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RESEARCH ARTICLE

Phenotypic Variation in Black Pepper (*Piper nigrum* L.) Germplasm Grown under Arecanut Plantation in North East India

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The importance of local genotypes and landraces as a contributor to the gene pool of modern varieties with high economic value is well known. Though many varieties of black pepper were released for cultivation in different parts of India, only a few varieties are found suitable for North-East India, especially in the state of Assam where black pepper is grown as an important cash crop. This study was undertaken during 2013-2019 to evaluate 13 local black pepper genotypes for their growth, yield and yield attributes under Assam conditions of India. Significant differences were recorded among the accessions for most of the characters studied. Spike length varied from 9.57-13.45 cm. Compared to the popular check variety, 'Panniyur 1', the accession, IC-0599150 recorded 43.62% higher dry pepper yield indicating its superior yield potential. The result of this study indicates the importance of collection and characterization of local germplasm.

Key Words: Germplasm, Pepper, Yield, Yield attributes

Introduction

Pepper (*Piper nigrum* L.) is one of the important spices grown in India. In the major black pepper growing states of India, *viz*., Karnataka, Kerala and Assam, farmers are growing pepper as an intercrop in arecanut (*Areca catechu* L.) plantations (Thomas and Balasimha, 2011). In India, it is grown in an area of 1,38,929 ha with a production of 48,000 t (Spices Board, 2020). Kerala and Karnataka are the largest producers of black pepper in India accounting for 90% of the area and production (Tripathy *et al*., 2018). Indian pepper fetches a premium price in major international markets due to its preference and intrinsic qualities (Thomas, 2010). Black pepper, one of the oldest and most popular spices in the world, originated in the Western Ghats of India. Globally, it is cultivated in more than 25 countries in an area of 4,589,731 ha and total production of 523,000 t (IPC, 2017). Vietnam, Brazil, Indonesia, India, China, and Malaysia are the main black pepper growing and producing countries (FAOSTAT, 2019).

Black pepper is a perennial climbing vine grown mainly for its berries, an important ingredient used as spice and medicine (Anandaraj *et al*., 2013). In North East Region of India (NER), black pepper varieties 'Panniyur 1', 'Karimunda' and other local landraces are mostly grown in the farmers' field. Work on germplasm collection, conservation and characterization of black pepper has been carried out mainly in the southern states of India (Potty *et al*., 1979; Mathew *et al*., 1993). The main breeding objectives in black pepper are high yield, resistance to biotic and abiotic stresses, coupled with good quality traits. Therefore, germplasm exploration activities with local cultivars, wild relatives and related species followed by characterization could be useful for genetic improvement of black pepper (Prayogya *et al*., 2020). The ICAR-Indian Institute of Spices Research (IISR), at Kozhikode, Kerala, India maintains the world's largest collection of black pepper germplasm and related species collected from the centre of origin (Krishnamoorthy and Parthasarathy, 2009). Characterization and evaluation of the conserved germplasm for yield, quality and resistance to stresses has resulted in the release of promising landraces/cultivars as popular varieties (Sasikumar *et al*., 2004). Systematic research in India involving hybridization, clonal selection and open pollination from popular cultivars through the

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All India Coordinated Research Project (AICRP) on Spices and ICAR-IISR in the last four decades resulted in the release of superior lines of black pepper varieties (Thangaselvabal *et al*., 2008). Studies on assessment of released varieties of black pepper from NER has been carried out by Deka *et al*. (2016). Though, NER is delineated as suitable for black pepper cultivation in India, its production and productivity is constrained by the use of low yielding cultivars, non-availability of superior varieties, losses due to incidence of disease and pests, drought, non-adoption of suitable agronomic practices and lack of quality planting materials (Krishnamoorthy and Parthasarathy, 2009). So far, no systematic work has been done to enhance the varietal wealth of black pepper in NER, other than the released variety 'Panniyur 1' for intercrop in arecanut plantations prevalent in the region. To improve the varietal wealth for these regions and to develop production technologies that mitigate the risk of the black pepper producing farmers, work on collection, conservation, characterization of black pepper accessions has been initiated in the past few years by ICAR-Central Plantation Crops Research Institute (CPCRI), Research Centre, Kahikuchi, Guwahati, Assam. The present investigation was undertaken to evaluate the performance of 13 local black pepper accessions under arecanut plantations in the Kahikuchi farm along with 'Panniyur 1' as check variety for growth, yield and yield associated traits and to identify accessions suitable for cultivation in NER.

