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Short Communication

Studies on Growth and Yield of Bush Pepper (*Piper nigrum* L.) Under Different Planting Densities

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The investigation entitled "Studies on growth and yield of bush pepper (*Piper nigrum* L.) under different planting densities" was conducted at Agricultural Research Station, Awashi, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dist. Ratnagiri (M.S) during the years 2019-2020, 2020-21 and 2021-22. The experiment was executed in randomized block design comprised of seven different planting densities *i.e.* Planting at 1 m x 1 m (T_1), Planting at 1.5 m x 1 m (T_2), Planting at 2 m x 1 m (T_3), Planting at 1.5 m x 1.5 m (T_4), Planting at 2 m x 2 m (T_5), Paired planting at 1 m x 1-1.5 m (T_6) and Paired planting at 1 m x 1-2 m (T_7) with three replications. Planting at 1.5 m x 1 m (T_1) recorded significantly maximum number of spikes bush^{-1} (121.60), fresh weight (801.78 g bush^{-1}) and dry weight of berries (240.53 g bush^{-1}). Maximum gross returns (11470 Rs Guntha^{-1}), net returns (3436 Rs Guntha^{-1}) and B:C ratio (1.43) also recorded in Planting at 1.5 m x 1 m spacing. From the present investigation it is concluded that for getting maximum yield with maximum gross returns, net returns and B:C ratio from bush pepper, it should be planted at 1.5 m x 1 m spacing under 50% shade net condition.

(***Key words:*** *Bush pepper, Growth, Planting density, Yield)*

Spices are an indispensable part of Indian food habit. Besides adding taste, it also adds to several health benefits. Black pepper is regarded as "King of Spices" and "Black Gold" (Parthasarathy *et al.,* 2008). Black pepper is having great socio-economic importance as well. India is known to have a highest area of black pepper cultivation in the world. India was a dominant producer, supplier and consumer of black pepper in the world. But in the last few decades there are some newly emerging countries which are the major competitor in global market. The productivity of black pepper in India is being challenged by countries like Malaysia and it is ascribed basically to improper management practices (Hamza and Sadanandan, 2005). It is the largest foreign exchange earner among spices and the average quantity exported from India accounts for more than 70 percent of the total production. The demand for black pepper and its products is increasing year by year in the world market but the production is not up to the level. At present the productivity in India is very low due to non-adoption of good agricultural practices (Thangaselvabal *et al.,* 2008). In 2016-17 India produced 57000 tons of Black pepper from 131230 ha area with a productivity of 3.66 t ha^{-1}. The leading countries in the production of the Black Pepper are Vietnam, Indonesia, India and Brazil (Anonymous, 2019a). In India area under Black Pepper is 1,37,378 ha with 61,000 tonnes production (Anononymous, 2019b) with major black pepper producing regions are Kerala, Karnataka, Konkan, and Tamil Nadu (Anonymous, 2019a). USA, UK, Germany, Vietnam, Netherlands, Japan and Sweden are the major consumers of black pepper from the India (Abraham, 2018).

ICAR-Indian Institute of Spices Research, Calicut has come out with new technology which can relish the culinary needs for pepper throughout the year. The laterals are used as planting material the resultant plants grow like bush. These plants produce numerous laterals throughout the year unlike vines. Growing bush pepper is one of the good ideas to bridge the gap between demand and supply of black pepper (Madhura *et al.,* 2000). Considerable interest among urban people has been noted to grow bush pepper in the garden and terrace which in turn increased the demand for planting materials (Ramya *et al.,* 2017). As compared to black pepper trained on standard plant the bush pepper

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required limited area, easy spike harvesting and bearing throughout the year with no quality difference between both the peppers. Presently most of the growers demand peppers as a bush pepper as it shows bushy growth habit and can accommodate more number of plants per unit area (Shinde *et al.* 2019). However, information on the growth and yield performance of bush pepper under different planting densities is still limited. Therefore, an attempt was made to evaluate the effect of different planting densities on the growth, yield, and productivity of bush pepper.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Station, Awashi, Khed, Dist. Ratnagiri during the years 2019-2020, 2020-21 and 2021-22. The soil of the experimental plot was sandy clay loam in texture, slightly acidic in pH (5.80) and high in organic carbon content (15.6 g kg^{-1}). Soil was medium in available nitrogen (257.15 kg ha^{-1}), low in available phosphorus (15.81 kg ha^{-1}) and high in available potassium (246.73 kg ha^{-1}). The field experiment was laid out in Randomized block design. Experiment was comprised of seven different planting densities *viz.,* Planting at 1 m x 1 m (100 plants 100 m^{-1}) (T_1), Planting at 1.5 m x 1 m (67 plants 100 m^{-1}) (T^2), Planting at 2 m x 1 m (50 plants 100 m^{-1}) (T_3), Planting at 1.5 m x 1.5 m (45 plants 100 m^{-1}) (T_4), Planting at 2 m x 2 m (25 plants 100 m^{-1}) (T_5), Paired planting at 1 m x 1-1.5 m (80 plants 100 m^{-1}) (T_6) and Paired planting at 1 m x 1-2 m (67 plants 100 m^{-1}) (T_7).

