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Small outer cloves treated with different combinations of fertilizers

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Abstract

A field experiment was conducted to evaluate the effect of combined inorganic and biofertilizers on the growth of garlic and its bulb yield, using small outer cloves as planting material. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four fertilizer treatments and three replications. Data were analyzed using Analysis of Variance (ANOVA) to determine if there was a significant difference among the treatments, and comparison of treatment means was further tested using Tukey's Honest Significant Difference (HSD) at 5% level of significance. Results showed that garlic applied with mykovam and vermicompost (T4) has the highest survival rate (82.67%), longest (43.64cm) and widest (1.0cm) leaves, the most number of leaves (7.47), maximum plant height (52.73cm), widest bulb diameter (3.21cm), the most number of cloves per bulb (19.40), and the heaviest fresh (199.58g) and dry (137.65g) weight, and highest projected yield (6.12tons/ha), but was comparable to all fertilizer treatments in terms of plant height, leaf length, bulb diameter, and number of cloves per bulb. Moreover, garlic applied with a full dose of commercial fertilizer (T1) had the shortest length of days of emergence comparable to garlic applied with 50% RR and mykovam (T2).

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Introduction

Garlic (*Allium sativum* L.) is a widely cultivated monocotyledonous herb known for its flavor and medicinal properties. It is a significant vegetable crop worldwide and has been used for centuries due to its culinary and health benefits. It is one of the main vegetable crops worldwide which has been used for its flavor and its medical value (Nasir *et al*., 2017). Garlic and its secondary metabolites have shown excellent health-promoting and disease-preventing effects on many human common diseases (Ansary *et al*., 2020).

Soil nutrient management plays a crucial role in garlic production, alongside factors such as cultivar selection, agronomic practices, climate, and postharvest storage (Diriba-Shiferaw *et al*., 2014). However, the continuous and indiscriminate use of chemical fertilizers has caused environmental harm, leading to the exploration of biological methods to enhance soil fertility and crop productivity. Biofertilizers, including Vesicular arbuscular mycorrhizal (VAM) fungi and vermicompost, have gained attention as sustainable alternatives to traditional fertilizers.

VAM fungi are known to facilitate nutrient uptake in plants, while vermicompost can improve soil fertility, enhance plant growth, and increase crop yield, making it a valuable organic fertilizer for sustainable agriculture, Singh *et al.* (2012). The findings will contribute to understanding sustainable agricultural practices that promote soil health and reduce reliance on chemical inputs in garlic production. Hence, to determine whether biofertilizer or their combinations with commercial fertilizers had any favorable effects on the growth and yield of garlic, this study was carried out.

Materials and methods

Study Site and Research Design

The field experiment was set up at the DMMMSU Compound, Sapilang, Bacnotan, La Union geographically situated at 16°43'39.7"N 120°23'13.2"E from November 2021 to February 2022. The study was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were the following: T1 – 100% Recommended Rate (RR) / Commercial fertilizer (80-60-60 N, P_2O_5, K_2O kg/ha); T2 - 50% RR + Mykovam; T3 - 50% RR + Vermicompost; T4 - Mykovam + Vermicompost. The complete fertilizer (14-14-14) and urea (46-0-0) were used to satisfy the recommended rate for garlic.

Garlic Acquisition

The garlic, particularly the *Ilocos white* variety was obtained from the Department of Agriculture-Ilocos Norte Research and Experiment Center satellite station in the City of Batac, Ilocos Norte, and transported by courier to Don Mariano Marcos Memorial State University.

Vernalization

The planting materials were stored in a cooling room for at least 2 to 3 weeks to allow the induction of bulbs from extreme weather. From vernalization, small outer cloves were separated from the bulb to be used as the planting material.

Land Preparation and Soil Sampling

The cloves were planted using minimum tillage after rice harvesting. Soil sampling and testing were carried out.

Soil Characteristics

The experimental area is well-drained soil, silty loam texture, medium organic matter content (3.07%), high in available P (31ppm), medium exchangeable K (0.54cmol(+) /kg soil), and moderately acidic soil pH (5.78).

Planting

Before planting, cloves were treated with malathion. The cloves were sown upright from the soil at 1cm to 3cm depth by using a dibble to insert 2/3 of the length of the clove with a planting distance of 15cm x 15cm between hills. The bed was laid with rice straw as mulching material with a 2-3cm thickness to maintain moisture content and control weed emergence. The garlic that was planted is physiologically mature and has developed bulbs from small outer cloves. Moreover, it is free from diseases and mechanical damage for good growth and development.

