Electronic Journal of Plant Breeding, 10 (3): 1234 - 1239(Sep2019) DOI: 10.5958/0975-928X.2019.00156.X
ISSN 0975-928X

Research Article

Genotype x environment interactions in rainfed grown greengram (*Vigna radiata*)

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(Received: 14 Mar 2019; Revised: 05 Jun 2019; Accepted: 11 Jun 2019)

Abstract
The low productivity is mainly due to fact that green gram is grown under rainfed environments with vagaries of monsoon. Hence stability of green gram genotypes was analysed during three years in rainfed condition in this study to identify stable genotypes. Among the 15 genotypes along with three checks studied the genotypes G14, G5 and G7 were stable genotypes with high mean yield. These three genotypes show stability for number of pods per plant. The genotype G14 also recorded the lowest value for days to 50 percent flowering with high stability showing early maturity.

Key words
Greengram, Stability, AMMI analysis

Introduction

Green gram [*Vigna radiata* (L) Wilczek] is an important pulse crop rich in protein (24-26%), carbohydrate (54-56%) minerals (4%) and vitamin (3%) required to the tune of 70-80g per capita per day for balance diet of an adult person (Anonymous, 2004).It is an important pulse crop in developing countries of Asia, Africa and Latin America where it is consumed as dry seeds, fresh green pods (Karuppanapandian *et al.,* 2006). More than 70 per cent of total world greengram production is from India (Anonymous, 2016). In India the total production of green gram is 1.71m tons from an area of 3.43m ha with a productivity of 4.98 qha -1 (Anonymous,2012). Pulse crop act an important role in Indian agriculture as they are rich sources of protein and essential oils for predominant vegetarian population of India (Armugam *et al.,* 2010).

The crop is an important short season summer grown grain legume, well suited to smallholder production under adverse climatic conditions and commonly used in Indian cuisine (Vijayalakshmi *et al.,* 2003).Mungbean is produced in tropical and sub-tropical rainfed environments with little or no impounding of water, and it is prone to drought when soil moisture or rainfall is inadequate to meet plant requirements. The average productivity of greengram over globe is 577 kg ha-1 and in India it is 426 kg ha-1, when compared to the productivity levels over globe, it is far below in India (Anonymous, 2010). The low productivity is mainly due to fact that green gram is grown under rainfed environments with vagaries of monsoon. Hence stability of green gram genotypes was analysed during three years in rainfed condition in this study to identify stable genotypes.

Materials and Methods

The experiment was conducted during the north east monsoon season at Aruppukottai,Virudhunagar district in Tamil Nadu, India during 2010-13 over three years. The test environment chosen represents typical rainfed which receives less than 300mm rainfall during cropping period. The green gram genotypes used in this study comprised three genetically distinct approved varieties (VBN 2, VBN 3 and CO 7), 15 promising advance lines (Table 1). Six rows in a plot of size 4 x 1.8m were planted with a spacing of 30 cm between rows. Each row contains 40 plants spaced at 10 cm apart.

Additive main effect andmultiplicativeinteraction (AMMI) model was usedto determine the stability of the genotypes across environments.The AMMI model first fits the additive effects forthe genotypes and the growing environments and multiplicative term forgenotype x environmental interactions.The AMMI model according to Farshadfar *et al.*(2011) ispresented as

$$Y_{ij} = \mu + g_i + e_j + \sum_{k=1}^{n} \lambda_k \alpha_{ik} \gamma_{jk} + e_{ij},$$

whereY_{ij} is the yield of the i^{th} genotype in the j^{th} environment,g_i is the mean of the i^{th}

genotype minus the grandmean, λ_k is the square root of the eigenvalue of the PCA axis$k$, α_{ik} and γ_{jk} are the principal component scores for PCA axis$k$ of the i^{th} genotype and the j^{th} environment, respectively, and e_{ij} is the residual. The environment and genotypic PCAscores are expressed as unit vector times the square root of λ_k;i.e., environment PCA score=$\lambda_k^{0.5}Y_{ik}$; 0.5; genotype PCAscore = $\lambda_k^{0.5}\alpha_{ik}$.