The experiment was laid out under 50% shade net conditions with different panting densities as per treatments. The pit of 30 cm^3 were dug and filled with well decomposed FYM and 50g single super phosphate. The well grown bush pepper plants were planted in the pits.

The partial support was given to the bush pepper plant. FYM was applied @3 kg $bush^{-1}$ at yearly interval. NPK was applied @ 10:5:20 g $plant^{-1}$ at 3 months interval *viz.,* June, October and February. Drip irrigation with two drippers of 4 LPH per bush was applied for 10 min. on daily basis. In addition to this sprinkler irrigation was also applied to maintain the relative humidity. Pruning of hanging shoots were done to maintain the bushy nature by repeating at every year. Two weeding were given during the months of June-July and October-November. Winey growth (water shoots) detached at an interval of 40-45 days for proper growth management and yield of bush pepper. Incidence of scale insect was observed during the experimentation period. To check this scale insect, integrated approach was followed. For this swabbing with soapnut water was done after incidence. After 10-15 days of swabbing, spraying of bufro benzene, showed positive effect against incidence. To avoid soil borne fungal effect, drenching of *Trichoderma* with cow dung slurry twice in a year was done. The data recorded third year onwards. The experimental data was statistically analyzed as per Randomized block design as described by Panse and Sukhatme (1995).

RESULTS AND DISCUSSION

Pooled data of three years (2019-2020, 2020-21 and 2021-22) revealed that the growth parameters did not vary significantly however yield parameters of bush pepper differed significantly. Spike weight, number of berries $spike^{-1}$, weight of 100 green berries, number of leaves $bush^{-1}$ were found non-significant in all the treatments during the period of investigation. Number of spikes $bush^{-1}$ was significantly different among the treatments. The maximum spikes (121.60) were recorded in T_2 followed by T_3(105.69). Whereas minimum spikes (72.19) were noticed in T_1. Similar findings are in conformity with research findings of Bhattacharya and Bandopadhyay (2017) and Shinde *et al.* (2019) in bush pepper.

Length of spike (cm) was significantly different among treatments. It is revealed from pooled data (Table 1) that the significantly maximum spike length (13.79cm) was noticed T_3 followed by T_2 and T_6 whereas minimum spike length was noticed T_7 (10.98 cm). Similar findings are in conformity with research findings of Bhattacharya and Bandopadhyay (2017) and Shinde *et al.* (2019).

The planting densities showed significant variation for fresh yield as well as dry yield of berries (g $bush^{-1}$)

Table 1. *Number of leaves bush^{-1}, number of spikes bush^{-1} and spike length (cm) of bush as influenced by different planting densities*

Treatment	Number of leaves bush^{-1}				Number of spikes bush^{-1}				Spike length (cm)			
	2019-20	2020-21	2021-22	Pooled mean	2019-20	2020-21	2021-22	Pooled mean	2019-20	2020-21	2021-22	Pooled mean
T_1 : 1 m x 1 m	245.20	116.00	106.13	155.78	37.07	93.93	87.37	72.79	12.23	10.73	10.40	11.12
T_2 : 1.5 m x 1 m	271.80	135.40	121.27	176.16	64.40	155.93	144.47	121.60	14.03	12.73	12.33	13.03
T_3 : 2 m x 1 m	273.93	122.33	109.27	168.51	36.87	147.73	132.46	105.69	15.03	14.33	12.00	13.79
T_4 : 1.5 m x 1.5 m	260.33	123.47	112.53	165.44	50.47	109.27	98.15	85.96	12.07	11.40	12.07	11.84
T_5 : 2 m x 2 m	274.27	146.87	133.80	184.98	44.33	136.80	120.11	100.42	13.23	12.00	11.00	12.08
T_6 : 1 m x 1-1.5 m	241.47	128.73	112.53	160.91	40.80	122.47	107.92	90.39	13.10	12.43	12.10	12.54
T_7 : 1 m x 1-2 m	213.07	114.53	98.53	142.04	39.73	114.93	104.03	86.23	11.23	10.90	10.80	10.98
SE +	29.70	13.13	11.86	14.03	11.95	7.94	6.50	5.78	0.10	0.43	0.37	0.20
CD @ 5%	NS	NS	NS	NS	NS	24.47	20.2	17.80	0.30	1.32	1.15	0.62

