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RESEARCH ARTICLE

Identification of the stable mungbean variety through GGE biplot analysis from the two mega environments of North Western of Amhara region of Ethiopia

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Abstract

Mungbean production in Ethiopia has promising progress and it is one of exporting pulse crop and it is an alternative pulse crop for crop rotation to buildups soil fertility. Efforts were made to select a wide adaptable genotype among the entire tested genotype or to recommend each genotype for the exact area in different mega zones through GGE biplot analysis. This study was conducted at with five varieties at four location for two years during 2016 and 2017 cropping season each location and each cropping season comprising totally twelve environments in the North-Western Amhara region, to decide the adaptability of released varieties with stable performance across the environments. Highly significant differences among the varieties were well as for variety x environment interactions was observed in the present study. Among the tested genotype for the all the locations the highest yielding mungbean variety was Rasa which yielded a mean yield of 1848 kg ha^{-1} The stable variety across the environment was Rasa among the tested variety and two mega environments is classified, on the first mega environment classification includes three environments and the leading variety were NLV-1 while the second mega environments classification includes nine environment Rasa and Boreda was the high yielding Variety.

Keywords: Mungbean, high yield, stable, environment, GGE biplot

Introduction

Mungbean (*Vigna radiate* (L.) Wilczek) is one of the *Fabaceae* families and are closely related to cowpea (in the same genus but different species). Also, it calls as green gram it is a food and supply of financial gain and it's important to have the reach and balanced nutrient value and high amount of amino acid and protein (Asari *et al.*, 2019). Mungbean is considered a speculate crop due to its capacity to tolerate or escape the drought situation, early maturity and increase soil fertility through biological nitrogen fixation (Mbeyagala *et al.*, 2016). In Ethiopia, mungbean is widely grown by smallholder farmers and one of the important pulses crop which is grown in the different regions of the country (Amhara, Oromia, South nation nationality peoples, and Tigray regions). The total production of the country was 57,620 t and 48,074.5 hectares of land covered (CSA 2018). In the Amhara region, the highest area of mungbean is cultivated compare to the other part of the country it accounts for 76% of total production.

Amhara region is categorized by the high rainfall and drought saver climatic condition (Bewket, 2009) and the cropping system practiced mono-cropping and sole cropping system is more common and the soil fertility highly is diminished time to time. A variety of adaptations program will optimize location-sensitive variety by creating alternatives and testing varieties in distinct locations. New environment adaptable varieties are needed to make sure to earn a good income and sustainable for different cropping systems for those areas, the new adaptable varieties should show promising performance in terms of grain yield and other additional vital agronomic traits. Moreover, good performance must be consistent over a wide range of environmental conditions (Kucek *et al.,* 2019).

GGE biplot evaluation presents a framework for figuring out target testing places and discriminates genotypes (Shrestha, 2019), PC1 represents a proportional cultivar response across locations, which leads to non crossover GE interactions, whilst PC2 represents a disproportional cultivar response across locations, which is responsible for any crossover GE interactions. Consequently, genotypes with large PC1 ratings tend to give higher average yield, and locations with large PC1 rankings and near-zero PC2 scores helps identification of such genotypes (Yan and Kang, 2002).

Genotype by Environment interaction is a multiplicative interaction model to identify mega-environments with a distinct variety of performance across different locations. GXE indicate targeting cultivars or for a selecting material is the crossover has a top-yielding genotype and also it identifies genetic correlation among the environment (Kucek *et al.,* 2019). GXE is giving better to have a successful breeding program for better understanding the types and the size of GXE expected in a given region, most of the time GXE is reporting for the pair of contrasting environment for a given the genotypes yield stability and adaptability for different agronomical practices (Bänzigerand and Cooper., 2001, Mbeyagala *et al.,* 2016)

Hence, by considering all above points the present study was panned with objective to study the recommend the alternative pulse crop for the area with high yielding, stable and good agronomical traits. And indicate a suitable location for the production of mungbean for the North-Western Amhara region.

Materials and methods

The trial was conducted by using five released mungbean variety Table(1) were conducted four location Table (2) for two years (2016 and 2017) cropping season each location and cropping season consists an environment totally twelve environments were addressed the environment was selected by their environmental condition and farmers cropping system, like intercropping and for double cropping system.

