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Research Article

Evaluation of Yield Performance and Stability of Vetch in Highland of Southern Oromia

Teshale Jabessa*, Ketema Bekele, Getachew Tesfaye

Oromia Agricultural Research Institute Bore Agricultural Research Center, Bore, Ethiopia

Abstract

Vicia sativa L. (common vetch) is an annual legume species of high ecological importance which is characterized by high nutritive value and has ability to adapt to various edaphic-climatic conditions. The study was conducted to evaluate the performance of Vetch genotypes across various locations of Guji high land areas. Twelve genotypes of common vetch including standard check using randomized complete block designs (RCBD) with three replications were used. A 3x2 plot size were used in 2021-2022 cropping season across three locations (Anno, Sorra and Songo). The genotypes revealed highly significant ($P < 0.05$) difference for all parameters except non-significant ($P > 0.05$) for leaf to steam ratio. The highest and lowest dry mater yield recorded were 6.83 t/ha from standard check Gabisa and 3.99 t/ha from G-5207 respectively. There was no yield advantage obtained from the tested genotypes tested across all environments. Genotypes and genotypes environmental biplot analysis explained that Gabisa variety used as standard check was the most high-yielding and stable. Therefore, Gabisa variety was selected until another variety was released for the study area.

Keywords

Bore, Dry Matter, Environment, Stability, Vetch

1. Introduction

Vicia sativa L. (common vetch) is a self-pollinating, annual legume species of high economic and ecological importance [1]. It is mainly used for animal feed as forage in different items [2] as well as grain legume [3]. Moreover, it is used as a cover crop and green manure [4] and its ability to fix nitrogen as well as to restrict the incidence of crop diseases in the rotation systems [5], makes it an important crop for sustainable agriculture. Its main advantage compared with other legumes is its ability to grow in various pedoclimatic conditions, even in harsh ones such as dry [6] and cold environments [7]. Furthermore, common vetch is suitable for both conventional and organic production systems [8]. It is well documented that the performance of cultivars/genotypes is highly affected by environmental factors (temperature, participation), the variation of which depends on regions and years. The way that different genotypes respond to environmental variation is referred to as genotype x environment (GXE) interaction [9] and it is a very important factor in the release of stable, well-adapted, and high-yield cultivars. Highly significant GXE interaction has been recorded for various agronomic traits of common vetch such as dry matter yield and yield components, seed yield, shattering rate [10].

However, the productivity of the forage is far below the potential due to limited varietal options and several biophys-

*Corresponding author: teshalejabessa@gmail.com (Teshale Jabessa)

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ical and socio-economic constraints. Hence, developing forage crop varieties resistant to major biotic and abiotic stress, and improving adaptation to changing environments and in different agro ecologies are among the best strategies for provoking those production constraints. Therefore, the present study was initiated to estimate the magnitude of genotype, environment and genotype by environment interaction for forage yield and yield components of Vetch yield stability across different environments.

2. Materials and Methods

2.1. Description of the Study Locations

The experiment was conducted at three locations for two consecutive years (Songo Baricha on station, Anno Qerensa and Raya Boda) on farm and the tested locations represents highland parts of the study area.

2.2. Treatments and Experimental Design

Genetic materials comprised 12 vetch genotypes including standard check (Gabisa) were evaluated at 6 locations over two consecutive years (2021-2022). Randomize complete block (RCBD) with three replications was used across all locations. Each genotype was sown in 6 rows; 2 m length with 1.8 m width and 30 cm inter-row spacing. Seed rates of 20 kg ha^{-1} and combination of fertilizer rate of 100 Kg ha^{-1} nitrogen, phosphorus and sulfur were applied at the time of planting.

2.3. Sources of Planting Materials

The planting materials used for this study were obtained from the international livestock research institute (ILRI and the standard check (*Gabisa*), evaluated in the presented study were selected from previously adapted to the environment based on their herbage yield performance and other agronomic traits.

2.4. Methods of Data Collections

Agronomic data like date of 50% flowering, days to maturity, Leaf to stem ratio, plant height, and dry matter yield tone per hectare and, seed yield qt/ha was carefully collected. Forage sampling was collected at the 50% flowering stage and seed sampling was conducted at the maturity stage of the plants. In all plots, sampling was done from the middle four rows excluding the guard rows.

2.5. Biomass Yield Determination

Herbage yield was harvested 10 cm above the ground and weighed in the field using a sensitive balance. Fresh sub-samples will be taken from each plot separately, weighed, and chopped into pieces (2-5 cm) for dry matter determination. The weighed fresh sub-samples (FWss) were oven-dried at 60 ℃ for 72 hours and re-weighed (DWss) to estimate dry matter yield [11].

