Food Science and Quality Management
ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)
Vol.102, 2020 www.iiste.org

Performance Evaluation of Groundnut Varieties in Eastern Parts of Ethiopia

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Abstract
Groundnut plays an important role as a food as well as cash crop in Ethiopia. Its production in Ethiopia is found to be constrained by several biotic and abiotic factors. To this end, this study was done with the objective of identifying the high yielding, biotic and abiotic resistance or tolerance varieties in 2019. A total of six varieties were evaluated in RCBD. AMMI showed that environments, varieties and their interaction effects were significantly different. The stability and high yielding ability of the varieties has been graphically depicted by the AMMI bi-plot. The variation for seed yield among the varieties for each variety was significant at different environments. Varieties G1 (Bulki), G6 (Babile2) and G4 (Werer962) were specifically adapted to high yielding environments. G2 (Shulamiz) was the most unstable variety. G1 (Bulki) was more stable in comparison to other varieties. In GGE bi-plot; $IPCA_1$ and $IPCA_2$ explained 48.07% and 25.93%, respectively, of groundnut variety by environment interaction and made a total of 74.00% of variation. Therefore, Bulki (1075kg ha^{-1}) and Babile2 (1030kg ha^{-1}) were most stable recommended for the study area and similar agro-ecologies and Fedis was the ideal environment for groundnut production.
Keywords: AMMI, G x E interaction, Groundnut
DOI: 10.7176/FSQM/102-04
Publication date: November 30th 2020

Introduction

Groundnut (*Arachis hypogaea* L.) plays an important role as a food as well as a cash crop in Ethiopia (Dereje A. *et al*., 2012). Currently the crop is becoming one of the high value crops that are growing in the lowlands areas of the eastern Oromia. Groundnut, or peanut, is commonly called the poor man's nut. Today it is an important oilseed and food crop (FAO, 2002). Groundnuts are produced in the tropical and subtropical regions of the world, on sandy soils.

In Ethiopia, groundnut is cultivated predominantly by the traditional and undeveloped farming community under rain-fed conditions. It occupies about 79,947 hectares of land with a corresponding gross annual production of about 1128,887 qt. (CSA, 2013/14). The yields of groundnut in Ethiopia compared to other countries are very low i.e. below 1.1 ton ha^{-1} as compared to average yields on a global scale i.e. 1.52 ton ha^{-1} but with good management practices, yields can be increased to 3.0 ton ha-1 (CSA, 2009; FAOSTAT, 2009). Groundnut production in Ethiopia is found to be constrained by several biotic and abiotic factors i.e. critical moisture stress especially during flowering and then after, lack of improved varieties and appropriate production and post-harvest practices, and diseases affecting both above- and underground parts of the plant (Alemeyehu C. *et al*., 2014).

Objective of the study was;-

- To evaluate and recommend the best high yielding and early matured varieties in study areas.

Materials and Methods

This activity has been conducted at Fedis on station. A total of seven recently released varieties of groundnut were collected from BARC and one local check was used as planting materials. The experiment was arranged in RCBD. The varieties were grown under uniform rain fed conditions. The experimental plots consisted of six rows of 3 m length, 3.6m width and 0.6m row space. The central four rows were harvested to estimate grain yield. The spacing between adjacent replications and plots were 1m, and 1m, respectively. Important data like: - date of emergency, date of flowering, plant height, pod per plants, seed per pod, numbers of branches per plants and yielded per plots were collected.

Days to flowering: The number of days from date of emergence to the stage where 75% of the flower have fully opened.

Days to maturity: The number of days from date of emergence to the stage when 90% the plants in a plot have reached physiological maturity.

Pods per plant: This was recorded by mean number of pods obtained from ten randomly taken plants at harvest.

Seeds per pod: Mean numbers of seeds obtained from five plants were selected at random from each plot and the total number of seeds was counted, the average was calculated and recorded as the number of seeds per plant.

