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Influence of Jeevamrutha (Fermented Liquid Manure) on Growth and Yield Parameters of Tomato (*Solanum Lycopersicum*L.)

Vibha Gopal[1], Lingaraju Honnur Gurusiddappa[1*]

[1]Department of Environmental Science, JSS Academy of Higher Education and Research, Sri Shivarathreeshwara Nagara, Mysuru- 570015 Karnataka, India.

ABSTRACT

Correct input use not only aids in achieving higher levels of sustainable production but also,serves to enhance the concentration of organic matter in soils. This reduces the bulk density and compaction. Organic liquid formulations such as jeevamrutha assist in the rapid development of soil fertility by increasing the activity of soil microflora and fauna. These act as both a fertilizer and a biopesticide, and they are crucial in fostering plant growth as well as providing immunity. Jeevamrutha is a type of organic liquid formulation, which is made with readily availableingredients like water, jaggery, pulse flour, and farm wastes like cattle dung and urine. When applied to soil, it creates a friendly microorganismenvironment, which supports the availability of essential nutrients for plant growth. Therefore, this experiment aims to provide an alternative to chemical farming by utilizing jeevamrutha. The experiment was conducted to see how varying concentrations of jeevamrutha affected the growth parameters and yield attributes of the tomato plant. Five treatments with different combinations were laid out with three replications in a factorial randomized complete block design. The results obtained from the experiment revealed that jeevamrutha at a 50% concentration significantly influenced crop growth parameters such as plant height, the total number of leaves, leaf area index, root length, and shoot length. Owing to the improvements in yield attributes such as the total number of fruits per plant, weight, length, and diameter of fruits, using jeevamrutha at 100% increased tomato fruit yield significantly.

Keywords: *Chlorophyll, Growth, Jeevamrutha, Organic liquid manure, Yield*

Corresponding author: Lingaraju Honnur Gurusiddappa
e-mail ✉ lingarajuhg@jssuni.edu.in
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INTRODUCTION

The main challenge in India's post-independence period has been producing enough food to feed an expanding population. As a result, in the 1960s, the Green Revolution was introduced to increase food production and feed millions of Indians (Yadav, 2021). While the green revolution is good for food security, it has unintended consequences that are negative to society's health and agriculture (John & Babu, 2021). The current model of agricultural intensification, based on agrochemical inputs, large monocul-tures and landscape homogenisation, has successfully increased yields, but is associated with severe losses of biodiversity and ecosystem services (Sánchez-Bayo & Wyckhuys, 2019; Tscharntke *et al.,* 2021). Agricultural intensification is believed to cause acidification, loss of organic matter, nutritional value loss, weathering, soil compaction, and xenobiotic accumulation, among other things (Niemiec *et al.,* 2020). Furthermore, the overuse of fertilizers and artificial growth regulators has resulted in a 'pollution' problem. A natural balance between life and property is required for continued existence (Elayaraja & Vijai, 2020; Özatik *et al*., 2022). Organic farming is the practice of agriculture that emphasizes the health of the soil, plants, food, and environment over crop yield. Organic farming, which uses no or only natural pesticides and organic fertilizers, is seen as a more environmentally friendly option (Gong *et al.,* 2022). It is also an ecologically sound method of production that benefits small-scale farmers in a variety of ways (Singh *et al.,* 2020). It is achieved by using compounds to appease any particular evolution within a system to safeguard the soil's long-term biological activity, facilitate optimal peak management, recycle waste to return nutrients to the soil, care for farm animals, and produce agricultural goods without using special chemical additives (Kumar *et al.,* 2021). Furthermore, higher prices in fresh markets for organically grown vegetables than for conventionally grown vegetables encourage farmers to grow vegetables organically (AL-Kahtani *et al.,* 2018). The need for an alternative farming system has emerged as a result of growing worries about the sustainability of the current input-intensive agriculture system. Zero Budget Natural Farming (ZBNF), one of the many alternative farming techniques used around the globe, has recently gained attention (Koner & Laha, 2020).