The trial for hole location by using randomized complete block (RCB) design with four replication the entire size of the plot was 1.2 m × 4m the distance between row and plant 30 cm and 5cm respectively the total size of the plot was 4.8m2 and three-row was harvested the rest two-row use for border effect and 100 kg/ha diammonium phosphate (DAP) applied one time at the time of sowing and Dimethoate 40%EC was spraying before flowering to control bean fly.

At the time of physiological maturity all phonotypical and metric data were recorded (number of pod per plant, number of seed per pod, pod length, thousand seed weight and grain yield adjusted by 10% seed moisture content). Combine analysis of variance (ANOVA) across the trial site was analyzed to assess the significant level among varieties and interaction among the environment by using SAS version 9.0 software and GGE by plot was analyzed by using Genstat version 18.

Table 1:List of mungbean varieties evaluated in an adaptation study in North Western Amhara

Sr. No.	Name of varieties	Yield potential (kgha^{-1})	Year of released
1	Rasa	8-15	2011
2	Shewarobit local	Unknown	Local variety
3	Arkebe	19.55-25.56	2014
4	NLV-1	7.5-15	2014
5	Boreda	13.5	2008

Table 2: Description of experimental sites to evaluate mungbean genotypes in an adaptation study in North Western Amhara

Attributes	Location		
	Metema	**T/Armachihi**	**West and E/Belesa**
Altitude above sea level (m)	760	1100	850-1100
Total rainfall (mm)	1030.2	970.88	611.7
Temperature			
Maximum	19.5	18.32	12
Minimum	35.9	34.03	36.2
Relative humidity	45.1	59.34	
Latitude	12 39 N	13 88N	10 35N
Longitude	36 17 E	61 43 E	36 63 E
Soil type	Vertisol	Vertisol	Vertisol

Result and discussion

In GGE biplots, genotype plus genotype × environment (G + GxE) interaction was studied in order to idenfy the most superior genotype at one and across the locations. Highly significant differences (*P*<0.001) among the varieties as well as for variety x environment interactions (G x E) (Table 3).The genotypic and environmental main effects were highly significant (*P*<0.001) which increase the chances of conducting Multi-Environment Trials (METs) across years and locations, that were accurately targeted to the farming system and the genotypes grow a wide range in the area across over the environment and these result shows serious difficulty to breeders to recommending a better variety, as this decision depends where the comparison is conducted (Mbeyagala *et al.*, 2016). G x E interaction is used to select a wide adaptable genotype among the entire tested genotype or to recommend each genotype for the exact area (Ceccarelli 2012). Among the tested genotype for the all the locations the highest yielding mungbean variety was Rasa which yielded a mean yield of 1848 kg ha-1, while the poorest performed or low yielding variety was Arkebe, for which the mean yield was 1149 kg ha-1 which is least. (Table 4 and Fig. 1).

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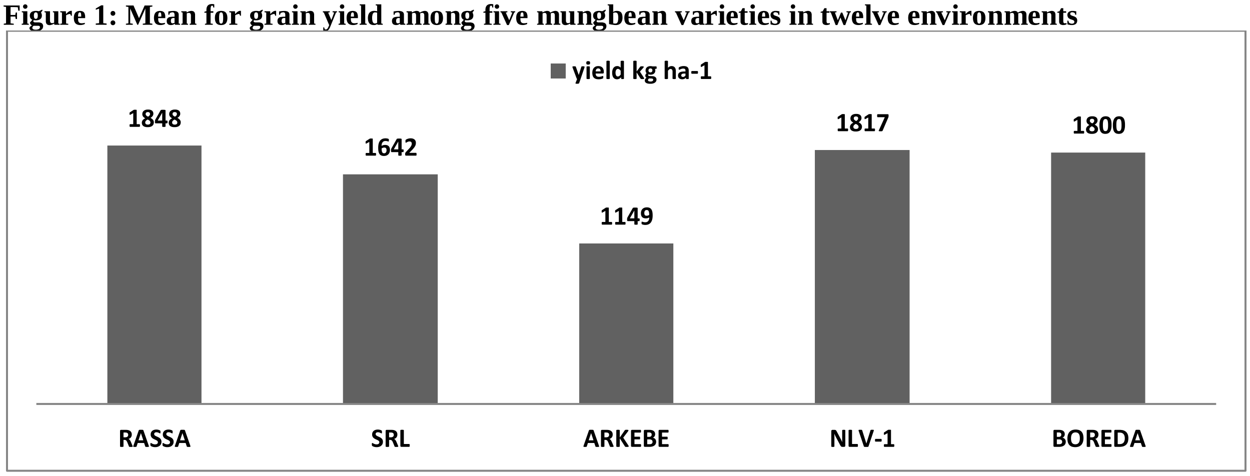
Table 3: Analysis of variance for grain yield among fivemungbean genotypes grown in twelve environments , North Western Amhara

