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Impact of Organic Manures and Liquid Formulations on Garlic Growth, Yield and Quality in Uttarakhand, 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.

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ABSTRACT

The field study was carried out to VCSG, UUHF, Pauri Garhwal in 2022-2023 to investigate the integrated effect of organic manures and organic liquid formulations on the growth and yield of garlic. The main objective of this study was to determine the benefits of using organic manures and liquid formulations over conventional farming because the abundant use of nitrogenous fertilizers

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causes excessive vegetative growth at the expense of bulb formation. Among fourteen different treatment combinations that consist of various combinations of organic manures (FYM and Vermicompost) and organic liquid formulations (Panchgavya and Jeevamrit) treatment T_3 *i.e.,* FYM (10t/ha) + Panchgavya (2%) emerged as the best treatment concerning growth and yield of garlic. The findings showed that the maximum plant height (69.080 cm), number of leaves (8.400), leaf length (47.880 cm) and breadth (3.207 cm), and leaf area index (1.023) at all the 30 days intervals after sowing of garlic has been observed with the application of Treatment T_3. The fundamental reason for the increased growth might be due to growth-promoting substances like auxins and gibberellins in panchgavya and high nitrogen and phosphorus in FYM. Concerning yield and quality attributes, the bulb diameter (5.657 cm), fresh weight of bulb (64.643 cm), length of the bulb (5.853 cm), number of cloves per bulb (12.200), bulb yield (120.833 q), total chlorophyll content (2.127 mg/g) and ascorbic acid content (15.333 mg/100g) was obtained maximum with the application of same treatment T_3 *i.e.,* FYM (10t/ha) + Panchgavya (2%) with yield increases up to 30% compared to control. However, the harvest index percent was found to be maximum (89.243 %) in treatment T_{13} *i.e.,* Vermicompost (5t/ha) + Jeevamrit (6%). These findings suggest that organic farming practices can effectively enhance garlic production, offering a sustainable alternative to chemical fertilizers. Moreover, this study provides practical insights for farmers and contributes to the growing body of research on sustainable agriculture.

Keywords: Allium sativum; FYM; panchgavya; jeevamrit; growth parameters.

1. INTRODUCTION

Garlic (*Allium sativum* L.), after onions, is the second most important crop grown from bulbs which is used as a spice or condiment. It is often referred to as Lahsun in India and is an element of the Amaryllidaceae family. Some scholars believe that the wild ancestor of garlic is *Allium longicuspis* Regael. With 75% of the world's production, China is by far the greatest producer of garlic worldwide. India ranks second in terms of both area and production, but its productivity—5.22 tons/hectare—is extremely poor [1]. It is cultivated on 3.21 lakh hectares on average, with an average yield of 5.27 t/ha, producing 1693 thousand metric tonnes [2].

In the Financial Year 2022, more than two million metric tonnes of garlic were produced. Madhya Pradesh dominated all other Indian states in this regard [3]. Garlic production in Uttarakhand is 11,270.19 metric tonnes, while its area is 1924.23 hectares [4]. In the tradition of Ayurveda, garlic possesses healing and medicinal properties; it is usually more in demand in the winter. Moreover, it has high levels of protein (6.30%), phosphorus (0.30%), magnesium (71 mg/100 g), and ascorbic acid content (13 mg/100 g) in addition to carbohydrates (29%).

It is a perennial crop that is hardy to frost and has narrow leaves. When the bulb reaches maturity, it needs a fairly dry period during growth and a chilly, humid temperature throughout maturity. Due to environmental concerns and greater awareness of global health, there is a growing need for organic food products. The irresponsible application of chemicals created pollution, a decline in soil fertility and productivity, and other negative consequences on the environment, water, and soil. Without a doubt, the application of organic fertilizer is crucial for modern agriculture as a means to achieve both better yields per unit area and crops of high quality.

The vast majority of small and marginal farmers in the entire country cannot afford the highly expensive chemical fertilizers. Its long-term negligent use has reduced microbial activity, harmed the environment, degraded soil fertility and health, and limited the availability of vital nutrients. Conventional agriculture has resulted in global environmental pollution and deterioration, negatively impacting the balance of the ecosystem [5]. As a result, organic liquid formulations and manures are inexpensive, environmentally friendly, as well as financially beneficial for farmers. The principal organic manures include neem cake, FYM, and vermicompost. FYM is considered to be an ideal source of nutrients for soil microbiology and plant growth.

