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Yield stability analysis of gum guar genotypes in North Eastern Karnataka

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Abstract
Stability analysis studies for seed yield of ten gum guar genotypes was carried out at five locations during *Kharif* / Rainy season, 2013-14 using randomized block design. Regression of the mean yield of the individual genotypes on the environmental index and deviations of the regression co-efficient from the unity was used to calculate stability of the trait for each genotype. Pooled analysis of variance for seed yield displayed significant differences among environments, genotypes and environments × genotype interactions advocating the adequacy of stability analysis. Genotype GAUG-13 recorded highest (718.33 Kg/Ha) average mean yield followed by RGC-986(647.40 Kg/Ha), RGC-936-1-5 (646.70 Kg/Ha), HG-884 (635.00 Kg/Ha), HGS-563 (623.83 Kg/Ha) and HG-365 (619.07 Kg/Ha) across locations. Based on stability parameters, genotypes RG-936-1-5-1 (646.70 Kg/Ha) and HG-884 (635.00 Kg/Ha) recorded mean yield above the overall mean along with regression value nearer to unity (*bi*= 1.07) and (bi= 1.06) and non-significant deviation from regression (S^2di = -2277.91) and (S^2di = -4651.56), respectively, indicating the high stability and wider adaptability across the environments.

Keywords: Kharif, Yield stability, gum guar genotypes

Introduction
Guar (*Cyamopsis tetragonoloba*) is a drought tolerant and multi-purpose legume crop, cultivated mainly in the *kharif* season in arid regions of northern-western parts of Indian states viz., Rajastan, Gujatath, Punjab and Haryana. It can be cultivated in poor and marginalized soil and require lower agronomic inputs. It comes up well on light texture, sandy to sandy loam soils receiving 300-500 mm annual rainfall. In recent days, significantly higher prices of Guar and the qualities of the crop like high adaptation towards erratic rainfall, multiple industrial uses and its importance in cropping system for factors such as soil enrichment properties, low cost of cultivation etc., have helped expand the crop to non-traditional areas or regions and seasons. Due to this reason guar crop has spread to Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Karnataka, Tamil Nadu and other parts of country in *kharif* as well as in summer season. India is the largest producer with annual production of around 2 million metric tons and contributes 80 % of total Guar production in the globe (Anon, 2014) [1].

The guar crop has experienced a remarkable journey from a traditional crop grown on marginal non fertile soils mainly for food, animal feed and fodder to a crop with various industrial usages. Hence, the need is emerging for bridging the gaps between yields obtained on the experimental farm yields and at farmer's field. In view of this, an attempt has been made to identify suitable and stable Gum guar genotypes (released and being cultivated in Rajasthan, Gujarat and Haryana) for North eastern parts of Karnataka.

Stability of yield is an important feature of new generation's plant breeding programs, owing to the high annual variation in mean yield, especially in the arid and semi-arid areas (Mohammadi *et al*., 2012) [6]. Farmers are most interested in a genotype that gives consistent yields under different growing environmental conditions; thus, plant breeders usually try a number of genotypes in multi-environments, before releasing a new or improved variety for production to farmers (Naghavi *et al*., 2010) [7].

Response of genotypes to different or varied environments is defined as the Genotype–Environment Interactions (GEI). In the development and evaluation of plant varieties, genotype–environment interactions are extremely important because they can reduce genotypic stability values in diverse environments (Hebert *et al*., 1995) [4]. Magnitude of the response of individual genotypes to their environments is required for an understanding of genotype–environment interactions.

Regression analysis approach proposed by Yates and Cochran (1938) [11] and later modified by Finlay and Wilkinson (1963) [3] is used for identifying stable cultivar, where stability as a linear

relationship between the yield of genotypes over many environments is given by the regression coefficient (*bi*), and a genotype with b*i* = 1 can be considered as stable. Eberhart and Russell (1966) [2] used the regression deviation mean square (S^2di) as a measure of stability. Genotypes with low (close to zero) deviation from the regression (S^2di) value and high (above average) mean efficiency are regarded as stable. A number of stability studies on different crops have previously been carried out. However, no stability study has been performed for Gum guar in North Eastern Karnataka. The objectives of this study were to (1) evaluate the seed yield capacity of gum guar genotypes (G) in different environments (E); (2) identify and assess the G × E interactions; and (3) determine the stability of these interactions using stability parameters.

Materials and Methods

Field experimentations

Ten genotypes of gum guar released and cultivated in Rajasthan, Haryana and Gujarat were procured and evaluated in *Kharif* / Rainy season, 2013-14 using randomized block design with three replications at five locations coming under the jurisdiction of University of Agricultural Sciences, Raichur (Karnataka) *viz*., Agricultural Research station, Bidar (Bidar district), Agricultural Research station, Hagari (Ballary district) Agricultural Research station, Gulbarga (Gulbarga district) Main Agricultural Research station Raichur, (Raichur district) and College of Agriculture Farm, Bheemarayanagudi (Yadgir district). Each plot was accommodating eight rows of 4 m length with 45 and 20 cm distance from rows and plants, respectively. The recommended agronomical practices *viz.*, thinning, weeding, fertilizer application, plant protection measures etc were carried out time to time throughout crop duration. The experiments were carried out strictly under rain-fed conditions and no additional irrigation was provided. The detailed weather condition of experimental station where the study was conducted is presented in Table 1.

