Asian Journal of Soil Science and Plant Nutrition

Volume 10, Issue 2, Page 250-260, 2024; Article no.AJSSPN.116186
ISSN: 2456-9682

Effect of Different Organic Manures on Chilli (*Capsicum annuum* L.) Production in Central Region of Punjab, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJSSPN/2024/v10i2282

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/116186

Original Research Article

Received: 18/02/2024
Accepted: 22/04/2024
Published: 26/04/2024

ABSTRACT

The present investigation was carried out at Experimental Farm of the Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India during summer season, 2018. The experiment was laid out in a randomized block design (RBD) with three replications and fourteen treatments having basal dose of FYM @ 15 t ha^{-1} except in control. The present study was done to find out the effect of different levels of organic manures i.e. poultry manure and vermi-compost on the production of the chilli (*Capsicum annuum* L.).All the growth parameter i.e. plant height (cm), plant

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spread (cm), number of leaves plant^{-1}, number of branches plant^{-1}, days to 1st flowering, days to 50% flowering and yield attributes such as number of fruits plant^{-1}, average fresh fruit weight (g), fruit length (mm), fruit breadth (mm), yield plant^{-1}(g) were found maximum in treatment 12 (T_{12}) which was carried out at 25% FYM+25% Poultry manure+50% Vermi-compostamong all the treatments which was statistically at par with treatment T_{14}(50% Poultry manure+25% FYM+25% Vermi-compost) and T_2 (RDF @ N-75, P-30, K-30 kg ha^{-1}) in most of the attributes but the control (T_0)shown the poor results in all the attributes. These results suggested that the optimum production of chilli can be obtained with application of 25% FYM+25% Poultry manure+50% Vermi-compost.

Keywords: Chilli; FYM; organic manures; poultry manure; vermicompost.

1. INTRODUCTION

“Chilli (*Capsicum annuum* L.) is known as hot pepper and comes under family Solanaceae. It is diploid (2n=24) species and genetically self-pollinated and chasmogamous crop whose flowers open only after pollination. Chilli originated in South and Central America and domesticated around 7000 BC. The genus Capsicum includes 30 species, 5 of which are cultivated: *Capsicum annuum* L., C. frutescens, C. chinense, C. pubescens and C. baccatum” [1]. “Throughout the world, chilli is consumed in fresh, dried and in powder. Chilli is an important spice as well as a vegetable crop. Both ripe and unripe fruits are used in culinary, salad and processing purposes. It is rich in proteins, lipids, carbohydrates, fibres, mineral salts (Ca, P, Fe) and in vitamins A, C, D3, E, K B2 and B12. The level of fruit pungency determines the quality and market value of chilli pepper grown for food” [2].

“The fruits are excellent source of health-related phytochemicals compounds such as ascorbic acid (Vitamin C), careotenoids (vitamin A), tocopherols, flavonoids, and capsaicinoids that are very important on preventing chronic diseases such as cancer, asthma, coughs, sore throats, toothache, diabetes and cardiovascular diseases. Consumption of such fresh fruits facilitates starchy food digestion. Pungency in chilli is due to an alkaloid capsaicin, generally the highest capsaicin concentrations are found in the ovary and in the lower flesh of pepper fruit” [3]. Capsaicin works as a digestive stimulant. The red colour in chillies due to 2 major carotenoidesviz., Capsanthin (35–45%) and capsorubin (6–18%). Chilli can be very helpful in curing many ailments [4].