Grain yield per hectare: Grain yield obtained from each experimental plot and converted to grain yield per hectare and corrected to 13% humidity

Result and Discussion

Combined Analysis of Variance

Analysis of variance was carried out to determine the effects of varieties, location and their interaction on seed yield of groundnut varieties. Accordingly, Environment and Genotype for seed yield showed statistically highly significant differences ($P<0.01$) indicating the presence of genetic variation and possible selection of high yielding and stable varieties (Table 1). This indicates the big influence of environment and varieties on yield performance of groundnut varieties. The significant effect of environments indicated that the testing environments were significantly different from each other for expressing their yield potential. Similarly, Sunday C. *et al.*, (2013) reported the different performance of genotypes across environments could also be indicative of wide variation in climatic conditions and soil types in the different growing environments. The mean yield potential of the varieties varying across environments and among varieties indicating the varieties were expressing their potentials even though they were affected by environments and genetic variations.

Table 1. Analysis of variance for seed yield of Groundnut varieties evaluated across two years for different locations.

Source of variation	d.f.	mean square
Block	2	3.75
Genotypes	7	11.667*
Environment	5	154.47**
Interaction	35	7.083
Error	94	5.081
Total	143	

Mean seed yield of groundnut varieties evaluated at six environments

The average environmental seed yield across varieties ranged from the lowest of 6.44 $Qtha^{-1}$ at E2 (Erer 2017) to the highest of 12.85 $Qtha^{-1}$ at E1 (Fadis 2017), with a grand mean of 9.59 $Qtha^{-1}$(Table 2). The varieties average seed yield across environments ranged from the lowest of 8.06 $Qtha^{-1}$ for Shumaliz to the highest of 10.75 $Qtha^{-1}$ for Bulki (Table 2). This difference could be due to their genetic potential of the varieties and also environment explained large variation indicated the existence of diverse mega environments.

Table 2: Mean seed yield (Qt/ha) of groundnut varieties evaluated at six environments

Varieties	Mean of seed yield across environment						mean
	E1(Fadis 2017)	E2(Erer 2017)	E3(Fadis 2018)	E4(Dire 2018)	E5(Qile 2018)	E6(Qile 2019)	
Bulki	10.99	7.23	11.73	9.50	16.20	8.88	10.75a
Shumaliz	12.46	6.61	9.04	4.27	8.60	7.38	8.06c
Werer961	14.17	5.32	14.06	5.75	9.05	7.05	9.23bc
Werer962	13.56	6.37	13.03	9.05	9.25	7.69	9.83ab
Roba	14.22	7.16	10.94	7.36	9.81	8.78	9.71ab
Babile2	12.68	6.72	12.96	11.18	9.46	8.79	10.30ab
Baha Jiddu	13.33	6.57	12.73	7.86	9.08	8.04	9.60ab
Local Variety	11.42	5.56	12.30	8.62	9.57	7.84	9.22bc
Mean	12.85	6.44	12.10	7.95	10.13	8.06	9.59

Additive Main Effects and Multiple Interaction (AMMI) model

AMMI analysis of variance for Seed yield of eight groundnut varieties tested in six environments showed that environments, varieties and their interaction effects were significantly different ($P<0.01$) (Table 3) demonstrating the importance of applying AMMI analysis to investigate the main effects of varieties and environment and the complex patterns of their interaction. The environment modeled significant effect on the seed yield of groundnut, which explained 48.67% of the total variation indicating the existence of a considerable amount of deferential response among the varieties to changes in growing environments and the differential discriminating ability of the test environments. GEI contribute 15.62% of total variation while the Varieties contribute only 5.15% of the total variation. Similarly, Amare Kebede and Adisu Getahun (2017) reported the analysis of variance showed genotype (8.8%), environment (69.8%), and GEI (21.4%) effects were significant ($P < 0.01$).

Table 3. Partitioning of the Explained Sum of square (Ex.SS) and Mean of square (MS) from AMMI analysis for seed yield of eight groundnut varieties evaluated at six environments

Source of variation	d.f.	Sum square	Ex Sum square	Mean square
Total	143	1587.1	100	11.1
Treatments	47	1101.9	69.43	23.45**
Genotypes	7	81.7	5.15	11.67**
Environments	5	772.4	48.67	154.47**
Block	12	174.3	10.98	14.53**
Interactions	35	247.9	15.62	7.08**
IPCA 1	11	136.1	8.58	12.37**
IPCA 2	9	74.3	4.68	8.25*
Error	15	37.5	2.36	2.5
Pooled Error	84	310.8	19.58	3.7

As reported by Purchase *et al*., 2000, genotype with least ASV score is the most stable varieties. Accordingly, Bulki and Babile2 were most stable and Werer961 and Baha Jiddu were the most unstable. This measure is essential in order to quantify and rank varieties according to their seed yield stability. The least Genotype Selection Index (GSI) is considered as the most stable with high grain yield (Hagos *et al.,* 2011). Based on the GSI, the most desirable variety for selection of both stability and high seed yield was Bulki followed by Babile2.

