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Variability, Heritability and Genetic Advances in Wheat (*Triticum aestivum* L) Breeding lines grown at Horro Guduru Wollega Zone, Western Ethiopia

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Abstract

A total of thirty-six bread wheat (Triticum aestivum L.) genotypes were evaluated for variability's at two different highland and midlatitued environments from the preliminary studied and commenced depending on their performance. The genotypes were grown in a simple lattice design. Data were collected on 12 morpho-agronomic characters. The analysis of variance at each location showed significant ($P< 0.05$) difference for all of the characters, except spikelet's per spike at Guduru. This indicated the existence of variability and hence the potential for selection and improvement within characters. The mean performance of the genotypes indicated that genotype ETBW7173 at Guduru and genotype ETBW7238 at Gitilo gave high grain yield than the other genotypes. Thousand-kernel weight, tillers per plant, grain yield, harvest index, spike length and kernels per spike at both locations were found to have high coefficient of variability, intermediate to high heritability and genetic advance as percent of the mean. This means that effective and satisfactory selection for practical improvement of these important traits is possible.

Keywords: *Triticum aestivum, Ethiopia, variability, Heritability,* ETBW7173, ETBW7238

1. Introduction

The world food problem needs solution on two fronts (1) to produce enough and (2) to produce quality food. The yields of major food crops is plateuing and in many cases is coupled with diminishing land both on account of urban expansion and on reducing fertility. About one third of the developing world's wheat area is located in environments that are regarded as marginal for wheat production because of drought, heat and soil problems. Gains in wheat productivity in marginal environments are important because it is unlikely that increased productivity in the favorable environments will be sufficient to meet the projected growth in demand for wheat from the present to 2020. The demand for wheat is projected to be 40 percent greater than its current level of 552 million metric tons by 2020 (Rosegrant, 1997 as cited in Lantican et.al., 2002).

Bread wheat (Triticum aestivum L.) has originated from natural hybrids of three diploid wild progenitors native to the Middle East. These are T. monococcum, T. tauschii (syn. Aegilops squarosa) and Aegilops speltoides (Lelley 1976; Ribaut et al., 2001). It is an annual cool season cereal crop but it can grow in a wide range of environments around the world. Its production is highly concentrated between the latitudes of 30o and 60o N, and 27o to 40o S (Heyne, 1987), and within the temperature range of 3oC to 32oC. Wheat can grow best on well-drained soil from sea level to about 3000 masl.

In Ethiopia, wheat is an introduced crop, although its time of introduction is immemorial (Hailu, 1991). This author also mentioned that, this crop is one of Ethiopian's staple foods and the main sources of calorie in the major producing regions; and it is grown between latitudes of 6o to 16oN, and 35o to 42oE, with altitudes ranging from 1500 to 2800 masl. It covers more than one million hectares accounting for 13% of nearly 8 million hectares of land allocated to all cereals. Bread wheat stands fourth in total national grain production and third in yield per hectare (CSA, 2002).

The integrated approach of evaluating the genotypes uses both visual and statistical approaches. The relative influence of various traits and their degree of associations can be estimated statistically by correlation (Dewey and Lu, 1959). Determination of relationships of characters can help to identify traits of economic importance. The contribution of different traits for yield can also be quantified by path coefficient analysis. Path analysis also splits the correlation coefficient of a set of independent variables on dependent variables into direct and indirect effects. The nature of yield and yield contributing traits are highly variable and significantly modified by external factors. The effectiveness of selection depends on the amount of variability present in the genetic material for grain yield and related traits. Hence, estimation of variability is of prime importance (Johnson et al., 1955b).

The present study was carried out with the objective to evaluate the variability of bread wheat breeding lines on the study area.

