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Agronomic Performance of Exotic Wheat Lines under Kabul Agro-Ecological Conditions

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Abstract

This research was conducted to assess the agronomic performance of wheat advanced lines developed by Purdue University small grain program under Kabul agro-ecological conditions. Eleven wheat advanced lines from Purdue University and three local check varieties from Kabul were tested for three years under Kabul agro-ecological conditions. Genotypes differed significantly ($P < 0.05$) for grain yield and the yield components, and a fairly stable performance across years. Spike length and kernel weight were significantly correlated with grain yield, having R^2 values of 0.54 and 0.53 respectively. Two Purdue lines: SNOWMASS and IN0762 outperformed the local checks, yielding 2.79 t/ha and 2.62 t/ha respectively. A genetic similarity analysis clustered the studied genotypes into three distinct groups, with some of the local varieties falling in the same category as the exotic lines. The study found exotic lines to be adapted to Kabul conditions, and can be utilized in local breeding programs.

Keywords: Advanced lines, Wheat, Genotype by Environment interaction, Adaptation.

1. Introduction

Afghanistan is a mountainous country with only about 12% of the land being suitable for farming and actually about 6% is being cultivated (USDA 2010; Khanzada, Raza et al. 2012). Wheat is the staple food crop in Afghanistan and is produced under both irrigated and rain-fed conditions (Khanzada, Raza et al. 2012). Currently it is planted on around 75% of the crop land of Afghanistan and accounts for approximately 70% of the Afghan people's annual caloric intake (Chabot and Dorosh 2007; Persaud 2010). A large proportion of the rural Afghan farming population is reliant upon wheat production for subsistence making it a primary source of income(Qureshi and Akhtar 2004). However, domestic wheat production has never been sufficient to meet the country's demand, necessitating additional importation from neighboring countries and various international development agencies (Persaud 2008). As of 2011, some 50% of the total wheat consumed in Afghanistan was imported.

Despite these additional imports and the foreign aid being donated to the country, USAID estimates that over six million Afghans – nearly one-fifth of the population – do not have enough food. This has made Afghanistan highly vulnerable to food insecurity, and if the foreign food supply vanishes, the results will be disastrous (Persaud 2008). Lack of improved wheat seeds and well adapted varieties are the main constraints to wheat production sector in Afghanistan; other constraints are, low quality fertilizers, and lack of proper technology such as farm machinery. Addressing the problem of adaptability requires effective utilization of the germplasm resources including new introductions.

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However, any variety introduced into a new environment should be tested, at least for two years, and should be checked for adaptation. Improved wheat varieties may perform differently in diverse environments and the differences in their performance might be due to genetic by environmental interaction(Osmanzai and et al 2008). The genetic by environment interaction reduces correlation between phenotype and genotype making it hard to detect the genotypic effects of a variety (Osmanzai and Sharma 2008). For complex traits like yield that are conditioned by many genes, environmental influence on performance is often high. For this reason, wheat breeders need to conduct multi-environment performance tests on exotic wheat varieties in order to determine their adaptability and stability. Presence of G x E interactions is often an indication of lack of stability of genotypes across environments. However, presence of G x E can be exploited in the selection of genotypes that are adapted to specific environments (Crossa, Burgueño et al. 2006).

In Afghanistan, limited research has been conducted on adaptability of wheat genotypes, and this has resulted in farmers growing varieties that are poorly suited to their environments, with eventual low yields. Previous studies on bread wheat in Afghanistan demonstrated the importance of G x E in genotypic selection (Osmanzai and Sharma 2008; Sharma, Morgounov et al. 2010, Siddiqui and Naz 2009). Particularly, Osmanzai and Sharma (2008), performed a multi environment evaluations of 49 spring wheat and found that genotypes performances were specific to environments. The authors identified five lines that yielded (4.5-5.7 t/ha) better than the checks which is much more in comparison to the 1.5 t/ha average national wheat yield in Afghanistan. These five lines then were released to farmers as new improved wheat varieties. In the current study, 11 different wheat advanced lines from USA were evaluated on the research farm of agriculture faculty at Kabul University. The objective of this study was to assess the important agronomic traits of these advanced lines and Afghan local varieties to identify the promising wheat genotype for wide and specific adaptation based on grain yield performance under Kabul agro-ecological conditions for use in wheat breeding programs in Afghanistan.

