of high N use efficiency of wheat landraces in a breeding program. In this experiment, landraces Bc-5, Bc-11 and Bc-15 were the best genotypes with high yield potential and N Uptake.

Key words: Grain N content, Nitrogen use efficiency, Nitrogen uptake, stable N content.

INTRODUCTION

Native wheat landraces provide new sources of germplasm for bread wheat breeding programs. Pervious research had been founded on high-input agricultural systems. Due to economical and ecological factors, agricultural practices attempt to go towards extensive systems with lower inputs of Nitrogen (N) fertilizers. During mid 1960s, the high yielding, semi dwarf wheat varieties released after Green Revolution, were selected to respond to high N input (Earl and Ausubel 1983). Wheat yield increased significantly per hectare in the world at that time (Le Gouis and Pluchard 1996). Consume rate of nitrogen in the world

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Table 1. Soil characteristics of the experimental site

Depth (cm)	pH	Ec	P(ppm)	K(ppm)	SP%	OC%	N%	CaCo3	Texture
0-60	7.62	0.40	20	330	50	1.3	0.16	30	Clay Loam

Table 2. Source, name abbreviations, heading, maturity and plant height in 18 bread wheat landraces.

Genotype	*Source	Abbreviation	Date of Heading	Date of Maturity	Plant height (cm)
1	Girmizigul-1	G1	164	205	120
2	Bc-1	G2	167	209	115
3	Bc-2	G3	176	211	125
4	Bc-3	G4	166	212	118
5	Bc-4	G5	174	210	125
6	Bc-5	G6	175	210	123
7	Bc-6	G7	177	211	120
8	Bc-7	G8	174	211	120
9	Bc-8	G9	173	206	122
10	Bc-9	G10	174	209	125
11	Bc-10	G11	169	209	120
12	Bc-11	G12	167	209	117
13	Bc-12	G13	168	211	125
14	Bc-13	G14	172	210	127
15	Bc-14	G15	166	212	110
16	Bc-15	G16	174	209	137
17	Bc-16	G17	176	210	128
18	Bc-17	G18	168	212	120

*Baku Gene Bank Collection (Bc), Azerbijan.

increase from 1962 (13.5 million tons) to 2004 (84.4 million tons), half of this nitrogen, applied in developing countries (FAO 2004). Nowadays nitrogen is responsible for an important part of agriculture related pollution through leaching (a. Mariotti 1997). As a result of leaching when high rates of N fertilizers are applied to agricultural fields is marine ecosystems and eutrophication of freshwater (i. g., London 2005). But, today scientists try to release cultivars with low-input of manure and decrease of pollution risk to ecosystem (j. Le Gouis et al. 2000). Unfortunately, nitrate manures do not use effectively, thus nitrogen use efficiency on cereal is about 33% in the world (Byerlee and Siddiq 1994).

Plant breeders would have to introduce varieties with minimizes pollution risks and maximizes yield potential. Expanding cultivars with high N absorb with low fertilizer would be necessary. Cultivars that absorb N more efficiently and use it more efficiently to grain production (j. Le Gouis et al. 2000). Genetic variation has been reported on wheat for nitrogen use efficiency (r. Ortiz-Monasterio et al. 1997; Van Sanford and Mackown 1986; Dhugga and Waines 1989). As described of Lemaire et al (2004) and Hirel and Lemaire (2005), it is possible to develop a framework for analysis the genotypic variability of crop N uptake capacity across a wide range of genotypes. Nitrogen use efficiency can be defined as the product of uptake efficiency 'total N uptake/applied N through fertilizer' and utilization efficiency 'yield/total N uptake'. At low N rates, uptake efficiency is dominant as compared to utilization efficiency whereas utilization efficiency is relatively more important than uptake efficiency at high N rates (r. Ortiz-Monasterio et al. 1997). In the past more emphasis was on grain yield than on grain N concentration. Therefore, our objective was to assess the important some Azerbaijanian bread wheat landraces, for yield potential, N concentration in grain and straw, N uptake and utilization efficiency and use their characters on them in crossing block programs.

MATERIAL AND METHODS

The experiment was conducted in 2008-2009 planting season with 18 bread wheat (*T. aestivum* L.) landraces of Azerbijan Gene Bank Collection of Baku. Trial was sown on 18 November 2008 in Agricultural Research Center of Moghan (North West of Iran). The soil, classified as a deep clay loam soil (Orthic Luvisol, FAO classification), contained an average of 14 g kg^{-1} organic matter and was of pH 7.6 and Ec was about 0.40 ds/m. soil samples were found to have 65 kg N ha^{-1} (before sowing) and 55 kg N ha^{-1} (after harvest) mineral nitrogen in the upper 60 cm profile (some extra information exist in Table 1).

