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Pattern and variability of black pepper yields in tropical humid climatic conditions

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ABSTRACT

Ten improved lines were selected for the study. Six-month-old uniform cuttings one each @ 40 per line was planted on three years old *Ailanthus malabarica* DC live support during July 1994. The fresh green berry yield was recorded from first bearing (1996-97) year to third bearing year (1998-99). The number of yielding vines, yield per vine and mean yield (g vine⁻¹) and CV (%) varied among lines in all three years of yielding. Yield variability was not consistent over the years for same line and among the line. Irrespective of lines, the CV for yield during I, II and III years were 72.1, 50.1 and 35.6%, respectively. Yield distribution at different percentile values (0.01, 0.25, 0.50, 0.75, 0.90 and 1.0) and number of yielding vines between these percentile values were recorded. On an average, the yield (g vine⁻¹) distribution at different percentile values were 10, 140, 240, 500, 1070, 2620 in first year 10, 270, 560, 1110, 1726, 7500 in second year and for third year, it was 50, 1000, 2450, 5043, 7806, 15250; and number of yielding vines between these percentile yield values were 5.9, 3.7, 4.7, 2.4, 1.8 for first year, 8.4, 7.7, 8.0, 4.3, 3.1 for second year and 8.7, 7.5, 7.4, 4.8, 3.4 for third year. On an average maximum number of yielder was seen under 0.01 to 0.25 percentile yield group in all the three years of yielding and it varies with cultivars. Quantum of yield share also varies with percentile yield groups. The contribution of yield to the total production of lines were maximum from the yield obtained with vines belonging to higher percentile yield groups in spite of being their numbers less. The yield increment was observed from I to II year and II to III year. The mean magnitude of yield increment was 164.9% for I to II year and 259.3% for II to III year. The study quantified the yield variability in black pepper and would form the basis for examining the causes for such variability and develop technologies to overcome it.

Key words: Black pepper, yield, variability.

INTRODUCTION

India is one of the largest producer, consumer and exporter of black pepper (*Piper nigrum* L.). Presently, more than 25 countries are growing this crop in Asia, Africa and America, but few countries play significant role in the international trade. The yield of black pepper is seldom consistent. The variety, age of the vine, soil fertility and weather are main determinants of the final yield (Menon, 8). The yield varies greatly between countries depending upon the method and intensity of cultivation (Purseglove *et al.*, 12). The average commercial yield of black pepper in India is 237.2 kg ha⁻¹, which is low compared to other countries like Vietnam (1410.5 kg ha⁻¹), Indonesia (798.8 kg ha⁻¹), Brazil (2634.0 kg ha⁻¹), Malaysia (1641.8 kg ha⁻¹), Thailand (2555.6 kg ha⁻¹) and Sri Lanka (578.9 kg ha⁻¹) (FAO, 4). Black pepper starts bearing in third year after planting and economic life span varies with cultivars between 9 and 51 years and mean green yield also varies between 2.42 and 4.80 kg vine⁻¹ year⁻¹ (Sukumara Pillay *et al.*, 19). More than 100 cultivars with local names are available in India and majority of the common cultivars resemble one another closely. Ratnambal *et al.* (13) noted morphological variability

in 10 to 15 years old popular cultivar 'Karimunda' grown at different locations of Kerala. Similarly, Pradeepkumar *et al.* (11) observed yield variability in 20-year-old hybrid variety Panniyur-1 grown under identical environments. There was no information available on yield distribution and variability of improved black pepper lines in a plantation. Therefore, present study examines the yield distribution, variability and yield pattern of improved black pepper lines under identical management and the study would form the basis to identify the causes for such variability and develop technologies to get stable yield from vines in a black pepper plantations.

MATERIALS AND METHODS

Experiment was conducted at the Indian Institute of Spices Research - Experimental Farm, Peruvannamuzhi, Calicut between 1994 and 1999. Black pepper is a climbing vine propagated through seeds as well as vegetative cuttings. The time taken for first flowering by seed propagated vine is more (5 to 6 years) compared to 3 years by vines propagated through vegetative cuttings. Black pepper plant has three types of shoots namely, climbing orthotrope shoots, fruit bearing lateral plagiotrope shoots and runner shoot (runners) creeping on the ground. Cuttings can be made from all these shoots. However, runners