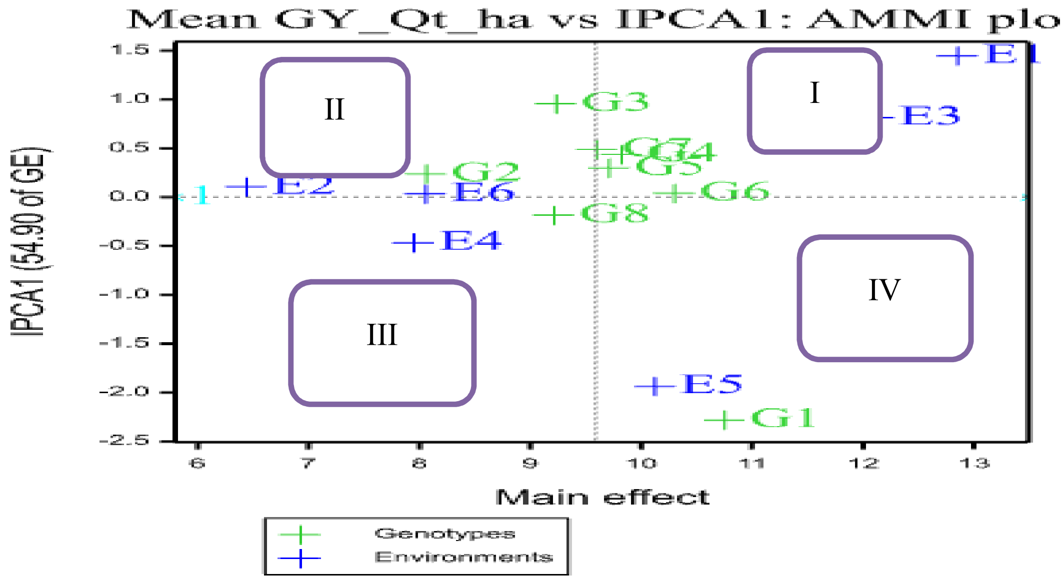
Table 4. $IPCA_1$, $IPCA_2$ scores, AMMI stability value and Genotype Selection Index of eight groundnut varieties

Variety	Mean yield	RYi	IPCA1	IPCA2	ASVi	RASVi
Bulki	10.754	1	-2.28129	0.2415	0.933	7
Shumaliz	8.06	8	0.23873	1.42978	1.80	3
Werer961	9.233	6	0.95733	0.24238	3.533	8
Werer962	9.826	3	0.43839	-0.56141	2.067	5
Roba	9.713	4	0.29972	0.69252	2.867	6
Babile2	10.301	2	0.04194	-1.23832	1.733	2
Baha Jiddu	9.601	5	0.48956	-0.11966	3.40	1
Local Variety	9.217	7	-0.18438	-0.68679	1.933	4

The stability and high yielding ability of the varieties has been graphically depicted by the AMMI bi-plot. Environments E3 (Fadis 2018) and E1 (Fadis 2017) relatively showed high IPCA scores, contributed largely to GEI. These environments were favorable for high yielding varieties based on mean yield as they had more than the grand mean. Environment E2 (Erer 2017) is the least favorable environment for almost all the varieties with low yield and smaller $IPCA_1$ score (Fig 1).

The variation of yield for each variety was significant at different environments. Varieties G1 (Bulki), G6 (Babile2) and G4 (Werer962) were specifically adapted to high yielding environments (Fig 2). Considering the IPCA1 score, G2 (Shulamiz) was the most unstable variety and also adapted to higher yielding environments. G1 (Bulki) was more stable in comparison to other varieties. Generally, Fadis was the most favorable environment for ground nut production with maximum mean of yield potential.

