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Response of integrated nutrient management on growth and yield of Garlic (*Allium sativum* L.)

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ABSTRACT

A field experiment entitled "Response of integrated nutrient management on growth, yield and nutrient uptake of Garlic (*Allium sativum* L.)" was conducted during *rabi* season of 2024-25 at Crop Research Farm, Department of Horticulture, Tantia University, Sri Ganganagar, Rajasthan, India. The experiment was laid out in Randomized Block Design with seven treatments which are replicated thrice viz. T_1: control, T_2: 100% FYM 100% FYM (20 t/ha), T_3: 100% FYM (20 t/ha) + *Azospirillum*, T_4: 50% FYM (10 t/ha) + 50% inorganic fertilizers (N, P, K), T_5: 100% vermicompost (5 t/ha), T_6: 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K), T_7: 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The results obtained that 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum* was recorded significantly maximum plant height (59.58 cm), number of leaves/plant (8.76), leaf area index (3.29 cm), bulb weight (11.80g), bulb diameter (3.48 cm), number of cloves/bulb (14.45), clove length (3.18 cm), clove breadth (1.51 cm), clove weight (0.90g), bulb yield (6.18 kg/plot) and bulb yield (13.85 t/ha).

KEYWORDS

Garlic, NPK, INM, Vermicompost, *Azospirillum*, *Yield*, *Growth*

HOW TO CITE THIS ARTICLE

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Vegetables are an important part of the human diet since they include key nutrients including vitamins, minerals, fiber, and antioxidants that are needed to be healthy. In order to achieve food and nutritional security worldwide, they are crucial. Growing vegetables helps sustain rural communities, diversify agriculture, and provide revenue. Growing health and nutrition consciousness has led to a steady increase in the demand for both fresh and processed vegetables worldwide. Therefore, increasing vegetable yield and production is essential for both better human welfare and sustainable agriculture (Chadha, 2019). Garlic (*Allium sativum* L.), a diploid chromosome with number 2n=16, is one of the most commonly grown *Allium* species, second only to onions, in the Amaryllidaceae family. While, the Mediterranean region is thought to be garlic's secondary center of origin, Central Asia is its major center. One of the most lucrative and extensively grown *Allium* vegetable crops worldwide is garlic, according to (Block, 2010). It is grown all over India, but the most production-intensive states are Gujarat, Odisha, Madhya Pradesh, Rajasthan, Uttar Pradesh, and Maharashtra. Both fresh and dried, it is used as a flavoring in vegetarian and non-vegetarian recipes. Fresh garlic leaves are a popular salad ingredient on Indian sub-continent; cloves may be used to make a delicious pickle.

FYM is popular organic manure, enhances the physical and chemical characteristics of soil in addition to providing nutrients for plants. Because FYM and inorganic fertilizers complement and enhance one another in maintaining crop output and soil productivity, their joint use is especially significant in intensive cropping systems. Three nutrient sources could form the basis of INM: inorganic fertilizers, organic manures, and microbial inoculants or biofertilizers such as *Azotobacter*, *Azospirillum*, and phosphate solubilizing bacteria (PSB). To guarantee the best possible supply of all necessary nutrients for sustained crop production, INM also advises the prudent use of specific nutrient inputs. Mineral elements are heavily fed by onions. About 120 kg of N, 50 kg of P_2O_5, and 160 kg of K_2O are removed each hectare by a 40 t/ha crop (Tandon and Tiwari, 2008). Therefore, the potential yield increases with its capacity to use nutrients for crop production.

Vermicompost application is essential for improving crop development, productivity, and bulb quality in garlic agriculture. It improves soil structure, aeration, and microbial activity by enriching the soil with organic matter and vital nutrients. Throughout the crop cycle, vermicompost offers a consistent supply of nutrients, which promotes uniform bulb growth and improved root development. Its application also lessens reliance on artificial fertilizers, encouraging environmentally responsible and sustainable garlic farming. Additionally, research indicates that applying vermicompost enhances the size, flavor, and storability of garlic bulbs (Sharma *et al*., 2019).

Materials and Methods

The present investigation entitled "Response of integrated nutrient management on growth, yield and nutrient uptake of Garlic (*Allium sativum* L.)" was carried out during the year 2024-2025. The field experiment was conducted in *Rabi* Season of 2024-2025 at Crop Research Farm, Department of Horticulture, Tantia University, Sri Ganganagar, Rajasthan, India. This located at 28.4° N latitude, 72.2° E longitude and 178 m above mean sea level.

Experimental Details

The experiment was under taken in order to find out the response of integrated nutrient management on growth, yield and nutrient uptake of garlic. There were seven treatments and each treatment was allocated randomly in each replication during experimentation and subjected to different manurial treatment combinations given below. Details of the treatments are in table 1.