ZBNF is perhaps the most successful agrarian movement in the world in terms of reach. Diversification, microbial activities, nutrient recycling, and beneficial microorganism interactions are all promoting soil health for long-term crop production (Khadse & Rosset, 2019; Oran *et al.,* 2022). Seed germination is excellent with jeevamrutha, organic liquid manure. It's made with native cow's urine, dung, horse gram, and jaggery, and using cow-based products is a time-honored agricultural tradition (Bharadwaj, 2021). Organic manure, as well as liquid manure like jeevamrutha, results in significantly increased crop growth, yield, and quality (Hameedi *et al.,* 2018). They are rich in beneficial microflora, macronutrients, essential micronutrients, many vitamins, essential amino acids, and growth-promoting factors like IAA and GA (Nitin & Purohit, 2021). Organic manures improve the soil's physical, biological, and chemical properties, improving fertility, productivity, and water holding capacity (Verma *et al.,* 2019). Beneficial organisms thrive in jeevamrutha and aid in phosphate solubilization, nitrogen fixation, and other processes. The use of jeevamrutha will boost microbial activity and population in the soil to a greater extent (Boraiah *et al.,* 2017). With this in thought, the current objective is to produce healthy organic tomato crops using jeevamrutha and evaluate its impact on the growth and yield of the tomato crop.

MATERIALS AND METHODS

The experiment was conducted in the form of pot culture in the naturally ventilated garden of the Department of Environmental Scienceon the campus of Jagadguru Sri Shivarathreeshwara Academy of Higher Education and Research in Mysore district, Karnataka, India. The pots were filled with media in a 2:1:1 ratio of soil, vermicompost, and coco peat per pot, and this media was evenly applied to each pot by mixing before transplanting tomato seedlings, and the planting began on February 1, 2021. Seeds were sown in a seedling tray, and seedlings were transferred to pots measuring 25.4D x 25.4W x 25.4H after 60 days. Factorial Randomized Complete Block Design (FRCBD) with three replications and five treatments was the design of choice for this study. Organic manure was used as treatment in different combinations, this included T_1- Control + Vermicompost + Cocopeat, T_2- 25% Jeevamrutha + Vermicompost + Cocopeat, T_3- 50% Jeevamrutha + Vermicompost + Cocopeat, T_4- 75% Jeevamrutha + Vermicompost + Cocopeat, T_5- 100% Jeevamrutha + Vermicompost + Cocopeat. Jeevamrutha was applied as soil application at 15, 30, 45, 60, 75, and 90 DAS (Days After Sowing). The effect of the application of jeevamrutha was observed by determining the different growth parameters like plant height (cm), the number of leaves and branches, Leaf Area Index, root and shoot lengths (cm), and dry matter production (g plant^{-1}). Yield parameters such as the number of flowers and fruits (plant $^{-1}$), the weight of fruits (grams), fruit length (cm), and fruit diameter (cm) were measured. Chlorophyll-a (μg/ml), chlorophyll-b (μg/ml) and total chlorophyll content (μg/ml) were recorded. Growth and yield observations were recorded at 30, 60, and 90 DAS. Composite soil samples from the upper 0 - 15 cm soil layer were taken from the experimental pots before the start of the experiment. Chemical properties of the soil viz., pH (7.21), electric conductivity (0.18 dSm^{-1}), soil organic carbon content (0.53 %), nitrogen (137 kg/acre), phosphorus (13 kg/acre) and potassium (61 kg/acre) were investigated **(Table 1)**. To give conclusions the data was statistically analyzed (p=5%).

Table 1. Chemical characteristics of the soil used in the study

Parameter (unit)	Value	Interpretation
Moisture content (%)	1.33	-
pH	7.21	Alkaline
Electrical conductivity ($EC\text{-}dsm^{-1}$)	0.18	Harmless
Available Nitrogen (N) kg/acre	137	Medium
Phosphorus (P_2O_5) kg/acre	13	Medium
Potassium (K) kg/acre	61	Medium
Organic Carbon (OC) %	0.53	Medium

Preparation of jeevamrutha and its application

Jeevamrutha was developed by integrating 125 grams of cow dung, 50 ml of cow urine, 25 grams of locally available jaggery, 25 grams of pulse flour, and a handful of soil. All of this was carefully mixed in a drum with a capacity of 1.5 liters, and the volume was increased to 1.5 liters. The mixture was stirred clockwise and covered with a wet jute bag before being stored in the shade (Singh & Lal, 2019). Before its application to the soil, the mixture was continuously stirred in a clockwise direction every morning and evening for seven days. Jeevamrutha was used near the crop root zone when the soil was wet (Sutar *et al.,* 2018).

