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Studies on fruit set in coconut upon artificial pollination in various cross combinations

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ABSTRACT

Studies on fruit set in coconut have important implications in nut yield. A detailed study was carried out to determine the fruit set in coconut as influenced by variety, cross combination, climatic variables such as rainfall, temperature and relative humidity. Artificial pollination was carried out on selected parental palms of West Coast Tall (WCT), Chowghat Green Dwarf (CGD) and Chowghat Orange Dwarf (COD) in farmer's plots over a period of five years commencing from 1996-2000. The various cross combinations tried among the three varieties, *viz.*, WCT, CGD and COD were three selfing, two *inter se* and three crosses. The mean fruit set for the different cross combinations was 24.67%. The maximum fruit set (39.54%) was in COD (self) followed by WCT (self) and COD x WCT, and minimum in CGD x WCT (19.16%) indicating that COD variety as a female parent gave significantly higher fruit set compared to other varieties. Generally, the varieties WCT and CGD under selfing gave a higher fruit set (27.43 and 24.65%) when compared to *inter se* (21.63 and 21.22%). Fruit set was maximum (28.73%) during March and minimum (18.80%) during May but the year-to-year variation was not significant. The bimonthly average relative humidity (%), number of rainy days and rainfall (cm) had a significant negative correlation (-0.504, -0.428, -0.395, respectively) with fruit set. Studies also revealed that there was a significant reduction in fruit set to the tune of 35%, when climatic conditions are not favourable. The present investigations revealed that fruit set in coconut vary significantly due to genotype, cross combination and climatic variables.

Key words: Coconut, fruit set, artificial pollination, weather parameters.

INTRODUCTION

Fruit set has important implication in the yield of coconut, as yield is estimated based on the number and weight of nuts produced. Though it is known that yield of coconut varies depending on variety and season, there are only few detailed studies on these important aspects. Reasons for scanty publications are due to the difficulties in carrying out crossing due to height of palms and time taken for the fruits to mature. Even the limited published studies undertaken were based on small numbers of palms, inflorescence and buttons.

Root (wilt) is a serious disease of coconut in Kerala and in certain districts of Tamilnadu (Srinivasan *et al.*, 9). In the disease endemic areas, in the midst of heavily disease-affected coconut palms, a number of disease-free and high yielding coconut palms belonging to the varieties, *viz*., West Coast Tall (WCT), Chowghat Green Dwarf (CGD) and Chowghat Orange Dwarf (COD) are found. Artificial pollination on these selected mother palms in farmers plots located in the nearby districts of Alappuzha and Pathanamthitta was carried out to study the fruit set. Nuts produced from these crosses were subsequently utilized for the production of root wilt resistant/tolerant planting materials for establishing nucleus seed gardens. This paper analyses the variation in fruit set in different varieties and cross combinations of coconut during different months and years. The influence of weather parameters such as rainfall, temperature and relative humidity were also studied.

MATERIALS AND METHODS

Artificial pollination was carried out from January 1996 to December 2000 (five years) on the mother palms of varieties namely West Coast Tall (WCT), Chowghat Green Dwarf (CGD) and Chowghat Orange Dwarf (COD), located in farmer's gardens in the districts of Pathanamthitta and Alappuzha (Kerala). Only high yielding and disease-free palms showing typical characters of WCT, CGD and COD varieties were included in the crossing programme. The mother palms were serologically tested every year to ascertain their disease-free nature (Solomon *et al.*, 8) to ensure that fruit set is not adversely affected due to root (wilt) disease. Number of mother palms under pollination during each year is furnished in Table 1. The cross combinations tried among the three varieties included three selfings, two *inter se* and three crosses, one of which was reciprocal. The

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following cross combinations were studied.

1. WCT (self / *inter se*)
2. CGD (self / *inter se*)
5. COD (self)
2. WCT × CGD
4. CGD × WCT
6. COD × WCT

On an average around 30-46 palms were pollinated every year. Artificial pollination of mother palms was carried out during the morning hours (7.00 am to 11.00 am) as per the procedure described by Pillai and Rao (6). The pollination was carried out throughout the year except during the rainy season (June till October).

The mature nuts produced as a result of artificial pollination were harvested 10 to 12 months after pollination. Mother palms were provided with recommended prophylactic plant protection measures. Fruit set percentage was calculated based on the ratio of number of nuts harvested in relation to the number of buttons (female flowers) pollinated during the previous year. Fox Pro based computer software was developed for computerization and analysis of pollination data (Ajithkumar *et al*., 2). The weighted average was considered for calculating the fruit set percentage (Table 3). The relationship between fruit set percentage and various weather parameters was also studied. The weather data were collected from the records maintained at Sugarcane Research Station (Kerala Agricultural University,

Table 1. Number of mother palms under artificial pollination in coconut.

Year	WCT	CGD	COD	Total
1996	19	22	05	46
1997	16	23	04	43
1998	15	13	03	31
1999	10	21	02	33
2000	11	17	02	30
Total	71	96	16	183

Table 2. Details of artificial pollination in coconut.

