***Original Research Article***

# Effect of integrated nutrient management on growth, yield and quality in garlic (*Allium sativum* L.)

**Abstract**

Garlic has the charisma of a potent remedy and has held its repute as a therapeutic panacea since the dawn of civilization. So to increase its productivity and medicinal value integrated approach will be required. Allicin is the main bioactive compound, which is responsible for the medicinal value produced by garlic. It is present in the bulb in the form of allicin, which is converted to allicin when the bulb is cut or crushed. The study was conducted on the garlic variety "Kandaghat Selection". The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications comprising fourteen treatments was carried out at the Experimental farm of Horticulture Research and Training Station and KVK, Kandaghat, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during the Rabi season of 2018-19. Out of the fourteen treatments comprising of 100% recommended dose of NPK + 50 kg S/ha + 5% Jv @ 1 L/ $m^2$ ($T_7$) recorded significantly higher plant height, number of leaves per plant, bulb weight, bulb diameter, number of cloves per bulb, bulb yield, dry matter content of bulb and TSS. Phytomedical evaluation by HPLC showed that all bulbs from all treatments are rich in allicin content and their recorded values were higher than pharmaceutical grade.

**Keywords:** INM in garlic, Sulphur, Allicin, , jeevamrit

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## INTRODUCTION

Garlic (*Allium sativum* L.) is popularly grown *Allium* species after onion belonging to the family Alliaceae. It is originated in Central Asia and mainly used for food as well as medicinal purposes (Diriba *et al*., 2013). Garlic is grown for its therapeutic benefits, which are increasing in popularity around the world. It reduces total plasma cholesterol, blood pressure, and platelet aggregation (Sterling and Eagling, 2001). The majority of garlic's therapeutic properties are due to a sulfur component known as allicin (Schulz et al., 1998). The minimal allicin content required to assure the medicinal and economic viability of garlic powder products, according to British Pharmacopoeia 1998, is 4.5 mg/g. Globally, it occupies an area of 1,577.77 thousand hectares and a production of 28,164.05 thousand metric tonnes with an average productivity of 17.85 tonnes per hectare (FAO, 2017). In India, it is grown in an area of 319 thousand hectares with a production of 1862 thousand metric tonnes (NHB, 2019). In Himachal Pradesh garlic is mainly grown as a cash crop covering an area of 4.95 thousand hectares and production of 8.49 thousand metric tonnes (Anonymous, 2018). Sulphur which is the fourth major plant nutrient after nitrogen, phosphorus and potassium is essential for building up sulphur-containing amino acids (cystine, cysteine and methionine) in plant cells, particularly in the early stage of plant growth (Havlin, 2004). Sulphur is a critical component in excellent garlic production; consequently, a lack of optimal supply in different plant sections inhibits crop growth at any stage, resulting in yield reduction. Recent research has shown that amino acids can influence plant growth and development physiological activities either directly or indirectly. Furthermore, amino acids are widely known as bio-stimulants with good effects on plant growth and yield, as well as greatly mitigating the effects of abiotic stressors. Sulphur is a constituent of the enzyme nitrite reductase which is responsible for the reduction of $NO_2^-$ in chloroplasts and thus reduces the accumulation of cancerous compounds like nitrates in vegetables. Sulphur-deficient plants also displayed inadequate use of macro and micronutrients. Sulphur is an important macronutrient that, at optimal concentrations, stimulates plant development (Magray et al., 2017). Many types of living creatures are activated by organic manures, which emit phytohormones that may drive plant growth and nutrient absorption. As a result, organic manures play an important role in the growth and development of garlic (Yoldas et al., 2011). Organic manure works as a great substrate for soil microbes and raises the fraction of labile carbon and nitrogen, directly driving microorganism population and activity. According to Marathe et al. (2012), the presence of organic manures increased the microbial population since there was more organic carbon and mineralized nutrients available for their growth and continued cellular development. Jeevamrut contains a high concentration of beneficial microflora, which helps to maintain and accelerate plant growth, resulting in stronger vegetative growth and a higher quality output (Devakumar et al., 2014).

