DOI : 10.5958/0974-0112.2017.00006.8

Indian J. Hort. 74(1), March 2017: 11-15

Stability analysis for nut yield and component traits in cashew

K. Sethi, K. Pradhan**, K.C. Mohapatra***, P. Tripathy and P.L. Saroj*

All India Coordinated Research Project on Cashew, Directorate of Research, Orissa University of Agriculture and Technology, Bhubaneswar 751 003, Odisha

ABSTRACT

Thirteen cashew genotypes developed at different Cashew Research Stations of India, *i.e.* NRCC Sel.-1, NRCC Sel.-2, M 44/3, M 15/4, BPP 3/33, BPP 10/19, BPP 30/1, BPP 3/28, H- 303, H-320, H-255, H-367 and H-68 were planted at 7.5 m apart during 1994 at Cashew Research Station, AICRP on Cashew, Orissa University of Agriculture and Technology, Odisha. Observations on various parameters like plant height (m), trunk girth (cm), canopy spread (m), flowering laterals per meter square, average nuts panicle^{-1}, nut weight (g), apple weight (g), shelling percentage and nut yield plant^{-1} (kg) were recorded on four plants of each varieties for 14 years. Stability parameters for different characters were computed using the regression approach. There were considerable variations in yield and its contributing traits within genotypes, years and genotype × year interactions. Estimates of stability parameters revealed that no single genotype was stable for all the traits under study. The stability parameters for nut yield indicated that genotype H-320 was the most stable genotype among the group as it showed high yield *per se* performance, thus can be recommended for commercial cultivation along with regression coefficient around unity but the deviation from regression line was significantly different from zero. Whereas, BPP-3/28 and BPP-3/33 exhibited high shelling percentage with high mean performance for all vegetative growth characters, though low mean performance for nut yield, which can be utilized as parent in crop improvement programme with special reference to increase shelling percentage.

Key words: Cashew, G × E interaction, nut yield, shelling percentage, stability analysis.

INTRODUCTION

Cashew (*Anacardium occidentale* L.), a member of Anacardiaceae family, is native of Brazil and introduced to India by Portuguese during Sixteenth century. Presently, total cashewnut production in the country is 7.28 lakh tonnes from an area of 9.82 lakh ha with productivity of 772 kg ha^{-1} (Saroj *et al.*, 10). There is a wide gap between the present level of productivity (722 kg/ha) and potential productivity (2 tonnes ha^{-1}). This is practically due to large scale senile plantation of old as well as inferior varieties and non adoption of scientific management practices in traditional cashew growing areas of the country. In fact, the poor nut yield levels remains a major challenge to both the producer as well as processor in cashew industries around the world in general and India in particular. Therefore, development of stable high yielding varieties to improve nut production will play a very vital role in achieving sustainability in cashew production. In general, there is a lack of information on cashew genetic resources to exploit them in crop improvement programme (Dhanraj *et al*., 4; Aliyu and Awopetu, 1; Desai *et. al*., 3). Further, information on performance of cashew genotypes in different environments, *i.e.* G × E that could influence the phenotypic stability is not available. Therefore, it is very essential to identify superior genotypes exhibiting improved adaptation in general or specific environments. The study of stability in performance of a genotype is the most important factor to measure genotype × environment interaction before it is released for wide cultivation. An array of techniques is available for the study of genotype × environment interaction such as an analysis of variance, linear regression, multivariate analysis, ranking and other parametric tests. The multivariate statistics which includes the AMMI (additive main effect and multiplicative interaction) is now widely accepted but the mathematical complexity still makes the univariate methods a preferred choice. One of the methods commonly used, is a conventional analysis of variance followed by a joint regression analysis. This technique was first proposed by Yates and Cochran (11) later modified by Finlay and Wilkinson (7) and was further refined as well as adopted by other workers (Eberhart and Russell, 5). A major advantage of this technique is that it provides a visual picture as well as a summary and thus the approach is favoured because of its inherent appeal. The present study was carried out to determine the magnitude of G × E interaction variation in cashew for yield and its yield attributing characters, thereby determining

*Corresponding author's present address: ICAR-Central Institute of Arid Horticulture, Bikaner, Rajasthan; E-mail: plsaroj@yahoo.co.in
**Dept. of Plant Breeding and Genetics, OUAT, Bhubaneswar, Odisha
***Dept. of Fruit Science and Horticulture Technology, OUAT, Bhubaneswar, Odisha

stability of genotypes over different years in a given location. Hence, the most stable genotype could be recommended for cultivation and it can also be used as parent in breeding programmes for its existing genetic potential.

