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Seasonal variation in yield performance of 16 cashew clones on bris soil

H. Salleh*, T. B. Chai* and M. L. Bakri*

Key words: cashew, yield, nut weight, bris soil

Abstrak
Pengeluaran kekeras 16 klon gajus di tanah bris telah diuji di MARDI Sg. Baging selama 7 tahun. Perbezaan yang sangat ketara dalam tindak balas klon x tahun menunjukkan prestasi hasil genotip tidak stabil dari tahun ke tahun. Klon C 11 dan C 21 mengeluarkan hasil yang tertinggi (masing-masing 1 535 dan 1 144 biji kekeras/pokok setahun) tetapi hasil kedua-duanya tidak konsisten sepanjang tempoh kajian kerana tingginya nilai sisihan daripada regresi (s^2d masing-masing 0.57 dan 0.55) dan pekali regresi (masing-masing b = 2.34** dan b = 2.37**). Parameter kestabilan ini dibincangkan.

Abstract
Sixteen cashew clones were evaluated for their nut number and nut weight on the bris soil environment at MARDI Sg. Baging for over 7 years (1977–83). Highly significant clone x year interaction was observed indicating that yield performance of genotypes varied disproportionately over the years. C 11 and C 21 clones have the highest mean yields (1 535 and 1 144 nuts/tree per year respectively) but they were also less consistent over the years of study because of their high deviations from regression (s^2d = 0.57 and 0.55 respectively) and large regression coefficient (b = 2.34** and 2.37** respectively). The stability parameters were discussed.

Introduction

One of the major problems facing the cashew nut (*Anacardium occidentale* L.) industry in Malaysia is the lack of superior clones. Most of the present plantings comprise unselected open-pollinated seedlings of obscure origin. They are poor yielders and generally possess low genetic potential for most characters. As a result, the production of raw nuts to support a viable cashew industry has been very low. The necessity to develop and introduce superior clones for the industry, therefore, cannot be over-emphasized. Any new clones developed must be well-adapted to, and stable in the environment in which it is intended to be grown.

Ideally, the identification of superior clones requires trials being carried out over a number of seasons and at various sites. This is to assess environmental influences on character expressions. The performance stability is often assessed using regression methods (Finlay and Wilkinson 1963; Eberhart and Russel 1966; Abington 1972). This article reports on the performance and stability of 16 cashew clones. The trial, however, was

*Fruits Research Division, MARDI Sg. Baging, 26080 Kuantan, Malaysia
Authors' full names: Salleh Hassan, Chai Tiang Bian and Bakri Mat Lasa+
+Present address: Technology Promotion Division, MARDI, IADP Complex, Jalan Karat, 28700 Bentong, Malaysia

conducted only on one site (Sg. Baging). In the absence of replication over locations, the year-to-year (season) variation was studied to assess stability. The effects of plant age will be confounded within seasons.

Materials and methods

Sixteen cashew clones were planted at 8 m x 8 m spacing in a 1-ha area in Sg. Baging in November 1973. A randomized complete block design (RCBD) with two replicates was used. Each plot consisted of five marcot plants. The 16 clones were selected based on single plant performance of accessions present in a 35-ha germplasm plot established in 1964. The selection criteria used were yield (in terms of nut number) and nut size.

The plants received 1.2–2.4 kg/tree per year of bris soil fertilizer mixture (8.4:8.4:12:2.6 + TE) at the initial stages of growth. This was followed with 3.2–4.8 kg/tree per year of 12:12:17:2.5 + TE from the third year onward. The fertilizer was given in three equal amounts at 4 month interval.

The trees started fruiting in 1976, 3 years after planting. However, as the first year production figure would not be representative, it was not included in the analyses to reduce error variation. Nut number was recorded for each tree and continued until 1982. In 1981 and 1982, nut weight per tree was also recorded. The trees were heavily pruned after the 1981 fruiting season.

Analyses of variance for all the years (1976–83) were done on nut number and similarly for the 1981–82 data on nut weight. Tests for stability over season with age of trees confounded were done based on the method of Eberhart and Russel (1966).

