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Effect of NPK and Biofertilizers on Growth and Yield of Chilli (*Capsicum annuum* L.)

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ABSTRACT: The present investigation entitled "Effect of NPK and biofertilizers on growth and yield of chilli (*Capsicum annuum* L.)" was carried out at the Research Area, ITM University, Gwalior (M.P.) Chilli (*Capsicum annuum* L.) belongs to family Solanaceae and it is originated in Tropical America. A large number of constraints limit the production of chilli which includes low yielding ability of genetic material, imbalanced supply of nutrients and pest and diseases. Biofertilizers are inputs containing microorganisms which are capable of mobilizing nutritive elements from non-usable form to usable form through biological process. These natural fertilizers help to enhance productivity by biological nitrogen fixation or solubilization of insoluble phosphate or producing hormones, vitamins and other growth factors required for plant growth. The experiment was laid out in the Randomized Block Design with three replications. Each replication was comprised of seven treatments (*viz*., T_1 – Control (100 % RDF), T_2 – 100 % RDF + FYM + PSB, T_3 – 75 % RDF + FYM + PSB, T_4 – 100 % RDF + FYM + *Azotobacter*, T_5 – 75 % RDF + FYM + *Azotobacter*, T_6 – 100 % RDF + FYM + PSB + *Azotobacter* and T_7 – 75 % RDF + FYM + PSB + *Azotobacter*) were applied in chilli. Result reported that the FYM and biofertilizers with different dose of NPK were significantly influenced the all the growth parameters *viz* plant height (cm), number of branches per plant, days to first flowering and days to 50 % flowering and yield parameters *viz* number of fruits per plant, fruit length (cm), fruit diameter(mm), number of fruits per plant, number of seed per fruit, average fruit weight (g), fruit yield per plant (g), fruit yield per plot (kg) fruit yield per hectare (q) etc. Among all the treatment T_6 (100 % RDF + FYM + PSB + *Azotobacter*) was found the best treatment and it gave the maximum growth parameters yield parameters of chilli whereas the minimum growth parameters and yield parameters were recorded in treatment T_1 (Control -100 % RDF). The maximum cost of cultivation, gross returns, net returns and B:C ratio was recorded in treatment T6 (100 % RDF + FYM + PSB + Azotobacter), 47 whereas the minimum cost of cultivation, gross returns, net returns and B:C ratio was observed in treatment T1 (Control -100 % RDF).

Keywords: Biofertilizers, Chilli, Growth, Yield, Treatment.

INTRODUCTION

Chilli (*Capsicum annuum* L.) belongs to family *Solanaceae* and it is originated in Tropical America. Chilli is an often cross pollinated herbaceous or semi-woody annual Though chilli is an introduced crop in India, it is grown throughout the country in almost all the states with a production of 17.64 lakh tons from 7.33 lakh hectare area which accounts around 22.90 per cent of the total Indian spice production (Anon., 2019). Chilies are nature's wonder. Its fruit appear in different sizes, shapes and colours. Chili fruits are rich source of several vitamins like vitamin C (ascorbic acid), pro-vitamin A, thiamine (B1), riboflavin (B2) and niacin (B3) and minerals like molybdenum. They have biting pungency attributed to an alkaloid capsaicin and captivating red colour due to a pigment capsaithin. In recent past horticulture has undergone enormous change due to introduction of new varieties and hybrids, development of new technologies such as use of chemical fertilizers, pesticides, weedicides, growth regulators and other inputs as well as improved agricultural practices like drip irrigation and fertigation. Across the country monoculture systems have been developed due to such practices which led to loss of biodiversity and rampant soil degradation. Chili is also grown with all modern agricultural practices, which includes chemical fertilizers and pesticides. Because of continuous use of chemicals in chili, the crop has been

highly vulnerable to more of pest and diseases. So, the dependency on chemical fertilizers alone not only invite the soil health problems but it adds more production cost per unit area to farmers as these chemical fertilizers are imported from foreign countries.

