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Genotype by Environment Interaction and Stability Analysis of Dolichos Lablab (*Lablab purpureus*) Genotypes for Forage Biomass and Seed Yields in Lowlands of East Hararghe Zone of Oromia, Ethiopia

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Abstract

Introducing lablab to mixed farming systems would improve feed supply, and could be a robust option for sustainable intensification. Thus, the study was conducted to evaluate and identify stable and high-yielding genotypes of Lablab purpureus for herbage dry matter yield, seed yield, nutritional quality, and disease and pests tolerant. Eleven lablab genotypes and one standard check (Gebi-17) were used in the experiment at each testing site. The genotypes were arranged in a randomized complete block design (RCBD) with three replications. The combined analysis of variance for herbage dry matter yield, plant height, seed yield over six locations showed highly significant ($p < 0.001$) variation due to genotypes by environment interaction. Accordingly, among the lablab genotypes tested, ILRI-14490 genotype performed well over other lablab genotypes in terms of mean herbage dry matter and seed yields across all locations. This genotype had dry matter and seed yield advantages of 14.3% and 20.22%, respectively, over the standard check (Gebi-17). It was also tolerant to diseases and pests in the study areas. The current study also stated that the crude protein content of the lablab genotypes obtained (25.41-33.3%) was found to be adequate and satisfactory. Hence, ILRI - 14490 was found to be the most stable across locations, high yielding and quality and disease-tolerant genotype. Therefore, based on its yield and stability genotype ILRI-14490 was promoted to Variety Verification Trial for possible release and registration of improved lablab variety.

Keywords: Crude protein, Genotypes, Herbage dry matter, Lablab purpureus, Seed yield, Stability

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1. Introduction

Sub-Saharan livestock production and productivity are very low; due to inadequate quantity and quality of feed available (Kindomihou Missiakô Valentin et al., 2014). In mixed crop-livestock systems, livestock feed supply is mainly

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dependent on crop residues, natural pastures, and other agricultural by-products. However, the quantity and quality of these available feed resources is declining from time to time as most of the available land is cultivated for crop production (Tolera et al., 2012). Ethiopia has a large livestock population and diverse agro-ecological zones suitable for livestock, and fodder production. However, livestock production has been characterized by very low reproductive and production performance due to primarily shortages of quality and quantity of animal feed (Malede, 2013). This might be due to land degradation, land shortage, and poor soil fertility (Tewodros et al., 2007) and due to rapidly increasing human population pressure, cropping is expanding and grazing areas are shrinking (Adugna, 2007). Crop residues are the dominant livestock feed resources in Ethiopia mainly under crop-livestock mixed production but they are characterized by high fiber and low crude protein contents.. The intake of these feeds is limited and they scarcely satisfy even the maintenance requirements of animals. Supplementation of crop residues with leguminous forage crops can improve protein deficiency as legumes contain medium to high levels (12-25%) of CP. Lablab is one of the forage legumes used for this purpose.

Lablab is a high-yielding forage legume that can be grazed, harvested for hay or silage, or used as a green manure and break crop in sub-tropical and tropical farming systems (Chakoma et al., 2016). It is commonly used as a supplementary feed (Tulu et al., 2018), for intercropping with cereal crops (Mpairwe et al., 2002) and is considered to have significant potential for the sustainable intensification of smallholder crop/livestock production systems (Ewanisha et al., 2007; Nord et al., 2020). The leaf has about 21 to 38% and the seed contains about 20 to 28% crude protein (Cook et al., 2005). It is tolerant to acid soil conditions (Mugwira and Haque, 1993) and to address soil fertility decline (Cook et al., 2020). *Lablab purpureus* is used as a nitrogen-fixing green manure to improve soil quality. It is a prolific root system remains in the soil after harvest and enriches the soil with organic carbon (Pasternak, 2022). It is not only produces nitrogen through fixation but returns nitrogen through leaf decay (FAO, 2012). Lablab is also used for the control of insect pests (Qureshi et al., 2016). It can continue to grow in drought conditions and grows in areas with an average annual rainfall regime of 650-3000 mm and altitude up to 2000 m a.s.l. (Maass et al., 2010). Lablab is considered to cope better with drought conditions compared to some of the more widely grown legumes such as common beans (*Phaseolus vulgaris* L.) or cowpeas (*Vigna unguiculata* L. Walp.) (Maass et al., 2010).

