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Research Article

Genetic variability and correlation for yield and yield attributes in promising black pepper genotypes

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Abstract
Black pepper (*Piper nigrum* L.), belonging to the Piperaceae family, is the oldest known spice. Genetic variability and correlation for yield and yield attributes were estimated in nine black pepper genotypes. Analysis of variance revealed significant differences for all the characters studied. Maximum Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) were recorded for rachis weight vine^{-1} followed by dry berry yield vine^{-1} and fresh berry yield vine^{-1}. These characters exhibited high heritability coupled with high genetic advance over mean indicating the considerable contribution of additive genetic variance in the expression of these characters. Dry berry yield vine^{-1} had a highly significant and positive correlation with rachis weight vine^{-1}, fresh berry yield vine^{-1}, spike length and lateral branch length both at the genotypic and phenotypic level. Genotypes HP 2173 (HP1117 × Thommannkodi), OPKM, HP 780, Hp 1411 and HP 820 were found promising for the economically important characters and have the potentiality to release as new commercial varieties.

Keywords
Black pepper correlation, heritability, new variety and selection

INTRODUCTION

Black pepper of commerce, the dried fruits of *Piper nigrum* L. christened as "Black gold", is one of the important and earliest known spices produced and exported from India. Black pepper is mostly dioecious in its wild state while most of the cultivated types are bisexual. Cultivated black pepper is predominantly self-pollinated perennial vine propagated by cuttings (Sasikumar *et al.* 1992). Blessed with the twin advantage of vegetative propagation and viable sexual reproduction, black pepper offers immense scope for exploiting hybrid vigour as well as selective breeding. Highly heterozygous in genetic composition, seedling progenies show considerable variation. Clonal selection, hybridization and open-pollinated progeny selection have been used for evolving new varieties of black pepper (Ravindran and Sasikumar, 1993).

As black pepper production in India faces stiff competition from other producing countries, there is an urgent need to increase the production per unit area involving superior varieties coupled with matching package of practices. Apart from increasing productivity, new genotypes are also needed to arrest genetic vulnerability. Thus breeding new hybrids and varieties of black pepper have been an ongoing program in the country. At ICAR-Indian Institute of Spices Research, Kozhikode, Kerala a large number of inter cultivar hybrids have been produced and being evaluated. The present investigation was carried out with the objective of estimating the genetic variability in nine black pepper promising lines and also to identify superior lines for berry yield and its attributing characters.

MATERIAL AND METHODS

The present experiment was carried out at ICAR-Indian Institute of Spices Research (IISR), Experimental farm, Peruvannamuzhi (11°362343N 75°492123E), Kozhikode, Kerala, India. The materials included 9 genotypes comprising of five hybrids, two open-pollinated progenies and 2 IISR released varieties (controls) (**Table 1**). The experimental material was planted in a Randomized Block Design with three replications with 10 plants in each replication. All the recommended package of practices was followed to raise a good crop. Data on 12 quantitative characters *viz*., lateral branch length (cm), leaf petiole length (cm), leaf length (cm), leaf width (cm), peduncle length (cm), spike length (cm), setting percentage (%), test weight (100 fresh berry weight in grams), fresh berry yield vine^{-1} (g), fresh rachis weight vine^{-1}(g), dry recovery (%) and dry berry yield vine^{-1} (g) were recorded from 5 random plants per replication as per IPGRI descriptors (IPGRI 1995). Analysis of variance (ANOVA), Genotypic and Phenotypic Coefficient of Variations (GCV & PCV), heritability in broad sense (h^2_{bs}) genetic advance (GA) and Genetic Advance over Mean in percentage (GAM) were calculated by using the OPSTAT software developed by CCS HAU, Hisar, India.

Table 1. List of black pepper genotypes and its pedigree

Sl. No.	Hybrid No./ Name	Pedigree
1	HP 2173	Progeny of HP 1117 × Thommankodi (HP 1117 is F_1 of Cholamundi × Thommankodi)
2	HP 1411	F_1 of Aimpiriyan × Panniyur-1
3	IISR-Thevam	Clonal selection of Thevanmundi
4	HP 780	F_1 of Panniyur-1 × Karimunda
5	HP 820	$F_1$of Cholamudi × Panniyur-1
6	Sreekara	Clonal selection from Karimunda
7	OPKM	Open-pollinated progeny of Karimunda
8	HP 728	F_1 of Perambramundi × Karimunda
9	$P_{24}O_4$	Open pollinated progeny of Perambramundi

