Research Article

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Investigations on self-compatibility and extent of self and cross- pollination in cashew

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Abstract

To address the issues of presence of self-incompatibility and extent of self and cross-pollination in cashew, studies were carried out employing eight cultivars and four types of pollinations *viz*., self-pollination, geitonogamy, hand self-pollination, hand cross-pollination. Observations on percentages of initial fruit set, final fruit set, fruit shed as well as total fruit set were recorded. The cultivars differed significantly for all the traits studied. In hand self-pollination, initial fruit set varied from 7.97 to 17.03 per cent. The final fruit set ranged from 10.47 to 3.13 per cent. The fruit shed varied from 9.53 to 1.85 per cent. The total final fruit set varied from 12.50 per cent (NRCC Sel-2) to 41.88 per cent (Ullal-3). In hand cross-pollination, the initial fruit set varied from 9.30 to 18.83 per cent. The final fruit set ranged from 3.77 to 7.90 per cent and the fruit shed varied from 4.12 to 15.06 per cent. The total final fruit set ranged from 15.06 per cent (Priyanka) to 31.58 per cent (NRCC Sel-2). Cultivar, Ullal-3 showed more fruit set in self-pollination and geitonogamy. All the varieties were found to be self- compatible and hence self-incompatibility does not seem to operate in cashew. Six varieties were cross-compatible and two were partially cross-compatible as female parents. The study indicated that self as well as cross-pollination play significant roles in fruit set in cashew. The estimates of heritability in broad sense and genetic advance for final fruit set were high in self- pollination and geitonogamy, high and moderate in hand self and cross-pollinations.

Keywords: Cashew, cross-pollination, fruit set, self-compatibility, self-pollination

Introduction

The crop, *Anacardium occidentale* (L.) is usually grown for cashew nuts and cashew apples. Globally, cashew is cultivated in 37 nations with an average productivity of 4.90 MT from an area of 6.08 MH. India has the highest area with 1.04 million ha and third in the production with 0.67 million tonnes, but yields levels are below world average with 647.7 kg ha^{-1} (FAOSTAT, 2016). Several factors have been reported to influence the yield levels in cashew crop (Nambiar 1977; Parameswaran *et al*., 1984; Chacko *et al*., 1990; Foltan and Ludders 1995). Earlier workers viewed inadequate pollination in nature as one of the reasons for lower yields in cashew (Rao, 1974; Kumaran *et al*., 1976a; Reddi, 1987). Reduced fruit set and higher premature fruit fall were attributed to cause low yield in cashew (Nawale *et al.*, 1984; Patnaik *et al.*, 1985). Some reports indicated that there is significant difference between initial fruit set and final fruit set from 3 to 40 per cent. Rao (1956) reported fruit set of 3 per cent while Murthy *et al*. (1975) recorded 6 to 12 per cent fruit set.

Cashew is considered as allogamous species with insects as pollinating agents, but a few studies have reported of autogamy (Westergaard and Kayumo, 1970; Wunnachit *et al*., 1992; Foltan and Ludders, 1995) and self-incompatibility (Wunnachit *et al.*, 1992) in Tanzania and Australia. Aliyu (2008) reported 34 per cent cross-compatibility and 37 per cent self-compatibility in cashew clones in Nigeria. However, there are no studies on self-compatibility and genetic variability for fruit set in Indian cashew cultivars. Therefore, the present studies on self-compatibility, extent of fruit set in self and

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cross- pollination and genetic variability for fruit set in cashew cultivars was under taken at the ICAR-DCR, which would be useful for designing cashew breeding programmes.

Materials and methods

The research was carried out at ICAR-Directorate of Cashew Research (ICAR-DCR), Puttur, situated at the latitude of 12° 46' N and longitude of 75° 12' E with mean annual precipitation of 4329 mm and mean annual temperature of 26.8 °C. Ten cashew clones including eight popular cultivars (NRCC Sel-2, Bhaskara, Ullal-3, VRI-3, Vengurle-4, Vengurle-7, Madakkathara-2, and Priyanka) from major cashew growing regions of India, H-130, a jumbo nut hybrid and NRC-493, a jumbo nut germplasm accession maintained at ICAR-DCR, Puttur were used in the study. The eight 15 year old cultivars were planted following a plant to plant as well as row to row distance of 5m. Five year old cultivars *viz*., H-130 and NRC-493 were planted following a plant to plant as well as row to row distance of 7.5 m. The varieties were subjected to four types of pollination *viz*., self-pollination (bagging of panicle with removal of daily opened male flowers), geitonogamy (bagging of panicle without removal of daily opened male flowers), hand self-pollination and hand cross-pollination (Fig. 1). Bags having a dimension of 30 cm x 20 cm made from cora cloth were used for bagging of panicles. Single panicle was bagged in three trees of each variety and each tree was treated as a replication. Thus, there were three replications for self-pollination and geitonogamy. The panicles in trees were selected such that at least 15-20 bisexual flowers were present in that panicle to effect self - pollination or geitonogamy.