2. Materials and Methods

Thirty-six genotypes of bread wheat constitute the experimental material of the study. The planting was done in Randomized complete block Design. Each genotype will be planted in 4 row plot where row to row and plant to plant distance maintained at 20 cm and 5cm respectively. Experiment was planted at two different locations i.e., Gitilo and Guduru Animal production in 2013/14 cropping season in Western Ethiopia. The locations are characterized in medium and long duration environments. Experiment was planted on 10th July under rain fed condition. At the time of maturity, the data was recorded on Days to heading, Days to maturity, Grain filling period, Grain yield, 1000-kernel weight, Biological yields, Harvest index Ten plants were randomly selected from the four central plots for recording the following observations, Tillers per plant, Plant height, Kernels per spike, Spikelet per spike, Spike The data obtained for different traits were statistically analyzed using SAS v9.0 for analysis of variance analysis. For each location analysis of variance, according to simple lattice design, was done using the mean of ten sampled plants for the characters like plant height, tillers per plant, spikelets per spike, spike length, kernels per spike and spikes per plant. And based on their plot mean analysis of variance was done for the characters Days to heading and maturity, grain yield per hectare, harvest index, grain filling period, thousand- kernel weight was used their plot means. The analysis of variance was also conducted using randomized complete block design.

3. Results and Discussion

3.1 ANALYSIS OF VARIANCE

Combined analysis of variance for different characters at Gitilo and Guduru are presented in table 1. The analysis of variance showed that the genotypes differed significantly ($p< 0.05$) in all of the 10 characters, except grain per spike and harvest index.

Grain filling period is significant in Gitilo, but it was non significant at Guduru. This indicates that at highland area, long grain filling period has positive response to yield and yield related components. Estimation of various genetic parameters is easier and standardized in RCBD especially to estimate correlations and path coefficient analysis and simple lattice being flexible, further analysis of the data were based on the RCBD only (Cochran and Cox, 1957). Similar results were obtained by using both designs in the analysis of variance. The coefficient of variability from RCBD did not differ significantly from that of simple lattice design. The relative efficiency of the two designs showed that for most characters simple lattice design is not more efficient than RCBD design .Before pooling of the data across environments, test of heterogeneity for error variance was done. All the characters, except spike length, showed homogeneity in the tested environments since the ratio of the highest error mean square is not three fold large than the smallest error mean square (Gomez and Gomez, 1984).

Table 1: Analysis of variance using RCBD for the 12 characters across the two locations

Source	Loc	Rep	Genotype	Loc x Genotype	Error	C.V.%
Plant height	17004.3**	101.8	81.1*	52.2**	15.2	5.5
Days to heading	10764.1**	31.1	50.8*	48.9*	5.9	3.3
Days to maturity	24858.7*	2.2	56.9**	74.6**	33.5	4.8
Grain filling period	2516.6**	34.2	56.9	61.2*	29.7	11.8
Tillers per plant	1.7	0.16	0.3	0.4	0.2	15.9
Spike length	133.1*	0.5	2.7	3.5*	0.2	6.5
Spikelet per spike	938.1**	6.6	4.5**	5.3*	1.4	9.2
Grain per spike	3.7	0.9	0.2	0.2	0.2	16.5
Biological yield	53392100.9**	327256.6	304223**	241903**	74590.6	16.7
Grain yield kg/ha	417984054**	2607983	2220622**	1902655**	461174.5	20.1
Harvest index	0.4*	0.000667	0.01	0.01	0.1	15.6
1000kernel weight	1660.5*	4.3	23.3*	18.6**	4.6	5.5

As the test of homogeneity of variance showed uniformity, the data were pooled across environment and analyzed. The result of the combined analysis of variance across the two locations is presented in Table 1. In some of the traits studied, the mean squares from the combined variance analysis over the two locations showed significant ($P< 0.01$) variations among the genotypes. However, location effects were significant, at $P< 0.05$, for days to heading and maturity, grain filling period, plant height, thousand-kernel weight, and tillers per plant.

Locations x genotype interaction was significant ($P< 0.05$) for days to heading, grain filling period, spike length and spikelet's per spike and highly significant ($P< 0.01$) for plant height, days to maturity, biological yield, grain yield, and thousand-kernel weight (Table 1). This indicated that for most traits the genotypes showed differential performance at the two locations. Significant genotypes by environment interactions are commonly reported in wheat either *in vitro* or *in vivo* experiments in different types of stress including moisture less (Sivapalan *et al.*, 2001; Desalegn *et al.*, 2000; Prakash and Shastri, 1999). Because of significant genotype by environment interaction for most of the characters, the analysis of variance and other estimates were done location-wise.

