Greener Journal of Agricultural Sciences
ISSN: 2276-7770
Vol. 14(4), pp. 203-211, 2024

https://gjournals.org/GJAS
DOI: https://doi.org/10.15580/gjas.2024.4.121924203

Performance Evaluation of Groundnut (*Arachis hypogea* L.) Varieties in Buno Bedele, South Western Oromia, Ethiopia

Garoma Firdisa*; Mohammed Tesiso

Oromia Agricultural Research Institute, Bedele Agricultural Research Center, P.0.Box 167, Bedele, Ethiopia.

ARTICLE INFO

Article No.: *121924203*
Type: *Research*
Full Text: *PDF. PHP, HTML, EPUB, MP3*
DOI: *10.15580/gjas.2024.4.121924203*

Accepted: *23/12/2024*
Published: *31/12/2024*

****Corresponding Author***
Garoma Firdisa
E-mail: *garomafirdisa21@ gmail.com*

Keywords: *AMMI, G x E interaction, Groundnut, IPCA, grain yield*

ABSTRACT

The objective of this activity is to evaluate, select and recommend the high yielding, adaptable, stable and disease resistant varieties. This activity has been done during the 2023 and 2024 main cropping seasons. A total of six groundnut varieties including local were evaluated using RCBD with three replications. The data on days to 50% flowering, days to 90% maturity, plant height, number of primary branch per plant, number of seed per pod and grain yield were collected and subjected to analysis of variances using R- software. Combined analysis of variance revealed that there was significant difference for all studied traits except of primary branch per plant and number of seeds per pod across the locations. The highest grain yield (1932.9 qt ha-1) was recorded by Babile-1 followed by BaHa gudo (1799.8 qt ha-1) while the lowest yield (1206.4 qt ha-1) was recorded by local check. Also the combined ANOVA 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. Environment Dabo Hana-2023 relatively showed high IPCA scores, contributed largely to GEI. This environment was favorable for high yielding varieties based on mean yield as they had more than the grand mean. The variation for seed yield among the varieties for each variety was significant at different environments. Varieties Babile-2 and BaHa gudo were specifically adapted to high yielding environment. Local check variety was the most unstable variety, while Babile-1 was more stable in comparison to other varieties. In GGE bi-plot; IPCA1 and IPCA2 explained 69.99% and 19.69%, respectively, of groundnut variety by environment interaction and made a total of 89.68% of variation. Therefore, Babile-1 (1932.9 kg ha-1) and BaHa gudo (1799.8 kg ha-1) were most stable recommended for the study area and similar agro-ecologies and Dabo Hana was the ideal environment for groundnut production.

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). In Ethiopia, groundnut is grown in the lowlands and is the second important lowland oilseed of warm climate next to sesame. It is playing an increasingly important role as an alternative oil crop to an increasing number of small holder farmers. 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 77,283.21 hectares of land with a corresponding gross annual production of about 1,392,784.61 qt. (CSA, 2022). The yields of groundnut in Ethiopia compared to other countries are very low i.e. below 18.02 qtha^{-1} as compared to average yields on a global scale i.e. 15.2 qtha^{-1} but with good management practices, yields can be increased to 30 qtha^{-1} (CSA, 2022). 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 et al., 2014).

Environmental conditions play a significant role in the variation of agricultural traits in groundnuts (Bonchev et al. 2018), and the performance of groundnuts is strongly influenced by environmental factors (Gulluoglu et al. 2016). Therefore, studying the stability of groundnuts genotypes to identify a suitable variety is essential for maximizing yield potential for the regions (Kasno and Trustinah 2015). Additionally, research on peanut stability can contribute to the development of resilient and adaptable peanut varieties that can ultimately lead to a more secure and sustainable peanut production system in the region. Significant G×E interactions (GEI) reduce the association between genotype and phenotype, making it hard to identify superior genotypes, thus affecting breeding progress (Delacy et al. 1996).