Source	DF	Sum of square	Mean square	F-value	Significance
Genotype	4	1.637E+07	4091258	54.18	0.0000
Replication	3	565577	188526	2.5	0.0616
Environment	11	3.514E+07	3194304	42.3	0.0000
Genotype x Replication	12	343292	28608	0.38	0.9695
Genotype x Environment	44	6839673	155447	2.06	0.0006
Error	165	1.246E+07	75519		
Total	239	7.17E+0			

Figure 1: Mean for grain yield among five mungbean varieties in twelve environments



This result is similar to (Yehuala *et al.*, 2018) and (Teame *et al.*, 2017). The highest yielding in the highest yielder site was Metema site 2 (E5), the variety was Rasa (2490 kg ha-1) .as the same time the lowest variety in Metema site 2 (E5) was Arkebe (1263 kg ha-1). The lowest yielding site observing was East Belesa site 1(E1) Boreda (1167 kg ha-1) and Arkebe (771 kg ha-1) records the highest and the lower yield respectively. Previous study conduct in southern part of Ethiopia Gofa, Awassa and InsenoMH-96-4 show high yielder and multi environment stability(Asfaw *et al.*, 2012) so environment are key factors for achieving optimum growth and dry matter production of mung bean cultivars (Lema *et al.*, 2018).

Analysis Genetic by environment interaction by using GGE biplot indicate a good visual estimation with PCA1 (Axis 1) and PCA2 (Axis 2), it is explaining 96.67% of the total G x E sums of squares. The main concept GGE originated for analyzing METs the yield of cultivars in an environment is a mixed effect of genotype main effect (G), environment main effect (E), and (G×E) interaction (Ceccarelli, 2012) as a result among the tested mungbean varieties away from the biplot origin and vertical axis to the right side, exhibited higher mean yield performance (Fig. 2).Then, the varieties that gave higher yield values were Rasa, Boreda and NLV-1 respectively, whereas variety Arkebe and Shewa robit local was recorded the lowest mean yield performance.

Table 4: Mean grain yield (kg ha^{-1}) of five mungbean varieties evaluated at twelve environments in, North Western Amhara

Code	Variety Name	2016 (Environments)						2017 (Environments)						
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	
		East Belesa site one	Tachi Armachiho site one	Tachi Armachiho site two	Metema site one	Metema site two	Metema site one	Metema site two	East Belesa site one	East Belesa site two	Tachi Armachiho site one	West Belesa site one	West Belesa site two	Mean
1	Rasa	1049	1433	1374	1630	2490	1630	2431	1958	1839	2099	2042	2201	1848
2	SRL	881	1383	1014	1504	2120	1428	2013	2144	1790	1993	1467	1966	1642
3	Arkebe	771	541	588	1362	1263	1073	1472	1431	1475	1965	710	1135	1149
4	NLV1	1019	1599	1069	1479	2274	1539	2394	2144	1947	2111	2117	2114	1817
5	Boreda	1167	1482	1191	1393	2226	1688	2436	2029	1785	1932	2007	2262	1800
	Mean	977	1288	1047	1474	2075	1472	2149	1941	1767	2020	1669	1936	1718
CV														29.43
LSD														195

