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HA 10-2 (HA 5) : Promising High Yielding Advanced Breeding Line for Use in Commercial Production of Dolichos Bean (*Lablab purpureus* L. Sweet)

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Abstract

Seven dolichos bean advanced breeding lines (ABL) along with one released pure-line variety, HA 4 were evaluated in randomized complete block design with three replications to identify those with high stability for dry seed yield ha^{-1} across years in two locations [Gandhi Krishi Vignana Kendra (GKVK) & Balagigapade) representing eastern dry zone (EDZ) of Karnataka. Pooled analysis of variance indicated significant mean squares attributable to ABL and years at both the locations. However, mean squares attributable to ABL × year interaction were non-significant at Balagigapade, which was amply reflected by high magnitude of correlation between dry seed yields of ABL evaluated in two years. Thus, ABL' performance for dry seed yield across two years was predictable and hence, regarded as stable at Balagigapade. Though means squares attributable to ABL × year interaction were significant, the capture of most of this interaction variance by the first two interaction principal components suggested the predictability of the performance of ABL at GKVK as well. The ABL, HA 10-2 (HA 5) among those evaluated was identified as the best one with high stability coupled with high dry seed yield ha^{-1} (as indicated by lower estimates of AMMI stability value and yield stability index) in both the locations. Hence, HA 5 could be used for commercial production of dolichos bean in EDZ of Karnataka.

Keywords : AMMI, bi-plot, stable, genotype by environment interaction

Genotypes very often differ in their performance in different production environments represented by temporal (year-to-year) and spatial (location-to-location) variation resulting in significant crossover genotype × year and genotype × location interactions (GLI) (Annicchirarico, 1992). From commercial crop production point of view, crop varieties should maintain consistent performance across years, referred to as stability and across locations refered to as adaptability (Lin and Binns, 1988). Concerted efforts of breeding dolichos bean at University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bengaluru, India led to the development and identification of several high yielding advanced breeding lines (ABL) through pedigree selection from population derived from HA 4 × GL 153. While HA 4 is a high yielding determinate photoperiod insensitive pure-line variety, GL 153 is an indeterminate photoperiod sensitive germplasm accessions collected from farmer's field in a village belong to Bengaluru rural district of Karnataka. Dolichos bean is one of the important grain legumes grown in southern districts of Karnataka and neighbouring districts of Andhra Pradesh, Tamil Nadu and Maharashtra. It is predominantly grown for fresh beans for use as a vegetable and for split dhal for use in various food preparations (Ramesh and Byregowda, 2016). The objective of the present study is to identify stable and high yielding dolichos bean ABL in two locations [Gandhi Krishi Vignana Kendra (GKVK) & Balagigapade) representing eastern dry zone (EDZ) of Karnataka.

Material and Methods

The material for the study comprised of eight genotypes which included seven advanced breeding lines (ABL) (HA 10-2, HA 10-8, HA 11-3, HA 12-1, HA 12-2, HA 12-3 & HA 12-5) and one released pure-line variety HA 4. While, HA 10-2 (HA 5) among the seven ABL exhibit semi-determinate growth habit and photoperiod insensitivity to flowering time (PSFT), others exhibit determinate growth habit and PSFT.

The seeds of the seven ABL and HA 4 were sown in randomized complete block design (RCBD) with three replications during 2013, 2014, 2015 and 2016 rainy seasons at GKVK, Bengaluru and during 2015 and 2016 rainy seasons at Agricultural Research Stations (ARS), Balagigapade, representing EDZ of Karnataka. The seeds of each genotype were sown in six rows of 3.6 m length with a row-to-row spacing of 0.6 m. Twelve days after sowing, the seedlings were thinned and a spacing of 0.3 m was maintained between plants within a row. Recommended management practices were followed during the crop growth period to raise a healthy crop.

Collection and statistical analysis of data: The pods borne by the plants in each of the genotypes and replication were manually harvested when they turned beige colour and sun-dried. The seeds separated from sun-dried pods from each replication were weighed separately and expressed in kg ha^{-1}. The mean dry seed yields of three replications were subjected to statistical analysis. Pooled analysis of variance was performed for detection of ABL × year interaction at GKVK for dry seed yield ha^{-1}. Rank correlation coefficient (r) between dry seed yields of the genotypes evaluated in two years in Balagigapade was estimated to detect ABL × year interaction. While less than unity but fairly high magnitude of 'r' suggest significant non-crossover ABL × year interaction, low magnitude of 'r' indicate significant crossover ABL × year interaction. Additive Main effects and Multiplicative Interaction (AMMI) model (Gouch and Zobel, 1988) was used to detect and characterize the patterns of interaction of ABL with temporal environments represented by four years in GKVK. While additive main effects of ABL and years were fitted by univariate analysis of variance (ANOVA), interaction of ABL with years was fitted by principal component (PC) analysis based on the following AMMI model.