Vermicompost, which originates using a variety of worm species through the decomposition process—most often red wigglers, white worms, and other earthworms—improves soil fertility, aggregation, and structure. Organic liquid formulations, such as Panchgavya, Jeevamrit,

Sanjivak, Bijamrita, Amritpani, and Vermiwash, are products derived from the fermentation or decomposition of organic matter. Panchgavya provides resistance to the plant and can stimulate growth. Its name suggests that it is composed of five ingredients: cow dung, urine, milk, curd, and ghee. Yet another natural liquid fertilizer that is extremely high in biomass and natural carbon and has every nutrient that's needed is known as Jeevamrit. Therefore, organic manures and organic liquid formulations are eco-friendly, cheap sources of nutrients, and are also cost-effective for farmers. Along with enhancing soil microbial population, slow nutrient release, fertilizer usage efficiency, and soil phosphate availability, they additionally increase cation exchange capacity, water retention capacity, and soil phosphate availability [6].

Because inorganic fertilizers are used improperly and continuously, the texture and structure of the soil degrades, microbial activity declines, groundwater is contaminated, and eventually soil fertility and production are reduced [7]. Whereas using organic manures improves output and reduces environmental risks by improving the texture, structure, humus, color, aeration, water-holding capacity, microbial activity, and nutrient-use efficiency of the soil [8]. The main cause of India's decreasing garlic output is the scanty and improper use of agronomic methods. Nowadays, the export market prefers and demands vegetables grown with very little or no inorganic fertilizer use to fetch higher prices. Garlic needs to be made more profitable by using additional nutrient sources in addition to ensuring good soil health for sustainable agriculture. This is crucial since garlic is one of the crops that has the potential to be eaten and marketed. Hence, this study has been done to find out the best combination of organic manures and organic liquid formulations and their impact on growth, yield, and increased quality of garlic.

2. MATERIALS AND METHODS

A field experiment was carried out on garlic cv. Agrifound Parvati during the winter (rabi) season of 2022 at Organic Research Block, College of Horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Uttarakhand. The soil type of the experimental field was classified as clay-loam soil with a pH of 6.06, with organic carbon content of 1.47 % indicating sufficient organic matter. The available Nitrogen, P_2O_5, and K_2O in the soil were 524.96 kg/ha, 39.66 kg/ha, and 45.25 kg/ha respectively. Randomized Complete Block Design (RCBD) with three replications has been used for the experiment. Each replication consists of fourteen treatments, *viz.* organic manures *viz.,* FYM (having 0.5%N, 0.2% P_2O_5 and 0.5% K_2O) and Vermicompost (1.5-2.5% N, 1.2-1.8% P_2O_5 and 1.5-2.4% K_2O) as basal, Organic liquid formulations *viz.* Panchgavya and Jeevamrit at different concentrations were applied as foliar application at 30-day intervals after sowing. The standard nutrient dose recommended for a garlic crop is 100 kg of N, 50 kg of P and 50 kg of K per hectare.

The sowing process involves sowing cloves at a spacing of 15cm x 10cm and each plot size was 0.8 m². The panchgavya having that was utilized consisted mainly of five products *viz.* Cow dung, Cow urine, Cow milk, Curd, and Cow ghee. Other components like jaggery, ripened bananas, tender coconut, and water were also used to boost the fermentation process [9]. Jeevamrit, a wonderful source of natural carbon, nitrogen, phosphorous, potassium, and many other micronutrients required by the crops, was another organic formulation used. It consists of a mixture of cow dung, cow urine, jaggery, pulse flour, and a handful of fertile soil in water. A statistical analysis was conducted for each character that was identified during the investigation. The average data values were examined using the Randomized Complete Block Design (RCBD) method described in Gomez and Gomez's [10] standard book "Statistical Procedures for Agricultural Research.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Application of organic liquid formulations and manures significantly impacted plant height, leaf area index, number of leaves, average leaf length, and leaf breadth. After sowing, data was collected every 30 days. Tables 1 and 2 presents a summary of this. The maximum plant height (69.080 cm) was recorded with the application of treatment T_3 *i.e.,* FYM (10t/ha) + Panchgavya (2%) at 180 days after sowing of garlic respectively, Auxins and gibberellins, which are growth boosters found in Panchgavya, are likely responsible for this effect.