3.2 Range and Mean of Different Characters

Table 2: Range, mean, variance, broad sense heritability, genotypic and phenotypic coefficient of variability, genetic advance as percent of mean for the 12 characters of bread wheat genotypes tested at Gitilo

Characters	Range	Mean + SE mean	σ2g	σ2 ph	h2 (%)	GCV (%)	PCV (%)	GA	GA as % Mean
Plant height	66.5-95.3	81.2±1.14	32.95	34.25	96.2	7.01	25.3	11.59	14.27
Days to heading	70-93	80.8±1.5	25.5	28	91	6.25	6.5	9.91	12.26
Days to maturity	124-141	131.7±1.7	7.75	10.75	72	2.03	2.4	4.82	3.65
Grain filling period	39-61	50.3±2.7	22.6	29.9	75.5	9.45	10.8	8.5	16.89
Tillers per plant	1.5-3.5	2.8±0.3	0.05	0.19	26.3	7.98	15.5	0.23	8.21
Spike length	6-11	8.2±0.11	2.3	2.4	95.8	18.4	18.8	3.05	37.19
Spiklet per spike	12-20	15.9±1.2	1.96	2.16	91.6	8.83	9.2	2.77	17.42
Grain per spike	2.2-4.5	2.9±0.41	-0.013	0.157	8.2	3.93	13.6	0.06	0.29
Biological yield	1202-3688	2238±290	155351	239605.7	64.8	17.6	21.8	653.4	29.19
Grain yield kg/ha	3735-7563	5082±302.6	265770	35788.68	74.8	6.92	2.5	291.8	5.74
Harvest Index	0.33-0.49	0.44±0.04	0.0002	0.0018	11.1	3.21	9.6	0.097	22.04
1000 Kernel weight	33.5-49	41.9±1	10.83	11.84	91.4	7.85	8.2	6.47	15.44

Table 3: Range, mean, variance, broad sense heritability, genotypic and phenotypic coefficient of variability, genetic advance as percent of mean for the 12 characters of bread wheat genotypes tested at Guduru

Characters	Range	+S.E.mean, Mean	σ2 g	σ2 ph	h2 (%)	GCV (%)	PCV (%)	GA	GA as % mean
Plant height	32.7-72	±5.17,59.42	19.5	46.3	42.1	7.4	11.45	40.15	67.5
Days to heading	53-75	±3.08, 63.51	18.3	27.5	66.5	6.7	8.2	37.67	59.3
Days.to maturity	93-119	±8.05,105.45	24.1	89	27.07	4.6	8.9	49.6	47.03
Grain filling period	28-57	±7.26, 41.94	6.35	59	10.7	6.04	18.3	13	30.99
Tillers per plant	1.99-3.66	±0.54, 3.10	0.1	0.39	25.6	10.2	20.14	0.2	6.45
Spike length	3.8-8.8	±0.64,6.28	0.55	0.96	57.2	11.8	15.8	11.3	17.99
Spiklet per spike	7.55-14.22	±1.28, 10.81	1.45	3.1	46.7	11.1	16.3	2.98	27.56
Grain per spike	2.1-3.6	±0.53,2.69	0.03	0.31	9.67	6.4	20.69	0.06	2.23
Biological yield	472.6-1766.9	±219.4 1020.4	51512.3	99657.2	51.7	552.1	768.5	106137	25.8
Grain yieldkg/ha	655.5-3620.5	±459.38,1674.	319140	530175	60.2	33.7	43.79	657481	39.276
Harvest Index	0.16-0.49	±0.07, 0.32	0.0032	0.008	36.3	17.6	29.3	0.065	20.3
1000 Kernel Weight	28-45	±2.88, 35.19	5.47	13.7	39.9	6.6	10.5	11.26	31.99

Estimated range, mean, and standard error of the mean are presented in Tables 2 and 3 for Gitilo and Guduru, respectively. Wide ranges were recorded for grain yield, plant height, days to heading, days to maturity, thousand-kernel weight, and kernels per spike at Gitilo, and for kernels per spike, grain yield, and plant height, at Guduru. The highest grain yield (3013.5kg/ha) was recorded from ETBW7173, while low yield of (783kg/ha) was obtained from ETBW7195 at Guduru. At Gitilo, the highest grain yield of (7563 kg/ha) was recorded from ETBW7238 and the lowest yield of (2780.5 kg/ha) was obtained from ETBW 7248.