The experimental design was a randomized complete block design with three replications with two splits for N levels. Control plots did not received nitrogen, while fertilized plots (N+) were treated with 200 kg ha^{-1} N as urease, 50 kg ha^{-1} before sowing, one-fourth at tillering, one-fourth at beginning of stem elongation and one-fourth at grain filling stage.

Table 3. Analysis of variance (mean squares) of agronomic characteristics of 18 bread wheat landraces.

S.O.V	df	Mean Squares										
		Grain yield	TKW	Kernels/ Spike	Spiks/m^2	HI	Grain N consentration	Stable N concentration	Grain N yield	NHI	N uptake efficiency	N utilization efficiency
Rep.	2	66682 ns	205.4 **	130.77 ns	12750 ns	119.62 ns	0.319 ns	0.004 ns	58.23 ns	166.57 ns	0.005 ns	24.256 ns
Nitrogen	1	8036579 **	85.3 *	128.49 ns	67650 *	26.01 ns	4.236 ns	0.674 **	11203.7 *	396.75 ns	0.555 *	1019.98 *
Ea	2	135086	1.444	63.29	3577.7	60.34	0.502	0.003	242.68	48.028	0.008	48.412
Genotype	17	10597636 **	79.98 **	240.54 **	18669 **	155.43 **	0.319 **	0.108 **	510.906 **	167.01 **	0.019 **	84.622 **
G·N	17	917754 **	8.75 *	38.77 ns	13968 *	9.03 ns	1.014 *	0.025 **	52.155 **	28.77 **	0.003 **	6.336 **
Eb	68	1455842	4.062	30.58	6651	12.256	0.008	0.002	14.297	9.512	0.001	2.214
Mean		1487	40.7	41.1	496	37.2	2.63	0.446	39.8	78	0.257	30.2
CV%		9.8	5.0	13.5	16.6	9.4	3.3	11.1	9.5	4.0	9.7	4.9

Ns, Not significant at $p \geq 0.05$: *, significant at $p < 0.05$: **, significant at $p < 0.01$

Source of landraces, abbreviation name and some agronomic characters of genotyies are presented in Table 2.

Each plot, consisting of six rows of 3 m long and 20 cm apart. Wheat seeds were sown on density of 300 grains m^{-2}. Dates of heading were recorded on one block for N+ as the number of days from planting until stamens were visible on 50% of the spikes. Before mechanical harvest with a plot combine, about 20 shoots were randomly cut at ground level on all six rows and then oven-dried at 80 °C for 48 h. These shoots were used to estimate Thousand Kernel Weight (TKW), number of kernels per ear, Harvest Index (HI), grain and straw N concentration.

N in grain and straw was determined by a Kjeldahl method (I. Walinga et al. 1989). Grain dry weight was estimated as the sum of plot harvest plus grain weight of the shoot samples. Total above-ground dry weight was estimated from grain dry weight, HI, TKW. Nitrogen Harvest Index (NHI) was calculated as grain N/total above-ground N. Nitrogen Use Efficiency (NUE) is grain dry weight/N supply. Grain N utilization efficiency is grain dry weight/total above-ground N (I. May et al. 1991). In order to calculate of contribution of variation of component trials we used the method of Moll et al. (1982) and Dhugga and Waines (1989).

$Yn=X_{1n}+X_{2n}$, Y_n is logY and X_{1n} and X_{2n} are two component logs, $\sum (X_{1nYn}) / \sum Y^2_n$ and $\sum (X_{2nYn}) / \sum Y^2_n$ are contribution of each depend trial (Dhugga and Waines 1989).

Log(NUE)= log(N uptake efficiency)+ log(N utilization efficiency)+ log(HI)

When the G×N interaction was significant for a character, we computed the Wricke (1962) equivalence(W^2_g): $W^2_{g=}\sum_n{}^N{}_{=}1(X_{gn} - X_{g..} - X_{.n} + X_{..})^2$

N is the nitrogen level, $X_{g..}$ is the mean of genotype in all N levels, $X_{.n}$ is the mean of N level n in all levels, $X_{..}$ is general mean. For calculated of dates we used from Excel, Spss and Mstatc soft wares.