Understanding the GEI and stability analysis can help plant breeders' select stable genotypes. Several stability procedures have been developed to explain the GE interaction. Multivariate methods include additive main effects and multiplicative interaction models (AMMI) (Gauch and Zobel 1988). In addition, the GGE biplot methodology as a superior approach for the graphical analysis of multi environmental data (Yan and Kang 2003), that provides the possible identification of high-yield and stable genotypes (Karimizadeh et al. 2013). Therefore, this activity was conducted with objective of evaluating adaptability of improved ground nut varieties and selects the best performing adapted variety for the target areas.

MATERIALS AND METHODS

Description of the study Area

The field experiment was conducted during the 2023-2024 G.C main cropping seasons for two years at three districts (Bedele, Dabo Hana and Gechi) in Buno Bedele Zone, South Western Oromia where agro ecology assumed to be conducive for Linseed production (Fgure 1).

Bedele District

Bedele district is located in Buno Bedele zone of Oromia Regional National State, Southwestern Ethiopia. The district is located between 8°14'30''N to 8°37'53''N and 36°13'17''E to 36°35'05''E is about 483km road distance south-west of Finfine. It is covers 74497.425 hectares of which 47,986, 9477, and 10,120 hectares are cultivated, forest and grazing land, respectively. The area is covered with variety of crops and species of natural vegetation. The dominant crops in the area are maize, tef, sorghum, finger millet and haricot bean. The major land use types are cultivated land/cropland, forestland and grazing land (Bedele development agricultural office, 2019).

Dabo Hana District

Dabo Hana is one of the districts in Buno Bedele Zone, Oromia Regional State Southwest part of Ethiopia. The district is bordered on the south by Bedele, on the west by Dega and Mako, on the north by Chewaka and Leka dulecha, on south west by Chora, on the east and north east by Jima Arjo. The administrative center of this district is Dabo Hana. The district is located 521 km away from the capital city of the country and 38 km away from Bedele Town. The district is located at an average elevation of 1190-2323 masl and located at 8°30' 21'' to 8°43' 29" N latitude and 36°5'27" to 36°26' 19"E longitude. It is generally characterized by warm climate with mean annual maximum temperature of 28°C and minimum temperature of 11°C. The annual rainfall ranges from 900-2200mm

Gechi District

Gechi is one of the districts in Buno Bedele Zone, Oromia Regional State Southwest part of Ethiopia. The district is bordered on the south by Didessa, on the west by Didessa River, on the north by Bedele, and on the east by Jimma Zone. The administrative center of this district is Gechi. The district is located 465 km away from the capital city of the country and 18 km away from Bedele Town. The district is located at an average elevation

1277-2467m.a.s.l and located at 8°16'60''N latitude and 36°34'00''E longitude. The annual rainfall ranges from 1500-2100mm. The economy of the area is based on coffee production system in which the dominant crops are maize, tef, sorghum and wheat and also horticultural crops.