## Material and Methods

A field experiment was conducted at the Experimental farm of Horticulture Research and Training Station and KVK, Kandaghat, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during the rabi season of 2018-19. This experiment was laid out in Randomized Block Design (RBD) with fourteen treatments and three replications. The size of the experimental plot was 2.0 m × 2.0 m with spacing of 20 cm × 10 cm. The cultivar of garlic used for the present study was 'Kandaghat Selection'. In each treatment, ten plants were randomly selected from each replication for recording morphological and biochemical parameters. Total soluble solids (TSS) was estimated using a hand refractometer. Allicin content of bulbs of different treatments from each replication was determined with HPLC by using the method of British Pharmacopoeia 1998. Baghalian et al. (2005) provide a detailed description of this approach. **Treatment details:**

**List 1: Treatment no. with treatment details**

| **Treatment No.** | **Treatment Details** |
|---|---|
| $T_1$ | No application of fertilizers and Jeevamrit |
| $T_2$ | 100% recommended dose of NPK (125:75:60)kg/ha |
| $T_3$ | 100% recommended dose of NPK + 40kg S/ha |
| $T_4$ | 100% recommended dose of NPK + 50kg S/ha |
| $T_5$ | 100% recommended dose of NPK + 60kg S/ha |
| $T_6$ | 100% recommended dose of NPK + 40kg S/ha + 5% Jv* @ 1 L/$m^2$ |
| $T_7$ | 100% recommended dose of NPK + 50kg S/ha + 5% Jv @ 1 L/ $m^2$ |
| $T_8$ | 100% recommended dose of NPK + 60kg S/ha + 5% Jv @ 1 L/ $m^2$ |
| $T_9$ | 75% recommended dose of NPK + 40kg S/ha |
| $T_{10}$ | 75% recommended dose of NPK + 50kg S/ha |
| $T_{11}$ | 75% recommended dose of NPK + 60kg S/ha |
| $T_{12}$ | 75% recommended dose of NPK + 40kg S/ha + 5% Jv @ 1 L/ $m^2$ |

|  |  |
|---|---|
| $T_{13}$ | 75% recommended dose of NPK + 50kg S/ha + 5% Jv @ 1 L/ $m^2$ |
| $T_{14}$ | 75% recommended dose of NPK + 60kg S/ha + 5% Jv @ 1 L/ $m^2$ |

*Jv = First jeevamrit drenching after 15 days of sowing and repeated at fortnightly intervals (total 14 applications) FYM @ 250q/ha applied in all the plots (Except $T_1$)

**Preparation of Jeevamrit**

Jeevamrit drenching at fortnightly intervals and first drenching after 15 days of sowing was given. Table 1 shows the standardized techniques of preparing the Jeevamrit as suggested by Sreenivasa *et al*. (2010).

**Table 1: Ingredients of Jeevamrit used for drenching**

| **Ingredient** | **Quantity** |
|---|---|
| Cow dung | 10kg |
| Cow urine | 10L |
| Jaggry | 2 kg |
| Pulse Flour | 2 kg |
| Fertile Soil | 1 kg |
| Water | 200 L |

**Flow chart for the preparation of Jeevamrut**

Add fresh cow dung and cow urine in a plastic drum

↓

Mix jaggery + pulse flour and live soil in water and make the final volume

↓

Mix all the ingredients by stirring clockwise (morning and evening)

↓

On the fifth day, filter the solution and the filtrate is ready for soil drenching

↓

Jeevamrit 5 per cent was applied as a soil drench at the fortnightly interval and the first drench was given after fifteen days of sowing, the last application being fifteen days before harvesting

**Statistical analysis.** The experimental results were statistically analysed by using a general linear model of the standard errors of the mean. The data obtained in Randomized Complete Block Design (RCBD) for each parameter were tested by ANOVA using MS-Excel and OPSTAT. The difference between the treatments was compared by critical difference (CD) at a 5 per cent level of probability (confidence), wherever the results were significant. The calculated F-values were compared with tabulated F-values. When the F-test was significant, CD was then calculated to find out the comparative effectiveness among different treatments.

## Results and Discussion

### Growth and yield parameters

The plant height, number of leaves per plant, bulb weight, number of cloves per bulb, bulb diameter and bulb yield per hectare of garlic were significantly affected by the different treatments of integrated nutrient management. The plant height of garlic was significantly affected by the application of sulphur and jeevamrit (Table 2). S is the chief constituent of several enzymes and amino acids that are required for chlorophyll synthesis and it increases the uptake of N which is a chief constituent of chlorophyll (Verma *et al.*, 2013). S deficiency causes the accumulation of soluble N within the plant but prevents utilization of N (Charities & Carpentiers, 1956). Thus, increasing the level of S in turn improved plant growth by meeting higher nutritional demand for plant growth. The results also support the findings of Jawagadi *et al*. (2012) who reported that integrated nutrient management improved soil fertility by increasing organic carbon, available N, S, Mn and Fe and improvement in nutrient availability resulted in a significant increase in plant height.

