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Simultaneous selection using AMMI procedure for yield and stability of chickpea genotypes in northwest plain zone of India

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ABSTRACT

Multi-environmental trials have generally significant genotype main effects and genotype x environment interaction (GEI) effect and, therefore different univariate and multivariate stability methods have been used to study the GEI. Among the multivariate methods, the additive main effects and multiplicative interaction (AMMI) analysis is widely used for GEI investigation. This method has been effective because it captures a large portion of the GEI sum of squares; it clearly separates main and interaction effects and often provides meaningful interpretation of data to support a breeding program such as genotypic stability. Based on the AMMI model, stability index has been used to rank the genotypes. This index is the weightage of stability and yield component and higher the index value better is the genotypes. The index of 40 promising chickpea genotypes were calculated with two different weight of yield (50% and 75%) and stability component (50% and 25%). These genotypes were evaluated at seven locations *viz.*, Pantnagar, Durgapura, Ludhiana, Sriganganagar, New Delhi, Samba and Hissar representing the northwest plain zone of All India Coordinated Research Project on chickpea program during 2015-16. Ranking of genotypes are done based on two different weight of stability and yield component.

Key words: AMMI, G×E interaction, Multi-environment, Stability, Yield

Chickpea is one of the important pulse crop grown and consumed all over the world, especially in India. It is a good source of carbohydrates and protein, and has significant amounts of all the essential amino acids except sulphur-containing amino acids, which can be complemented by adding cereals to the daily diet. Most of the cultivar currently grown by farmers are characterized by unstable yields and variable maturity. It is considered as a wonder crop among smallholder farmers due to its ability to improve soil fertility through nitrogen fixation. However, shifts in rainfall patterns and seasons due to climatic change require the development of varieties suited to particular riches. Such new varieties must show high performance for yield and other essential agronomic traits and their superiority should be consistent (stable) over a wide range of environmental conditions (Becker and Leon, 1988). Yield stability between genotypes is variable due to the wide occurrence of genotype × environmental interactions (G×E) *i.e*. the ranking of genotypes depends on particular environmental conditions where they are grown (Becker & Leon, 1988). Genotype × Environment (G×E) interaction poses a continuous challenge among plant breeders and agronomists in making cultivar recommendations to farmers because of the associated consequences especially when selection is based on yield alone (Kang, 1993). This is due to lack of emphasis on both yield and stability in most breeding programs (Mekbib, 2002) as well as lack of appropriate policy in which variety are released without consideration of yield and stability simultaneously. Kang (1993) warns that cultivar recommendations made by breeders and/ or agronomists on the basis of yield alone as is conventionally done pause a serious risk to growers.

Rao and Prabhakaran (2005) developed AMMI (Additive Main Effects and Multiplicative Interaction) based selection index for that integrates both yield and stability in selecting genotypes tested across a range of environments. This study therefore aimed at identifying the varieties that have a stable performance across regions using the AMMI based selection index.

MATERIALS AND METHOD

Forty promising genotypes of chickpea in initial varietal trial were evaluated at seven locations *viz.*, Pantnagar, Durgapura, Ludhiana, Sriganganagar, New Delhi, Samba and Hisar representing the North West Plain Zone of All India Coordinated Research Project on chickpea program during 2015-16. In all locations, genotypes laid out in a Randomized Complete Block Design (RCBD) with each genotype replicated three times. In each season, experimental plots were kept free of weed by different means. Fertilizers and/or supplementary water through irrigation were applied during the trials. The threshed grain was then weighed on a plot basis to obtained plot grain yield which was later extrapolated to yield per hectare.

The AMMI model for T genotypes and S environments is given as

$$Y_{ij} = \mu + g_i + e_j + \sum_{n=1}^{n'} \lambda_n a_{in} \gamma_{jn} + \theta_{ij}$$

$$\theta_{ij} \sim N(0, \sigma^2), i=1,2,...T; j=1,2,...,S$$

The model can be reparameterized as

$$Y_{ij} = \mu + g_i + e_j + Z_{ij}$$

$$Z_{ij} = \sum_{n=1}^{n'} \lambda_n a_{in} \gamma_{jn} + \theta_{ij}$$

Let the interaction in the *(i,j)th* cell Z_{ij} and using matrix notation, denote Z= Z_{ij} a matrix of order T x S.