Year	No. of inflorescence	Buttons (female flowers)	*Harvested nuts	Fruit set (%)
1996	221	5,611	1,264	22.52
1997	209	5,507	1,610	29.23
1998	122	3,238	820	25.32
1999	187	6,272	1,496	23.85
2000	141	3,716	805	21.66
Total	880	24,344	5,995	-
Average				24.63

*Harvested during the next year after pollination

Table 3. Details of artificial pollination carried out in various cross combinations in coconut.

Cross combination	No. of inflorescence	Buttons (female flowers)	*Nuts harvested	Fruit set (%)
WCT (self)	99	2,310	655	28.35
WCT (inter se)	233	5,516	1,340	24.29
CGD (self)	215	6,121	1,612	26.34
CGD (inter se)	71	2,325	517	22.24
COD (self)	34	874	336	38.44
WCT X CGD	66	1,790	367	20.50
CGD X WCT	138	4,794	1,004	20.94
COD x WCT	24	614	164	26.71
Total	880	24,344	5,995	-
Average				24.63

*Harvested during the next year after pollination

Thiruvalla located at a distance of 2-12 km from most of the farmers' plantations where pollination work was carried out.

RESULTS AND DISCUSSION

Studies on fruit set in coconut under artificial pollination in relation to different cross combinations, months and years are reported. Details regarding the pollination carried out during each year are given in Table 2. The fruit set percentage obtained in various cross combination of WCT, CGD and COD as shown in Tables 3, 4a&b are slightly different because weighted averages alone were considered to calculate the fruit set percentage.

It can be seen that the average fruit set percentage of various cross combinations involving WCT, CGD and COD was 24.67 with a range of 19.16 to 39.54 (Table 4a). An average fruit set of 26.1% has already been reported in coconut by Nair *et al.* (4). Among the different cross combinations, the maximum fruit set percentage (39.54) was obtained in COD (self) and lowest in CGD × WCT (19.16) (Table 4a). Chowghat Orange Dwarf variety as female parent gave a higher fruit set percentage. In the case of other two varieties, WCT and CGD, there was higher fruit set (27.23 and 24.65%) under selfing compared to *inter se* crosses (21.63 and 21.22%) even though the differences are not significant, indicating that coconut can tolerate both selfing and *inter se* crossing. The inbred homozygous nature of Chowghat Green Dwarf (Swaminathan and Nambiar, 10) may be the reason for the non-significant variation in fruit set under both selfing and *inter se* pollination. It further showed that in nature, fruit set was promoted by the pollen produced from the next younger spadix on the same palm (selfing) along with the pollen from other palms (*inter se*). In coconut, inter-spadix overlapping of female and male phase is an important factor in fruit set along with cross-pollination from nearby palms carried by agents like wind, insects etc. (Henderson, 3).

It was interesting to note that there was higher fruit set percentage both in selfing and *inter se* (intra-varietal crosses) in all the three varieties (WCT, CGD and COD) compared to their inter-varietal crosses (Table 4a&b). Reduction in fruit set noticed in inter-varietal crosses (when compared to intra-varietal crosses) involving dwarf and tall varieties may be due to the preference for pollen from the same genotype compared to other genotypes. There were no reciprocal differences in fruit set in WCT × CGD and CGD × WCT. The case may be the same

Table 4. Fruit set (%) in various cross combinations in coconut.

a) Cross combination × month

Cross combination	Jan	Feb	March	April	May	Nov	Dec	Av. fruit set (%)
WCT (self)	22.90	29.88	32.80	37.03	13.25	26.84	22.63	27.43^{b}
WCT (inter se)	22.00	22.84	31.47	21.32	21.15	12.67	18.94	21.63^{bc}
CGD (self)	23.22	29.25	26.45	20.79	18.13	21.06	32.94	24.65^{bc}
CGD (inter se)	33.66	19.08	22.80	15.19	17.35	10.48	25.99	21.22^{bc}
COD (self)	50.76	40.44	40.38	39.20	38.48	26.42	29.20	39.54^{a}
WCT × CGD (TXD)	23.84	21.09	29.30	26.64	07.14	21.05	12.62	21.92^{bc}
CGD × WCT (DXT)	20.39	19.91	21.53	18.37	18.11	13.51	18.72	19.16^{c}
COD × WCT (DXT)	29.23	36.99	24.16	32.01	03.45	06.67	38.37	26.12^{b}
Average	27.62^{a}	25.44^{ab}	28.73^{a}	24.83^{abc}	18.80^{c}	19.16^{bc}	22.98^{abc}	24.67

Mean values followed by the same letter are not significantly different by ANOVA ($p < 0.05$).

$CD_{0.05}$ Cross combination = 6.86; Month = 6.50.