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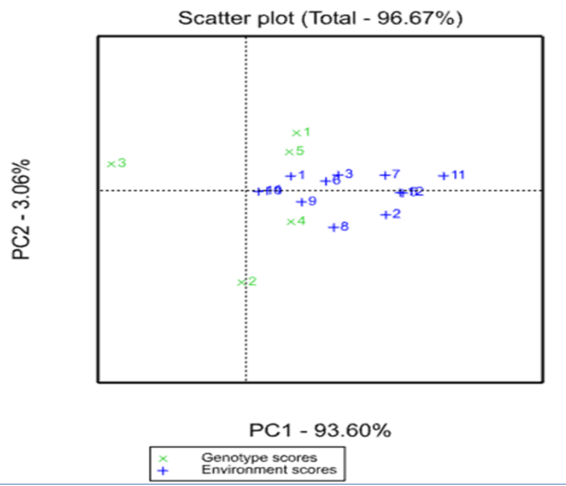
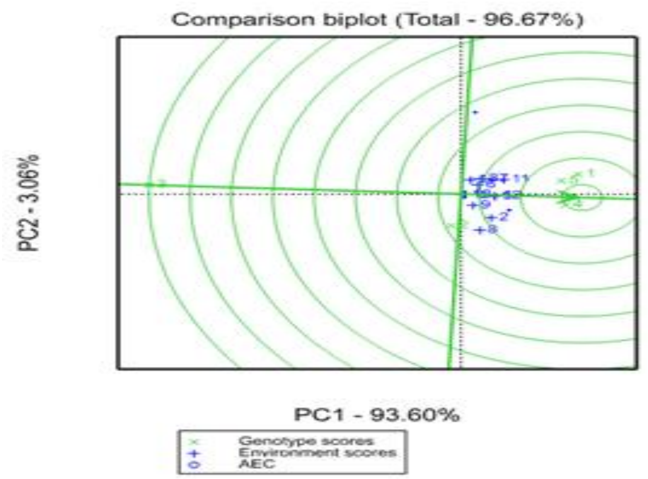
Figure 2 and 3: Biplot showing mean grain yield and yield stability where as bplot of concentric circles ranking mungbean genotypes of mungbean varieties, the green sign indicated the variety and the blue indicate the tested environment





The stability of the varieties was graphically represented by the projection from the genotype to the stability axis (the horizontal axis) the varieties close to horizontal axis on the graph indicate the stability of the varieties across the tested environments (Ceccarelli 2012), by this way excluded SRL all varieties were stable while Arkebe is stable but low yielding variety., To select widely adapted genotypes with high performance GGE Biplot is one of the most precious analysis for breeder in multi-environmental trial (Blanche *et al.*, 2007) and a stable genotype has the ability to tolerate the environmental stress factor to improve performance (Fig. 3). Among the tested genotypes close to the center of concentric curricle it indicates the ideal genotypes (Yan 2001) the most promising varieties were Rasa , NLV-1 and Boreda being greater than the grand mean, those three genotypes show the best combination grain yield and stability(Yan and Kang 2003). While the remaining two varieties are not desirable they show unstable and low yielder(less than the grand mean).the result is in line with the current study (Mbeyagala *et al.*, 2016a) and biplot graph give effective overview of environmental stability and indicate the promising genotype for the given area (Ullah *et al.*, 2011) .Among the tested twelve environments in this experiment, the suitable mega environment for mungbean production grouped in to two (Fig.4). The first mega-environment comprised of (E2,E8 and E9) the highest performed variety were shewa robit local.

The second mega environment includes (E1, E3, E4 E5, E6, E7, E10, E11, and E12) the wining varieties on those sites are Rasa NLV-1 and Boreda. As a result Rasa is the highest performed variety and the second mega-environment is the suitable area for mungbean production among tested site. In order to determine and to identify the best yield performance for promising genotypes across several years suitable environment is the crucial parameter. Yan and Tinker (2006); Yan *et al.*, (2005) planned that categorizing test locations into important mega-environments, and deploying genotypes in different mega-environments, is the best way of exploiting optimistic G x E interactions, while avoiding the negative ones. Therefore, two mega-environments identified in this study (Fig. 4).