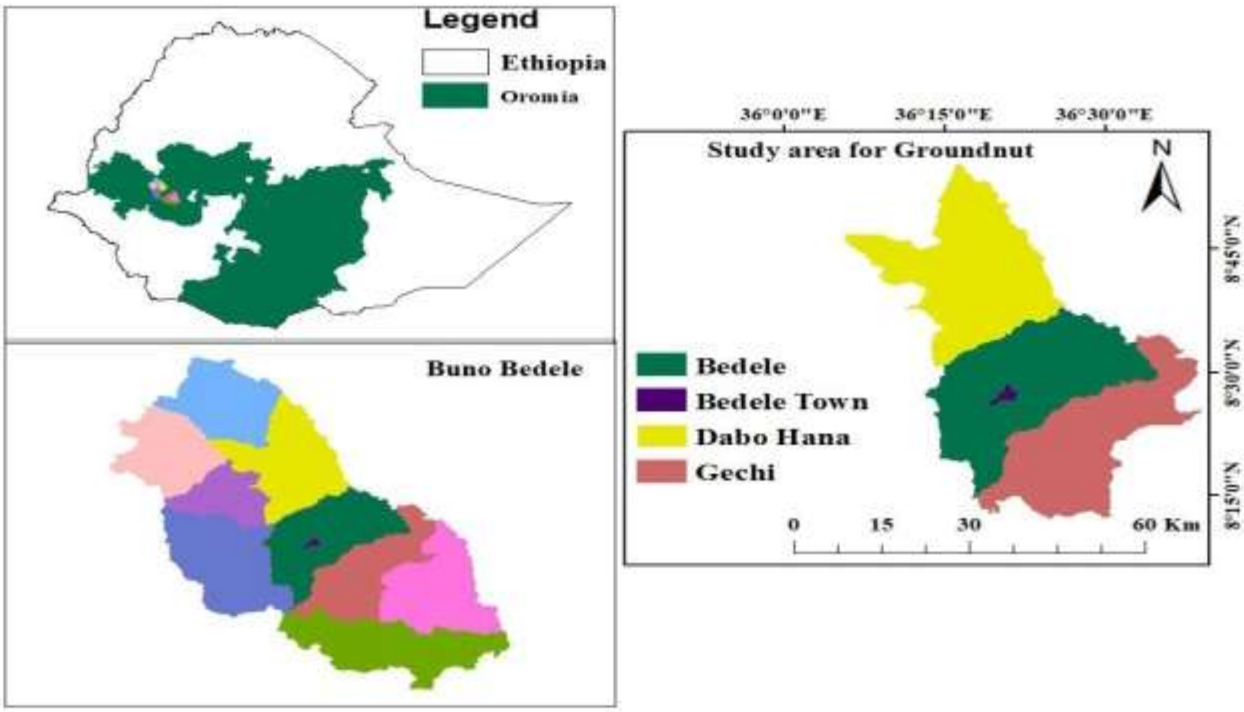


Figure 1: Map of the study areas

Experimental Materials

A total of six groundnut varieties (Babile-1, Babile-2, Baha gudo, BaHa jidu and Werer-961) including one local check were used as planting materials.

Table 1: Description of Groundnut varieties used in the experiment

Varieties	Altitude ranges (m.a.s.l)	Year of Release	Source
Babile-1	650-1400	2016	HU
Babile-2	650-1400	2016	HU
BaHa-jidu	650-1400	2012	HU
Werer-961	650-1400	2004	WARC/EIAR
BaHa gudo	650-1400	2012	HU
Local	650-1400	-	Farmer

Note: HU=Haramaya University, WARC= Werer Agricultural Research Center, EIAR=Ethiopia Institute of Agricultural Research

Experimental Design and Field Work

The treatments were laid with a randomized completed block design (RCBD) with three replications was used in the study. The experimental plots were 1.5 m × 3 m (4.5m^2) in size, with rows separated by 0.3m. The distance between plots and blocks was 0.5 m and 1m, respectively. Each plot had five rows, with the middle three used for the collection of the data and the two outermost rows were used as border rows. The experimental sites were plowed three times with draught animals called oxen before planting, and 100 kg ha^{-1} seed rate and 100 kg ha^{-1} of NPS fertilizer rate were used according to crop recommendations.

Data Collection

Days to flowering - were calculated from the date of planting when 75% of the crop stand produced the first flower.

Days to maturity - The number of days from planting to physiological maturity of the plants was used to compute the days to maturity.

Plant height - the average height of five randomly selected plants, measured from the base to the tip of the plant.

The number of crop stand - was recorded as the average number of plant's population taken from the four middle rows of the plots

The number of seeds per plant - It was calculated as the mean number of seeds collected from five randomly selected from the four middle rows of the plots.

Seed yield (kg plot^{-1}) - It was calculated as the entire seed yield produced from the plants harvested and threshed and converted into seed yield per hectare.

Data Analysis

The analysis of variance (ANOVA) for each location and combined analysis of variance over locations were performed using the R program and the mean separation was done using Least Significant Difference (LSD) at the 5% probability level.

