Effect of Environment on Different Traits of Teff Evaluated on Debrezeit Research Institution, Oromia, Ethiopia

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ABSTRACT

Superior grain yield across environment is the main goal of teff breeders. The genotype by environment (G x E) interaction influence on grain yield, plant height and shoot biomass were analyzed by application of ANOVA. The objective of this study was to compare the means of teff genotypes tested in an experiment and to identify the effect of genotypes and environment on teff production. Data for this study comprised of 18 teff genotypes grown in twelve locations (environment) obtained from Debre Zeit teff research program. Result of this study revealed that grain yield; plant height and shoot biomass was highly influenced by environmental (location) factors. On the other hand there was strong evidence of difference among genotype effects for plant height, shoot biomass, and grain yield showing that genotypes performed differently across arrange of environment.

Key Words: ANOVA, Environment, Genotype, Teff

1. INTRODUCTION

Teff is among cultivated cereals in Ethiopia. It is the main food security crop in Ethiopia with an annual cultivation over three million hectares of land thereby ranking first among all cereals cultivated in the country and a total production of 3.8 million tons (CSA, 2013). In spite of its advantages, the productivity of teff is very low with the national average standing at 1.5 t/ha compare to wheat and maize. Teff is one of the most important grain cereals adapted to a wide range of climatic conditions (Ketema, 1993). It grows at altitudes ranging from 0 to 2800 m above sea level with diverse amounts of rainfall, temperature and soil regimes. The ability of teff to perform well over a wide range of environments is of major interest and a challenging issue to breeders. However, a significant genotype by environment interaction creates difficulty in identifying superior genotypes (Eberhart & Russell, 1966). According to Kassa.e*t al*. (2013) crop performance depends on the genotype, the environment in which it grows and the interaction between them. Information on the interaction of genotypes with environment is crucial in developing new cultivars for production in diverse environments. Such information guides the breeder in choice of selection methods and to test locations for optimal character expression.

According to Gomez (1983) one of the most important statistical techniques used in agricultural research is the analysis of variance (ANOVA). The classical approach to ANOVA gives an F- ratio and the probability value (P), inference concepts which requires some effort to properly interpret. The application of analysis of variance is powerful tool which gives information about treatment effects, difference among treatment effects. It is also essential for detecting and measuring the interaction of genotypes with location and/or season to identify high yield teff genotypes for wide agro- ecological adaptability and specific environments.

Research has been conducted on genetic analysis of variance of genetic diversity of teff to identify teff varieties with high grain yield and other important traits ((Assefa *et al*., 2011). When the combined data analyzed, a performance test of genotypes over a series of environments gives information on genotype-environment interactions. Therefore, the study of combined data analysis of variance of genetic diversity is very important for teff research program whose main goals include identify of genotypes with high grain yield and other desirable traits.

Analysis of variance (ANOVA) is the most efficient parametric method available for the analysis of data from experiments. ANOVA is a method of great complexity and subtlety with many different variations, each of which applies in a particular experimental context. Hence, it is possible to apply the wrong type of ANOVA in a particular experimental situation and, as a consequence, draw the wrong conclusions from the data (Armstrong *et al.,* 2002). Analysis of variance is a method of considerable complexity and subtlety, with many different variations, each of which applies in a particular experimental context.

Genotypes effect on teff traits

According to Wondewosen *et al*., (2012) the estimation of genetic parameter for different agronomic traits is necessary in the selection of superior teff genotypes and to evaluate the breeding strategies. Research has been conducted on genetic analysis of variance of genetic diversity of teff to identify varieties with high grain yield and other important traits and reported that the effect of genotypes was significant for days to maturity, grain yield, shoot biomass and plant height (Wondewosen *et al*., 2012).Thus the analysis of variance amongst teff varieties is an important component of improvement programs because it provides information about the genetic diversity of the crop and sets a platform for stratified sampling of breeding populations (Kassa *et al.*, 2013).

Environmental effect on teff traits

The test locations has showed substantial effects on all the traits studied (grain yield, shoot biomass, plant height etc.) indicating that the locations were adequately diverse to reveal the performance of the teff genotypes (Habte *et al*., 2015). Substantial genotype by environment interactions for all traits evaluated indicating that the test genotypes had differential performance at diverse locations. Depending up on the magnitude of the interactions or the differential genotypic response to environments, the varietal ranking can differ greatly across environments. The performance of a genotype is not necessarily under diverse agro- ecological zones. Therefore, crop performance depends on the genotype, the environment in which it grows and the interaction between them. According to Eberhart & Russell (1966), information on the interaction of genotypes with environment is crucial in developing new cultivars for production in diverse environments. Such information guides the breeder in choice of selection methods and to test locations for optimal character expression. When analyzed, a performance test of genotypes over a series of environments gives information on genotype-environment interactions.