At Main Agricultural Research station, Raichur, (Raichur district), the data of eight morphological characters (Table 2) *viz*., plant height (cm), number of branches / plant, number of pods/plant, number of seeds / pod and pod length (cm) were recorded at maturity, whereas, observations on flowering was recorded for different genotypes as and when they attained 50% flowering stage. The 1000-seed-weight and seed yield/plot were recorded after threshing of the harvested crop. In rest of the research stations only seed yield / plot was recorded.

Statistical analysis

Regression of the mean yield of the individual genotypes on the environmental index and deviations of the regression co-efficient from the unity as suggested by Eberhart and Russell (1966) [2] was used to calculate stability of the trait for each genotype. The model is:

$$Yij = \mu i + \beta i\, Ij + \delta ij$$

Where,

Yij = Mean of the ith variety at jth environment,

μi = Mean of the ith variety over the environments

βi = Regression coefficient of ith variety to varying environments indices.

Ij = Environmental index i.e. mean of all varieties at jth environment minus grand mean

δij = Deviation from regression of ith variety at jth environment

Environmental Indices

The environmental index was calculated as the mean of all the ten gum guar genotypes at each environment by subtracting the grand mean.

Table 1: Weather conditions of locations of the experiments conducted for stability study

Name of the Research Station	Agro-climatic zone	Soil type	Average Annual Rainfall (mm)
Agricultural Research Station, Bidar (Bidar District),	North-Eastern Transitional Zone (Zone-1)	Medium black clay laterite type	870
Agricultural Research Station, Gulbarga (Gulbarga District)	North-Eastern Dry Zone (Zone-2)	Red and Medium to Deep black clay	710
Main Agricultural Research Station Raichur, (Raichur District)			
College of Agriculture Farm, Bheemarayanagudi (Yadgir District)			
Agricultural Research Station, Hagari (Ballary District)	Northern Dry Zone (Zone-3)	Red and Medium to Deep black clay	574

Table 2: Data on Ancillary Characters of Gum Guar Varieties recorded at Main Agricultural, Research Station, Raichur during *Kharif* 2013-14

S. No	Genotypes	DFF	Plant Height (cm)	Branches / plant	Pods/ plant	Pod length (cm)	Seeds / pod	Test Wt. (gram)
1	RGC-936	38.67	104.60	8.93	91.00	5.69	6.37	39.20
2	RGC-936-1-5-1	38.00	104.27	8.87	84.13	5.80	7.53	35.54
3	HGS-563	35.33	99.00	8.07	77.40	5.49	7.33	36.10
4	HG-884	35.33	103.40	8.53	82.93	5.39	7.07	37.30
5	RGC-1031	47.67	138.80	0.00	73.07	5.42	7.80	36.27
6	GAUG-13	47.33	111.47	6.80	72.07	5.27	7.07	32.33
7	RGC-986	41.00	107.20	8.07	80.07	5.51	7.67	37.87
8	HG-365	38.00	110.13	7.53	76.60	5.49	7.73	34.93
9	Gourishankar-15	41.33	114.47	0.00	73.07	5.41	6.93	35.43
10	Gourishankar-09	37.67	95.67	8.33	77.87	5.33	7.33	34.73

Table 3: Analysis of variance for seed yield stability of Gum guar across five environments *Kharif* 2013-14

Source of Variation	Df	Sum of Squares	Mean Squares	F Ratio	Probability
Replication within Environment	10	2405.71	2405.71	0.67	0.72872
Genotypes	9	414931.62	46103.51	13.15	0.0000 ***
Environment+(Genotypes × Environment)	40	6004558.86	150113.97	42.82	0.0000 ***
Environment	4	5630438.56	1407609.64	401.52	0.0000 ***
Genotypes × Environment	36	374120.30	10392.23	2.96	0.00159**
Environment (Linear)	1	5630438.56	5630438.56	1606.08	0.0000 ***
Genotypes × Environment (Linear)	9	268949.18	29883.24	8.52	0.0000 ***
Pooled Deviation	30	105171.11	3505.70	0.65	0.91013
Pooled Error	90	486399.33	5404.43		
Total	49	6419490.48	131010.00		

Table 4: Stability parameters for seed yield and mean performance (Seed yield, Kg/Ha) of Gun guar genotypes over the environments