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are the most prepared for commercial planting. A rapid method is available for fast multiplication of selected runners from proven line. The selected runners are allowed to grow on rooting medium under nursery and periodically harvested to produce cuttings. In this study, cuttings of ten black pepper lines viz., Sreekara, Subhakara, Panchami, Pournami, P 24 and Panniyur 1 to 5 raised through rapid method were selected. Six months old uniform cuttings one each @ 40 per line were planted on three years old *Ailanthus malabarica* DC live support during July 1994. The crop grown as rain-fed under laterite soil. All the standard packages of practice were adopted. Rainfall during the study years (1994 through 1999) were 5380, 4725, 4081, 5798, 4444 and 4588 mm distributed in 165,161,129,158,159, 151 rainy days, respectively. The fresh berry yield vine⁻¹ was recorded from first bearing year (1996-97) to third bearing year (1998-99) for all the lines. Percentile yield values at 0.01, 0.25, 0.50, 0.75, 0.90 and 1.0 percentile and number yielding vines between percentile yield values, percentage share of percentile yield groups to the total yield of lines and percentage share of yielding vines between percentile yield groups to total yielding vines of a line and yield contribution of each line to the total yield of plantation and percentage increase over the years were computed.

RESULTS AND DISCUSSION

The number of yielding vines varied among different lines of black pepper. The number of yielders during first year of fruiting was less compared to second and third years of yielding (Table 1). The yield of individual lines and total yield of plantation were also of same trend. During first year, range of number of yielding vines was 10-32 with a mean of 18.5. Panniyur 1 had the maximum numbers followed by Subhakara and minimum was with Panniyur 2. In second year of yielding, range of yielders was 28-39 with a mean of 31.5, maximum by P-24 and Panniyur-4 and minimum with Sreekara and Panniyur-5. For third year of yielding, range was 23-39 with a mean of 31.8, P-24 and Panniyur 4 recorded maximum numbers and minimum was with Panniyur-5 and 3. In terms of percentage of yielding vine to total planted, it was in the range of 25 to 80%, 70.5 to 97.5% and 57.5 to 97.5% in first, second and third years, respectively. Nambiar (9) stated that as much as 30% are vacant without vines in a plantation due to diseases or drought. Total yield of a line, mean and median for per plant yield also varied in all the three years.

Yield of black pepper also varied among lines over the year considerably. During first year, mean fresh yield (g vine⁻¹) of lines ranged from 142 (Panniyur 3) to

Table 1. Summary statistics for green (fresh) yield of black pepper.

Genotype	No of yielding vines	Yielding vines (%)	Total yield (kg)	Mean (g vine ⁻¹)	Median (g vine ⁻¹)	Mode (g vine ⁻¹)	CV (%)
1996-97 (First year of yielding)							
Sreekara	19	47.5	3510	167.1	160	200	49.2
Subhakara	28	70.0	23450	837.5	650	600	72.3
Panchami	16	40.0	3220	201.3	175	100	59.0
Pournami	14	35.0	6580	470.0	375	350	73.1
P-24	19	47.5	3240	170.5	150	240	49.4
Panniyur 1	32	80.0	21190	706.3	500	500	75.0
Panniyur 2	10	25.0	2310	231.0	175	150	75.9
Panniyur 3	17	42.5	2410	141.7	130	100	44.4
Panniyur 4	13	32.5	7420	570.8	600	900	51.9
Panniyur 5	17	42.5	2665	156.8	150	100	59.2
Overall	185	46.3	75995	419	240	100	105.9
1997-98 (Second year of yielding)							
Sreekara	28	70.0	18400	657	445	360	104.6
Subhakara	34	85.0	33660	990	785	300	80.3
Panchami	31	77.5	27060	873	320	100	11.7
Pournami	28	70.0	17990	642	507.5	80	94.9
P-24	39	97.5	31780	788	740	1100	58.7

Contd.....

Table 1. (Contd...)

