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BREEDING BEHAVIOUR OF BLACK PEPPER

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ABSTRACT

Three cultivars of black pepper evaluated for breeding behaviour revealed high potency of autogamy and self-compatibility. High autogamy did not exactly reflect high self-compatibility. Water was found not essential for pollination. However, berry set under water-free condition was less than under open pollination. Cultivars differed in their breeding behaviour under water-free pollination. Good spike and berry set was observed in insect- proof cage. Indication of apomictic reproduction was also observed.

Key words: *Piper nigrum*, black pepper, autogamy, self compatibility, seed set.

Black pepper (*Piper nigrum* L.) is a perennial vine propagated by cuttings. The fruits (berries) are borne on the auxiliary lateral branches in spikes. Various degrees of protogyny are observed in this species. Breeding behaviour of the cultivated species is still not precisely understood. George et al. [1] reported that self-fertilization is undoubtedly the rule in the cultivated species. However, cross-pollination by rainwater, insects and wind are also reported [2–5]. Nair [6] as well as Shanmugavelu and Madhava Rao [7] reported *Piper nigrum* as cross-pollinated. Gentry [8] reported high fruit set in a dioecious clone of black pepper with no visible staminate flowers, possibly due to apomixis. The present article deals with an investigation on selfing (through autogamy and geitonogamy), self-compatibility, and berry set in three cultivars of black pepper. It also describes the possible role of rain water, insects, and apomixis in pollination and fruit set.

MATERIALS AND METHODS

The experiment was conducted at the National Research Centre for Spices, Calicut, Kerala, during main flowering seasons using potted black pepper laterals (bush pepper) of three vegetatively propagated cultivars, viz., Karimunda, Panniyur-1 and Aimpirian, which are predominantly bisexual. Observations were recorded on seed set, autogamy (selfing) and self-compatibility. Self- pollination was ensured through bagging the entire spike before exertion of the stigma with a perforated polythene bag (25 x 8 cm; 250 gauge). Hand

pollination was ensured by pollinating bagged spikes five times with the fresh pollen of the same plant with a soft camel hair brush. For assessing success of open pollination, randomly labelled unbagged spikes were utilized. The part of rain water in pollen transfer was tested by sheltering the plants from rain water by keeping them in a thatched shed. In order to confirm the role of insects in pollination, the plants were kept in a conventional insect-proof cage erected in a thatched shed. Apomixis was tested only in cv. Karimunda by emasculating the spike daily and keeping it bagged without pollination. Selfing, seed set, and self-compatibility were calculated following the method [1] for sunflower with suitable modification as below:

$$\text{Seed set (\%)} = \frac{\text{No. of filled berries}}{\text{No. of female + bisexual flowers}} \times 100$$

$$\text{Selfing (\%)} = \frac{\text{Seed set under bagging (\%)}}{\text{Seed set under open pollination (\%)}} \times 100$$

$$\text{Self-compatibility (\%)} = \frac{\text{Seed set with hand pollination (\%)}}{\text{Seed set under open pollination (\%)}} \times 100$$

RESULTS AND DISCUSSION

The data on seed set, selfing and self-compatibility (Table 1) reveal highest berry setting under open pollination in all the cultivars. Berry setting under self-pollination and hand pollination were almost similar in cvs. Karimunda and Panniyur-1. However, bagging + hand pollination registered slightly less berry setting as compared to selfing in cv. Aimpirian. Spike setting was completed (100%) in all the three cultivars under selfing, bagging + hand pollination, and open pollination. Self- fertilization was highest in cv. Aimpirian, followed by cvs. Panniyur-1 and Karimunda. However, high self-compatibility was observed in cv. Panniyur-1, followed by Aimpirian and Karimunda. Under water-free pollination, highest spike and berry set was observed in cv. Panniyur-1. Eventhough Karimunda registered a slightly higher spike set than Aimpirian under water-free pollination, the berry set was higher in Aimpirian than Karimunda. In all the cultivars, berry set was less under water- free pollination than under open pollination. However, the magnitude was very pronounced in cv. Karimunda. When the plants were transferred directly from the open into the insect-proof cage, profuse shedding of spikes, leaves and twigs was observed, probably due to insufficient light. Hence the plants already adapted to diffused light were tried only in cv. Aimpirian. In this cultivar, 77.3% spike set was recorded in the insect-proof cage. These spikes also started dropping progressively. Hence the bush with very immature berries was transferred to open condition. Berry setting (53.6%) in such spikes was as good as under open pollination, water-free pollination, and selfing.