2. Data and Methodology

2.1. Source of Data

The experiment was conducted by Debre Zeit teff research programme at 12 different research field station (Debre Zeit light soil, Debre Zeit black soil, Akaki, Minjar, Holeta, Ginch, Addadi mariam, Axum, Adet, Bechina, Chefe donsa and Assosa). Data on 18 different teff genotypes was provided by Debre Zeit National teff research programme.

2.2. Variables of the study

Dependent variables

Plant height: 10 randomly selected plants in a plot base was measured in centimeters by breeders

Shoot biomass: after harvest the total shoot biomass of each genotype was measured in grams

Grain yield: each replication was calculated for each genotype in grams for a plot base and finally it was converted into kilogram/ hectare.

Independent variables

Genotype and locations

2.3. Method of Data Analysis

Randomized complete block design (RCBD) which is the most widely used experimental design in agricultural research used in the field. Experimental material is grouped into homogenous sub groups called blocks. Therefore, the field experiment was done by randomized completely block design (RCBD) with four replications across 12 locations, 2m x 2m plot size for each genotype with the following statistical model.

$$Y_{i,j,k} = \mu + \gamma_i + \beta_{j,i} + \tau_k + (\gamma\tau)_{i,k} + \varepsilon_{i,j,k} \quad [1]$$

μ = mean effect

γ_i= i^{th}location effect

$\beta_{j,i}$= j^{th} block effect within the i^{th} location

τ_k = k^{th}treatment effect

$(\gamma\tau)_{i,k}$= interaction of the k^{th} treatment in the i^{th}location

$\varepsilon_{i,j,k}$= pooled error

2.3.1. One -way ANOVA

An ANOVA conducted on a designed in which there is only one factor is called a one way ANOVA. In general, one- way (factor) ANOVA techniques can be used the effect of treatments (k >2) levels of a single factor to determine if different level of the factors affects observations differently. In one-way ANOVA, the total observation can be split into two components: variation between groups and variation within groups (error). Completely randomized design is an example of one-way ANOVA. However, if an experiment has two factors (independent variables), then the ANOVA called two-way ANOVA. Therefore, since the current experiment is conducted using randomized block design (RCBD) which has two factors, block and genotype, one way ANOVA is not appropriate for this experiment.

2.3.2. Two-way ANOVA

An RCBD has two factors: the factor of interest that includes the treatments to be studied and the “Blocking Factor” that identifies the blocks used in the experiment. Since there was two factors, treatment and block, the analysis of variance was conduct in two- way ANOVA with the assumption that the outcomes for each treatment are normally distributed with a common variance. The errors (deviations of individual outcomes from the population group means) are assumed to be independent.

The F-statistic, defined by F = $MS_{between}$ (treatment) /MS_{within} (error)

ANOVA is used to test general rather than specific differences among means.

The critical step in an ANOVA is comparing MSE and MSB. Since MSB estimates a larger quantity than MSE only when the population means are not equal, a finding of a larger MSB than an MSE is a sign that the population means are not equal. But since MSB could be larger than MSE by chance even if the population means are equal, MSB must be much larger than MSE in order to justify the conclusion that the population means differ (*Glen, 1997)*.

In analysis of variance we compare the variability between the groups (how far apart are the means?) to the variability within the groups (how much natural variation is there in our measurements?). This is why it is called analysis of variance, abbreviated to ANOVA. Therefore, combined analysis of variance (ANOVA) will conduct for all agronomical data recorded at 12 locations.

Factorial experiment: in order to know from an experiment whether genotypes are interact with locations or were independent in there effect, genotype x location interaction analysis was conducted to see the effect of environment by genotype.

3. Result and Discussion

Combined analysis of variance was conducted for plant height, yield and shoot biomass across 12 locations to explore differences among genotypes, to test whether genotype was independent of environment or not for plant height, shoot biomass and grain yield and to determine the effect of environments/locations on different teff genotypes (genotype x location interaction). The result of combined analysis of variance for plant height, shoot biomass and grain yield of 18 genotypes in teff are discussed as follows.

Environmental/location effects on teff traits

There was very strong evidence of highly significant ($p < 0.0001$) difference across locations for 18 genotypes for all plant height, shoot biomass and grain yield. This revealed that these environments represented a wide range of agro-climatic conditions to assess the performance and stability of the genotypes. Likewise, there was strong evidence ($P < 0.001$) of differences among the interaction effects of genotype and environment, indicating that the performance of these genotypes was highly dependent on the type of environment/locations considered for grain yield and similarly, ($P=0.0007$) and ($p=0.0004$) of significance difference among interaction effect of genotype and environment/locations showed for plant height and shoot biomass respectively.

Genotype effect on teff traits

Result from analysis of variance, there was strong evidence ($P < 0.0001$) of differences among genotype effects for plant height, shoot biomass and grain yield showing that they performed differently across a range of environments.

