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Effect of water soluble fertilizers on yield and economics of bush pepper (*Piper nigrum* L.) under agro-climatic conditions of Konkan region of Maharashtra

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Abstract
The present investigation entitled "effect of soluble fertilizers on yield and economics of bush pepper (*Piper nigrum* L.) under agro-climatic conditions of Konkan region of Maharashtra" was carried out at College of Horticulture, Dapoli. Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri (Maharashtra) during 2020-21 and 2021- 2022. The experiment was laid out in randomized block design with seven treatments and four replications. In respect of two years cumulative fresh berry yield per plant (2340.83g), dry berry yield per plot (23.17 kg), and dry berry yield per guntha (38.62 kg) and per cent increased (36.67%) in yield of second year over yield of first year was observed in treatment T_5 (application of 125 % RDF through WSF). The highest net returns of Rs. 13172.35/- per guntha with B: C ratio (2.32) was recorded in treatment T_5.

Keywords: Indian mustard, path coefficient analysis

Introduction
Pepper (*Piper nigrum* L.) is one of the important commercial spices of India which is a major producer, consumer and exporter of black pepper in the world. It is a crop of tropics and sub-tropical regions and requires warm and humid climatic conditions. Black pepper is native of South India. It is a flowering vine in the family piperaceae, cultivated for its berries which are usually dried and used as a spice. The cultivation of bush pepper directly in field and also under protected environment is gaining popularity in the district of Konkan region of Maharashtra comprising Sindhudurg, Ratnagiri, Thane, Palghar and Raigad districts. On an average, about 500-1000 ha. area of Konkan region is occupied with bush pepper (Sharon *et al*., 2019) [11]. In Konkan region of Maharashtra, the black pepper variety Panniyur-1 which generally grown as bush pepper at a spacing of 1×1m under 50% shade net or using poly-house under protected cultivation. During last two decades, farmers understood the real value of WSFs and now, these are being widely used in almost all the crops across geographies. The market size for WSFs grew from mere 10,000 tons (t) in early 2000s to 3, 00,000 t in 2021. Water soluble fertilizers provide an optimal solution to increase the agricultural yields. WSFs are extremely convenient to use as they are available premixed with salts and can be simply sprayed on plants. Being water soluble, these fertilizers are the ideal solution for feeding the necessary amounts of micro and macro nutrients to growing crops. This also makes them cost-effective and eliminates the additional cost of buying in bulk, a major hindrance with traditional fertilizers. (Suvarna and Singh, 2021) [15]. Use of water soluble fertilizers also reduced the chances of wastage of nutrients by leaching or by fixation and making them unavailable to crops. Both these features are very common in traditional chemical fertilizers. High yield of pepper is urgently needed to meet the increasing population and growing demand for food. One of the main problems faced by the pepper farmers is the high cost of production due to increasing trend of using inorganic fertilizers. The problem is complex because black pepper is a high nutrient demanding crop. Bush Pepper is a surface feeder crop and as it yields throughout the year. Further its nutrient scheduling is the most important aspect to gain higher yields. The evaluation of nutrient uptake from soil and partitioning can provide the foundation for fine tuning nutrient management practices as producers aim for increased yield and profitability.

Keeping in view this experiment was conducted to study effect of water soluble fertilizers on yield and economics of bush pepper.

Materials and Methods

The experiment was conducted at the College of Horticulture, Dapoli, Dist. Ratnagiri (MS) during the years 2020 and 2021. The healthy, pest and disease free three months old rooted cuttings of variety 'Panniyur-1' planted in polybags were used for planting for this experiment. The three grades of water-soluble fertilizers like urea, 19:19:19 and 00:00:50 were used. The recommended dose of straight fertilizers like urea, single super phosphate and muriate of potash were used as control. Bush pepper is small bush grown either in field or pots with yield of 300-500g per plant per year. A fertilizer dose of 25:10:35g NPK per plant per year was considered as recommended dose i.e. ¼ of the vine black pepper plant. From treatment T_1 to T_6 water soluble fertilizers were applied by drenching 100 ml solution to each plant at weekly interval from 1st January, 2020 to 31st December, 2021 i.e. in all 52 drenching were done in each year. For treatment T_7 recommended fertilizers were applied in August and January months. All the treatments were supplied with FYM @ 5kg/bush/year + *Trichoderma harzianum* @ 50g / bush/ year (Devasahayam *et al.*, 2015) [2] in equal split doses twice in a year. The field experiment was laid out in a randomized block design (RBD) comprising of seven treatments with four replications. i.e., T_1 -25 % of the RDF through soluble fertilizers at weekly interval, T_2-50% of the RDF through soluble fertilizers at weekly interval T_3-75 % of the RDF through soluble fertilizers at weekly interval, T_4-100 % of the RDF through soluble fertilizers at weekly interval, T_5-125 % of the recommended dose of fertilizer through soluble fertilizers at weekly interval, T_6-150 % of the RDF through soluble fertilizers at weekly interval, T_7- Control - 100 % of the RDF through straight fertilizers in two equal split doses in a year.(25:10:35g NPK per plant per year)