RESULT AND DISCUSSION

Pooled Analysis of Variance

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, the Environment and Genotypes on their own displayed significant level of variability in their yield responses at $p < 0.001$, while GEI effect was significant at $p < 0.05$. This indicates that this indicates the big influence of environment and varieties on yield performance of groundnut varieties and the varieties do not show consistent performance across the studied environments. The significant effect of environments indicated that the testing environments were significantly different from each other for expressing their yield potential. 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 2: Combined ANOVA for GY of six (6) Groundnut varieties across locations

SOV	Df	SS	MS	F value	Pr(>F)
Rep	2	93108	46554 ^{ns}	0.2888	0.75000
Years	1	22102	22102^{ns}	0.1156	0.7346542
Locations	2	6576279	3288140***	20.3967	8.110e-08
Treatment	5	6499475	1299895***	8.0634	3.841e-06
Trt*years	5	7437121	1487424***	3.8888	0.0001972
Loc*years	2	66413788	33206894***	11.5757	1.625e-06
Trt*locations	22	6465531	293888*	1.8230	0.02893
Error	76	12251930	161210		

Note: SOV=Source of Variations, SS=Sum of Squares, MS=Mean Sum of Squares, Df=Degree of freedom, ***=Highly significant (0.001), *=significant at (0.05) & ns= non-significant

Mean Seed Yield of Groundnut Varieties Evaluated at Six Environments

The average environmental seed yield across varieties ranged from the lowest of 1393.2 kgha^{-1} at Bedele -2023 to the highest of 2035.5 kgha^{-1} at Dabo Hana-2023), with a grand mean of 1651.7 kgha^{-1} (Table 3). The varieties average seed yield across environments ranged from the lowest of 1206.4 kgha^{-1} for local check to the highest of 1932.9 kgha^{-1} for Babile-1 (Table 3). 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 3: Mean seed yield (kgha^{-1}) of groundnut varieties evaluated at six environments

Varieties	Mean of seed yield across environment					Mean
	D/Hana-2022	D/Hana-2023	Bedele-2022	Bedele-2023	Gechi-2023	
Babile-1	1961.4^{abc}	2787.0^{a}	1932.0^{a}	1735.2^{a}	1774.1^{a}	1932.9^{a}
Babile-2	2100.0^{ab}	2081.5^{b}	1396.9^{b}	1511.1^{ab}	1685.2^{a}	1743.3^{ab}
BaHa jidu	2576.9^{a}	1927.8^{b}	1546.3^{ab}	1238.9^{bc}	1673.2^{a}	1772.7^{ab}
Werer-961	1548.3^{bc}	1703.7^{b}	1400.0^{b}	1688.9^{a}	1011.1^{b}	1454.9^{bc}
BaHa gudo	2144.6^{ab}	2562.9^{a}	1302.5^{bc}	1242.6^{bc}	1773.1^{a}	1799.8^{a}
Local	1296.0^{6c}	1150.0^{c}	857.6^{c}	942.6^{c}	1495.9^{ab}	1206.4^{c}
Mean	1937.9	2035.5	1405.9	1393.2	1568.8	1651.7
LSD 0.05	727.9	395.8	466.8	440.1	31.4	332.6
CV %	20.7	10.7	18.3	17.4	581.8	30.5
P-value	*	***	*	*	*	**

Note: GM= grand mean, LSD=least significant difference, CV= coefficient of variation, *= significant, **= highly significant

Agronomic performance

Differences among the genotypes were significant for a number of characters (Table 3). The tested groundnut varieties shows statistically significant variation that ranged from 37.00 (BaHa jidu) to 54.78 (local check) for days to flowering and 110.94 (Babile-1) to 142.1667 (local check) for days to maturity. From this result Babile-1 was the earliest to maturity whereas local check was the late maturing variety. On the other hand, in terms of plant height Babile-1, Babile-2, and BaHa gudo were the shorter whereas BaHa jidu and Werer-961 were comparatively the taller varieties.