Self-pollination / geitonogamy | **Hand self-pollination in Ullal-3** | **Hand cross-pollination in Ullal-3**

Fig. 1. Self-pollination, geitonogamy and hand pollination in cashew

In case of hand self-pollinations, 160 pollinations were carried out in eight varieties using four trees per variety covering 40 hand self-pollinations in each tree. The same approach was followed for hand cross-pollinations. Thus, there were four replications for hand self and cross-pollination with 40 pollinations per replication. The study was carried out during the flowering season from November 2017 to March 2018. The point worth mentioning here is that fertility status of pollen grains of most of these varieties has been reported to be very high (Eradasappa *et al*., 2014). In case of self-pollination, the panicles were bagged and male flowers opened were removed daily and again bagged the panicle till no male flowers were found in those panicles. In geitonogamy, the bagged panicles were opened after 60 days and fruit set was recorded. The hand self and cross-pollinations were carried out following the hybridization technique described by Bhat *et al*. (2005) with slight modification. Male flowers from the same or different panicle of same tree of each variety were used for effecting hand self-pollinations whereas male flowers from three sources *viz*., Bhaskara, H-130 and NRC-493 were used for effecting cross-pollinations in eight cultivars. The crosses made were as follows: NRCC Sel-2 x Bhaskara, Bhaskara x NRC-493, Ullal-3 x H-130, VRI-3 x H-130, Vengurle-4 x H-130, Vengurle-7 x H-130, Madakkathara-2 x H-130 and Priyanka x NRC-493. Initial fruit set was recorded at 7-10 days after pollination in hand self and cross-pollinations. Thereafter, final fruit set was recorded at six weeks after the pollination as per the procedure of Ohler (1979). Percentages of initial fruit set, final fruit set and fruit shed were worked out as follows:

$$\textit{Initial fruit set (\%)} = \frac{\textit{No. intial fruits set}}{\textit{No. of flowers pollinated}} \; x100$$

$$\textit{Final fruit set (\%)} = \frac{\textit{No. final fruits set}}{\textit{No. of flowers pollinated}} \; x100$$

$$\textit{Fruit shed (\%)} = [\textit{No. of intial fruits set - No. final fruits set}] \; x100$$

The total final fruit set percentage was also worked out from 160 pollinations (40 pollinations x 4 replications). The replicated data was analyzed

using a web-based agriculture statistical software (WASP 2.0). Since the data range was within 0 to 20 per cent for the above three parameters, square root transformation was applied before subjecting the data for analysis. Genetic variability parameters such as in terms of PCV and GCV have been computed as per Burton and Devane (1953); heritability in broad sense and genetic advance were estimated according to Johnson *et al*. (1955). Means of final fruit set of four types of pollination were tested for significance using t-test for two sample assuming unequal variances using MS Excel.

Results and discussion

Cora cloth bags, used for bagging of panicles, was found the most suitable choice as they provided proper aeration. The results revealed that varieties differed significantly for initial fruit set, final fruit set and fruit shed. Mean percentage values of initial fruit set, final fruit set and fruit shed are presented in the Table 1. In hand self-pollination, the lowest average initial fruit set was recorded in VRI-3 (7.97%) and the highest was observed in Bhaskara (17.03%). The cashew varieties NRCC Sel-2, Vengurle-4, Vengurle-7 and Madakathara-2 showed on par performance for average initial fruit set while remaining four varieties showed significant differences. Maximum average final fruit set was observed in Ullal-3 (10.47%) and minimum was observed in NRCC Sel-2 (3.13%). There were three groups of varieties showing same level of final fruit set; Bhaskara and Vengurle-4, VRI-3 and Vengurle-7 and Madakathara-2 and Priyanka. The average percentage of fruit shed was highest in Priyanka (9.53%) and lowest in VRI-3 (1.85%).