Results and discussion

Nut number

In the analyses of variance (ANOVA) for nut number, phenotypic variance between genotypes (clones), between years and the interaction of clone x year were highly significant (*Table 1*). The highest mean of nut number was recorded in C 11 (1 535 nuts/tree per year) while the lowest in F 413 (277 nuts/tree per year) (*Table 2*). The only other clone yielding over 1 000 nuts was C 21 (1 144 nuts/tree per year).

The alternate bearing habit in cashew is clearly seen when the yearly yields of all the clones are compared (*Table 2*). A 'trough' in one year is followed by a 'peak' in the following year. This gives rise to the 'between years' significance in the analysis of variance (*Table 1*). The trough signifies the time when the plant is accumulating storage reserves in the 'off-

Table 1. ANOVA of nut number and nut weight of 16 cashew clones at Sg. Baging

Source	Nut number[+]		Nut weight[‡]	
	df	MS	df	MS
Rep	1	594248.21**	1	3.02ns
Clone	15	1561563.99**	15	84.51**
Rep x clone	15	46274.45ns	15	4.51ns
Year	6	1693523.77**	1	525.35**
Clone x year	90	135720.47**	15	15.49**
Error	96	36817.67	271	3.95

[+]nut number based on 7-year data (1976–83)
[‡]nut weight based on 2-year data (1981–82)
**Significant at 1% level
ns = not significant

Table 2. Mean yields of 16 cashew clones at MARDI Sg. Baging (1977–83)

Clone	Yield (no. of nuts/tree)							
	1977	1978	1979	1980	1981	1982	1983	Mean
C 4	612	437	845	833	1 247	528	112	659cde
C 5	676	694	888	923	771	644	614	744cd
C 9	454	220	419	407	1 010	311	359	454fgh
C 11	1 230	1 487	1 238	1 970	2 846	934	1 038	1 535a
C 21	854	447	1 374	2 078	2 023	1 010	221	1 144b
C 22	443	229	414	267	779	317	438	412fgh
C 105	495	303	874	385	764	441	441	529efg
F 192	477	211	739	238	809	306	135	445fgh
F 193	679	300	512	272	402	15	359	363gh
F 379	944	668	1 392	911	765	322	695	814c
F 410	640	222	636	306	792	215	255	438fgh
F 411	636	251	1 315	1 014	936	479	143	682cde
F 412	374	115	424	358	618	175	369	348gh
F 413	424	212	408	186	401	135	169	277h
F 633	297	158	274	282	782	235	137	301h
F 896	797	510	800	388	831	231	370	561def
Mean	627	404	785	676	983	406	366	

Means in the same column followed by the same letter are not significantly different at 1% level

season' for fruit production in the following peak season. A similar production trend was reported for a different cashew population at the same location (Salleh et al. 1988). Generally, the yields in both 'on' and 'off' years showed an increasing trend with the age of the trees. However, the trough in 1981 fell below that of 1980 because of the heavy pruning done following the 1981 fruiting season. In 1983, the overall production in the plot did not show the expected increase because of a spell of very dry weather that prevailed during the floral initiation and fruit formation stages.

Nut weight

Analyses of variance of mean nut weight (expressed in kilogrammes per tree) for the 2 years (1981–82) also indicated significant differences among the 16 clones tested (*Table 1*). The 2-year data on nut weight per tree (*Table 3*) indicated that C 11 produced the highest yield (9.7 kg/tree per year), followed by C 21 (6.1 kg/tree per year). C 11 produced acceptably large nut (5.6 g) and this was substantially larger than that of C 21 which gave the smallest nut among the 16 clones (4.1 g). F 633 and F 896 clones produced very large nuts (6.8 g and 6.3 g respectively) but their respective nut weight per tree for the 2 years were significantly lower than those of C 11 and C 21, suggesting a negative correlation between the two characters. Similarly, their average nut number for the 9 years were also very much smaller than those of C 11 and C 21. The other clones were mediocre.