Table 4: Combined mean yield related traits of six (6) *Groundnut* varieties over two years at Dabo Hana, Gechi and Bedele districts, Buno Bedele Zone

Varieties	DTF (days)	DTM (days)	PLH (cm)	NPB/sta	NS/P	HSW(g)	Dis(ELS)
Babile-1	40.83[b]	110.94[b]	40.79[b]	28.59	1.94	74.17[a]	2mr
Babile-2	37.11[c]	117.28[b]	40.72[b]	29.44	2.22	76.67[a]	2mr
BaHa jidu	37.00[c]	118.17[b]	45.29[ab]	30.10	2.11	61.39[b]	2mr
Werer-961	37.06[c]	116.00[b]	47.28[a]	27.17	2.00	56.39[b]	3ms
BaHa gudo	38.22[c]	117.39[b]	39.43[b]	27.74	2.28	75.44[a]	2mr
Local	54.78[a]	142.1667[a]	44.8[ab]	33.97	2.00	58.89[b]	2mr
GM	40.83	120.32	43.06	29.50	2.10	67.16	
LSD (0.05)	1.99	8.26	6.13	6.34	0.48	6.64	
CV %	7.37	10.38	21.51	5.92	34.62	14.95	
P-value	***	***	*	NS	NS	**	

Note: DTF= Days to Flowering, DTF= Days to Maturity, PLH= Plant height (cm), NB/PL= Number of primary stand, NS/P= Number of seed per Pod, ELS=early leaf spot, GM= Grand mean, LSD= Least significant different, CV= Coefficient of variation, NS= Non-significant, *=significant, **= highly significant

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< 0.001 & 0.05). (Table 5) indicating 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 17.81% 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 17.06% of total variation while the varieties contribute 17.38% of the total variation.

Table 5: Partitioning of the Explained Sum of square (Ex.SS) and Mean of square (MS) from AMMI analysis for seed yield of six groundnut varieties evaluated at five environments

SOV	DF	SS	MS	%Variance Explained	% Cumulative
Environment	4	6663466.4	1665866.59**	17.81	
Genotype	5	6499475.4	1299895.08**	17.38	
Interaction.	20	6378344.0	318917.20*	17.05	
PCA1	8	2467351.2	308418.90*	44.8	44.8
PCA2	6	2065963.5	344327.24*	37.5	82.3
Error	68	11198488.2	164683.65		
Total	127	37395259.5	294450.86		

***Note**: ** Significant difference at (P≤0.01), SOV=source of variation, DF=degree of freedom, SS=sum of square, MS=mean sum of square, PCA=principal component of axis*

AMMI Biplot Analysis for Seed Yield

The AMMI 1 biplot was generated using the first IPCA and mean grain yield of the genotypes and environments whereas AMMI 2 biplots was used genotypic and environmental scores of the first two IPCAs. Furthermore, the relative magnitude and direction of genotypes along the abscissa and ordinate axis in biplot is also important to understand the response pattern of genotypes across environments and to differentiate high yielding and adaptable genotypes (Samonte et al., 2005). In the present study, the genotypes and environment which found at the right side of the perpendicular line are those which gave mean grain yield above the grand mean. Accordingly Babile-1, Babile-2, BaHa gudo and BaHa jidu were found in this category. Furthermore, environment Dabao Hana-2022 and Dabo Hana-2023 which found at the right side of the perpendicular line, were also gave mean grain yield above the grand mean. Thus, they are better environments for commercial production of groundnut lines found specifically or widely adapted to them. The rest of the genotypes and environments gave mean grain yield lower than the grand mean (Figure 2).