Biofertilizers are the substances containing variety of microbes having the capacity to enhance plant nutrient uptake by colonizing the rhizosphere and make the nutrients easily accessible to plant root hairs. Biofertilizers are well known for their cost effectiveness, environment-friendly nature, and composition. These are effective alternatives to the hazardous synthetic fertilizers. Forpopularization of high yielding varieties and hybrids of various vegetable crops, it may not be possible to completely replace the chemical fertilizers, but the possibility of reducing the dose of inorganic fertilizers by substituting some part of nutrients with biofertilizers is always there. For this, the doses of fertilizers need to be gradually reduced and should be balanced by increasing the use of optimum quantity of organic manures and biofertilizers. Keeping in view of the balanced nutrition (organic, inorganic and biofertilizers) the present investigation entitled "Effect of NPK and biofertilizers on growth and yield of chilli (*Capsicum annuum* L.)" was carried out to find the suitable dose of RDF along with FYM and biofertilizers for growth and yield of chilli and to find out the best economics of treatments. The maximum cost of cultivation, gross returns, net returns and B:C ratio was recorded in treatment T_6 (100 % RDF + FYM + PSB + Azotobacter), whereas the minimum cost of cultivation, gross returns, net returns and B:C ratio was observed in treatment T_1 (Control -100 % RDF).

MATERIAL AND METHODS

Field investigation was carried out during kharif season 2021-2022 at experimental field of ITM School of Agriculture, Gwalior. The experimental soil (0-15 cm) had clay, texture, uniform topography and slightly alkaline in reaction (pH 7.6), normal in salt content (0.32 dSm^{-1}), low in available N (197.58kg ha^{-1}), medium in available P_2O_5 (19 kg ha^{-1}) and high in available K_2O (241 kg ha^{-1}). The experiment was laid out in randomized block design with three replications. Treatment comprised of T_1 – Control (100 % RDF), T_2 – 100 % RDF + FYM + PSB, T_3 – 75 % RDF + FYM + PSB, T_4 – 100 % RDF + FYM + *Azotobacter*, T_5 – 75 % RDF + FYM + *Azotobacter*, T_6 – 100 % RDF + FYM + PSB + *Azotobacter* and T_7 – 75 % RDF + FYM + PSB + *Azotobacter*). RDF i.e120:80:80 kg NPK per ha was applied in the form of urea, single super phosphate and muriate of potash, respectively. 1/3 part of nitrogen and full dose of phosphorus and potassium were applied at basal dose, while nitrogen was applied in two split doses; 1/3 part 30 days after transplanting and 1/3 part after 30 days of first application. Well decomposed FYM @ 25 tonnes per hectare was applied at the time of land preparation. FYM used in experiment was analysed and it was having 0.48, 0.20 and 0.51 per cent N, P and K respectively. FYM was thoroughly mixed in the soil one week prior to sowing. Seed treatment with bio-fertilizers (Azotobactor and PSB) @ 10g per kg seeds was used before sowing. Local Chilli variety was sown in 30 cm apart by using 20 kg seed ha^{-1}**.** The land was brought to a fine tilth by ploughing and harrowing, a spacing of 1.5 m between two replications and 0.5 m between two plots were provided for laying out the irrigation channel and bunds, respectively. The size of each plot was 4 m length and 3 m width. Seeds were sown in portrays on 0 on the first week of June 2021 and seedlings were ready for transplanting at 40 days after seed sowing. 40 days of healthy and uniform seedlings were used for transplanting. Seedlings were transplant in the plots with a spacing of 60 cm (between rows) 22 and 45 cm (between plants with in a row), at the rate of one seedling per hill and light irrigation was given immediately after transplantation. Seven and ten days after transplanting the gap filling was done twice with fresh seedlings in order to maintain 100 percent plant population in each plot. The plots were kept free from weeds by periodic hand weeding. Protective irrigation was given at an interval of 4-6 days. After 30 days of transplanting, earthing up operation was carried out in the main field to keep the plants in the upright position. The schedule of different plant protection measures taken against pests and diseases during the period of investigation. The fully developed green fruits were harvested at weekly intervals till the green fruits ceased, totally 4 pickings were taken. The harvested green fruits were further used for recording different observations data recorded on various parameters were subdivided into four categories during the period of experimentation. The data were recorded as per standard procedure. For different treatments total cost was calculated on the basis of prevailing market rates of fertilizer, field preparation, sowing of seeds, labour charges, cultural and intercultural operations etc. Gross returns were calculated by multiplying yield with sale rate of produce. Sale rate was depicted on the basis of prevailing market rate of produce. It was calculated treatment wise. The cost of cultivation per hectare was subtracted from the gross income for computing net returns of each treatment. Net return (₹/ha) = Gross return (₹/ha) - Cost of cultivation (₹/ha). B:C ratio is the ratio of gross returns to cost of cultivation. It is expressed as returns per rupee invested. The data obtained from set of observation for each character were subjected to "Analysis of Variance" as advocated by Panse and Sukhatme (1985).

