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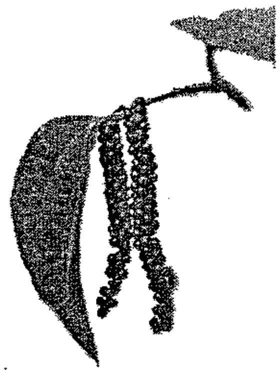
(*Piper nigrum* L.)



INTERNATIONAL PEPPER COMMUNITY

ROLE OF WEATHER PARAMETERS AND GENOTYPES ON FLOWER COMPOSITION OF BLACK PEPPER IN INDIA

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ABSTRACT

Global assessments elucidate the expected significant effect of climate change on future agriculture. In black pepper also, change in weather parameters plays an important role in its productivity. The present study attempts to make an assessment of the impact of genotypes and environment on sex form in black pepper. The observation on the flower composition of pepper varieties in different regions, revealed that there exists considerable extent of variability among genotypes and is highly influenced by the weather parameters. High percentage of bisexual flowers is essential for pollination and fruit set. For Panniyur-1, a popular variety, high altitudes and heavily shaded conditions cause the proportion of female flowers to be higher compared to hermaphrodite flowers. In contrast, the shift towards femaleness was not much pronounced in a few of the local cultivars such as Karimunda, Thevanmundi, Chumula and Neelamundi under similar conditions. Light availability, temperature and rainfall are found to be the major factors influencing the flower composition which in turn determine the productivity. The shift towards femaleness and lack of pollination are one of the major reasons for spike shedding among popular varieties such as Panniyur-1 in high altitudes.

Keywords: black pepper, flower composition, genotypes, light availability, rainfall, temperature.

INTRODUCTION

Black pepper (Piper nigrum L.), known as the "King of Spices", originated in the tropical evergreen forests of Western Ghats in India. India has the largest area under black pepper and the crop it is grown under varied cropping and climatic conditions. The average productivity of black pepper in India is around 300 kg/ha and 214 kg/ha in Karnataka (Anon. 2009). The major production constraints in hilly regions are diseases and non-availability of suitable varieties and planting materials. Crop failure due to spike shedding is becoming a major production constraint in high elevations of Karnataka. Shedding of spikes is attributed to various factors viz., fungal pollu (Colletotrichum sp.) (Menon, 1949; Kurian et al., 2000), insects, drought, absence of pollination (Anandan, 1924) and inadequate pollination (Geetha & Nair 1989). Predominance of female flowers in the spikes was reported as the major cause for pollination failure and subsequent spike shedding (Ravindran et al., 2000).

Over 100 cultivars and 15 released varieties are under cultivation in different agro-climatic conditions (Sasikumar et al., 1999). The performance of varieties depends on local climatic conditions, management methods, pests and diseases prevalent in that area. The wild P. nigrum is dioecious, while most of the cultivars are monoecious (Ravindran et al., 2000). Flowers are borne on solitary leaf-opposed spikes, morphologically terminal, filiform, and bisexual or unisexual. Among the cultivars, variations occur with regard to the relative proportion of male, female and bisexual flowers in spikes. The composition of flowers in the spikes is primarily governed by the genotype. However environmental factors also play a major role. The effect of climate on black pepper productivity is more related to local weather rather than global climate patterns. In general, high percentage of bisexual flowers is essential for effective pollination and fruit set (Ravindran et al., 2000).

While investigating the specific problem of spike shedding, several samples revealed predominance of female flowers in Panniyur-1, a popular variety among growers in coffee plantations of Coorg and Chickmagalur Districts of Karnataka. Based on this background, studies were undertaken in high altitudes of Karnataka and selected plots in other black pepper zones of Kerala and Tamil Nadu to study the flower composition in relation to genotypes and environmental factors.

MATERIALS AND METHODS

To study the flower composition, experimental plots were selected across the black pepper regions in high altitudes of Karnataka and selected plots in other zones of Kerala and Tamil Nadu. The experimental blocks were maintained with recommended package of practices (Devasahayam et al., 2006). A series of experiments were conducted to understand the flower composition at a particular growth period, over a period of time and the effect of shade, rainfall and temperature on flower composition.

Variation in flower composition

Observations on the flower composition of spikes were recorded from the different varieties /cultivars in 12 selected locations (nine in Karnataka, two in Kerala and one in Tamil Nadu). These areas were located at 900-1,400m above sea level with rainfall of 1,200-4,500 mm/annum. Ten vines (6-7 m height) per variety/cultivar per observations on flower composition, i.e. female, male and bisexual flowers were recorded in 50 spikes/vine collected from different heights of canopy (30% in top, 40% in middle and remaining 30% in 1-2 m height). Flower composition of spikes was recorded at 50% flower opening stage.