Irrigation

Irrigation was done 1–2 days before planting to guarantee sufficient moisture content. The amount of water that was applied depended on the soil type. The irrigation was done manually using a pail with a sprinkler. The duration of irrigation was started before planting and ended up 70 to 85 days after planting.

Harvesting

Harvesting was done 100–120 days after planting until the plants were observed with 80% yellowing of the leaves. The bulb was manually pulled and removed the undesirable debris to ensure a clean harvested bulb.

Data Gathering

Days of emergence. This was done by observing the number of days at which a shoot emerged from the clove.

Survival rate (%). This was taken by counting the number of survived plants per plot at harvesting divided by the total number of cloves planted then multiplied by 100.

Plant height (cm). This was done by measuring the height of 10 randomly selected garlic plants using a tape measure at 45 DAP, 60 DAP, and 75 DAP.

Leaf length (cm). This was done by measuring the length of leaves of 10 randomly selected garlic plants using a tape measure at 45 DAP, 60 DAP, and 75 DAP.

Leaf width (cm). This was done by measuring the width of the leaves of 10 randomly selected plants using a tape measure at 45 DAP, 60 DAP, and 75 DAP.

Number of leaves. This was done by counting the number of leaves of 10 randomly selected garlic plants at 45 DAP, 60 DAP, and 75 DAP.

Number of cloves per bulb. This was done by counting the number of cloves per bulb on 10 random bulb per plot at harvest.

Bulb Diameter (cm). This was taken by measuring the diameter of 10 randomly selected bulbs per plot after curing using manual vernier caliper and then dividing it by 10 to get the average.

Fresh weight and dry weight (g). This was taken by weighing 10 randomly selected bulbs per plot during harvest and after sun drying.

Yield per hectare. The yield per hectare was projected based on the yield of 10 random dry bulbs per plot using this formula:

$$Yield/ha = \frac{Yield\ of\ 10\ sample\ bulbs, kg}{area\ of\ 10\ hills, m^2} = \frac{x}{10{,}000m^2}$$

Result and discussion

Growth Parameter

Table 1 presents the mean number of days of emergence and mean survival rate (%) of the garlic plants under each treatment. Garlic under T1 (100% commercial fertilizer) had the shortest day of emergence at 2.29, which was comparable to T2 (50% RR + mykovam), with an average number of days of emergence of 2.71. Having an average of 3.15 days of emergence, garlic applied with mykovam + vermicompost had the longest day of emergence. This was found to be comparable with T3 (50% RR + vermicompost) at 2.88 and T2 (50% RR + mykovam) at 2.71 days.

Table 1. Growth parameter.

Treatment	Number of days of emergence	Survival Rate (%)
T1- 100% Recommended rate	2.29 b	47.33 b
T2- 50% RR + Mykovam	2.71 ab	67.67 ab
T3- 50% RR + Vermicompost	2.88 a	59.00 b
T4- Mykovam+ Vermicompost	3.15 a	82.67 a

Means with the same letter in a column are not significantly different at α=0.05 level (Tukey's HSD).

Results implied that application of vermicompost + mykovam did not affect much the number of days of emergence of garlic plants from the small outer cloves. Meanwhile, Garlic applied with mykovam + vermicompost (T4) obtained the highest survival rating of 82.67%, which was comparable to T2 (50% RR + mykovam) with a survival rate of 67.67%.

Garlic applied with pure commercial fertilizer (T1) had the lowest survival rate of 47.33%, which was comparable both to T2 (50% RR + mykovam) and T3 (50% RR + vermicompost). This suggests that the application of biofertilizers has significantly affected the survival of garlic plants.

Vegetative Characteristics of Garlic

Table 2 presents the mean plant height, leaf length, leaf width, and number of leaves at 45 DAPS, 60 DAP, and 75 DAP. Simple main effects analysis showed that different fertilizer treatments did have a statistically significant effect on the plant height of garlic ($p = .004$). Post-hoc analysis showed that garlic provided with biofertilizers (T4) had the highest plant height (50.6cm) which is statistically different from the plant heights applied with the other three fertilizer treatments. The other treatments are comparable to each other. Results imply that mykovam + vermicompost as fertilizer has the best effect on the vegetative growth of garlic in terms of leaf length. This implies that these biofertilizers can serve as substitute to the commercial and inorganic fertilizers. On the other hand, application of combinations of biofertilizers and commercial fertilizers has the same effect as the full recommended rate of commercial fertilizer in terms of plant height of garlic. This also means that addition of biofertilizers to commercial fertilizers can be an alternative way to commercial fertilizer. The findings agrees with the study of Zaki (2014) where it showed that application of organic treatments gave the highest values of vegetative parameters compared with control (100% of RR of inorganic fertilizers) and treatments of compost combined with 50% or 100% of RR inorganic fertilizers improved the plant height. Also, the results corroborate the findings of Kumar and Singh (2020) which showed that the maximum height of plant was noted under a treatment with VAM.