Genotype	No. of yielding vines	Yielding vines (%)	Total yield (kg)	Mean (g vine ⁻¹)	Median (g vine ⁻¹)	Mode (g vine ⁻¹)	CV (%)
Panniyur 1	33	82.5	29050	880	570	200	146.6
Panniyur 2	32	80.0	28485	890	710	950	88.7
Panniyur 3	29	72.5	16855	581	400	300	73.9
Panniyur 4	33	82.5	20950	635	480	230	91.0
Panniyur 5	28	70.0	40080	1431	1090	–	97.9
Overall	315	78.8	264310	839	560	300	103.6
1998-99 (Third year of yielding)							
Sreekara	30	75.0	37410	1247	700	400	104.1
Subhakara	36	90.0	93850	2606	2300	400	83.3
Panchami	30	75.0	58300	3843	2550	2550	112.0
Pournami	32	80.0	71630	2238	1975	50	93.4
P-24	39	97.5	198975	5232	5160	6100	44.8
Panniyur 1	34	85.0	138100	4062	1350	4950	108.2
Panniyur 2	31	77.5	145540	4695	4400	1500	66.4
Panniyur 3	23	57.5	45100	1961	1500	1450	60.2
Panniyur 4	37	92.5	96650	2655	1850	450	74.4
Panniyur 5	26	65.0	108350	4167	3150	1600	79.1
Overall	318	79.5	993905	3325	2450	400	108.9

706 (Panniyur 1) having overall mean of 419. The coefficient of variations (CV) was 44.4% (Panniyur 3) and 75.9% (Panniyur 2). In second year, the mean yield ranged from 581 (Panniyur 3) to 1431 (Panniyur 5) with overall mean of 839 and CV ranged between 11.7 (Panchami) and 146.6% (Panniyur 1). For third year, mean yield ranged from 1247 (Sreekara) to 5232 (P-24) with overall mean of 3326. The CV ranged from 44.8 (P-24) to 112.0% (Panchami). In the earlier studies, green yield of black pepper vine⁻¹ during first, second and third year of yielding were recorded by Sivan Pillay and Balakrishnan (18), Ibrahim *et al.* (5), Anon (1) and Sasikumar *et al.* (17). The yield range in their results for first year was 170-1670, 74-2647, 160-1050 and 400-6170 g green vine⁻¹, during second year 410-1560, 31-923, 990-4980 and 160-7330 g green vine⁻¹ and for third year 590-2000, 641-3477, 460-2790 and 240-4800 g vine⁻¹, respectively. Sukumara Pillay *et al.* (19) recorded mean green yield for first three years of bearing in the range for different varieties as 1650-4260 g vine⁻¹. Sainamole *et al.* (16) noted mean green yield for first three years for different lines in the range of 88.5 to 906.5 g vine⁻¹. Blacklock (3) stated that the first crop yield in the third year after planting under intensive methods in Sarawak (Malaysia) was 1-1.8 kg of green pepper vine⁻¹, increasing from 3.6 to 9.0 kg vine⁻¹ in the fourth to seventh year and there after declining to 2 kg vine⁻¹ in eighth to twelfth or

fifteenth year, after which the yields were negligible and the garden was abandoned or replanted.

The yield variability was not consistent over the years in different lines. Irrespective of lines, the CV for yield during I, II and III years were 72.1, 50.1 and 35.6%. It was noted that, as vine age advances, yield variability in a plantation reduced in spite of the more intra-vine variability in a line for yield. The mean yield of the vines in all the lines also increased over the year. Yield increment for I to II year was noted in all except Panniyur 1. The line Panniyur 1 is a hybrid and possibilities for alternate bearing were reported (Pradeepkumar *et al.*, 10).

Distribution of yielding vines varies with percentile groups (Table 2). Maximum number of yielders was seen under 0.01 to 0.25 percentile yield group in all the three years of yielding. It indicates that in a black pepper plantation at given point of time, more number of yielding vines would yield less. However, it varies with cultivars (Fig. 1). On an average, the percentile values for number of yielding vines for first year were 5.9, 3.7, 4.7, 2.4, 1.8, for second year 8.4, 7.7, 8.0, 4.3, 3.1 and for third year 8.7, 7.5, 7.4, 4.8, 3.4. The percentile value for yield (g vine⁻¹) were 10, 140, 240, 500, 1070, 2620 in first year, 10, 270, 560, 1110, 1726, 7500 in second year and for third year 50, 1000, 2450, 5043, 7806, 15250. Quantum of yield share also varies with percentile groups and contribution of yield from

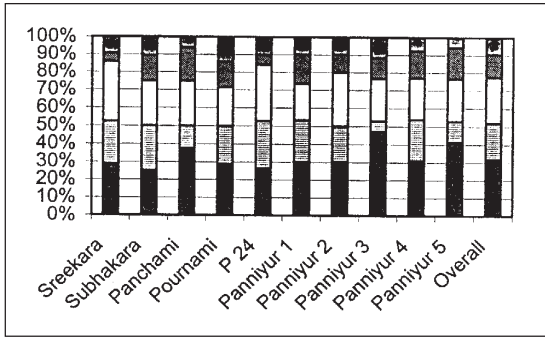
Table 2. Distribution of percentile yield (green yield vine⁻¹) and number of yielding vines.

