Research Article

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Performance of black pepper varieties as intercrop in coconut gardens in the lower Brahmaputra valley of Assam state, India

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Abstract

Black pepper (*Piper nigrum*) is well habituated as an inter/under/mixed crop in plantation crops. A field experiment was conducted at Horticultural Research Station (AICRP on Palms), Kahikuchi of Assam Agricultural University for 12 consecutive years (2009-2021) for studying the performance of black pepper varieties/hybrids when grown as intercrop in 38 year old Assam Green Tall. Panniyur-1 produced a higher number of laterals with more spread compared to other varieties. Similarly, a significantly higher number of spikes (134.0), spike length (15.0 cm) and number of berries per spike (82.0) were also recorded in Panniyur-1. Sreekara recorded the lowest spike length (9.8 cm), while IISR Malabar Excel recorded the lowest number of spikes (85.0). Six-year mean dry berry yield indicated that the yield was significantly higher with Panniyur-1 (1.60 kg vine^{-1}) followed by Sreekara (1.49 kg vine^{-1}) and average yield of 1.00 kg vine^{-1} recorded in IISR Malabar Excel, IISR Thevam and IISR Shakthi. The oleoresin content (11.7%) and piperine content (5.2%) was found highest in Panniyur-1, followed by Sreekara (10.9 % and 4.5%) whereas, the lowest oleoresin content (8.8%) and piperine content (2.9%) were recorded in IISR Malabar Excel and IISR Thevam, respectively. Intercropping of Panniyur-1 in coconut garden recorded the highest net return (₹ 237088 ha^{-1}) and B: C ratio (3.48) followed by Sreekara (₹ 212764 ha^{-1}; B: C ratio 3.12) and the lowest net return (₹ 177938 ha^{-1}) and B: C ratio (2.61) were obtained in IISR Malabar Excel.

Keywords: Black pepper, coconut, quality, varieties, yield

Introduction

Black pepper is cultivated for its fruits (berries) and serves as a cash crop in both domestic and international markets. In India, pepper is cultivated as an intercrop in plantation crops *viz.,* coconut, arecanut, rubber, and shade trees of tea and coffee estate where the height is boundless. The domestic consumption of black pepper has increased from five thousand tonnes (1961-70) to 50- 60 thousand tonnes during 2018-19 (DASD, 2020). Kerala, Tamil Nadu and Karnataka contribute about 90 per cent of the total production. Recently, Assam and Odisha became the latest state in the country to start black pepper cultivation. Coconut is an important crop of Assam mostly grown in the homestead garden as monocropping with an area under coconut plantation is 20,610 ha with the productivity of 8868 nuts ha^{-1} (CDB, 2020), and only a very small area has been tapped for pepper cultivation. Pepper is also an excellent crop for home gardens where it can be trained on the existing coconut palm.The Venetian structure and orientation of the adult coconut canopy permit about 55 per cent active light to infiltrate down (Nelliat, 1973), and the gardens spaced at 7.5 m × 7.5 m offers a wide purview for intercropping with perennial spices like nutmeg, cinnamon and black pepper leading to a sustainable increase in the production and productivity per unit area (Nagawekar *et al.,* 2002; Shinde *et al.,* 2020).

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Earlier research efforts on mixed/inter-cropping of black pepper with coconut and arecanut plantations in different agro-climatic zones of the country have shown its suitability as a lucrative crop (Maheswarappa *et al.,* 2012; Deka *et al.,* 2016 and Nath *et al.,* 2018). The performance of black pepper varieties also varies significantly in plains and higher altitudes due to the difference in environmental conditions and genetic differences (Sainamole Kurian *et al*., 2002). Deka *et al*. (2016) reported that Panniyur-1, Panniyur-5, and Subhakara are the best-suited varieties in the arecanut gardens of Assam. The diverse climatic and soil conditions in the northeastern states like Assam necessitate the identification and popularization of pepper varieties in prevailing coconut gardens to enhance productivity per unit area. Hence, a field experiment was undertaken to evaluate the performance of different black pepper varieties/hybrids as intercrop in coconut gardens under rainfed conditions of Assam.