RESULTS

Analysis of variance showed significant differences among genotypes for all traits expect number of spike/m^2 (Table. 3). G×N interaction showed significant for most traits except kernel/spike, spike/m^2, grain yield and grain N concentration. Differences between two N levels in grain yield, TKW, spike/m^2, stable N concentration and NHI was significant at $p<5\%$ (Table. 3). Means of traits for G and G×N interactions and also their LSD were presented in Table 4.

Grain yield and yield components

Grain yield decrease from 1759.9 gr/plot on average at N+ to 1214.3 at N0. The highest grain yield were in G1, G6 and G18 with above of 1781 gr/plot. Calculating of Wricke's equivalence coefficient was showed the genotypes of G8, G10 and G12 (Figure. 1a).

Table 4. Mean of grain yield, TKW, spikes/m^2, kernels/spike, HI. grain N concentration, stable N concentration, NHI, N uptake efficiency and N utilization efficiency in two N levels.

Interaction	**genotype**	**Grain yield (gr/plot)**	**TKW (gr)**	**Spike/ m^2**	**Kernels/ Spike**	**HI (%)**	**Grain N concentration (%)**	**Stable N concentration (%)**	**NHI (%)**	**Grain N yield (gr/m^2)**	**N uptake efficiency (gr gr^{-1})**	**N utilization efficiency (gr gr^{-1})**
N0	G1	1954	39	583	43.5	50	2.22	0.55	80	43	0.27	35.9
	G2	1321	43	499	41.3	44	2.40	0.37	83	31	0.19	34.9
	G3	1084	39	440	37.6	33	2.61	0.52	70	28	0.21	26.9
	G4	1216	41	396	42.8	32	2.63	0.43	73	32	0.22	28.1
	G5	1364	44	484	39.3	39	2.42	0.51	76	33	0.22	31.3
	G6	1727	46	557	37.9	40	2.45	0.23	88	42	0.24	35.9
	G7	1220	38	587	46.2	42	2.33	0.33	83	29	0.17	35.9
	G8	1314	37	513	53.3	40	2.20	0.36	80	29	0.18	36.7
	G9	1041	39	513	34.2	33	2.71	0.31	80	29	0.18	29.6
	G10	1083	35	445	46.1	38	2.09	0.34	78	23	0.15	37.5
	G11	958	40	396	31.4	34	2.10	0.25	81	20	0.13	38.8
	G12	1095	41	557	47	42	2.51	0.31	85	28	0.16	34.0
	G13	753	35	543	28.7	35	2.20	0.25	83	16	0.1	37.9
	G14	993	44	567	36.9	33	2.72	0.51	72	27	0.19	26.5
	G15	994	45	557	33.6	33	2.69	0.44	75	27	0.18	28.2
	G16	1335	49	566	47.7	35	2.73	0.34	82	36	0.22	30.1
	G17	881	43	528	31.1	36	2.18	0.28	82	19	0.12	37.5
	G18	1522	50	533	41.5	41	2.61	0.28	87	40	0.23	33.4
N200	G1	2369	36	495	43.9	47	2.87	0.92	75	67	0.45	26.0
	G2	1762	40	454	53.1	40	2.85	0.49	79	50	0.32	27.8
	G3	1534	37	396	33.5	30	3.05	0.8	63	47	0.37	20.7
	G4	1470	39	484	38.7	31	3.01	0.69	67	44	0.33	22.1
	G5	1936	41	359	38.2	40	2.88	0.54	78	56	0.36	27.1
	G6	2351	39	572	43.7	42	2.91	0.45	82	68	0.41	28.3
	G7	1847	35	572	47.6	45	2.77	0.44	84	51	0.3	30.4
	G8	2186	38	533	57.3	42	2.59	0.35	85	57	0.33	32.6
	G9	1588	38	513	33.1	29	3.18	0.38	78	50	0.33	24.4
	G10	1864	38	469	53.5	35	2.51	0.63	68	47	0.35	27.1
	G11	1380	38	411	35.5	33	2.50	0.33	79	35	0.22	31.6
	G12	2079	43	425	46.3	42	2.85	0.72	74	60	0.4	26.1
	G13	1201	38	411	39.1	30	2.40	0.31	76	29	0.19	31.5
	G14	1377	43	389	38.9	33	3.08	0.76	67	42	0.32	21.6
	G15	1317	42	381	36.9	34	3.00	0.4	79	40	0.25	26.5
	G16	2008	48	411	41.2	33	3.14	0.48	76	63	0.41	24.3
	G17	1369	38	513	38.7	35	2.45	0.36	78	34	0.21	32.1
	G18	2040	47	670	40.1	39	2.91	0.39	82	59	0.36	28.2
LSD 5%	N	121.7	0.57	28.05	3.77	3.67	0.333	0.024	4.37	7.33	0.041	3.27
	G	168.6	2.32	93.96	6.37	4.03	0.103	0.052	3.55	4.36	0.037	1.71
	G·N	238.4	3.28	132.90	9.01	5.70	0.146	0.073	5.03	6.16	0.052	2.42