Conversely, the minimum was obtained under control. Similar results have been reported by Kumaravelu and Kadamban [11] in green gram, Mathews et al. [12] in cowpea, tomato, lady finger, chilli and brinjal, Sornalatha et al. [13] in *Luffa acutangula*, Bua et al. [14] in onion,

Ranpariya et al. [15] in garlic and Patle et al. [16] in garlic. The maximum number of leaves at 180 days after sowing of garlic was again obtained with the application of FYM (10t/ha) + Panchgavya (2%) which is due to the presence of appreciable amounts of major nutrients in Panchgavya. High nitrogen and phosphorus content in FYM causes more photosynthesis and, therefore greater number of leaves. Similar results have also been reported by Lal et al. [17] in onion, Yassen and Khalid [18] in onion, Mathews et al. [12] in cowpea, tomato, lady finger, chilli and brinjal and Bua et al. [14] in onion.

Concerning the average length of leaves, the maximum value (47.880 cm) was obtained with the application of treatment T_3 at 180 days after sowing. Moreover, a higher dose of FYM provides more amount of nutrients to the plant, and the presence of magnesium in it helped in the synthesis of chlorophyll, which in turn increased the rate of photosynthesis resulting in higher leaf length. Similar outcomes were put out by Kumaravelu and Kadamban [11] in Greengram, Premsekhar and Rajshree [19] in Okra, Maheshwari and Rajkumar [20] in Cluster Onion and Pallavi and Anuja [21] in Moringa. Applying the same treatment T_3 again showed the highest breadth of *i.e.,* 3.207 cm at 180 days after sowing. This may be caused by the gibberellin and auxins present in panchgavya in addition to the micronutrients that FYM had supplied. With the application of treatment T_3, the leaf area index was also observed at its maximum *viz.,* 1.023 at 180 days after sowing. An increase in LAI may have been relied on by the bigger leaf surface area. The respective parameter's lowest readings were found under control.

3.2 Yield Parameters

The application of treatment T_3, or [FYM (10t/ha) + Panchgavya (2%)], yielded the largest bulb diameter (5.657 cm), fresh weight of the bulb (64.643 g), length of the bulb (5.853 cm), number of cloves (12.200), and bulb yield (120.833 q/ha) because nutrients and growth stimulants could be supplied easily, resulting in enhanced bulb diameter and length. The findings are in close conformity with the findings of Anbarasi and Haripriya [22] in onion and Ranpariya et al. [15] in garlic. The application of treatment T_{13} [Vermicompost (5t/ha) + Jeevamrit (6%)] produced the maximum harvest index (89.243%), which was followed by T_3 (88.117%). These results are closely agreed with the results obtained by Yadav et al. [23] in garlic, and Kenea and Gedamu [24] in garlic. With a net return of 3,66,494.0 ₹/ha, treatment T_3 [FYM (10t/ha) + Panchgavya (2%)] was the most cost-effective. The highest C: B ratio, however, was attained with treatment T_7, which is FYM (10t/ha) + Jeevamrit (6%).

Table 1. Integrated effect of organic manures and organic liquid formulations on Plant Height (cm), Number of Leaves per plant, and Average Length of Leaves of Garlic (*Allium sativum* L.) at 180 DAS

	Treatments	Plant Height (cm)	Number of Leaves per Plant	Average Length of Leaves (cm)
T_1	Control	55.127	7.133	38.347
T_2	FYM (10t/ha) + Vermicompost (5t/ha)	61.153*	7.467	40.893
T_3	FYM (10t/ha) + Panchgavya (2%)	69.080*	8.400*	47.880*
T_4	FYM (10t/ha) + Panchgavya (4%)	60.767*	7.800*	43.160*
T_5	FYM (10t/ha) + Panchgavya (6%)	65.780*	8.000*	43.433*
T_6	FYM (10t/ha) + Jeevamrit (4%)	56.640	8.200*	39.993
T_7	FYM (10t/ha) + Jeevamrit (6%)	67.000*	8.133*	43.400*
T_8	FYM (10t/ha) + Jeevamrit (8%)	67.467*	7.933*	43.600*
T_9	Vermicompost (5t/ha) + Panchgavya (2%)	56.487	8.267*	38.860
T_{10}	Vermicompost (5t/ha) + Panchgavya (4%)	58.067	7.867*	40.213
T_{11}	Vermicompost (5t/ha) + Panchgavya (6%)	59.057	8.067*	41.747
T_{12}	Vermicompost (5t/ha) + Jeevamrit (4%)	59.713*	7.667	39.027
T_{13}	Vermicompost (5t/ha) + Jeevamrit (6%)	59.553	7.933*	40.147
T_{14}	Vermicompost (5t/ha) + Jeevamrit (8%)	59.003	7.867*	38.420
S.E (d)		2.175	0.319	1.832
C.D $_{(0.05)}$		4.495	0.659	3.787