As to the leaf length, post-hoc analysis showed that garlic applied with biofertilizers mykovam and vermicompost had the longest leaf length (42.34cm) which is statistically comparable with garlic applied with mixtures of vermicompost and commercial fertilizer (39.07cm) but is statistically different with the other two treatments T1 and T2. Fertilizer treatments with full or partial application of inorganic fertilizers are found to be comparable to each other. Results imply that mykovam + vermicompost and inorganic fertilizer + vermicompost have the best effect on the vegetative growth of garlic in terms of leaf length. This also suggests that addition of vermicompost has good effect on the growth of leaf of garlic plants. On the other hand, application of combinations of mykovam and commercial fertilizers has the same effect as the full recommended rate of commercial fertilizer in terms of plant height of garlic. This also means that addition of mykovam to commercial fertilizers is as good as full application commercial fertilizers.

Post-hoc analysis showed that garlic applied with biofertilizers mykovam and vermicompost had the widest leaves (42.34cm) which is statistically different with the other three treatments T1, T2 and T3. Garlics applied with mixtures of biofertilizers and inorganic fertilizer are found to be comparable to each other. Garlic applied with pure inorganic fertilizer gained the minimum leaf width which is significantly lower than the three treatments. Moreover, results imply that mykovam + vermicompost (T4) has the best effect on the vegetative growth of garlic in terms of leaf length.

Furthermore, results also revealed that garlic applied with biofertilizers mykovam and vermicompost (T$) had the most number of leaves (6.46) which is statistically comparable with garlic applied with mixtures of biofertilizers and commercial fertilizer but is statistically different with garlic treated with full recommended rate of commercial fertilizer (T1). Results imply that application of mixtures mykovam and vermicompost or combination of these biofertilizers and inorganic fertilizer and vermicompost is a good alternative to inorganic fertilizers applications in garlic plants. These results are in conformity with the findings of Meena *et al.* (2019) and Kumar and Singh (2020). In their study, it was found out that maximum number of leaves per plant was noted under two treatments with VAM and minimum number of leaves was recorded under the control treatment. The increase in the vegetative growth of garlic plants by biofertilizers might be due to its effect on increasing availability of nitrogen and phosphorus beside improving biological fixation of atmospheric nitrogen and produce hormones and anti-metabolites in root zone (Zaki *et al.*, 2014).

Bulb Characteristics

The bulb diameter and number of cloves per bulb was presented in Table 3. Application of 50% commercial fertilizer + vermicompost (T3) produced the lowest bulb diameter of 2.60cm. This was followed by those garlics applied with 100% commercial fertilizer and 50% commercial fertilizer + mykovam, with bulb diameters of 2.69cm and 2.73cm, respectively. The largest bulb diameter was recorded with the application of mykovam + vermicompost, at 3.21cm, which was remarkably higher than the other 3 treatments. However, there was no significant difference in the mean bulb diameter observed among them. This means that applications of the three mixtures of fertilizers produced the same garlic bulb diameter as compared with the pure commercial fertilizer. Similar results have been reported by Gowda *et al.* (2007) and Singh *et al.* (2012) in garlic where they found out that application of vermicompost resulted in vigorous vegetative growth and greater accumulation of food material which ultimately increased the quality of bulb.

Table 2. Vegetative characteristics of garlic.

Treatments	Plant height, cm				Leaf length, cm				Leaf width, cm				Number of leaves			
	45 DAP	60 DAP	75 DAP	Mean	45 DAP	60 DAP	75 DAP	Mean	45 DAP	60 DAP	75 DAP	Mean	45 DAP	60 DAP	75 DAP	Mean
T1- 100% Recommended rate	40.78	45.87	48.10	44.92b	36.55	36.93	39.06	37.51b	0.69	0.76	0.83	0.76c	5.08	6.08	6.23	5.80b
T2- 50% RR + Mykovam	39.95	45.07	47.33	44.12b	36.00	37.02	38.78	37.27b	0.75	0.81	0.88	0.81b	5.23	6.30	6.53	6.02ab
T3- 50% RR + Vermicompost	40.40	47.80	48.92	45.71b	37.52	39.36	40.32	39.07ab	0.76	0.84	0.91	0.84b	5.23	6.22	6.57	6.00ab
T4- Mykovam+ Vermicompost	48.32	50.83	52.73	50.6a	40.80	42.59	43.64	42.34a	0.845	0.93	1.00	0.93a	5.32	6.60	7.47	6.46a

Means with the same letter in a column are not significantly different at α=0.05 level (Tukey's HSD).