Promising results were obtained during the preliminary variety trial phase of lablab genotypes study. Thus, further study was crucial to evaluate and identify high yielder and disease-tolerant lablab genotypes. Therefore, the objective of the current study was to evaluate and identify stable and high-yielding genotypes of *Lablab purpureus* for herbage dry matter yield, seed yield, nutritional quality, and disease and pests tolerant for varietal development.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at Fedis and Babile districts of East Hararghe Zone of Oromia. They are situated at an altitude of 1050 to 2118 meters above sea level (Fuad et al., 2018). The amount of rainfall varies between 650 and 750 mm, while the average temperature of the districts ranges between 25 and 30°C (Zenna, 2016). The farming system of the districts is characterized by mixed crop-livestock farming. The major crops grown in the districts are maize, sorghum, groundnut, and *chat*. Important livestock species abundantly reared in the districts include cattle, shoat, camels, donkeys, and chickens.

2.2. Experimental Materials

Twelve lablab genotypes including standard check (ILRI 6529, ILRI 14490, ILRI 11609, ILRI 11630, ILRI 14489, ILRI 211422, ILRI 13702, ILRI 154364, ILRI 204648, ILRI 21060, ILRI 211424 and Gebis-17) were evaluated at Boko station and Erer sub-station in 2018/19, 2020, and 2020/21 main cropping seasons. The genotypes were collected from ILRI (International Livestock Research Institute). Lablab genotypes were evaluated for herbage yield, seed yield, and other agronomic parameters and their stability across environments.

2.3. Experimental Design

The genotypes were arranged in a randomized complete block design with three replications on a plot size of 2 m x 1.8 m. The space between rows and plants was 40 cm and 30 cm, respectively. The distance between the block and the plot was 1.5 m. NPS fertilizer was applied at a rate of 100 kg/ha and all other agronomic practices were applied equally to all plots as per the recommendation.

2.4. Data Collected

The data collected were days to 50% flowering, plant height (cm), fresh biomass yield (t/ha), dry matter yield (t/ha), days to first maturity, pod per plant, seed per pod, thousand seed weight, seed yield (qt/ha) and diseases incidence. The data for plant height was recorded from five randomly selected plants from each plot. The forage was harvested at 50% flowering stage from the two middle rows and a sample of 200 g of fresh biomass was taken and dried in an oven at 65 °C for 72 hours. Partially dried feed samples were ground to pass through a 1 mm sieve screen using Wiley mill and stored in plastic bags for chemical analysis. The partially dried and ground feed samples were filled in plastic bags and submitted to Holeta Agricultural Research Center and nutritional quality (DM%, TA%, CP%, NDF%, ADF%, ADL %) were analyzed.

The dry biomass yield (DM t/ha) was calculated using the following formula:

$$DM\ yield\ (t/ha) = TFW \times (DW_{ss} / HA \times FW_{ss}) \times 10\ ()$$

where

TFW = total fresh weight kg/plot, DW_{ss} = dry weight of subsample in grams, FW_{ss} = fresh weight of subsample in grams, HA = Harvest plot area in square meters, and 10 is a constant for conversion of yields in kg/m² to t/ha, t/ha = ton per hectare. Descriptions and sources of the materials used for this experiment are listed in Table 1 below.

| Table 1: Descriptions of Lablab Genotypes Used for the Experiment | | |
|---|-------------|--------|
| No. | Genotypes | Source |
| 1 | ILRI-6529 | ILRI |
| 2 | ILRI-14490 | ILRI |
| 3 | ILRI-11609 | ILRI |
| 4 | ILRI-11630 | ILRI |
| 5 | ILRI-14489 | ILRI |
| 6 | ILRI-211422 | ILRI |
| 7 | ILRI-13702 | ILRI |
| 8 | ILRI-154364 | ILRI |
| 9 | ILRI-204648 | ILRI |
| 10 | ILRI-21060 | ILRI |
| 11 | ILRI-211424 | ILRI |
| 12 | Gebis-17 | BARC |
| Note: ILRI = International Livestock Research Institute, BARC= Bako Agricultural Research Center | | |

2.5. Data Analysis

Data on agronomic performance, dry matter yield, seed yield, and chemical composition was analyzed using SAS software version 9.3. Means were separated using Tukey test at 5% level of significance.