Materials and Methods

The present study was conducted for consecutive seven years from 2013 to 2019 at the research farm of ICAR-CPCRI, Research Centre, Kahikuchi, Guwahati, Assam, India. The research farm is situated at 20º18′ N latitude and 91º78′ E longitude with an altitude of 50 m above mean sea level. The mean maximum temperature varies from 15-32 ºC and the mean minimum temperature ranges between 8-22 ºC. The climate is sub-tropical with an annual rainfall of about 1,500 mm. The soil of the experimental site is alluvial clay loam with a pH range of 4.8-5.5. The study involved 13 black pepper collections bearing accessions number IC-0599138, IC-0599139, IC-0599140, IC-0599141, IC-0599142, IC-0599143, IC-0599144, IC-0599145, IC-0599146, IC-0599147, IC-0599148, IC-0599149 and IC-0599150 which are registered at ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India. The 16 year old vines were collected from farmers' field of Kamrup district of Assam and supported on arecanut (*Areca catechu* L.) planted at a spacing of 2.7 m × 2.7 m. The experiment was laid out in Randomized Block Design (RBD) with three replications and under each replicate, 11 vines were selected for observations. Vegetative growth parameters like vine diameter and petiole length were recorded following the black pepper descriptors (IPGRI, 1995). A total of 50 spikes were taken randomly from each vine for recording spike length, peduncle length, length of berry and number of berries per spike. Number of spikes per lateral branch and the length of lateral branch were also recorded from individual vine. Number of spikes per kilogram and fresh yield was recorded from each vine at the time of harvesting during April to May. Dry berry recovery was recorded by drying the berries (one kilogram each) for one week from each vine. The dry recovery percentage was calculated using the formulae: dry weight / fresh weight × 100.

The mean values of all the characters on 13 accessions were subjected to statistical analysis. To estimate the association among the different characters observed, simple correlation coefficients were calculated (Panse and Sukhatme, 1961). Data were statistically analyzed using MSTATC software (Russel, 1995).

Results and Discussion

Vegetative growth characteristics

Vegetative growth parameters recorded for 13 accessions showed that vine diameter was found to be significantly different among the accessions varying between 75.00-119.32 cm (Table 1). Accession IC-0599145 collected from Panbari area of Kamrup district of Assam had the highest vine diameter (119.32 cm). Longer length of lateral branch and broader leaf area (104.63 m^2) in the accession IC-0599145 might have contributed to greater diameter of the vine. In North East region India, an experiment conducted at Horticultural Research Station, Assam Agricultural University, Kahikuchi, Guwahati, Assam, India, Deka *et al*. (2016) reported higher vine column diameter in the varieties 'Subhakara' and 'Karimunda' among 12 tested genotypes. Similarly, study conducted at ICAR-CPCRI, Kasaragod, on evaluation of 16 black pepper varieties and hybrids grown as mixed crop in coconut (*Cocos nucifera* L.) garden showed variation in vine column diameter after five years of planting, with higher vine column diameter in the variety 'Thevam' (Maheswarappa *et al*., 2012). Leaf area among

Table 1. Vegetative growth characters of black pepper accessions under Assam condition

Accessions	Vine diameter (cm)	Leaf area (m^2)	Petiole length (cm)	Length of lateral branch (cm)	No. of nodes/lateral branch
IC-0599138	75.00	66.91	1.67	37.91	21.83
IC-0599139	87.16	75.40	1.85	47.45	20.66
IC-0599140	91.67	76.71	1.76	45.67	18.33
IC-0599141	88.32	75.88	1.86	42.36	17.16
IC-0599142	93.33	72.34	1.88	44.20	18.83
IC-0599143	99.16	78.52	1.92	48.25	25.20
IC-0599144	111.67	76.42	1.97	43.70	15.50
IC-0599145	119.32	104.63	2.14	49.70	21.50
IC-0599146	97.50	83.92	1.90	46.67	25.32
IC-0599147	97.52	85.92	2.03	45.70	29.16
IC-0599148	101.67	75.45	1.86	44.95	17.83
IC-0599149	98.65	72.69	1.96	48.81	21.16
IC-0599150	93.30	83.58	2.01	47.38	32.67
Panniyur 1	97.64	71.98	2.05	42.80	32.65
CV (%)	15.54	19.24	10.57	17.28	12.68
SEm +/-	4.98	3.58	0.07	3.12	2.88
CD (0.05)	14.48	10.43	0.21	NS	8.38

