



Interpretation of genotype x environment interaction and stability analysis for grain yield of pigeon pea (*Cajanus cajan* L.)

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Abstract: Fourteen pigeon pea (*Cajanus cajan* L.) genotypes were evaluated for their yield performance at two locations during kharif season of 2009-10 and 2010-11. A significant genotypic difference for yield character was observed. Highly significant genotype–environment interaction indicated differential response of the genotypes to the environmental changes. The stability analysis showed significance of linear component of variation for grain yield. The genotypes TJT-501 (1728.667Kg/Ha) and GRG-2009-3 (1570.000 Kg/Ha) exhibited low mean performance along with regression value nearer to unity ($b_i=1$) and non significant deviation from regression ($S^2_{di}=0$) indicating, the high stability and wider adaptability across the different environments. The genotype ICPH-2671 (3134.833 Kg/Ha) exhibited highest mean value and regression value ($b_i>1$) and non significant deviation ($S^2_{di} < 0$). But genotypes JKM-197 (3072.667 Kg/ha), GRG-2009 (29993.167 Kg/ha), TS-3R (2823.333 Kg / Ha) and ICP-8863 (2740.417 Kg/Ha) exhibited high mean performance but higher regression value ($b_i>1$) and significant deviation ($S^2_{di} < 0$) value indicating adapted for high performance environments showing these genotypes are sensitive to environments and give maximum yield when inputs are not limited.

Keywords: *Cajanus cajan*, Environment interaction, Genotype, Pigeonpea, Stability

INTRODUCTION

Pigeonpea (*Cajanus cajan*.L.) is the important grain legume. It is cultivated in varied agro climatic conditions ranging from moisture stress and input starved conditions to irrigated conditions. Selection and yield testing are the two major phases of varietal development and the later one is highly influenced by the locations and years of testing. The genotype x environment (G×E) interactions can be defined as differential phenotypic response of genotypes to environmental changes and quantified using several procedures, all of which are based on evaluation of genotypes under multiple environments (Tolessa, *et. al*, 2013). The final yield of a genotype is determined by interaction of genotype with prevailing environment. By providing suitable environment, the maximum yield potential from a particular crop variety can be released. Hence, it is, necessary to determine the environment which may allow full expression of genes controlling the quantitative traits. To plan the future breeding program, to determining the environment and number of tests to be conducted for evaluation of the prepotency of the breeding material developed, the degree of genotype environment interaction involved in the expression of given characters is very much important (Thanki *et al.*, 2010).

Stability is the ability to show a minimum interaction with the environment (Eberhart and Russell,1966).

Hence, the stability of genotype performance is directly related to the effect of G x E (Campbell and Jones, 2005). The adaptability of a variety over diverse environments is usually tested by the degree of its interaction with different environments under which it is tested (Finlay and Wilkinson, 1963). A genotype is considered to be more adaptive/stable one, if it has high mean yield but a low degree of fluctuation in yielding ability when grown over diverse environments. A specific genotype does not always exhibit the same phenotypic traits under all environments and different genotypes respond differently to specific location (Sawargaonkar *et al.*, 2011).

Therefore, knowledge of G x E interaction and yield stability are important for breeding new cultivars with improved adaptation to environmental constraints prevailing in the target environments. The present research study was conducted to know genotype–environment interaction and to identify stable and high yielding pigeon pea genotypes under changing environments.