Flower composition during various months

An experiment was conducted at Indian Institute of Spices Research, Cardamom Research Centre, Appangala, Karnataka (1,100m above sea level with annual rainfall of 3,000-3,200mm) to study the flower composition during different months of flowering (May to November). The observations were recorded in the variety Panniyur-1 (9-12 years old) vines trailed on silver oak standards. The experimental plot was irrigated from 20th March and shade regulation was done during the second week of April to give 70% exposure (6,500-8,500 Lux on cloudy day at noon). Ten vines (6-7 m height) per replication were selected and the percentage of bisexual flowers per spike for 50 spikes on each vine was recorded during third week of each month from May to November.

Flower composition and environmental influence

In another experiment, pepper plots receiving all recommended package of practices were selected and varying shade levels were induced to study the influence of shade on flower composition. For this study, 9-12 year old Panniyur-1 vines trailed on silver oak standards were selected. Shade regulation was selectively done during the second week of in April to provide different levels of exposure to sunlight. Ten plants were selected from each exposure level viz., dense shade, partial shade and complete exposure for recording bisexual flower status. Similar observation on the composition of flowers was also recorded from the representative plots where excessive spike shedding was noticed. Fifty shed spikes were observed in nine locations (seven in Karnataka, one each in Kerala and Tamil Nadu).

RESULTS AND DISCUSSION

Variation in flower composition among genotypes

The present study revealed considerable variability among the genotypes for flower composition in spikes. The percentage of hermaphrodite flowers under high elevations was in the range of 2-63% in Panniyur-1, 55-99% in Panniyur-5, 68-94% in Karimunda, 74-77% in Balankotta, 56-78% in Chumula and 76-78% in Thevanamundi (Table 1). The hermaphrodite flower composition in spikes of different cultivars/varieties reported by various workers are 99.2% (Panniyur-1), 99% (Subhakara, Neelamundi and Kottanadan), 98% (Sreekara and Vadakkan), 96% (Aimpiriyan, Thevanmundi, Vellanamban and Panchami), 94% (Karimunda), 90% (Balankotta), 87% (Jeerakamunda), 83% (Chumula) and 78% (Kalluvalli) (Ravindran et al. 2000; Nambiar et al. 1978). In the present study, hermaphrodite to female phase shift was recorded in high altitude locations. The shift towards female flowers was noticed in all the 16 cultivars/varieties studied. However, the shift towards female phase was drastic in Panniyur-1 in all the high altitude locations. Generally, black pepper genotypes showed higher hermaphrodite flower combination in moderate rainfall zones of lower elevation (Ravindran et al., 2000). Among different cultivars/varieties, the male flowers in a spike varied from 0-19% and the proportion of hermaphrodite flowers showed even greater variation of 2-100%. The proportion of female flowers has been found to increase with an increase in the intensity of shade (Geetha and Nair, 1989). Spikes produced during the off season (July–August) are characterised by more number of female flowers compared to spikes produced during normal season (May–June). This study supports the views of Devasahayam et al. (2006) and suggests the need of exposure of vines to sunlight to induce higher proportion of hermaphrodite flowers which is essential for good fruit set (Ravindran et al., 2000). Higher proportion of female flowers under dense shaded condition and more hermaphrodite flowers under exposed condition indicates the necessity of shade regulation in the initial stages of spike emergence. The cultivars viz., Thevanmundi, Neelamundi, Chumula, Vellanamban and Karimunda recorded higher proportion of bisexual flowers compared to Panniyur 1 (under higher elevations).