Estimation of chlorophyll

The concentration of chlorophyll in the crops was assessed after collecting leaves and observing them with a spectrophotometer. Photosynthetic tissue of known size was ground to precise proportions. The ground leaves were soaked in a concentration of 1 part 0.1 normal (N) ammonium hydroxide solution to 9 parts acetone. The supernatant from the centrifuged slurry was diluted to the necessary concentration to produce an absorbance reading between 663 and 645 nanometers (nm) was obtained. At these wavelengths, the absorbance for every solution was measured, and the concentration levels of chlorophyll a and b were estimated. Chlorophyll a, chlorophyll b, and total chlorophyll concentrations were estimated by referring to research papers (Parida & Parida, 2021; Rinawati *et al.,* 2021).

RESULTS AND DISCUSSION

Growth parameters

The application of jeevamrutha at varying levels has recorded significantly higher growth parameters. Application of jeevamrutha @ 50 % has recorded significantly higher plant height at 30 DAS (60.53 cm), followed by control at 30 DAS (58.42 cm) while significantly lower measurement in plant height was recorded injeevamrutha @ 25% (50.8 cm). The height of the plants was not significant at 60 and 90 DAS (63.07 cm, 65.61 cm @ 50% jeevamrutha), (63.5 cm, 63.5 cm @ 100 % jeevamrutha), and control (60.11 cm, 61.38 cm). Similarly, significantly higher leaf area index was recorded in jeevamrutha @ 50 % (1.51, 1.53, 1.53 at 30, 60 and 90 DAS), followed by jeevamrutha @ 75 % (1.46, 1.49, 1.5 at 30, 60 and 90 DAS) while significantly lower leaf area index was recorded in jeevamruthat @ 100 % and control (0.59, 0.60, 0.63 and 0.78, 0.85, 0.86 at 30, 60 and 90 DAS). Significant increase in number of leaves was observed between control to jeevamrutha @ 50 % followed by a steady decline (control- 143.3, 157, 163.3 <jeevamrutha @ 100 %- 170, 180, 183.3 <jeevamrutha @ 75 %- 169, 188.3, 193.3 <jeevamrutha @ 25 %- 193.3, 212.6, 222.6 <jeevamrutha @ 50 %- 258.3, 282, 300 at 30, 60 and 90 DAS, respectively). In similarity, significant increase was found in number of branches (control- 29, 33.3, 34.6 <jeevamrutha @ 25 %- 39, 42.6, 47 <jeevamrutha @ 50 %- 41.3, 68.3, 72 <jeevamrutha @ 75 %- 57.66, 79.3, 83.6 <jeevamrutha @ 100 %- 56.33, 82.3, 85.3 at 30,

60 and 90 DAS, respectively) and shoot length (jeevamrutha @ 100 %- 21.76 cm, 23.04 cm, 27.06 cm <jeevamrutha @ 75 %- 28.17 cm, 29.81cm, 34.73 cm < control- 42.77 cm, 43.91 cm, 45.47 cm <jeevamrutha @ 25 %- 44.78 cm, 48.26 cm, 52.12 cm <jeevamrutha @ 50 %- 53.16 cm, 56.57 cm, 66.38 cm at 30, 60 and 90 DAS, respectively). Application of jeevamrutha @ 50 % documented significantly higher root length (57.57 cm) and total dry matter production (11.44 g plant^{-1}) with 100 % jeevamrutha when compared to without jeevamrutha (42.9 cm) (9.6 g plant^{-1}) **(Table 2)**.

The nutrients that have been soluble in the soil and accumulated have made them available to plants all through their growth cycle, leading to an increase in growth attributes due to jeevamrutha application (Chaithra & Sujith, 2021). Fermented liquid organic manures are rich carriers of microbial load and substances that promote plant growth, metabolic activities, and disease and pest resistance, in addition to nutrients (Lanka, 2018).