“Among the various factors responsible for low production of chilli, nutrition is of prime importance. It has been proved that indiscriminate use of inorganic fertilizers results in decrease in soil fertility and increase in soil acidity with depletion of organic humus content in addition to poor crop quality” (Naik, 2018). Because of the continuous use of chemicals in chilli, the crop has become increasingly vulnerable to pests and diseases. So, relying solely on chemical fertilisers not only invites soil health issues, but also raises farmers' production costs per unit area because these chemical fertilisers are imported from other countries [5]. “Organic manure application increases the availability of organic elements in soil, improving crop nutrient use efficiency (NUE) and mitigating the negative impact of climate change on crop production” [6]. “The application of chemical fertilizers has lead to increase in production but also deteriorated ecosystem. The chemical fertilizers are not eco-friendly but also costly. The use of inorganic fertilizer has come to level of causing a concern to environment and human health. Hence, it has become essential to adopt strategy of organic manures and vermicompost. Organic manure plays a vital role in plant growth as a rich source of all necessary macro and micronutrients that helps in improving physical and chemical properties of soils” [7]. “Organic matter acts as a reservoir for plant nutrients and inhibits the leaching of essential plants nutrients which are critical for plant growth. Organic manure also provides soil swathe in which beneficial micro-organisms can grow and works properly and thus conserves bio-diversity of the soil. Organic manures generally improve the soil’s physical, chemical and biological properties. Organic manures are slow releasing, hence are less prone to loss than inorganic fertilizers, hence soil, water and air pollution can be reduced. Vermi-compost is a by-product of earthworm mediated organic waste contains nutrients like nitrogen, phosphorus, potassium, calcium, magnesium. Suphur, iron, manganese, zinc, copper and boron, the uptake which has a positive effect on plant nutrition. Vermi-compost contain enzymes like amylase, lipase, cellulase and chitinase which constantly break down organic matter in the soil and makes soil nutrients available to the plant for uptake. It also contains beneficial bacteria and micorrhizae, several plant growth promoters and enzymes that collectively increase the yield [8]. Organic nutrients increase soil enzyme activity, available nitrates, total organic carbon and metabolic quotients resulting in enhanced soil fertility" [9].

Considering the above facts, the present experiment was planned and undertaken with the objective to study the response of different organic manures on chilli production in central region of Punjab.

2. MATERIALS AND METHODS

The present investigation entitled "Effect of different organic manures on chilli (*Capsicum annuum* L.) production in Central Region of Punjab" was carried out at Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab during summer season, 2018. Chilli (*Capsicum annuum* L.) cv. 'CH-1' was selected for present study. The soil was brought to fine tilth and two raised seed beds of 3 m length and 1 m width and 15 cm height were prepared. Application of FYM at the rate 15 t ha^{-1} in all the plots except in control plots, at the time of plot preparation. The treatments were applied and mixed manually in plots before ridge making. RDF was applied in the form of Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) before the transplanting of seedlings. Half of the recommended dose of nitrogen and full of phosphorus and potassium were applied as basal dose. The remaining half dose of nitrogen was applied after first picking.The healthy seedlings were transplanted after 31 days of sowing on 4 ridges which were 75 cm apart and 8 plants on every ridge with plant to plant distance of 45 cm in every plot with dimensions of 3 m breadth and 3.6 m length.The experiment was laid out in a randomized block design with three replications and fourteen treatments with basal dose of FYM @ 15 t ha^{-1} except in control. The treatments consisted of T_1: Control, T_2: RDF @ N-75, P-30, K-30 kg ha^{-1}, T_3: FYM @ 15t ha^{-1}, T_4: Poultry manure @ 5t ha^{-1}, T_5: Vermicompost @ 2.5t ha^{-1}, T_6: 25% FYM + 75% Poultry manure, T_7: 25% FYM + 75% Vermicompost, T_8: 50% FYM + 50% Poultry manure, T_9: 50% FYM + 50% Vermicompost, T_{10}: 75% FYM + 25% Poultry manure, T_{11}: 75% FYM + 25% Vermicompost, T_{12}: 25% FYM + 25% Poultry manure + 50% Vermicompost, T_{13}: 50% FYM + 25% Poultry manure + 25% Vermicompost, T_{14}: 50% Poultry manure + 25% FYM + 25% Vermicompost.Observations were recorded on nine randomly selected plants per plot for different parameters i.e. plant height (cm), plant spread (cm), number of leaves $plant^{-1}$, number of branches $plant^{-1}$, days to 1^{st} flowering, days to 50% flowering, number of fruits $plant^{-1}$, average fresh fruit weight (g), fruit length (mm), fruit breadth (mm), yield $plant^{-1}$(g).The data was analyzed as per design of the experiment.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

The analysis of variance revealed significant differences among the treatments for all the plant growth attributes under study.