AMMI stability value (ASV) was calculated for eachgenotype according to the relative contributions of theprincipal component axis scores (IPCA1 and IPCA2) to theinteraction sum of squares.TheAMMIstability value (ASV) as described by Purchase*et al.*(2000) was calculated as ASV equal to IPCA1Sum of squares/IPCA2Sum of squares is the weightgiven to the IPCA1-value by dividing the IPCA1 sum ofsquares (from the AMMI analysis of variance table) by theIPCA2 sum of squares. The larger the IPCA score is, eithernegative or positive, the more adapted a genotype is to acertain environment. Smaller ASV scores indicate a morestable genotype across environments Farshadfar *et al.*(2011).

Results and Discussion

The result of combined analysis of variance (Table 2) showed high significant differences for genotypes,environment and genotype x environment interaction indicating the effect ofenvironment in the genotype x environment interaction, genetic variability andpossibility of selection for stable genotypes. As it is indicatedby different scientists (Farshadfar and Sutka(2003),Farshadfar and Sutka (2006), when GE interaction wassignificant, it is possible to proceed and calculate the stabilityfor the tested genotypes.

In AMMI model, principalcomponent analysis is based on the matrix of deviation from additivity or residual will be analyzed. In this respect boththe results of AMMI analysis, the genotypes andenvironment will be grouped based on their similar responses(Pourdad and Mohammadi 2008). Using ANOVA yield sum of square waspartitioned into genotype, environment, and GE interaction.GE interaction was further portioned by principal component analysis. According to Farshadfar *et al.*(2011). Stability analysis methods are often used by breeders to identify genotypes that have stable performance and respondpositively to improvements in environmental conditions.

AMMI stability value (ASV) indicates the stability ofgenotypes. It is the distance fromzero in a two dimensional scattergram of IPCA1 scores against IPCA2 scores. Since the IPCA1 score contributesmore to the GE sum of square, it has to be weighted by theproportional difference between IPCA1 and IPCA2 scores tocompensate for the relative contribution of IPCA1 and IPCA2 total GE interaction sum squares (Fig 1-3b).The distance fromzero is then determined using the theorem of Pythagoras (Purchase *et al.*, 2000).Genotypes having low ASV are considered morestable whilst those with high values are less stable genotypes(Hagosand Abay2013). Genotypes G14, G5 and G7 were stable genotypes with high mean yield. These three genotypes show stability for number of pods per plant. The genotype G14 also recorded the lowest value for days to 50 percent flowering with high stability showing early maturity.

Stability alone for yield performancedoes not warrant selection since a consistently low yieldinggenotype can still be stable (Yan and Tinker 2006). In this study, G1, G2, G8 and G9 are low yielding stable genotypes. In some cases themost stablegenotypes do not always have the best yield performance (Oliveira and Godoy 2006). The highest yield was recorded by G12 but is not stable.

Acknowledgements

I acknowledge the trainers Dr. N. Nadarajan, Former Director, Indian Institute of Pulses Research, Kanpur, Dr. N. Manivannan, Professor and head, National Pulse Research Institute, Vamban and Dr. P. Arunachalam, Assistant Professor, AC&RI, Madurai

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Table 1. List of green gram genotypes used in this study

S. No.	Genotype	Parentage	Genotype code
1	AGG 29	VGG 77 x ADT 3	G1
2	AGG 31	CoGG 913 x VGG 112	G2
3	AGG 32	CoGG 912 x VGG 112	G3
4	AGG 34	ADG 2080 x VGG 77	G4
5	AGG 35	ADG 2080 x VGG 112	G5
6	AGG 37	VRM 1 x VGG 112	G6
7	AGG 40	ML 267 x ML 682	G7
8	AGG 41	Pusa bold x ML 682	G8
9	AGG 43	ML 267 x Co 4	G9
10	AGG 44	Pusa bold x ML 267	G10
11	AGG 45	Pusa bold x Co4	G11
12	AGG 47	ADT 3 x VGG 77	G12
13	AGG 09 – 068	Co 6 x ML 267/11/1/1	G13
14	AGG 09 – 072	Co 6 x BDYR 2/1/1/1	G14
15	AGG 09 – 077	Co 3 x Jalagon 2/1	G15
16	VBN 2	Check	G16
17	VBN 3	Check	G17
18	Co 7	Check	G18