Similar results were reported in a blackgram experiment, where the application of jeevamruthaincreasedthe plant height (45.96 cm) at 60 DAS and (46.67 cm), root length (23.87 cm at harvest), the number of leaves (14.71 at 60 DAS and 6.70 at harvest plant^{-1}), and accumulation of dry matter (13.23 g plant^{-1}) at harvest (Nitin & Purohit, 2021). Research into the development and yield of the floribunda rose cv. Mirabel treated with jeevamrutha @ 400 liters/ha, infused with panchagavya (Sanskrit: "five cow-derivatives") reported taller plants (82.25 cm), more primary and secondary branches, and more leaf area (839.37 cm^2). The presence of nitrogen in cow urine may have aided the plant's production of chlorophyll, which promotes lustrous, healthy, and darker-colored leaves (Bohra & Nautiyal, 2019; Praveen *et al.,* 2021). Similarly, the application of jeevamrutha @ 20 % and 10 % at 2 weeks intervals resulted in significantly taller plants, a significantly higher number of shoots per square meter, and significantly higher dry matter accumulation per square meter (Kaur *et al.,* 2021). The findings follow a study on the tomato crop where the application of jeevamrutha resulted in maximum plant spread, height, and the number of branches per plant at 30, 60 DAT, and at harvest (Yadav *et al.,* 2019). Jeevamrutha ensures that essential nutrients are available and absorbed for plant physiological growth and development (Rijal *et al.,* 2021). A study was conducted to analyze the impact of bioorganic nutrients like jeevamrutha on sustainable production of French bean. The results showed that plant height, branches per plant, nodules per plant, green pod length, green pods per plant, pods weight per plant and total pod yield of french bean were significantly greater with the application of vermicompost and jeevamrurth @ 5% at a weekly interval as compared to all other treatments (Sharma & Thakur, 2022).

Table 2. Various growth parameters of tomato crops are influenced by the application of jeevamrutha.

Treatments	Plant height			Leaf Area Index			Number of leaves			Number of branches			Shoot length			Root length	Dry matter production
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	90 DAS	90 DAS
T_1	58.42	60.11	61.38	0.78	0.85	0.86	143.3	157	163.3	29	33.3	34.6	42.77	43.91	45.47	42.9	9.6
T_2	50.8	61.80	62.23	1.10	1.17	1.19	193.3	212.6	222.6	39	42.6	47	44.78	48.26	52.12	48.26	10.52
T_3	60.53	63.07	65.61	1.51	1.53	1.53	258.3	282	300	41.3	68.3	72	53.16	56.57	66.38	57.57	9.99
T_4	57.57	62.65	62.65	1.46	1.49	1.50	169	188.3	193.3	57.66	79.3	83.6	28.17	29.81	34.73	30.48	10.35
T_5	57.57	63.5	63.5	0.59	0.60	0.63	170	180	183.3	56.33	82.3	85.3	21.76	23.04	27.06	23.71	11.44
S.Em ±	2.14	1.21	1.38	0.18	0.17	0.17	23.23	25.28	26.56	6.03	10.27	10.92	6.26	6.60	6.90	4.23	0.05
CD (P = 0.05)	6.20 Significant	0.976 Non-significant	2.07 Non-significant	3144 Significant	1551 Significant	1047 Significant	12.23 Significant	13.17 Significant	23.51 Significant	23.53 Significant	60.38 Significant	66.40 Significant	31.41 Significant	34.43 Significant	913.38 Significant	3.59 Significant	830 Significant

Yield Parameters

Application of jeevamrutha @ 100 % at harvest (T_5) recorded significantly more number of fruits (33 fruit plant^{-1}), followed by T_3 (22.66 fruit plant^{-1}) while the number of fruits was significantly lower in T_1 (10.66 fruit plant^{-1}). A significant difference between the treatments was found in terms of average fruit weight (T_5- 56.25 gm > T_3- 31 gm > T_4- 30.40 gm > T_1- 27.6 gm > T_2- 29.33 gm). Significantly higher fruit length was recorded in T_5 (7.31 cm), T_4 (6.22), and T_3 (6.22) in comparison with T_1 (5.70 cm). Fruit diameter increased in accordance with increase in treatment variations (T_5- 12.3cm > T_3- 8.67cm > T_4- 8.51 cm > T_2- 8.26 > T_1- 6.4 cm). Findings from this study confirmed that the difference in the pH of fruits from treated and control plants was not noticeable, as pH values did not differ significantly **(Table 3)**.

