



Distribution of staminate and hermaphrodite flowers and fruit-set in the canopy of cashew genotypes

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ABSTRACT

Production of staminate (S) and hermaphrodite (H) flowers was studied in the north, east, south and west sides of the cashew tree canopy from December 2003 to May 2005 at S.G. College of Agriculture and Research Station, IGKVV, Jagdalpur (C.G.). Flower production was recorded daily on selected plants throughout the main flowering season and, subsequently, yield of each plant was recorded. Results showed differences in number of flower types on different sides of the tree. However, there was consistently greater number of staminate flowers than hermaphrodite flowers during both early and late flowering. Significant variability between genotypes and sides was recorded for sex ratio (S/H). Hybrid-255 showed highest sex ratio for north, south and west sides and Vridhachalam-2 for the east side. Differences in fruit-set and nut-yield were also found between sides. Hybrid 30/1 had highest per cent fruit-set. Highest number of fruits carried to maturity was recorded in Hybrid-30/1. Distribution of yield over the tree-canopy showed that south side had significantly high nut yield, followed by west side.

Key words: *Anacardium occidentale*, cashew, flower distribution, sex type, side of canopy

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is a high-value export crop. Yields in fruit crops is determined primarily by flowering and subsequent fruit-set from these flowers. The cashew produces innumerable flowers, of which less than 10% are bisexual. Under normal conditions, nearly 85% of the flowers are fertilized of which only 4-6% reach maturity. Very little is known about factors controlling yield in cashew and in particular the extent to which yield is influenced by flowering behaviour. Cashew is reported to be a cross-pollinating tree crop (Pavithran and Ravindranathan, 1974; Free and Williams, 1976; Palaniswami *et al*, 1979). Cashew flowers are borne on an inflorescence that is an indeterminate panicle. Each flowering panicle possesses both hermaphrodite and male flowers (Rao and Hassan, 1957; Ascenso and Mota, 1972; Kumaran *et al*, 1976; Thimmaraju *et al*, 1980), and, other than these, abnormal flowers have also been reported (Masawe, 1994; Mota, 1973). Cashew trees require 4-5 months to complete sequential anthesis in the panicle (Pavithran and Ravindranathan, 1974).

The cashew tree normally bears nuts with attached false fruit (the cashew 'apple') on the periphery of the canopy. Casual observation suggests that one side of the tree may have higher nut-set than another. Existence of such differences has not been established, nor is the distribution of flower types between sides (e.g. sunny or shaded side) or whether yield is directly related to flower distribution. It is important for future breeding work or developing cashew ideotype, as well as orchard establishment to determine whether high yield is pre-determined by number, distribution in time and / or ratio among flower types.

MATERIAL AND METHODS

The present investigation was carried out at S.G. College of Agriculture and Research Station, IGKV, Jagdalpur (C.G.) during flowering seasons of 2003-04 and 2004-05. The material comprised of 14 varieties of cashew, released from different parts of the country, receiving the same cultural treatment. The experiment was carried out in randomized block design with three replications. Fourteen cashew genotypes, each represented by four individuals,

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vegetatively propagated by softwood grafting were selected. The genotypes were Hybrid-3/28, Hybrid-3/33, Hybrid-30/1, Hybrid-10/19, Vridhachalam-1, Vridhachalam-2, Hybrid-68, Hybrid-255, Hybrid-367, Hybrid-320, Hybrid-303, Selection-1, Selection-2 and Vengurla-4. Each genotype was planted in a block of four trees at spacing of 7.5 x 7.5 m. The cashew tree canopy of each selected tree was marked on four sides i.e., north, south, east and west using a compass. From each marked side, a total of four young panicles (2 for flowering and 2 for fruiting) of almost the same size by (visual appearance) were selected at random for taking observation during the entire flowering and fruiting period (December to May). Each panicle was tagged and numbered. Counting of the type of opened flower within each panicle was carried out daily by detaching them from the cashew panicle using fine forceps. Care was taken to ensure that the residual parts of labelled panicles were not physically damaged.

