**Optimizing Garlic Production Through Organic and Inorganic Nutrient Sources**

**Abstract**

**The present investigation entitled “Optimizing garlic production through organic and inorganic nutrient sources” was conducted in year 2021–22 at experimental farm of Department of Agriculture, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab, India. The sowing was done on second fortnight of October 2021 with a 15 × 7.5 cmspacing, followed a Randomized Block Design (RBD) with three replications and 12 treatments, including a control. Results showed that among various growth and yield parameters treatment combining 50% recommended dose of fertilizers (RDF) and 50% poultry manure (T8) yielded significantly highest plant height (54.57 cm), leaves number (6.07), Bulb weight (23.73 g), yield (12.46 t/ha), and quality attributes like total soluble solids (35. 40 ˚Brix) and ascorbic acid (12.32 mg/100g). These findings highlight the efficacy of integrated nutrient management especially with the use of poultry manure as organic nutrient source for optimizing garlic production.**

**Key words**: *Garlic, Farmyard manure, Poultry manure, Vermicompost, NPK.*

**Introduction**

Garlic (*Allium sativum* L.) belongs to the family Alliaceae and is the second most widely used bulb crop next to onion (Yadav *et al.,* 2017). It is one of the most important bulb crops and commercially cultivated for both local consumption and export. It is native of the Central Asia and Southern Europe especially Mediterranean region (Thompson and Kelly, 1957). Its medical usefulness is recognized in the prevention, treatment, and management of worms, and bacteria, and hypertension, diabetes, cancer, ulcers, and rheumatism, as well as bacterial and fungal infections. Its allicin content is responsible for its cholesterol and blood sugar-lowering activities. It has insecticidal and repellant qualities as well (Farooqui *et al.,* 2005). A fresh bulb contains about 62.8 % moisture, 0.1 % fat, 0.8 % fiber, and is a good source of carbohydrates, vitamin- C, calcium (Ca), selenium (Se), phosphorous (P) and manganese (Mn). Garlic is used in flavoring foods, preparing chutneys, pickles, curry powder, tomato ketchup, etc. Besides the nutritive value of garlic and its use in various forms, include its use in Indian system of medicines (Ayurveda, Unani and Siddha) as carminative and gastric stimulant to help in digestion and absorption of food (Sankaracharya, 1974). Leaves of garlic are rich in protein, vitamin A and C.

Application of requisite nutrients through chemical fertilizers is known to have harmful effects on soil fertility leading to unsustainable yields, while integration of chemical fertilizers with organic manures enable to maintain the health, productivity and fertility of the soil (Yadav *et al.,* 2017). Organic manure is an environmentally beneficial, economically feasible, and ecologically sound product that also contributes to soil biology, chemistry, and physics. Vermicompost (VC) and Farm yard manure (FYM) acts as a store house of several macro and micro nutrients as well as plant growth regulators which are released during the process of mineralization to release nutrients in the soil and increases its fertility. Organic manure helps in reducing soil C: N ratio, increases humic acid content and provide the nutrients in the readily available form to the plants such as nitrate (NO3), exchangeable P, soluble K, Ca and magnesium (Mg) (Talashilkar *et* *al.,* 1999). Poultry manure is an excellent organic fertilizer, concentrated source of nitrogen and other essential nutrients. It has direct effect on plant growth with increased nutrient uptake (Abusaleha, 1992). Farmyard manure is easily available and widely used by farmers in North India. The decomposing mixture of urine, excrement of animals and kitchen wastages are used in Farmyard manure, which have micro and macro nutrients which enhance the soil productivity. The agriculture development strategy for India in the 21st century must be through increasing productivity of the land under cultivation, with reduced costs of production and efficient use of inputs with no harm to the environmental quality. The prime requisite is the promotion of health of the soil- plant environment system to be free from economic exploitation under overuse and abuse of the input as if with impunity (Ayala and Rao, 2002). Therefore, increasing garlic yield and improving bulb quality is the main target for both growers and consumers. This study’s significance lies in identifying sustainable nutrient combinations that enhance garlic productivity while reducing reliance on chemical inputs, offering practical insights for farmers in semi-arid regions.