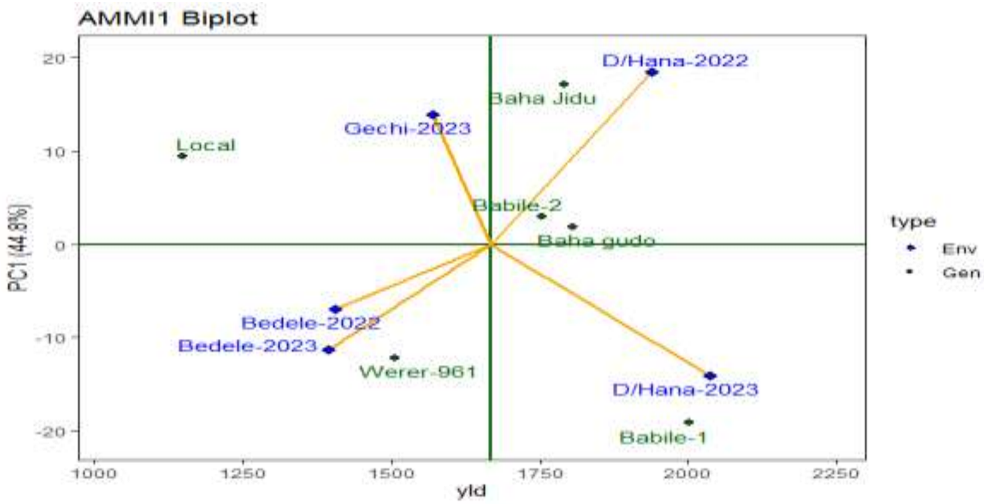


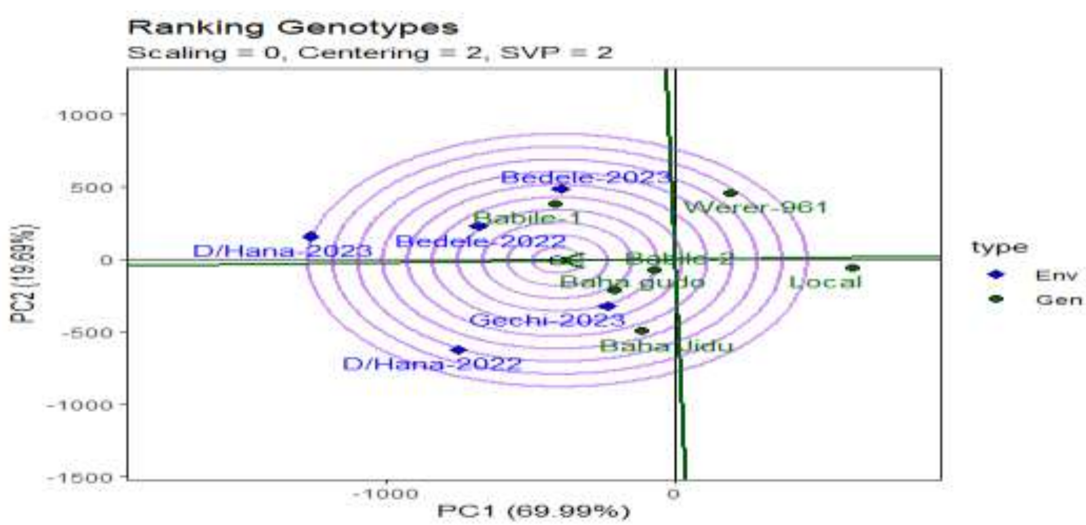
Figure 2*: AMMI bi plot of IPCA 1 against grain yield*

GGE Biplot Analysis for Yield

GGE bi plot is important to visualize the genotype by environment interaction. The GGE bi plot graphic analyses of the thirty soybean genotypes tested across the six locations are presented in the figures below.

Ranking of Genotype

Stability can be identified using concentric circles and also ideal genotypes are at the center of the concentric circle. The ideal genotype is the one that with the highest mean performance and absolutely stable (Yan and Kang, 2003). The genotypes that are closer to the ideal genotypes are the best performing genotypes. Hence, the GGE bi plots shows that BaHa gudo is an ideal variety, with other varieties like Babile-1 and Babile-2 are desirable varieties as they are closer to the ideal variety on the bi plot. The varieties local and Werer-961 are the most undesirable varieties as they are too far to the ideal variety on the bi plot.