As bush pepper yields throughout the year and spike initiation is associated with growth of plagiotropic shoots and matures at different periods harvesting was done many times and total of fresh yield per plant at the end of 1st and 2nd year and cumulative yield of two years was recorded. After harvesting of spikes from plants the berries were separated and dried in oven at$70^0 \pm 5^0$C until constant weight was obtained and mean was expressed in kilogram. The dry yield of berries per plot and per guntha (kg) was computed by converting per plant yield into per plot and guntha. On the basis of results obtained from the treatments in the experiment the economics was worked out. The net profit was calculated considering all input costs including planting material cost which was subtracted from gross yield (Rs.) and expressed in B:C ratio. The observations recorded about yield and economics were presented in Table 1 and 2 respectively. The data obtained in the present investigation was statistically analyzed by the method suggested by Panse and Sukhatme (1995) [9]. The standard error of mean (S.E) was worked out and the critical difference (C.D.) at 5 per cent was calculated wherever the results were found significant.

Table 1: Effect water soluble fertilizers on fresh berry yield per plant (g), dry berry yield per plot (g), fresh berry yield per guntha (kg), and per cent increased over yield of 1st year (%).

Treatments	Fresh berry yield/plant (g)			Dry berry yield/plot (kg)			Dry berry yield/R (t)			Percent increased over 1st year
	Total of 1st year	Total of 2nd year	Cumulative yield of two years	Total of 1st year	Total of 2nd year	Cumulative yield of two years	Total of 1st year	Total of 2nd year	Cumulative yield of two years	
T_1	210.74	248.34	459.08	1.71	2.01	3.72	2.84	3.35	6.20	18.08
T_2	394.50	487.86	882.36	3.31	4.10	7.41	5.52	6.83	12.35	23.54
T_3	683.22	858.34	1541.56	5.94	7.47	13.41	9.91	12.45	22.35	26.69
T_4	803.58	1029.63	1833.21	7.23	9.27	16.50	12.05	15.44	27.50	28.13
T_5	989.87	1350.96	2340.83	9.80	13.37	23.17	16.33	22.29	38.62	36.67
T_6	354.62	451.47	806.09	2.98	3.79	6.77	4.96	6.32	11.29	27.41
T_7	254.32	304.82	559.14	2.06	2.47	4.53	3.44	4.12	7.55	19.77
SEm±	15.43	17.49	31.10	0.16	0.22	0.30	0.21	0.29	0.47	1.89
CD AT 5%	44.79	50.75	90.25	0.45	0.63	0.87	0.62	0.86	1.35	5.49

T_1	25% of RDF	T_2	50% of RDF	T_3	75% of RDF
T_4	100% of RDF	T_5	125% of RDF	T_6	150% of RDF
T_7	Control- (100% RDF) 25:10:35 g NPK/bush/year (54:63:58 g Urea:SSP:MOP) applied through straight fertilizer in two equal split doses in a year (August and January)				

RDF – Recommended dose of fertilizers

Table 2: Effect of water soluble fertilizers on economics of bush pepper cultivation per guntha

Treatments	Per Guntha (Projected)				
	Cumulative yield of two years (kg)	Expenditure (RS.)	Gross Returns (Rs.)	Net Returns (Rs)	B : C Ratio
T_1	6.20	9262.46	3718.53	-5543.93	0.40
T_2	12.35	9447.79	7411.82	-2035.97	0.78
T_3	22.35	9631.49	13411.53	3780.04	1.39
T_4	27.50	9816.82	16498.85	6682.03	1.68
T_5	38.62	10002.15	23174.50	13172.35	2.32
T_6	11.29	10189.01	6771.05	-3417.96	0.66
T_7	7.55	11241.41	4530.21	-6711.20	0.40