RESULT AND DISCUSSION

Effect of NPK and biofertilizers on growth attributes of Chilli (*Capsicum annuum* L.). Glance of data on plant height (cm) at 30, 60 and 90 DAS and the number of branches per plant and days to flowering (first to 50 % flowering) was presented in Table1. Result clearly shows that the maximum plant height (40.34, 64.92 and 85.51 cm) at 30, 60 and 90 DAT was found in treatment T6 (100 % RDF + FYM + PSB + Azotobacter) and it was found significantly superior treatment as compared to all other treatments for influencing the plant height of chilli plant. It was at par to treatment T_7 (75 % RDF + FYM + PSB + Azotobacter) at 30 and 60 DAT, while at par to treatment T_4 (100 % RDF + FYM + Azotobacter) and

T_7 (75 % RDF + FYM + PSB + Azotobacter) at 90 DAT. However, the minimum plant height (32.56, 46.56 and 79.95 cm) at 30, 60 and 90 DAT was observed in treatment T_1 (Control -100 % RDF). Again, the maximum number of branches per plant (15.78) was found in treatment T_6 (100 % RDF + FYM + PSB + Azotobacter) and it was found the best treatment among all the treatments for influencing the number of branches per plant of chilli plant. It was at par to treatment T_4 (100 % RDF + FYM + Azotobacter) and T_7 (75 % RDF + FYM + PSB + Azotobacter) at 90 DAT. However, the minimum number of branches per plant (10.81) was recorded in treatment T_1 (Control -100 % RDF).

It is evident from the above data that the FYM and biofertilizers with different dose of NPK were significantly influenced the flowering. The treatment T_6 (100 % RDF + FYM + PSB + Azotobacter) was found the best treatment among all the treatments and it gave the minimum days to first flowering (44.80). It was at par to treatment T_4 (100 % RDF + FYM + Azotobacter) and T_7 (75 % RDF + FYM + PSB + Azotobacter), whereas the maximum days to first flowering (54.46) was recorded in treatment T_1 (Control -100% RDF)

The data regarding days to 50% flowering was also presented in Table1. Results revealed that the treatment T_6 (100% RDF + FYM + PSB + Azotobacter) was found significantly superior treatment as compared to all FYM and biofertilizer treatments and it gave the minimum days to 50% flowering (49.30). It was at par to treatment T_4 (100% RDF + FYM + Azotobacter) and T_7 (75% RDF + FYM + PSB + Azotobacter). However, the maximum days to 50% flowering (59.51) was recorded in treatment T_1 (Control -100% RDF). The pattern of increasing plant height and number of branches per plant under the treatment receiving nitrogen through the chemical fertilizers coupled with nitrogen fixation through Azotobacter supported by additional use of FYM leads to more growth in plant. The increase in plant height and number of branches might be due to more availability of nitrogen in soil physically improved by organic manure. These results are supported by the findings of Bharathi *et al.* (2011); Bhuvaneswari *et al.* (2013); Kashyap *et al.* (2014); Leelarani *et al.* (2015); Shiva *et al.* (2015); Guinoza *et al.* (2015); Alaboz *et al*. (2017); Nchang *et al*. (2018); Khurshid *et al.* (2021); Sakthivel (2021).