They were responsible for about 50% of G×N interaction (Not showed datas). All of these genotypes had the high grain yield at N+ and low grain yield at N0. Means of grain yield showed high differences and significant differences. Effect of N showed significant differences between two N levels. TKW was decreased significantly from N0 (41.6 gr) to N+ (39.8 gr) (Table. 4). Most of increasing in TKW at two N levels was belong to G6, G10, G12 and G13. Those four genotypes showed the highest iteraction to N levels, also were responsible for 74% of the G×N interaction (Figure. 1b).

Mean number kernel per spike for genotype, showed the G8, G10, G2, G7 and G12 the highest kernel number per spike (Table. 4). Cultivars of G7, G8 and G12 had the lowest Wricke equvlalece but genotype of G2 showed the highest (21%) reaction to N consumption. Three genotypes of G7, G8 and G10 had the lowest TKW. The effect of N did not showed significant differences in number of spike/m^2. Genotypes and G×N interaction were showed significant differences (Table. 3). Genotypes of G18, G7 and G6 with 602, 579 and 565 spike/m^2 showed the highest ones. Interaction of G×N and G showed the highest variability in genotypes of G4, G14, G15 and G18 with 54.3% variance. All of those genotypes had the high spike per m^2 at N+ than N0 levels.

Nitrogen use efficiency and its components

N uptake, N utilization efficiency and HI are three components of NUE.

Mean of Harvest Index for effect of N and G×N interactions showed non-significant differences, but genotypes had significantly differences (Table. 3). Genotypes G1, G7, G12, and G2 showed the highest HI at both N levels. 75% of G×N interaction variance belongs to six genotypes (G2, G6, G7, G8, G9 and G13). Expect G9 and G13 other four genotypes showed high HI at both N levels. N harvest index for G and G×N interaction showed significant differences at ($p<0.01$). Eeffect of N in NHI was not significant (Table. 3). Mean of comparision for genotypes G6, G18, G7, G8 and G2 showed the highest (Table. 4). The highest sensibility to N belongs to G10 and G12 with 31.7% (Figure. 1e). N uptake efficiency was significant for all effects of N, G and G×N interaction. It showed higher at N+ (0.33) than at N0 (0.19) (Table. 4). Genotypes showed high variability for N uptake efficiency. Four genotypes, G1, G6, G12 and G16 showed the most deduction from N+ to N0. G1, G6 and G16 indicated the highest N uptake efficiency at N+ than N0. Genotypes G10, G12 and G15 were responsible to 56.2% of G×N interaction variance (Figure. 1d). The lowest decrease of N uptake efficiency at N+ to N0 belongs to G11, G13 and G15.

Means of grain N yield (Table. 4) was higher at N+ (49.9 gr/m^2) than N0 (29.6 gr/m^2). We had significant differences for genotypes and G×N interaction. Means of comparision showed the highest grain N yield for G1, G6, G16 and G18 with about 55 gr/m^2. Genotype of G4, G8, G12, G13 and G15 were responsible for 64.3% of Wricke equivalence. Ggenotypes with high grain N yield had the lowest sensibility to N deduction. Nitrogen utilization efficiency showed significant differences for all effects of nitrogen, genotypes, and G×N interactions (Table. 3). It ranged from 26.5 to 38.8 g g^{-1} at N0 to 20.7 to 32.6 g g^{-1} at N+. The highest N utilization efficiency was shown in G8, G11, G13 and G17. Genotypes 1, 10 and 15 showed the highest sensibility to N utilization efficiency to N deduction.

Grain and stable N concentration showed significant differences for all effects of N, G and G×N interaction (Table. 3). Effect of N on grain N concentration was (2.43%) at N0 and (2.83%) at N+. Grain N concentration ranged from 2.09 to 2.73% at N0 and 2.40 to 3.18% at N+. All treatments had a lower value at N0. Means comporision for Genotypes G9, G16, G14 and G15 showed the highest ones.