MATERIALS AND METHODS

The investigation was carried out at Cashew Research Station operating under AICRP on Cashew of OUA&T, Bhubaneswar, Odisha during 1994 to 2011. The experimental area is located 25.5 m above mean sea level at 20° 15' North latitude and 82° 52' East longitudes. The soil of experimental site is red lateritic with pH ranges from 5.0 to 5.3. Average annual rainfall of the region is 1380 mm. The mean minimum and maximum temperatures are 15° and 40°C, respectively. The mean humidity ranges from 42 to 85%. Thirteen genotypes developed at different Cashew Research Stations of India, *viz.*, NRCC Selection-1, NRCC Selection-2 (DCR, Puttur, Karnataka); M-44/3, M-15/4 (Vridhachalam, Tamil Nadu); BPP- 3/33, BPP-10/19, BPP-30/1, BPP-3/28 (Baptala, Andhra Pradesh) and H-320, H-255, H-367, H-68 (Vengurle, Maharashtra) were planted at 7.5 m apart during 1994 for the present study. Each treatment comprised of four plants of similar age group. The experiment was laid out in Randomized Block Design and replicated thrice. The plantation was raised under rainfed conditions and all recommended package of practices were adopted uniformly including nutrition (500:250:250 g NPK/ plant/ year) and plant protection measures. Observations on various parameters like plant height (m), trunk girth (cm), canopy spread both in East-West and North-South (m), flowering laterals per meter square, average nuts panicle^{-1}, nut weight (g), apple weight (g), shelling percentage and nut yield plant^{-1} (kg) were recorded on four plants of each varieties for 14 consecutive years. Stability parameters for different characters were computed with regression approach (Eberhart and Russell, 5) using statistical software (SPAR-2).

RESULTS AND DISCUSSION

The results obtained during the course of this investigation have been put to stability analysis and presented in Table 1. The data on analysis of variance revealed significant difference among genotypes and environments for all the traits studied suggesting the presence of variability among genotypes as well as environments. Significant mean squares for genotype × environment interactions were observed for all the traits indicating inconsistent phenotypic response of the tested genotypes across the temporal environments, which may cause selection made in one environment to perform poorly in other environments (Romagosa and Fox, 9). However, a proper dissection of the G × E interaction often leads to identification of genotypes possessing either specific or broad adaptation. Besides, this ensures that genotypes are recommended for where they are best suited, thereby alleviating unpredictable performance (Dashiell *et al.*, 2). Significant mean squares due to environment (linear) indicated considerable differences among environments and their predominant effect on all the traits. Genotype × Environment (linear) interaction was significant for all the traits emphasizing the importance of linear regression in the prediction of these traits with some reliance under different environments. The mean square due to environment + (genotype × environment) was significant for all the traits. It showed that there was considerable

Table 1. Analysis of variance for stability in cashew nut.

Sources of variation	df	Mean square values									
		Plant height (m)	Trunk girth (cm)	Canopy spread (E-W) (m)	Canopy spread (N-S) (m)	Flowering laterals per m^2	Nut wt. (g)	Nuts/ panicle	Shelling (%)	Apple wt. (g)	Nut yield/ plant (kg)
Genotype	12	3.41**	1506.79**	14.15**	13.14**	56.16**	23.8**	5.96**	6.63**	2728.34**	39.57**
Environment	13	17.82**	6667.46**	56.08**	55.64**	280.09**	1.62**	1.13**	3.98**	739.96**	22.08**
G × E	156	0.05**	15.99**	0.13**	0.18*	14.55**	0.27**	0.31**	0.9-	91.88**	2.58**
Env. + (G × E)	169	1.41	527.64	4.43	4.44	34.98	0.37	0.37	1.14	141.73	4.08
Env (linear)	1	231.74	86677.34	729.08	723.34	3641.29	21.13	14.71	51.77	9619.41	287.05
G × E (linear)	12	0.39**	166.92**	0.96**	1.35**	31.93**	0.48**	0.75**	1.85**	206.66**	8.86**
Pooled deviation	156	0.02	3.15	0.05	0.07	12.1**	0.23**	0.25**	0.76**	75.98**	1.9**
Pooled error	364	0.02	4.71	0.06	0.11	3.01	0.06	0.14	0.46	13.27	0.22

**Significant at 1% level

interaction of genotype with environment in different years. Significant pooled deviations for all the traits indicated predominance of non linear component in the manifestation of genotype × environment interaction.

