with compliments
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PRELIMINARY OBSERVATIONS ON 106 CROSSES FROM A DIALLEL CROSSING PROGRAMME IN *THEOBROMA CACAO* L.

Separata do livro
MEMÓRIAS DA SEGUNDA
CONFERÊNCIA INTERNACIONAL
DE PESQUISAS EM CACAU

OPEKE, L.K. & JACOB, V.J. Preliminary observations on 106 crosses from a diallel crossing programme in Theobroma cacao L. In Conferencia Internacional de Pesquisas em Cacau, 2.. Salvador, e Itabuna, Bahia, Brasil, 19 - 26 de novembro, 1967. Memórias. Itabuna, Centro de Pesquisas do C..c..u, 1969. pp.94-97.

PRELIMINARY OBSERVATIONS ON 106 CROSSES FROM A DIALLEL CROSSING PROGRAMME IN *THEOBROMA CACAO* L.

The tecnique of diallel crossing is of immense importance in the breeding of tree crops. By this method as with other methods, it is possible to investigate the direct genetic control of various quantitative characters, as well as detecting reciprocal differences. Credit goes to JINKS (1954) and HAYMAN (1954) for developing the diallel cross analysis as a technique for studying quantitative inheritance. This techniques is of particular value for assessing the potentialities of a large number of cultivars within a short period. This paper reports observations on 106 crosses from a diallel crossing programme involving W.A.C.R.I. 'C' clones and I.C.S. clones. Some of these clones are vigorous and others are less vigorous, but are included in this programme in order to study their combining ability and performance in various combinations. The diallel hybrids will serve as a source of germplasm for future selection and at the same time provide useful information on the genetic basis of establishment ability, growth, jourquetting and fruiting. It is proposed to select the promising progenies from these crosses for clonal trials. The diallel crossing programme which includes the 106 combinations reported below was started in 1964 at the Cocoa Research Institute of Nigeria, Ibadan. It is estimated that all the cross combinations will be in the field by 1970.

MATERIALS AND METHODS

Twenty-nine W.A.C.R.I. 'C' and seven I.C.S. clones were selected for this programme. Crosses in all possible combinations including the reciprocals are being carried ou at Moor Plantation and at Gambari Experimental Stations of the Cocoa Research Institute of Nigeria. The clones are C6, C13, C14, C18, C20, C22, C23, C24, C25, C26, C27, C40, C42, C43, C57, C62, C64, C65, C67, C68, C69, C70, C71, C72, C73, C74, C75, C77, C85, I.C.S.1, I.C.S.6, I.C.S.8, I.C.S.40, I.C.S.45, I.C.S.60, and I.C.S.95.

All control pollinations are being carried ou by the method described by RUINARD (1963). Fourteen days after pollination, the percentages of flower setting are scored and all the developing cherelles are labelled indicating the male and female parents and the data of pollination.

Sixty combinations each with 100 pollinations or more, have been analysed for the correlation studies of flower setting and fruit harvest. Success of pollinations, on the basis of pod harvest have been analysed using 45 crosses involving five female and nine male parents. All hybrid progenies were grown in the nursery for about six months before they were planted in the field in June 1965 at a spacing of 10' × 10'. Progenies were grown in 15 plant rows. Records on growth, percentage survival, jourquetting, flowering and fruiting were taken on the first set of 106 combinations planted in the field. Height and girth measurements were taken at an interval of six months starting from December, 1965. Correlation studies were made between the mean girth of the progeny in June 1967, 24 months after field planting, and the mean percentages of plants flowering.

RESULTS

The results of pollinations in 45 crosses involving five female parents and nine male parents, are presented in TABLE 1. A pollination was considered successful only if it gave rise to a ripe pod. Since the proportions of successful pollinations in each combination was based on total number of pollinations, which varied considerable from combination to combination, the table of results was of non-orthogonal nature. The analysis was carried out as outlined by VAN EIJNATTEN (1967). The parental variance and variances due to male and female parents, corrected for the alternative parents, were tested both against the theoretical estimate of error variance (Fe) and against the variance due to interactions (fi). The analysis of variance is presented in TABLE 2. The variance due to influence of the parents was greater than both the error variance and interactions variance ($P < .001$). The influence of both male and female parents, corrected for the alternative parents, on the success of pollinations was significant when tested against both the theoretical estimate of error variance ($P < .001$) and interaction variance ($P < .01$). The interaction between male and female parents was highly significant ($P < .001$). The average percentage success for male and female parents is given in TABLES 3(a) and 3(b) respectively, and the deviations in the performances of combinations from the expected proportions are presented in TABLE 4.