RESULTS AND DISCUSSION

The ANOVA indicated that there was highly significant (P>0.001) difference among the genotypes for the characters under study (**Table 2**), except for leaf petiole length (P>0.05). The significance difference indicates the high variability with respect to all characters. One of the ways in which the variability is judged is through a simple approach of studying the range of variation. Mean, range and coefficient of variation are presented in **table 3**. The Maximum range was observed for Fresh berry yield vine^{-1} followed by dry berry yield vine^{-1}. In general, for all the characters under study, the PCV was higher in magnitude than GCV indicated the involvement of environmental factors in the manifestation of yield and the yield traits. Highest PCV was recorded for rachis weight vine^{-1} (56.86) followed by dry berry yield vine^{-1}(48.36) and fresh berry yield vine^{-1} (48.05). Lowest GCV and PCV were observed for dry recovery percentage (8.91 and 10.22, respectively) followed by lateral branch length (9.81 and 11.92, respectively). Ibrahim *et al.* (1985a), Pradeepkumar *et al.* (2003) and Preethi *et al.* (2018) observed high variation for yield plant^{-1}. Broad sense heritability estimates ranged from 53.49 % (leaf petiole length) to 91.58 % (test weight). Heritability estimates considered along with predicted genetic gain hike the reliability of the parameter as a tool in the selection programme (Johnson and Hanson, 2003). A comparison of these two estimates revealed that rachis weight vine^{-1} (75.60 and 88.84) followed by fresh berry yield vine^{-1} (81.11 and 80.28) and dry berry yield vine^{-1} (79.52 and 79.21) recorded high heritability coupled with high genetic advance over mean indicating the considerable contribution of additive genetic variance in the expression of these characters and the effectiveness of selection. Whereas, Preethi *et al.*, 2018 also reported high heritability and high genetic advance for spike length, vine column height and leaf width. Bekele *et al.* (2017) observed a high GAM of 145.37 for economic yield.

Table 2. ANOVA for berry yield and its components in black pepper genotypes

Sources of variation	DF	Mean Sum of squares for each character											
		Lateral branch length	Leaf Petiole length	Leaf length	Leaf width	Peduncle length	Spike length	Setting %	Test weight	Fresh berry yield vine^{-1}	Rachis weight vine^{-1}	Dry recovery (%)	Dry berry yield vine^{-1}
Replication	2	24.58	0.024	1.50	0.36	0.007	1.46	3.953	0.579	272740	1030	1.81	35125
Treatment	8	61.27**	0.101*	5.88*	4.60**	0.090**	16.50**	413.4**	15.282**	2296519**	15149**	27.09**	233403**
Error	16	8.387	0.023	1.025	0.28	0.008	0.886	24.52	0.455	165473	1471	2.287	18453

*Significant at 5% and **Significant at 1% level

Genotypic and phenotypic correlation coefficients among 12 quantitative characters are presented in **Table 4.** Dry berry yield vine^{-1} had a highly significant and positive correlation with rachis weight vine^{-1}, fresh berry yield vine^{-1}, spike length and lateral branch length both at the genotypic and phenotypic level. Lateral branch length on which spikes are produced showed positive and significant correlation with dry berry yield vine^{-1}, rachis weight vine^{-1}, fresh berry yield vine^{-1} and spike length indicating as one of the important traits for yield improvement. Studies by Ibrahim *et al.* (1985b); Bekele *et al.* (2017) and Sainamole Kurian *et al.* (2002) revealed that fresh and dry yields were positively and significantly correlated in black pepper. Leaf length and leaf width showed positive correlation as reported earlier by Preethi *et al*. (2018). Test weight had a significant negative association with setting percentage. Abhinaya *et al*., (2016) in hot pepper reported a significant and positive correlation of dry fruit yield per plant with fruits per plant and fresh fruit yield per plant. Shivakumar and Saji (2019) while characterizing the germplasm also observed a negative association with berry size and the number of immature berries with setting percentage. Dry recovery was the only trait which showed either negative or non-significant correlation (P >0.01) with all other characters.

Table 3. Range, mean, genotypic and phenotypic CV, heritability and genetic advance for different characters in black pepper genotypes

Character	Range	Grand mean	SE ±	Coefficient of Variation		Heritability % (H)	Genetic advance	
				GCV	PCV		GA	GAM
Lateral branch length, cm	31.50 -54.33	42.81	2.37	9.81	11.92	67.76	7.12	16.63
Leaf Petiole length, cm	0.90 – 1.87	1.39	0.12	11.62	15.89	53.49	0.24	17.50
Leaf length, cm	10.20 – 15.80	13.48	0.83	9.44	12.06	61.24	2.05	15.22
Leaf width, cm	5.00 – 9.74	7.94	0.44	15.13	16.55	83.51	2.26	28.48
Peduncle length, cm	0.79 – 1.50	1.22	0.07	13.52	15.35	77.59	0.30	24.53
Spike length, cm	6.95 – 16.25	9.59	0.77	23.79	25.74	85.46	4.35	45.31
Setting %	42.52 – 86.92	73.27	4.04	15.54	16.95	84.09	21.51	29.36
Test weight, g	10.00 – 17.83	13.94	0.55	15.95	16.66	91.58	4.38	31.44
Fresh berry yield vine^{-1},g	850 – 4770	1947.80	332.14	43.27	48.05	81.11	1563.61	80.28
Rachis weight vine^{-1},g	60 – 394.60	136.59	31.32	49.43	56.86	75.60	12.94	88.54
Dry recovery (%)	27.02 – 37.25	32.10	1.31	8.91	10.22	75.94	5.13	15.99
Dry berry yield vine^{-1},g	294 - 1568	620.75	110.92	43.12	48.36	79.52	491.72	79.21