Most of the genotypes matured earlier at Guduru than at Gitilo with the mean days to maturity of 105.5 for Guduru and 131 for Gitilo. This is due to the effect of temperature and its distribution during the crop-growing season; it also affected other traits like plant height. Higher mean plant height (81 cm) was recorded at Gitilo. At Guduru, mean plant height was shorter (59 cm) as a result of high temperature and short growing season. The highest mean for grain yield (7173 kg/ha) and biological yield (3688 gm/plot) were recorded at Gitilo as compared to mean grain yield (3620 kg/ha) and biological yield (1766.9 gm/plot) that were recorded at Guduru. This indicated that the crop performance was much better at Gitilo than at Guduru.

Some of the genotypes had equal or higher-thousand kernel weight at Gitilo in comparison to Guduru. Observation made in this study suggests that under moisture stress condition such as end of September and mid October, certain genotypes namely, ETBW 7175, ETBW 7194 and ETBW 7182 stayed greener and produced better grains at Guduru. Other genotypes had longer grain filling period as a result they had higher thousand-kernel weight. Highest mean was recorded for characters such as tillers per plant, spikes per plant and spike length at Guduru.

Generally, low rainfall or drought stress can affect many traits such as tillering and plant height (Richards et al., 2001) but the result obtained for tillers per plant at Guduru had higher value, but high sun light during flowering can affect the pollen grain before fertilization. Especially, the number of tiller in plant is not similar with productive plant.

3.3 Phenotypic and Genotypic Variations

The amount of genotypic and phenotypic variability that exists in a species is of utmost importance in breeding better varieties and in initiating a breeding program. Genotypic and phenotypic coefficients of variation are used to measure the variability that exists in a given population (Burton and Devane, 1988). Estimated variance component, phenotypic coefficient of variability (PCV) and genotypic coefficient of variability (GCV) of the characters studied at Gitilo and Guduru are presented in Tables 2 and 3, respectively.

In general, the PCV values were greater than GCV values across environments although the differences were small. This indicated that the environmental effect was small for the expression of most characters. Among all characters, higher GCV and PCV values (>10%) were observed for thousand-kernel weight, tillers per plant, spikes per plant, kernels per spike and biological yield at Guduru; at Gitilo, higher GCV and PCV values were observed for grain yield, thousand-kernel weight, tillers per plant, spikes per plant, spike length, kernels per spike and harvest index. Lowest GCV and PCV values (< 5%) were observed for days to maturity, grain filling period and harvest index at Guduru, and for grain per spikelet's and days to maturity at Gitilo. Plant height, grain yield, biological yield, harvest index, spike length and spikelet's per spike at Guduru, and grain filling period, plant height and biological yield at Gitilo showed intermediate (>5% and <10%) coefficients of variability. Among the yield components, tillers per plant, kernels per spike and spikes per plant had considerable variation at both locations.

3.4 Heritability

Estimated heritability for the characters considered at Gitilo and Guduru are presented in Tables 11 and 12, respectively. The heritability values were sufficiently high for most of the traits at Gitilo and Guduru, indicating the possibility of progress from selection. The high heritability values for most of the characters could be attributed to the relatively favorable environment at both locations. Heritability estimates are expected to be lower in poor environments where heritability is concealed due to a greater genotype by environment interaction component.