Material and Methods

Five released black pepper varieties/hybrids were planted in 2009 at the Horticultural Research Station, Kahikuchi, Guwahati, Assam under All India Co-ordinated Research Project on Palms, which is situated at 26.3^0 N latitude and 91.7^0 E longitude with an altitude of 64.0 m above mean sea level (MSL). The station enjoys a sub-tropical climate, with an annual rainfall of about 1500 mm. The soil of the experimental site was alluvial clay-loam with a pH of 4.9, low in available nitrogen (236 kg ha^{-1}), medium in available phosphorus (26 kg ha^{-1}), medium in available potassium (162 kg ha^{-1}) with an organic carbon of 0.45 per cent and evaluated for 12 years. The coconut trees were planted at a 7.5 x 7.5 m distance and trained six black pepper vines on individual coconut palms with four replications in a Randomized Block Design. The experiment was maintained under standard management practices under rainfed conditions. The Observations were recorded on growth and yield traits such as No. of laterals in one m column height, spike length (cm), number of berries per spike, dry yield (kg $vine^{-1}$).

The harvested spikes were heaped, threshed, boiled for 2-3 minutes in boiling water and dried under sun for 6-7 days and dry weight was taken as yield per vine. Quality parameter such as oleoresin was estimated by ASTA (1968) method, while piperine was estimated by HPLC method (Wood *et al*., 1988). The yield (nuts $palm^{-1}$ $year^{-1}$) was recorded periodically during each harvest from July to June and pooled to get the yield $palm^{-1}$ $year^{-1}$. Economic analysis of the system was carried out based on the prices of input and output prevailed during the study period. The establishment cost for black pepper was considered for the first three years after planting along with the variable cost for a coconut from the fourth year onwards; the variable cost involved for coconut together with black pepper was considered to work out the cost of production. The average market price for coconut @ ₹ 15/- per nut and black pepper @ ₹ 450/- per kg of dry pepper during the experimental period was considered to work out the gross return. The data on different characters were subjected to statistical analysis as per the standard procedures (Panse and Sukhatme, 1985).

Results and Discussion

Growth characters

The results of growth characters recorded at six years of age, showed that significantly the highest number of laterals (35.8 at one m column) and the spread of the vines in North-South and East-West were recorded in Panniyur-1 followed by Sreekara compared to other varieties. IISR Malabar Excel and IISR Shakthi recorded significantly the lowest growth as well as the number of laterals (in one m column) per vine. All the varieties/hybrids of black pepper started flowering from the fourth year of planting. The mean yield attributing characters recorded during January 2015-2021 are presented in Table 1. Among the varieties/hybrids, Panniyur-1 recorded a significantly higher number of spikes (134 in one-meter column height), followed by Sreekara (98.4). Similar findings were also reported by Maheswarappa *et al.* (2012). Spike length is an important yield contributing trait in black pepper. The average spike length in Panniyur-1 was 15.0 cm, followed by IISR Thevam, IISR Shakthi, IISR Malabar Excel (11 cm), while it was lowest in Sreekara (9.8 cm). The average number of berries per spike ranged from 52.5 per spike in

Table 1. Growth and reproductive characters of different black pepper varieties

Varieties/Hybrids	Plant spread (m)		No. of laterals	No. of spikes	Spike	No. of
	E-W	N-S	(one m column height)	(one m column height)	length (cm)	berries spike^{-1}
IISR Thevam	0.94	0.99	29.0	93.5	11.1	59.0
IISR Shakthi	0.87	0.89	28.1	88.6	11.7	66.6
IISR Malabar Excel	0.89	0.90	26.4	85.0	11.4	61.0
Sreekara	0.95	0.99	32.0	98.4	9.8	52.5
Panniyur-1	1.02	1.06	35.8	134.0	15.0	82.0
S. Em (±)	0.02	0.03	1.01	3.88	0.55	2.56
CD (p=0.05)	0.04	0.06	2.12	8.16	1.16	5.37