MATERIALS AND METHODS

Fourteen pigeon pea genotypes were evaluated at two locations *viz.*, Agricultural Research Station, Bidar, (North eastern transitional zone- 1) having medium black clay laterite soil and Agricultural Research Station, Gulbarga. (North eastern dry zone-2) consisting of deep black soil during *Kharif* 2009-10 and 2010-11 to

study the stability of seed yield. The experiments were laid out in randomized block design with three replications, keeping row and plant distance at 90 and 30 cm, respectively. Recommended package of practices were followed for raising the good crop. The crop was harvested at the time of 90 % pod maturity. Data was collected for seed yield per plot from two locations during both years and converted to Kg/ha. The data was analyzed and stability parameters were estimated as suggested by Eberhart and Russell, 1966 using computer software written in "INDOSTAT"

RESULTS AND DISCUSSION

Phenotypically stable varieties are usually sought for commercial production of crop plants. In any breeding program it is necessary to screen and identify phenotypically stable genotypes, which could perform more or less uniformly under different environmental conditions. Considering this fact in mind, the present investigation was carried out to collect information on newly developed and some released genotypes of pigeon pea which may be of great use in launching a dynamic and efficient breeding programme.

The analysis of variance for seed yield displayed significant differences among locations, years, genotypes and location x year, location x genotype and location x year x genotype interactions and significant for year x genotype interactions advocating the adequacy of stability analysis (Table 1). This showed that the genotypes were not only genetically variable but some of them also exhibited different response to variable environments (locations and years). The partitioning in pooled analysis of variance showed that genotype x environments interaction was significant (Table 1). Environment linear and genotypes x environment linear were highly significant. Ch.Sreelakshmi *et al.* (2010) and Reddy *et al.* (2011) reported highly significant genotype x environment (G x E) interaction in pigeon pea

Eberhart and Russel (1966) and Westerman (1971) emphasized that both linear (bi) and non-linear ($S^2 di$) components of $G \times E$ interaction should be considered in judging the phenotypic stability of a particular genotype. From the ANOVA table, the value for the Genotype X Environment (linear) sum of squares was not as a large portion of the $G \times E$ interaction, when compared with the environment E (linear) sum of squares and the residual. Table 1 shows the variation among the genotypes and for $G \times E$ interaction was significant. It means that genotypes exhibited different performance in different years /environments which is due to their different genetic makeup or the variation due to the environments or both.

The environmental indices for seed yield are presented in Table 2. The location, Agricultural Research Station (ARS), Gulbarga was the most favourable environment for the better expression of trait as revealed by high and positive environmental indices during both the years 2009-10 (560.526) and 2010-11 (876.642). While, the location, ARS, Bidar was the most unfavourable environment due to high negative environmental indices during both the years 2009-10 (-702.048) and 2010-11 (-735.120). Genotypes GRG-2009 (5073.333 Kg/Ha), JKM-197 (4980.000 Kg/Ha), TS 3R (4726 Kg/Ha) and ICPH 2671 (4386.667 Kg/Ha), JKM-19 (3856.667 Kg/Ha) and GRG-2009 (3760.000) were the promising genotypes respectively during 2009-10 and 2010-11 at ARS, Gulbarga. At Agricultural Research Station, Bidar, ICP-8863 (1786.667 Kg/Ha) followed by JKM-197 (1770.000 Kg/Ha) and ICP-85063 (1746.667 Kg/Ha) were promising genotypes in the year 2009-10 and in 2010-11, promising genotypes were ICPH-2671 (1782.667 Kg/Ha) followed by JKM-197 (1684.000) and ICPL-87119 (1613.667 Kg/Ha) (Table 2).

According to Eberhart and Russell (1966) model of stability analysis, a stable variety is one which has above average mean yield, a regression coefficient of

Table 1. Pooled analysis of variance for seed yield of pigeon pea.

Source of variance	DF	Sum of squares	Mean sum of squares	F ratio
Replication with error	8	274555.66991	34319.45874	0.195
Genotype	13	30962797.65511	2381753.66578 ***	13.500
Environment + (Genotype × Environment)	42	50937514.12359	1212797.95532 ***	6.874
Environment	3	29623483.26006	9874494.42002 ***	55.968
Genotype × Environment	39	21314030.86353	546513.61189 **	3.098
Environment (Linear)	1	29623483.26006	29623483.26006 ***	167.903
Genotype × Environment (Linear)	13	16373940.32422	1259533.87109 ***	7.139
Pooled deviation	28	4940090.53931	176431.80498 ***	4.202
Pooled error	104	4366589.27686	41986.43535 ***	
Total	55	81900311.77870	1489096.57779 ***	

* Significance at 5% level; ** Significance at 1% level

Table 2. Mean performance (seed yield, Kg/Ha) of pigeon pea cultivars over the environments.