**MATERIALS AND METHODS**

The field experiment entitled “**Optimizing garlic production through organic and inorganic nutrient sources**” was conducted at the Horticulture farm and quality observations were recorded at the Horticulture Laboratory of Department of Agriculture, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab, India during the Rabi season, 2021–2022. The location is situated in Punjab at 30.6435 ˚N and 76.3970 ˚E, at a height of 246 meters above mean sea level. The state's agro-climatic zone 3 (Central Plain zone) encompasses this area. The climate of this region is classified as tropical, hot and semi – arid which is mainly dry. Both summer and winter are severe except during monsoon season. The temperature in this zone ranges from 7°C to 32°C. The annual rainfall of the region is 692 mm. Monsoon rainfall contributes 79 % of annual rainfall in the region. The soil is loamy sand in texture, slightly alkaline in reaction, rich in organic carbon with medium available nitrogen, and phosphorus and high potassium status. The planting material was obtained from Punjab Agricultural University, Ludhiana. Experiment consist of 12 treatments comprising chemical fertilizers, FYM, PM, VC & their combinations i.e. T1: Control, T2: 100 % recommended dose of fertilizers (RDF), T3: 100 % FYM, T4: 100 % PM, T5: 100 % VC, T6: 50 % RDF + 50 % VC, T7: 50 % RDF + 50 % FYM, T8: 50 % RDF + 50 % PM, T9: 75 % RDF + 25 % VC, T10: 75 % RDF + 25 % FYM, T11: 75 % RDF + 25 % PM and T12: 25 % RDF + 25 % FYM + 25 % PM + 25 % VC, all replicated three times arranged under Randomized Block Design. PG18 garlic variety was selected for the present study planted at spacing of 15 × 7.5 cm.

The required quantity of fertilizers or organic manures as per treatment combination were applied at the time of land preparation. The RDF was applied through urea, SSP & MOP. Half of the nitrogen was applied as a basal dose along with full dose of phosphorus and potassium. Remaining half of nitrogen was applied in three equal splits at 90 days after planting following planting of cloves. Other cultural practices like weeding, hoeing and irrigation were done as and when required. Observations on growth, yield and quality parameters were recorded at various stages of plant growth and the data thus obtained was subjected to analysis of variance (ANOVA) through WASP- Web Agri Stat Package (Jangam and Thali, 2004).

**RESULTS AND DISCUSSION**

The height of plant was varied in all treatments, as evident from the data (Table 1). Organic manures likely enhanced soil texture, boosting root proliferation and plant height (Acharya and Kumar, 2018). The maximum plant height was recorded with 50% RDF + 50% PM (T8) (54.57cm), which was at par with 75% RDF + 25% VC (T9) (52.34 cm). However, the minimum was recorded in T1 (46.98 cm). Similar results have been reported by Suem *et al.,* (2013), who have achieved a maximum plant height 50.32 cm with PM @ 1.92 kg plot-1 and the minimum plant height 42.77 cm was recorded in the control plot.

The maximum number of leaves were recorded with 50% RDF + 50% PM (T8) (6.07), which were statistically at par with T9, T7, and T10. Whereas, the minimum number of leaves were recorded in control (T1). Results obtained in the present investigation are in agreement with those of Adamu and Fagam (2012) who reported the maximum number of garlic leaves as 6.75 in treatment 5.0 t ha-1 PM and minimum number of leaves per plant 5.75 in control. The results are also in agreement with those of Prajapati *et al.,* (2019).

In treatment 50% RDF + 50% PM (T8) achieved the maximum leaf length (51.37 cm), which was significantly higher than the other treatments. Whereas, the minimum leaf length (43.71 cm) was observed in control (T1). Result achieved with 50% PM with 50% RDF in the present study are in agreement with the results obtained by Sharma *et al.,* (2021) who achieved leaf length of 51.4 cm with combination of 50% RDF + 2.5 t VC + 1.5 t PM. Khatri *et al.,* (2019) also noted that the addition of organic manures resulted in improved leaf development. The length of the leaves and other vegetative parameters were significantly impacted by organic sources.

