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Growth and Yield Response of Garlic *(Allium sativum L.) under Organic Production System*

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Abstract
Aim: The study aimed to evaluate the effect of various growth promotant applied as foliar spray on garlic cultivation.
Methodology: Five foliar fertilizers (Vermitea, Fermented Fruit Juice, Manure Tea, AMO, and Gibberellic acid) and pure water as control each applied at a rate of three liters per hectare, along with basal application of vermicompost at 10 bags per hectare were subjected to a Randomized Complete Block Design (RCBD) with three replications. The study was conducted at the Provincial Plant Nursery – Annex of the Provincial Agriculture Office located at Brgy. Alibagu, City of Ilagan, Isabela from September to December, 2022 to determine the effects of growth enhancers as foliar spray on garlic. Using five sources of foliar fertilizers, the study was laid out in RCBD replicated three times.
Results: Based on the findings of the study, the utilization of growth promotant particularly AMO or Vermitea, into the cultivation practices enhances the weight of garlic bulbs, consequently increasing the overall bulb yield.
Conclusion: The application of growth promotants through foliar spray had a significant effect on the fresh and dry weights as well as the bulb yield of garlic. Particularly, among the foliar fertilizers tested, AMO and Vermitea resulted in the highest bulb weight, leading to increased profits. These discoveries underscore the potential advantages of foliar fertilizers in augmenting both garlic bulb weight and overall yield, showing its potential applicability in garlic cultivation.

Keywords: *Garlic, growth promotant, foliar fertilizer, bulb*

INTRODUCTION

The Philippines is still among the countries rich in natural resources and its fertile land produces varieties of agricultural crops and spices. One of these often used spices across the country is garlic, or "bawang" as it is commonly referred to in the Philippines. All varieties grown in the Philippines are native ones such as Batangas White, Ilocos White, and Batanes White. Despite being smaller in size, native garlic is more expensive and has a stronger flavor and aroma. It is one of the most important food products in the world and an ancient and widespread medicinal herb. It is rich in minerals and vitamins, which are both essential nutrients for human health. (Gambeli, et al., 2021)

Increasing garlic yield and enhancing bulb quality are crucial for profitable production. In the current global context, there is a strong emphasis on adopting eco-friendly agricultural practices for sustainable farming (Fawzy et al., 2012). There has been significant focus on reducing pollution sources in modern agriculture and one effective approach to minimize soil pollution is the use of organic fertilizers and foliar fertilizers, which are organic-based.

These nutrient sources are widely used for their safety and effectiveness in ensuring rapid and efficient nutrient uptake, improving yield and quality, mitigating stress, and complementing soil fertilization for optimal plant health and productivity. The challenge for resource management is to consider the welfare of the ecosystem. This approach helps to ensure the concern for environmental awareness aligning with SDG 12 aiming for sustainable management and efficient use of natural resources to promote better production, improved nutrition, a healthier environment, and a better quality of life.

With this scenario, it is essential to explore ecologically sustainable alternatives that enhance both the quantity and quality of garlic. Although most growers use the recommended fertilizer doses to boost output, they

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might not realize that one or more micronutrients could be limiting their yields which are supplemented by the foliar fertilizer. Considering these points, an experiment was conducted to evaluate the effectiveness of foliar fertilizers as growth promotants for garlic.

The study's scope is limited to the growth and yield of garlic that has been amended with a growth promoter. For a single cropping season (off-season planting), the following parameters were gathered: plant height, number of leaves, number of cloves, and bulb weight.

Objectives

The study aimed to evaluate the effect of various growth promotants applied as foliar sprays on garlic cultivation. Its Specific objectives

1. determine the effect of growth promotant on the growth and yield of garlic;
2. determine which among the growth promotant increases the yield of garlic; and
3. assess which among the growth promotant is the most economical in terms of the return on investment.

MATERIALS AND METHODS

Description of the Experimental Area

The experimental area used is previously planted with vegetables and more or less levelled and provided with good drainage and source of artificial irrigation. It was located besides the nursery area of the Provincial Agriculture Building and used as demonstration area for high vegetable crops production.

Soil Analysis

Soil samples from the experimental area were collected and air-dried for three days. These were brought at the Soils Laboratory of the Department of Agriculture, Soils Laboratory, Tuguegarao City, Cagayan for analysis.

Land Preparation

The area was plowed two times using a hand tractor with two (2) weeks intervals. Harrowing was done manually to secure good aeration of the soil and to eliminate weeds prior to planting.