Table 1. Mean of initial fruit set, final fruit set and fruit shed percentages in eight varieties of cashew across four types of pollination

Variety	Hand self-pollination			Hand cross-pollination			Self-pollination	Geitono-gamy
	Initial fruit set (%)	Final fruit set (%)	Fruit shed (%)	Initial fruit set (%)	Final fruit set (%)	Fruit shed (%)	Final fruit set (%)	Final fruit set (%)
NRCC Sel-2	11.09 (3.33)^{c}	3.13 (1.76)^{e}	7.97 (2.81)^{ab}	16.52 (4.06)^{b}	7.90 (2.81)^{a}	8.63 (2.93)^{c}	0.00 (0.71)^{e}	1.32 (1.17)^{c}
Bhaskara	17.03 (4.13)^{a}	7.66 (2.77)^{b}	9.38 (3.06)^{a}	17.13 (4.14)^{b}	4.01 (2.00)^{c}	13.12 (3.62)^{ab}	0.82 (1.02)^{d}	0.00 (0.71)^{d}
Ullal-3	15.94 (3.99)^{a}	10.47 (3.24)^{a}	5.47 (2.33)^{c}	13.30 (3.65)^{d}	5.12 (2.26)^{b}	8.19 (2.86)^{c}	4.76 (1.92)^{a}	6.67 (2.22)^{a}
VRI-3	7.97 (2.82)^{d}	6.25 (2.50)^{c}	1.85 (1.27)^{e}	15.18 (3.90)^{c}	5.51 (2.34)^{b}	7.40 (2.47)^{cd}	1.43 (1.21)^{c}	0.00 (0.71)^{d}
Vengurle-4	11.41 (3.38)^{c}	8.44 (2.90)^{b}	2.97 (1.72)^{d}	13.23 (3.64)^{d}	7.85 (2.80)^{a}	5.38 (2.32)^{cd}	0.81 (1.02)^{d}	0.00 (0.71)^{d}
Vengurle-7	10.47 (3.23)^{c}	6.72 (2.59)^{c}	3.75 (1.89)^{d}	9.30 (3.05)^{e}	5.18 (2.27)^{b}	4.12 (2.01)^{d}	0.00 (0.71)^{e}	0.00 (0.71)^{d}
Madakkathara-2	11.25 (3.35)^{c}	4.53 (2.13)^{d}	6.72 (2.59)^{bc}	14.43 (3.80)^{c}	5.67 (2.38)^{b}	8.76 (2.96)^{bc}	2.78 (1.53)^{b}	2.82 (1.54)^{b}
Priyanka	14.06 (3.75)^{b}	4.43 (2.13)^{d}	9.53 (3.08)^{a}	18.83 (4.34)^{a}	3.77 (1.94)^{c}	15.06 (3.88)^{a}	0.00 (0.71)^{e}	0.00 (0.71)^{d}
CV (%)	**3.11**	**4.53**	**10.42**	**2.53**	**5.69**	**16.21**	**3.94**	**7.36**
CD @ P=0.05	**0.16**	**0.17**	**0.36**	**0.14**	**0.20**	**0.69**	**0.08**	**0.14**

* Values in parentheses are square root transformations; Values with different letters are significantly different

The total final fruit set percentage varied from 12.50 per cent (NRCC Sel-2) to 41.88 per cent (Ullal-3). Vengurle-4, the national check, showed total final fruit set of 33.75 per cent while Bhaskara, the local check for west coast region, gave total final fruit set of 30.63 per cent (Fig. 2). The total final fruit set observed in these two varieties can be considered as fairly high. Two varieties *viz*., VRI-3 and Vengurle-7 showed considerable amount of total final fruit set with 25.00 and 26.88 per cent respectively. Both Priyanka and Madakkathara-2 recorded total final fruit set of 18.13 per cent. Aliyu (2008) reported average final fruit set ranging from 0 to 11 per cent in self-pollination done by hand in cashew clones. Holanda-Neto *et al*. (2002) observed that fruit set can be seen in self as well as cross-pollination; however, fruits obtained from self-pollination are shed 9 to 15 days after the pollination, and hence nuts obtained are mainly of cross-pollination. They deduced that fruits set through self-pollination in cashew are rejected due to discriminative abortion. They also suggested that lower fruit set could be attributed to self-incompatibility. But considerable amount of fruit set observed in the hand self-pollination in the present study suggests that self-incompatibility does not exist in cashew.