2. Methods and Materials

2.1 Study site and plant materials: This study was conducted at the Agricultural research stations in Kabul, Afghanistan during the three wheat successive growing seasons 2011-2012, 2012-2013 and 2013-2014. The genetic materials included eleven different advanced breeding lines developed by Purdue University small grain program and three local varieties adapted to diverse agro-ecological conditions of Afghanistan. These eleven advanced lines were SNOWMASS, IN0762, IN05247, INW0412, IN0722, IN0556E1-18-6K, IN04620A1, INW0731, MILLENIUM, RIPPE5 and GOOD STREAK. These advanced lines developed by Purdue University had good agronomic characteristics and performed very well under Indiana agro-ecological conditions. Three local varieties were KOSHAN09 (control), CHONTE (control), ARIANA 94 (control). The three local varieties used in this experiment as checks, were obtained from cereal research department in ministry of agriculture, irrigation and livestock (MAIL), Afghanistan. The more descriptions of those advanced lines and local varieties are presented in Table 1.

2.2. Experimental design: The seeds were planted on 26 October 2011, 2012 and 2013 in a randomized complete block design (RCBD). In each year the design consisted of three replications and 42 plots and each plot contained six rows and the distance between two rows was 25 cm. Plot size was 2 by 1.5 meter. Seed rate 45 g per plot; DAP and Urea used in each plot was 100 g and 50 g, respectively. The seeds were irrigated in the common method of the locality. Only the advanced lines and local varieties planted differed from one experimental plot to another and all other factors, such as fertilizers, insect control, and water management, were applied uniformly to all plots.

Table 1: The descriptions of wheat advanced lines and local varieties used in this research (2011)

Advanced lines and local varieties	Accession number	Country	Growth Habit	Pedigree
SNOWMASS	PI-658597	USA:Colorado	W	KS-96-HW-94//TREGO/CO-960293[3682][3739]; KS-96-HW-94/CO-980352[3814]
IN0762	PI-661055	USA:Indiana	W	981129A1-45-3/99793RE2-3//INW0301/92145E8-7-7-3-57/3/ 9
IN05247	PI-659721	USA:Indiana	W	99840C4-8/03726A1//99840C4-8-3-6-1/3/ 99794RA4-14-4-5
INW0412	PI-661112	USA:Indiana	W	981359C1-4-2-1-8= ACC3130 HYAPEI57-2/PATTERSON
IN0722	PI-659842	USA:Indiana	W	INW0731/3/ 981129A1-45-3/99793RE2-3//INW0301/92145E8-
IN0556E1-18-6K	PI-659723	USA:Indiana	W	99608C1-1-3-4/5/ ARINA//981542A1-10-1-2/INW0315/4/INW
IN04620A1	PI-661155	USA:Indiana	W	TRUMAN/6/ 9017C1-1-2-X-4//92823A1-2-1-5/9218B4-4-1/3/P
INW0731	PI-661136	USA:Indiana	W	99608C1-1-3-4= 95172D1-6-1/961331A49-1/4/INW9811//283-
MILLENIUM	PI-613078	USA:Nebraska	W	ARAPAHOE/ABILENE//NE-86488[1972][2414][2793]
RIPPE5	CI-18290	USA:Indiana	W	PD-3369-63-4-1/PD-4126-A-9-32-2-1[424][1318]
GOOD STREAK	AUS-3102	USA:Indiana	W	KNOX(SIB)/PD-4127-A-4-12-1[423][39]
KOSHAN09 (control)	------	Afghanistan	S	BABAX/Lr42//BABAX*2/VIVITSI[3686]
ARIANA 94 (control)	-----	Afghanistan	W	BOBWHITE/NACOZARI-76//VEERY/3/BLUEJAY/COCOR [1922]; CHINA-13/TEETER//GLENNSON-M-81[3589]
CHONTE (control)	------	Afghanistan	W	SERI.1B*2/3/KAUZ*2/BOBWHITE//KAUZ/4/PBW-343*2/K

Data collection and analysis: Data were collected on agronomic characteristics such as yield, 1000 kernel weight, Kernels per spike, tilling capacity, plant height, spike length, and days to heading. Agronomic traits were measured on 15 plants in the center of the row and average values were used for analysis. GenStat statistical package was used to analyze the data. Analysis of variance was calculated using the model: $Rij = \mu + Gi + Yj + GYij$. Where Rij is the corresponding variable of the i-th genotype in j-th year, μ is the total mean, Gi is the main effect of i-th genotype, Yj is the main effect of j-th year, GYij is the effect of genotype x year interaction. In this model Y fixed and G is random. Correlation (r), regression coefficients (b) and coefficient of determination (R^2) of various traits in this research calculated. To determine similarity and genetic distances between advanced lines and local varieties, cluster analysis by Ward method was used.