Effect of NPK and biofertilizers on yield parameters attributes of Chill (*Capsicum annuum* L.). Effect of NPK and biofertilizers on yield parameters attributes of Chilli (*Capsicum annuum* L.) *viz* number of fruits per plant, fruit length(cm),fruit diameter (mm),number of seed per fruit, average fruit weight (g), fruit yield per plant (g), fruit yield per plot (kg), Fruit yield per hectare (q)was presented in Table 2. A perusal of data indicated that the treatment T6 (100 % RDF + FYM + PSB + Azotobacter) was found the best treatment among all the treatments for influencing the number of fruits in chilli plant and it gave the maximum number of fruits per plant (71.55). It was at par to treatment T_7 (75 % RDF + FYM + PSB + Azotobacter) at 90 DAT. However, the minimum number of fruits per plant (51.70) was observed in treatment T_1 (Control -100 % RDF). It is recorded that the treatment T_6 (100 % RDF + FYM + PSB + Azotobacter) was found the best treatment among all the treatments for influencing the fruit length in chilli plant and it gave the maximum fruit length (6.78 cm). It was followed by treatment T_7 (75 % RDF + FYM + PSB + Azotobacter). However, the minimum fruit length (5.26 cm) was noted in treatment T_1 (Control -100 % RDF). The FYM and biofertilizers with different dose of NPK were also significantly influenced the fruit diameter of chilli and the treatment T_6 (100 % RDF + FYM + PSB + Azotobacter) was recorded the best treatment among all the treatments and it gave the maximum fruit diameter (25.29 mm). It was at par to treatment T_4 (100 % RDF + FYM + Azotobacter), T_5 (75 % RDF + FYM + Azotobacter) and T_7 (75 % RDF + FYM + PSB + Azotobacter), whereas the minimum fruit diameter (19.42 mm) was found in treatment T_1 (Control -100 % RDF). It was also recorded that the maximum number of seed per fruit (45.04), the maximum fruit yield per plant (604.27 g) was found and the maximum in treatment T_6 (100 % RDF + FYM + PSB + Azotobacter) and it was found the best treatment among all the treatments for influencing the number of seed per fruit of chilli plant. Both the number of seed per fruit (42.16), the fruit yield per plant (572.03 g) was at par to treatment T_7 (75 % RDF + FYM + PSB + Azotobacter) at 90 DAT. However, the minimum number of seed per fruit (32.56) and the minimum fruit yield per plant (348.81 g) was noted in treatment T_1 (Control -100 % RDF).

The investigation revealed that the maximum average fruit weight (8.45 g) was recorded in treatment T6 (100 % RDF + FYM + PSB + Azotobacter) and it was found the best treatment among all the treatments for influencing the fruit weight in chilli plant. It was at par to treatment T7;75 % RDF + FYM + PSB + Azotobacter (8.30 g) and T4 ;100 % RDF + FYM + Azotobacter (8.08 g) at 90 DAT. However, the minimum average fruit weight (6.75 g) was observed in treatment T1 (Control -100 % RDF).

The result revealed that the treatment T6 (100 % RDF + FYM + PSB + Azotobacter) was found the best treatment among all the treatments for influencing the fruit yield per plot, maximum fruit yield per hectare and it gave the maximum fruit yield per plot (24.17 kg), the maximum fruit yield per hectare (193.37 q) was observed in treatment T_6 (100 % RDF + FYM + PSB + Azotobacter). It was found the best treatment among all the treatments. It was followed by treatment T_7; 22.88 kg fruit yield per plot and 183.05 kg/ha (75 % RDF + FYM + PSB + Azotobacter). whereas fruit yield per hectare (111.62 q) was noted in treatment T_1 (Control -100 % RDF). However, the minimum fruit yield per plot (13.95 kg) was recorded in treatment T_1 (Control -100 % RDF).

Similar results were reported by Khurshid *et al.* (2021) where treatment 75% vermicompost + biofertilizer recorded the maximum the yield parameters like the number of fruits plant^{-1} fruit length, fruit girth average fruit weight fruit yield plant^{-1}, fruit yield hectare^{-1}.and absolute control recorded minimum values for various yield parameters. Sakthivel (2021) also recorded highest number fruit set, fruits plant^{-1} , fruit length, fruit

girth, pericarp thickness, pulp seed ratio, single fruit weight, total fruit yield and quality parameters like capsaicin content and ascorbic acid content (171.3 mg g^{-1}) of the treatments, with 75% RDF + 20 t FYM + 20 kg Sea weed extract granules + 5 t neem cake ha^{-1}.

Economics of the treatments of chilli(*Capsicum annuum* L.). Result recorded (Table 3) that the maximum cost of cultivation (₹ 122500 /ha), gross returns (₹ 386731 /ha), net returns (₹ 264231 /ha) and B:C ratio (3.2) was recorded in treatment T6 (100 % RDF + FYM + PSB + Azotobacter). However, the minimum cost of cultivation (₹ 106000 /ha), gross returns (₹ 223237 /ha), net returns (₹ 117237 /ha) and B:C ratio (2.1) was observed in treatment T1 (Control - 100 % RDF). It might be due to the reason that the plant consumed nutrient provided directly through inorganic and organic fertilizer along with bio-fertilizer. This combination improved the quality as well as yield of plant and enhanced the economic profit. Similar results for most of the characters were also reported by Manna *et al*. (2012); Samsangheile and Kanaujia (2014); Raturi *et al*. (2019); Khurshid *et al*. (2021).

Table 1: Effect of NPK and biofertilizers on growth attributes of Chilli (*Capsicum annuum* L.)