Figure 1: Biplot of interaction principal component axis ($IPCA_1$) against mean Seed yield of eight groundnut varieties and six environments



Genotype and Genotype by Environment interaction (GGE) bi-plot analysis

In GGE bi-plot (Figure 2), $IPCA_1$ and $IPCA_2$ explained 48.07% and 25.93%, respectively, of groundnut variety by environment interaction and made a total of 74.00%. The other study conducted on the same crop showed 81.8% total of $IPCA_1$ and $IPCA_2$ (Amare *et al.,* 2014). Environments and genotypes that fall in the central (concentric) circle are considered as ideal environments and stable genotypes, respectively (Yan, 2002). A genotype is more desirable if it is located closer to the ideal genotype. Thus, using the ideal genotype as the center, concentric circles were drawn to help visualize the distance between each genotype and the ideal genotype. Therefore, the ranking based on the genotype-focused scaling assumes that stability and mean yield are equally important (Ezatollah *et al*., 2011). Fig. 2 revealed that G6 (Werer 962), which fell into the center of concentric circles, was ideal variety in terms of higher yielding ability and stability, compared with the rest of varieties. In addition, G1 located on the next concentric circle, may be regarded as desirable varieties. An environment is more desirable and discriminating when located closer to the center circle or to an ideal environment (Naroui *et al*., 2013). In the present study, E4 and E6 were the most discriminating and representative environments followed by E5 (Fig.3). E1was were non-discriminating and less representative sites. This implied that, varietal stability could be challenged not only due to the change in the test environment but also due to differential response of tested varieties per environment.

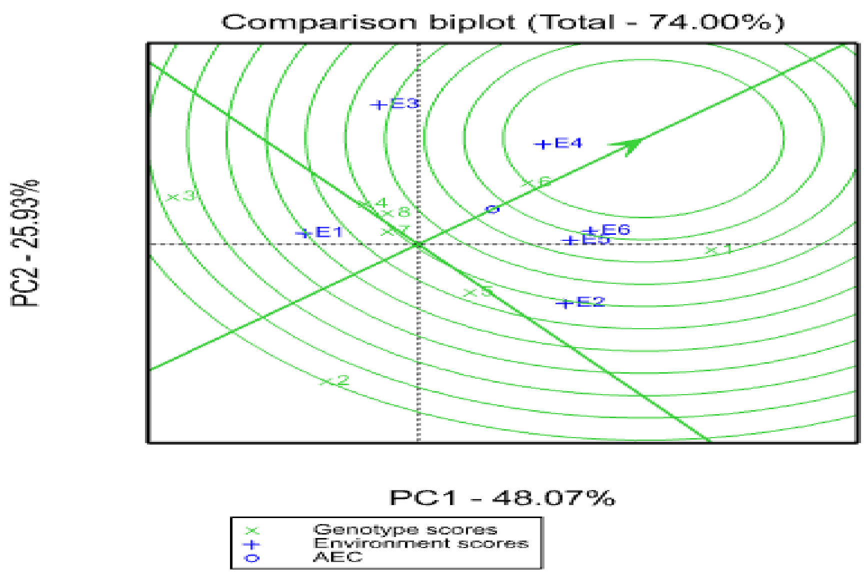


Fig. 2. The vector view of the GGE bi-plot based on environment focused scaling for environments to show relationship among testing environments.

G and E letters stand for genotypes and environments respectively.

GGE bi-plot based on genotype-focused scaling for comparison of genotypes for their yield potential and stability

Figure 3 provides the summary of the interrelationships among the environments. The varieties that connect the bi-plot origin and the markers for the environments are called environment vectors. The angle between the vectors of two environments is related to the correlation coefficient between them. The cosine of the angle between the vectors of two environments approximates the correlation coefficient between them (Dagnachew *et al*., 2014). Based on the angles of environment vectors, the six environments are grouped in to two groups. Group one includes E1 and E3 and Group two involve E2, E4, E5 and E6. For instance, the smallest angle between E1 and E3 is implying that there are the highest correlations between them. The angle between E1 and E2; E3 and E2 are bigger than others showing the poor correlation between them (Figure 3). Two criteria are required to suggest existence of different mega-environments. First there are different winning genotypes in different test locations. Second, the between-group variation should be significantly greater than the within-group variation, common criteria for clustering. Dividing the target environment into different mega-environments and deploying different genotypes in different mega-environments is the best way to utilize GE interaction.