The correlation studies between the percentage flower setting and the number of fruits harvested per 100 pollinations in 60 crosses revealed that there is significant correlation between these two variables ($r = 0{,}67+++$).

Correlation studies between mean girth of the progenies, twenty four months after field planting, and the percentage of plants flowering at the time in 103 combinations revealed that there is no significant correlation between

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TABLE 1 — Number of Pollinations (n), Number of Set (s) and Pods Harvested (h) in Forty Five Crosses Involving Five Female and Nine Male Parents.

		C14	C23	C25	C67	C68	C69	C74	C75	C77
C26	n	120	20	70	121	166	25	25	117	70
	s	50	7	40	48	74	12	19	69	48
	h	9	0	2	9	0	0	0	8	0
C42	n	207	209	120	156	120	176	141	44	130
	s	124	85	103	5	84	5	66	19	24
	h	28	22	21	0	27	2	11	5	6
C43	n	91	28	40	102	41	100	122	65	363
	s	42	25	36	47	36	65	70	44	345
	h	7	2	12	11	4	22	6	2	35
C68	n	36	97	37	132	71	100	123	190	104
	s	11	39	9	64	30	42	19	44	41
	h	0	6	1	20	0	2	11	6	6
C73	n	5	200	129	100	48	100	106	106	37
	s	5	125	120	54	45	24	45	21	16
	h	1	21	25	2	1	7	1	2	1

these two variables (r = 0.16). The mean girth and the mean height of 106 combinations at 6, 12 and 18 months after field planting is presented in TABLE 5.
Results of the studies on percentage survival, jourquetting and flowering are given in TABLE 6.

DISCUSSION

The analysis of the pollination data of fourthy five combinations revealed that the best male and female parents are C25 (15.3 per cent) and C43 (11.4. per cent) respectively. Since the influences of male and female parents and their interactions were highly significant, the combinations deviated considerably from the theoretically expected proportions. The crosses, C42 × C68 (+ 14.68), C73 × C14 (+12.39), C43 × C69 (+11.24) and C42 × C67 (—11.69), C68 × C14 (—11.43) and C68 × C25 (—10.70) were least successful. This shows that some crosses are more successful than others. Pattern of production can only be constructed when all the cross combinations are analysed.

Highly significant correlation (r = 0.67+++) was observed between percentage flower setting and the number of fruits harvested per 100 pollinations, being an increase of 0.35 per cent for every one percent increase in setting, indicating that yield can be predicted (b = 0.35+++ and y = 3.41+ 0.35 ×). The mean girth of the progenies, 24 months after field planting, and the percentage of plants flowering were not significantly correlated.

The progeny C42 × C68, which scored 100 per cent survival, 12 months after field planting, was the best combination for establishment ability. However, it scored the lowest percentage for flowering (8 per cent). In combination C6 × C24, C14 × C14 and C42 × C26 all the plants died between 18 and 24 months after field planting. As all the progenies were grown under identical nursery and field conditions at the same time, the death of all the progenies from combinations C6 × C24, C14 × C14 and C42 × C26 could not be environmental. These crosses are being repeated for the purpose of investigating the probable genetic factors resulting in the early death. Sixty-two combinations jourquetted within six months after field planting. Precocious jourquetting before six months after planting was observed in C40 × C64, C42 × C43 and C42 × C85. Mature pods were harvested from C85× C26 and ICS1 × C64, twenty two months after field planting. This is a new record in precocity in cacao in West Africa. The old Amelonado variety produces first mature pods about 60

TABLE 2 — Analysis of Variance of Successful Pollinations in 45 Combinations Involving Five Female Parents and Nine Male Parents.

Source	DF	Variance	Fe	Fi
Total	44	2980		
Parents	12	6690	8.1486+++	4.0818+++
(a) Males ignoring females	8	5752	7.0060	
Females allowing for males	4	8566	10.4336+++	5.2264+++
(b) Females ignoring males	4	8200	9.9878	
Males allowing for females	8	5935	7.2289+++	3.6211+++
Interaction	31	1639	1.9963+++	
Error		821		

TABLE 3(a) — The Average Percentage Success for Male Parents.

Rank	Male Parents	Percentage Success	Angle
1	C25	15.3	23.04
2	C23	9.9	18.30
3	C14	9.7	18.17
4	C67	5.8	13.90
5	C68	5.4	13.44
6	C77	5.0	12.94
7	C74	5.0	12.93
8	C69	4.9	12.83
9	C75	4.5	12.25
	Average	6.7	15.00

TABLE 3(b) — The Average Percentage Sucess for Female Parents.