A study on the French bean revealed that the yield attributing parameters were significantly influenced by the addition of fermented liquid organic formulations. At harvest, a significantly higher yield of the green pod (16.43 t ha^{-1}),number of green pods per plant (24.12), length of green podper plant (15.52 cm), and the weight of green pod per plant (193.57 g) were recorded with the application of jeevamrutha (soil application @ 500 L ha^{-1}) along with panchagavya and vermicompost (Gowthamchand & Soumya, 2019). This may be due to the beneficial effects of fermented liquid organics combined with an increase in the availability of nutrients and the microbial population (Chakraborty & Sarkar, 2019). A perusal of data from a study on strawberriesreveals jeevamrutha had a significant influence on the maximum duration of flowering (63.38 days) and highest number of flowers (20.12). Similarly, the maximum berry yield of 210.09 g per plant and 42.01 t/ha were also recorded withthe application of jeevamrutha (Maher *et al*., 2020). All parameters in a study concerning the yield of finger millet were significantly higher when treated with jeevamrutha at 1000 l ha-1 which can be because of the plant growth-promoting factors such as IAA, GA3, macro, and micronutrients, as well as the abundance of beneficial micro organisms in jeevamrutha (Naveena *et al*., 2019). Larger fruit size may be because ofjeevamrutha, as a rich source of plant growth substances like auxins, gibberellic acid, and cytokinin, is involved in the increase ofcell size, cell elongation, and cell division, all of which contribute to increased fruit length, diameter, and volume (Thejaswini *et al.,* 2022). A two-year experiment was undertaken during kharif seasons of the year 2019 and 2020 to investigate the effect of jeevamruthat, and ghanajeevamrutha on fruit yield of okra in Entisols of Himachal Pradesh. The findings revealed that jeevamrutha application (100% N equivalence) in combination with vermicompost obtained the greatest value for okra yield (11.95 t ha-1) (Sharma & Chadak, 2022). According to the findings of a study on paddy, natural farming practices recorded significant t values of 1.76 and 1.64 with an increased average grain yield of 48.59 quintals with a straw yield of 63.06 quintals as opposed to the average yield of 47.32 q per ha with 61.54 quintals of conventionalfarming system, respectively (Ranjeetha *et al.,* 2022).

Table 3. Effect of jeevamrutha on yield parameters of tomato

Treatments	Number of flowers ($plant^{-1}$)	Number of fruits ($plant^{-1}$)	Fruit pH	The average weight of fruits (grams)	Average fruit length (cm)	Average fruit diameter (cm)
T_1	11.66	10.66	5.76	27.6	5.70	6.4
T_2	19	18	5.75	29.33	6.18	8.26
T_3	23.66	22.66	5.76	31	6.22	8.67
T_4	22.33	21.33	5.74	30.40	6.22	8.51
T_5	33.66	33	5.74	56.25	7.31	12.3
S.Em ±	1.39	1.95	0.00	0.68	0.15	0.51
CD (P = 0.05)	3.59 Significant	123 Significant	4.04 Non-significant	4.29 Significant	48.16 Significant	76.91 Significant

Chlorophyll content

Jeevamrutha significantly influenced chlorophyll 'a', chlorophyll 'b', and total chlorophyll content in all the treatments **(Figure 1)**. Chlorophyll 'a' was found to be the highest in T_4 treatment (0.7, 0.733, 0.748 µg/ml at 30, 60, and 90 DAS, respectively). Gradual decline in chlorophyll 'a' content with the increasing concentration of jeevamrutha at T_5 was recorded (0.329, 0.333, 0.334 µg/ml at 30, 60, and 90 DAS). The lowest chlorophyll 'a' content was found in treatment without jeevamrutha (0.309, 0.312, 0.318 µg/ml at 30, 60, and 90 DAS). Similarly, chlorophyll 'b' content was maximum in T_4 (1.062, 1.073, 1.093 µg/ml at 30, 60 and 90 DAS) in comparison to treatment without jeevamrutha (0.750, 0.768, 0.772 µg/ml). Total chlorophyll content was maximum in T_4 (23.22, 23.42, 23.60 µg/ml at 30, 60, and 90 DAS) in comparison to without jeevamrutha treatment (11.28, 11.36, 11.42 µg/ml at 30, 60, and 90 DAS, respectively) **(Figure 2)**.

As per the findings of a study on the chili crop, the application of jeevamrutha resulted in better foliage with dark green colored leaves. This implies that when chlorophyll content is high, it produces more photosynthates and enhances their translocation to the vegetative buds and fruits (Gangadhar *et al.,* 2020). A study on sweet basil that was subjected to NaCl-induced salt stress and the effect of jeevamrutha on this factor revealed that plants treated with jeevamrutha had increased levels of chlorophyll 'a', 'b', and carotenoid. According to the findings, the organic liquid formulation jeevamrutha is successful in helping plants in optimum growth and progress under NaCl-induced stress (Singh & Lal, 2019). Using jeevamrutha in combination with other organic fertilizers has been shown to improve the chlorophyll content of treated plants in similar studies (Ekanayake *et al.,* 2020). A study was conducted to determine how organic manures affected the quality and biochemical characteristics of strawberries; the plants treated with jeevamrutha had the highest chlorophyll content (Sahana *et al.,* 2020).