Two types of flowers namely, staminate and hermaphrodite, were observed throughout the flowering period. Both flower types were morphologically distinct with each other, male flowers usually having five sepals, five petals, one large exerted stamen and 7-9 small inserted stamens, with each stamen comprising an anther and a short filament. The large stamen was nearly twice the length of small stamens. The large stamen and most of the small stamens produced pollen. Hermaphrodite flowers were similar to the staminate flowers but had a well-developed gynoecium, which consisted of an ovary, style and a stigma that was normally longer than the large stamen but occasionally shorter or of equal size. Analysis of variance was carried out as per Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Flowering : Number of days to flower was taken as the number of days, from 30th November, for appearance

Table 1. Mean number of days taken from 30 Nov. (2004 and 2005) for first flower to open on different sides in various cashew genotypes

Side	Type	Genotype														Mean	
		3/28	3/33	30/1	10/19	VRI-1	VRI-2	H-68	H-255	H-367	H-320	H-303	Sel-1	Sel-2	V-4	Type	Side
North	S	39	28	14	30	15	39	29	34	36	33	30	52	33	39	32.21	35.07
	H	42	31	18	36	22	46	38	39	46	39	38	56	38	42	37.93	
South	S	28	20	8	18	9	29	23	22	28	27	22	39	24	34	23.64	26.18
	H	31	23	14	25	12	32	30	29	32	34	29	45	30	36	28.71	
East	S	23	18	6	15	8	26	18	17	26	24	19	36	22	32	20.71	22.56
	H	27	24	12	21	12	31	27	19	31	31	24		25	35	24.54	
West	S	29	23	10	20	10	32	27	23	29	27	23	40	25	34	25.14	26.93
	H	33	29	14	26	15	37	34	25	34	35	29		28	36	28.85	
Mean	S	29.75	22.3	9.5	20.75	10.5	31.5	24.25	24	29.75	27.75	23.5	41.8	26	34.8		
	H	33.25	26.8	14.5	27	15.25	36.5	32.25	28	35.75	34.75	30	50.5	30.3	37.3		
	OA	31.5	24.5	12	23.88	12.88	34	28.25	26	32.75	31.25	26.75	46.1	28.1	36		

S= Staminate, H= Hermaphrodite, OA= Overall average

of the first flower of each type (staminate or hermaphrodite) to open. Thus, 1st December was considered as the first day, and so on. Number of days to flower varied between genotypes (Table 1). Among the genotypes, Hybrid-30/1 was clearly the earliest, producing the first flowers on sixth day on the north side, together with production of male flowers on the east side. Vridhachalam-1 was the next earliest. There were differences between genotypes in the date of first flower opening and in the time and duration of peak flowering. There is, therefore, a possibility for carrying out selection for earliness to flower as well as duration of flowering. This characteristic is important, as extended flowering may lead to undesirably late nut/fruit production. Some genotypes such as Hybrid-30/1 and Vridhachalam-1 peaked early and yielded over a short period, while others, like Selection-1 and Vengurla-4, yielded over a wider span of time. The genotype Selection-1 was considerably later than all other 13 genotypes, taking nearly 36 days. With respect to sides of a tree, the east side produced flowers first, taking on average 22.56 days, followed by south (26.18 days) which was very close to the west side (26.93 days). Flowering in the north side took more time (35.07 days) than other sides. In terms of different flower types, all genotypes produced staminate flowers first followed by hermaphrodite ones.

Flower type: It was observed that at Bastar, flowering was early on the east and south sides of the tree. Production of all flower types increased with time, as shown in Fig. 1. The figure shows mean number of flowers per panicle on each side (of on average over all fourteen genotypes). However, it was seen that the production of staminate flowers increased dramatically compared to hermaphrodite flowers. The trend in production of staminate flowers was similar in all the genotypes, with two phases, i.e. an early peak and a late peak. Major production of