Table 1. Details of the treatments

Treatment	Treatments Details
T_1	Control
T_2	100% FYM (20 t/ha)
T_3	100% FYM (20 t/ha) + *Azospirillum* (20g)
T_4	50% FYM (10 t/ha) + 50% inorganic fertilizers (N, P, K)
T_5	100% vermicompost (5 t/ha)
T_6	50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K)
T_7	50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum* (20g)

The data recorded during the course of investigation was subjected to statistical analysis by "Analysis of variance technique" (Gomez and Gomez, 1976). The significant and non-significant treatment effects were judged with the help of 'F' (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level.

Results and Discussions

Vegetative Parameters

Plant Height (cm)

As perusal of the data reveals that there is study increase in plant height due to different treatment combinations plant height was significantly influenced, which was shown in table 2. At 120 DAP, significantly and higher plant height (59.58 cm) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (56.79 cm) was found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The lowest plant height (40.23 cm) at 120 DAP was observed under T_1 (control).

Plant height and leaf number are genetically controlled characteristics, but they are also influenced by nutrient availability and cultivar. The increase in plant height may be due to major nutrient supplied by the inorganic fertilizers will be utilized quickly by the crop and all other micro and macro nutrients available in organic manures will be released slowly and the increased root system of the plants might have resulted in an increased uptake of nutrients which were used in photosynthesis (Bhandari *et al*., 2012).

Numbers of Leaves/ Plant

As perusal of the data reveals that there is study increase in numbers of leaves/ plant due to different treatment combinations number of leaves per plant was significantly influenced which was shown in table 2. At 120 DAP, significantly and maximum numbers of leaves/plant (8.76) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (8.15) was found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum numbers of leaves/plant (5.19) at 120 DAP was observed under T_1 (control). Vermicompost is known to contain micronutrients apart from major nutrients. Besides this, vermicompost has been reported to contain several plant growth promoters, enzymes, beneficial bacteria and mycorrhizae. Therefore, the availability of higher quantity of nutrients, improvement in the physical properties of soil and increased activity of microbes with higher levels of organics might have helped in increasing plant height, number of leaves and neck thickness of garlic. The findings of present investigation are in close conformity with findings of (Degwale, 2016, Yadav *et al*., 2017, Patel *et al*., 2018 and Solanki *et al*., 2020).

Leaf Area Index (cm)

As perusal of the data reveals that there is study increase in Leaf Area Index due to different treatment combinations leaf area index was significantly influenced which, was shown in table 2. At 120 DAP, significantly and maximum leaf area index (4.12 cm) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*.

However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (4.02) was found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum leaf area index (2.85 cm) at 120 DAP was observed under T_1 (control).

Yield Parameters

As perusal of the data reveals that there is study yield parameter due to different treatment combinations yield was significantly influenced which was shown in table 3.

Bulb Weight (g)

The significantly and higher bulb weight (11.80 g) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (11.35 g) was found to be statistically at par T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum bulb weight (9.00 g) was observed under T_1 (control). Integrated application of different organic manures with inorganic fertilizers, proved to be the principal factor that enhance yield. Bulb crops are a heavy feeder, requiring optimum supplies of nitrogen, phosphorus, potassium and other nutrients which can adversely affect the growth, yield and quality of bulbs under sub-optimal levels in the soil. The findings of present investigation are in close conformity with findings of (Gowda *et al*., 2007, Suthar, 2009).

Bulb diameter (cm)

The significantly and higher Bulb diameter (3.48 cm) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (3.47 cm) was found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum bulb diameter (2.62 cm) was observed under T_1 (control).

Number of Cloves per Bulb

The significantly and higher number of cloves per bulb (14.45) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*.

However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (14.32) was found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum number of cloves per bulb (12.03) was observed under T_1 (Control).

Cloves Length (cm)

The significantly and higher cloves length (3.18 cm) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (3.09 cm) and T_5 100% vermicompost (5 t/ha) (3.05 cm) were found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum cloves length (2.39 cm) was observed under T_1 (Control). Similarly (Surindra, 2009) showed that integrated nutrient supply, in the form of inorganic NPK and in the form of organic manures, brings an excellent biochemical changes in soil structure, which ultimately promotes plant growth and production. However, the earthworm casts not only affects soil physio-chemical structure, but also promotes biological properties of it.

Cloves Breadth (cm)

The significantly and higher cloves breadth (1.51 cm) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (1.40 cm) and T_5 100% vermicompost (5 t/ha) (1.38 cm) were found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum cloves breadth (0.50 cm) was observed under T_1 (control). The application of the vermicompost which helps in promoting the sink size in terms of bulb size and vermicompost relatively contains more exchangeable plant nutrient than those by other plant growth media (Nainwal *et al*., 2015).

Cloves Weight (g)

The significantly and higher cloves weight (0.90 g) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*.

However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (0.85 g) and T_5 100% vermicompost (5 t/ha) (0.81 g) were found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum cloves weight (0.74 g) was observed under T_1 (control). The application of RDF and vermicompost are affected the soil ability and balancing nutrient supply to the plant increase with the bulb yield. From the results, it was noted that vermicompost and NPK fertilizers when combinedly used, the nutrients become more available to plants and much bulb formation was occurred and combined application also improved physical conditions of the soil for better growth as well as supplied sufficient plant nutrients during all stages of plant growth. Similar results were also reported by (Shashidhar *et al*., 2009, Damse *et al*., 2014).