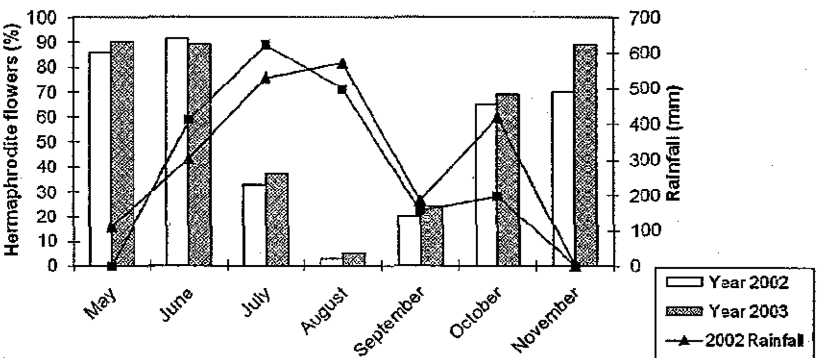


Fig 1. Hermaphrodite flowers (%) during May - November in Panniyur 1

Flower composition influenced by light availability, rainfall and temperature

Light availability plays an important role in pollination and hence the productivity of black pepper. Plants grown under dense shade will not come into good bearing, because only a small portion of the solar energy reaches the plant canopy (Wahind, 1984). In the present study, the hermaphrodite flower combination was altered drastically between May to November (Fig. 1) leading to female phase. The maximum percentage of bisexual flowers was recoded in the month of June (90%), while the lowest was recorded in August (4%), which coincides with heavy rainfall and less light availability. The sunshine hours rise from lowest in December to the peak in May (DeWaard and Zevan, 1969). High percentage of bisexual flowers is essential for good fruit set. Hence, the shift towards female phase led to pollination failure and spike shedding during July, August and September. Fig. 2 shows the impact of light on flower composition. Though irrigation, variety, standard (support tree), age of the vine and management were uniform, the quantum of light availability made the difference in the flower composition. In shaded condition (3,280 Lux), the drift towards female status is pronounced and spikes comprised only 3.9% of hermaphrodite flowers as against 83% hermaphrodite flowers in exposed conditions (10,000 Lux) and 8% in partially shaded condition (6,547 Lux). The light availability can be enhanced by proper shade regulation of standards or shade trees in the plantation during May–June for higher hermaphrodite to female flower ratio.

The data on flower composition in spikes that emerged and were shed during the month of August (Fig. 3) indicated predominance of female flowers instead of bisexual flowers and the trend is same for ~~in~~ all the nine locations. All the locations were heavily shaded and this might be the reason for the higher composition of female flowers.

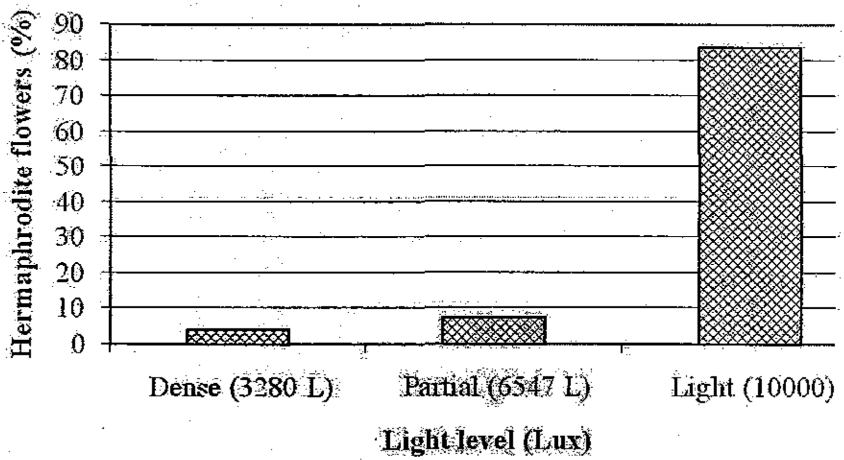


Fig.2 Hermaphrodite flower (%) under different shade level (Paniyur 1)

The observation on the flower composition of pepper varieties in different regions, revealed considerable extent of variability among the genotypes studied and was ~~is~~ highly influenced by the weather parameters. In Panniyur-1, under high altitude and highly shaded conditions, the proportion of female flowers was observed to be higher as compared to hermaphrodite flowers. The shift towards higher composition of female flowers was, however, not pronounced in a few local cultivars such as Karimunda, Thevanmundi, Chumula and Neelamundi. The shift towards female flowers and lack of effective pollination is one of the major reasons for spike shedding among popular varieties such as Panniyur-1 in high altitudes.

Flushing in black pepper starts with pre-monsoon showers in May and maximum flushing occurs during July (Anandaraj, 2000). Each new leaf also subtends a spike. When ~~In case~~ the pre-monsoon showers are delayed or absent, the flushing will also be delayed. Bright light plays an important role in the production of bisexual flowers. For the last few years there was absence of summer showers and the monsoon rain was also erratic. This had resulted in the production of more female flowers and increased spike shedding especially in the variety Panniyur-1 in Kodagu and adjoining areas. The experimental evidence also suggests the production of predominantly female flowers in spikes produced during July–August. Thus, change in local weather in Kodagu and adjoining areas for the last few years has resulted in reduced crop productivity as there was delayed flushing and spike production during peak monsoon with predominantly female flowers instead bisexual flowers. This was offset to some extent by irrigation and shade regulation. When there is no possibility of irrigation, resorting to planting of cultivars that are less sensitive to changes in weather would help to overcome the problem in black pepper growing areas.