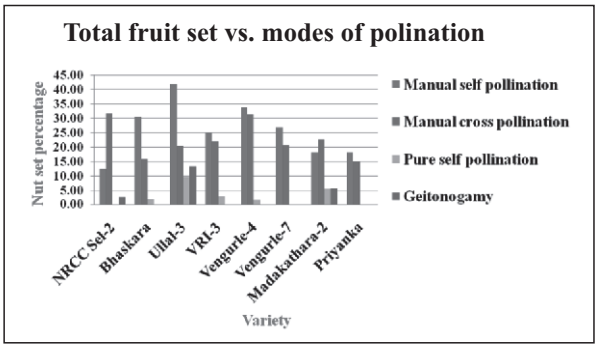

Fig. 2. Total fruit (nut) set in four types of pollination in eight cultivars

In hand cross-pollination, the average initial fruit set varied from 9.30 per cent (Vengurle-7) to 18.83 per cent (Priyanka). It was on par between Bhaskara and NRCC Sel-2; VRI-3 and Madakkathara-2; Vengurle-4 and Ullal-3. Heard *et al*. (1990) reported mean initial fruit set of 15.5 per cent. Foltan and Ludders (1995) reported that the mean percentage of bisexual flowers is 14 per cent over all the varieties and below 41 per cent of the hermaphrodites set fruits initially later just 1- 18 per cent turned into harvestable fruits. The percentage of fruits shed was lowest in Vengurle-7 and highest in Priyanka. It was on par between NRCC Sel-2 and Ullal-3 and Vengurle-4 and VRI-3. Pillay and Pillai, (1975) reported that even though close to 85 per cent of the bisexual flowers are pollinated, merely 4-6 per cent finally set fruits, dropping of the left over 79-81 per cent occurs during various phases of growth. The reasons for shedding of fruits during the initial phases of growth may be physiological (Northwood, 1966) or pest incidence. Wunnachit and Sedgley (1992) have stated that below 40 per cent of the bisexual florets give rise to fruits but subsequently show high rate of premature fruit shedding. Chattopadhyay and Ghosh (1996) reported that setting of fruits in the open field situation varied from 5.03 to 10.07 per cent and overall fruit shed was 12.23-16.67 per cent with highest fruit shed observed in the mustard stage and pea stage followed it. Leonardi *et al*. (1994) viewed elevated pace of fruit shed in the initial phases of growth as a signal of incompatibility and cautioned that, it could not be viewed as the sole cause of fruit dropping as provision of resources also play a greater role.

Average final fruit set ranged from 3.77 per cent (Priyanka) to 7.90 per cent (NRCC Sel-2). The varieties Ullal-3, VRI-3, Vengurle-7 and Madakkathara-2 were at par for average final fruit set. The total final fruit set percentage ranged from 15.06 per cent (Priyanka) to 31.58 per cent (NRCC Sel-2). Vengurle-4 showed total final fruit set percentage close to NRCC Sel-2 while Bhaskara was close to Priyanka. The remaining four varieties showed total final fruit set close to 20 per cent. Rao and Hassan (1957) observed up to 55 per cent fruit set from hand pollination. Similarly, Chacko *et al*. (1990) reported 25 per cent fruit set in Darwin, NT region in Australia. Sapkal *et al*. (1994) and Narayan and Ghosh (1996) observed final fruit set ranging from 5-18 per cent. Hegde (1999) recorded highest final fruit set of 11.62 per cent in Ullal-2 while the lowest fruit set of 3.09 per cent in Vengurla-3. Aliyu (2008) reported average final fruit set ranging from 4 to 56 per cent in cashew clones. Sundararaju (2011) reported final fruit set of 24.6 per cent in hand cross-pollination in Bhaskara variety. The lowest fruit set was 3.2 per cent and the highest was 36.9 per cent in 15 cross combinations attempted at ICAR-DCR (DCR, Annual Report 2012-13).