F*igure 3:* *Ranking of the varieties*

Ranking of Environment

The most representative of the locations (ability to represent the mega environment) and the most powerful to discriminate varieties (*Naroui* et al., 2013) reported that the ideal environment is the one located at the center of the concentric circles, and it is possible to identify desirable environments based on their closeness to the ideal environment (*Mahdieh* et al., 2016) reported that a testing location has less power to discriminate genotypes when located far away from the center of the concentric circle or to an ideal location. Therefore, Among the test locations, location Dabo Hana-2023 which fell into the center of concentric circles was an ideal test location in terms of being the most representative of the overall locations and the most powerful to discriminate the performance of the tested genotypes Next to the first concentric circle location, locations Bedele-2022 is close to the ideal location while, Gechi-2023 is detected as the weakest locations to discriminate varieties (Figure 4).

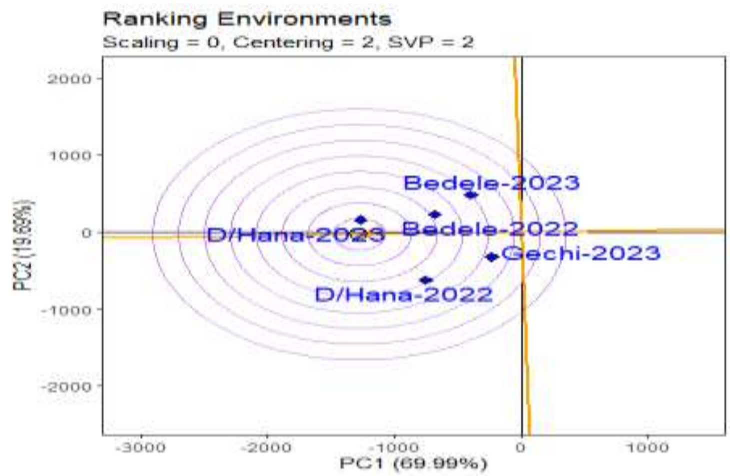


Figure 4: *Ranking of the varieties of six groundnut variteis acroos the locations*

Which-Won-Where Pattern

According to Yan et al., (2002), the polygon view of GGE bi plot indicates the best genotypes in each environment and group of environments. In this situation, the polygon is formed by connecting the genotypes that are farthest away from the bi plot origin, such that all the other genotypes are contained in the polygon. In this case, the polygon connects all the farthest genotypes and perpendicular lines divide the polygon into sectors. Sectors help to visualize the mega-environments. This means that winning genotypes for each sector are placed at the vertex. Polygon view of the groundnut varieties tested at three locations presented in (figure 5). The genotypes found at the vertex of the polygon perform best in the environments within the sector (Yan and Tinker, 2006). Accordingly, Babile-1, BaHa jidu, Werer-961 and local varieties were the vertex groundnut varieties. From this figure, Babile-1 variety best performer at Beadele-2022, Bedele-2023 and Dabo Hana 2023 in the first mega environment. In the second mega environment is Daba Hana-2022 and Gechi-2023, with winner variety BaHa jidu. From the figure, Werer-961 and local had no environment on the vertex. This indicates that varieties in the vertex without environment performed poorly in all the locations (Alake et al., 2012).