**Table 2: Effect of different treatments of integrated nutrient management on growth and yield**

| Tr. No. | Plant height (cm) | No. of leaves/plant | Days to harvest | Bulb weight (g) | Bulb diameter (cm) | No. of cloves/bulb | Peeling index (%) | Bulb yield (q/ha) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 64.53 | 7.97 | 219.67 | 39.63 | 3.71 | 10.90 | 90.33 | 153.63 |
| $T_2$ | 72.63 | 8.73 | 230.33 | 51.67 | 4.53 | 12.50 | 93.82 | 194.33 |
| $T_3$ | 77.54 | 9.24 | 231.00 | 57.29 | 4.84 | 13.00 | 92.97 | 206.65 |
| $T_4$ | 80.48 | 9.61 | 231.67 | 60.22 | 5.05 | 13.22 | 90.92 | 213.62 |
| $T_5$ | 79.74 | 9.56 | 231.33 | 59.78 | 4.95 | 13.12 | 89.95 | 212.23 |
| $T_6$ | 82.65 | 9.87 | 234.00 | 61.57 | 5.06 | 13.37 | 93.65 | 220.88 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_7$ | 86.39 | 10.23 | 235.00 | 64.84 | 5.39 | 14.17 | 93.32 | 233.57 |
| $T_8$ | 86.15 | 10.15 | 235.33 | 64.25 | 5.28 | 13.90 | 93.54 | 231.66 |
| $T_9$ | 69.94 | 8.28 | 226.67 | 49.82 | 4.38 | 12.10 | 93.38 | 185.17 |
| $T_{10}$ | 72.55 | 8.71 | 228.00 | 51.37 | 4.49 | 12.47 | 92.26 | 191.40 |
| $T_{11}$ | 72.09 | 8.68 | 228.33 | 51.21 | 4.44 | 12.40 | 93.80 | 190.23 |
| $T_{12}$ | 73.83 | 8.90 | 229.00 | 53.53 | 4.57 | 12.63 | 92.94 | 196.09 |
| $T_{13}$ | 77.36 | 9.18 | 230.33 | 55.59 | 4.72 | 12.87 | 92.17 | 202.33 |
| $T_{14}$ | 77.29 | 9.07 | 230.33 | 55.22 | 4.65 | 12.87 | 90.43 | 202.03 |
| $CD_{0.05}$ | 2.38 | 0.52 | 2.16 | 1.88 | 0.19 | 0.86 | NA | 9.52 |

The number of leaves in a plant is directly correlated with the leaf area for photosynthetic activity and ultimately with yield. The photosynthates that are formed in the leaves are ultimately stored in the bulb as garlic is an underground crop. So, there is a direct correlation between leaf number, photosynthates manufactured in the leaves and the carbohydrates stored in the bulb. An increase in a number of leaves per plant under integrated nutrient management treatments might be due to the steady release of nutrients throughout the crop growth period. The above findings conform with the findings of Farooqui *et al.* (2009) and Anand *et al.* (2017). The application of jeevamrit might have increased the microbial population which may have led to improved nutrient availability thereby, resulting in a maximum number of leaves per plant. Findings are also supported by Chatoo *et al.* (2007). Increasing the dose of sulphur and jeevamrit application had a positive effect on several leaves as observed in treatment $T_7$, Similar results were also obtained by Verma *et al.* (2013) and Patidar *et al.* (2017).

The significant effect on bulb weight as a consequence of integrated nutrient management can be attributed to the increased nutritional status of the soil resulting in increased crop growth. This may be further attributed to the favorable effect of organic sources on microbial activity and root penetration in soil which might have caused a solubilizing effect on native nitrogen, phosphorus, potassium, sulphur and other nutrients. Maximum bulb weight in treatment $T_7$ (Table 2) might be due to the role of nitrogen on protein synthesis, chlorophyll and enzymatic activity; the role of P on root development, phosphor-lipid and phosphor- proteins formation as well as due to the role of K on the promotion of enzymes activity and enhancing the translocation of assimilates (El-Desuki *et al*., 2006). It might also be due to the role of sulphur in building up of sulphur-containing amino acids in plant cells, particularly in the early stage of plant growth and also it is the fourth major plant nutrient after nitrogen, phosphorus, and potassium (Havlin, 2004). These results are also confirmed by Magray *et al.* (2017) and Chattoo *et al.* (2019).

Application of sulphur increases the uptake of N which is a chief constituent of chlorophyll. Due to this reason, a significant increase in chlorophyll content and other growth and yield attributes was observed. The similar results also found by Zaman *et al*. (2011), Verma *et al.* (2013), Damse *et al*. (2014) and Shete *et al*. (2017). Sulphur is essential for building up sulphur-containing amino acids in plant cells, particularly in the early stage of plant growth and also it is the fourth major plant nutrient after nitrogen, phosphorus, and potassium (Havlin, 2004). Amino acids can either directly or indirectly affect the physiological processes that contribute to plant growth and development, according to studies. Additionally, amino acids are widely known as bio-stimulants that promote plant growth, increase yield, and greatly lessen the harm brought on by abiotic stresses. Anand *et al.* (2017), Patidar *et al*. (2017) and Singh *et al*. (2018) also reported a similar effect of sulphur. Kurubetta *et al.* (2017) reported that the application of jeevamrit has a significant effect on the yield parameters such as bulb weight, bulb diameter and number of cloves. Similar results of an increase in yield were reported by Manjutha *et al*. (2009).