3. Results and Discussion

3.1. Magnitude of genetic variation: Analysis of variance (ANOVA) for the studied traits is summarized in Table 2. There were significant differences ($p \leq 0.01$) among the genotypes included in the study for all measured traits. This observation suggested that the advanced lines and local varieties had considerable amount of genetic variations, implying that breeding for the studied traits is possible (Khodadadi et al 2011). The result is consistent with previous studies in wheat that documented high genetic variability among wheat genotypes (Mohammadi , et al 2011; Khodadadi et al 2011). Genotype by year interaction was not significant for all traits except for number of tillers/plants, suggesting stable performance across seasonal variations. The mean performances of advanced lines and local varieties have been provided in Table 3. Of particular interest, advanced lines SN0WMASS and IN0762 had outstanding performance with mean grain yield well above that of the local checks. This implied that these lines could be the best potential candidates for release with a few more testing.

Table 2: ANOVA for seven traits of 14 wheat advanced lines and local varieties grown in 3 years under Kabul

Mean square								
SOV	df	Grain yield (t	1000-Kernel	Kernels/spik	Tillers/plant	Plant height (	Spike length (	Days to head
Genotype(G)	13	94.21**	78.31**	5.58**	1278.21**	373.42**	9.08**	210.49**
Year(Y)	2	23.15ns	31.74ns	3.66*	75.45ns	90.45ns	3.85ns	30.22ns
Replication	2	30.45ns	25.41ns	6.81*	120.21ns	145.63*	4.02*	44.29ns
G x Y	26	11.01ns	9.87ns	0.54ns	67.14*	76.12ns	0.98ns	21.01ns
Pooled Error	117	0.02	0.92	11.94	1.67	34.4	0.34	0.5

**Significant at the 0.01 level of probability; * Significant at the 0.05 level of probability, ns: not significant, in this ANOVA table, Y fixed and G random.

3.2. Relationship among genotypes: Correlation analysis is widely used in statistical evaluations to establish relationships between variables. According to the data presented in Table 4, the correlation coefficient (r) for number of tillers per plant, number of kernels per spike, spike length (cm) and 1000-kernel weight were positive and significantly correlated with grain yield (t/ha), suggesting that selection for these traits may simultaneously improve grain yield. When we looked at the relationship among traits, the results revealed that the number of tillers per plant, number of kernels per spike, spike length (cm) and 1000-kernel weight had the highest significant positive correlations with yield (t/ha), r= 0.703**, r=0.719**, r=0.739** and r= 0.734**, respectively (Table 4), suggesting the dependency of yield on these characters. Other traits including plant height and days to heading showed non-significant and negative 'b' values suggesting that yield would be decreased with the increase of both characters. Based on simple regression analysis, a unit increase in number of tillers per plant, number of kernels per spike, spike length (cm) and 1000-kernel weight resulted in yield increase of 0.77, 0.42, 0.40 and 0.74 units, respectively. The coefficient of determination (R^2) revealed that about 53% of total variability in yield was due to its association with 1000-kernel weight.

Table 3: Mean performance of fourteen wheat advanced lines and local varieties under Kabul agro-ecological conditions (2011-2014)

Advanced lines and local varieties	Grain yield (t/ha)	1000- kernel weight(g)	Kernels/spike	Tillers/Plant	Plant height (cm)	Spike length (cm)	Days to heading
SNOWMASS	2.79	43.63	29.83	10.33	100.33	7.17	202.67
IN0762	2.62	47.52	39.60	10.00	106.00	8.57	201.33
IN05247	1.58	37.21	30.93	9.00	79.00	7.63	199.33
INW0412	1.78	40.10	34.30	7.33	90.00	8.90	193.33
IN0722	1.42	37.45	42.80	8.00	72.67	7.17	204.67
IN0556E1-18-6K	1.31	35.04	38.00	10.67	78.33	8.27	200.33
IN04620A1	1.80	40.69	37.57	10.33	86.00	8.13	193.33
INW0731	1.37	32.95	35.23	10.33	79.87	8.23	199.67
MILLENIUM	1.33	32.52	41.57	8.67	79.00	8.50	198.67
RIPPE5	1.41	35.80	41.63	9.00	82.67	9.23	205.33
GOOD STREAK	1.40	37.50	47.33	11.33	76.00	9.00	200.67
KOSHAN09 (control)	2.24	42.93	33.43	12.67	99.33	6.33	192.67
ARIANA 94 (control)	2.35	41.78	31.63	11.67	105.33	6.07	198.33
CHONTE (control)	1.11	38.87	36.67	9.67	77.00	7.40	199.33
LSD (5%)	0.19	1.61	5.80	2.17	9.84	0.98	1.19
CV (%)	10.20	2.60	9.30	13.00	6.80	7.40	0.40

A study by Aycicek and Yildirim (2006) reported a significant and positive correlation grain yield number of productive tillers per plant, plant height, 1000-grain weight and spike length. Majumder, (2008) had shown that spikes number per plant, number of grains per spike, spike length and 1000-grain weight were the most important characters which possessed positive association with grain yield. However, Mohammed, (2009) showed a negative correlation between plant height and grain yield. Baloch, (2013) suggested that major portion of total variability in grain yield was attributable to traits such as tillers per plant, spike length and 1000-grain weight.