Source of Planting Materials

The cloves of garlic were obtained from the Provincial Agriculture's Office, Ilagan City. Uniform sizes of garlic cloves were prepared for planting. Fully-matured and well-developed bulbs from the native variety were used in the study. These were from diseases and mechanical damage to ensure healthy plants. The garlic bulbs were soaked into water with fungicide for two (2) hours to get rid from soil-borne diseases. These were air dried before planting. The planting material was prepared by separating the cloves from one another. The cloves from the outer parts of the bulb were chosen as these are best used for planting material.

Laying-out of the Experimental Area and Design

An area of 101.50 square meters were divided into three (3) equal blocks and each block were further subdivided into 6 plots wherein each plot had a dimension of 1 meter by 3.5 meters. Alley ways of 1 meter between blocks and 0.5 meter between plots were provided.

Fertilizer Application

Basal application of organic fertilizer (vermicompost) was done to improve the physical conditions of the soil before planting. The fertilizer rate was adjusted based on the recommended application rate. The application of growth promotants as foliar spray at the rate of three liters per hectare was done at 30 and 60 days after planting (DAP).

Planting and Replanting

Two cloves of garlic were planted in every hill at a spacing of 20 cm between row and 20 centimeters between hills. Planting was done in the afternoon immediately followed by irrigation for proper establishment. All other recommended package of practices was followed to raise a healthy crop. Missing hills were replanted 10 days after planting to maintain the desired plant population.

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Application of Mulching Materials

Rice straw was applied evenly in all plots two weeks after planting to maintain the moisture and to prevent the emergence of weeds in the area.

Treatments

The different growth promotants as treatments are as follows:

T1 – Vermitea (3 Liters per hectare)
T2 – Fermented Fruit Juice (FFJ) (3 Liters per hectare)
T3 – Manure Tea (3 Liters per hectare)
T4 – AMO (3 Liters per hectare)
T5 – Gibberellic Acid (GA3)
T6 – Control (Pure Water)

The dilution of the different foliar fertilizers as growth promotant was based on the recommended rate of application applied as foliar spray.

Care and Management of the Plants

a. Weeding. The experimental plots were kept weed free. Hand weeding was done as soon as weeds emerged in the area. The crop was sprayed with fungicide to keep the crop free from pest during the growth period.

b. Control of Insect Pests. Spraying of pesticide was done to control and minimize insect infestation in the area as the need arises.

c. Irrigation. Light irrigation was applied just after planting and subsequent irrigation was done as the need arises.

Harvesting

The garlic plants matured at 120 days after planting. The indices are the softening of the main stem above the bulb and the yellowing of 75% of the leaves. Harvesting was done by pulling the individual plants by hand.

Collection of Data and Analysis

For the collection of data, ten (10) sample plants were randomly pick and tag from each treatment for the following parameters.

1. Plant Height (cm). The height of plant was taken from crown region to its tip by using the meter stick from 30 and 60 days after planting.

2. Number of Leaves per Plant. The number of leaves of per plant randomly selected per treatment were counted at 30 and 60 days after planting.

3. Number of Cloves. The numbers of cloves were taken from each bulb through manual method by breaking the bulbs.

4. Bulb Weight (g). The weight of bulbs was taken by the use of weighing balance.

Statistical Analysis of Data

All collected data were statically analyzed following the ANOVA for Randomized Complete Block Design. All significant F results were compared using the Tukey's Honestly Significant Difference (HSD) test at 1 % level of significance.

OBSERVATION AND DISCUSSION OF RESULTS

Observations

1. Percentage Germination. Approximately 90% of the cloves sprouted from the ground within 10 days after planting.

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2. Seedling Vigor. Plants treated with growth promotant from various sources exhibited robust growth, as evidenced by the by the erect and green leaves. Towards development, the plants in all treatments registered uniform heights including the control plants.

3. Occurrence of Insect Pests and Diseases. There was occurrence of slight neck rot in some of the plants. This was distinctly differed from the natural senescence of the oldest leaves on healthy onions, which occurs when the plants reach mid-bulbing. To minimize the incidence, pesticide was applied following the recommended rate of application. Likewise, furrow irrigation was applied whenever necessary.

Discussion of Results

Plant Height. Data presented in Table 1 shows that the different growth promotant applied as foliar spray did not affect the height of garlic plants at 30 days after planting. The result showed that all the plants have uniform growth compared to the control group (without foliar application) with mean ranging from 24.22 cm to 28.19 centimeters.

Considering the height of the plants at 60 days after planting, likewise there was no significant increase observed in any of the treatment groups including the control (Table 1, Column 2). The result showed that treatment's effect did not result in the significant growth increase across all treatment groups compared to the control, with average mean ranging from 28.87 cm to 31.41 centimeters.