T_1	25% of RDF	T_2	50% of RDF	T_3	75% of RDF
T_4	100% of RDF	T_5	125% of RDF	T_6	150% of RDF
T_7	Control- (100% RDF) 25:10:35 g NPK/bush/year (54:63:58 g Urea:SSP:MOP) applied through straight fertilizer in two equal split doses in a year (August and January)				

RDF – Recommended dose of fertilizers

Results and Discussion

Yield

The data presented in Table 3 showed that the plants which supplied with 125 per cent recommended dose of fertilizers through soluble fertilizers i.e. treatment T_5 produced maximum cumulative fresh berry yield per plant (2340.83g), cumulative dry berry yield per plot (23.17 kg) and cumulative dry berry yield per guntha (38.62 kg) of two years. Treatment T_5 also showed maximum percent increased of the yield of second year over yield of 1st year (36.67%). The minimum cumulative fresh berry yield per plant (459.08 g), cumulative dry berry yield per plot (3.72 kg) which was at par with treatment T_7 i.e. 4.53 kg and cumulative dry berry yield per guntha (6.20 kg) of two years was recorded in treatment T_1 (25% RDF through WSF) which was at par with treatment T_7 (7.55 kg) i.e. application of 100 percent recommended fertilizer dose through straight fertilizers. However, minimum per cent increase in yield over 1st year was found in treatment T_1 (25% RDF through WSF) i.e. 18.08 per cent which was at par with treatment T_7 (19.77%) and T_2 (23.54%). Increase in berry yield with increase in levels of soluble fertilizers might be due to better response of the crop to the nutrient availability due to application of fertilizers in soluble form at weekly interval. It also might be due to the base of flowering and fruiting formed by stimulating effect of nitrogen on the vegetative growth characters. Another possible reason might be more carbohydrate production and assimilation in fruit by the effect of N, P and K. These findings are supported by the results obtained by Aminifard *et al.* (2010) [1] in egg plant, Dixit *et al.* (2018) [3] in tomato and Supekar *et al.* (2020) [14] in chilli.

It is confirmed that the application of NPK accelerated the growth which provided efficient framework for high rates of nutrient absorption and net assimilation, which are principle factors responsible for productive metabolism and enhanced out turn. Nitrogen is an integral component of many compounds which are essential for plant growth processes. It encourages growth above ground. Phosphorus in adequate quantity helps in the development of root system of the crop due to its proliferation effect on root. Photosynthesis processes activates rapidly by potassium within the plant which leads to accelerate growth and yield parameters and ultimately dry yield of bush pepper. The results are in close line with the results obtained by Mahalakshmi *et al*. (2001) [6] in banana, Manjunatha (2003) [7] in long pepper, Godara *et al.* (2013) [4], Koyani *et al*. (2014) [5] and Meena *et al.* (2016) [8] in fennel.

Economics

Highest net return (Rs.13172.35/-) and B:C ratio i.e. 2.32 was registered by the plants supplied with 125 per cent recommended fertilizer dose supplied through water soluble fertilizers i.e. treatment T_5. Whereas, lowest net return (Rs. 5543.93/-) was recorded by treatment T_1. The lowest B:C ratio (0.40) was registered by treatment T_1 and T_7.

Due to higher uptake of nutrients and nutrient use efficiency the water-soluble fertilizers registered higher gross income through significantly higher yields. Thus, the extra expenditure towards water-soluble fertilizers was well compensated through higher additional income. High net return in bush pepper could be assured by increasing the productivity by adopting proven management practices. This result was in strong association with the findings of Sajitha (2013) [10] in watermelon who reported that fertigation at 125 per cent recommended dose of nutrients as water-soluble fertilizer recorded the maximum BCR as compared to lower BCR recorded in the treatment 100 per cent recommended dose of fertilizers as straight fertilizer. Also, Vaidehi and Subramanian (2015) [16] in nutmeg reported higher gross return (Rs. 7, 29,144/- ha^{-1}) under the fertigation treatment with 100% water soluble fertilizer. Similarly, Shweta and Hiremath (2017) [12] in garlic and Suman Kumari *et al.* (2020) [13] in cucucmber recorded maximum cost benefit ratio when plants were supplied with 100 per cent recommended fertilizers dose applied through water soluble fertilizers.

Conclusion

Thus, from the present investigation, it is concluded that application of 125 per cent of the recommended dose of fertilizer i.e. treatment T_5 (31.25:12.50:43.75 g NPK/plant/year) through water-soluble fertilizer found to be optimum and economically viable as evidenced through higher yield and net returns.

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