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

Where, Y_{ij} is the dry seed yield of i^{th} ABL in the j^{th} year, μ is the experimental mean dry seed yield, g_i and e_j are the i^{th} ABL and j^{th} year mean deviation from experimental mean dry seed yield, respectively. λ_k is the squre root of eigen value of the k^{th} PC axis, α_{ik} and γ_{jk} are the interaction PC scores for k^{th} PC of the i^{th} ABL and j^{th} year, respectively and ε_{ij} is the residual. The parameters of AMMI model were estimated using least square principle implemented by GENSAT software, version 12.

Graphical (subjective) interpretation of stability of ABL: Genotype + Genotype × year (GGY)-biplot methodology which is a combination of AMMI biplot and GGE concepts (Yan *et al.*, 2000) was used for visual interpretation of patterns of ABL × year interaction at GKVK. ABL × year interaction PC1 (IPC1) scores were plotted against their IPC2 scores to visually identify ABL with high stability and similarity between genotypes and years of evaluation. The ABL that are more similar to each other in terms of their trait expression are more close to each other in the GGY biplot than those that are less similar. The ABL placed near the origin of IPCA1 *vs.* IPCA 2 biplot are regarded as highly stable across years than those located far from the origin (Crossa *et al.*, 1990).

Objective criteria to identify ABL with high stability: To facilitate an objective method of identifying ABL with high stability across years at GKVK, the AMMI stability value (ASV) was estimated (Purchase *et al*., 2000).

$$ASV = \sqrt{\left[\frac{SS\ IPC1}{SS\ IPC\ 2}(IPC1\ score)\right]^2 + (IPC2\ score)^2}$$

Where, SSIPC1 and SSIPC2 are sum of squres attributable to first two IPC's. Lower the magnitude of ASV, greater is stability of a genotype and *vice-versa* (Purchase *et al.*, 2000). To facilitate simultaneous selection of genotypes for dry seed yield and stability, yield stability index (YSI) which incorporates both mean dry seed yield and stability in a single criterion (Farshadfar, 2011) was estimated as YSI=RASV+RY (*ie.*, ranks of genotypes based on mean dry seed yield across years added to ranks of ABL based on ASV). The ABL with low YSI were regarded as high yielding and stable.

Results and Discussion

Pooled analysis of variance indicated significant mean squares attributable to ABL and years at both the locations (Table I). However, mean squares

TABLE I

Pooled analysis of variance for dry seed yield (Kg/ha) at GKVK and Balagigapade

Source of variation	Degrees of Freedom		MSS		'F' Probability	
	GKVK	Balagigapade	GKVK	Balagigapade	GKVK	Balagigapade
Replications	02	02	6078.00	16.00	0.02	0.99
Advanced breeding lines (ABL)	07	07	182703.00	57983.00	<.001	<.001
Years	03	01	467000.00	129169.00	<.001	<.001
ABL × Years	21	07	64042.00	3002.00	<.001	0.09
Pooled error	62	30	1464.00	1527.00		

attributable to ABL × year interaction were non-significant at Balagigapade, which was amply reflected by high magnitude of correlation (0.86) between dry seed yields of ABL evaluated in two years. Thus, ABLs' performance for dry seed yield across two years could be predicted with high confidence and hence regarded as stable at Balagigapade. Though means squares attributable to ABL × year interaction were significant (Table I), the capture of most of this interaction variance (82.30%) by the first two interaction principal components (Table II) suggested the adequacy of AMMI Model II with R^2 value of 94.30 per cent and hence predictability of the performance of ABL for dry seed yield at GKVK as well.