Table 4. Phenotypic (below diagonal) and genotypic (above diagonal) correlation coefficients among different characters in black pepper genotypes

Character	Lateral branch length	Leaf Petiole length	Leaf length	Leaf width	Peduncle length	Spike length	Setting %	Test weight	Fresh berry yield vine^{-1}	Rachis weight vine^{-1}	Dry recovery (%)	Dry berry yield vine^{-1}
Lateral branch length	1	0.084	0.623**	0.297	-0.081	0.636**	-0.085	0.346	0.810**	0.929**	0.181	0.866**
Leaf Petiole length	0.076	1	0.954**	0.964**	0.111	0.342	-0.261	0.705**	0.140	0.178	-0.827**	0.015
Leaf length	0.478**	0.405*	1	0.960**	0.204	0.710**	-0.199	0.690**	0.674**	0.842**	-0.472**	0.616**
Leaf width	0.211	0.663**	0.869**	1	0.077	0.373*	-0.163	0.683**	0.385*	0.516**	-0.640**	0.281
Peduncle length	0.031	0.204	0.215	0.114	1	0.580**	-0.140	-0.053	0.212	0.167	0.270	0.302
Spike length	0.488**	0.209	0.536**	0.306	0.555*	1	-0.148	0.214	0.696**	0.764**	-0.119	0.720**
Setting %	-0.029	-0.146	-0.132	-0.129	0.016	-0.056	1	-0.604**	0.333	0.125	-0.423*	0.272
Test weight	0.197	0.473**	0.466*	0.592**	-0.053	0.222	-0.507**	1	0.287	0.336	-0.247	0.239
Fresh berry yield vine^{-1}	0.559**	0.048	0.450*	0.325	0.160	0.660**	0.326	0.284	1	0.969**	-0.248	0.985**
Rachis weight vine^{-1}	0.609**	0.106	0.513**	0.385*	0.165	0.699**	0.218	0.316	0.935**	1	-0.188	0.959**
Dry recovery (%)	-0.001	-0.451*	-0.364	-0.467*	0.196	-0.087	-0.353	-0.133	-0.179	-0.109	1	-0.085
Dry berry yield vine-$^{-1}$	0.568**	-0.024	0.397*	0.244	0.226	0.676**	0.270	0.254	0.983**	0.928**	-0.004	1

*Significant at 5% and **Significant at 1% level

Hybrid HP 2173 (HP 1117 × Thommannkodi) is found superior to all other genotypes including released varieties IISR-Thevam and Sreekara for dry and fresh yield vine^{-1} followed by HP 820 (**Table 5**). For other economically important characters like dry recovery and test weight, HP 780 was found promising. HP 2173 and OPKM recorded long spike length (**Fig. 1**). It was observed that HP 1411 was early maturing genotype and OPKM is having alternate bearing tendency. Barring the line HP 820, four genotypes are in the coordinated varietal trial under AICRP on spices and the initial yield data indicated the superiority of these lines (Krishnamurthy *et al*. 2019). After confirming the performance of these genotypes in the different agro-climatic condition they can be recommended for release as new hybrids/varieties

Table 5. Comparison of genotypes mean for economically important characters

Genotype	Dry berry yield vine^{-1}	Dry recovery (%)	Fresh berry yield vine^{-1}	Test weight
HP 2173	1269.3^{a}	32.82^{b}	3856.5^{a}	15.27^{bc}
HP 1411	554^{cd}	33.64^{ab}	1645.85^{cde}	11.75^{e}
IISR-Thevam	809.3^{b}	29.06^{cd}	2774.66^{b}	16.28^{b}
HP 780	437.33^{cd}	36.11^{a}	1209de	17.61^{a}
HP 820	652.20^{bc}	31.72^{bc}	2059.16^{c}	11.91^{de}
Sreekara	613.22^{bcd}	32.64^{b}	1872.91^{cd}	12.96^{d}
OPKM	454.47^{cd}	27.71^{d}	1633.16^{cde}	14.517^{c}
HP 728	397.71^{d}	29.06^{cd}	1380^{cde}	14.32^{c}
$P_{24}O_4$	398.53^{d}	35.98^{a}	1098^{e}	10.83^{e}

Trait means not followed by the same superscript letter are significantly different at $p = 0.05$.

Fig 1. Spike length in HP 2173 (HP1117 × Thommannkodi)

A high level of variation for all quantitative characters measured in 9 genotypes comprising of five hybrids, two open-pollinated progenies and two IISR released varieties. High heritability coupled with high genetic advance over mean was observed for fresh berry yield vine^{-1} and dry berry yield vine^{-1}. The characters that make up the yield components (fresh berry yield vine^{-1}, rachis weight vine^{-1} and spike length) were found positively associated with dry berry yield. Genotypes like HP 2173, OPKM, HP 780 and HP 1411 were found promising for different economically important characters.

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