Table 2. *Spike weight (g), number of berries spike^{-1} and weight of 100 berries (g) of bush as influenced by different planting densities*

Treatment	Spike weight (g)				Number of berries spike^{-1}				Weight of 100 berries (g)			
	2019-20	2020-21	2021-22	Pooled mean	2019-20	2020-21	2021-22	Pooled mean	2019-20	2020-21	2021-22	Pooled mean
T_1 : 1 m x 1 m	11.73	10.07	9.67	10.49	65.20	62.47	61.73	63.13	22.83	22.43	21.33	22.20
T_2 : 1.5 m x 1 m	13.90	10.60	10.00	11.50	74.47	64.80	63.80	67.69	22.98	23.18	22.37	22.84
T_3 : 2 m x 1 m	12.00	10.71	9.93	10.88	70.00	61.67	60.67	64.11	21.10	22.97	15.47	19.84
T_4 : 1.5 m x 1.5 m	13.43	8.63	9.27	10.44	83.77	57.60	56.60	65.99	23.00	22.90	21.80	22.57
T_5 : 2 m x 2 m	14.77	10.39	10.40	11.85	89.17	69.07	68.07	75.43	23.28	23.48	23.00	23.26
T_6 : 1 m x 1-1.5 m	13.57	11.00	10.00	11.52	69.80	68.60	67.60	68.67	23.03	23.20	22.00	22.74
T_7: 1 m x 1-2 m	12.97	9.40	10.37	10.91	66.00	62.53	61.53	63.36	22.70	23.07	22.77	22.84
SE +	0.23	0.65	0.48	0.36	0.74	4.33	4.29	2.97	0.44	0.32	2.35	0.76
CD @ 5%	0.72	NS	NS	NS	2.29	NS	NS	NS	NS	NS	NS	NS

(Table 3). The maximum fresh yield (801.78 g bush^{-1}) as well as dry yield (240.53 g bush^{-1}) was recorded in T_2 followed by T_3 (625.25 g bush^{-1}and 187.58 g bush^{-1}). The superior yield obtained under these planting densities may be attributed to the higher number of spikes per bush, which contributed to increased berry production. Whereas minimum fresh weight 435.91 g bush^{-1} and dry yield 130.77 g bush^{-1} was observed in T_1. The quantitative traits, spike number, spike length are known to influence the yield of black pepper in positive way. Similar results were also reported by Hussain *et al.* (2017) in Panniyur 1 variety of black pepper. The higher berry yield may be attributed to the greater number of spike bush^{-1} and increased spike length, which together

Table 3. *Fresh and dry yield of bush (g bush^{-1}) as influenced by different planting densities*

Treatment	Yield (g bush^{-1}) (fresh weight)				Yield (g bush^{-1}) (dry weight)			
	2019-20	2020-21	2021-22	Pooled mean	2019-20	2020-21	2021-22	Pooled mean
T_1 : 1 m x 1m	299.07	539.39	487.00	435.91	89.72	161.82	146.10	130.77
T_2 : 1.5 m x 1m	537.33	988.14	920.10	801.78	161.20	296.44	276.03	240.53
T_3 : 2 m x 1m	255.27	911.13	831.57	625.25	76.58	273.34	249.47	187.58
T_4 : 1.5 m x 1.5 m	414.27	574.43	520.99	499.57	124.28	172.33	156.30	149.87
T_5 : 2 m x 2 m	307.33	893.75	798.87	609.18	92.20	268.13	239.66	182.75
T_6 : 1 m x 1-1.5 m	316.00	737.10	706.05	530.65	94.80	221.13	211.82	159.20
T_7 : 1 m x 1-2 m	330.67	732.47	732.47	548.72	99.20	219.74	219.74	164.62
SE +	104.59	66.54	51.04	57.40	31.38	19.96	15.31	17.22
CD @ 5%	NS	205.03	157.28	176.88	NS	61.51	47.18	53.06

enhanced the overall yield potential. Similar findings have been reported by Ramesh *et al.* (2002). Similar results were reported by Kurian *et al.* (2002), who observed a significant positive correlation between fresh and dry berry yield and both spike length and the number of spikes in black pepper. The present findings are also in agreement with those of Shinde *et al.* (2019), Reshma *et al.* (2022), and Shigwan *et al.* (2023), who reported similar results in bush pepper.