The dry matter yield (t/ha) = (10 x TotFW x DWss / HA x FWss))

Where: TFW = total fresh weight from the plot in kg,
DWss = dry weight of the sample in grams,
FWss = fresh weight of the sample in grams,
HA = Harvest area in meter square and,
10 is a constant for the conversion of yields in kg m^2 to tone/ha.

2.6. Methods of Data Analysis

The pooled analysis was performed by using Genstat 18th edition [12] was used to draw AMMI and GGE bi-plots.

3. Results and Discussions

3.1. Combined Agronomic Yield and Yield Component Data over Year and Locations

Combined analysis of variance for measured agronomic traits of *Vecia villosa* genotypes tested over environments is presented in (Table 1). The genotypes revealed highly significant ($P < 0.05$) difference for days to flowering, days to maturity, plant height, dry matter yield tone per hectare and, seed yield across the tested environments, except showed non-significant ($P > 0.05$) (Table 1) deference for leaf to steam ratio. The shortest number of days flowering was obtained from Gabisa standard check (101.3 days) whereas; G-5227 (113.8 days) took longer number of days. The shortest number of day's physiological maturity of genotype G-5269 (195.3 days) whereas, standard check Gabisa variety (173.8 days) took longer number of days. This might be due to the influence of the environment during forage crop physiological growth and development. The longest plant height was obtained from G-5269 (153.5 cm) and the shortest plant height was obtained from G-5207 (104.4 cm). Mean dry matter yield tone/hectare of the tested genotypes across different environment was ranged from 6.83 to 3.99 tone/ha-1. The highest and lowest dry mater yield recorded were 6.83 t/ha from standard check Gabisa and 3.99 t/ha from G- 5207 respectively. There was no yield advantage obtained from the tested genotypes over all tested environment. The highest seed yield was obtained from Gabisa (16.4 qt/ha) and the small seed yield was obtained from G-5269 (1.59 qt/ha).

Table 1. *Mean dry matter yield, agronomic traits for Lablab genotypes at 6 locations (Songo Baricha on station, Anno Qerensa and Raya Boda) over two years 2021 and 2022.*

Genotypes	DF	DM	LSR	PH (cm)	DMY t/ha	SY qt/ha	% DMY t/ha adv.
5252	115.8a	192.3ab	0.65	128b	5.56b	5.11ef	-
5186	101.3e	172.3d	0.79	118.2bc	5.54b	13.9b	-
5158	110.3bc	181.3bcd	0.91	130.5b	5.12bc	11c	-
5219	107.6cd	187abc	0.69	123.2b	4.84bcd	2.51g	-
5763	104.9de	181.2bcd	0.62	120.1bc	4.82bcd	8.12d	-
Gabisa	101.3e	173.8d	0.82	131b	6.83a	16.4a	
5157	110.6bc	182.3bcd	0.85	122.2	4.75bcd	10.7c	-
8521	108.6cd	176.8cd	0.77	152.4a	4.69bcd	2.08g	-
5127	113.8ab	188abc	0.77	127.3b	4.49bcd	6.02de	-
5208	114.9a	190.7ab	0.88	127.6b	4.41cd	6.57de	-
5269	116.3a	195.3a	0.86	153.5a	4.32cd	1.59g	-
5207	117.1a	192.3ab	0.57	104.4c	3.99d	3.41fg	-
Mean	110.20	184.5	0.759	128.2	4.94	7.29	
C.V	5.6	9.3	45.8	18.2	28.8	2.06	
LSD	4.071	11.27	0.2284	15.33	0.94	43.1	
SL	*	*	NS	*	*	*	

Means across a column within the same category having different superscripts differ (P<0.05); DF= days to flowering; Days to maturity; LSR= leaf to steam ratio; PH= plant height; SY; seed yield DMt/ha=dry matter yield tone per hectare; LSD=Least Significance difference; CV=coefficient of variations; SL= significant level.

3.2. AMMI Bi-plot Stability Analysis of Dry Matter Yield

The GGE bi-plot has been used in crop genotypes trials to effectively identify the best performing genotypes across environments, identify the best genotypes for specific environments delineation, whereby specific genotypes can be recommended to specific environments and can be used to evaluate the yield and stability of genotypes [13]. G-5219, G-5269 and G-5157 had broad adaptability across the environments as they were located closer to the center of the bi-plot. This mean genotypes; with small value of IPCA1 have consistent responses to the changing environment. Environment; Anna Sorra was considered highly discriminating for the tested materials since they had longer vectors (Potential environments).