As per the Eberhart and Russell model, a variety is considered to be stable if it shows high mean performance with unit regression co-efficient (bi = 1) and minimum deviation (non-significant) from the regression line ($S^2di = 0$). Estimation of stability parameters (Table 2) revealed that no single genotype was stable for all the traits in the present study. The stability parameters for nut yield indicated that genotype H-320 followed by H-367 and BPP-3/33 were the stable genotypes among the group as they showed high *per se* performance

Table 2 (a). Stability parameters of cashew genotypes for vegetative traits.

Genotype	Plant height (m)			Trunk girth (cm)			Canopy spread (E-W) (m)			Canopy spread (N-S) (m)		
	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di
NRCC Sel-1	4.92	1.13	0.025	68.36	0.88	-3.18	6.87	1.21	0.07	7.87	1.11	-0.08
NRCC Sel-2	4.36	1.04	-0.006	67.21	0.99	-2.45	7.51	1.13	-0.005	7.44	1.11	-0.06
M 44/3	4.45	0.83	-0.009	58.31	0.63	-0.64	5.79	0.80	-0.004	5.84	0.95	-0.05
M 15/4	4.77	0.89	-0.012	69.05	0.97	-0.93	7.73	0.91	-0.013	8.02	1.03	-0.07
BPP 3/33	5.65	1.04	0.006	83.31	1.16	-1.83	8.53	0.92	0.006	8.73	0.96	-0.05
BPP 10/19	5.38	0.95	-0.002	82.07	1.06	-0.92	9.02	0.94	0.006	9.14	1.07	-0.07
BPP 30/1	5.13	0.74	0.003	79.52	1.09	-2.25	8.44	0.90	-0.002	8.41	0.93	-0.06
BPP 3/28	5.52	0.92	-0.005	79.18	1.05	-1.67	9.1	1.05	-0.035	8.93	0.98	-0.09
H 303	5.5	0.87	-0.014	69.79	0.89	2.18	8.7	1.03	-0.023	9.23	1.14	-0.06
H 320	5.27	1.31	0.022	65.45	1.07	-2.87	8.88	1.05	0.041	9.08	1.18	-0.01
H 255	5.97	1.06	-0.01	99.44	1.28	0.87	9.36	0.93	0.003	9.52	0.86	-0.15
H 367	5.29	1.09	0.003	73.61	0.94	-3.21	8.54	0.85	-0.053	8.2	0.58	-0.09
H 68	5.79	1.08	-0.009	74.45	0.92	-3.32	8.44	1.21	-0.034	8.41	1.05	-0.06
SE(m) ±	0.04	0.03	NS	0.49	0.02	NS	0.07	0.10	NS	0.07	0.04	NS

Table 2(b). Stability parameters of cashew genotypes for yield and yield attributing traits.

Genotype	Flowering laterals/ m^2			Nut wt. (g)			Nuts/ panicle			Shelling (%)			Apple wt. (g)			Nut yield/ plant (kg)		
	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di	Xi	bi	S^2di
NRCC Sel -1	17	0.74	11.17	7.97	1.57	0.08	2.1	1.2	-0.03	30.64	0.38	-0.26	65.6	0.6	63.9	3.1	0.97	1.21
NRCC Sel -2	21.5	1.27	0.46	8.82	0.76	0.18	2.8	0.54	0.11	29.95	0.76	0.02	69.0	1.27	54.1	6.87	2.13	2.89
M 44/3	24.8	1.57	11.09	5.49	-0.26	0.04	4.1	-0.41	0.04	29.16	1.26	-0.16	33.5	-0.05	3.54	2.68	0.4	0.18
M 15/4	21.3	1.17	10.93	6.89	1.37	0.43	2.3	1.88	0.22	29.81	1.83	0.21	59.4	1.01	12.5	2.52	0.35	0.33
BPP 3/33	21.4	1.54	22.38	6.51	1.06	0.31	2.8	0.13	0.01	30.9	2.1	1.5	56.4	1.3	136.9	4.23	0.98	0.36
BPP 10/19	19.2	0.8	6.68	6.44	1.14	0.07	2.7	0.92	-0.03	29.59	0.83	0.10	55.1	1.0	23.65	3.22	0.67	0.38
BPP 30/1	20.7	0.77	9.58	6.31	1.48	0.21	3.8	0.83	0.41	28.83	2.18	1.23	45.2	1.44	32.9	5.10	0.44	3.02
BPP 3/28	18.6	0.64	18.73	7.67	1.22	0.22	2.9	1.03	0.16	30.19	1.32	-0.08	62.1	1.28	65.17	3.94	0.6	2.03
H 303	21.3	0.55	3.42	8.3	1.35	0.41	3.2	0.31	0.06	29.64	0.72	0.57	60.2	0.1	105.7	7.42	1.79	1.09
H 320	21.5	1.14	4.82	8.2	1.38	0.02	2.7	0.96	0.27	29.19	0.38	0.65	66.2	1.21	43.5	5.59	1.24	4.56
H 255	21.9	0.64	11.21	9.45	1.19	0.31	1.8	2.86	0.16	30.61	0.51	-0.18	68.7	0.7	42.4	2.72	0.34	0.59
H 367	23.4	1.06	6.36	9.86	0.25	0.00	2	1.32	0.09	28.76	0.51	-0.19	94.1	1.6	156.4	4.65	1.01	2.71
H 68	22.2	1.05	1.29	8.25	0.45	-0.50	2.7	1.73	-0.08	30.02	0.16	-0.48	64	1.6	74.08	6.46	2.03	2.45
SE(m) ±	0.96	0.21		0.13	0.38		0.1	0.47		0.24	0.44		2.42	0.32		0.96	0.21	