The treatments showed significant variation for fresh yield as well as dry yield (kg Guntha^{-1}) on guntha basis (Table 4). Among the treatments maximum fresh yield (54.62 kg Guntha^{-1}) as well as dry yield (16.39 kg Guntha^{-1}) was recorded in T_2 followed by T6 kg Guntha^{-1}) and T_1 (44.18 kg Guntha^{-1} and 13.25 kg Guntha^{-1}), whereas minimum fresh and dry yield was shown by T_5. Huevelink, (1995) reported that decrease in yield with increasing population density is explained by the fact that, the mutual shading between plants negatively affects the production of photo-assimilates, to the degree that the number of fruits plant^{-1} or the mean weight of each fruit decreases drastically. Similar results were also noticed by Sadandan and Hamza (1996), Shinde *et al.* (2019) and Shigwan *et al.* (2023) in bush pepper.

The economics of different treatments in one Guntha (1 R) area revealed, T_2 with planting density at 1.5 m x 1 m recorded maximum gross returns (11470 Rs. Guntha$^{-1)}$, net returns (3436 Rs. Guntha^{-1}) as well as B:C ratio (1.43) followed by treatment, T_6. The lowest B:C ratio (0.44) was observed in T_5 which positively correlated with yield and plant population (Table 5). From the present investigation it is concluded that for getting maximum yield with maximum gross returns, net returns and B:C ratio from bush pepper, it should be planted at 1.5 m x 1 m spacing under 50% shade net condition.

Table 4. *Fresh and dry yield of bush (kg* Guntha^{-1}*) as influenced by different planting densities*

Treatment	Yield (kg Guntha^{-1}) (fresh weight)				Yield (kg Guntha^{-1}) (dry weight)			
	2019-20	2020-21	2021-22	Pooled mean	2019-20	2020-21	2021-22	Pooled mean
T_1 : 1m x 1m	29.91	53.94	48.70	44.18	8.97	16.18	14.61	13.25
T_2 : 1.5 m x 1m	36.00	66.21	61.65	54.62	10.80	19.86	18.49	16.39
T_3 : 2 m x 1m	12.75	45.56	41.58	33.30	3.83	13.67	12.47	9.99
T_4 : 1.5 m x 1.5m	18.64	25.85	23.44	22.65	5.59	7.75	7.03	6.79
T_5 : 2 m x 2 m	7.68	22.34	19.97	16.67	2.31	6.70	5.99	5.00
T_6 : 1m x 1-1.5 m	25.28	58.97	56.48	46.91	7.58	17.69	16.95	14.07
T_7 : 1 m x 1-2 m	22.15	49.08	49.08	40.10	6.65	14.72	14.72	12.03
SE +	7.55	3.96	2.70	3.69	2.27	1.19	0.81	1.11
CD @ 5%	NS	12.21	8.32	11.37	NS	3.66	2.50	3.41

Table 5. *Economics of different treatments in 1R area as affected by different planting densities in bush pepper*

Treatments	Total cost (Rs. Guntha^{-1})	Gross returns (Rs. Guntha^{-1})	Net returns (Rs. Guntha^{-1})		B:C ratio	
			Input cost	Total cost	Input cost	Total cost
T_1 : 1 m x 1m	8165	9278	5955	1113	2.79	1.14
T_2 : 1.5 m x 1m	8034	11470	8146	3436	3.45	1.43
T_3 : 2 m x 1m	7966	6992	3669	-974	2.10	0.88
T_4 : 1.5 m x 1.5m	7942	4755	1432	-3186	1.43	0.60
T_5 : 2 m x 2m	7866	3500	176	-4366	1.05	0.44
T_6 : 1m x 1-1.5m	8086	9851	6528	1766	2.96	1.22
T_7 : 1 m x 1-2m	8034	8421	5098	388	2.53	1.05

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