3. Results and Discussion

3.1. Combined Analysis of Variance

Combined analysis of variance (ANOVA) showed significant ($p < 0.01$) variations for genotype and environment for herbage DM yield, plant height and, leaf to stem ratio (Table 2). The results of the genotype by environment (GxE) interaction were significantly ($p < 0.01$) affected dry matter yield, plant height, and seed yield, while the leaf-stem ratio showed non-significant results. These results illustrated the evidence for genetic variability among lablab genotypes and the diversity of locations.

Table 2: Combined ANOVA Result of Lablab Genotypes Over Locations and Years

| | Df | Mean Square | | | |
|---|-----|---------------------|----------------------|-----------------------|------------------------|
| | | DMY | Pht | SY | LSR |
| Rep | 2 | 44.86 ^{ns} | 1008.1 ^{ns} | 442083 ^{ns} | 0.009795 ^{ns} |
| Genotype (G) | 11 | 68.25 ^{**} | 1165.6 ^{**} | 458943. ^{**} | 0.004828 ^{**} |
| Environment (E) | 5 | 19.69 ^{**} | 452.22 ^{**} | 25573.6 ^{**} | 0.009395 ^{**} |
| Year (Y) | 2 | 7.65 ^{ns} | 1327.2 [*] | 5751 ^{ns} | 0.022267 ^{**} |
| G x Loc | 55 | 3.42 ^{**} | 5417.0 ^{**} | 32325 ^{**} | 0.000539 ^{ns} |
| G x Y | 22 | 2.27 ^{ns} | 185.3 ^{ns} | 17710. ^{ns} | 0.000712 ^{ns} |
| Residual | 142 | 2.736 | 226.6 | 22140 | 0.001233 |
| Note: df = degree of freedom, DMY= dry matter yield, Pht= Plant height, LSR= leaf to stem ratio, SY = seed yield, ** = highly significant and * = Significant, ns = non-significant, Loc=Locations | | | | | |

3.2. Herbage Dry Matter Yields Performance

Significant differences ($p < 0.05$) were observed among genotypes in the mean herbage dry matter yields across years and locations (Table 3). The genotypes ILRI-14490 and ILRI-6529 were produced significantly higher ($p < 0.01$) mean herbage

Table 3: The Mean Herbage Dm Yield (T/Ha) and Plant Height (cm) of Lablab (*Lablab purpureus*) Genotypes and Standard Check Across Locations

| Genotypes | DMY | | Mean DMY | Pht | | Mean Pht |
|-------------|---------------------|--------------------|---------------------|----------------------|----------------------|----------------------|
| | Fedis | Erer | | Fedis | Erer | |
| ILRI-6529 | 13.24 ^{ab} | 12.14 ^a | 12.69 ^a | 144.47 ^b | 134.6 ^b | 139.54 ^{ab} |
| ILRI-14490 | 13.89 ^a | 12.35 ^a | 13.22 ^a | 144.2 ^b | 123.9 ^c | 134.05 ^{ab} |
| ILRI-11609 | 10.72 ^{bc} | 8.12 ^{bc} | 9.42 ^b | 141.43 ^b | 122.23 ^c | 131.83 ^b |
| ILRI-11630 | 8.96 ^c | 8.05 ^c | 8.50 ^c | 143.3 ^b | 127.43 ^{bc} | 135.38 ^{ab} |
| ILRI-14489 | 7.75 ^{cd} | 8.67 ^{bc} | 8.21 ^c | 149.7 ^{ab} | 128.03 ^{bc} | 138.87 ^{ab} |
| ILRI-211422 | 6.45 ^d | 8.04 ^c | 7.25 ^d | 164.0 ^a | 125.0 ^c | 144.48 ^a |
| ILRI-13702 | 13.06 ^{ab} | 10.53 ^b | 11.80 ^a | 141.67 ^b | 126.2 ^{bc} | 133.93 ^{ab} |
| ILRI-154364 | 10.34 ^{bc} | 7.84 ^c | 9.09 ^{cd} | 155.57 ^{ab} | 125.17 ^c | 140.37 ^{ab} |
| ILRI-204648 | 7.78 ^{cd} | 8.23 ^{bc} | 8.01 ^{cd} | 149.4 ^{ab} | 134.13 ^b | 141.77 ^{ab} |
| ILRI-21060 | 9.48 ^{bc} | 8.09 ^c | 8.84 ^{cd} | 154.4 ^{ab} | 142.93 ^a | 148.67 ^a |
| ILRI-211424 | 10.37 ^{bc} | 7.93 ^c | 9.15 ^{cd} | 151.57 ^{ab} | 126.8 ^{bc} | 139.18 ^{ab} |
| Gebis-17 | 12.48 ^b | 10.18 ^b | 11.33 ^{ab} | 142.33 ^b | 121.23 ^c | 131.78 ^{ab} |
| CV (%) | 19.6 | 13.2 | 18.7 | 12.0 | 18.1 | 14.9 |
| P-value | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 | 0.002 |

