Int.J.Curr.Microbiol.App.Sci (2020) *9*(4): 1990-1995

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 4 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.904.238

Genotype X Environment Interaction and Stability Analysis in Pigeonpea [*Cajanus cajan* (L.) Mill sp.]

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Keywords

Stability, Genotypes, Environment

Article Info

Accepted:
15 March 2020
Available Online:
10 April 2020

A B S T R A C T

Twenty one pigeonpea genotypes were evaluated at four environments during *kharif* 2018-19, to study genotype × environment interaction for yield and its contributing traits. The experiment was laid out in randomized block design with three replication. Analysis of variance in each environment and on a pooled basis expressed a significant difference among genotypes for yield and yield contributing characters except for branches per plant and seeds per pod. Environment (linear) interaction component was significant for all the traits. Highly significant genotype-environment interaction indicated differential response of the genotypes to the environmental changes. The variance due to pooled deviation (non-linear) was highly significant for all the characters except for pods per plant and seeds per pod which reflect considerable amount of genetic diversity in the material. The genotypes GJP 1606 and GJP 1601 were high yielding and stable across environments for seed yield per plant.

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is the important grain legume which occupies a major place in dietary requirement. It is cultivated in varied agro climatic conditions ranging from moisture stress and input starved conditions to irrigated conditions. In India, this crop occupies 4.43 million hectare area with total production of 4.25 million tones (Directorate of Economics and Statistics), where as in the world, it occupies an area of 7.02 million hectare with total production 6.80 million tones having productivity of 969 kg/ha respectively (FAO STAT). Gene action and phenotypically stable genotypes are of great importance, because the environmental conditions vary from region to region. The stability is the consistency in performance of a variety over a wide range of environments (Singh and Chaudhary, 1985). Genotype may react to variable environments in such a way that its development is buffered against environmental variations and more or less similar phenotype is produced under varying environmental conditions. Thus, stability depends upon the relative insensitivity of a genotype to varied environments. Wide adaptation to the particular environment and consistence performance of recommended varieties/ hybrids are very important for successful cultivation of pigeonpea. Pigeonpea breeders look forward for widely adopted genotypes responsive to input intensive as well as input deficient agriculture in order to enhance production and productivity of the crop. With this back ground the present study was undertaken under at three different locations to identify stable genotypes of pigeonpea for seed yield and other component.

Materials and Methods

Experimental material for the present study consists of twenty one pigeonpea genotypes grown in randomized complete block design with 3 replications during *kharif* 2018-19 at Sardarkrushinagar, Junagadh, Navsari and Vadodara. Each plot consisted of six rows of 4 m length with spacing of 60 x 20 cm. All recommended agronomic practices were followed to raise the normal crop at each location. Observations were recorded on five randomly selected plants of each genotype in each replication for various characters i.e. plant height (cm), number of branches per plant, number of pods per plant, pod length (cm), Number of seeds per pod, 100-seed weight (g), seed yield per plant (g), Days to flower on the basis of 50 per cent plants of each genotype flowered and days to maturity, on the basis of 80 per cent plants of each genotype matured were recorded. The replication wise mean value of each genotype for various characters was used for statistical and genetical analysis. The statistical analysis for G X E interaction and stability parameters was carried out according to the method of Eberhart and Russell (1966). The following assumptions according to Finley and Wilkinson (1963) and Eberhart and Russell (1966) were considered for finding stable genotype for different characters. (i) above average yield in all locations, (ii) regression coefficient (bi) is near '1'(bi = 1) and (iii) deviation from regression (s^2 di)is as small as possible to '0' (s^2 di = 0). Genotype superior for favorable environment having higher than average mean, significant bi above the unity and least s^2 di (s^2 di = 0), whereas for poor environment having higher than average mean, significant bi lower the unity and least s^2 di ((s^2 di = 0).