Genotype	Percentile groups										
	0.01	No.	0.25	No.	0.50	No.	0.75	No.	0.90	No.	1.00
1996-97											
Sreekara	20	6	120	5	160	7	200	1	240	2	400
Subhakara	80	7	322.5	7	650	7	1250	4	1660	3	2050
Panchami	80	6	100	2	175	4	300	3	300	1	500
Pournami	40	4	187.5	3	375	3	750	2	882	2	1150
P-24	50	5	105.0	5	150	6	240	1	260	2	350
Panniyur 1	200	9	400.0	7	500	6	875	5	1361	3	2620
Panniyur 2	20	3	112.5	2	175	3	300	1	429	1	600
Panniyur 3	70	8	100	1	130	4	190	2	204	2	300
Panniyur 4	140	4	300.0	3	600	3	800	2	900	1	1020
Panniyur 5	10	7	100	2	150	4	200	3	300	1	310
Mean	10	59	140	37	240	47	500	24	1070	18	2620
1997-98											
Sreekara	10	7	175	7	445	7	913	4	1436	3	2750
Subhakara	60	9	463	8	785	13	1365	3	1779	1	3750
Panchami	100	10	210	6	320	7	1340	5	2650	3	3450
Pournami	30	7	155	7	508	3	893	4	1390	3	2500
P-24	140	10	515	11	800	8	1090	6	1262	4	2100
Panniyur 1	150	9	340	8	570	8	870	4	1316	4	7500
Panniyur 2	60	8	330	8	710	8	1278	4	1481	4	3400
Panniyur 3	140	8	290	7	400	7	800	5	1300	2	1700
Panniyur 4	50	9	230	8	480	8	850	4	1424	3	2100
Panniyur 5	150	7	395	7	1090	7	1748	4	2775	3	5750
Overall	10	87	270	77	560	76	1110	43	1726	30	7500
1998-99											
Sreekara	50	11	400	4	700	7	2138	5	2805	3	5910
Subhakara	400	9	938	9	2300	9	3363	6	5950	3	9500
Panchami	50	8	863	8	2550	6	5538	5	9570	3	15200
Pournami	50	8	238	8	1975	8	3748	4	4992	4	8400
P-24	385	10	3975	10	5160	9	7045	6	7910	4	9765
Panniyur 1	50	9	313	8	1350	8	6750	5	11205	4	15250
Panniyur 2	1000	8	2050	8	4400	7	6575	5	9350	3	11450
Panniyur 3	600	7	1150	5	1500	5	2600	3	3390	3	5500
Panniyur 4	450	10	1400	9	1850	9	3150	5	5850	4	7450
Panniyur 5	200	7	1813	6	3150	6	6313	4	9325	3	11100
Overall	50	87	1000	75	2450	74	5043	48	7806	34	15250

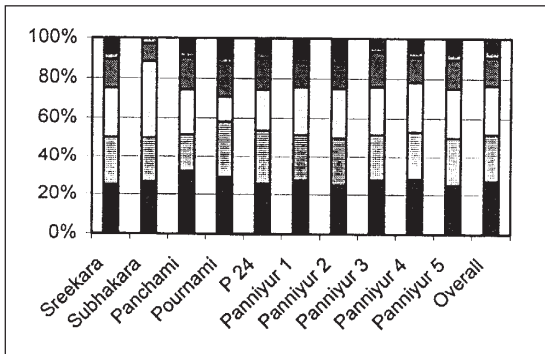
vines belonging to higher percentile groups to the total production of lines were maximum compared to the yield obtained from vines belonging to lower percentile groups (Fig. 2). The mean magnitude of yield increment was 164.9% for I to II year and 259.3% for II to III year (Table 3).