Note: DMY=dry matter yield, ha=hectare, t=ton, Pht= plant height

dry matter yields of 13.22 and 12.69 t/ha and had higher herbage DM yield advantages (14.3% and 10.71%), respectively, over the standard check Gebis-17 (11.33 t/ha).

The herbage dry matter yield obtained in the current study was comparable to the findings of Mihailovic *et al.* (2016), who reported values ranging from (1.8–12.9 DM t/ha and higher than those found by Mekonnen *et al.* (2018), who reported values ranging from 9.32–11.86 t/ha in East Wollega and Wubshet *et al.* (2021) who recorded values ranging 8.25 and 12.62 t/ha at Harari region and Dire Dawa, respectively. The present study also obtained a notably higher result than Melkam *et al.* (2022), who found values ranging from 6.0 to 10.5 t/ha.

3.3. Plant Height

The combined ANOVA revealed significant ($p < 0.01$) variation among genotypes for plant height across locations (Table 4). In the present study, the tallest and the shortest plant height (148.67 cm and 131.78 cm) were recorded for genotypes ILRI-21060 and lablab variety (Gebis-17) respectively (Table 4). This result is considerably higher than the reports of Salah (2015) who found that the plant height of lablab varied from 38.0 to 86.3 cm with a mean value of 63.81 cm. However, almost it is similar to Melkam *et al.* (2022) who observed 144.3 to 191.7 cm with a mean value of 179.7 cm.

Table 4: The Mean Leaf to Stem Ratio (LSR) and Days to 50% Flowering of Lablab (*Lablab purpureus*) Genotypes and Standard Check Across Locations

| Genotypes | LSR | | Mean LSR | DFF | | Mean |
|-------------|-------|------|----------|---------------------|---------------------|--------|
| | Fedis | Erer | | Fedis | Erer | |
| ILRI-6529 | 1.35 | 1.33 | 1.34 | 115.0 ^a | 125.0 ^a | 120 |
| ILRI-14490 | 1.34 | 1.36 | 1.35 | 115.0 ^a | 125.0 ^a | 120 |
| ILRI-11609 | 1.31 | 1.29 | 1.30 | 115.0 ^a | 125.0 ^a | 120 |
| ILRI-11630 | 1.32 | 1.29 | 1.31 | 115.0 ^a | 125.0 ^a | 120 |
| ILRI-14489 | 1.28 | 1.28 | 1.28 | 102.0 ^b | 115.0 ^c | 108.5 |
| ILRI-211422 | 1.33 | 1.27 | 1.30 | 106.3 ^{ab} | 125.0 ^a | 115.65 |
| ILRI-13702 | 1.32 | 1.29 | 1.31 | 113.3 ^a | 121.7 ^{ab} | 117.5 |
| ILRI-154364 | 1.27 | 1.29 | 1.28 | 110.7 ^{ab} | 125.0 ^a | 117.85 |
| ILRI-204648 | 1.30 | 1.28 | 1.29 | 106.3 ^{ab} | 117.3 ^{bc} | 111.8 |
| ILRI-21060 | 1.32 | 1.30 | 1.31 | 110.7 ^{ab} | 125.0 ^a | 117.85 |
| ILRI-211424 | 1.29 | 1.31 | 1.30 | 110.7 ^{ab} | 118.3 ^{bc} | 114.5 |
| Gebis-17 | 1.31 | 1.33 | 1.32 | 115.0 ^a | 125.0 ^a | 120 |
| CV (%) | 3.2 | 3.0 | 2.7 | 4.3 | 2.4 | |
| P-value | Ns | Ns | Ns | 0.03 | 0.001 | |

