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Influence of organic manures, bio-fertilizers and inorganic fertilizers on the growth and yield of chilli (*Capsicum annum* L.)

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Abstract
The experiment to study the performance of chilli under different integrated nutrient supply was conducted at the Experimental Field, School of Agriculture, Lovely Professional University, Phagwara, and Punjab during 2017. The experiment was conducted in Randomized Block Design with three replications. The variety of chilli used for the experiment was Super-Hot with the combination of twelve treatments along with one control. The treatment combinations included different organic manures (FYM, Vermicompost and Mustard cake), three levels of NPK (100, 75 & 50 per cent) along with bio-fertilizers such as *Azospirillum*, PSB and K-Solubilizers. Among all the treatments, better performance for growth and yield was observed Vermicompost + NPK 75% + *Azospirillum* + PSB + K-Solubilizers with a recorded plant height of (64.55 cm), number of branches per plant (16.92), minimum days to 50% flowering (29.26 days), number of fruits per plant (367.51), fruit length (7.90 cm), fruit diameter (4.58 cm) and yield per hectare (14.28 t) compared to the lowest performance in T_{13}-control with a recorded plant height of (47.51 cm), number of branches (12.02 cm), days to 50 per cent flowering (38.23), maximum number of fruits per plant (271.25), fruit length (4.63 cm) and yield (6.56 t/ha). The results clearly indicated the chance of saving 20-25 per cent inorganic chemical fertilizers which will eventually reduced the cost of production and lesser impact on soil health and environment.

Keywords: Chilli, organic manures, bio-fertilizers, NPK, growth, yield and quality

Introduction
Chilli (*Capsicum annum* L.) is amongst one of the most important solanaceous vegetable of tropical and subtropical regions with chromosome number 2n=24, a native of Mexico is one of the most valuable crops of India belonging to the family of Solanaceae. It is grown largely for its fruits and is used as a principle ingredient of various curries. It is also used in the processing industries for making sauces and pickles. Dry chilli is used for making curry powder.

Production of organic chilli is gaining importance especially for health conscious consumers, however, use of organic manures alone cannot fulfil the crop nutrients requirements which often lead to poor production. There is a proper ratio between the organic and chemical sources and it should be worked out to derive the best combination of the inputs for attaining yield and quality in chilli. Hence, the integrated approach to supply the crop with nutrients from chemical fertilizers and organic sources has been shown to produce higher crop yields than when they are applied alone besides reducing the harmful effects of chemical fertilizers on soil health and environment (Shashidhara and Shivamurthy, 2008) [6]. Therefore, an experiment was set up to investigate the performance of chilli using different treatment combination involving nutrients obtained from organic and inorganic sources to arrive at a suitable integration for better growth and yield of chilli.

Materials and methods
The experiment was conducted at the experiment farm of Lovely Professional University, Jalandhar, and Punjab during 2017. The experiment was laid out in Randomized Block Design with 3 replications and 12 different treatment combinations of organic manure, inorganic fertilizers and biofertilizer along with one control (without any treatment). The variety of chilli used in the experiment was 'Super-Hot' hybrid chilli. Seedlings were raised in nursery and transplanted to main field when they are about one month old on raised beds of 2 x 2 m size at a spacing 60 x 45 cm.

Three bio-fertilizers namely *Azospirillum*, PSB and K-solubilzers and three organic manures (FYM, vermicompost and Mustardcake) were included as bio-organic inputs. The bio-fertilizers were applied in combination with organic manures and inorganic fertilizers. All together there are 12 treatments including one control without any treatments. After the final land preparation, FYM @ 25 tonnes/ha, Vermicompost @ 2 tonnes/ha and Mustard cake @ 3 tonnes/ha were applied along with recommended dose of fertilizers (NPK: 90: 60: 60 kg per ha) in the form of Urea, Single Super Phosphate and Muriate of Potash, respectively, either as full dose (100 %) or at reduced rate (75 % or 50 % of RDF) according to treatment details. Nitrogen was applied in two split doses, the first dose as basal application and the other dose at 30 days after planting as top dressing. The entire dose of Phosphorus and Potash were applied at the time of sowing as basal dose. The Bio-fertilizers *viz*., *Azospirillum* @ 10 kg/ha, PSB @ 10 kg/ha and K-solubilizers @ 10 kg/ha were mixed with organic manures and soil thoroughly and applied to the beds just before planting.

Irrigation was provided immediately after planting and fertilizer application. Depending on the rainfall and soil moisture conditions, further irrigations were given as required. Hand weeding was done at an interval of 30 days from planting until the complete coverage of canopy. The crop was harvested in different pickings as chilli produces fruits continuously. Observations on growth parameters were recorded on five randomly selected plant in each treatment at 90 days after planting and the total yield of fruits was obtained after adding all the weights of the fruits from different pickings. The different parameters on which data was recorded were analysed as per RBD design as suggested by Panse and Sukhatme (1985) [4]. The results have been interpreted on the basis of 'F' test value and critical difference (CD) was calculated at 5 % level of significance.