Table 2. Yield of black pepper varieties as intercrop in coconut garden

Varieties/Hybrids	Dry yield (kg vine^{-1})						Pooled dry yield
	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	(kg vine^{-1})
IISR Thevam	0.79	0.98	1.10	1.20	1.21	1.25	1.08
IISR Shakthi	0.88	0.92	1.20	1.10	1.15	1.20	1.07
IISR Malabar Excel	0.75	0.95	1.00	1.26	1.17	1.19	1.05
Sreekara	1.34	1.32	1.48	1.63	1.55	1.60	1.49
Panniyur-1	1.45	1.42	1.60	1.75	1.65	1.70	1.60
S.Em (±)	0.059	0.055	0.284	0.065	0.057	0.060	0.057
CD (p=0.05)	0.125	0.115	0.135	0.137	0.119	0.127	0.120

Sreekara to 82 per spike in Panniyur-1. The number of berries per spike is directly related to spike length. The higher number of berries per spike (82) in Panniyur-1 is due to more spike length (15 cm), and a similar trend was noticed in all other varieties. Similar results of high spike length and the number of berries spike^{-1} were reported in different locations *viz.,* Kerala (Maheswarappa *et al.,* 2012), Assam (Deka *et al*., 2016) and Karnataka (Tripathi *et al*., 2018).

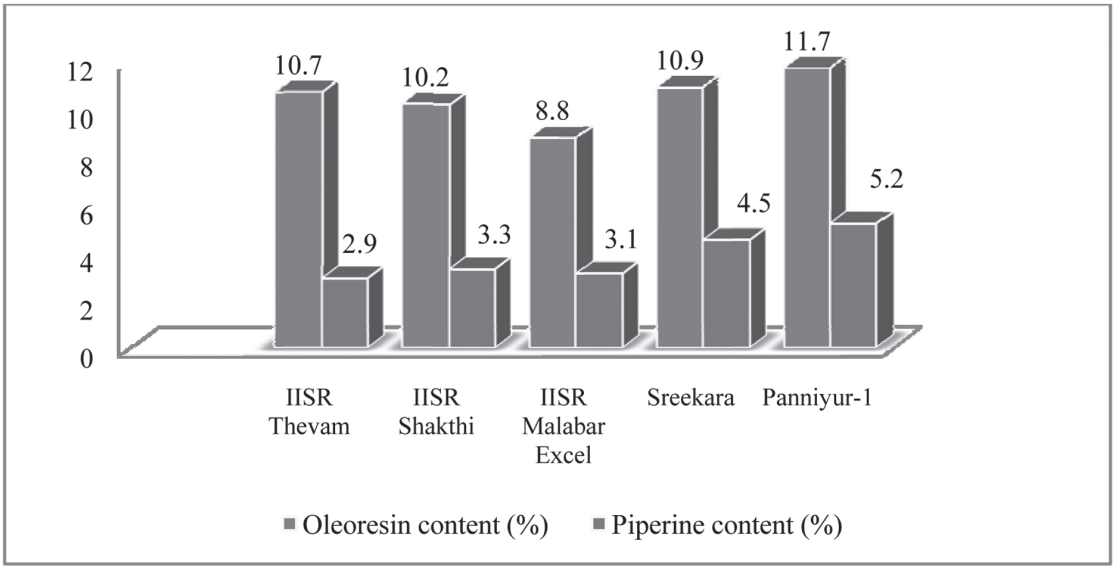

Fig 1. Chemical constituent of different black pepper varieties as intercrop in coconut garden

Table 3. Coconut yield as influenced by intercropping of pepper varieties a period of six years (Nut yield palm^{-1}year^{-1})

Varieties/ Hybrids	2008-09 (Initial yield)	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	Mean
IISR Thevam	52	53.0	56.6	59.7	61.5	63.4	65.1	59.8
IISR Shakthi	54	55.0	57.0	62.1	64.0	66.5	67.0	61.9
IISR Malabar Excel	51	53.5	54.5	58.2	59.6	62.3	64.2	58.7
Sreekara	50	51.5	54.0	56.7	58.0	60.2	63.6	57.3
Panniyur-1	55	57.5	58.0	61.7	64.2	66.8	69.5	62.9
F test	NS	NS	NS	NS	NS	NS	NS	NS
Overall Mean	52.4	54.1	56.0	59.7	61.5	63.8	65.9	59.9