**Significant at 5% level of significance as compared with T_1 (Control)*

Table 2. Integrated effect of organic manures and organic liquid formulations on Average Breadth of Leaves (cm) and Leaf Area Index of Garlic (*Allium sativum* L.) at 180 DAS

	Treatments	Average Breadth of Leaves (cm)	Leaf Area Index
T_1	Control	2.427	0.630
T_2	FYM (10t/ha) + Vermicompost (5t/ha)	2.833*	0.773*
T_3	FYM (10t/ha) + Panchgavya (2%)	3.207*	1.023*
T_4	FYM (10t/ha) + Panchgavya (4%)	2.793*	0.807*
T_5	FYM (10t/ha) + Panchgavya (6%)	2.820*	0.820*
T_6	FYM (10t/ha) + Jeevamrit (4%)	2.633	0.703
T_7	FYM (10t/ha) + Jeevamrit (6%)	2.800*	0.810*
T_8	FYM (10t/ha) + Jeevamrit (8%)	2.607	0.757*
T_9	Vermicompost (5t/ha) + Panchgavya (2%)	2.653*	0.683
T_{10}	Vermicompost (5t/ha) + Panchgavya (4%)	2.620	0.667
T_{11}	Vermicompost (5t/ha) + Panchgavya (6%)	2.673*	0.743*
T_{12}	Vermicompost (5t/ha) + Jeevamrit (4%)	2.440	0.650
T_{13}	Vermicompost (5t/ha) + Jeevamrit (6%)	2.780*	0.743*
T_{14}	Vermicompost (5t/ha) + Jeevamrit (8%)	2.613	0.670
S.E (d)		0.100	0.052
C.D $_{(0.05)}$		0.207	0.107

**Significant at 5% level of significance as compared with T_1 (Control)*

Table 3. Integrated effect of organic manures and organic liquid formulations on yield attributes of garlic (*Allium sativum* L.)

	Treatment details	Bulb diameter (cm)	Fresh weight of bulb (g)	Length of bulb (cm)	No. of cloves	Bulb yield (q/ha)	Harvest Index (%)
T_1	Control	4.563	23.600	4.273	9.733	43.750	73.297
T_2	FYM (10t/ha) + Vermicompost (5t/ha)	5.020	52.643*	5.013*	11.200*	98.327*	79.183
T_3	FYM (10t/ha) + Panchgavya (2%)	5.657*	64.643*	5.853*	12.200*	120.833*	88.117*
T_4	FYM (10t/ha) + Panchgavya (4%)	5.117	49.867*	5.347*	10.533	92.917*	84.967*
T_5	FYM (10t/ha) + Panchgavya (6%)	5.297*	58.490*	5.160*	10.800	109.167*	75.417
T_6	FYM (10t/ha) + Jeevamrit (4%)	5.110	53.053*	5.453*	11.067*	98.790*	84.017*
T_7	FYM (10t/ha) + Jeevamrit (6%)	5.560*	60.547*	5.440*	11.267*	112.917*	80.773
T_8	FYM (10t/ha) + Jeevamrit (8%)	5.380*	56.747*	5.413*	11.533*	105.833*	76.400
T_9	Vermicompost (5t/ha) + Panchgavya (2%)	4.650	44.830*	5.253*	10.533	82.917*	83.183*
T_{10}	Vermicompost (5t/ha) + Panchgavya (4%)	5.017	47.067*	5.040*	10.933	87.917*	84.580*
T_{11}	Vermicompost (5t/ha) + Panchgavya (6%)	5.247*	50.303*	5.133*	10.733	93.753*	78.930
T_{12}	Vermicompost (5t/ha) + Jeevamrit (4%)	4.947	45.480*	5.227*	10.400	84.580*	85.337*
T_{13}	Vermicompost (5t/ha) + Jeevamrit (6%)	4.690	47.193*	5.080*	9.933	88.750*	89.243*
T_{14}	Vermicompost (5t/ha) + Jeevamrit (8%)	4.903	45.513*	5.067*	10.667	85.003*	83.053*
S.E. (d)		0.299	3.760	0.285	0.594	5.586	4.605
C.D $_{(0.05)}$		0.618	7.772	0.590	1.228	11.546	9.518

**Significant at a 5% level of significance as compared with T_1 (Control)*

Table 4. Integrated effect of organic manures and organic liquid formulations on qualitative analysis of Garlic (*Allium sativum* L.)