The data presented in Table 1 reveals that maximum leaf width (1.94 cm) was recorded with 50% RDF + 50% PM (T8), which were statistically at par with T6, T7, T9 and T11, respectively. In control (T1), a minimum leaf width of 1.68 cm was noted. These results are in agreement with study of Sharma *et al.,* (2021) who found that the maximum garlic leaf width of 2.10 cm in treatment 50% RDF + 2.5 t VC + 1.5 t PM and the minimum leaf width of 1.70 cm in treatment 100% RDF. One of the explanations might be enhancement of soil texture by organic manures thereby assisted plants in developing strong roots which might have increased the leaf width (Acharya and Kumar, 2018). Abou-Elmagd *et al.,* (2006) reported that poultry manure is rich in nitrogen and other plant nutrients and as a result it favors the growth and development of root system which reflects better growth, photosynthetic activity and dry matters accumulation.

The perusal of the data presented in Table 1, 50% RDF + 50% PM (T8) produced the highest amount of fresh weight (30.42 g), which was statistically equal to (29.61 g) achieved in T9 and both the observations were significantly higher than other treatments and control (T1) that revealed the lowest amount of fresh weight (19.44 g). This might be due to use of organic manures which lead to better yield of crop as they serve as a storehouse for a variety of macro, micro nutrients as well as plant growth regulators which are slowly released during the process of mineralization in the soil, thereby extended period of availability of these nutrients for plant uptake is achieved (Sati *et al.,* 2023). This improves the fertilizer use efficiency also (Yadav *et al.,* 2017). Sitaula *et al.* (2020) also reported similar results with the use of poultry manure as organic nutrient source along with inorganic.

The findings of our study revealed that the amount of dry weight differed considerably amongst the various treatments. According to the data, 50% RDF + 50% PM (T8) produced the highest dry weight (11.10 g). The least quantity of dry weight (4.21 g) was obtained in control (T1). Combining inorganic chemical fertilizers with organic nutrition sources had a substantial impact on biometric observations, bulb characteristics, and garlic output. This could result from the continuous and progressive release of nutrients during the growth phase, from increased biological activity, and from providing the crop with the right nutrition (Patil *et al.,* 2007).

Bulb weight is a crucial component of the garlic produce. The data presented in Table 2, reveals how various organic manures in conjunction with inorganic fertilizer affected garlic bulb weight. Data revealed that the 50% RDF + 50% PM (T8) had the highest bulb weight of 23.73 g which was significantly higher than rest of the other treatments. The lowest bulb weight of 16.90 g was noted in control (T1). Similar trend has also been reported by Nasreen *et al.,* (2009), who obtained the maximum bulb weight of 21 g that was significantly greater in inorganic fertilizers + 5 t ha-1 poultry manure compared to control. Following this treatment garlic bulb produced in T9, T7, T10, T11 had a diameter of 4.03, 3.97, 3.94 and 3.90 cm, respectively. Smallest bulb diameter of 3.16 cm was recorded in control (T1). Increased bulb diameter may stem from greater glucose accumulation. Similar results have been Singh *et al.,* (1997) reported in onion.

It is evident from the data presented in Table 2 that the maximum yield per hectare of 12.46 t was recorded with 50% RDF + 50% PM (T8) which was significantly higher than rest of the all treatments. The minimum value of yield per hectare (8.87 t) was recorded in control (T1). The application of plant nutrients directly through organic manures and indirectly through the solubilization of unavailable nutrients of intermediate organic molecules produced during the decomposition of additional manures resulted in an increase in yield with the application of inorganic nutrients (Mitra *et al.,* 2010).

The analysis of variance pertaining to the ascorbic acid showed that the effect of treatments on ascorbic acid content was significant. Higher ascorbic acid content of 12.32 mg/100g was ascertained with 50% RDF + 50% PM (T8) which was statistically at par with T7 (12.05 mg/100g) and T9 (11.85 mg/100g). The lowest amount (9.16 mg/100g) of ascorbic acid was found in control (T1). This might be due to increased activity of nitrate reductase enzyme, which helped in synthesis of certain amino acids and protein as reported by Yadav and Vijayakumari (2004). An improvement in the rhizosphere’s nutrient environment and its use by the plant system, which would increase the translocation of minerals, vitamins, and proteins needed for the production of ascorbic acid in the bulb (Ramesh *et al.,* 2006). These results are in close agreement with those of Kalirawna *et al.,* (2022) who observed the treatment75% of RDF + 25% organic manure exhibited significantly higher ascorbic acid (13.34 mg/100g). Minimum ascorbic acid (9.84 mg/100g) assessed in control treatment.