Effect of N on stable N concentration was (0.37%) at N0 and (0.53%) at N+. Stable N concentration ranged from 0.23 to 0.555% at N0 and 0.31 to 0.992% at N+. Genotypes of G1, G3 and G14 showed the highest N content in stable (Table. 4).

Contribution of components to grain yield and NUE

The relative contribution of grain yield, grain N yield, NUE and NUEgn components are presented in Table 5. Between of three components of grain yield, almost of variation belong to kernels/spike specialy at N+. The variation of N uptake efficiency accounted almost of variation of N Use efficiency at N levels and G·N interaction (95%). Between two components of grain N yield (grain yield anf grain N concentration), Contribution of grain yield for both N level was very high (94%) but for grain N content it was low. The almost grain N yield was explained by grain yield not grain N concentration. The contribution of grain yield was more important than grain N concentration.The Contribution of N uptake efficiency was more important than NHI on physiological efficiency and NUEgn. N uptake efficiency was the best explained of NUEgn and NUE (Table 5).

DISCUSSION

The results of experiment showed genetic differences for the almost characters. The range of grain yield at

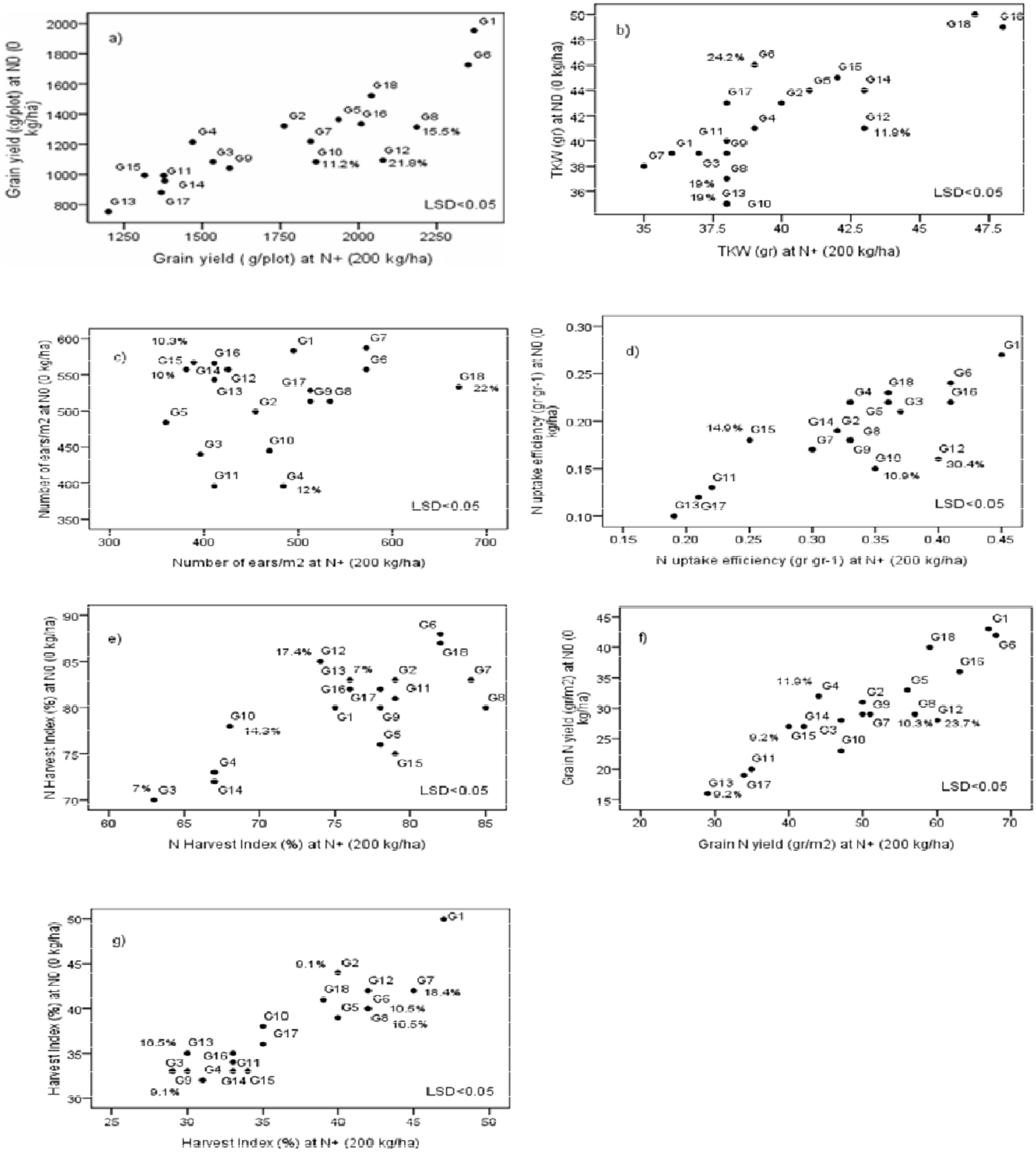

Figure1. Thousand Kernel Weight (a), Harvest Index (b), Nitrogen Harvest Index (c), N uptake efficiency (d), Grain nitrogen yield (e) and Nitrogen utilization efficiency (f) of 18 bread wheat landraces at two N levels. The contribution of each genotype to the G×N level interaction (equivalence) was indicated when

Table 5. Contribution of the components traits of the resultant trait in 18 bread wheat landraces at each N level and G×N interactions.

		N levels		G×N
Resultant trait	**Component trails**	**N0(0 Kg N ha^{-1})**	**N+(200 Kg N ha^{-1})**	**Interaction**
Log(Grain yield)	Log(TKW)	0.320	0.116	0.010
	Log(Spike/m^2)	0.372	0.394	0.068
	Log(Kernel/spike)	0.483	0.540	0.493
Log(Grain N yield)	Log(grain yield)	0.936	0.944	0.959
	Log(grain N concentration)	0.0372	0.456	0.695
Log(*NUEgn)	Log(N uptake efficiency)	0.957	0.925	0.970
	Log(N harvest index)	0.180	0.246	-0.097
Log(N use efficiency)	Log(N uptake efficiency)	0.957	0.926	0.970
	Log(Total N utilization efficiency)	-0.223	-0.197	-0.568
	Log(Harvest index)	0.508	0.653	0.333

*NUEgn=NUE grain nitrogen (grain N yield/N supply)