Treatment symbols	Treatment detail	Plant height (cm)			Number of branches per plant	Days to first flowering	Days to 50 % flowering
		30 DAT	60 DAT	90 DAT			
T_1	Control (100 % RDF)	32.56	46.56	79.95	10.81	54.46	59.51
T_2	100 % RDF + FYM + PSB	35.14	50.35	81.54	12.26	50.01	58.96
T_3	75 % RDF + FYM + PSB	33.87	49.62	80.99	12.09	51.47	58.97
T_4	100 % RDF + FYM + *Azotobacter*	36.11	58.09	83.51	13.51	47.35	51.85
T_5	75 % RDF + FYM + *Azotobacter*	35.62	54.91	82.09	12.48	49.63	57.13
T_6	100 % RDF + FYM + PSB + *Azotobacter*	40.34	64.92	85.51	15.78	44.80	49.30
T_7	75 % RDF + FYM + PSB + *Azotobacter*	39.25	62.90	84.27	14.27	45.46	50.96
	SEm ±	**1.159**	**1.691**	**1.076**	**0.794**	**2.046**	**1.625**
	CD 5%	**3.573**	**5.211**	**3.315**	**2.448**	**6.305**	**5.006**

Table 2: Effect of NPK and biofertilizers on yield parameters attributes of Chilli (*Capsicum annuum* L.).

Treatment symbols	Treatment detail	Number of fruits per plant	Fruit length (cm)	Fruit diameter (mm)	Number of fruits per plant	Number of seed per fruit	Average Fruit weight (g)	Fruit yield per plant (g)	Fruit yield per plot (kg)	Fruit yield per hectare (q)
T_1	Control (100 % RDF)	51.70	5.26	19.42	51.70	32.56	6.75	348.81	13.95	111.62
T_2	100 % RDF + FYM + PSB	57.76	5.76	22.50	57.76	35.14	7.76	448.54	17.94	143.53
T_3	75 % RDF + FYM + PSB	55.62	5.65	21.19	55.62	33.87	7.65	425.19	17.01	136.06
T_4	100 % RDF + FYM + *Azotobacter*	64.09	6.08	23.71	64.09	39.01	8.08	517.97	20.72	165.75
T_5	75 % RDF + FYM + *Azotobacter*	60.91	5.90	22.72	60.91	37.32	7.90	481.23	19.25	153.99
T_6	100 % RDF + FYM + PSB + *Azotobacter*	71.55	6.78	25.29	71.55	45.04	8.45	604.27	24.17	193.37
T_7	75 % RDF + FYM + PSB + *Azotobacter*	68.90	6.30	24.68	68.90	42.16	8.30	572.03	22.88	183.05
	SEm ±	**2.046**	**0.123**	**0.848**	**2.046**	**1.625**	**0.149**	**17.346**	**0.694**	**5.551**
	CD 5%	**6.305**	**0.379**	**2.613**	**6.305**	**5.006**	**0.458**	**53.453**	**2.138**	**17.105**

Table 3: Effect of NPK and biofertilizers on economics of the treatments of chilli.

Treatment details	Treatment details	Cost of cultivation(₹/ha)	Gross returns	Net returns	B:C ratio
T_1	Control (100 % RDF)	10600	223237	117237	2.1
T_2	100 % RDF + FYM + PSB	122000	287063	165063	2.4
T_3	75 % RDF + FYM + PSB	120500	272123	151623	2.3
T_4	100 % RDF + FYM + *Azotobacter*	121500	331501	210001	2.7
T_5	75 % RDF + FYM + *Azotobacter*	120000	307987	187987	2.6
T_6	100 % RDF + FYM + PSB + *Azotobacter*	122500	386731	264231	3.2
T_7	75 % RDF + FYM + PSB + *Azotobacter*	12100	366101	245101	3.0

CONCLUSIONS

It can be concluded from the result that the FYM and biofertilizers with different dose of NPK were significantly influenced the growth and yield of chilli and the treatment T_6 (100 % RDF + FYM + PSB + Azotobacter) was found the best treatment among all the treatments and it gave the maximum growth, yield and economic parameters, whereas the minimum growth, yield and economic parameters were recorded in treatment T_1 (Control-100 % RDF). On the basis of the result obtained after completion of present investigation we can also say that using integrated farming system not only increase the production but reduce the consumption of chemical fertilizer and may also improve the soil health. But the further research work is needed to confirm the findings of the present investigation.

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Conflict of Interest. None.

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