Results and Discussion

The growth parameters recorded at 90 days after transplanting differed significantly among the different treatments (Table 1). Among the different treatment combination, Vermicompost + NPK 100% + *Azospirillum* + PSB + K-Solubilizers (T_4) gave maximum plant height (65.72 cm), number of branches (17.88 cm), minimum days to 50 per cent flowering (28.75), maximum number of fruits per plant (381.57), fruit length (8.50 cm) and yield (14.78 t/ha) closely followed by T_1 (FYM + NPK 100% + *Azospirillum* + PSB + K-Solubilizers) with a recorded plant height of (65.45 cm), number of branches (17.64 cm), days to 50 per cent flowering (28.96), number of fruits per plant (374.21), fruit length (8.29 cm) and yield (14.41 t/ha) compared to the lowest in T_{13} (control) with a recorded plant height of (47.51 cm), number of branches (12.02 cm), days to 50 per cent flowering (38.23), maximum number of fruits per plant (271.25), fruit length (4.63 cm) and yield (6.03 t/ha).

However, statistical analysis showed that the results were not significant by reducing the RDF upto 25 per cent and showed at par results in different growth and yield parameters of chilli in treatment combinations involving NPK 75 per cent. Among them, higher performance was observed in T_5 (Vermicompost + NPK 75% + *Azospirillum* + PSB + K-Solubilizers) with a recorded plant height of (64.55 cm), number of branches (16.92 cm), days to 50 per cent flowering (29.26), number of fruits per plant (367.51), fruit length (7.90 cm) and yield (14.28 t/ha). Findings of Hangarge *et al*. (2001) [3] and Shashidhara and Shivamurthy (2008) [6] in chilli have also exhibited similar results with maximum growth characters in chilli under integrated nutrient supply system. These results are in conformity with the findings of Chumyani *et al*. (2012) [3] in tomato, Vimera *et al*. (2012) [7] in king chilli and Chumei *et al*. (2013) [1] in brinjal, who found maximum growth characters under integrated nutrient supply system. The increase in yield components such as number of fruits per plant and fruit length in these treatment combinations especially T_4 (Vermicompost + NPK 100% + *Azospirillum* + PSB + K-Solubilizers) & T_5 (Vermicompost + NPK 75% + *Azospirillum* + PSB + K-Solubilizers) may be attributed to better growth in terms of plant height and number of branches which was reflected into improved yield components. The improved growth components under application of Vermicompost + NPK 75% + *Azospirillum* + PSB + K-Solubilizers may be attributed to increased availability and continuous supply of nutrients for longer period which might help the crop to put forth better growth and eventually better yield in these treatment combination. The present findings were similar to the results reported by Sharma (1995) [5] tomato and Shashidhara and Shivamurthy (2008) [6] in chilli.

In conclusion, based on the present findings, it can be concluded that integrated nutrient application in chilli can be followed with reduced NPK upto 25 per cent without compromising on the growth and yield besides reducing the cost of production (cost incurred towards 25 per cent NPK) and reduced impact of harmful chemical fertilizers on soil health and environment.

Table 1: Effect of organic manures, bio-fertilizers and inorganic fertilizers on the growth and yield of chilli

Treatments	Plant height (cm)	Number of branches / plant	Days to 50 % flowering	Number of fruits/ plant	Fruit length (cm)	Yield/ha (t)
T_1- FYM + NPK 100% + *Azospirillum* + PSB + K-Solubilizers	65.45	17.64	28.96	374.21	8.29	14.41
T_2- FYM + NPK 75% + *Azospirillum* + PSB + K-Solubilizers	64.35	16.85	29.57	359.47	7.75	13.94
T_3- FYM + NPK 50% + *Azospirillum* + PSB + K-Solubilizers	57.25	13.52	33.83	325.10	6.45	10.01
T_4- Vermicompost + NPK 100% + *Azospirillum* + PSB + K-Solubilizers	65.72	17.88	28.75	381.57	8.50	14.78
T_5- Vermicompost + NPK 75% + *Azospirillum* + PSB + K-Solubilizers	64.55	16.92	29.26	367.51	7.90	14.28
T_6- Vermicompost + NPK 50% + *Azospirillum* + PSB + K-Solubilizers	56.36	14.38	33.38	330.51	6.95	10.26
T_7- Mustard cake + NPK 100% + *Azospirillum* + PSB + K-Solubilizers	64.96	17.45	29.09	369.87	8.05	14.32
T_8- Mustard cake + NPK 75% + *Azospirillum* + PSB + K-Solubilizers	63.91	16.77	29.79	354.28	7.41	13.85
T_9- Mustard cake + NPK 50% + *Azospirillum* + PSB + K-Solubilizers	55.28	14.32	34.05	318.76	6.13	9.97

T_{10}- NPK (100%)	63.87	17.26	32.00	353.74	7.86	11.78
T_{11}- NPK (75%)	62.81	16.62	35.17	340.28	7.11	10.17
T_{12}- NPK (50%)	54.11	14.22	36.44	311.89	5.87	8.07
T_{13}- Control	47.51	12.02	38.23	271.25	4.63	6.03
S.Em±	1.204	0.368	0.760	8.793	0.293	0.323
CD at 5%	3.52	1.07	2.22	25.66	0.85	0.94

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