Bulb Characteristics

The bulb diameter and number of cloves per bulb was presented in Table 3. Application of 50% commercial fertilizer + vermicompost (T3) produced the lowest bulb diameter of 2.60cm . This was followed by those garlics applied with 100% commercial fertilizer and 50% commercial fertilizer + mykovam, with bulb diameters of 2.69cm and 2.73cm, respectively. The largest bulb diameter was recorded with the application of mykovam + vermicompost, at 3.21cm, which was remarkably higher than the other 3 treatments. However, there was no significant difference in the mean bulb diameter observed among them. This means that applications of the three mixtures of fertilizers produced the same garlic bulb diameter as compared with the pure commercial fertilizer. Similar results have been reported by Gowda *et al.* (2007) and Singh *et al.* (2012) in garlic where they found out that application of vermicompost resulted in vigorous vegetative growth and greater accumulation of food material which ultimately increased the quality of bulb.

Meanwhile, the highest number of cloves per plant of 19.40 was observed with T4 (mykovam + vermicompost). The corresponding lowest number of cloves per bulb of 16.93 was recorded under T1 (100% commercial fertilizer). Moreover, garlics applied with 50% commercial fertilizer + mykovam (T2) and 50% commercial fertilizer + vermicompost (T3) had an average number of cloves per plant of 17.90 and 17.20, respectively. Analysis of variance showed that there was no significant difference in the number of cloves per bulb among the treatments. This suggested that applications of the three mixtures of fertilizers significantly produced the same number of cloves per bulb in comparison with the pure commercial fertilizer.

Table 3. Bulb characteristics and yield parameters.

Treatments	Bulb diameter (cm)	Number of cloves / bulb	Yield, dry weight (g)	Yield, fresh weight (g)	Projected yield, t/ha
T1- 100% Recommended rate	2.69	16.93	91.97b	112.65b	4.09b
T2- 50% RR + Mykovam	2.73	17.90	95.57b	124.06b	4.25b
T3- 50% RR + Vermicompost	2.60	17.20	80.39b	106.82b	3.57b
T4- Mykovam+ Vermicompost	3.21	19.40	137.65a	199.58a	6.12a

Means with the same letter in a column are not significantly different at α=0.05 level (Tukey's HSD)

Yield Parameter

The average fresh and dry yield as well as the projected yield was presented in Table 3. The results indicated that there was an observed significant variation among the treatments in the two yield parameters. Garlic applied with mykovam + vermicompost produced the heaviest dry and fresh weights of 137.65g and 199.58g, respectively, which were significantly higher compared to the other treatments. Garlic under commercial fertilizer (T1) had the lowest yields of 112.65g in fresh weight and 91.97g in dry weight. These yields were comparable to 95.57g and 124.06g, the dry and fresh weights under T2 (commercial fertilizer + mykovam), and 80.39g and 106.82g, the dry weight and fresh weight under T3 (commercial fertilizer + vermicompost).

Results suggest that the application of the combination of biofertilizers, mykovam and vermicompost, leads to a better yield of garlic compared to the full and partial application of commercial fertilizers. Furthermore, the same trend was observed for the projected yield of garlic. Garlic applied with mykovam + vermicompost (T4) obtained the highest projected yield with 6.12 tons/ha for dry weight basis and was significantly different among all other treatments.

This further suggests that these biofertilizers can serve as an alternative to commercial fertilizer in producing better harvest in garlic. Results of this study conformed with the study of Kumar and Singh (2020) which showed that the application of VAM had obtained the best response of garlic in terms of yield.

Conclusion

Based on the salient findings of this research study on garlic, the following conclusions were drawn: a) Garlic applied with mykovam + vermicompost has the longest and widest leaves, the most number of leaves, and the highest plant height, while garlic applied with full dose of commercial fertilizer has the shortest length of days of emergence. b) Garlic applied with mykovam and vermicompost (T4) has the highest bulb diameter, most number of cloves per bulb, and heaviest fresh and dry weight, and the highest projected yield.

Recommendation

Based on the conclusions derived from this study on garlic, the following are recommended: a) Application of biofertilizers like vermicompost and mykovam is recommended for better vegetative growth of garlic. b) Biofertilizers like mykovam and vermicompost are recommended as addition to inorganic fertilizers in producing high yield for garlic.

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