Results and Discussion

Pooled mean sum of squares values for different quantitative characters over three environments (Table 1) showed that the mean differences among genotypes and environments were highly significant indicating that genotypes possessed significant amount of variation for these traits confirming random and variable nature of environments selected, which influenced the expression of these traits. These results were similar to the earlier findings of Patel *et al.,* (2009). All the traits showed significant differences due to environment, indicating that all the locations were highly variable. Partitioning of this variation into linear and non-linear components exhibited that mean square due to environment (linear) were highly significant for important traits under study. It suggested that environments were random and different and they reflected the expression of these traits and this variation could have arisen due to the linear response of the regression of the cultivars to the environments. The G x E (Linear) interaction revealed significant differences for pods per plant, days to maturity, branches per plant and hundred seed weight indicating that phenotypic performance of the genotypes was predictable for these characters. The same trend was also observed by Singh *et al.*, (2015).

Phenotypic stability was estimated on the basis of three parameters namely; mean performance over years (x), regression coefficient (bi) and deviation from regression (S^2di) as suggested by Eberhart and Russell (1966). The estimation of stability for yield and its attributing traits is depicted in Table 2. High value of regression (bi>1) indicates that the variety is more responsive to the rich input environments, whereas low value of regression coefficient (bi<1) indicates that the variety may be suitable in poor environment. Based on stability parameters the genotypes viz., SKNP 1413, BDN 2 and GJP 1715 were found to be stable for days to 50% flowering as indicated by non significant deviation from regression and regression coefficient (bi=1). The genotypes AAUVT 15-13, GJP1508 and GJP 1606 showed low mean, bi>1 and less deviation from regression were identified as desirable and stable for days to maturity. The similar results were also reported by Reddy *et al.*, (2011). Genotypes viz., SKNP 1614, AAUVT 15-13 and GJP 1303 had highest mean number of pods among 21 tested genotypes while genotypes BP 15-11, AAUVT 13-20 and BP 17-11 recorded highest pod length. Genotypes BP 17-11, GJP 1 and GJP 1721 showed highest test weight. These characters are important as they contribute directly towards final product i.e. grain yield.

The genotype GJP 1606 showed highest mean performance for grain yield per plant, with regression coefficient (bi=0.996) and non significant deviation from regression. This indicated that this genotype is stable across all the environments and it can be recommended for cultivation in variable conditions. Further genotype AAUVT 15-13 and Genotype SKNP 1614 showed high mean grain yield with regression coefficient greater than one indicating suitability of these genotypes to specific environments. Similar results were also observed by Sreelakshmi *et al.*, (2010).

Table.1 Pooled MSS values for different quantitative characters over three environments

Characters	Genotypes X Environment	Genotypes	Environments	Genotypes X Environment (Lin.)
Days to 50 % flowering	12.735**	56.487**	1,378.663**	8.041
Days to 80 % maturity	21.739**	43.985*	5,646.175**	42.237**
Plant height (cm)	78.475	969.340**	13,071.100**	75.411
Branches per plant	1.037	1.304	386.861**	1.448*
Number of pods per plant	412.792	465.796**	18,595.833**	894.329**
Pod length (cm)	0.096	0.342**	2.957**	0.075
Number of seeds per pod	0.129	0.283*	0.879**	0.061
100 seed weight (g)	0.226**	2.581**	6.819**	0.318*
Yield kg per Ha.	70,073.415*	211,051.608**	8,817,934.166**	40,194.585