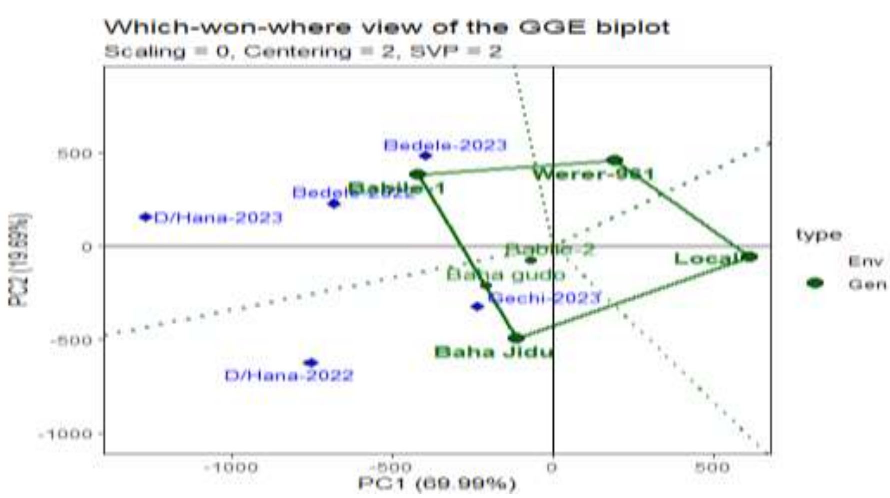


Figure 5: *Which Won Where pattern plot*

CONCLUSION AND RECOMMENDATION

The combined analysis of variance of total seed yield (kgha^{-1}) indicated that there was highly significant ($p < 0.01$) difference among genotypes, locations and genotype by location interaction. Most of the total sum of squares in total seed yield was explained by genotype (17.38%) than location and the interaction.

The presence of significant genotype by location interaction effect showed that some genotypes adapted to wider locations. The ANOVA from AMMI model showed that environment, genotype and genotype x environment interaction contributed 17.81, 17.38 and 17.05%, to total sum square of grain yield, respectively.

The results indicated the presence of genetic variability in the groundnuts varieties for most of agro morphology traits The significant differences among locations, the significant effects of G x L interactions on seed yield and other traits showed the differential response of varieties over locations and managements and the test locations were different each other.

Acknowledgments

The authors greatly acknowledged Oromia Agricultural Research Institute (IQQO) through the Bedele Agricultural Research Center for the financial support and Fdis Agricultural Research Center and Haramaya University are also highly acknowledged for providing the groundnut improved varieties also all research staffs for technical support.

REFERENCES

Bonchev B., Velcheva N. and Stamatov S. 2018. Assessment of productive potential of peanut varieties (Arachis hypogaea L.) from the Bulgarian breeding program and opportunities for genetical improvement. Int. J. Environ. Agric. Biotech., 3(5): 1700-1703

Delacy I.H., Basford K.E., Cooper M., Bull J.K. and Mclaren C.G. 1996. Analysis of multi-environment trail an historical perspective. In: Plant adaptation and crop improvement (Cooper M., Hammer G.L., eds). CAB International: Wallingford, UK. pp. 39-124

Gauch H.G. and Zobel R.W. 1988. Predictive and postdictive success of statistical analysis of yield trials. Theor. Appl. Genet., 76: 1-10.https://doi.org/10.1007/BF00288824

Gulluoglu L., Bakal H., Onat B., El Sabagh A. and Arioglu H. 2016. Characterization of peanut (Arachis hypogaea L.) seed oil and fatty acids composition under different growing season under Mediterranean environment. J. Exp. Biol. Agric. Sci., 4(5): 64-571. http://dx.doi.org/10.18006/2016.4(5S).564.571

Karimizadeh R., Mohammadi M., Sabaghni N., Mahmoodi A.A., Roustami B., Seyyedi F. and Akbari F. 2013. GGE Biplot Analysis of Yield Stability in Multi-environment Trials of Lentil Genotypes under Rainfed Condition. Not. Sci. Biol., 5(2): 256-262.

Kasno A. and Trustinah M. 2015. Genotype environment interaction analysis of peanut in Indonesia. SABRAO J. Breed. Genet., 47: 482–492

Purchase, H., 1997, September. Which aesthetic has the greatest effect on human understanding? In International Symposium on Graph Drawing (pp.248-261). Springer, Berlin, Heidelberg.

Samonte, S., Wilson, LT., McClung AM., and Medley JC. (2005). Targeting cultivars onto rice growing environments using AMMI and SREG GGE biplot analysis. Crop Sci. 45: 2414- 2424.

Yan, W. and Kang, M.S., 2002. GGE biplot analysis: A graphical tool for breeders, geneticists, and agronomists. CRC press.

Cite this Article: Firdisa, G; Tesiso, M; (2024). Performance Evaluation of Groundnut (*Arachis hypogea* L.) Varieties in Buno Bedele, South Western Oromia, Ethiopia**.** *Greener Journal of Agricultural Sciences*, 14(4): 203-210, https://doi.org/10.15580/gjas.2024.4.121924203.