the accessions varied from 66.91-104.63 m^2. Accession IC-0599145 also recorded the maximum leaf area (104.63 m^2) among the other accessions and were found to be much greater than the check variety 'Panniyur 1' Difference in growth characters, such as vine diameter and leaf area, among black pepper accessions might be attributed to various factors such as environment, soil moisture, availability of nutrients and genetic factor of the vine. The present study also showed the variation of petiole length from 1.67-2.14 cm. Three accessions (IC-0599145, IC-0599147 and IC-0599150) had petiole length of above 2.0 cm. Greatest petiole length was observed in accession IC-0599145 (2.14 cm) and was significantly greater than all the other accessions (Table 1). Similar finding was reported in Morogoro district in Tanzania by Shango *et al*. (2021) where they observed variation in petiole length of black pepper. Babu Kubwa types had significantly longer petiole (2.8 cm) than all other black pepper types grown in the district.

Spike characteristics

Number of spikes per lateral branch and fresh weight of 1,000 berries differ significantly among the accessions (Table 2). Accession IC-0599150 was found to produce higher number of spikes per lateral branch (17.83), much greater than 'Panniyur 1' (11.32). Bernawie *et al*. (2019) based on their study on black pepper variety Ciinten in three agro ecological conditions in Indonesia, reported differences in the number of spike/lateral branch, peduncle length as well as berry weight between locations, though the materials were clonally propagated from same mother vines. Accessions IC-0599145 and IC-0599150 produced the longest spike length and length of berry while the rest of the accessions were found to have shorter spikes, much smaller than 'Panniyur 1'. Among the black pepper landraces including 'Panniyur 1' evaluated in an experiment conducted in farmer's field of Uttar Kannada district in Karnataka, India, Naik *et al*. (2013) observed varying spike length, from 7.1-13.8 cm with 'Panniyur 1' (13.8 cm) producing longest spike length. Other yield associated traits, *viz*., number of berries per spike and number of spikes per kilogram had significant differences for the fresh and dry pepper yield (Table 2). Number of berries per spike was found to be significantly higher in accession IC-0599150 followed by IC-0599145 and the lesser number of spikes per kilogram can be attributed to more berries per spike. On the other hand, more spikes per kilogram was found in accession IC-0599148 followed by IC-0599144 which might be due to shorter spike length as compared to other accessions. Interestingly, the accession IC-0599147, with relatively more number of spikes per lateral branch, had the lowest number of berries per spike and recorded the least fresh as well as dry pepper yield. The accessions IC-0599150 and IC-0599145 had the highest fresh pepper yield with dry pepper yield increases of 43.62% and 34.89%, respectively over 'Panniyur 1'. Other accessions which

Table 2. Yield and yield associated traits of black pepper accessions under Assam condition

Accessions	No. of spikes/ lateral branch	Fresh weight of 1000 berries (g)	Spike length (cm)	Peduncle length (cm)	Length of berry portion (cm)	No. of berries /spike	No. of spike/kg	Fresh yield/ vine (kg)	Dry yield/ vine (kg)	% dry yield increase over check	% fresh yield increase over check	Dry recovery (%)
IC-0599138	12.00	100.00	10.91	1.51	9.49	56.07	226.06	5.20	1.76	18.12	5.26	33.84
IC-0599139	10.67	103.32	10.76	1.60	9.19	54.21	215.96	4.74	1.39	-6.71	-4.04	29.32
IC-0599140	9.33	93.33	11.26	1.55	9.72	59.45	233.18	5.19	1.70	14.09	5.06	32.75
IC-0599141	9.00	133.30	11.05	1.52	9.57	53.43	191.18	4.46	1.23	-17.44	-9.71	27.57
IC-0599142	9.83	96.67	10.85	1.44	9.32	57.37	223.28	3.94	0.99	-33.55	-20.24	25.12
IC-0599143	10.50	96.66	10.53	1.35	9.16	57.36	217.02	5.29	1.79	20.13	7.08	33.83
IC-0599144	9.34	96.65	9.57	1.26	8.31	50.63	242.67	4.35	1.17	-21.47	-11.94	26.89
IC-0599145	10.00	113.32	13.45	1.43	12.01	64.64	138.62	5.74	2.01	34.89	16.19	35.01
IC-0599146	12.16	96.64	10.08	1.25	8.74	55.80	230.37	3.95	1.25	-16.10	-20.04	31.64
IC-0599147	15.15	113.33	10.28	1.39	8.72	47.28	196.28	3.39	0.86	-42.28	-31.37	25.36
IC-0599148	9.50	103.30	9.58	1.27	8.35	52.22	340.20	3.50	1.08	-27.51	-29.14	30.85
IC-0599149	12.01	100.00	10.23	1.54	8.68	50.12	222.47	5.05	1.65	10.73	2.22	32.67
IC-0599150	17.83	110.00	12.97	1.37	11.59	80.69	160.33	6.02	2.14	43.62	21.86	35.54
Panniyur 1	11.32	133.33	12.85	1.50	11.33	52.58	149.69	4.94	1.49			
CV (%)	13.52	19.28	10.46	10.24	17.32	14.65	18.43	34.28	11.36			
SEm +/-	1.05	3.43	0.39	0.08	0.36	2.90	4.93	0.33	0.10			
CD (0.05)	3.07	9.97	1.14	0.18	1.06	8.46	14.39	0.98	0.32			