Contd...

b) Cross combination × year

Cross combination	1996	1997	1998	1999	2000	Av. fruit set (%)
WCT (self)	18.82	31.20	30.86	32.74	26.32	27.43[b]
WCT (*inter se*)	26.15	21.28	21.97	16.87	20.52	21.63[bc]
CGD (self)	21.25	29.13	24.54	21.34	26.99	24.65[bc]
CGD (inter se)	14.10	33.32	14.59	26.17	16.78	21.22[bc]
COD (self)	35.39	43.14	29.8	53.32	41.23	39.54[a]
WCT × CGD (TXD)	25.05	22.50	08.90	31.13	19.50	21.92[bc]
CGD × WCT (DXT)	19.46	26.37	17.48	17.40	15.98	19.16[c]
COD × WCT (DXT)	38.71	16.46	24.00	25.26	27.00	26.12[b]
Average	23.06	28.02	22.53	26.85	22.82	24.67

Mean values followed by the same letter are not significantly different by ANOVA ($p < 0.05$).

$CD_{0.05}$ Cross combination = 6.86; Month = 6.50.

in other D × T and T × D crosses, even though data is lacking. It indicates that no inhibitory factors are involved in reciprocal crosses and both types of hybrids (D × T and T × D) can be produced without any incompatibility.

There was significant difference in fruit set percentage during different months (Table 4a). The highest fruit set (28.73%) was recorded during March followed by January (27.62%) and February (25.44%). The lowest fruit set (18.80%) was recorded during May followed by November (19.16%). During May and November, fruit set was 30-35% lower than that realized during the months of Jan-April. The higher fruit set recorded during the summer months (Jan-March) may be due to the congenial climate that prevailed during summer. This difference in monthly variations in fruit set is a major factor that contributes to significant yield variation in different harvest of nuts done during a year. The mean fruit set of various crosses during different years is presented in Table 4b. There was no significant difference in crosses and the fruit set ranged from 22.53 to 28.02%. There was also no interaction for setting percentage between years and cross combination indicating that setting percentage in different cross combinations were similar during different years.

The completion of pollination process in individual inflorescences takes nearly one month after its opening. Hence, to analyze the influence of climate on fruit set, the average climatic conditions of two months (particularly the month in which the inflorescence opened and subsequent month) has to be considered (Peiris and Peiries, 5). The bimonthly average fruit set (%), number of rainy days, rainfall (cm), relative humidity (%), maximum and minimum temperature (°C) recorded during 1996-2000 is furnished in Table 5. The lowest fruit set (18.8%) was recorded during May/June. The low fruit set obtained during May and November may be due to the unfavorable climate, which includes more rainy days, rainfall intensity and relative humidity. However, fruit set in April was not significantly reduced though a higher average relative humidity (88.8%), rainfall (19.9 cm) and rainy days (6.5) were recorded. This may be due to the slightly higher (32.8°C) maximum temperature recorded during April/May as compared to the low maximum temperature during May/June and November/ December (31.7°C). In the month of March, the maximum fruit set (28.7%) was recorded though an average rainfall of 11 cm was recorded during March/April. This excessive rainfall was not found harmful for fruit set due to the accelerated transpiration facilitated by a high temperature (33.5°C) and low humidity (85.9%) (Abeywardena, 1). Table 6 shows the correlation of fruit set with different weather parameters. The

Table 5. Weather parameters during experimentation (1996-2000).

Month	Av. fruit set (%)	Av. rainy days	Av. rainfall (cm)	Av. relative humidity (%)	Max. temp (°C)	Min. temp. (°C)
Jan/Feb	27.62	0.5	1.90	84.03	32.6	21.4
Feb/Mar	25.44	0.7	3.27	83.68	33.2	21.7
Mar/Apr	28.73	3.2	11.08	85.94	33.5	22.2
Apr/May	24.83	6.5	19.90	88.80	32.8	22.7
May/Jun	18.80	12.2	41.69	90.58	31.7	22.9
Nov/Dec	19.16	7.2	10.46	86.94	31.7	22.5
Dec/Jan	22.98	3.5	4.92	85.40	32.2	21.2

Table 6. Correlation coefficients between fruit set and various weather parameters.

Parameter	Correlation coefficient
Rainy days (No.)	-0.504**
Average rainfall (cm)	-0.428**
Relative humidity (%)	-0.395**
Maximum temperature (°C)	0.194
Minimum temperature (°C)	-0.108

**Significant at 1%

bimonthly average relative humidity (%), number of rainy days and rainfall (cm) was significant and negatively correlated (-0.504, -0.428 and -0.395, respectively) with fruit set. The maximum and minimum temperature had no significant correlation with fruit setting percentage.

Studies revealed that higher relative humidity (>86%) and more number of rainy days lowered fruit set in coconut and thereby the yield. Conversely lower relative humidity and less number of rainy days during the summer months favoured higher fruit set (Abeywardena, 1; Prasada Rao, 7). The present studies for the first time revealed that there is a significant reduction in fruit set to the tune of 35%, when climatic conditions are not favourable. During the months of May and November, fruit set was 30-35% less than that realized during Jan-April. This has implications on the cost of hybrid seed nuts produced during the months of May and November.

The present investigations revealed that fruit set in coconut vary significantly due to genotype, cross combination and climatic variables. Chowghat Orange Dwarf (COD) as the female parent gave a significantly higher fruit set percentage. It was shown that summer months (Jan to April) are more favourable for fruit set and yield compared to May/June and November/ December. It was also revealed that higher relative humidity, number of rainy days and rainfall intensity had a significant negative correlation with fruit set in coconut.

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