3.3. GGE bi-plot Analysis

The genotypes located at the vertex of the polygon performed best-performance in the mega-environments (MGE). [14, 15] reported the polygon view of GGE bi-plot as the best way for identification of winning genotypes with visualizing the interaction patterns between genotypes and environments. As we can see in Figure 2, the single-arrowed line, “Average Environment Coordination” (“AEC”) abscissa, points to a higher mean yield across environments. Thus, across that averaged environment Genotypes G- 5158, Gabisa variety and G-5252 was the vertex (winning genotypes) in the sector where environments located in the MGE sector. The double-arrowed line, the “AEC” ordinate that points to greater variability (poorer stability) in either direction, indicated that G-8521 followed by G-5252 was highly unstable whereas G-5219 and G- 5157 were highly stable. The genotype that is near to the “ideal” for biomass production according to [13] ‘Gabisa’ variety used as standard check, which showed both high yield and stability.

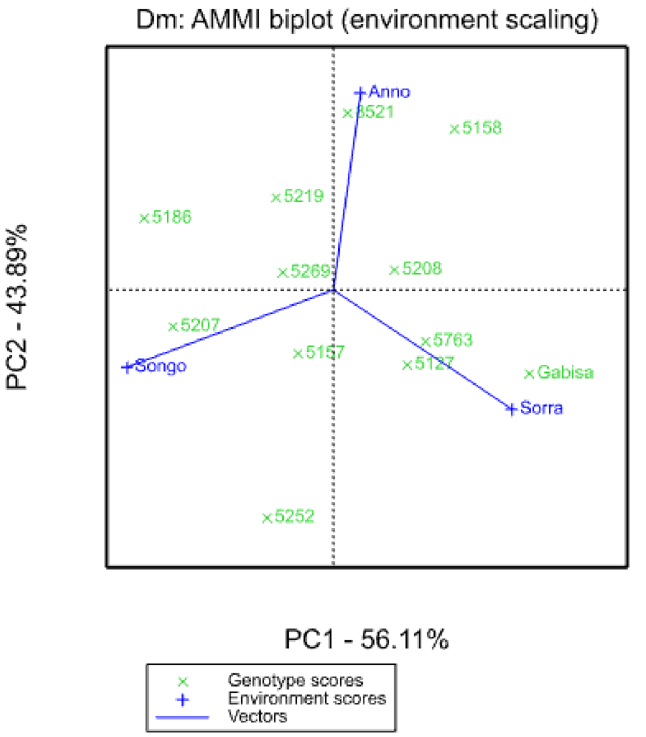

Figure 1. AMMI bi-plot for IPCA 1 against IPCA 2 scores for 12 genotypes and six environments.

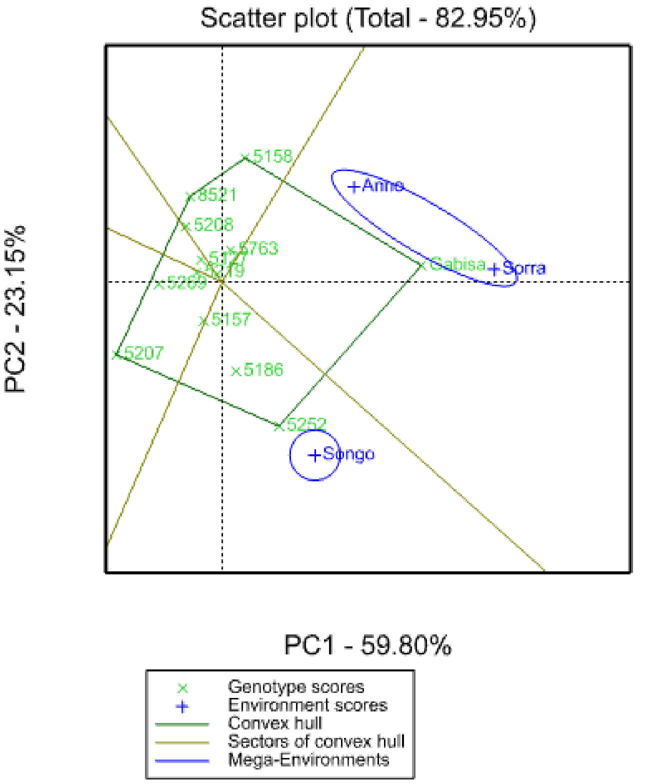

Figure 2. The GGE-bi-plot for which -won -where pattern for genotypes and environments.

3.4. Evaluation of Genotypes

Gabisa standard check variety which fell into the center of concentric circle was the ideal genotype in terms of higher dry matter yielding ability and stable. In addition, G-5252 and G-5183 located on the next consecutive concentric circle might be regarded as desirable genotype. Genotypes those very distant from the first concentric and the second circle were undesirable genotypes compared to other genotypes. Similar results were reported by different authors [16, 17] for other crops.