showed more modest increases in dry yield over check variety, are IC-0599138 (18.12%), IC-0599140 (14.09%), IC-0599143 (20.13%) and IC-0599149 (10.73%). Variation in fresh and dry yield among black pepper accessions were also reported by Kurian *et al*. (2002) and Kumar *et al*. (2003). In Indonesia, Bernawie *et al*. (2019) reported variation in yield of black pepper over the locations and seasons, which could be attributed to differences in agro-ecological condition.

Correlation studies

Correlation studies (Table 3) revealed that, fresh and dry yields were positively and significantly correlated with number of berries per spikes, number of spike per lateral branch, length of spikes and length of berry bearing portion, and will simplify selection methods to improve black pepper yield. The lack of significant correlations concerning vine diameter, length of lateral branch and number of nodes per lateral branch means selection methods to improve yield may ignore these traits to save the time and resources of the breeder. Sujatha and Namboothiri (1995) reported positive and significant influence of spike length on black pepper yield. Further, since fresh berry yield showed high positive significant correlation with dry yield, it can be considered for evaluation to save time and resources of

Table 3. Correlation among yield and yield associated traits of black pepper accessions/variety under Assam condition

	Vine diameter (cm)	Length of lateral branch (cm)	No. of spike/ lateral branch	No. of nodes/ lateral branch	Spike length (cm)	Length of berry bearing portion (cm)	No. of berries/ spike	Fresh yield/ vine (kg)	Dry yield/vine (kg)
Vine diameter (cm)		.409	-.180	-.070	.125	.160	.009	-.006	.017
Length of lateral branch (cm)			.170	.139	.032	.019	.201	.155	.190
No. of spike /lateral branch				.787**	.677**	.775**	.607**	.703**	.767**
No. of nodes /lateral branch					.506	.501	.358	.256	.298
Spike length (cm)						.996**	.669**	.708**	.663**
Length of berry bearing portion (cm)							.698**	.713**	.679**
No. of berries/spike								.690**	.723**
Fresh yield/vine (kg)									.968**

black pepper breeders. Ibrahim *et al*. (1985), Thanuja and Rajendran (2003), Preethy *et al*. (2018), Shivakumar and Saji (2019) and Shivakumar *et al*. (2020) also reported significant and positive correlation among fresh and dry berry weight. The results of this study indicated the presence of wide variations for important traits in the local black pepper populations in farmers' fields and importance of collection, conservation, characterization of local germplasm resources for utilization in the development of high yielding black pepper lines for cultivation in NER.

Review of black pepper as an excellent mix crop in arecanut farms has been done (Abraham, 1974; Thomas and Balasimha, 2011). Many authors have also emphasized the importance of black pepper as a mixed crop in coconut for increase in productivity and profitability of the mixed cropping system and also complementary effect of black pepper as a mixed crop towards the improvement of yield in the coconut (Maheswarappa *et al.,* 2012; Subramanian *et al*., 2016). Arecanut is grown in most of the states of NER and is an important crop due to its commercial value and food habit of Indians. Among the NER, arecanut is grown in an area of 81,000 ha in Assam alone (DASD, 2019). Other states of importance for cultivation of arecanut are Meghalaya, Mizoram and Tripura. Similarly, coconut is grown in an area of 19,917 ha in Assam followed by Tripura (5.201 ha) (CDB, 2018). So, there is ample scope to use arecanut and coconut plantations for mixed cropping with black pepper for increasing productivity and profitability per unit area. Hence, the implication of this study has far reaching consequences in improving livelihood security and enhancing profitability of the predominantly tribal communities in the agrarian scenario of NER, through cultivation of improved black pepper varieties suitable to the region.

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