3.1.1 Plant height (cm)

The data recorded on the effect of different organic manures on various growth attributes ofchilli cv. CH-1 presented in Table 1. Maximum plant height (90.13 cm) after final harvest was recorded in T_{12}(25% FYM + 25% Poultry manure + 50% Vermicompost) was statistically at par with treatment $T_{14}$and T_2 with value of 87.67and 85.10 cm, respectively. Channabasana Gowda et al. [8] stated that vermicompost increases the population of beneficial microorganisms such as N-fixers, P-solubilizers and increases the nitrogenase and urease enzyme activity. Another possible reason behind increased in plant height may be due to presence of microorganisms which are capable of producing plant growth regulators such as auxins, gibberellins and cytokinins (Frankenberger and Muhammad 1995) which cause rapid cell elongation and cell multiplication in the presence of adequate amount of plant nutrients. The results of present investigation in terms of plant height are in concordance with the finding reported by Bajeli et al. [10] in Japanese mint, Joshi and Vig (2010) in tomato and Singh et al. [11] in chilli.

3.1.2 Plant spread (cm)

The data (Table 1) revealed that maximum plant spread (57.00 cm) after final harvest was recorded in T_{12} (25% FYM + 25% Poultry manure + 50% Vermicompost**)** which was statistically at par with$T_{14}$and T_2 with the value of 55.83 and 52.93 cm, respectively.According to Arancon et al. [12] increase in plant growth probably due to the production of plant growth regulators by microorganisms present in vermicompost. The results are in conformity with Bajeli et al. [10] in Japanese mint, Tekasangla et al. [13] in cauliflower and Shree et al. (2014) in cauliflower, in terms of plant spread.

3.1.3 Number of leaves plant^{-1}

Maximum number of leaves plant $^{-1}$ 1413.87 was recorded in treatment T_{12} (25% FYM + 25% Poultry manure + 50% Vermicompost) which was significantly at par with T_{14} and T_2 with the values of 1378.60 and 1330.77 respectively, which were counted at final harvest and average was calculated.As nitrogen is an essential part of chlorophyll, helps in protein synthesis and increased number of leaves, may be due to sufficient amount of nitrogen provided an ideal environment and balanced nutrition to plants increased the number of leaves (Khandaker et al.2017). Singh et al. [11] in chilli, Bajeli et al. [10] in Japanese mint also reported similar results.

3.1.4 Number of branches plant^{-1}

The mean performance of different treatments showed that maximum number of branches plant^{-1} (12.40) was recorded in treatment T_{12} (25% FYM + 25% Poultry manure + 50% Vermicompost). This treatment T_{12} was statistically at par with T_{14} and $T_2$with 11.90 and 11.54number of branches plant^{-1} respectively. This might be due topoultry manure mineralize faster and provide nitrogen to the crop [14], proper nutrient supply from initial stages of growth result in more number of branches [15].Another possible reason might be that organic manures helps in proper root development which increases the nutrient uptake from the soil due to presence of microorganisms in manures which are capable of producing plant growth regulators such as auxins, gibberellins, cytokinins [16] which results in more number of branches. The similar finding was also observed by Ilodibia and Chukwuma [17] in tomato, Singh et al. [11] in chilli, Rekha et al. [18] in chilli.

3.1.5 Days to 1st flowering

The application of different organic manures significantly reduced the time taken fordays to 1st flowering. The treatment T_1 (control)took maximum 39.83 days for 1st flowering, whereas minimum days to 1st flowering (34.50 days) were recorded in T_{12} which was statistically at par with T_{14}, T_2 and T_{13} with the values of 35.53, 36.77 and 37.37 days. This might be due to improved soil health and the physico-chemical properties of soil were enhanced leading to an increase in both microbial activity and macro and micro nutrients [7]. The microbial activities produce humic acid and phytohormones which may also responsible for early flowering. The earliness can be attributed to the faster enhancement of vegetative growth and storing sufficient reserved food material for differentiation of buds into flower buds [19]. The findings of present investigation in terms of days to 1st flowering are in concordance with the finding reported by Pariari and Khan [20] in chilli.