Table 2. Analysis of variance for AMMI model of green gram for yield

Source	Degrees of freedom	Sum of Squares	Mean Sum of Squares	Variance Ratio	F pr value
Treatments	53	1030377	19441	39.94	<0.001
Genotypes	17	632910	37230	76.49	<0.001
Environments	2	120582	60291	177.09	<0.001
Block	6	2043	340	0.70	0.6506
Interactions	34	276885	8144	16.73	<0.001
IPCA 1	18	166892	9272	19.05	<0.001
IPCA 2	16	109992	6875	14.12	<0.001
Error	102	49645	487		
Total	161	1082064	6721		

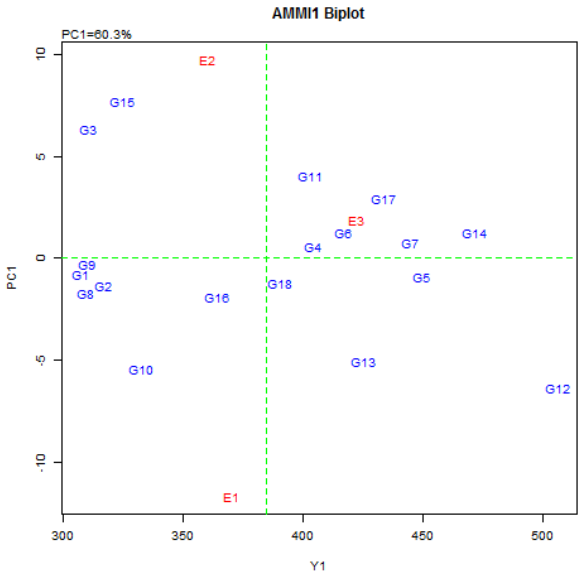

Fig. 1a.Grain yield per plant

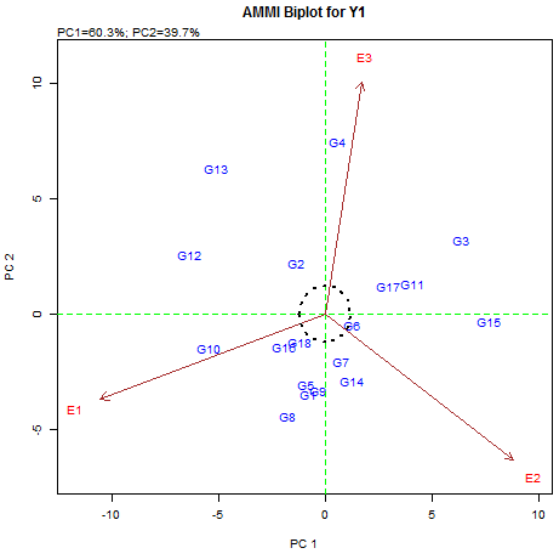

Fig 1b. Grain yield per plant

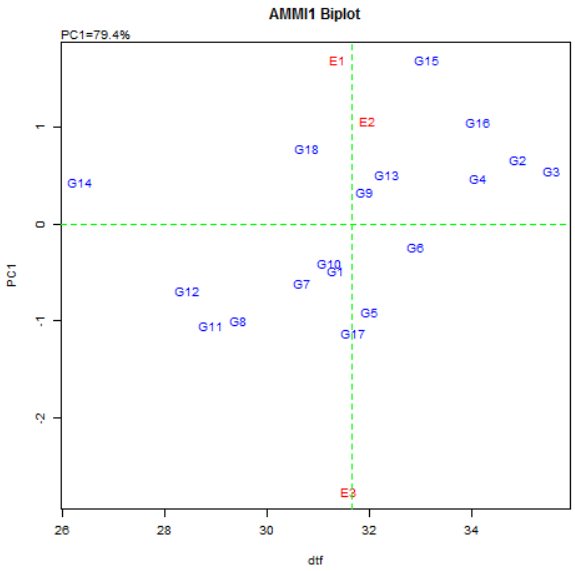

Fig. 2a. Days to 50% flowering

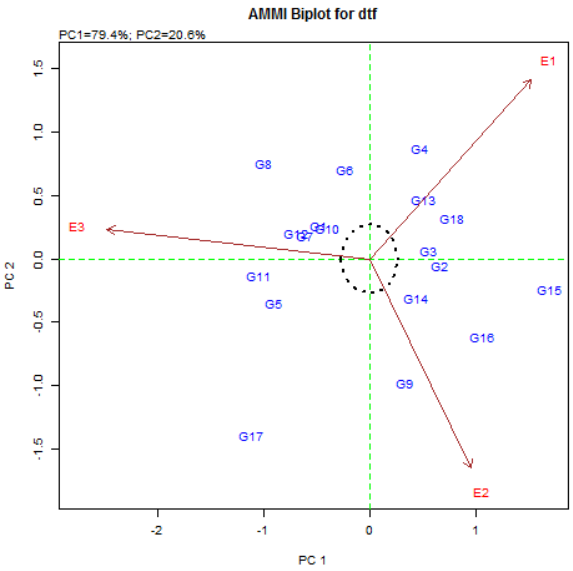

Fig. 2b. Days to 50% flowering

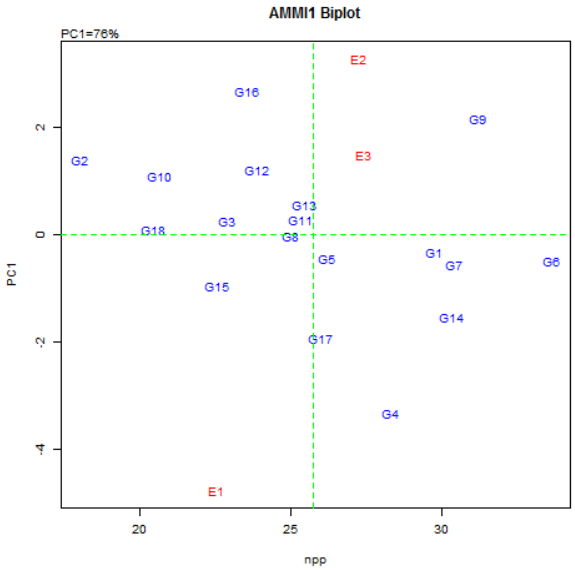

Fig. 3a.Number of pods per plant

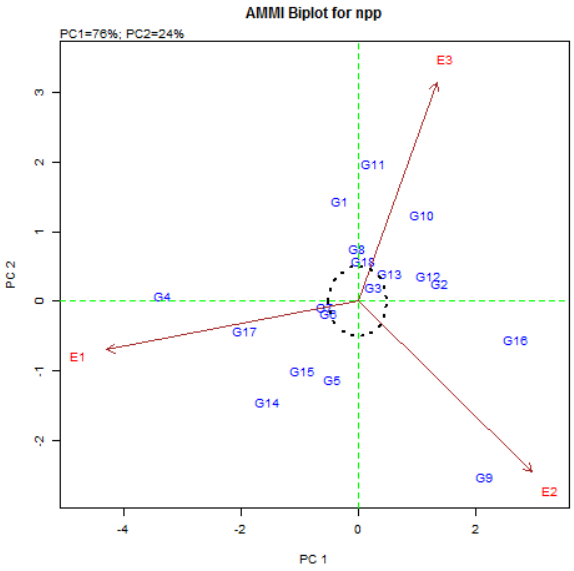

Fig. 3b. Number of pods per plan