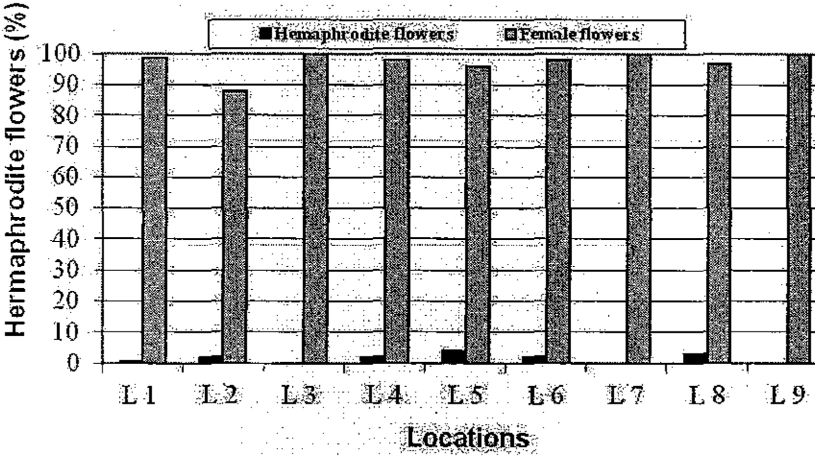


Fig 3. Hermaphrodite flowers (%) in shed spikes (Panniyur 1)

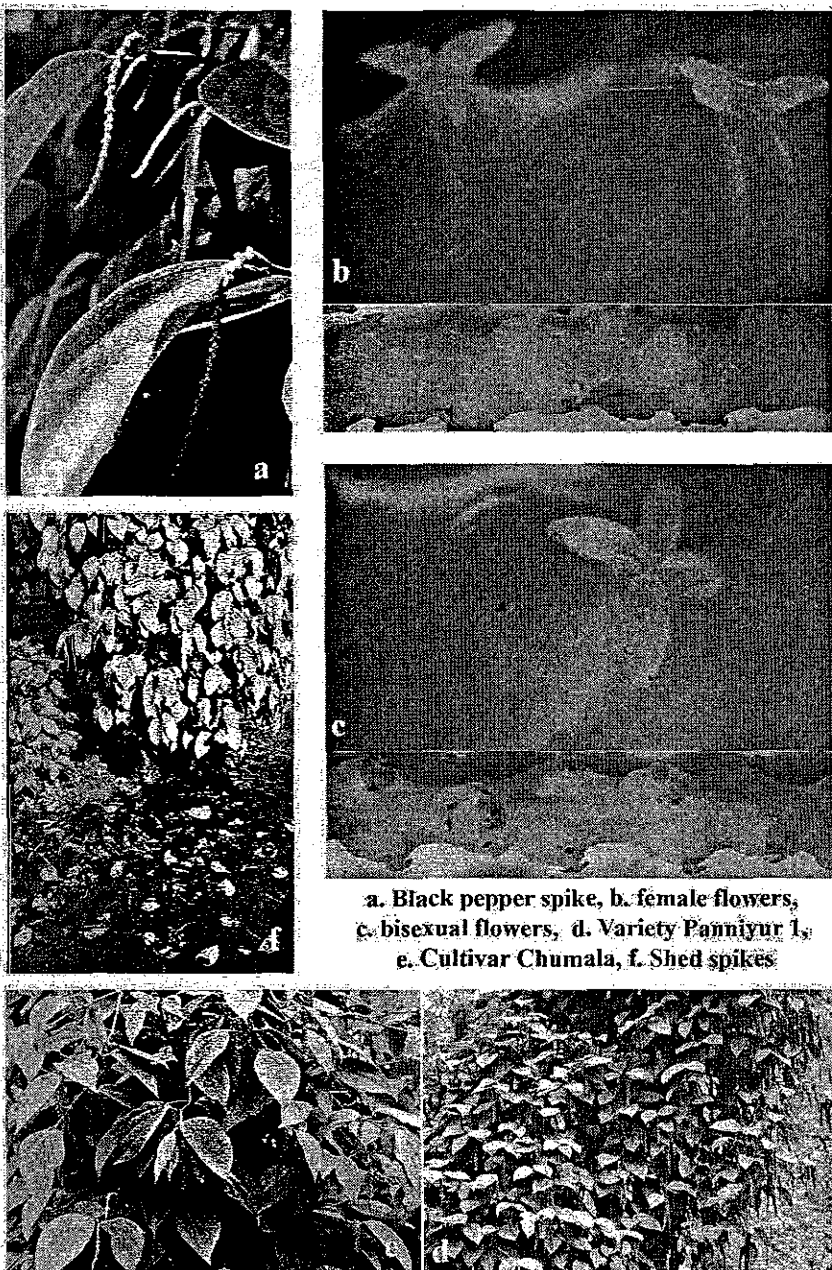
Table 1. Flowers composition (%) of varieties/cultivars grown under high altitudes