The lack of a significant effect observed with the use of growth promotant over control plants could be attributed to the soil's fertility from organic fertilizer applied as basal which are sufficient and enough to meet the crop's requirements at early growth of the plants. When soil fertility is already optimal, additional nutrients applied via foliar fertilizers might not lead to noticeable improvements in plant growth. In such cases, the plants may not respond significantly to the added nutrients because their needs are already being adequately met from the the soil. Moreover, blanket application of vermicompost in all treatments that contain micronutrients apart from macronutrients and plant growth promoters, enzymes, beneficial bacteria and mycorrhizae (Gupta, 2005) leading to a more vigor plants.

Table 1. Plant Height of Garlic at 30 and 60 Days after Planting (cm) as affected by Different Growth Promotants

TREATMENTS	**Height (cm)**	
	30 DAP	60 DAP
T_1 – Vermitea (3 L ha^{-1})	25.65	29.63
T_2 - Fermented Fruit Juice (FFJ) (3 L ha^{-1})	25.40	31.41
T_3 – Manure Tea (3 L ha^{-1})	28.19	29.21
T_4 – AMO (3 L ha^{-1})	27.69	30.99
T_5 – Gibberellic Acid (GA_3)	24.22	28.87
T_6 – Control	25.23	30.39
F- RESULTS	ns	ns
C. V. (%)	9.35	10.37

ns- not significant

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Number of Leaves per Plant. The application of growth promotant recorded at 30 days after planting failed to influence the difference on number of leaves of garlic. Leaf number from 2.67 to 3.67 counts showed that the growth promotant as treatments had similar effect as compared to the control treatments. The result might be due to garlic plants which did not respond to growth promoters and did not influence the leaf production as compared to the control which were applied without growth promotant.

No significant differences were observed in all treatments in terms on leaf number in garlic. Regardless of sources of growth promotant leaf number at 60 days after planting were comparable with mean values ranging from 3.67 to 4.00. This might be attributed to the inherent and genetic variation of the garlic variety in their growth habit and other physiological traits like the number of leaves.

Table 2. Number of Leaves at 30 and 60 Days after Planting as affected by Different Growth Promotants

TREATMENTS	Number of Leaves	
	30 DAP	60 DAP
T_1 – Vermitea	2.67	4.00
T_2 - Fermented Fruit Juice (FFJ)	3.67	3.33
T_3 – Manure Tea	2.67	3.67
T_4 – AMO	3.67	4.00
T_5 – Gibberellic Acid (GA_3)	3.67	4.00
T_6 – Control	3.33	4.00
F- RESULTS	ns	ns
C. V. (%)	17.37	8.35

ns- not significant

Number of Cloves. There was no notable variation recorded on the number of cloves per garlic bulb among all treatment. Regardless of the control treatments, it showed a slightly lower average value of 13.90 cloves, a similar trend was observed in plants treated with growth promotant where clove production ranged from 14.30 to 16.23. The unresponsiveness of the cultivar to growth promotant resulting in no significant increase in clove number could be due to cultivar used. This is evident as reflected in the comparable results reflected in the growth parameters, including plant height, leaf number, and cloves production which may be due to enhanced vegetative growth and bulb filling by nitrogen content from growth promoters (Tadila, 2011). On the other hand, growth promoter that contains organic molecules may affect the growth, development, and other physiological activity in the plant positively or negatively.

Table 3. Number of Cloves of Garlic as affected by Different Growth Promotants

TREATMENTS	Number of Cloves
T_1 – Vermitea	15.70
T_2 - Fermented Fruit Juice (FFJ)	15.27
T_3 – Manure Tea	14.30

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T_4 – AMO	16.23
T_5 – Gibberellic Acid (GA_3)	15.20
T_6 – Control	13.90
F- RESULTS	ns
C. V. (%)	3.11

ns- not significant

Fresh Weight of Bulbs (g). Fresh weight of bulbs per plant was remarkably influenced by the application of growth promotant. Heavier fresh bulb weight was noted by the treatment applied with AMO (27.52 grams) and gibberellic acid (26.19 grams). The observed increase in fresh bulb weight can be attributed to the multiple effects of AMO and gibberellic acid on plant physiology, including promoting cell growth, enhancing nutrient uptake, delaying senescence, inducing metabolic processes, and optimizing hormonal balance. AMO made from kelp seaweed extracts have many positive effects such as stimulated seed germination, enhanced plant growth, root development, leaf quality and yield, improved resistance to biotic and abiotic stresses, as well as increased post-harvest shelf life (Khan, 2009).