Yield and quality parameters of black pepper

Data on average dry berry yield for six years (2015 to 2021) indicated that Panniyur-1 had recorded a significantly higher yield (1.60 kg vine^{-1}) compared to other varieties (Table 2), which were mainly attributed to the higher number of laterals bearing capacity and production of more spikes. The next best-performing variety was Sreekara, which had recorded 1.49 kg vine^{-1}, followed by IISR Thevam, IISR Shakthi and IISR Malabar Excel with an average dry berry yield of 1.0 kg vine^{-1}. Pepper is well adapted as an under / mixed / intercrop with plantation crops. Similarly, Deka *et al.* (2016) reported that Panniyur-1, Panniyur-5 and Subhakara were found promising variety in arecanut based cropping systems in Assam. The main quality components in pepper are the content of essential oil, oleoresin and piperine. The hybrid Panniyur-1 recorded significantly higher oleoresin content (11.7%) and piperine content (5.2%), followed by Sreekara (10.9 % and 4.5%) compared to other varieties (Fig.1). The lowest oleoresin content (8.8%) and piperine content (2.9%) were recorded under IISR Malabar Excel and IISR Thevam, respectively. Generally, piperine content in pepper varieties ranged from 1.6-9 per cent (Nagar, 2018), oleoresin 0.1-13.9 per cent (Meghwal and Goswami 2012). Differences in chemical contents and compositions may be attributed to genotype, environment, method of processing and analyses.

Yield of coconut

The mean data of six years from 2015-16 to 2020-21 showed that the nut yield palm^{-1} did not differ significantly in the coconut intercropped with black pepper (Table 3). However, nut yield in terms of the number of nuts tree^{-1} increased over the years (post-experimental yield) than pre-treatment yield. Six years mean yield of coconut also indicated improvement in the yield (59.9 nuts palm^{-1} year^{-1}), which clearly indicates the positive influence of the intercropping system. Maheswarappa *et al.* (2012) have also observed the increase in nut yield of coconut due to mixed cropping of black pepper in coconut garden. Generally, in a high-density multi-species cropping system (HDMSCS), black pepper

Table 4. Economics of black pepper varieties as intercrop in coconut garden (₹ ha^{-1} year^{-1})

Varieties/Hybrids	Gross income (₹ ha^{-1})	Cost of production (₹ ha^{-1})	Net income (₹ ha^{-1})	Benefit cost ratio
IISR Thevam	251,475	68024	183451	2.69
IISR Shakthi	256113	68024	188089	2.77
IISR Malabar Excel	245962	68024	177938	2.61
Sreekara	280788	68024	212764	3.12
Panniyur-1	305112	68024	237088	3.48

Rate: Coconut = @ ₹ 15/- per nut, Black pepper = @ ₹ 450/- per kg.

provided additional yield and income, and there was an improvement in the yield of coconut (Krishnakumar *et al*., 2010; Nath *et al*., 2008; Palaniswami *et al*., 2007).

Economics of coconut + black pepper intercropping system

Data on the cost of production, gross return, net return and benefit-cost ratio are presented in Table 4. An assessment of the economics of black pepper varieties as an intercrop in coconut garden revealed that Panniyur-1 recorded the highest net return (₹ 237088 ha^{-1}) as well as the benefit-cost ratio of 3.48, followed by Sreekara (₹ 212764 ha^{-1}; B:C ratio 3.12) and the lowest net return (₹ 177938 ha^{-1}) and benefit-cost ratio (2.61) were observed in IISR Malabar Excel owing to its low berry yield. Nagawekar *et al.* (2002) reported that there was an increase of 37 per cent of average net profit from the coconut + pepper model compared to monocrop alone. Under HDMSCS, black pepper provided additional income when grown as one of the component crops in coconut gardens, as reported by Nath *et al*. (2008), Krishnakumar *et al*. (2010) and Maheswarappa *et al*. (2012). A similar result was obtained in arecanut mixed cropping with black pepper by Deka *et al.* (2016) in the north eastern region.

Conclusion

From the above study, it can be concluded that, under the lower Brahmaputra valley of the Assam region, intercropping of black pepper with Panniyur-1 and Sreekara was performed well in the coconut garden. Intercropping of black pepper in coconut and arecanut gardens should be focused on increasing area under cultivation in Assam with high piperine content varieties. In addition, coconut + black pepper also increased the productivity of coconut and thus increased the profitability of the system over time.

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