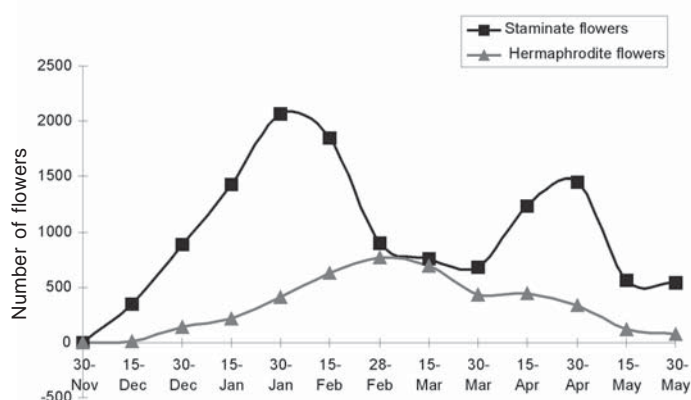


Fig 1. Comparison of flower-sex type during flowering in cashew

staminate flowers was more pronounced in the early part of flowering season. But, during the middle part, all genotypes tended to produce more hermaphrodite flowers. However, the number of hermaphrodite flowers was relatively low compared to the number of staminate flowers. Later, all the genotypes showed higher production of staminate flowers.

The total number for each type of flower is given in Table 2. The proportion of staminate and hermaphrodite flowers also varied with genotype. Staminate flowers were always more in number and ranged from 1005.25 to 1977.83, while hermaphrodite flowers ranged from 150 to 613 per panicle. Genotype Vridhachalam-2, produced the lowest number of total flowers (1274.25) and staminate flowers (1005.25). The lowest number of hermaphrodite flowers (150) was produced by Hybrid-10/19. Hybrid-255 produced the highest total number of flowers (2590.83) and hermaphrodite flowers (613). In India, Damodaran (1966) observed 486 flowers per healthy panicle, while, Hanamashetti *et al* (1986) reported a range of 165 to 837 flowers. Heard *et al* (1990) observed 16 panicles over 50 days in Australia and noted a mean number of 443 flowers per panicle. In most cases, the first flowers to open were staminate, as reported by Moranda (1941), Rao and Hassan (1957), Northwood (1966) and Pavithran and Ravindranathan (1974). For most of the season, staminate and hermaphrodite flowers opened at the same time, but the number of staminate flowers was considerably greater than number of hermaphrodite flowers. There were highly significant differences in the number of male flowers between genotypes and between the sides in the same clone. By contrast, difference in number of hermaphrodite flowers varied significantly between clones while there was significant difference between sides.

Sex ratio: The ratio of hermaphrodite to staminate flowers is shown in Table 2 which shows significant variability between genotypes and sides. On an average, it ranged from 0.10 to 0.31 among genotypes, whereas, for the east side from 0.09 to 0.29, west side from 0.10 to 0.40, south side from 0.14 to 0.40 and north side 0.05 to 0.26. Mean sex ratio was observed to be highest for the south side (0.25) and lowest for north side (0.14). Hybrid-255 showed highest sex ratio for north, south and west sides and Vridhachalam-2 for east side whereas, Selection-1 had low sex ratio for all the four sides. However, considering overall number of flowers, summed over sides, Hybrid-255 stood out with high sex ratio (0.31) and Selection-1 lowest (0.10). The others had moderate ratios. The ratio of hermaphrodite to staminate flowers varied between genotypes and different sides in the same genotype. In most genotypes, higher ratio was found on the south side. Present results are in agreement with those reported by Chakraborty *et al* (1981) who reported that panicles on the south side gave maximum number of hermaphrodite flowers and higher sex ratio. They also suggested that distribution of flowers was influenced by light and temperature. It has been claimed by Wunnachit and Sedgeley (1992) that the number of hermaphrodite flowers can be used as a selection criterion. Heard *et al* (1990) reported that pollination was not a limiting factor in cashew production.

Nut yield: The distribution of nut yield (kg) on different sides of the tree, number of hermaphrodite flowers and fruit set is presented in Table 3. Average fruit set (%) ranged from 2.23 to 4.28% among genotypes and, on the east side, it varied from 1.56 to 2.67; west side from 1.56 to 3.34, south side from 4.67 to 9.12 and north side, 1.20 to 2.10. In general the south side had highest fruit set, followed by west, east and north, in all the genotypes. Hybrid 30/1 had highest per cent fruit set (4.28), followed by Hybrid-303 (4.02). Selection-1 had the lowest fruit set (2.23). Highest fruit set in north was recorded in Hybrid-3/33 (2.10), whereas, highest values for south (9.12), east (2.67) and west sides (3.34) were observed in Hybrid-30/1.