3.1.6 Days to 50% flowering

A perusal of the data (in Table 1) revealed that there was significant effect of various treatments on days to 50% flowering. Minimum days taken to 50% flowering (45.00 days) were recorded in T_{12}. This treatment (T_{12}) was statistically at par with T_{14}, T_2 and T_{13} with the value of 46.30, 47.53 and 48.70 days to 50% flowering, respectively. Whereas, maximum (53.83) days to 50% flowering was recorded in T_1 (control). Which might be due to organic manures might have created more favourable condition for plant growth via improvement in the soil physical properties and increase the availability of macro and micro nutrients for longer period [10]. Another possible reason for lesser days to 50% flowering may be the presence of humic acid and growth regulators produced by microorganisms [21] affect the flowering time. The combined effect of micro and macro nutrients with growth regulators may reduce the time taken to 50% flowering. The results of days to 50% flowering were in conformity with Okokoh and Bisong [22] in *Amaranthuscruentus*.

3.2 Yield Parameters

3.2.1 Number of fruits plant^{-1}

It is clear from the data that number of fruits plant^{-1} was affected by the treatments as results obtained was significant. Maximum number of fruits plant^{-1} 344.03 was recorded in T_{12} which was statistically at par with treatments T_{14} with 323.11 and T_2 having 312.42number of fruits plant^{-1}.This might be due to combination of organic manures provided the micronutrients such as Zn, Cu, Fe, Mn, and Mg in an optimum level. Zinc is involved in the biochemical synthesis of the most important phytohormones, Indole Acetic Acid through the pathway of conversion of tryptophan to IAA. Iron is involved in chlorophyll synthesis pathway. Copper and Manganese are the important coenzymes for certain respiratory reaction. Magnesium is involved in chlorophyll synthesis which in turn increases the rate of photosynthesis [23]. The increase in chlorophyll content in leaves resulting in better synthesis of charbohydrates and buildup of more new cells which might have increased the number of fruits (Ghayal et al.2018). Similar results were also found by Khandaker et al. (2017) in chilli.

3.2.2 Average fresh fruit weight (g)

Maximum average fresh fruit weight (2.25 g) was recorded in treatment T_{12} (25% FYM + 25% Poultry manure + 50% Vermicompost) which was statistically at par with treatment T_{14} and T_2 with the values of 2.18 g and 2.12 g average fresh fruit weight respectively. The possible reason for increase inaverage fresh fruit weightwhich might be due to proper and steady supply of macro and micro nutrients from combination of organic manure throughout the life cycle of the plant [10]. Poultry manure proved to be a good source of micro nutrients for plants [24]. Micro nutrients are responsible for the synthesis of phytohormones, enzymatic activities, production of biochemical synthesis [23] so increased supply of micro nutrients from organic manures may contributed in increased fruit weight. Another possible reason might be that vermicompost increase microbial population resulting from earthworm activity influence growth regulators and humic acids which may result in increased in plant growth resulted in more fresh fruit weight [25]. Khandaker et al. (2017) in chilli found similar results on average fresh fruit weight.

3.2.3 Fruit length (mm)

The examination of the data as depicted in Table 2 showed that there was a significant effect of various treatments on fruit length. Maximum fruit length (57.41 mm) was obtained in T_{12} which was statistically at par by T_{14} and T_2 having value of 55.55 and 53.23 mm, respectively. This might be due to organic manures supplies direct available nutrients such as nitrogen to the plants [15]. Khandaker et al. (2017) noticed that improvement in fruit size with increasing nitrogen contents. Poultry manure show nitrogen mineralization due to low C: organic N ratio which may provide more mineral nitrogen [14]. The results are in conformity with Pariari and Khan [20] in chilli, Panda et al. [26] in tomato in terms of fruit length.

3.2.4 Fruit breadth (mm)

It is expressed from the data (Table 2) that application of different treatments brought about significant deviation in this parameter. The best treatment $T_{12}$was found significantly superior fruit breadth as regards (12.22 mm) over rest of all the treatments. The treatment T_{14}50% Poultry manure + 25% FYM + 25% Vermicompost (11.89 mm) and T_2 RDF @ N-75, P-30, K-30 kg ha^{-1} (11.50 mm) were found at par with treatment T_{12}. This additional nutrients may contributed in increment of fruit breadth (Khandaker et al. 2017). These results are in akin with Pariari and Khan [20] in chilli for fruit breadth.