Grain yield at Guduru had medium heritability estimate indicating some influence of external environment; at Gitilo, however, it had higher heritability estimate. Moderately high heritability values were found for spike length , grain yield, grain filling period , biological yield and 1000grain weight at Gitilo, and for days to heading), grain yield (61%), 1000grain weight at Guduru. Moderately high heritability values were obtained for most of the trait including grain yields as reported by previous workers (ICARDA, 1990; Whan et al., 1991; Desalegn et al., 2000). The low heritability values were recorded for grain per spikelet at Gitil0, and for harvest index and spike length at Guduru,

Generally, higher heritability estimates (for nine characters out of twelve) were recorded at Gitilo, and for five characters out of twelve at Gitilo, indicating that Guduru's growing environment was less favorable than that of Gitilo. According to Singh (1990), if heritability of a character is very high, say 80% or more, selection for such a character should be fairly easy, because there would be a close correspondence between genotype and phenotype due to a relatively smaller contribution of environment to phenotype. But for a character with low heritability, say less than 40%, selection may be considerably difficult or virtually impractical due to the masking effect of the environment on genotypic effects.

3.5 Estimates of Expected Genetic Advance

The estimated genetic advance and expected genetic advance as percent of the mean for the characters considered at Gitilo and Guduru are presented in Tables 2 and 3, respectively. Expected genetic advance as percent of the mean was generally high for most characters at both locations. Among the characters, the highest genetic advance as percent of mean was recorded for biological yield at Guduru, and for spike length , plant height and spike length at Gitilo. Estimates of genetic advance as percentage of mean ranged from less than 5% for grain per spike to 29% for Tiller number at Gitilo, and from less than 5% for days to maturity to 59.4 for days to maturity at Guduru. Generally, days to heading at both locations, and grain filling period, and spikelet's per spike at Gitilo, and days to maturity at Guduru depicted genetic advance values lower than 10%. As opposed to these, grain yield, thousand-kernel weight, harvest index, tillers per plant, kernels per spike and at both locations and days to heading, spikes per plant, spike length and at Guduru showed relatively high (> 15%) genetic advance expectations. However, plant height, biological yield, spikes per plant, spike length at Gitilo, and grain filling period, plant height and grain filling period at Guduru depicted, genetic advance as percentage of the mean values between 10 and 15%.
Estimated genetic advance for grain yield indicated that the appropriate environment for improving grain yield for the genotypes grown at highland environment in Gitilo than Guduru. Generally, for most characters higher genetic advance as percent of mean was recorded at Gitilo than at Guduru. Since thousand-kernel weight, harvest index and biological yield had relatively high genetic advance as percent of mean and high heritability at both locations; hence, they can be used as a selection criterion, but ultimate evaluation must be performed in the target environment prior to using them.

4. Summary and Conclusion

Variability, heritability and genetic advance study was carried out for a total of thirty-six bread wheat (*Triticum aestivum* L.) genotypes at two different highland and midlatitued environments of "Guduru and Gitilo" in Western Ethiopia. From the two locations, the second one is the potential for bread wheat production in the country but now decline for the lack of productive improved variety. T o select the variety with best performing to the selected environment, study of heritability and genetic advance is of primary duty to have clear selection intensity. The genotypes were grown in a simple lattice design. Data were collected on 12 morpho-agronomic characters. The analysis of variance at each location showed significant ($P< 0.05$) difference for all of the characters, except spikelets per spike at Guduru. This indicated the existence of variability and hence the potential for selection and improvement within characters. Higher heritability estimates (for nine characters out of twelve) were recorded at Gitilo, and for five characters out of twelve at Guduru, indicating that Guduru's growing environment was less favorable than that of Gitilo. Estimated genetic advance for grain yield indicated that the appropriate environment for improving grain yield for the genotypes grown at highland environment in Gitilo than Guduru. The mean performance of the genotypes indicated that genotype ETBW7173 at Guduru and genotype ETBW7238 at Gitilo gave high grain yield than the other genotypes. Thousand-kernel weight, tillers per plant, grain yield, harvest index, spike length and kernels per spike at both locations were found to have high coefficient of variability, intermediate to high heritability and genetic advance as percent of the mean. This means that effective and satisfactory selection for practical improvement of these important traits is possible.

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