In self-pollination, three varieties *viz*., NRCC Sel-2, Vengurle-7 and Priyanka did not set fruits in the bagged panicles. Ullal-3 showed highest self-pollination in this method while Bhaskara and Vengurle-4 were at par. In geitonogamy, five varieties *viz*., Bhaskara, VRI-3, Vengurle-4, Vengurle-7 and Priyanka did not set fruits in the bagged panicles. Ullal-3 showed highest self pollination in this method. Previous studies too observed zero nuts in the bagging experiments (Free and William, 1976; Akinwale, 1990; Bhattacharya, 2004).

The study indicated that self as well as cross-pollinations play significant roles in fruit set in cashew as evidenced by 41.88 per cent and 31.58 per cent total final fruit set in self and cross-pollination respectively. Nevertheless, achieving optimum fruit set in cashew plantations depends on aspects like load of pollinators/efficiency and distribution of resources (Aliyu, 2008). It was viewed that fruit setting in cashew is restricted by maternal resources rather than by number of fertile ovules (Subbaiah, 1983; Nawale *et al*., 1984; Ghosh, 1989). It was suggested that the troubles of lower yield levels in cashew are manageable through choice of compatible parents, nutrient management and enhancing the pollination though provision of pollinators (Aliyu, 2008). It was stated that partitioning of resources than the quantity of flowers involved in pollination usually determine generally decide the higher limit of fruit set (Leonardi *et al*., 1994; Stephenson, 1981) and hence cashew breeders and growers have to make efforts for proper resource allocation.

Analysis of compatibility

Since the total final fruit set varied from 12.50 to 41.88 per cent, all the varieties were classified as self-compatible as per the self-compatibility classification by Jacob and Atanda (1972) (Table 2). Hence the present study confirms that cashew is a self–compatible species though it is allogamous in nature. These results are in agreement with previous studies (Ohler, 1979; Heard *et al*., 1990; Holanda-Neto *et al*., 2002). Wiersma (2003) attributed the prevalence of self-compatibility in cross-pollinated species like cashew to partial breakdown of the self-incompatibility system due to raise in the choice for maximum fruit set down the line of cultivation. Six varieties *viz*., NRC Sel-2, Ullal-3, VRI-3, Vengurle-4, Vengurle-7 and Madakkathara-2 were found cross-compatible and two varieties *viz*., Bhaskara and Priyanka were found partially cross-compatible as female parents as per the classification given by Drewlow *et al*. (1973). These results validate the allogamous nature of cashew and support the results of Aliyu (2008). However, further studies on compatibility of these varieties as pollen parents and their combining ability is required for utilizing them in future breeding programmes in cashew.

Table 2. Analysis of compatibility of varieties

Genotype	Self- compatibility			Cross-compatibility (as females)		
	++	+ -	- -	++	+-	- -
NRCC Sel-2	✓			✓		
Bhaskara	✓				✓	
Ullal-3	✓			✓		
VRI-3	✓			✓		
Vengurle-4	✓			✓		
Vengurle-7	✓			✓		
Madakathara-2	✓			✓		
Priyanka	✓				✓	

+ +: Highly compatible, - +: Partially compatible and - -: Incompatible

Cross-pollination
- -: Cross-incompatible (CI) (0-10% fruit-set)
+ -: Partially cross-compatible (PC) (10.01–20.00% fruit-set)
+ +: Cross-compatible (CC) (>20.0% fruit-set) (Drewlow *et al*., 1973)

Self-pollination
- - : Self-incompatible (SI) (0-2.0% fruit-set)
+ -: Partially self-compatible (PSI) (2.01–4.99% fruit-set)
+ +: Self-compatible (SC) (>5.0% fruit-set) (Jacob and Atanda, 1972)

Table 3. Genetic variability estimates for fruit set and fruit shed in four types of pollination

Parameter	Hand self-pollination			Hand cross-pollination			Self-pollination	Geitono-gamy
	Initial fruit set (%)	Final fruit set (%)	Fruit shed (%)	Initial fruit set (%)	Final fruit set (%)	Fruit shed (%)	Final fruit set (%)	Final fruit set (%)
NRCC Sel-2	11.09	3.13	7.97	16.52	7.90	8.63	0.00	1.32
Mean	12.40	6.47	5.95	14.74	5.62	8.83	0.88	0.90
Range	7.97-17.03	3.13-10.47	1.85-9.53	9.30-18.83	3.77-7.90	4.12-15.06	0.00-4.76	0.00-6.67
Standardized range	0.73	1.13	1.29	0.65	0.73	1.24	5.41	7.41
GCV (%)	3.44	7.36	10.99	2.66	5.58	6.65	49.62	62.16
PCV (%)	3.55	7.57	11.73	2.74	6.07	8.50	49.88	62.76
h^2_{bs} (%)	93.81	94.58	87.69	94.48	84.55	61.28	98.96	98.12
GA as % of Mean (GAM)	6.86	14.74	21.20	14.74	10.58	10.73	101.68	126.85

