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Research Article

The Andean Red Common Bean (*Phaseolus vulgaris L.*) Genotypes Yield Stability Study in Southern and Central Rift Valley of Ethiopia

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ABSTRACT

The presence of significant genotype x environment interaction (GEI) has effect on the stability of genotypes across environments. Sixteen Andean red common bean genotypes were evaluated at six sites using triple lattice design in 2017 cropping season. The objective of the study was to evaluate seed yield stability of the genotypes using Additive Main Effects and Multiplicative Interaction (AMMI) and Genotype plus Genotype by Environment (GGE) bi-plot analyses. The AMMI ANOVA showed that the magnitude of G, E and GEI was 3.8%, 80.9% and 11.1% respectively of the total variation. The genotypes Red kidney, Melkadima and DAB 478 were identified as stable genotypes using AMMI bi-plot analysis. Based on GGE bi plot analysis, genotypes DAB 544, Red kidney, DAB 478, DAB 532 and DAB 481 were adapted to all environments. Three mega-environments were identified using GGE bi-plot analysis; namely high potential and discriminating environments (Melkassa), medium potential environments (Arsi Negele and Alem Tena) and low potential and undiscriminating environments (Areka, Gofa and Kokate). Therefore, Genotypes Red kidney and DAB 478 were the most stable according to the two stability analysis models and can be recommended for production in southern region and central Rift valley areas of Ethiopia.

Keywords: AMMI; Common bean; GGE bi-plot; GEI; Genotypes; Yield; Emergency

INTRODUCTION

Common bean *(Phaseolus vulgaris L.)* with 2n=22 diploid chromosome number belongs to genus Phaseolus, species vulgaris, family Fabaceae. It is the most important food legume contributing 50% for human consumption of the total production [1] in the world. In Africa, common bean is grown mainly for subsistence and it is a main source of dietary protein in Kenya, Tanzania, Malawi, Uganda and Zambia. In Ethiopia, the production obtained from red and white types of common beans was 14.3% (380, 499.453 tons) and 6% (159, 739.484 tons), of the pulse production respectively. Thus, the total area allotted for common bean production was 357, 299.89 ha in Ethiopia and the yield obtained was 540,238.94 tons [2].

The main challenge for the production of common bean in Ethiopia is believed to be shortage of high yielding and stable varieties. Genotype x environment interaction (GEI) is present when the expression of any trait of genotypes is inconsistent over environments. When a significant GEI is present, researchers are interested to know the cause of the interaction in order to make accurate predictions of genotype performance under a variety of environments [3]. The current research is aimed to estimate the interaction and performance of genotypes across environments using the multivariate methods; i.e., Additive Main Effects and Multiplicative Interaction (AMMI) and Genotype plus Genotype by Environment (GGE) bi-plot analysis.

In AMMI analysis, genotype (G) and environment (E) are considered as additive main effects and the GEI as a multiplicative component and is interpreted by principal component analysis (PCA) [3]. AMMI bi-plot is identified as GEI bi-plot which combines the yield stability parameters [4]. The use of AMMI is effective to evaluate multi-environment trial with the data collected from two to five times more replications [5].

MATERIALS AND METHODS

For multi-environment trials, which are not possible with the use of AMMI model, GGE bi-plot analysis is used to evaluate the environments [4]. GGE bi-plot graphically displays a GEI in a two way table [4]. It is an effective method for 1) mega-environment analysis (e.g. “which-won-where” pattern), whereby genotypes can also be recommended to specific environments [3,4], 2) genotype evaluation (the mean performance and stability of genotypes) and 3) environmental evaluation (the discriminating power of genotypes in target environments). GGE bi plot is able to identify which genotypes perform best in a given environment and also which genotype shows the highest stability across the test environments [6].

Genotype by environment interaction (GEI) is an important issue in crop breeding. When the expression of any trait of genotypes

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order to make accurate prediction of genotypes under a variety of environments. According to [6], the major objective of plant breeding is to select genotypes that are consistently high yielding (stable) over a range of environments, regardless of environment and/or season. However, GEI causes selection to be inefficient because the selected genotypes may fail to repeat their relative performance in different environments. Therefore, the relative magnitude of G, E, GEI and use of AMMI and GGE bi-plot stability analyses in the Andean red common bean genotypes have not been yet studied in common-bean-growing areas of southern and central rift valley of Ethiopia with the objective of analyzing seed yield stability using these models [7-13].

RESULTS AND DISCUSSION

ANOVA for combined environments

In the analysis of individual location, significant differences ($p<0.01$) were observed among the genotypes in seed yield in all six environments and there was also a highly significant difference among the genotypes ($p<0.01$) for combined analysis (Table 1). The existence of significant GEI in legume crops in previous studies was reported by various authors, such as common bean [14-20], chickpea, soybean and pigeon pea [20].

Table 1: Description of 16 common bean genotypes used for the study.

No.	Treatment name	Status
1	DAB 317	Under NVT
2	DAB 496	Under NVT
3	DAB 513	Under NVT
4	DAB 481	Under NVT
5	DAB 540	Under NVT
6	DAB 512	Under NVT
7	DAB 525	Under NVT
8	DAB 478	Under NVT
9	DAB 482	Under NVT
10	DAB 523	Under NVT
11	DAB 497	Under NVT
12	DAB 532	Under NVT
13	DAB 544	Under NVT
14	DAB 545	Under NVT
15	Melkadima (Ch.)	Released (2006)
16	Red kidney (Ch.)	Released (2007)

*NVT= National Variety Trial.

Andean red common bean genotypes mean performance

The combined mean seed yield analysis revealed that the maximum and minimum yields for each environment obtained were 2.0 to 3.7, 1.0 to 1.6, 2.3 to 4.0, 1.0 to 2.0, 1.0 to 1.7 and 2.0 to 4.0 t ha-1 in Alem Tena, Areka, Arsi Negele, Gofa, Kokate and Melkassa respectively and with their respective environment mean yield of 2.7, 1.2, 3.3, 1.3, 1.2 and 3.2 t ha-1 (Table 2). Arsi Negele, Melkassa and Alem Tena were the best environments for Andean red common bean genotypes with the mean seed yield of 3.3, 3.2 and 2.7 t ha-1 respectively. In the southern environments (Areka, Gofa and Kokate) performance was relatively poor with the mean seed yield of 1.2, 1.3 and 1.2 t ha-1, respectively; even though in these environments yield was fair as compared to the national average of common bean. However, the stability of genotypes across environments has to be evaluated by stability analysis using multivariate methods such as AMMI and GGE bi-plots.

Table 2: Combined ANOVA for seed yield (ton ha-1) of 16 common bean genotypes.

Source of variation	Degree of Freedom	Sum of Squares	Mean Square
Environment (E)	5	246.07	49.21**
Genotypes (G)	15	11.76	0.78**
Block	12	2.17	0.18*
GxE	75	36.82	0.49**
Error	180	23.17	0.13
Total	287	319.99	

CV= 16.9%; R-Square= 0.96; Grand Mean= 2.19

CONCLUSION

The Andean red common bean genotypes Red kidney and DAB 478 were selected as the stable genotypes which showed higher seed yield based on AMMI and GGE bi-plot analyses. Therefore, these genotypes can be recommended for southern regions and central Rift valley of Ethiopia.

Melkassa was identified as the most discriminating environment followed by Arsi Negele and Alem Tena. The southern environments, Gofa, Areka and Kokate, were non-discriminating but showed fairly acceptable yield as compared to the national average of common bean.

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CONFLICT OF INTEREST

There is no conflict of interest to be reported by any of the authors.

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