Stability parameters

A significant clone x year interaction (*Table 1*) implies that clones yield inconsistently in relation to one another over seasons. This was possible because in certain years, the weather was more favourable and high yielders like C 11 and C 21 showed much greater response than others. Conversely, in poor weather conditions, all are equally and adversely affected and good and poor yielders alike

Table 3. Mean nut weight, nut size and stability parameters for 16 cashew clones at MARDI Sg. Baging

Clone	Nut weight+ (kg/tree)	Nut size (g)	*b* value	s^2d
C 4	4.1c	4.8cd	1.33**	0.17
C 5	3.6cd	5.2bc	0.78*	0.23
C 9	3.4cde	5.1bc	0.87**	0.19
C 11	9.7a	5.6b	2.34**	0.57
C 21	6.1b	4.1d	2.37**	0.55
C 22	2.9cdef	5.7b	0.57*	0.17
C 105	2.9cdef	4.9c	0.82**	0.18
F 192	3.5cde	5.5b	0.81*	0.22
F 193	1.0h	5.5b	0.40*	0.25
F 379	2.5defg	4.7cd	1.01*	0.37
F 410	2.1efg	4.8cd	0.84**	0.16
F 411	3.3cdef	4.6cd	1.33**	0.33
F 412	1.8fgh	4.7cd	0.61**	0.12
F 413	1.4gh	5.6b	0.43**	0.11
F 633	3.1cdef	6.8a	0.64**	0.14
F 896	3.4cde	6.3a	0.84**	0.21

+nut weight based on 2-year data (1981–82)
*significant at 5% level
**significant at 1% level
Means in the same column followed by the same letter are not significantly different

showed low yield. In Sg. Baging, good weather for cashew production is when the monthly rainfall during floral development and fruit formation stages (February-March) is about 130–132 mm, followed by about the same or lesser amount during ripening stage 3–4 months later. Heavier rain is often accompanied by pest and disease infestation while very dry conditions tend to cause the flowers to wither and abort. Under favourable growing conditions (good weather and low incidence of pest and disease infestation), the 'trough' and 'peak' in the alternate bearing cycle will be lifted to a higher level than in adverse weather conditions. The trough and peak also showed tendency to increase as plants became older.

A measure of the relative change in yield performance in the respective years for each clone was provided by the stability parameters. Eberhart and Russell (1966) defined a stable genotype as one having a high mean yield, a regression coefficient of unity ($b = 1.0$) and a deviation from regression as small as possible ($s^2d = 0$). The table of *b* values (*Table 3*) indicates significant linear regression in all the clones with F 193 having the lowest value. It is the lowest yielding clone in terms of nut weight (kg/tree) in 1981–82. Its average yield of 363 nuts/tree per year for 7 years (1977–83) was also among the lowest (*Table 2*). The low *b* value implies that it is a stable, low yielding clone which performs poorly under adverse conditions, and is not likely to respond to favourable seasonal changes. The same arguments hold for F 412 and F 413. Consistent and stable clones exemplified by F 379 ($b = 1.01 \pm 0.37$) were generally mediocre bearers.

The two high yielding clones (C 11 and C 21) have the highest *b* values

(2.34** and 2.37** respectively). the reason for their high *b* values is their sensitivity in response to favourable seasons. They are unstable but are able to exploit favourable environment better thereby giving relatively higher yields than others. Under adverse conditions, their yields are substantially reduced but are nevertheless significantly higher than the others and consistently so over the period of study. Their other stability parameters (s^2d) were also high. This can be expected because these two high yielding clones, evaluated in the company of low yielders which have different nut yielding behaviour altogether, will surely deviate significantly from the regression whose values were mostly generated from a different group of genotypes.

Conclusion

C 11 and C 21 are promising high yielding clones which are sensitive to changes in seasonal influences while the low yielding clones are relatively more stable as explained by their low *b* values and small deviation from regression. The interpretation of the stability parameters in this study may be academic because even in adverse conditions, the yields of the two high yielding clones mentioned were better than the others.

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References

Abington, J. B. (1972). Genotype-environment interactions and their application in maize breeding programme. *Expl. Agric.* ***8***: 283–7

Eberhart, S. A. and Russell, W. A. (1966). Stability parameters for comparing varieties, *Crop Sc.* ***6***: 36–40

Finlay, K. W. and Wilkinson, G. N. (1963). The analysis of adaptation in a plant breeding programme. *Australian J. agric. Res.* ***14***: 742–54

Salleh, H., Chai, T. B., Abd. Wahab, N., Bakri, M. L. and Abu Abidah, T. (1988). Identification of promising materials from a seedling population of cashew based on nut number and nut weight. *MARDI Res. J.* ***17(1)***: 155–66

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Abu Bakar Hussin (Dr)
Ahmad Jantan (Dr)
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