3.2.5 Yield plant^{-1} (g)

The maximum yield plant^{-1}(751.57 g) was recorded in T_{12} (25% FYM + 25% Poultry manure + 50% Vermicompost) which was statistically at par with treatment T_{14} (50% Poultry manure + 25% FYM + 25% Vermicompost) and T_2 (RDF @ N-75, P-30, K-30 kg ha^{-1})having704.38 and 662.33 gyield plant^{-1}respectively.This might be due to application of combination of organic manure improved the soil properties which helps in better root development and nutrient uptake (Khede et al.2019). Schlecht et al. [27] stated that some of the organic substances released during the mineralization may act as chelates that help in the absorption of iron and other micro-nutrients. This increase the plant growth and increase photosynthetic surfaces and this increased photosynthates which increase dry matter in fruits, resulted in better yield [28]. It also may be due to presence of microorganisms which produce humic acid and plant growth regulators, which shows the effect on yield in long run [21]. The similar finding was also observed by Vimala et al. [29] in bird chilli and Masud et al. [30] in chilli for yield plant^{-1}.

3.3 Economics

The economics of the chilli production as affected by various treatments revealed maximum net returns and benefit: cost ratio was computed by the application of 25% FYM + 25% Poultry manure + 50% Vermicompost [31-35]. The reason for increased profit and benefits: cost ration is due to maximum marketable yield due to healthy and better fruit size, maximum number of fruits per plant, higher net return as compared to the other treatments. Hence, the application of 25% FYM + 25% Poultry manure + 50% Vermicompost is rated as the most economical treatment for quality production of chilli. Whereas, lowest benefits: cost ratio was calculated in control. Similar findings were reported by Tekasangla et al. [13] in cauliflower and Latha et al. (2017) in broccoli.

Table 1. Effect of different organic manures on growth attributes of chilli grown under Central Region of Punjab

Treatments	Plant height (cm)	Plant spread (cm)	Number of leaves plant^{-1}	Number of branches plant^{-1}	Days to 1st flowering	Days to 50% flowering
T_1Control	57.99	39.43	947.17	4.93	39.83	53.83
T_2RDF @ N-75, P-30, K-30 kg ha^{-1}	85.10	52.93	1330.77	11.54	36.77	47.53
T_3 FYM @ 15 tha^{-1}	61.80	41.37	1000.93	5.90	39.60	53.27
T_4Poultry manure @ 5 tha^{-1}	67.77	45.70	1114.93	7.90	38.80	51.80
T_5 Vermicompost @ 2.5 tha^{-1}	70.07	46.93	1147.73	8.39	38.57	51.40
T_6 25% FYM + 75% Poultry manure	77.69	49.63	1243.53	9.80	37.73	49.80
T_7 25% FYM + 75% Vermicompost	80.06	50.50	1274.10	10.23	37.60	49.50
T_8 50% FYM + 50% Poultry manure	73.10	47.63	1171.73	8.90	38.23	51.00
T_9 50% FYM + 50% Vermicompost	75.07	48.40	1209.87	9.30	37.90	50.30
T_{10} 75% FYM + 25% Poultry manure	63.57	43.57	1049.07	6.57	39.40	52.83
T_{11} 75% FYM + 25% Vermicompost	65.47	44.27	1075.87	7.33	39.17	52.30
T_{12} 25% FYM + 25% Poultry manure + 50% Vermicompost	90.13	57.00	1413.87	12.40	34.50	45.00
T_{13} 50% FYM + 25% Poultry manure + 25% Vermicompost	83.57	51.67	1307.92	10.80	37.37	48.70
T_{14} 50% Poultry manure + 25% FYM + 25% Vermicompost	87.67	55.83	1378.60	11.90	35.53	46.30
SEm(±)	2.19	1.47	35.15	0.32	1.03	1.54
CD $_{0.05}$	**6.36**	**4.28**	**102.17**	**0.93**	**3.01**	**4.48**

Table 2. Effect of different organic manures onyield attributes of chilli grown under Central Region of Punjab