Table.2 Mean stability parameters in 14 advanced genotypes of pigeon pea

Traits	Days to 50 % flowering			Days to 80 % maturity			Plant height (cm)		
Genotypes	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
VAISHALI (C)	116.500	0.795	4.176	165.417	0.831	23.118	158.333	0.824	145.009
AAUVT 13-35	114.667	0.990	2.062	165.750	1.252	1.190	175.017	0.904	-4.307
GJP 1606	120.833	1.279	16.639	171.917	1.025	1.350	173.750	0.901	-19.304
SKNP 1413	118.167	1.018	1.183	170.250	0.975	-1.447	172.950	1.124	-2.887
AAUVT 15-06	114.917	1.113	4.928	165.167	1.307	7.646	169.767	1.191	-4.594
AGT 2 (C)	107.750	1.043	24.106	161.583	1.324	13.377	170.983	1.351	-13.534
GJP 1508	116.083	1.057	14.173	169.583	1.018	-0.891	181.633	1.181	18.759
GJP 1 (C)	124.583	1.307	30.082	169.417	0.375	6.849	167.433	1.045	5.482
SKNP 1315	118.167	1.038	-0.100	168.500	0.834	7.440	159.067	0.834	-17.317
GJP 1303	119.583	1.071	13.219	171.750	0.837	6.500	150.533	0.871	286.001
BDN 2 (C)	112.667	1.027	45.252	167.000	1.166	18.130	138.217	0.566	-20.624
AAUVT 13-20	115.083	1.316	1.285	168.833	1.160	-1.555	177.500	1.088	-19.945
GJP 1601	117.583	1.203	2.629	170.083	0.839	0.339	151.550	0.973	17.155
GJP 1715	117.917	1.027	10.288	167.917	0.805	1.339	168.583	0.623	164.548
SKNP 1617	115.333	0.836	4.734	165.167	0.993	28.822	180.800	1.260	28.189
SKNP 1614	118.583	0.595	5.314	166.333	1.132	11.329	169.267	1.165	21.681
AAUVT 15-13	113.750	0.551	9.517	165.583	1.013	30.571	177.717	1.132	132.621
BP 17-11	113.667	0.965	45.257	162.750	1.266	13.124	207.483	1.096	81.122
SKNP 1621	110.750	1.048	15.394	159.333	1.087	5.164	153.067	1.014	46.067
GJP 1721	121.417	0.871	15.431	170.667	0.697	3.790	187.033	1.056	5.576
BP 15-11	118.000	0.849	9.244	168.500	1.064	4.615	191.467	0.801	61.538

Traits	Number of branches per plant			Number of pods per plant			Pod length (cm)		
Genotypes	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
VAISHALI (C)	8.117	0.907	-0.408	191.117	1.292	-172.039	4.588	0.773	0.048
AAUVT 13-35	9.000	1.148	0.095	187.967	1.297	-241.729	5.060	1.292	-0.016
GJP 1606	8.933	1.033	-0.237	189.850	1.740	-216.676	5.007	0.195	0.001
SKNP 1413	9.517	1.138	0.663	165.600	0.642	-119.126	5.140	1.421	0.160
AAUVT 15-06	8.417	1.096	0.065	181.683	1.837	-16.410	4.805	1.100	0.121
AGT 2 (C)	7.983	0.828	0.618	190.117	2.215	-75.963	4.711	1.010	0.006
GJP 1508	9.183	1.125	-0.080	176.017	0.811	-190.630	4.970	0.457	0.110
GJP 1 (C)	9.500	1.270	0.632	188.800	1.389	-51.213	4.948	1.369	0.118
SKNP 1315	8.633	0.972	0.078	177.350	1.630	408.747	4.956	1.292	0.006
GJP 1303	8.900	1.106	0.320	193.550	1.323	-142.492	4.867	0.802	0.046
BDN 2 (C)	8.000	0.738	0.361	177.667	0.635	430.461	4.509	0.803	0.083
AAUVT 13-20	7.950	0.818	2.193	177.583	1.042	-225.316	5.413	0.776	-0.001
GJP 1601	8.583	1.007	0.140	175.000	0.618	79.862	4.951	0.525	0.322
GJP 1715	8.767	0.944	-0.238	170.017	0.433	-262.600	4.703	1.339	-0.005
SKNP 1617	8.867	1.007	-0.303	175.633	0.283	-240.718	5.213	1.423	0.183
SKNP 1614	9.283	1.140	-0.248	204.200	1.283	-204.641	4.656	1.230	0.036
AAUVT 15-13	8.833	0.969	-0.241	193.983	0.860	-156.084	5.195	0.364	0.027
BP 17-11	7.667	0.771	0.168	171.100	0.059	-240.579	5.331	1.963	0.335
SKNP 1621	8.533	1.001	0.164	168.300	0.644	-239.271	4.860	0.946	-0.016
GJP 1721	9.583	1.270	0.405	171.200	0.841	-263.023	5.039	1.004	0.004
BP 15-11	7.967	0.712	3.865	164.992	0.125	-43.429	5.736	0.917	-0.012