Rank	Female Parents	Percentage Success	Angle
1	C43	11.4	19.70
2	C42	7.1	15.42
3	C68	6.0	14.13
4	C73	5.8	13.94
5	C26	3.2	10.35
	Average	6.7	15.00

TABLE 4 — The Performances of Combinations Above (+) and Below (—) the Expected Percentages.

	C14	C23		C67	C68	C69	C74	C75	C77
C26	+ 3.54	— 5.02	— 5.41	+ 6.45	+ 6.74	— 1.88	— 1.95	+ 6.80	— 4.94
C42	+ 2.99	+ 0.19	+ 1.21	— 11.69	+ 14.68	— 6.39	+ 3.11	— 1.39	— 0.50
C43	— 7.51	— 4.03	+ 3.24	+ 1.24	+ 1.25	+ 11.24	— 3.78	— 5.19	+ 1.22
C68	— 11.43	— 2.44	— 10.70	+ 10.01	— 8.15	— 3.18	+ 5.52	— 1.04	+ 2.11
C73	+ 12.39	+ 2.00	+ 4.89	— 4.01	— 2.87	+ 3.78	— 5.46	— 2.86	— 0.92

TABLE 5 — Mean Girth and Mean Height of 106 Combinations at 6, 12 and 18 Months After Field Planting.

	Mean height (in inches)	Mean girth (in cm)
6 months after field planting	35.1 ± 0.59	1.25 ± 0.21
12 " " " "	41.15 ± 0.87	1.64 ± 0.03
18 " " " "	63.27 ± 1.07	2.65 ± 0.04

months while the F3 Amazon produces first mature pods about 36 months after planting. The earliness of these two combinations are being studied. In cacao the effects of both male and female parents on the success of pollinations are highly significant unlike that in kola. Generally in kola the effect of the female parents is more pronounced than that of the male parents on the success of pollinations (VAN EIJNATTEM, 1967).

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TABLE 6 — Percentage Survival, Jourquetting and Flowering.

Jourqueting		Percentage survival (one year after field planting)		Flowering	
Time	No. of progenies	Range	No. of progenies	Time	No. of progenies
1- 6 months	62	1- 25 Per cent	9	13-15 months	1
7-12 "	33	26- 50 " "	40	16-18 "	5
13-18 "	9	51- 75 " "	38	19-21 "	10
19-24 "	0	76-100 " "	19	22-24 "	62

OBSERVAÇÕES PRELIMINARES DE 106 CRUZAMENTOS COM DIALELOS EM *THEOBROMA CACAO* L

PRELIMINARY OBSERVATIONS ON 106 CROSSES FROM A DIALLEL CROSSING PROGRAMME IN *THEOBROMA CACAO* L.

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São apresentados os resultados de estudos de 106 cruzamentos com dialelos, que envolviam 29 clones WACRI "C" e 7 clones ICS. A porcentagem de lançamento de flôres manifestava uma correlação significativa com o número de frutos colhidos a cada 100 polinizações ($r = 0{,}67+++$). Por outro lado, não havia correlação significativa entre o diâmetro da progênie e a porcentagem das plantas que produziam flôres. Em 45 combinações obtidas com cinco ascendentes fêmeas e nove ascendentes machos, os efeitos transmitidos pelos genitores eram significativos, ao serem avaliados à luz da estimativa teórica da variação devida ao êrro e da variação causada pela interação. Os referidos resultados foram corrigidos para compensar os efeitos do parentesco alternado e das interações, em relação ao sucesso das polinizações. O clone C25 provou ser o melhor progenitor (15,3 por cento) enquanto que o C43 era a melhor progenitora (11,4 por cento). Dentre as combinações a única progênie para a qual foi registrada uma sobrevivência de 100% — doze meses após o plantio em campo — foi a de C42 × C68.

Results of the studies on 106 crosses forming part of a diallel crossing programme involving 29 W.A.C.R.I. 'C' clones and seven ICS clones are presented. The percentage flower setting was significantly correlated to the number of pods harvested per 100 pollinations ($r = 0.67+++$) while there was no significant correlation between the mean girth of the progeny and the percentages of plants flowering. In 45 combinations involving five female parents and nine male parents, the effects of the parents, male and female parents — corrected for the alternative parents and their interactions on the success of pollinations were significant when tested, both against the theoretical estimate of error variance and against the variance due to interaction. Clone C25 came out as the best male parent (15.3 per cent) and C43 was the best female parent (11.4 per cent). Among the combinations studied, the only progeny which scored 100 per cent survival, 12 months after field planting was C42 × C68.