After analysis of variance showed significant difference, mean separation was done using least significant difference (LSD) at $\alpha = 0.05$ level of significance differences to compare among means of genotypes and checks respectively.

The difference between two means is declared significant at any desired level of significance if it exceeds the value derived from the general formula:

$LSD\alpha = t\alpha\sqrt{\frac{2MSE}{r}}$, Where $\alpha = 0.05$ level of significance, t tabulated value from student t distribution at $\alpha = 0.05$ and r is number of replication.

Mean performance of 18 teff genotypes over 12 locations for plant height, shoot biomass and grain yield traits

Three quantitative traits (plant height, shoot biomass and grain yield) were investigated for 18 genotypes used in the study. Presented in Table 4 are the observations recorded for mean performances of the 18 genotypes evaluated across 12 locations. In general, the F-test in the ANOVA showed significant (P<0.01) differences among the 18 genotypes for all the characters studied (Table 1). Since the analysis of variance for all traits was significant, further analysis such as, means separation (LSD), has been carried out to compare the genotype means over all locations and among genotypes.

Table 1: Mean performances of teff genotypes for plant height tested at across 12 locations.

Treatment grouping	MEAN	N	INTRACTION	Location
A	114.888	72	NVTADETL	9
B	104.292	72	NVTLSMNI	3
B				
BC	102.978	72	NVTLSDZB	4
C				
DC	100.329	72	NVTLSDZL	1
D				
D	99.817	72	NVTHOLS	5
E	93.667	72	NVTADDLS	7
E				
E	92.569	72	NVTGHLS	6
E				
E	92.242	72	NVTBCNAL	10
E				
E	91.444	72	NVTLSAKB	2
F	78.117	72	NVTASOSA	12
G	74.975	72	NVTAXLS	8
H	66.076	72	NVTCHLS	11
LSD (0.05)	3.0103			
CV	9.79%			

Means with the same letter are not significantly different

For plant height among 18 genotypes, treatment A has the highest plant height (114.888 cm) at location 9 in national variety trial set Adet and is statistically the same as treatment B,BC,DC and D but significantly different with treatment E , E, E, E, and F . On the other hand, treatment H has the shortest plant height (66.076) and is statically the same as treatment G.

Therefore this result shows how plant height is affected by environment from one location to another this result is in agreement with (Habte *et al*., 2015) who reported location effect on plant, shoot biomass and grain yield and is similar to the previous report (Wondewosen *et al*., 2012) who reported plant height, shoot biomass and grain yield were different among genotypes.

Table 2: Mean performance of teff genotype for shoot biomass tested at across 12 locations

TRT grouping	Mean	N	Interaction	LOCATION
A	17590.3	72	NVTLSMNI	3
B	12177.1	72	NVTLSDZL	1
B				
B	12163.2	72	NVTHOLS	5
B				

B	12069.6	72	NVTADDLS	7
C	11048.6	72	NVTLSDZB	4
D	8611.1	72	NVTADETL	9
D				
DE	8246.5	72	NVTGHLS	6
E				
E	7868.5	72	NVTASOSA	12
F	5961.8	72	NVTBCNAL	10
F				
F	5746.5	72	NVTCHLS	11
G	5125.0	72	NVTLSAKB	2
H	3076.4	72	NVTAXLS	8
LSD (0.05)	600.47			
CV	19.86			

Mean with the same letter are not significantly different

From the result of mean of genotypes for shoot biomass treatment group A has the highest shoot biomass (17,590.3 kg/ha) at location 3 in National variety let set Minjar and treatment group H has the poor shoot biomass (3076.4kg/ha) at location 8 in National variety let set Axum. Among location 1, 5 and 7 has no significant shoot biomass difference and also location 6 and 9 has no significant mean difference. Between location 6 and 12 also no significant mean difference observed.

The result analysis of mean performance of genotypes of traits showed significant mean separation difference by locations. This result indicates that traits of teff tested genotypes are not independent of environmental effects. Among 12 locations of this experiment, location 2 has highest grain yield (553.700 kg/ha) whereas location 10 recorded the lowest grain yield.

4. Conclusion And Recommendation

Application of analysis of variance is a statistical tool for agricultural research data enabled to identify superior genotypes across locations and also give information about interaction of genotypes and their environments.

The analysis of variance showed the genotype effect on plant height, shoot biomass and grain yield traits. Similarly the environmental/location effects on this studied traits was statistically highly significant on teff traits. Information on studied teff genotype by environment effect has been generated from the analysis of variance and showed highly significant difference for all studied traits.

Among 18 genotypes number 2, 4, 6, 12, 18 were identified as good yielding varieties by comparison of their means across locations.

Therefore, it can recommended that application of analysis of variance as a statistical tool for agricultural research data enabled to identify best performance of genotypes across locations to make selection decision for teff breeders.

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