along with regression co-efficient around unity but the deviations from the regression line were significantly different from zero. A high value of S^2di indicates a more significant deviation from regression and unsatisfactory stability of the studied genotypes. Significant S^2di is less important than bi in heterozygous genotypes (Fakorede and Mock, 6) like cashew. The genotype H-303 exhibited the highest *per se* performance followed by NRCC Sel.- 2 and H-68 but regression co-efficient was above unity with significant S^2di, indicating adaptability of these genotypes (high sensitivity, below average stability) to favorable environment, *i.e.* climatic factor of a year. Rest of the genotypes was unsuitable with low mean performance, bi< 1 and significant S^2di.

For nut weight only genotype H-320 exhibited high nut weight with regression co-efficient around unity and S^2di non-significant. Thus, H-320 was considered to be stable genotype for exhibiting large nut weight over the years. The genotypes like H-255, H-303 and NRCC Selection- 2 exhibited large nut weight, bi around unity but significant S^2di, which implies the predominance of environment effect on these genotypes. High mean performance of H-367 and NRCC Selection-1 for nut weight was observed. But bi value >1 of NRCC Sel.-1 implies high sensitivity and adaptability to favourable environmental years and bi <1 of H 367 implies greater resistance to environmental changes and adaptation to unfavourable environmental years.

Highest number of nuts panicle^{-1} exhibited by M-44/3 and it was suitable to unfavorable environmental condition. Genotype BPP-30/1 with more number of nuts panicle^{-1}, exhibited bi around unity and significant S^2di, was less predictable for its stability. Genotype H-303 produced more number of nuts panicle^{-1}, but bi<1 with S^2di=0 implies its adaptability to unfavorable environment. The high yielding stable genotype, H-320 exhibited less number of nuts panicle^{-1} but stable over years. The apple weight was not predictable due to significant S^2di, for all genotypes under study. NRCC Selection-2, H-320 and H-255 exhibited high apple weight, which was stable over the environments. H-367 and H-68 were adaptable to favourable environmental condition for high apple weight.

Among all the genotypes, H-68 was predictable for its stability in exhibiting more number of flowering laterals with high mean performance and non-significant S^2di. M-44/3 exhibited the highest number of flowering laterals adaptability to favorable years. The only genotype exhibited consistently high, stable and predictable shelling percentage was BPP-3/28. Other genotypes such as NRCC Sel.-1, H-255 and H-68 exhibited high and stable shelling percentage over years but adaptable to unfavourable environment. BPP-3/33 exhibited high shelling percentage and adaptable to favourable environment.

For all vegetative growth characters like plant height, trunk girth, canopy spread in E-W and N-S, all most all the genotype can be predicted due to non significant S^2di. A good number of genotypes were found to be stable in canopy spread East-West direction, while few genotypes were stable for their canopy spread in North-South direction. BPP-3/28 and BPP-3/33 were stable in canopy spread in all directions. All the genotypes were unstable for plant height and trunk girth due to their growth over environment (years). Genotypes BPP-3/33, BPP-10/19, BPP- 3/28 and H-255 exhibited good growth for both plant height and trunk girth. BPP-30/1 exhibited high trunk girth without corresponding increase in plant height. H-303, H-320, H-367 and H-68 were increased in plant height over years without increase in corresponding trunk girth. This indicates the genotypic improvement of cashew in plant architecture at Vengurle (Maharashtra) and Baptala (Andhra Pradesh) are different.