Table 4: Correlation (r), regression coefficients (b) and coefficient of determination (R2) of various traits in this research

Character association	r	b	R2
Days to heading vs grain yield (t/ha)	-0.080ns	-0.01	0.006
Plant height(cm) vs grain yield (t/ha)	-0.220ns	-0.20	0.04
Number of tillers per plant vs grain yield (t/ha)	0.703**	0.77	0.49
Number of kernels per spike vs grain yield (t/ha)	0.719**	0.42	0.51
Spike length (cm) vs grain yield (t/ha)	0.739**	0.40	0.54
1000-kernel weight (g) vs grain yield (t/ha)	0.734**	0.74	0.53

**Significant at P < 0.01 and ns = non-significant according to the t-test, respectively; r is the correlation coefficient, b is the regression coefficient and R^2 is the coefficient of determination

To determine similarity and genetic distances between advanced lines and local varieties, cluster analysis by Ward's method was used and all genotypes divided into 3 clusters similarity (Figure 1). First cluster included (SNOWMASS, IN0762, KOSHAN09 and ARIANA 94), second cluster (INW0412, IN04620A1, IN0556E1-18-6K, MILLENIUM and CHONTE) and third cluster included (IN05247, IN0722, RIPPE5, GOOD STREAK and INW0731). So beside advanced lines, Afghan varieties such as ARIANA 94 and KOSHAN09 are suitable for use in future of Afghan wheat breeding programs.

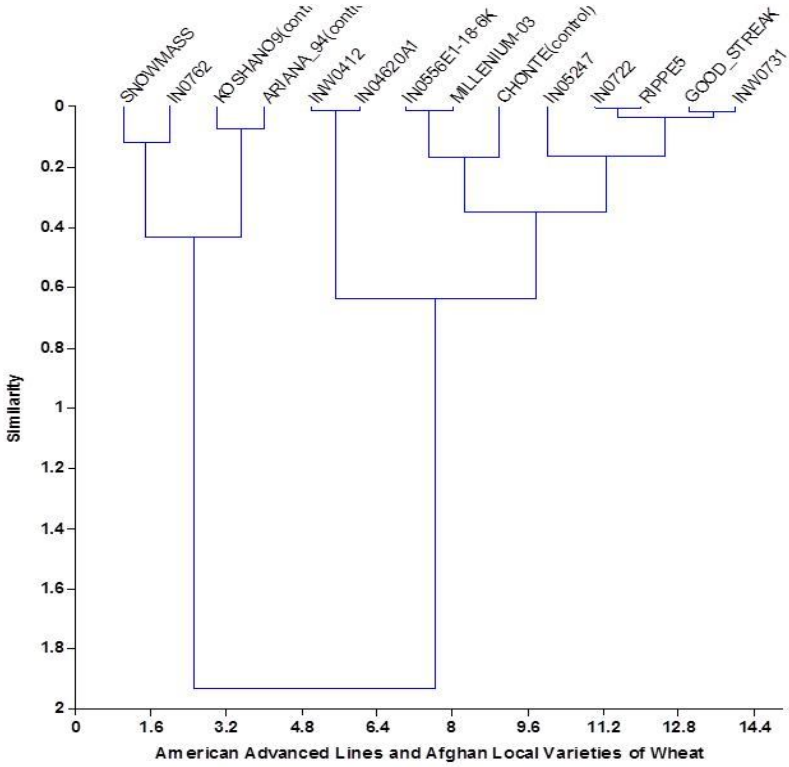

Figure 1- Determination of similarity and genetic distances between advanced lines and local varieties.

4. Conclusion

This study revealed the presence of considerable genetic variation among the advanced lines, for the measured traits, meriting their usage in wheat improvement. Results of the study showed that these advanced lines may provide good source of material for future usage in the wheat breeding programs. It was evident from our results that number of tillers per plant, number of grains per spike, and 1000-grain weight were the major contributors towards grain yield since and selection for these traits may simultaneously improve grain yield. The study identified three candidate lines that out yielded the check varieties. These lines included; SNOWMASS, IN0762, and IN04620A1. These lines are suitable candidates for release upon additional evaluation in multiple locations.

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