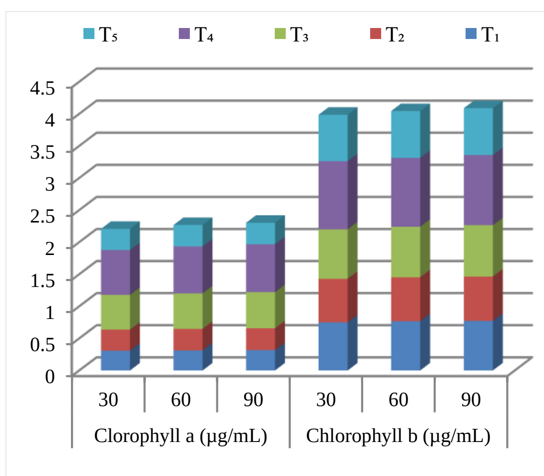

Figure 1. Concentrations of chlorophyll 'a' and 'b' as influenced by jeevamrutha

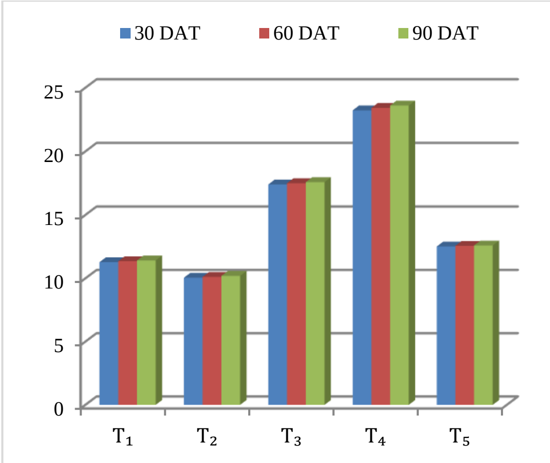

Figure 2. Total chlorophyll content with application of jeevamrutha.

Economics

Among the different treatment combinations, jeevamrutha application @ 50 % recorded higher gross return (Rs. 400/ pot), net return (Rs. 65/ pot) and benefit-cost ratio (0.19) **(Table 4)** compared to crop cultivation without jeevamrutha application (Rs. 310/ pot, Rs. 30/ pot, 0.10, respectively). The highest cost of cultivation (Rs. 345/ pot was incurred in treatment with jeevamrutha @ 100 % but gross return (Rs. 387/ pot), net return (Rs. 42/ pot) and benefit-cost ratio (0.12) was relatively lower when compared to jeevamrutha treatment @ 50 %. The greater net return was primarily due to the increased tomato fruit yield from organic manurial treatments (Siddappa, 2015; Upendranaik *et al.,* 2018). A field experiment was carried out during kharif 2013, 2014, 2015 and 2016 at Mandya to study the performance of cowpea under organic production system. The benefit: cost ratio was higher with application of jeevamrutha (2.81) in comparison with other treatments (Yogananda *et al.,* 2019; Moustafa *et al.,* 2022).

Table 4. Tomato cultivation costs, gross profit, net profit, and Benefit: Cost ratio as impacted by jeevamrutha.

Treatments	Cost of cultivation (Rs/ pot)	Gross return (Rs/ pot)	Net return (Rs/ pot)	B:C ratio
T_1	280	310	30	0.10
T_2	330	380	50	0.15
T_3	335	400	65	0.19
T_4	340	380	40	0.11
T_5	345	387	42	0.12

CONCLUSION

The use of jeevamrutha resulted in improved tomato growth and yield attributing parameters. The increased yield was due to the slow release of nutrients throughout the crop's growing period, as well as the improvement in the soil's physical, chemical, and mineralogical properties, improving its fertility status. On a large scale, jeevamrutha has the potential to become a viable alternative to conventional fertilizers. Based on the results obtained in the present investigation, it can be concluded that jeevamrutha can be successfully used for the production of good-quality tomatoes.

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