Genetic variability for fruit set and fruit shed

The estimates of genetic variability parameters such as mean, range, PCV and GCV, heritability in broad sense (h^2_{bs}) and genetic advance as percentage of mean (GAM) for initial fruit set, final fruit set and fruit shed are given in the Table 3. Variation for fruit shed and final fruit set in respect of self as well as cross- pollinations was high as indicated by the standardized range. However, variation was more self-pollination through hand than cross-pollination. Range of variation for final fruit set in geitonogamy was more compared to self pollination. Maximum GCV and PCV were recorded for final fruit set in geitonogamy and lowest GCV and PCV were recorded for initial fruit set in hand cross-pollination. It was said that ample information for the improvement through selection can be obtained by GCV coupled with heritability (Burton, 1952). In the present study, heritability was high for initial and final fruit sets as well as fruit shed in four types of pollination suggesting the effectiveness of selection for them.

In the present study, initial fruit set in hand self pollination recorded high heritability and low GAM meaning that selection may not be rewarding for this trait. However, initial fruit set in hand cross-pollination showed high heritability coupled with moderate GAM indicating moderate efficiency of selection. Final fruit set recorded very heritability along with moderate GAM in self-pollination by hand as against cross-pollination by hand also indicated moderate efficiency of selection. Heritability and GAM were high for fruit shed in hand self-pollination illustrating amenable for selection efficiency. Interestingly, heritability and GAM values for fruit shed in hand cross-pollination were much lower than those observed in hand self- pollination. The estimates of heritability and GAM for final fruit set were very high in self-pollination and geitonogamy describing selection would be more effective for obtaining selfed fruits for conducting basic studies in cashew breeding. Earlier, Sena *et al*. (1994) reported higher estimates of GCV, heritability and genetic advance for final fruit set. Recently, Mangal (2016) reported mean fruit set of 5.20 per cent, high PCV (25.60%), GCV (24.01%), heritability (88.0%) and GAM (46.41%) for final fruit set.

Test of significance of means of four types of pollination using t-test for unequal variances

The means of four types of pollinations were checked for significance following t-test for unequal variances. The results revealed that means of self-pollination as well as cross-pollination by hand did not differ statistically for final fruit set in the

varieties tested (Table 4). These results agree with Foltan and Ludders (1995) and are converse to significant differences reported for fruit set in cross and self-pollination using LSD test (Northwood, 1966; Rao and Hassan, 1957; Ohler, 1979; Thimmaraju *et al*., 1980; Wunnachit *et al*., 1992). Similarly means of self-pollination and geitonogamy did not show significant variation for final fruit set (Table 5). However, means of final fruit set of hand self-pollination and self-pollination; means of final fruit set of hand self-pollination and geitonogamy showed highly significant differences (Table 6). Likewise, means of final fruit set of hand cross-pollination and self-pollination; means of final fruit set of hand cross-pollination and geitonogamy showed highly significant variations (Table 7).

Table 4. Test of significance between means of final fruit set in hand self-pollination and hand cross-pollination via t- test: assuming unequal variances

Variety	Hand self-pollination	Hand cross-pollination
NRCC Sel-2	3.13 (1.76)	7.90 (2.81)
Bhaskara	7.66 (2.77)	4.01 (2.00)
Ullal-3	10.47 (3.24)	5.12 (2.26)
VRI-3	6.25 (2.50)	5.51 (2.34)
Vengurle-4	8.44 (2.90)	7.85 (2.80)
Vengurle-7	6.72 (2.59)	5.18 (2.27)
Madakkathara-2	4.53 (2.13)	5.67 (2.38)
Priyanka	4.43 (2.13)	3.77 (1.94)
Mean	**6.47 NS**	**5.62 NS**
Variance	**5.73**	**2.38**
Calculated t value	**0.84 NS**	
Table t value @ P=0.05	**2.18**	