Treatment code	Treatment Details	Total chlorophyll (mg/g)	Ascorbic acid content (mg/ 100 g)
T_1	Control	0.883	6.000
T_2	FYM (10t/ha) + Vermicompost (5t/ha)	1.057*	6.667
T_3	FYM (10t/ha) + Panchgavya (2%)	2.127*	15.333*
T_4	FYM (10t/ha) + Panchgavya (4%)	1.930*	14.667*
T_5	FYM (10t/ha) + Panchgavya (6%)	1.777*	11.333*
T_6	FYM (10t/ha) + Jeevamrit (4%)	1.583*	9.333*
T_7	FYM (10t/ha) + Jeevamrit (6%)	1.443*	8.000
T_8	FYM (10t/ha) + Jeevamrit (8%)	1.570*	8.667*
T_9	Vermicompost (5t/ha) + Panchgavya (2%)	1.707*	10.667*
T_{10}	Vermicompost (5t/ha) + Panchgavya (4%)	1.873*	13.333*
T_{11}	Vermicompost (5t/ha) + Panchgavya (6%)	1.227*	7.333
T_{12}	Vermicompost (5t/ha) + Jeevamrit (4%)	1.637*	10.000*
T_{13}	Vermicompost (5t/ha) + Jeevamrit (6%)	1.817*	12.000*
T_{14}	Vermicompost (5t/ha) + Jeevamrit (8%)	1.837*	12.667*
S.E. (d)		0.076	1.133
C.D. $_{(0.05)}$		0.156	2.343

**Significant at a 5% level of significance as compared with T_1 (Control)*

Table 5. Integrated effect of organic manures and organic liquid formulations on economics of different treatments

Treatment code	Treatment details	C: B
T_1	Control	1: 0.30
T_2	FYM (10t/ha) + Vermicompost (5t/ha)	1: 1.03
T_3	FYM (10t/ha) + Panchgavya (2%)	1: 1.54
T_4	FYM (10t/ha) + Panchgavya (4%)	1: 0.75
T_5	FYM (10t/ha) + Panchgavya (6%)	1: 0.87
T_6	FYM (10t/ha) + Jeevamrit (4%)	1: 1.32
T_7	FYM (10t/ha) + Jeevamrit (6%)	1: 1.64
T_8	FYM (10t/ha) + Jeevamrit (8%)	1: 1.46
T_9	Vermicompost (5t/ha) + Panchgavya (2%)	1: 0.57
T_{10}	Vermicompost (5t/ha) + Panchgavya (4%)	1: 0.51
T_{11}	Vermicompost (5t/ha) + Panchgavya (6%)	1: 0.48
T_{12}	Vermicompost (5t/ha) + Jeevamrit (4%)	1: 0.77
T_{13}	Vermicompost (5t/ha) + Jeevamrit (6%)	1: 0.85
T_{14}	Vermicompost (5t/ha) + Jeevamrit (8%)	1: 0.77

3.3 Quality Parameters

The highest total chlorophyll content (2.127 mg/ g) and ascorbic acid content (15.333 mg/100 g) were observed with the application of treatment T_3 [FYM (10t/ha) + Panchgavya (2%)]. The primary reason is the increasing leaf area of the plant, which causes more photosynthetic activity, resulting in higher production of photosynthetic products and their accumulation in the plant. The augment of ascorbic acid might be due to the good growth of plants resulting from higher assimilation of micronutrients which are made available due to well-decomposed organic matter.

4. CONCLUSION

After the investigation, it was revealed that treatment T_3 [FYM (10t/ha) + Panchgavya (2%)] recorded significantly highest plant height, number of leaves, average length and breadth of leaves, leaf area index, bulb diameter, fresh weight of the bulb, length of the bulb, number of cloves and bulb yield. The maximum C: B ratio was obtained under treatment T_7 *i.e.,* FYM (10t/ha) + Jeevamrit (6%). The findings prove to be of substantial importance for the farmers who are willing to go for organic farming and solve the real problem of chemical-based agriculture.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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