Where,

Y_{ij} = the mean yield of ith genotype in the j^{th} environment;

g_i = i^{th} genotypic effect;

e_j = j^{th} location effect;

λ_n = the non-zero eigen values of Z'Z or ZZ' (in descending order)

α_{in} = the principal components ofthe rows of the sum of squares and cross product matrix ZZ' and

γ_{in} = the principal components of the columns of the sum of squares and cross product matrix Z'Z

n' =the number of PCA axes retained in the model.

The stability measure $ASTAB_i$ for ith genotypes is given as

$$ASTAB_i = \sum_n^{n'} = 1 \lambda_n \alpha_{in}^2$$

A variety is considered more stable when the value of $ASTAB_i$ is lower,

The selection indices (Ij) consists of (i) a yield component, measured as the ratio of the average performance of the i^{th} genotype to the overall mean performance of the genotypes under test, and (ii) a stability component, measured as the ratio of stability information ($l/ASTAB_i$) of the it genotype to the mean stability information of all the genotypes under test. The simultaneous selection index is given as

$$I_i = \frac{\overline{Y}_i}{\overline{\overline{Y}}} + \alpha \frac{(1/ASTAB_i)}{\sum_{i=1}^{T}(1/ASTAB_i)}$$

where α is the ratio of the weights given to the stability components *(w2)* and yield (w1) with a restriction that w1+ w2= 1. The weights considered in the index are, in general, as per the plant breeders' requirement. By considering the values of á as 1.0 *(w1=w2=* 0.5), and 0.25 (w1 = 0.75, w2= 0.25).

In this study, simultaneous selection index (Rao and Prabhakaran, 2005) was used in studying the performance of chickpea genotypes in different growing areas of south zone of India.

RESULTS AND DISCUSSIONS

The presence of Genotype × Environmental interactions pause a challenge to plant breeders because it implies that the behaviour of the genotypes depends upon the particular environment in which they are grown (Ceccarelli, 1989; Hill, 1975). Thus the performance of any one of the genotypes relative to the remaining genotypes grown in the same environment will be inconsistent, such inconsistencies resulting either in alteration to the ordering of the genotypes from one environment to the next, or to changes in the absolute differences between genotypes which leave the rank order unchanged. Such interactions make utilizing data from multi-environmental trials complex (Tukamuhabwa *et al*. 2012).

Approach of exploiting the breeding objectives by analyzing and interpreting genotypic and environmental differences (Eisemann *et al.* 1990) enables researchers to identify the causes of genotype × environmental interactions and provides opportunities to address them through genetic or environmental manipulations to enhance productivity. In order to conserve resources, genotypes that are widely adaptable and with reliable performance across environments need to be identified through analysis and utilization of genotype × environmental interactions. In order to analyze genotype × environmental interactions, it is important to integrate both yield and stability of genotype performances across environments using reliable stability statistics (Kang, 1993).

The results in this study showed that genotype × environmental interactions were significant, therefore it was inappropriate to select genotypes on the basis of mean yield alone as is conventionally done (Kang, 1993) but instead both genotype yield and stability of performance were needed to evaluate genotype performance. Kang (1993) highlighted the fact that researchers who emphasize stability of performance than currently done in the selection process would benefit farmers. Farmers would have a greater risk of suffering yield losses when a variety is chosen only on the basis of mean yield alone than when selection is based on yield and stable performance. It is a fact that farmers would prefer to use a high-yielding cultivar that exhibits temporal adaptation and might be willing to sacrifice some yield if they are guaranteed, to some extent, that a cultivar would produce consistently from year to year.