As per Table 2, 50% RDF + 50% PM (T8) had the highest TSS of 35.40 ˚Brix, which was significantly higher than rest of the all treatments. In control (T1) garlic, TSS of 28.50 ˚Brix was recorded as the lowest value. In order to increase quality through desired enzymatic changes occurring during growth, organic manures are able to provide necessary macro and micro plant nutrients (Singh and Attrey, 2002). Dhakad *et al.,* (2019) studied and impact of different organic fertilizer on quality of onion (*Allium cepa* L.) under North Gujarat condition and results revealed that the highest TSS (12.86 ˚Brix) was recorded with the treatment 125 kg ha-1 N through poultry manure, while minimum TSS (10.77 ˚Brix) was recorded with the treatment 50 kg VC and 50 kg RDF. It is evident from the Table 2 that the maximum chlorophyll content 0.82 m/g was recorded with 50% RDF + 50% PM (T8). The minimum value of chlorophyll content of 0.69 mg/g was recorded in garlic of control (T1). It could be attributed due to improved nutrient uptake by plant roots and increased plant growth due to adequate nutrient availability and subsequently have increased photosynthesis and improved carbohydrates and sugar through increased photosynthesis (Parisi *et al.,* 2004).

**CONCLUSION**

This study demonstrates that integrating 50% recommended fertilizer dose with 50% poultry manure optimizes garlic growth, yield (12.46 t/ha), and quality parameters like ascorbic acid and TSS, outperforming other treatments. Therefore, T8 (50% RDF + 50% PM) may be utilized for obtaining higher production and quality of garlic. These findings advocate for balanced nutrient management as a sustainable strategy for garlic cultivation in similar agro-climatic zones.

**Table. 1:** Effect of different organic manures and NPK on vegetative parameters of garlic

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Treatments | Plant  Height  (cm) | Leaf number/  plant | Leaf length  (cm) | Leaf  width (cm) | Fresh weight  (g) | Dry weight  (g) |
| T1 | **46.98c** | **5.13d** | **43.71c** | **1.68d** | **19.16e** | **4.21f** |
| T2 | **49.01cde** | **5.40bcd** | **46.54bc** | **1.75bcd** | **23.74bc** | **7.80de** |
| T3 | **49.19cde** | **5.47bcd** | **45.69bc** | **1.71cd** | **21.66d** | **6.96e** |
| T4 | **48.55de** | **5.53bcd** | **46.28bc** | **1.74bcd** | **22.73cd** | **7.14e** |
| T5 | **49.46cde** | **5.40bcd** | **44.78bc** | **1.70d** | **22.50cd** | **7.54de** |
| T6 | **49.89bcd** | **5.67abc** | **47.36b** | **1.82abcd** | **24.99b** | **8.10cd** |
| T7 | **50.92bcd** | **5.73ab** | **47.89b** | **1.86abc** | **25.29b** | **9.29b** |
| T8 | **54.57a** | **6.07a** | **51.37a** | **1.94a** | **30.42a** | **11.10a** |
| T9 | **52.34ab** | **5.80ab** | **47.92b** | **1.88ab** | **29.61a** | **8.96bc** |
| T10 | **51.39bc** | **5.67abc** | **47.39b** | **1.77bcd** | **25.05b** | **8.89bc** |
| T11 | **50.27bcd** | **5.60abcd** | **46.55bc** | **1.79abcd** | **23.89bc** | **7.73de** |
| T12 | **49.84bcd** | **5.20cd** | **46.53bc** | **1.75bcd** | **23.58bcd** | **7.36de** |
| C.D. (5%) | **2.73** | **0.49** | **3.33** | **0.15** | **2.07** | **0.91** |

Note: Values superscript with same letter are not statistically significant.