Note: LSR = Leaf to stem ratio, Ns = non-significant, DFF = days to 50% flowering

3.4. Leaf to Stem Ratio and Days to 50% Flowering

The mean values of leaf to stem ratio (LSR) of the current study ranged from 1.28 to 1.35 which is in line with and within the range values of 1.2 to 1.7 reported by Melkam *et al.* (2022) and 0.76–2.55 reported by Murphy and Colucci (1999). ANOVA result showed that days to 50% flowering were significant ($p < 0.05$) among lablab genotypes. The days to 50% flowering of the current study were ranged from 115 to 125 days. The result of the current study is in agreement with KC *et al.* (2016) who reported that lablab genotypes took 81 to 130 days for 50% flowering and Melkam *et al.* (2022) reported that lablab genotypes took 102.9 to 119.3 days for 50% flowering, whereas, Kankwatsa (2018) reported shorter number of days to 50% flowering (52 to 69).

3.5. Days to Physiological Maturity and Seed Yield

The combined ANOVA results showed that there was no significant difference ($P>0.05$) in days to physiological maturity among lablab genotypes. The mean days to physiological maturity of the current study ranged from 171.4 to 179.2 days (Table 5). Melkam *et al.* (2022) reported that non-significant results for days to physiological maturity among lablab genotypes which is in agreement with the results of the current study. However, a significant difference ($p<0.05$) was observed for seed yield among lablab genotypes tested in the current study (Table 5). The combined mean seed yield over six locations ranged from 826 to 1325 kg/ha with a ground mean of 968.72 kg/ha. The present findings revealed that ILRI-14490 produced a higher seed yield (1324.7 kg/ha) and had yield advantages of 20.22% over the standard check (Gebis-17) (1057.5 qt/ha) (Table 5). The result of seed yield in the present study was in agreement with Adebisi *et al.* [21] who reported 450–1500 kg/ha seed yield in Netherlands. On the other hand, in comparing with the present study, a lower value ranged from 777.3 to 1080 kg/ha was reported by Melkam *et al.* (2022).

Table 5: The Mean Days To Physiological Maturity and Seed Yield (Kg/Ha) of Lablab (*Lablab purpureus*) Genotypes and Standard Check Across Locations

| Genotypes | DFM | | Over all Mean of DFM | Seed Yield | | Grand Mean of SY |
|-------------|-------|-------|----------------------|------------|---------------------|----------------------|
| | Fedis | Erer | | Fedis | Erer | |
| ILRI-6529 | 177.3 | 176.7 | 177 | 1272.1ab | 11.19 ^{ab} | 1195.5 ^{ab} |
| ILRI-14490 | 175.0 | 171.7 | 173.4 | 1386.9a | 12.62 ^a | 1324.7 ^a |
| ILRI-11609 | 176.7 | 177.7 | 177.2 | 921.1cd | 9.77 ^b | 949.3 ^{cd} |
| ILRI-11630 | 179.3 | 175.0 | 177.2 | 857.8cd | 7.94 ^{bc} | 825.9 ^d |
| ILRI-14489 | 173.3 | 175.0 | 174.7 | 701.3d | 9.76 ^b | 838.6 ^d |
| ILRI-211422 | 178.3 | 171.7 | 175 | 869.9cd | 8.61 ^{bc} | 865.7 ^d |
| ILRI-13702 | 175.0 | 171.7 | 173.4 | 1091.6bc | 10.20 ^{ab} | 1055.6 ^{bc} |
| ILRI-154364 | 173.3 | 177.3 | 175.3 | 918.3cd | 9.65 ^b | 941.9 ^{cd} |
| ILRI-204648 | 176.3 | 177.3 | 176.8 | 888.5cd | 8.43 ^{bc} | 865.7 ^d |
| ILRI-21060 | 172.7 | 170.0 | 171.4 | 857.8d | 9.28 ^b | 854.4 ^d |
| ILRI-211424 | 181.0 | 177.3 | 179.2 | 926.8cd | 7.67 ^c | 849.7 ^d |
| Gebis-17 | 178.3 | 176.7 | 177.5 | 1084.8bc | 10.30 ^{ab} | 1057.5 ^{bc} |
| CV (%) | 3.3 | 3.1 | 3.2 | 15.9 | 15.6 | 16.4 |
| P-value | Ns | Ns | Ns | 0.001 | 0.001 | 0.001 |