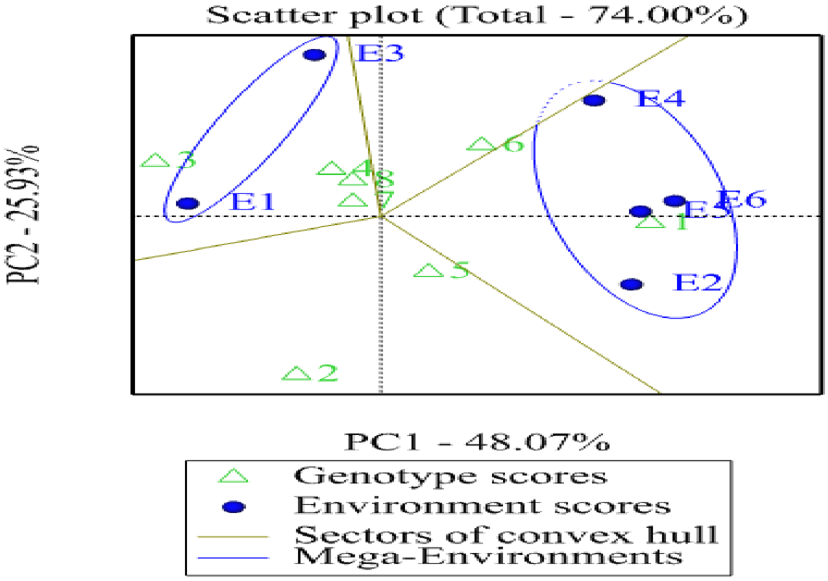


Fig. 3. GGE bi-plot based on genotype-focused scaling for comparison of genotypes for their yield potential and stability

Summary and Conclusion

Analysis of variance find out Environment and Genotype for seed yield showed statistically highly significant differences (P<0.01) indicating the presence of genetic variation and possible selection of high yielding and stable varieties. The average environmental seed yield across varieties ranged from the lowest of 6.44 Qtha^{-1} at E2 (Erer 2017) to the highest of 12.85 Qtha^{-1} at E1 (Fadis 2017), with a grand mean of 9.59 Qtha^{-1}. AMMI analysis of variance for Seed yield of eight groundnut varieties tested in six environments showed that environments, varieties and their interaction effects were significantly different (P<0.01). The environment modeled significant effect, which explained 48.67% of the total variation indicating the existence of a considerable amount of deferential response among the varieties to changes in growing environments and the differential discriminating ability of the test environments. Accordingly, Bulki and Babile2 were most stable and Werer961 and Baha Jiddu were the most unstable. The stability and high yielding ability of the varieties has been graphically depicted by the AMMI bi-plot. Environments E3 (Fadis 2018) and E1 (Fadis 2017) relatively showed high IPCA scores, contributed largely to GEI. These environments were favorable for high yielding varieties based on mean yield as they had more than the grand mean. The variation of yield for each variety was significant at different environments. Varieties G1 (Bulki), G6 (Babile2) and G4 (Werer962) were specifically adapted to high yielding environments. G2 (Shulamiz) was the most unstable variety and also adapted to higher yielding environments. G1 (Bulki) was more stable in comparison to other varieties. Generally, Fadis was the most favorable environment for ground nut production with maximum mean of yield potential. In GGE bi-plot; $IPCA_1$ and $IPCA_2$ explained 48.07% and 25.93%, respectively, of groundnut variety by environment interaction and made a total of 74.00%. GGE bi-plot revealed that G6 (Werer 962), which fell into the center of concentric circles, was ideal variety in terms of higher yielding ability and stability, compared with the rest of varieties. In addition, G1 located on the next concentric circle, may be regarded as desirable varieties. In the present study, E4 and E6 were the most discriminating and representative environments followed by E5. E1 was non-discriminating and less representative sites.

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