**Table. 2:** Effect of different organic manures and NPK on vegetative parameters of garlic (continued)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatments | Bulb Weight (g) | Yield per Hectare (t) | Ascorbic Acid (mg/g) | TSS (˚Brix) | Chlorophyll (mg/g) |
| T1 | **16.90e** | **8.87e** | **9.16g** | **28.50g** | **0.68g** |
| T2 | **20.13bcd** | **10.57bcd** | **11.01cdef** | **29.57fg** | **0.70efg** |
| T3 | **19.20d** | **10.08d** | **10.51ef** | **29.67fg** | **0.69fg** |
| T4 | **19.27cd** | **10.12cd** | **10.32f** | **28.60g** | **0.73cde** |
| T5 | **19.33bcd** | **10.15bcd** | **10.87def** | **29.77fg** | **0.72defg** |
| T6 | **20.97bcd** | **11.01bcd** | **11.14cdef** | **31.43cde** | **0.74bcd** |
| T7 | **21.40bc** | **11.24bc** | **12.05ab** | **32.37bc** | **0.76bc** |
| T8 | **23.73a** | **12.46a** | **12.32a** | **35.40a** | **0.82a** |
| T9 | **21.47b** | **11.27b** | **11.85abc** | **33.73b** | **0.77b** |
| T10 | **20.93bcd** | **10.99bcd** | **11.41bcd** | **31.60cd** | **0.75bcd** |
| T11 | **20.53bcd** | **10.78bcd** | **11.36bcde** | **30.67def** | **0.74bcd** |
| T12 | **19.73bcd** | **10.36bcd** | **10.78def** | **29.83efg** | **0.73cdef** |
| C.D. (5%) | **2.07** | **1.13** | **0.86** | **1.63** | **0.04** |

Note: Values superscript with same letter are not statistically significant.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare 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 this manuscript.