Bulb Yield (Kg/ Plot)

The significantly and higher bulb yield (6.18 kg/plot) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (6.07 kg/plot) and T_5 100% vermicompost (5 t/ha) (6.15 kg/plot) were found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum bulb yield (3.56 kg/ plot) was observed under T_1 (control).

Leaf Yield (Kg /Plot)

The significantly and higher leaf yield (13.54 kg/plot) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (13.29 kg/ha) and T_5 100% vermicompost (5 t/ha) (13.25 kg/plot) were found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum leaf yield (12.17 kg/ plot) was observed under T_1 (control).

Bulb Yield (t/ha)

The significantly and higher bulb yield (13.85 t/ha) was recorded in T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*.

Table 2. Response of integrated nutrient management on growth of Garlic

S. N.	Treatment Combination	Plant Height (cm) 120 DAP	Numbers of Leaves/ Plant 120 DAP	Leaf Area Index (cm) 120 DAP
T_1	Control	40.23	5.19	2.85
T_2	100% FYM (20 t/ha)	42.56	5.38	3.01
T_3	100% FYM (20 t/ha) + *Azospirillum* (20g)	48.89	7.12	3.19
T_4	50% FYM (10 t/ha) + 50% inorganic fertilizers (N, P, K)	51.19	5.85	3.65
T_5	100% vermicompost (5 t/ha)	53.46	7.53	3.95
T_6	50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K)	56.79	8.15	4.02
T_7	50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum* (20g)	59.58	8.76	4.12
	SEm(±)	1.26	0.20	0.06
	CD (p=0.05)	3.88	0.62	0.15
	CV	6.23	5.10	2.36

Table 3. Response of Integrated nutrient management on yield of Garlic

S. N.	Treatment Combination	Bulb Weight (g)	Bulb Diameter (cm)	Number of Cloves per Bulb	Cloves Length (cm)	Cloves Breadth (cm)	Cloves Weight (g)	Bulb Yield (kg/Plot)	Leaf Yield (kg/Plot)	Bulb Yield (t/ha)
T_1	Control	9.00	2.62	12.03	2.39	0.50	0.74	3.56	12.17	7.89
T_2	100% FYM (20 t/ha)	9.16	2.76	11.87	2.62	0.63	0.78	3.85	12.71	9.85
T_3	100% FYM (20 t/ha) + *Azospirillum* (20g)	9.21	2.97	13.33	2.66	0.73	0.78	3.90	12.89	10.90
T_4	50% FYM (10 t/ha) + 50% inorganic fertilizers (N, P, K)	9.86	3.00	13.22	2.87	0.91	0.79	5.32	12.90	11.01
T_5	100% vermicompost (5 t/ ha)	11.12	3.26	14.18	3.05	1.38	0.81	6.07	13.25	13.07
T_6	50% vermicompost (2.5 t/ ha) + 50% inorganic fertilizer (N, P, K)	11.35	3.47	14.32	3.09	1.40	0.88	6.15	13.29	13.48
T_7	50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha)+*Azospirillum* (20g)	11.80	3.48	14.45	3.18	1.51	0.90	6.18	13.54	13.85
	SEm(±)	0.22	0.06	0.09	0.05	0.04	0.03	0.47	0.19	1.24
	CD (p=0.05)	0.67	0.19	0.26	0.14	0.14	0.09	1.45	0.58	2.83
	CV	8.9	9.23	12.36	10.84	11.45	7.28	6.32	6.04	8.84

However, T_6 50% vermicompost (2.5 t/ha) + 50% inorganic fertilizer (N, P, K) (13.07 t/ha) and T_5 100% vermicompost (5 t/ha) (13.48 t/ha) were found to be statistically at par with T_7 50% inorganic fertilizer (N, P, K) + 50% vermicompost (2.5 t/ha) + *Azospirillum*. The minimum bulb yield (7.89 t/ha) was observed under T_1 (control). The application of RDF and vermicompost are affected the soil ability and balancing nutrient supply to the plant increase with the bulb yield. From the results, it was noted that vermicompost and NPK fertilizers when combinedly used, the nutrients become more available to plants and much bulb formation was occurred and combined application also improved physical conditions of the soil for better growth as well as supplied sufficient plant nutrients during all stages of plant growth. Similar results were also reported by (Solanki *et al*., 2020; Alam *et al*. (2022).

Conclusion

The investigation entitled "Response of integrated nutrient management on growth, yield and nutrient uptake of Garlic (*Allium sativum* L.)" revealed that integrating organic and inorganic nutrient sources significantly enhances growth, yield, and profitability.

Among all treatments, 50% inorganic fertilizer + 50% vermicompost + *Azospirillum* (T_7) consistently proved superior by ensuring faster germination, better vegetative growth, and higher yield.

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