Traits	Number of seeds per plant			Test weight (g)			Yield (kg ha^{-1})		
Genotypes	Mean	bi	S^2di	Mean	bi	S^2di	Mean	Bi	S^2di
VAISHALI (C)	4.150	0.744	-0.107	10.053	0.729	0.138	2,016.000	0.659	42,637.109
AAUVT 13-35	4.183	0.375	-0.081	10.711	0.524	0.095	2,142.083	0.828	-9,372.957
GJP 1606	4.133	1.054	-0.073	10.497	0.331	0.155	2,183.500	0.996	904.355
SKNP 1413	4.467	1.178	0.003	10.780	1.199	0.002	1,719.083	0.853	64,991.773
AAUVT 15-06	4.167	1.846	0.065	10.149	1.542	0.399	1,932.000	1.032	56,394.037
AGT 2 (C)	4.283	0.764	-0.113	9.270	1.079	0.142	1,641.000	1.052	-12,125.465
GJP 1508	4.200	0.088	-0.079	10.481	0.889	-0.028	1,714.333	0.751	83,303.382
GJP 1 (C)	4.533	3.409	2.205	11.812	0.076	0.238	1,809.167	1.209	92,836.972
SKNP 1315	4.000	1.236	-0.099	10.721	2.101	0.240	1,754.167	0.891	-2,523.852
GJP 1303	4.000	0.703	-0.101	10.261	0.940	0.134	1,897.583	0.894	10,046.218
BDN 2 (C)	3.767	0.825	-0.097	9.455	1.099	0.066	1,418.750	0.937	9,785.240
AAUVT 13-20	4.633	0.522	-0.036	11.514	1.352	-0.037	1,921.000	0.950	273,191.676
GJP 1601	4.133	0.467	-0.074	9.716	0.861	0.092	2,097.333	1.018	6,326.577
GJP 1715	4.242	0.448	-0.043	10.152	2.271	0.041	1,932.250	1.270	15,435.595
SKNP 1617	4.300	0.814	-0.078	10.508	1.664	0.064	1,846.500	1.206	42,680.865
SKNP 1614	3.950	0.645	-0.107	9.913	0.943	0.082	2,042.083	1.201	-14,140.710
AAUVT 15-13	4.383	1.057	-0.089	11.413	0.205	-0.037	2,086.583	1.194	98,342.269
BP 17-11	4.717	1.161	-0.037	12.367	0.700	0.216	1,718.833	1.054	202,678.353
SKNP 1621	4.117	0.798	-0.112	10.606	1.179	0.178	1,387.750	0.789	151,700.194
GJP 1721	4.333	1.067	-0.066	11.753	0.936	0.487	2,013.583	1.291	215,604.599
BP 15-11	4.867	1.799	-0.104	11.113	0.380	-0.014	1,499.417	0.926	62,662.989

In general, the hybrid which found stable for grain yield also depicted stability in respect of its one or more yield component. This indicated that the stability of various component traits might be responsible for observed stability of genotypes for grain yield. The chance for selection of stable genotypes could be strengthened by selection in favour of stability in some of the yield components. Grafius (1956) also suggested that the stability of yield might be due to the stability of various yield components. The mean yield of each genotype depends on the particular set of environmental conditions. It is therefore, suggested that in order to identify stable genotype, actual testing over a wide range of environments including poor and good ones would be advantageous while making selection and attention should be paid to the phenotypic stability of traits directly related to grain yield, particularly number of pods per plant, seeds per pod, days to maturity and test weight so as to achieve maximum stability for the end product *i.e.*, grain yield in pigeonpea. From the present investigation, it may be concluded that there was no superior genotype for all the traits in all the environments. The genotype GJP 1606 was found to be stable across environments for grain yield with desirable traits such as pods per plant, pod length and test weight and can be exploited for stabilizing yield of pigeonpea in different environments.

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How to cite this article:

Patel, P. R., Manish Sharma, M. P. Patel and Patel, P. T. 2020. Genotype X Environment Interaction and Stability Analysis in Pigeonpea [*Cajanus cajan* (L.) Mill sp.]. *Int.J.Curr.Microbiol.App.Sci.* 9(04): 1990-1995. doi: https://doi.org/10.20546/ijcmas.2020.904.238