Treatments	Number of fruits plant^{-1}	Average fresh fruit weight (g)	Fruit length (mm)	Fruit breadth (mm)	Yield plant^{-1} (g)
T_1Control	208.72	1.38	39.76	7.68	288.03
T_2RDF @ N-75, P-30, K-30 kg ha^{-1}	312.42	2.12	53.23	11.50	662.33
T_3FYM @ 15 tha^{-1}	228.28	1.46	42.74	8.26	333.29
T_4Poultry manure @ 5 tha^{-1}	253.50	1.67	45.99	9.31	423.35
T_5Vermicompost @ 2.5 tha^{-1}	260.67	1.74	46.91	9.68	453.57
$T_6$25% FYM + 75% Poultry manure	284.64	1.94	49.90	10.62	552.20
$T_7$25% FYM + 75% Vermicompost	287.91	2.00	50.56	10.97	575.82
$T_8$50% FYM + 50% Poultry manure	268.77	1.80	47.38	9.99	483.79
$T_9$50% FYM + 50% Vermicompost	274.85	1.87	48.48	10.30	513.97
T_{10}75% FYM + 25% Poultry manure	239.51	1.53	43.29	8.58	366.45
T_{11}75% FYM + 25% Vermicompost	246.47	1.60	44.88	8.89	394.35
T_{12}25% FYM + 25% Poultry manure + 50% Vermicompost	334.03	2.25	57.41	12.22	751.57
T_{13}50% FYM + 25% Poultry manure + 25% Vermicompost	293.19	2.08	51.89	11.17	609.84
T_{14}50% Poultry manure + 25% FYM + 25% Vermicompost	323.11	2.18	55.55	11.89	704.38
SEm(±)	10.35	0.05	1.69	0.35	33.70
CD $_{0.05}$	**30.10**	**0.16**	**4.93**	**1.02**	**97.96**

Table 3. Effect of different organic manures on Economics in chilli grown under Central Region of Punjab

Treatments	Cost of cultivation (ha^{-1})	Gross return (ha^{-1})	Net return (ha^{-1})	B:C ratio
T_1 Control	76072.50	153600.00	77527.50	1.02
T_2 RDF @ N- 75, P-30, K-30 kg ha^{-1}	79963.24	353220.00	273256.76	3.42
T_3 FYM @15 t ha^{-1}	84272.50	177740.00	93467.50	1.11
T_4 Poultry manure @5 t ha^{-1}	86772.50	225760.00	138987.50	1.60
T_5 Vermicompost @2.5 t ha^{-1}	91772.50	241880.00	150107.50	1.64
T_6 25% FYM + 75% Poultry manure	86147.50	294480.00	208332.50	2.42
T_7 25% FYM + 75% Vermicompost	89897.50	307080.00	217182.50	2.42
T_8 50% FYM + 50% Poultry manure	85522.50	258000.00	172477.50	2.02
T_9 50% FYM + 50% Vermicompost	88022.50	274100.00	186077.50	2.11
T_{10} 75% FYM + 25% Poultry manure	84897.50	195430.00	110532.50	1.30
T_{11} 75% FYM + 25% Vermicompost	86147.50	210300.00	124152.50	1.44
T_{12} 25% FYM + 25% Poultry manure + 50% Vermicompost	88647.50	400820.00	312172.50	3.52
T_{13} 50% FYM + 25% Poultry manure + 25% Vermicompost	86772.50	325220.00	238447.50	2.75
T_{14} 50% Poultry manure + 25% FYM + 25% Vermicompost	87397.50	375640.00	288242.50	3.30

4. CONCLUSION

In a trial of growing chilli in central region of Punjab among all the treatments application of treatment T_{12} (25% FYM+25% Poultry manure+50% Vermi-compost) showed maximum growth characters viz; plant height, plant spread (cm), number of leaves plant^{-1}, number of branches plant^{-1}, days to 1st flowering, days to 50% flowering and yield attributes such as number of fruits plant^{-1}, average fresh fruit weight (g), fruit length (mm), fruit breadth (mm), yield plant^{-1}(g). Therefore, the application of 25% FYM+25% Poultry manure+50% Vermi-compost may be suggested for commercial cultivation of chilli for getting higher growth and yield after further multi-location testing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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