**Quality Parameters**

Farooqui *et al*. (2009) reported that the increasing dose of nitrogen increases the dry weight of bulbs and bulb yield up to 150 kg N/ha. The availability of nitrogen is of prime importance for growing plants as it is a major constituent of protein and amino acids. Similar observations have also been recorded by Yadav *et al*. (2003) and Banafar and Gupta (2005). Neelima *et al.* (2011) reported that there was a significant improvement in the growth and yield in tomato plants with the combined application of liquid organic manures such as jeevamrit compared to RDF alone. Patidar *et al*. (2017) reported that 50 kg sulphur per hectare with RDF significantly increases the dry matter content of the bulb. This might be due to the role of sulphur in improving amino acids and that the uptake of nutrients directly enhances the dry matter accumulation in the bulb. Similar results were also reported by Damse *et al.* (2014) and Anand *et al.* (2017).

Oleoresin is an extremely concentrated product containing all the flavouring ingredients soluble in a particular solvent. Oleoresin content decides the quality and market value of the particular variety. Oleoresin content was significantly enhanced with the increasing levels of sulphur (Table 3). These results are in accordance with Jaggi (2004), Banafar and Gupta (2005) and Farooqui *et al*. (2009). According to Sindhu and Sekhon (2000), the improvement in the quality attributes due to various fertilizer treatments is directly correlated with the physico-chemical and biological properties of soil which enables roots to proliferate more resulting in better uptake and utilization of nutrients required for enhancing the quality of crop. The present findings are consistent with those of Mridula and Jayachandran (2001) and Velmurugen *et al.* (2008).

Singh *et al.* (2018) and Chattoo *et al.* (2018) also reported similar trends in total soluble solids with the application of sulphur. Sulfur is crucial for the growth and development of plants. It contributes to the production of amino acids like methionine, cysteine, and cystine. It is also responsible for the characteristic taste and smell of garlic like onion and mustard (Tisdale *et al*., 1985). Jeevamrit application also enhanced the total soluble solids content due to the conversion of organically bound sulphur to the inorganic form.

**Table 3: Effect of different treatments of integrated nutrient management on Quality parameters**

| Tr. No. | wt of unpeeled 100 cloves (g) | Dry matter content (%) | Oleoresin content (%) | TSS (°Brix) | Sulphur content (%) | Allicin (mg/g) |
|---|---|---|---|---|---|---|
| $T_1$ | 309.33 | 36.53 | 0.74 | 32.13 | 1.02 | 4.73 |
| $T_2$ | 373.33 | 39.23 | 1.08 | 33.77 | 1.11 | 5.28 |
| $T_3$ | 400.00 | 41.00 | 1.30 | 34.80 | 1.31 | 5.76 |
| $T_4$ | 418.33 | 42.25 | 1.42 | 35.30 | 1.42 | 5.94 |
| $T_5$ | 414.00 | 42.23 | 1.39 | 35.27 | 1.42 | 5.91 |
| $T_6$ | 421.67 | 42.98 | 1.42 | 35.47 | 1.38 | 5.95 |
| $T_7$ | 445.67 | 44.15 | 1.60 | 36.30 | 1.50 | 6.19 |
| $T_8$ | 443.33 | 44.05 | 1.61 | 35.97 | 1.52 | 6.15 |
| $T_9$ | 354.67 | 38.70 | 0.99 | 33.20 | 1.17 | 5.00 |
| $T_{10}$ | 370.33 | 39.08 | 1.10 | 33.60 | 1.26 | 5.15 |
| $T_{11}$ | 366.00 | 39.01 | 1.09 | 33.53 | 1.28 | 5.12 |
| $T_{12}$ | 370.00 | 40.44 | 1.14 | 33.83 | 1.23 | 5.23 |
| $T_{13}$ | 384.33 | 40.95 | 1.28 | 34.13 | 1.34 | 5.36 |
| $T_{14}$ | 382.33 | 40.91 | 1.25 | 34.17 | 1.35 | 5.33 |
| $CD_{0.05}$ | 17.60 | 0.83 | 0.14 | 0.63 | 0.06 | 0.23 |

The Allicin content of the bulb increased significantly with different treatments of integrated nutrient management might be due to sulphur application and an increase in inorganic sulphur in the soil. That ultimately enhances the sulphur-containing compounds.

## CONCLUSION

It can be concluded that among different treatments of integrated nutrient management the treatment comprising of 100% recommended dose of NPK + 50 kg S/ha + 5% Jv @ 1 L/ $m^2$ ($T_7$) performed best for most of the parameters under study.

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