TABLE II

AMMI analysis of variance for dry seed yield (Kg/ha) at GKVK

Source of variation	Degrees of freedom MSS	MSS	'F' Prob.	% Contribution
Replications	08	2154.00	0.21	0.42
Years	03	467000.00	0.00	33.94
Advanced breeding lines (ABL)	07	182703.00	0.00	30.98
ABL × Years	21	64042.00	0.00	32.58
IPCA 1	09	90938.00	0.00	60.86
IPCA 2	07	60405.00	0.00	31.44
IPCA 3	05	20723.00	0.00	7.70
Pooled error	56	1530.00		

Graphical (subjective) and objective interpretation of stability of ABL at GKVK: Near perfect fit of IPC1 and IPC2 (92.30%) to the total ABL × year interaction variation (Fig. 1) suggested a good approximation of the bi-plot regarding patterns of ABL × year interaction and good predictability of ABL performance across four years at GKVK. The

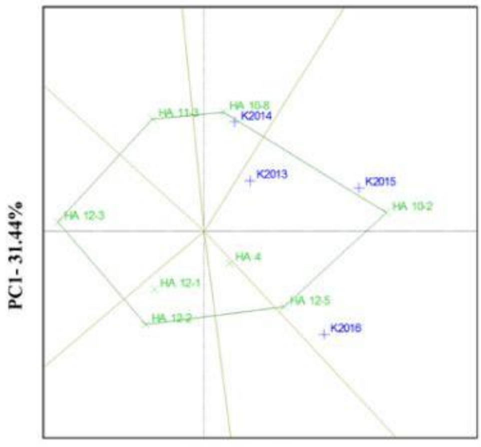

Fig. 1: GGL bi-plot showing patterns of interaction of advanced breeding lines with years

GGY bi-plot indicates that HA 5 was the highest yielder and its performance is better and similar during 2013, 2014 AND 2015 compared to that in 2016. Proximity of HA 4 and HA 12-1 to origin of HA4 GGY bi-plot suggests their high stability but they were not better performers compared to HA 5. Keerthi *et al*. (2014) have also reported that best yielders were not stable across different sowing date environment in dolichos bean. Such negative relationship between performance levels and stability could be attributed

TABLE III

Estimates of AMMI stability value (ASV) and yield stability index (YSI) of advanced breeding lines (ABLs) for dry seed yield (Kg/ha) at GKVK

ABLs	Mean	IPCA1	IPCA2	ASV	YSI
HA 5	1130.00	7.01	4.55	14.31	04.00
HA 10-8	959.20	-9.04	5.97	18.49	08.00
HA 11-3	882.50	-12.59	1.63	24.42	13.00
HA 12-1	800.20	3.42	-0.03	06.63	08.00
HA 12-2	838.80	2.20	-16.50	17.04	11.00
HA 12-3	717.20	-7.78	-3.18	15.38	12.00
HA 12-5	952.20	11.15	2.12	21.69	10.00
HA 4	887.20	5.62	5.44	12.16	06.00

HA 5 and HA 4 at GKVK (Table III). Thus, HA 5 and HA 4 with a fairly high dry seed yield and good stability could be extensively used in breeding dolichos bean pure-line varieties with high stability and high productivity. Such widely adaptable varieties are expected to contribute to sustainable dolichos bean production. Also, breeding varieties with high yield and stability is essential to increase economic returns to the farmers and hence maintain competitiveness of dolichos bean with other crops.

In both GKVK and Balagigapade, HA 5 was the highest yielder with high stability across years of evaluation (Table IV) and thus could be used for commercial production of dolichos bean in EDZ of Karnataka.

TABLE IV

Per se performance of advanced breeding lines (ABLs) for dry seed yield (Kg/ha) at GKVK and Balagigapade

ABLs	GKVK					Balagigapade			Overall Mean
	2013	2014	2015	2016	Mean	2015	2016	Mean	
HA 5	1002	990	1132	1396	1130.00	889	792	840.50	1033.50
HA 10-8	980	1010	897	950	959.25	708	639	673.50	864.00
HA 11-3	846	1077	707	900	882.50	722	653	687.50	817.50
HA 12-1	627	796	687	1091	800.25	551	494	522.50	707.67
HA 12-2	895	757	483	1220	838.75	717	521	619.00	765.50
HA 12-3	782	756	517	814	717.25	694	566	630.00	688.17
HA 12-5	803	760	939	1307	952.25	817	721	769.00	891.17
HA 4	787	747	900	1115	887.25	679	561	620.00	798.17
Mean	840	862	783	1099	896	722	618	670	820.67
SEm ±	50	64	51	60		44	49		
CD @5%	151	193	155	183		133	150		

to involvement of different sets of genes controlling *per se* performance and stability (Caligari and Mather, 1975) and trade-offs between performance and stability (Ludlow and Muchow, 1990).

Lower magnitude of estimates of ASV and YSI (which take into account both level of performance and stability) also suggested high stability of

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