**REFERENCES**

1. Abou-El-Magh, M.M., El-Bassiony, A.M. and Fawzy, Z.F. 2006. Effect of organic manure with or without chemical fertilizers on growth yield and quality of some varieties ofbroccoli plants. *J.* *Appl. Sci. Res.* **2**:791-798.
2. Abusaleha, A. 1992. Effect of different source and form of nitrogen on the uptake of major nutrients in okra. *Indian. J. Hori.* **49**: 192-196.
3. Acharya, S. and Kumar. H. 2018. Effect of some organic manure on growth and yield of garlic in greenhouse condition at cold desert high altitude Ladakh Region. *Def. Life. Sci. J.* **3**: 100-104.
4. Adamu, S. and Fagam, A.S. 2012. Effect of variety and poultry manure levels on the growth and yield of garlic (*Allium sativum* L.) in Bauchi, Nigeria. Sav. J. Agric. **7**: 63-68.
5. Dhakad, R.K., Dhaked, M.K., Verma, J., Jalpa, G. and Chudasama, V.R. 2019. Impact of different organic fertilizer on quality of onion (*Allium cepa* L.) under North Gujarat condition. *J. Pharmacogn. Phtochem.* **8**: 3109-3111.
6. Jangam, A.K. and Thali, P. 2004. WASP-Web Agri Stat Package. ICAR Research Complex for Goa, Ela, Old Goa, Goa. 403 402. India.
7. Farooqui, A.A., Sreeamu, B.S. and Srinivasappa, K.N. 2005. *Cultivation of spice crops.* Universities press (India), Private Limited Hyderguda, Hyderabad. Pp 457.
8. Kalirawna, A., Bahadur, V., Kalirawana, S., Kumari, S., Serawat, R. and Kumar, P. 2022. Effect of organic manures and inorganic fertilizers on growth, yield and quality of onion (*Allium cepa* L.) cv. Nasik Red. *The Pharm. Innov. J.* **11**: 1389-1392.
9. Khatri, K.B., Ojha, R.B., Pande, K.R. and Khanal, B.R. 2019. Effects of different sources of organic manure in growth and yield of radish (*Raphanus sativus* L.). *Int. J. Appl. Sci. Biotech.* **7**: 39-42.
10. Mitra, S., Roy, A., Saha, A.R., Mitra, D.N., Sinha, M.K., Mahapatra, B.S. and Saha, S. 2010. Effect of integrated nutrient management on fibre yield, nutrient uptake and soil fertility in jute (Corchorus olitorius). *Indian. J. Agric. Sci.* **80**: 801-804.
11. Nasreen, S., Yousuf, M.N., Mamun, A.N.M., Brahma, S. and Hoque, M.M. 2009. Studies on response of garlic to zinc, boron and poultry manure application. *Bangladesh. J. Agric. Res.* **34**: 239-245.
12. Parisi, M., Giordano, L., Pentangelo, A., Onofrio, B. and Villari, G. 2004. Effect of different levels of nitrogen fertilization on yield and fruit quality in processing tomato. *Acta. Horti.* **700**: 129-132.
13. Patil, M.B., Shitole, D.S., Shinde, S.B. and Purandare, N.D. 2007. Response of garlic to organic and inorganic fertilizers. *J. Hort. Sci.* **2**: 130-133.
14. Prajapati, M.K., Simon, S. and Khan, K.Z. 2019. Efficacy of organic amendments against the purple blotch of garlic caused by *Alternaria porri* (Ellis). *J. Pharmacogn. Phytochem.* **8**: 08-10.
15. Ramesh, P., Singh, M., Panwar, N.R., Singh, A.B. and Ramana, S. 2006. Response of pigeonpea (Cajanus cajan) varieties to organic manures and their influence on fertility and enzyme activity of soil. *Indian. J. Agric. Sci.* **76**: 252-254.
16. Sankaracharya, N.B. 1974. Symposium on spice industry in India. *AFST, Central Food Technological Research Institute, Mysore*. pp: 104-105.
17. Sati, U.C., Raghav, M., Yadav, L., Singh, N. and Sati, K. 2023. Influence of organic and inorganic nitrogen amendments on okra growth, yield, quality and economics. *Eco. Env. & Cons.* **29**(January Suppl. Issue): S468 –S478.
18. Sharma, A., Asati, K.P., Yadav, S.S. and Namdeo, K.N. 2021. Impact of organic and inorganic fertilizers on growth, yield and economics of garlic (*Allium sativum* L.). *Ann. Plant. Soil. Res.* **23**: 477-480.
19. Singh, L., Bhonde, B.R. and Mishra, U.K. 1997. Effect of different organic manures and inorganic fertilizers on yield and quality of Rabi onion. *Newsletter NHRDF*. **17**: 1-3.
20. Singh, N. and Attrey, D.P. 2002. Studies on round the year organic production of beat leaf in trenches (underground greenhouse) in cold desert high altitude condition of Ladakh. *Int. Conf. Veg. Banglore*. 11-14.
21. Sitaula, H.P., Dhakal, R., Bhattarai, C., Aryal, A. and Bhandari, D. 2020. Effects of different combinations of poultry manure and urea on growth, yield and economics of garlic (*Allium sativum* L.). *J. Agric. Natural. Res.* **3**(1): 253-264.
22. Suem, M.A., Ali, M., Robbani, M., Bose, S.K. and Rahman, M.S. 2013. Growth and yield of onion as influenced by organic manures. *J. Agrofor. Environ.* **7**:175-178.
23. Talashilkar, S.C., Bhangarath, P.P. and Mehta, V.B. 1999. Changes in chemical properties during composting of organic residues as influenced by earthworm activity. *J. Indian. Soc. Soil. Sci.* **47**: 50-53.
24. Thompson, H.C. and Kelly, W.C. 1957. *Vegetables crops*. Tata-McGrew-Hill book Co. Inc. New York. 368-370.
25. Yadav, R.H. and Vijayakumari, B. 2004. Impact of vermicompost on biochemical characters of chilli (*Capsicum annum*). *J. Ecotoxicol. Environ. Monit.* **14**: 51-56.
26. Yadav, R.N., Bairwa, H.L. and Gurjar, M.K. 2017. Response of garlic (*Allium sativum* L.) to organic manures and fertilizers. *Int. J. Curr. Microbiol. Appl. Sci.* **6**: 4860-4867.