Genotype	ARS, Bidar		ARS, Gulbarga		Mean	bi	S ² di
	2009-10	2010-11	2009-10	2010-11			
TS-3 (R)	1616.667	1590.000	3360.000	4726.667	2823.333	1.760	126953.818
JKM-197	1770.000	1684.000	3856.667	4980.000	3072.667	1.913	27606.959
GRG-2009	1636.667	1502.667	3760.000	5073.333	2993.167	2.033	74918.703
ICP-8863	1786.667	1425.000	3070.000	4680.000	2740.417	1.664	283297.442
ICPL-87119	1363.333	1613.667	3343.333	4006.667	2581.750	1.533	-10659.274
ICPH-2671	1650.000	1782.667	4386.667	4720.000	3134.833	1.951	-11090.615
ICP-85063	1746.667	1609.000	3063.333	630.000	1762.250	-0.066	1453218.351
GRG-2009-1	1383.333	1175.000	2015.000	1824.000	1599.333	0.422	-5111.376
GRG-2009-3	1053.333	1153.333	1891.000	2182.333	1570.000	0.655	-35930.734
TAT-9903	1270.000	1158.333	1977.000	1882.000	1571.833	0.480	-23600.320
JKE-114	1076.667	960.000	2020.000	1693.333	1437.500	0.546	24747.483
TJT-501	1240.000	991.667	2313.333	2369.667	1728.667	0.839	-18168.149
GC-11-39	980.000	1250.000	839.697	1252.000	1080.424	-0.018	21322.018
ICPL-87	686.667	901.667	1040.000	1341.667	992.500	0.290	-17602.156
Environmental index	-702.048	-735.120	560.526	876.642			
CV %	15.240	14.448	20.482	12.216			
CD @ 5 %	351.882	325.569	906.905	605.729			

unity (bi=1) and non significant mean square for deviations from regression (S²di=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 TJT-501 (1728.667 Kg/Ha) and GRG-2009-3 (1570.000 Kg/Ha) exhibited low mean performance along with regression value nearer to unity (bi=1) and non significant deviation from regression (S² di=0) indicating the high stability and wider adaptability across the environments. Similarly, Ch.Sreelakshmi *et al.* (2010) in their studies on genotype X environment interaction and stability in white seeded Pigeon pea found genotypes ICPL 6628, ICPL-7527 and ICPL-7534 showed stable performance across environments.

The genotype ICPH-2671 (3134.833 Kg/Ha) exhibited highest mean value and bi values (bi>1) and non significant deviation (S² di<0) but genotypes JKM-197 (3072.667 Kg/ha), GRG-2009 (29993.167 Kg/ha), TS-3R (2823.333 Kg/Ha) and ICP-8863 (2740.417 Kg/Ha) exhibiting high mean performance but bi>1 and significant deviation (S² di < 0) value indicating adapted for high performance environments (Table 2). Similarly, Patel, *et al.*, (2009) reported pigeonpea genotypes SKNP-9264 and SKNP-9256 had high mean and significant deviation (S²di<0) in their study.

Conclusion

It was concluded that none of the genotypes studied was found superior for all yield in all the environments. The genotypes TJT-501 and GRG-2009-3 exhibited low mean with regression value nearer to unity and non significant deviation from regression indicating, high stability and wider adaptability. Genotypes JKM-197, GRG-2009, TS-3R and ICP-8863 exhibiting higher mean and regression value and significant deviation value, but the genotype ICPH-2671 exhibited highest mean and regression and non significant deviation value indicating adapted for high performance environments. The stable genotypes identified could be used as parents in future breeding programme for developing suitable genotypes with wider adaptability.

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