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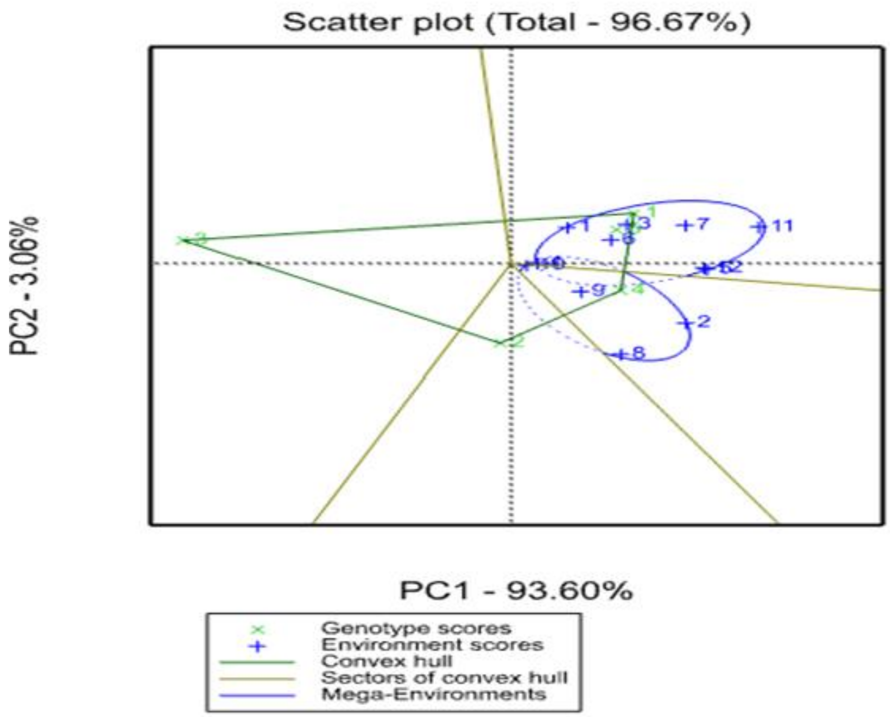
Figure 4: Biplot showing mega-environments and best performing genotypes, the green sign indicated the variety and the blue indicate the tested environment



The result of other metric data on table (5) shows there is no significant difference (P>0.001) among the genotypes on the traits of days to maturity and plant height while pod per plant ,seed per pod , pod length and hundred seed weight show highly significant difference (P<0.001) among the tested variety. The same result reported pod per plant and hundred seed weight has direct effect for grain yield improvement (Azam *et al.,* 2018). The highest pod per plant recorded on variety shewa robit local while the lowest is record on variety Arkebe, the result is in line with (Teame *et al.*, 2017) Shewa robit local exhibit high number of pod per plant. Variety rasa has promising performance on the traits of seed per pod, pod length and hundred seed weight it was recorded 11.25, 11 (cm) and 5.4(g) respectively, whereas variety Arkebe show the poor performance on the traits seed per pod, pod length and hundred seed weight, These results were similar to those reported by (Yehuala *et al.*, 2018), (Asfaw *et al.*, 2012) variety Rasa bolded seed and highly preferred for market.

Conclusion

Among the tested five varieties the three varieties (Rasa, NLV-1 and Boreda) show stable and high yielder variety in North Western Amhara region, as a result recommended to farmer for cultivation. Mungbean growing areas can be categorize at least into two candidate mega-environments in terms of grain yield the first mega environment is include the location of Tachi Armachiho and East Belesa and the second mega environments include Metema and West Belesa Among the tested area most of the site is favorable environment for mungbean production and few of site has unfavorable area , so to recommend the variety for contrast environment multi-year and multi-location data should be available so Metema is the best suitable area for the production of mungbean.

Table 5: Mean phonological and metric data of five mungbean varieties evaluated at twelve environments in North Western Amhara

Variety	Days to maturity	Plant height (cm)	Number of pod per plant	Number of seed per pod	Pod length (cm)	100 seed weight (g)
Rasa	67	61.5	11.4	12.5	11.0	5.4
SRL	69	61.2	14.0	11.3	7.9	3.7
Arkebe	68	55.7	11.6	10.6	8.6	4.0
NLV 1	68	62.9	11.5	12.1	10.7	5.1
Boreda	67	62.1	11.5	12.4	10.7	5.4
Mean	67	60.0	11.9	11.8	9.8	4.2
CV	7	52,7	27,8	15.0	11.4	7.7
Significance	NS	NS	**	**	**	**

** : high significant.; NS: Non significant

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