Location	Altitude (m MSL)	Rainfall (mm/year)	Variety/ cultivar	Hermaphrodite (%)		Female (%)		Male (%)	
1.Kodagu, Karnataka	1100	2000	Karimunda	89	(62.87)	11	(6.32)	0	
			Panniyur-1	14	(8.05)	86	(59.32)	0	
			Panniyur-5	99	(81.89)	1	(0.57)	0	
			Jeerakamunda	87	(60.46)	12	(6.89)	1	(0.57)
			Chumala	78	(51.26)	5	(2.87)	17	(9.79)
			Sreekara	98	(78.52)	1	(0.57)	1	(0.57)
			Shubhakara	99	(81.89)	1	(0.57)	0	
			Vadukkan	13	(7.47)	81	(54.10)	6	(3.44)
2. Kodagu, Karnataka	1150	3200	Panniyur-1	23	(13.30)	87	(60.46)	0	
			Panniyur-5	58	(35.45)	41	(24.20)	1	(0.57)
			Kottanadan	73	(46.89)	24	(13.89)	3	(1.72)
			Karimunda	68	(42.84)	32	(18.66)	0	
			Balankotta	74	(47.73)	26	(15.07)	0	
3. Kodagu, Karnataka	1100	3500	Panniyur-1	2	(1.15)	98	(78.52)	0	
4. Kodagu, Karnataka	1200	3200	Panniyur-1	2	(1.15)	98	(78.52)	0	
5. Kodagu, Karnataka	950	1800	Panchami	84	(57.14)	14	(8.05)	2	(1.15)
			Karimunda	94	(70.05)	5	(2.87)	1	(0.57)
			Panniyur-1	43	(25.47)	57	(34.75)	0	
			Jeerakamunda	73	(46.89)	23	(13.30)	4	(2.29)
			Arivally	72	(46.05)	25	(14.48)	3	(1.72)

Table 1. Flowers composition (%) of varieties/cultivars grown under high altitudes (*contd*)

Location	Altitude (m MSL)	Rainfall (mm/year)	Variety/ cultivar	Hermaphrodite (%)		Female (%)		Male (%)	
5. Kodagu, Karnataka			Karimunda	95	(71.81)	5	(2.87)	0	
			Balankotta	77	(50.35)	23	(13.30)	0	
			Kalluvalli	61	(37.59)	38	(22.33)	1	(0.57)
			Karevilanchi	12	(6.89)	88	(61.64)	0	
6. Kodagu, Karnataka	900	1800	Panniyur-1	63	(39.05)	36	(21.10)	1	(0.57)
7. Hassan, Karnataka	900	4500	Panniyur-1	9	(5.16)	91	(65.51)	0	
			Karimunda	83	(56.10)	17	(9.79)	0	
8. Chickmagalur, Karnataka	1350	1300	Panniyur-1	6	(3.44)	94	(70.05)	0	
9. Chickamagalur, Karnaatak	1400	3200	Panniyur-1	3	(1.72)	97	(75.93)	0	
10.Idukki, Kerala	1100	1450	Thevanmundi	82	(55.08)	18	(10.37)	0	
			Neelamundi	83	(56.10)	16	(9.21)	1	(0.57)
			Vellanomban	76	(49.46)	14	(8.05)	0	
			Aimpiriyan	66	(41.30)	32	(18.66)	2	(1.15)
			Karimunda	85	(58.21)	15	(8.63)	0	
			Panniyur-1	34	(19.88)	66	(41.30)	0	
11.Idukki, Kerala	1200	1500	Panniyur-1	14	(8.05)	86	(59.32)	0	
			Thevanmundi	76	(49.46)	24	(13.89)	0	
12. Nilgiris, Tamil Nadu	1300	1400	Panniyur-1	9	(5.16)	91	(65.51)	0	
			Chumala	56	(34.06)	32	(18.66)	2	(1.15)
CV (%)					6.85		7.91		17.20

(Figures within parenthesis are transformed values)



a. Black pepper spike, b. female flowers, c. bisexual flowers, d. Variety Panniyur 1, e. Cultivar Chumala, f. Shed spikes

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