Note: SY= seed yield, Kg = Kilogram, DFM = days to first maturity.

3.6. Nutritional Quality Analysis

The mean value of nutritional composition of lablab genotypes is presented in (Table 6). The crude protein (CP), ash, Neutral detergent fiber (NDF), Acid detergent fiber (ADF), and Acid detergent lignin (ADL) were significantly ($P<0.05$) different among the lablab genotypes. The CP value of the current study ranges from 25.41-33.3% which is in agreement with the study of Cook *et al.* (2005) who obtained CP yield ranges from 21-38% for lablab leaf, Hector and Jody (Hector and Jody, 2002) also reported that the CP content of lablab forage within a range of 15–30% which is in agreement with the current study. On the other hand, a lower range value of 21.3 to 25.9% was reported by Melkam *et al.* (2022). The crude protein values observed in this study could satisfactorily supply the crude protein acquirement of ruminant animals. Therefore, the tested lablab genotypes had high CP values which can supplement low-quality roughages that couldn't attain the CP requirement of ruminant livestock like natural pasture and crop residues with very low CP values

Table 6: Mean Nutritive Values of Lablab (*Lablab purpureus*) Genotypes and Standard Check Across Locations

| Genotypes | Ash% | CP% | NDF% | ADF% | ADL% |
|---|---------------------|-----------------------|---------------------|----------------------|--------------------|
| ILRI-6529 | 13.62 ^b | 25.41 ^f | 40.41 ^{ef} | 29.23 ^a | 6.15 ^{cd} |
| ILRI-14490 | 12.89 ^c | 30.44 ^{bcde} | 44.63 ^b | 28.15 ^{ab} | 9.58 ^b |
| ILRI-11609 | 13.70 ^b | 32.46 ^{abc} | 42.71 ^{cd} | 25.46 ^{de} | 6.53 ^{cd} |
| ILRI-11630 | 13.13 ^{bc} | 32.89 ^{ab} | 43.69 ^{bc} | 27.51 ^{bc} | 11.73 ^a |
| ILRI-14489 | 13.78 ^b | 29.66 ^{de} | 46.52 ^a | 26.79 ^{bcd} | 6.57 ^{cd} |
| ILRI-211422 | 13.79 ^b | 32.84 ^{ab} | 38.93 ^{fg} | 27.65 ^b | 3.29 ^f |
| ILRI-13702 | 13.37 ^{bc} | 33.30 ^a | 41.29 ^{de} | 24.09 ^e | 6.72 ^{cd} |
| ILRI-154364 | 14.85 ^a | 29.30 ^e | 45.07 ^{ab} | 26.82 ^{bcd} | 9.58 ^b |
| ILRI-204648 | 12.82 ^c | 31.64 ^{abcd} | 41.59 ^{de} | 27.56 ^b | 5.67 ^{de} |
| ILRI-21060 | 13.16 ^{bc} | 30.85 ^{bcde} | 38.53 ^g | 26.01 ^{cd} | 7.30 ^c |
| ILRI-211424 | 13.40 ^{bc} | 29.64 ^{de} | 35.62 ^h | 24.40 ^e | 4.23 ^{ef} |
| Gebis-17 | 14.46 ^a | 31.83 ^{abc} | 36.35 ^h | 22.40 ^f | 5.29 ^{de} |
| G. Mean | 13.58 | 30.86 | 41.78 | 26.34 | 6.89 |
| CV (%) | 1.7 | 2.4 | 1.5 | 1.9 | 7.8 |
| P-value | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Note: DM = dry matter, CP = crude protein, NDF = Neutral detergent fiber, ADF= Acid detergent fiber, ADL = Acid detergent lignin, IDMD= in-vitro dry matter digestibility, DOMD = digestible organic matter digestibility, ME = metabolizable energy | | | | | |