Table 5. Test of significance between means of self-pollination and Geitonogamy via t-test: assuming unequal variances

Variety	Self-pollination	Geitonogamy
NRCC Sel-2	0.00 (0.71)	1.32 (1.17)
Bhaskara	0.82 (1.02)	0.00 (0.71)
Ullal-3	4.76 (1.92)	6.67 (2.22)
VRI-3	1.43 (1.21)	0.00 (0.71)
Vengurle-4	0.81 (1.02)	0.00 (0.71)
Vengurle-7	0.00 (0.71)	0.00 (0.71)
Madakathara-2	2.78 (1.53)	2.82 (1.54)
Priyanka	0.00 (0.71)	0.00 (0.71)
Mean	**1.32 NS**	**1.35 NS**
Variance	**2.82**	**5.64**
Calculated t value	**-0.02 NS**	
Table t value @ P=0.05	**2.16**	

Table 6. Test of significance of hand self-pollination with self-pollination and geitonogamy *via* t- test: assuming unequal variances

Variety	Hand self-pollination	Self-pollination	Hand self-pollination	Geitonogamy
NRCC Sel-2	3.13 (1.76)	0.00 (0.71)	3.13 (1.76)	1.32 (1.17)
Bhaskara	7.66 (2.77)	0.82 (1.02)	7.66 (2.77)	0.00 (0.71)
Ullal-3	10.47 (3.24)	4.76 (1.92)	10.47 (3.24)	6.67 (2.22)
VRI-3	6.25 (2.50)	1.43 (1.21)	6.25 (2.50)	0.00 (0.71)
Vengurle-4	8.44 (2.90)	0.81 (1.02)	8.44 (2.90)	0.00 (0.71)
Vengurle-7	6.72 (2.59)	0.00 (0.71)	6.72 (2.59)	0.00 (0.71)
Madakathara-2	4.53 (2.13)	2.78 (1.53)	4.53 (2.13)	2.82 (1.54)
Priyanka	4.43 (2.13)	0.00 (0.71)	4.43 (2.13)	0.00 (0.71)
Mean	**6.47****	**1.32****	**6.47****	**1.35****
Variance	**5.73**	**2.82**	**5.73**	**5.64**
Calculated t value	**4.97****		**4.29****	
Table t value @ P=0.01	**3.01**		**2.98**	

** Indicates significance @ P=0.01 (1%)

Table 7. Test of significance of hand cross-pollination with self-pollination and geitonogamy via t- test: assuming unequal variances

Variety	Hand cross-pollination	Self-pollination	Hand cross-pollination	Geitonogamy
NRCC Sel-2	7.90 (2.81)	0.00 (0.71)	7.90 (2.81)	1.32 (1.17)
Bhaskara	4.01 (2.00)	0.82 (1.02)	4.01 (2.00)	0.00 (0.71)
Ullal-3	5.12 (2.26)	4.76 (1.92)	5.12 (2.26)	6.67 (2.22)
VRI-3	5.51 (2.34)	1.43 (1.21)	5.51 (2.34)	0.00 (0.71)
Vengurle-4	7.85 (2.80)	0.81 (1.02)	7.85 (2.80)	0.00 (0.71)
Vengurle-7	5.18 (2.27)	0.00 (0.71)	5.18 (2.27)	0.00 (0.71)
Madakkathara-2	5.67 (2.38)	2.78 (1.53)	5.67 (2.38)	2.82 (1.54)
Priyanka	3.77 (1.94)	0.00 (0.71)	3.77 (1.94)	0.00 (0.71)
Mean	**5.62***	**1.32***	**5.62***	**1.35***
Variance	**2.38**	**2.82**	**2.38**	**5.64**
Calculated t value	**5.34****		**4.27****	
Table t value @ P=0.01	**2.98**		**3.36**	

* Indicates significance @ P=0.05 (5%)

** Indicates significance @ P=0.01 (1%)

Conclusion

The present study revealed the following aspects in cashew: 1) prevalence of self-pollination (within perfect flower) and geitonogamy in bagged panicle, 2) self-compatibility, 3) cross-compatibility and 4) genetic variability for fruit set. The variety Ullal-3 was found more amenable for both self pollination and cross-pollination and could be used for conducting basic studies. Future studies on cross-compatibility and combining ability of the genotypes used are required for utilizing them in cashew breeding programme.

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