S. No.	Genotypes	ARS, Hagari	ARS, B'gudi	ARS, Gulbarga	MARS, Raichur	ARS,Bidar	Mean	*bi*	Rank	S^2di	Rank
1	RGC-936	415.00	252.50	570.00	1120.33	273.33	526.23	0.94	1	-3076.61	7
2	RGC-936-1-5-1	636.67	246.17	696.67	1287.33	366.67	646.70	1.07	3	-2277.91	4
3	HGS-563	470.00	270.50	806.67	1250.33	321.67	623.83	1.07	4	1900.38	2
4	HG-884	577.67	272.33	733.33	1265.00	326.7	635.00	1.06	2	-4651.56	10
5	RGC-1031	566.67	230.50	620.00	1086.00	286.67	557.97	0.90	6	3282.33	9
6	GAUG-13	663.33	334.67	856.67	1432.00	305.00	718.33	1.22*	9	-3205.63	8
7	RGC-986	514.67	360.67	686.67	1400.00	275.00	647.40	1.18	7	298.67	1
8	HG-365	470.00	259.00	723.33	1354.67	288.33	619.07	1.19	8	-2310.91	5
9	Gourishankar-15	478.33	179.83	350.00	0615.00	226.67	369.97	0.43*	10	2697.22	6
10	Gourishankar-09	526.67	296.50	550.00	1106.00	220.00	539.90	0.92	5	-2079.93	3
Environmental Index		**-56.54**	**-318.17**	**70.89**	**603.26**	**-299.44**					
Mean		531.90	270.27	659.33	1191.70	289.00	588.44				
CV		14.56	14.15	17.83	20.310	11.98					
SE of Difference		63.23	31.24	96.02	197.62	28.27					
CD 95%		132.85	65.62	201.72	415.17	59.38					
CD 99%		182.02	89.91	276.37	568.82	81.36					

Results and Discussion

Genotype × Environmental Interactions

The pooled analysis of variance for seed yield displayed significant differences among environments, genotypes and environments × genotype interactions advocating the adequacy of stability analysis (Table 2). This showed that the genotypes were not only genetically variable but some of them also exhibited different response to variable environments (locations). Component analysis of environments + (genotypes x environments) were also significant. Partitioning of this variation in to Environment (linear) and non-linear component revealed that the mean square due to environment (linear) was significant for seed yield.

The significance of mean square indicated the randomness and differences of environments and these factors exercised influence on the expression of the character seed yield and this variation could have arisen due to the linear response of the regression of the genotype to the environments. The significance of mean square due to G × E (linear) revealed that the behavior of the genotypes could be predicted over the environments more precisely and accurately as the G × E interaction was the outcome of the linear function of the environmental components. The magnitude of linear component i.e. environment (linear) and genotype × environment (linear) was higher than that of the non-linear component (pooled deviation). The results of present study are similar to the ones obtained by Stafford (1982), Pathak Rakesh *et al*. (2010) [8], Jain and Patel (2012) [5] and Wankhade *et al*. (2017) [10].

The environmental indices for seed yield are presented in Table 4. The location, Main Agricultural Research Station (MARS), Raichur was the most favourable environment for the better expression of trait as revealed by high and positive environmental indice (603.26) followed by Agricultural Research Station (ARS), Gulbarga (70.893). The locations, ARS, Bidar, ARS, Hagari and College of Agriculture farm, Bheemrayangudi were most unfavorable environment due to negative environmental indices.

In the present study, stability parameters such as mean (X), regression coefficient (bi) and deviation from regression (S2di) as suggested by Eberhart and Russell (1966) [2] were considered to explain and discuss the stability of different genotypes for grain yield (Table.4).The genotype GAUG-13 recorded highest (718.33 Kg/Ha) average mean yield across locations followed by RGC-986(647.40 Kg/Ha), RGC-936-1-5 (646.70 Kg/Ha), HG-884 (635.00 Kg/Ha), HGS-563 (623.83 Kg/Ha) and HG-365 (619.07 Kg/Ha) across locations. According to Eberhart and Russell (1966) [2] model, a stable variety is one which has above average mean yield, a regression coefficient of unity (bi=1) and non significant mean square for deviations from regression (S^2 *di*=0). High value of regression (*bi*>1) indicates that the variety is more responsive for input rich environment, while, low value of

regression (*bi*<1), is an indication that the variety may be adopted in poor environment. The phenotypic stability of genotypes was estimated by mean performance over years (X), the regression coefficient (b) and deviation from regression.

Based on stability parameters the genotypes RG-936-1-5-1 (646.70 Kg/Ha) and HG-884 (635.00 Kg/Ha) recorded mean yield above the overall mean along with regression value nearer to unity (*bi*= 1.07) and (bi= 1.06) and non significant deviation from regression (S^2di = -2277.91) and (S^2di = -4651.56) respectively, indicating the high stability and wider adaptability across the environments (Table 4). Similarly, Pathak Rakesh *et al*. (2010) [8], Jain and Patel (2012) [5] and Wankhade *et al*. (2017) [10] also reported stable genotypes of gum guar having recorded mean yield above the overall mean along with regression value nearer to unity (*bi*=1) and non significant deviation from regression (S^2 *di*= 0). Genotypes RGC-936, RGC-1031 and Gourishankar-15 are less stable and genotype Gourishankar-9 is highly stable and is adapted to low performance environments. Genotypes adapted to high performance environments are GAUG-13 with low stability and HG-563, RGC-986 and HG 365 with high stability.

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