Since none of the genotypes was found suitable for the entire yield and its component traits over all the years, the correlation studies of the traits would further reveal the traits which are more related to yield and with stable genotype. None of the traits were found significantly correlated with yield (Table 3). However, with yield, highest correlation coefficient r = 0.364 was observed by nut weight among all the component traits followed by canopy spread in east-west direction and apple weight. Correlation coefficient of nut weight was significantly negative with nuts per panicle and uncorrelated with shelling percentage. This finding suggested that any positive increase in nut weight will give kernel of large size. Large kernel being the most economic and quality trait of cashew, indirect selection for large nut size is desired in the breeding programme. Strong positive correlation of nut weight with apple weight suggested that selection of genotype stable for nut weight and apple weight as well as nut yield would lead to identify the best performing one for future use. All the four vegetative traits exhibited strong positive correlations out of which only trunk girth was negatively related with yield.

The present study indicated that genotype H-320 with high mean, stable and predictable nut yield and nut weight but with low shelling percentage, low nuts/ panicle, high apple weight and average flowering laterals. In vegetative growth traits, H-320 exhibited high mean and stable performance in canopy spread with high plant height but poor trunk girth. Though, low mean performance for nut yield, BPP-3/33 and BPP-3/28 exhibited high shelling percentage with high mean performance for all vegetative growth characters. Thus, for development of high yielding stable genotypes H-320 and for high shelling percentage, BPP-3/33 and BPP-3/28 could be used as parents in breeding programme. H-320 can be recommended for cultivation as it is moderately stable in yield and component characters and assume to perform well across a wide range of environments in farmers field.

ACKNOWLEDGEMENT

We gratefully acknowledge the Orissa University of Agriculture and Technology, Odisha for the research facilities and to the ICAR-Directorate of Cashew Research, Puttur (Karnataka) for providing the financial assistance.

REFERENCES

1. Aliyu, O.M. and Awopetu, L.A. 2007. Multivariate analysis of cashew (*Anacardium occidentale* L.) germplasm in Nigeria. *Silvae Genetica*, **56**: 170-79.
2. Dashiell, K.E., Ariyo, O.J., Bello, L and Ojo, K. 1994. Genotype × environment interaction and simultaneous selection for high yield and stability in soybeans (*Glycine max* (L) Merr). *Ann. Appl. Biol*. **124**: 133-39.
3. Desai, A.R., Mokashi, A.N., Korikanthimath, V.S., Fakudin, B., Patil, R.V. and Gadang, R.N. 2010. Comparative analysis of morphometric and molecular diversity in cashew (*Anacardium occidentale* L.) genotypes. *Indian J. Genet. Resour.* **23**: 104-09.
4. Dhanraj, A., Bhaskarrao Rao, E.V.V., Swamy, K.R.M., Bhat, M.G., Prasad, D.T. and Sondur, S.N. 2002. Using RAPDs to assess the diversity in Indian cashew (*Anacardium occidentale* L.) germplasm. *J. Hort. Sci. Biotech.* **77**: 41-47.
5. Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Sci.* **6**: 36-40.
6. Fakorede, M.A.B. and Mock, J.J. 1978. Change in morphological and physiological traits associated with recurrent selection for grain yield in maize. *Euphytica*, **27**: 397-409.
7. Finlay, K. and Wilkinson, G.N. 1963. Stability adaptation in a plant breeding programme. *Australian J. Agril. Res*. **14**: 742-54.
8. Lee, C.H. and Rajanaidu, N. 1999. Genotype environment interaction in oil palm. *Proc. Symp. Science of Oil Palm Breeding*, Montpellier, France, Rajanaidu, N. and Jalari, B. (Eds.), pp. 96-111.
9. Romagosa, I. and Fox, P.N. 1993. Genotype × environment interaction and adaptation. **In**: *Plant Breeding*: *Principles and Prospects*, M.D. Hayward, N.O. Bosemark and I. Romagosa (Eds.), Chapman and Hall, London. pp. 373-90.
10. Saroj, P.L., Krishna Kumar, N.K. and Janakiraman, T. 2014. Converting wastelands into goldmine by cashew cultivation. *Indian Horticulture* (November-December), pp. 49-56.
11. Yates, F. and Cochran, W.G. 1938. The analysis of groups of experiments. *J. Agric. Sci.* **28**: 556-80.

Received : March, 2015; Revised : December, 2016;
Accepted : January, 2017