N0 in genotypes was from 753 to 1954 gr/plot. Genotypes of G1 and G6 showed the highest Grain yield and N uptake efficiency and grain N yield. (Table. 4). Because of significant effects of G×N interaction for grain yield, genotypes shows different behaviors at different N levels. With added of 200 Kg/ha grain yield increased 45% (546 gr/plot). Naklang et al (2006), Hasanzadeh Gurttapeh et al (2009) showed a positive relation between N level and grain yield. Ceccarelli (1996) emphasized an optimal condition to select for low-input environments. He showed that lines selected for high yield in favorable environments, yield more in medium to high yielding conditions than lines selected in less favorable conditions. Between yield components, contribution of kernels/spike was more important than TKW and Sspike/m2. Almost of variation of G×N interaction explained by kernels/spike also. The relation of N supply and thousand kernel weight was reverse. That means with increasing of N manure consumption, weight of kernels be decreased. N uptake efficiency (Table. 3) showed significantly differences between G·N interactions. A difference between residual soil nitrogen in the upper 0-60 cm and total above-ground nitrogen at date of maturity was 57 kg N ha^{-1}. Evaluation of N uptake efficiency showed that more of variation in NUE explained with N uptake efficiency. This result was agreement with Ortiz-Monasterio et al (1997) and Le Gouis et al (2000). HI was more important than total N utilization efficiency in explained of NUE's variation (Table. 5) especially at N+. When N is not the limiting factor, N uptake and N utilization efficiency are determinant factors. When N is limited in the soil, the ability of absorb N become importance, and N absorb relates to root system characters. At low N rates, N uptake efficiency is dominant as compared to N utilization efficiency whereas utilization efficiency is relatively more important than uptake efficiency at high N rates (r. Ortiz-Monasterio et al. 1997). Three main N use efficiency components showed N uptake efficiency at both N0 and N+ levels(96% and 93% respectively) and G×N interaction (97%) had the highest variation contribution. Our data showed that the G×N interaction for N uptake efficiency explained most of the variation of the interaction. Evaluating of grain N yield component showed that the most variation belong to grain yield. Variation of G×N interaction for grain yield explained most of the variation (96%) for grain N yield. Existing of significant differences in trials for N uptake and utilization showed high genetic diversity for evaluated genotypes in this experiment. Our results suggest that the extent of the available genetic variation in efficiency of N uptake and N utilization is sufficient to progress in a breeding program. Genetic variability for grain yield at N levels, supply a facility for using, as parents, of the landraces evaluated in this experiment.

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