Intra-clone variations for growth and yield were recorded in black pepper (Ratanambal *et al.*, 13;

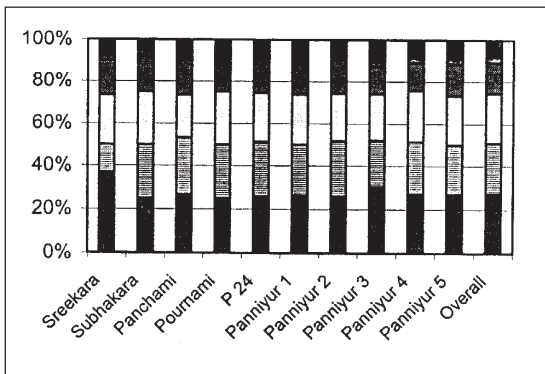
Pradeepkumar *et al.*, 11). Ibrahim *et al.* (6) reported that genotype x season interaction in black pepper was significant and it was through non-linear component. Similarly, Sasikumar *et al.* (17) also observed that black pepper genotypes exhibited unpredictable behaviour by judging regression slope and deviation from regression. De Waard and Zeven (4) stated that hermaphroditism varies from cultivar to cultivar and



Third year of yielding (1998-99)



Second year of yielding (1997-98)



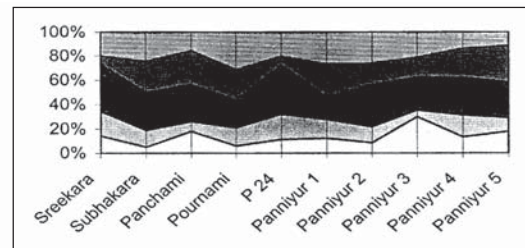
Second year of yielding (1996-97)

Fig. 1. Percentage share of number of yielding vines in the percentile yield groups for black pepper lines [Percentile yield group (bottom to top) 0.1 ↔ 0.25 ↔ 0.5 ↔ 0.75 ↔ 0.9 ↔ 1.0].

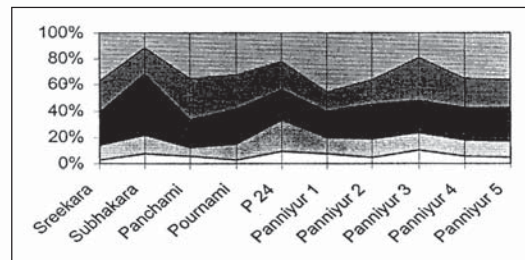
determines productivity to a large extent and this character is genetically controlled. Later studies showed that cultivars show a great variability in the composition of bisexual, female and male flowers in their spikes and this would affect the final yield of a vine (Ravindran and Nirmal Babu, 15). Crop irrigated during later part of March to mid May had 97.8% bisexual flowers compared to 3.9% in un-irrigated (rainfed) and heavy shaded conditions (IISR, 7). Ravindran (14) noted that in spite of the fact that black

Table 3. Percent yield increment in blackpepper over; the years from first (I) year to third year of yielding (III).

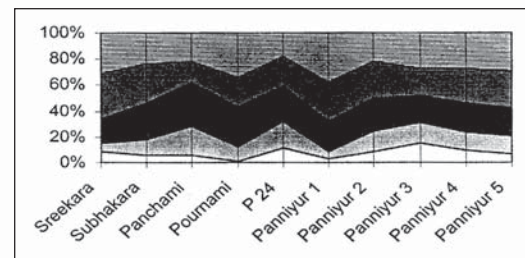
Genotype	Total yield increment (%)		Mean yield increment (%)	
	I-II	II-III	I-II	II-III
Sreekara	424.2	103.3	293.2	89.8
Subhakara	43.5	178.8	18.2	163.2
Panchami	740.4	115.4	333.7	340.2
Pournami	173.4	298.2	36.6	248.6
P-24	880.9	526.1	362.2	564.0
Panniyur 1	37.1	375.4	24.6	361.6
Panniyur 2	1133.1	410.9	285.3	427.5
Panniyur 3	599.4	167.6	310.0	237.5
Panniyur 4	182.3	361.3	11.2	318.1
Panniyur 5	1403.9	170.3	812.6	191.2
Over all	247.8	276.0	100.2	296.4



Third year of yielding (1998-99)



Second year of yielding (1997-98)



Second year of yielding (1997-98)

Fig. 2. Percentage share of quantity by yielding vines in the percentile yield groups for black pepper lines [Percentile yield group (bottom to top) 0.1 ↔ 0.25 ↔ 0.5 ↔ 0.75 ↔ 0.9 ↔ 1.0].

pepper has originated in Kerala and that it was under cultivation for centuries, the yield of pepper in India is the lowest. As a small holders crop, it reaches yield plateau in five to six years and then comes down after 12-15 years. It is evident that large variability in black pepper yield could be there in a plantation and measures to manage the plantation to reduce the yield variations have to be evolved for stable yield.

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