(Abebe *et al.*, 2015). The ash content, NDF, and ADL value of the current study are in agreement with the study reported by Melkam *et al.* (2022). The ADF value of the current study is higher than the study of Melkam *et al.* (2022) which reported in the ranges of 33-36%.

3.7. Reaction to Major Diseases

Bacterial blight, AL Spot, and Ascochy B are economically important diseases for herbaceous legumes like lablab (*Lablab purpureus*) production. Fortunately, the tested lablab genotypes including the standard check (Gebis-17) were not affected by these diseases throughout the study periods.

3.8. Stability Analysis

3.8.1. AMMI Analysis

AMMI analysis illustrates the stability, adaptability and high yielding of lablab genotypes to the testing environments (Table 8). It has been reported that IPCA scores of genotypes in AMMI analysis are an indication of the stability and adaptation over environments (Alberts, 2004).

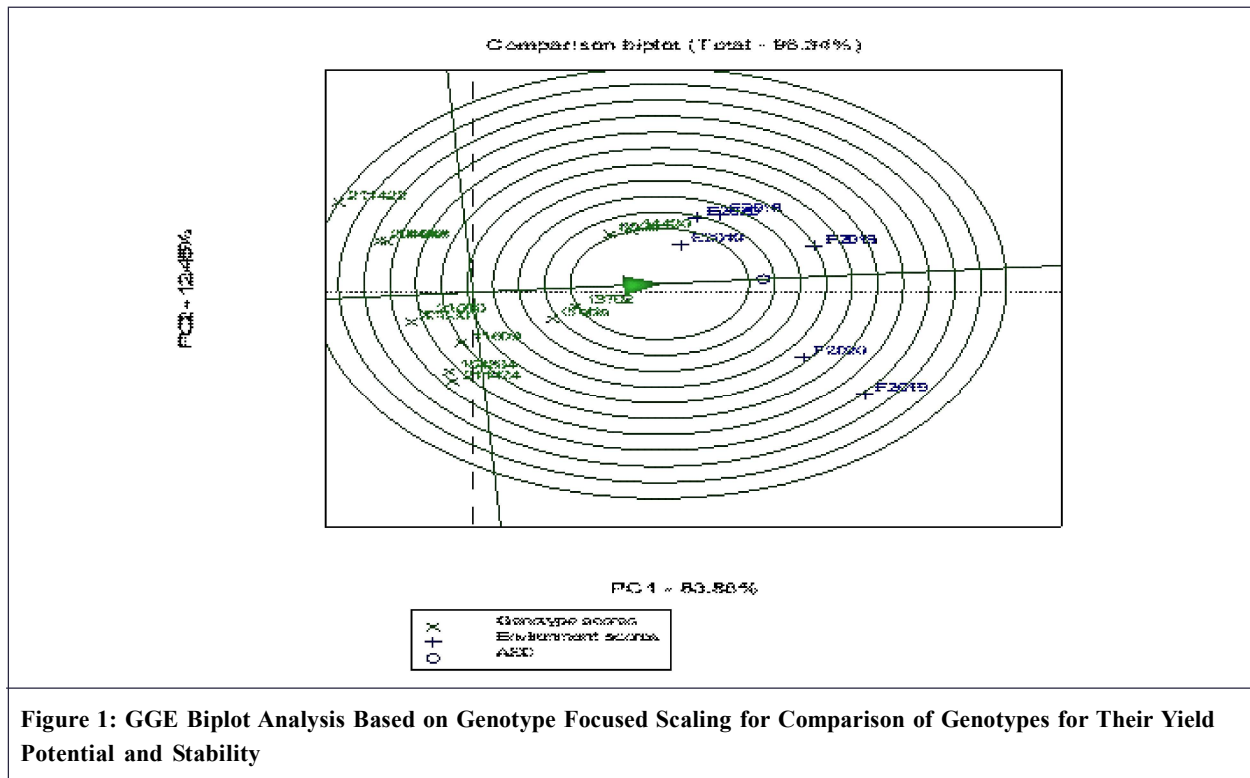
The lower or negative the IPCA scores; the more specific adapted is a genotype to certain environments. ILRI-11630, ILRI-14490 and ILRI-6529 genotypes had relatively lower IPCA value (Table 8). Based on the IPCA score ILRI-11630, ILRI-14490 and ILRI-6529 genotypes were relatively more stable genotypes in comparison to the other lablab genotypes. However, ILRI-14490 performed higher yielding than ILRI-11630 and ILRI-6529, and the other lablab genotypes including standard check (Table 8). This showed that ILRI-14490 genotype gave high herbage dry matter yield and stability than other lablab genotypes evaluated.