Distribution of yield over tree canopy showed the south side as having significantly highest nut yield, followed by the west side. Nut yield increased with increase in number of hermaphrodite flowers and fruit set. Data on average yield data showed that Hybrid-303 gave maximum nut yield (4.02), followed by Hybrid-68 (3.94), and the lowest was recorded in Vridhachalam-2 (0.72). In the present study the yield of cashew genotypes showed significant differences between the genotypes or between the sides of the same

Table 2. Number of staminate and hermaphrodite flowers per panicle (from four trees) of cashew genotypes from different sides of tree canopy

Side	Type	Genotype												SE(m)±	CD (5%)	Mean			
		3/28	3/33	30/1	10/19	VRI-1	VRI-2	H-68	H-255	H-367	H-320	H-303	Sel-1				Sel-2	V-4	Type
North	S	880.32	1113.55	1137.09	665.18	1007.74	627.28	876.56	988.92	1026.66	802.09	974.16	1308.53	903.08	976.18	28.01	60.52	949.10	539.39
	H	152.96	128.48	241.26	57.00	87.03	114.06	100.08	259.91	151.36	87.56	199.88	62.26	87.34	86.34	8.37	18.08	129.68	
	SR	0.17	0.12	0.21	0.09	0.09	0.18	0.11	0.26	0.15	0.11	0.21	0.05	0.10	0.09				0.14
South	S	2452.32	2358.12	2974.61	1722.93	1924.65	1592.32	2487.89	2587.00	2859.99	1698.55	2523.25	2499.12	2292.44	1864.37	67.10	144.96	2274.11	1431.44
	H	822.16	432.16	967.30	270.00	481.71	479.90	502.62	1042.10	813.56	294.52	946.80	344.62	367.50	477.90	38.03	82.16	588.78	
	SR	0.34	0.18	0.33	0.16	0.25	0.30	0.20	0.40	0.28	0.17	0.38	0.14	0.16	0.26				0.25
East	S	1320.48	1310.06	2774.49	1441.55	1135.33	804.20	1321.29	2412.95	1540.00	943.64	2111.16	1474.20	1157.80	1099.77	43.94	94.92	1489.07	877.74
	H	382.40	292.00	357.33	129.60	197.34	220.58	227.96	384.96	378.40	199.00	454.46	141.18	168.92	195.78	17.21	37.16	266.42	
	SR	0.29	0.22	0.13	0.09	0.17	0.27	0.17	0.16	0.25	0.21	0.22	0.10	0.15	0.18				0.19
West	S	1634.88	1768.59	2210.49	1047.02	1340.77	997.21	1727.35	1922.45	1906.66	1273.91	1533.38	1740.96	1435.67	1298.78	46.03	99.44	1559.87	964.35
	H	554.48	315.36	710.11	143.40	245.92	261.47	281.34	765.02	548.68	214.92	502.86	175.93	200.23	243.97	23.83	51.44	368.83	
	SR	0.34	0.18	0.32	0.14	0.18	0.26	0.16	0.40	0.29	0.17	0.33	0.10	0.14	0.19				0.23
Average	S	1572.00	1637.58	2274.17	1219.17	1352.12	1005.25	1603.27	1977.83	1833.33	1179.55	1785.49	1755.70	1447.25	1309.77	46.29	99.98	1568.03	
	H	478.00	292.00	569.00	150.00	253.00	269.00	278.00	613.00	473.00	199.00	526.00	181.00	206.00	251.00	21.86	47.21	338.43	
	SR	0.30	0.18	0.25	0.12	0.19	0.27	0.17	0.31	0.26	0.17	0.29	0.10	0.14	0.19	0.016	0.035		
Total		2050.00	1929.58	2843.17	1369.17	1605.12	1274.25	1881.27	2590.83	2306.33	1378.55	2311.49	1936.70	1653.25	1560.77				