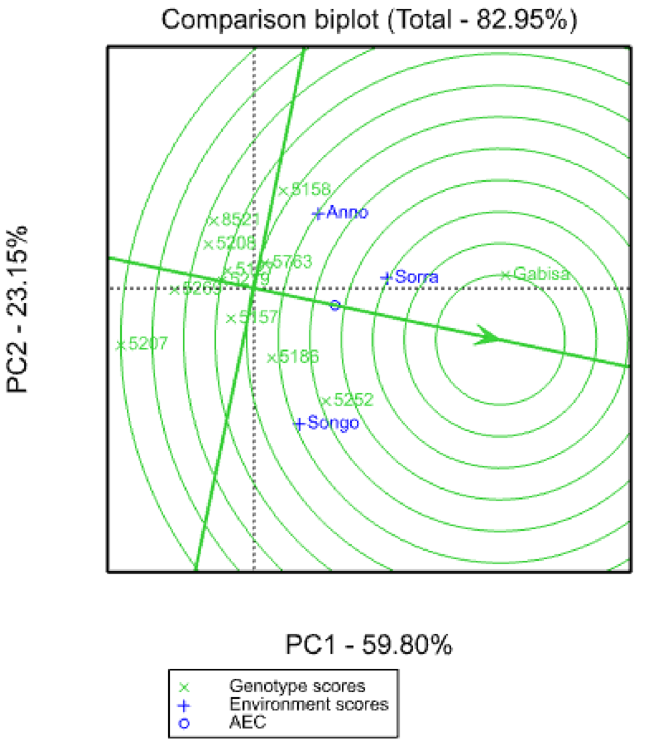

Figure 3. GGE-bi-plot based on genotype focused scaling for comparison of the genotypes.

3.5. Mean Performance and Stability of Genotypes

A genotype which has shorter absolute length of projection in either of the two directions of AEC ordinate (located closer to AEC), represents a less tendency of G x E interaction, which means it is the most stable genotype across all environments. The mean performance and stability of these Gabisa variety and G-5765 were high yielding and stable genotypes.

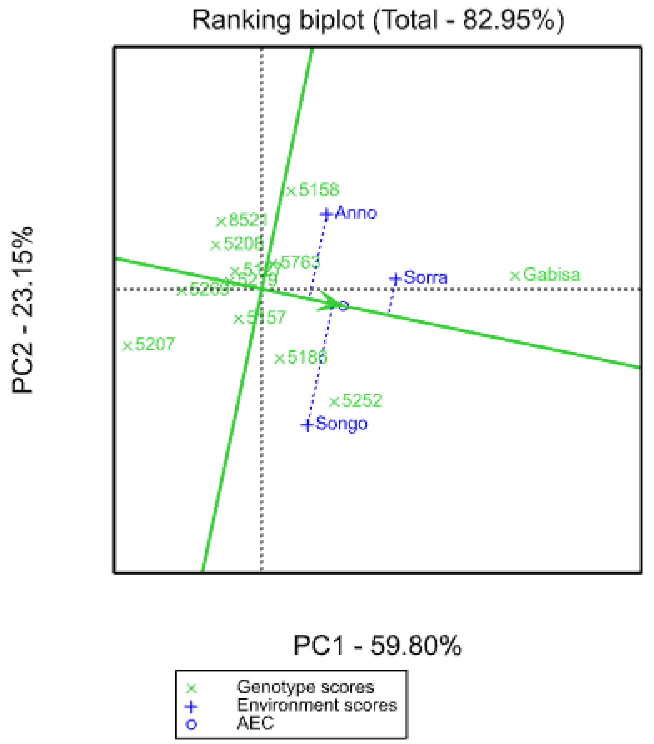

Figure 4. GGE ranking bi-plot shows means performance vs stability.

4. Conclusion and Recommendation

Combined analysis of variance indicated that dry matter yield performances of the tested vetch genotypes were showed significant differences among each other. This indicated that particular genotypes do not exhibit uniform performance under different environmental conditions or different genotypes may respond differently to a specific environment. Based on the results, it can be concluded that the environment and genotype can affect yield and yield components of vetch genotypes. Therefore, compared to other tested genotypes tested Gabisa variety used as standard check was still showed high dry matter yielder and found stable performance.

Abbreviations

DMY	Dry Matter Yield
LSR	Leaf to Stem Ratio
DM	Day to Maturity

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Conflicts of Interest

The authors declare no conflicts of interest.

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