Simultaneous selection index for the forty genotypes were calculated as listed below as described by Rao and Prabhakaran (2005) using SAS code and results in Table 1. Genotype CSJ855 with 3.1966 index value was best genotype followed by Phule G0616 with index value 2.7523 and Phule G13103 with index value 2.8657 when alpha=1 *i.e.* stability component w2=0.5 and yield component w1=0.5. When alpha=0.33 i.e. stability component w2=0.25 and yield component w1=0.75 genotype CSJ855 with 1.8359 index value was found best genotype followed by Phule G13103 with index value 1.6572 and AKG1201 with index value 1.6023. Hence, these genotypes and others (Table 1) may be used by the chickpea breeder for developing high

Table 1. Ranking of genotypes base on yield, stability and index

S.No.	Genotype	Yield	Yield Based Rank	Stability (ASTAB)	Stability Based Rank	Index (α=1)	Index Based Rank(α=1)	Index (α=0.33)	Index Based Rank (α=0.33)
1	GNG1958	2087	5	1297419.3	17	2.1260	14	1.4544	8
2	DCP92-3	2077	8	1105595.2	12	2.2954	10	1.5072	7
3	GNG1581	2029	9	1895207.3	29	1.7773	26	1.3175	21
4	NBeG807	1794	24	1029921.3	11	2.2305	11	1.3844	16
5	GNG2300	2313	1	2210769.7	37	1.8311	25	1.4369	13
6	PG160	1768	27	1926965.5	31	1.6258	31	1.1736	34
7	H12-26	2216	2	1711515.1	25	1.9513	19	1.4422	11
8	GJG1318	1716	30	2832183.1	40	1.3812	40	1.0735	38
9	JG74315-2	1826	22	966447.59	9	2.3307	9	1.4291	14
10	CSJ859	1784	25	1488704.4	23	1.8343	24	1.2489	25
11	RVSSG32	1721	29	1890039.5	28	1.6141	34	1.1530	36
12	AKG1201	2083	7	896249.95	5	2.5746	4	1.6023	3
13	IPC2011-141	1685	34	1884902.2	27	1.5963	35	1.1340	37
14	PBC508	1690	33	1370189	20	1.8594	21	1.2234	27
15	GL29095	1988	12	903095.42	6	2.5125	6	1.5476	5
16	PhuleG0616	1656	35	700830.73	2	2.7523	3	1.5089	6
17	BG3063	1859	18	2259508.1	38	1.5750	36	1.1894	30
18	NDG14-11	1837	21	1379404.5	21	1.9319	20	1.3001	22
19	RKG13-541	1865	17	1207481.1	13	2.0822	16	1.3605	17
20	CSJ855	2157	3	640424.8	1	3.1966	1	1.8359	1
21	NBeG806	1887	16	2433175.8	39	1.5489	37	1.1908	29
22	GL12021	2029	10	1228580.7	14	2.1511	13	1.4418	12
23	PBC507	1648	37	1355157.3	19	1.8475	23	1.2044	28
24	IPC2011-85	1783	26	1957091.5	33	1.6236	32	1.1783	33
25	AKG1109	1922	14	1933497.1	32	1.7062	29	1.2555	24
26	BG3064	1758	28	1841039.6	26	1.6520	30	1.1787	32
27	RG2009-16	1851	20	1329887.8	18	1.9750	18	1.3197	20
28	PhuleG13103	1965	13	721058.98	3	2.8657	2	1.6572	2
29	RVSSG33	1576	40	1924682.7	30	1.5237	38	1.0709	39
30	PG172	2008	11	1282190.4	15	2.0953	15	1.4157	15
31	GNG2302	2084	6	959664.65	8	2.4788	7	1.5707	4
32	RKG13-511	1856	19	958630.35	7	2.3582	8	1.4491	10
33	BDNG2015-1	1714	31	817063.45	4	2.5179	5	1.4514	9
34	BRC3	1819	23	2035296	34	1.6172	33	1.1890	31
35	DIBG201	1586	39	991568.47	10	2.1679	12	1.2890	23
36	H12-01	2104	4	2200104.6	36	1.7217	27	1.3256	19
37	GJG1320	1894	15	1283465.6	16	2.0332	17	1.3542	18
38	BRC4	1708	32	1387040.1	22	1.8575	22	1.2293	26
39	KGD12-2	1652	36	1591758.2	24	1.7065	28	1.1590	35
40	KGD12-1	1611	38	2143733.1	35	1.4734	39	1.0669	40

yielding and stable chickpea lines using simultaneous selection for yield and stability.

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