Table 1. Selfing, seed set and self-compatibility in black pepper

Mode of pollination	Parameter	Values in different cultivars		
		Karimunda	Panniyur-1	Aimpirian
Bagging (selfing)	No. of spikes	30.0	30.0	20.0
	Spike set (%)	100.0	100.0	100.0
	Berry set (%)	65.9	60.5	49.0
Bagging + hand pollination	No. of spikes	30.0	30.0	20.0
	Spike set (%)	100.0	100.0	100.0
	Berry set (%)	64.4	59.5	44.0
Open pollination	No. of spikes	30.0	30.0	20.0
	Spike set (%)	100.0	100.0	100.0
	Berry set (%)	76.6	65.5	51.7
Water-free pollination	No. of spikes	15.0	12.0	35.0
	Spike set (%)	53.3	66.7	51.4
	Berry set (%)	35.6	60.6	50.2
Insect-proof cage pollination	No. of spikes	—	—	22.0
	Spike set (%)	—	—	77.3
	Berry set (%)	—	—	53.6
Emasculation + bagging	No. of spikes	20.0	—	—
	Spike set (%)	7.0	—	—
	Berry set (%)	8.2	—	—
Autogamy (%)	—	86.0	92.0	95.0
Self-compatibility (%)	—	84.0	90.9	86.5

Karimunda is a cultivar where overlapping of male and female phases are more evident. Emasculation without pollination in this cultivar resulted in only 7% spike set and 8.2% berry set.

The cultivated pepper is thought to have evolved from its completely allogamous wild relatives. The Piperales is one of the most primitive dicot groups derived from and is closely related to the insect-pollinated Magnoliales [9]. Martin and Gregory [4] reported that both self-compatibility and self-pollination in pepper may represent its adaptations to cultivation. The evidence reported here indicates that selfing (geitonogamy) is predominant in cultivated bisexual black pepper. Even though protogyny occurs in cultivated black pepper, it appears ineffective to prevent selfing as the pendant spike is abundantly assured of pollen from upper flowers.

De Waard and Zeven [10] stated that positive geotropism, spatial arrangement of the flowers, sequential ripening of the stigmas, and nonchronological dehisence of anthers stimulate geitonogamic fertilization. Wind may be aiding the pollen dispersal by brief mechanical agitation of the spikes/branches. The stigmas are reported to be receptive up to

10 days after exertion and small quantities of pollen are found in pollen sacs even five or more days after dehiscence [4].

In this study autogamy and self-compatibility did not correspond fully. The highest percentage of autogamy was recorded in cv. Aimpirian, whereas Panniyur-1 registered maximum self-compatibility. Panniyur-1 is a hybrid cultivar evolved in the mid-1960s. Higher self-compatibility in hybrids as compared to other varieties as well as high self-compatibility in relatively less autogamous varieties of sunflower were reported [1]. Vanceanu [11] reported that even incompatible genotypes can exhibit high self-compatibility under induced pollination. The relatively lower berry set in cv. Aimpirian under hand pollination as compared to selfing may be due to higher sensitivity of the stigma to brush pollination, leading to injury.

Rain water is not essential for pollination in black pepper, as revealed by the present study and also reported earlier [12]. However, contradictory reports were also published [2]. Nevertheless, rain water may enhance pollination, as berry setting was lower in the spikes protected from rain water in all the three cultivars when compared to open pollination. Similar observations were also reported earlier [3, 4]. The poor berry set observed in cv. Karimunda under water-free pollination might be due to the highly glutinous condition of the pollen.

When the plants were kept in the insect-proof cage till complete pollen shedding were transferred to open condition, good fruit set was observed. This indicates that at least in cv. Aimpirian, which is highly autogamous (95%), insects may not have major role in pollen transfer. Anandan [2] also recorded similar observations. However, the possible role of insects in fruit set has also been indicated [4, 5].

When the spikes of cv. Karimunda were systematically emasculated and protected from stray pollen, 8.2% berry set was observed in 7% spikes. This may be due to apomixis [8]. However, only embryological studies can confirm apomictic reproduction.

The study thus indicates that selfing with occasional outcrossing is the predominant mode of pollination in cultivated bisexual black pepper. Allard [13] has shown that combination of self-fertilization with occasional outcrossing is highly successful and is a typical characteristic of a large number of colonizing species.

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