On the other hand, plants applied with neem products which produced mean fresh bulb weight of 26.19 grams were likewise superior with other treatments. Neem products not only improve soil structure as well as increases water holding capacity, but having insecticidal and nematicidal properties that promotes plants' growth and development. These effects collectively contribute to the overall improvement in fresh weight per plant which is similar to the study of Karaat (2011) on potato that gibberellic acid promotes size distribution ratio among tubers from largest tuber to smallest tuber. Moreover, neem is one of the plant sources of botanical insecticides that can be used for pest control.

With regards to the weight of fresh bulb applied with other sources of growth promotants, plants applied with Fermented Fruit Juice registered men values with 23.45 grams, manure tea with 21.82 and vermitea with 21.65 grams while mean fresh bulb in the control plot (15.57 grams) was significantly lower than all treatments which might be due to the absence of active substances thus reduce fresh weight of bulb. The poor yield of garlic observed without foliar spray (T6) is attributed to a lesser absorption of nutrients through the roots of the plants. Similar results were observed in tomato (Yadav et al., 2002), okra (Sundaram and garlic (Yadav, 2005).

Benefits of growth promotant as foliar spray is directly penetrated through leaf cuticle or stomata leads to efficient absorption and translocation of nutrients to increase plant metabolites for better allocation of photosynthesis from source to sink resulted in enhanced crop yield. Higher yield was observed in AMO and gibberellic acid with foliar spray of three liters per hectare is in accordance with earlier findings of Yadav (2002). Furthermore, when soil conditions are unfavorable and micro-nutrients are needed to the plants, foliar applications may be accomplished in terms of contemporary technique for correction of nutrient level in plants.

Table 4. Fresh Weight of Cloves per Plant (g) as affected by Different Growth Promotants

TREATMENTS	**Weight of Cloves (g)**
T_1 – Vermitea	21.65^b
T_2 - Fermented Fruit Juice (FFJ)	23.45^b
T_3 – Manure Tea	21.82^b
T_4 – AMO	27.52^a

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T_5 – Gibberellic Acid (GA_3)	26.19[a]
T_6 – Control	15.57[c]
F- RESULTS	**
C. V. (%)	3.15

Note: *Means with common letter are not significantly different with each other using Tukey's HSD*
***- significant at 1% level*

Dry Weight of Bulb (g). Significant increase in dry bulb weight (15.78 g) was observed when using AMO foliar fertilizer which was comparable to the yield achieved with vermitea application (14.32 g). This suggests that both treatments contributed similarly to enhancing plant yield. The plants treated with different foliar fertilizer showed varying dry bulb weights. Specifically, those treated with manure tea achieved 13.86 grams, followed by gibberellic acid at 13.38 grams, and fermented fruit juice at 13.02 grams. In contrast, plants that did not receive any foliar spray exhibited the lightest bulb weight, with only 8.05 grams. This demonstrates the effect of the different treatments on the dry bulb weight with certain substances evidently contributed to increased bulb weight compared to untreated plants.

The analysis of this parameter showed that dry bulb yield was significantly influenced by the effect growth promotant as foliar spray particularly AMO and vermitea. In comparison, the marketable yield of garlic was increased by 96.02 percent in AMO treated plants and 77.88 percent for the plants applied with vermitea. This may be ascribed to the availability of optimum nutrients contained in AMO and vermitea that may have led to increase bulb weight. AMO foliar fertilizer has many positive effects such as stimulated seed germination, enhanced plant growth, root development, leaf quality and yield, improved resistance to biotic and abiotic stresses, as well as increased post-harvest shelf life. Besides, the contents of total soluble protein, phenolics and flavonoid, as well as antioxidant capacity of the plants could be increased under the treatment of AMO (Fan. 2013).

On the other hand, vermitea, based on its composition, includes dissolved nutrients, organic acids, and earthworm mucus (Singh et al., 2011). This concoction has been found to significantly enhance plant vigor, nutritional content, and crop yield (Chen, 2006). Additionally, the application of vermicompost has been shown to stimulate tap root elongation (Siddiqui et al., 2008; Keeling et al., 2003).