S= Staminate, H= Hermaphrodite, SR= Sex ratio

Table 3. Comparison of number of hermaphrodite flowers and fruit-set per panicle to yield (kg per tree) of cashew genotypes on different sides of tree canopy

Side	Type	Genotype												SE(m)±	CD (5%)				
		3/28	3/33	30/1	10/19	VRI-1	VRI-2	H-68	H-255	H-367	H-320	H-303	Sel-1			Sel-2	V-4		
North	NHF	152.96	128.48	241.26	57.00	87.03	114.06	100.08	259.91	151.36	87.56	199.88	62.26	87.34	86.34	8.37	18.08		
	FS	1.33	2.10	2.00	1.87	1.44	1.56	1.87	1.42	1.50	1.64	2.12	1.12	1.42	1.78				
	Y	0.60	1.00	1.06	1.44	0.40	0.40	0.40	1.91	0.79	0.78	1.07	2.12	0.78	0.60	1.43			
South	NHF	822.16	432.16	967.30	270.00	481.71	479.90	502.62	1042.10	813.56	294.52	946.80	344.62	367.50	477.90	38.03	82.16		
	FS	5.75	7.50	9.12	6.08	6.98	5.58	8.45	7.71	7.02	7.14	8.36	4.67	8.51	8.78				
	Y	3.53	2.61	4.85	4.69	1.94	1.43	8.64	4.31	3.65	4.65	8.35	2.17	3.62	7.07				
East	NHF	382.40	292.00	357.33	129.60	197.34	220.58	227.96	384.96	378.40	199.00	454.46	141.18	168.92	195.78	17.21	37.16		
	FS	1.74	2.27	2.67	1.97	1.79	1.88	2.33	1.85	2.08	2.05	2.58	1.56	1.77	2.06				
	Y	0.78	0.98	1.42	1.52	0.50	0.48	2.37	1.03	1.08	1.33	2.58	0.78	0.75	1.66				
West	NHF	554.48	315.36	710.11	143.40	245.92	261.47	281.34	765.02	548.68	214.92	502.86	175.93	200.23	243.97	23.83	51.44		
	FS	2.14	3.14	3.34	2.06	2.14	2.20	2.78	2.27	2.65	2.45	3.04	1.56	2.11	2.34				
	Y	0.97	0.97	1.78	1.59	0.60	0.56	2.84	1.27	1.38	1.59	3.04	0.78	0.90	1.88				
Average	NHF	478.00	292.00	569.00	150.00	253.00	269.00	278.00	613.00	473.00	199.00	526.00	181.00	206.00	251.00	21.86	47.21		
	FS	2.74	3.75	4.28	2.99	3.09	2.80	3.86	3.31	3.31	3.32	4.02	2.23	3.45	3.74	0.82	1.69		
	PFR	40.27	34.72	56.49	34.42	36.82	30.24	46.42	42.48	42.01	40.66	51.15	34.97	47.48	46.40	5.03	10.36		
Y	1.47	1.39	2.28	2.31	0.86	0.72	3.94	1.85	1.72	2.16	4.02	1.13	1.47	3.01	0.36	0.75			

NHF= Number of hermaphrodite flowers, FS= fruit set, Y= Yield, PFR= Per cent fruit retention

genotype. This could be related to the pattern of flowering. However, it is worth noting that the south side recorded highest yield. There was continuous production of hermaphrodite flowers from onset of flowering till the end, while, production of male flowers decreased over time. Further, it was seen that hermaphrodite flowers produced very early or too late had few or no nuts thus indicating the importance of hermaphrodite rather than staminate flowers in determining yield potential as in the Philippines (Moranda, 1941).

The highest magnitude of fruits carried to maturity (% fruit retention) was recorded in Hybrid -30/1 (56.49%) and was at par with Hybrid -303, Selection-2, Hybrid -68 and Vengurla-4. Lowest fruit retention was noted in Vridhachalam-2 (30.21%).

It would greatly help devise future strategies if more studies are carried out on yield performance on different sides of cashew tree across a wide range of locations. Nevertheless, present results are in agreement with earlier reports and further show that selection for floral behaviour could give beneficial results for cashew production and for development of a cashew ideotype.

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