| Table 7: ANOVA for Herbage Dry Matter Yield of Lablab Genotypes for the Ammi Model Across Environments | | | |
|--|-----|------------|-------------|
| Source of variation | Df | Sum Square | Mean Square |
| Total | 215 | 1515.5 | 7.05 |
| Environments | 5 | 98.5 | 19.69 |
| Genotypes | 11 | 750.8 | 68.25** |
| Block | 12 | 108.7 | 9.06** |
| Interactions | 55 | 188.0 | 3.42 |
| IPCA 1 | 15 | 142.0 | 9.47** |
| IPCA 2 | 13 | 23.2 | 1.78 |
| Residuals | 27 | 22.8 | 0.84 |
| Error | 132 | 369.6 | 2.80 |
| Note: ** = highly significant, * = significant, Df = degree of freedom. | | | |

| Table 8: Estimate of AMMI Stability Value Across Environments | | | | | |
|---|--------|----------|----------|----------|---------|
| Genotypes | Mean | IPCA1 | IPCA2 | ASV | Ranking |
| 6529 | 12.689 | -0.15167 | 0.38088 | 0.534667 | 3 |
| 14490 | 13.116 | -0.08317 | 0.09562 | 0.226895 | 2 |
| 11609 | 9.418 | 0.54774 | -1.12579 | 1.76174 | 7 |
| 11630 | 9.418 | 0.07876 | 0.00099 | 0.194855 | 1 |
| 14489 | 8.209 | -0.97363 | -0.17778 | 2.415315 | 10 |
| 211422 | 7.244 | -1.54017 | 0.41966 | 3.833425 | 12 |
| 13702 | 11.795 | 0.57399 | -0.10620 | 1.424018 | 5 |
| 154364 | 9.089 | 0.84599 | 0.40907 | 2.132583 | 8 |
| 204648 | 8.006 | -0.93798 | -0.14080 | 2.324833 | 9 |
| 21060 | 8.789 | 0.07253 | -0.58079 | 0.607878 | 4 |
| 211424 | 9.149 | 0.96467 | 0.78228 | 2.511534 | 11 |
| Gebis-17 | 11.327 | 0.60294 | 0.04288 | 1.492291 | 6 |
| Note: ASV= AMMI stability value. | | | | | |

3.9. The GGE Biplot Analysis

Stability analysis for twelve (12) lablab genotypes tested for three years at two locations were studied based on the methods of Eberhart and Russel (1966). Fig. 1 shows GGE of genotypes for average yield and stability performance across environments. Hence, analysis using the GGE biplot confirmed that ILRI-14490 had highest mean herbage dry matter yield and the performance of this genotype was highly stable (Figure 1). Therefore, genotype ILRI-14490 is most desirable than other genotypes including standard check. This implies that it has good stability and adaptability compared to the remaining genotypes studied under these environments. Yan *et al.* (2003) reported that the polygon view of GGE biplot is the best way for the identification of winning genotypes by visualizing the interaction patterns between genotypes and environments (Abubeker Hassen *et al.*, 2003).



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