Table 5. Dry Weight of Bulb per Plot (g/3.50 m2) as affected by Different Growth Promotants

TREATMENTS	**Weight of Bulb (g)**
T_1 – Vermitea	859.20[ab]
T_2 - Fermented Fruit Juice (FFJ)	781.20[b]
T_3 – Manure Tea	831.60[b]
T_4 – AMO	946.80[a]
T_5 – Gibberellic Acid (GA_3)	802.80[b]
T_6 – Control	483.00[c]
F- RESULTS	**
C. V. (%)	13.63

Note: Means with common letter are not significantly different with each other using Tukey's HSD
***- significant at 1% level*

Projected Bulb Yield per Hectare. The projected bulb yield per plot was projected into per hectare and was expressed in tons and gradually increase with the application of foliar fertilizer (Table 6). It shows an increasing

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trend with the application of foliar fertilizer. Notably, the yield of plants treated with AMO foliar fertilizer (T4) exhibited a significant difference, with a remarkable yield increase of 96.02 percent compared to the control treatment. Following closely was T1 (Vermitea), which produced a yield of 2.45 tons per hectare, which recorded a substantial increase of 77.88 percent. Similarly, plots treated with manure tea yielded 2.45 tons per hectare, showing a yield increase of 77.88 percent. The application of Gibberellic Acid (GA3) in T5 resulted in a yield of 2.29 tons per hectare, indicating an increase of 66.21 percent, while Fermented Fruit Juice (FFJ) in T2 yielded 2.33 tons per hectare, reflecting a 61.73 percent increase compared to the control plants.

Table 6. Projected Yield per Hectare of Garlic as affected by Different Growth Promotants

TREATMENTS	**YIELD PER HECTARE**		**Percentage Increase over the Control (%)**
	Kilograms	Tons	
T_1 – Vermitea	2454.85	2.45	77.88
T_2 - Fermented Fruit Juice (FFJ)	2232.00	2.23	61.73
T_3 – Manure Tea	2376.00	2.37	72.17
T_4 – AMO	2705.14	2.70	96.02
T_5 – Gibberellic Acid (GA_3)	2293.71	2.29	66.21
T_6 – Control (Pure Water)	1380.00	1.38	

Cost and Return Analysis. The cost and return analysis of producing one-hectare garlic using different foliar fertilizers is presented. In descending order, it shows that plots supplemented with AMO foliar fertilizer obtained the highest return on investment with 124.59 percent. Followed by the plants in Treatment 1 (Vermitea) with 106.19 percent, T (manure tea) with 97.26 percent, T5 (Gibberellic Acid) with 90.43, T2 (Fermented Fruit Juice) with 85.31 percent and the lowest with 161.35 percent was noted in Treatment 6 (Control) with 14.57 percent. Cost of garlic @ P90.00 per kg

Projected Cost and Return Analysis

TREATMENTS	TOTAL COST OF PRODUCTION	GROSS INCOME	NET INCOME	ROI (%)
T1	107150	220936.50	113786.50	106.19
T2	108400	200880.00	92480.00	85.31
T3	108400	213840.00	105440.00	97.26
T4	108400	243462.60	135062.60	124.59
T5	108400	206433.90	98033.90	90.43
T6	108400	124200.00	15800.00	14.57

Summary

The study was conducted at the experimental area of the Provincial Agriculture Office, Ilagan City, Isabela from September to December, 2022 to determine the effects of growth enhancers as foliar spray on garlic. Using five sources of foliar fertilizers, the study was laid out in RCBD replicated three times. Results of the study are summarized as follows:

1. Any of the growth promotants as foliar spray did not influence plant height 30 and 60 days after planting.
2. The use of any of the growth promotant did not increase leaf production at at 30 and 60 days after planting.
3. There was no significant difference in the number of cloves per bulb of garlic across various treatments.

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4. Plants applied with AMO and gibberellic acid as foliar spray resulted in heavier fresh bulb weights.
5. The effectiveness of AMO and vermitea applied as foliar spray led to significant increases in dry bulb weight with 96.02 and 77.88 percent, respectively over the control plots.
6. An increasing trend in yield was noted with the use of foliar fertilizer particularly for plants treated with AMO foliar fertilizer following closely with Vermitea.
7. Plants treated with AMO foliar fertilizer obtained the higher return on investment of 124.59 percent.

Conclusion

The application of growth promotants through foliar spray had a significant effect on the fresh and dry weights as well as the bulb yield of garlic. Particularly, among the foliar fertilizers tested, AMO and Vermitea resulted in the highest bulb weight, leading to increased profits. These discoveries underscore the potential advantages of foliar fertilizers in augmenting both garlic bulb weight and overall yield, showing its potential applicability in garlic cultivation.

Recommendations

Based on the findings of the study, the utilization of growth promotant particularly AMO or Vermitea, into the cultivation practices enhances the weight of garlic bulbs, consequently increasing the overall bulb yield. Moreover, the observed increase in profits further supports the adoption of this practice in garlic production hence recommended. Further study along the way is recommended during dry season planting to verify the efficacy of these foliar fertilizers in garlic production.

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