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Influence of *trichoderma* applied alone or in Combination with Organic Fertilizer on the Growth and Yield of Garlic (*Allium Sativum* L.) under Pure Organic Cultivation

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ABSTRACT

The study was conducted to determine the influence of *Trichoderma* applied alone or in combination with organic fertilizer on the growth and yield of garlic (*Allium sativum* L.). Four treatments were evaluated: T1 (Recommended Rate of Organic Fertilizer (RROF) at 4.5 t ha-1), T2 (Recommended Rate of *Trichoderma* (RRTP) at 250 kg ha-1), T3 (½ RROF + ½ RRTP) and T4 (Full RROF + Full RRTP), the experiment was laid out following the Randomized Complete Block Design (RCBD) with four replication.Results of the study revealed that application of full recommended rate of organic fertilizer (RROF) + full recommended rate of *Trichoderma plus* (RRTP) significantly influences the plant height of garlic at 30 DAP (38.95 cm) and at harvest (41.09 cm), bulb diameter (28.94 mm), number of bulb per kilogram (90.50) and the yield obtained per hectare (18.0t/ha). Based from this result, combination of full recommended rate of organic fertilizer and *Trichoderma* is effective source of nutrients for garlic production under pure organic cultivation.

Introduction

In the past few years, the use of chemicals is rapidly increasing because most farmers became dependent on chemical inputs such as fertilizers and pesticides in agricultural production. This method of farming is a practical way to get a high yield by using different chemicals and applying large amounts to the crop. Although chemicals are most effective, particularly when multiple treatments are applied, yet this method presents a range of negative impacts in the environment such as air pollution, water contamination and further depletion of soil health, besides, negative effect on the health of farmers and consumers and the risk of coming out of resistant pathogen (Widawsky et al. 1998). In view of these serious drawbacks, the development of more environmentally friendly methods such as biopesticides, organic fertilizers and biocontrol agents using antagonistic microorganisms can help reduce negative effects of conventional farming in the environment. The use of biofertilizer is considered as one of the most promising ways to reduce dependence on synthetic inputs in agriculture.

Biofertilizer is a substance that has living microorganisms which when applied to seed, plant surfaces or soil enhances crops uptake of nutrients by their interactions in the rhizosphere (Himachal and Rashmi,2012). Trichoderma species have been long recognized as a biological control agent of plant diseases and for their ability to increase plant growth and development (Ranasingh et al., 2006). These microorganisms also served and function as a plant growth promoter for the crop to lessen dependence on input which causes a high cost of production.

Garlic (*Allium sativum*) is one of the most widely used herbal medicines in the Philippines and commonly found in the Filipino kitchen. Because of its many uses, the demand for this crop is continuously increasing. According to the Department of Health (2015), it is one of the top ten Philippine herbs with therapeutic value and the department recommends it use as an alternative herbal medicine plant. Hence, this study aims to determine the effectiveness of *Trichoderma* in enhancing the growth of cloves formation of garlic.

Generally, this study aims to evaluate the effectiveness of *Trichoderma* in garlic specifically it aims to:

Determine the growth and yield performance of garlic applied with *Trichoderma* applied alone or in combination with organic fertilizer, and determine the best combination of *Trichoderma* and organic fertilizer for organic garlic production.

Materials and Method

Cloves of garlic (*Allium sativum* L.), Ilocos white variety (native variety) were from Ilocos region. This variety is the most common and widely used by garlic farmers in the north and even at Central Luzon for commercial production. It has purple to white scales. It is moderately resistant to insect pests and diseases. It matures 90 to 110 days after planting and has a potential yield of 3.5 tons per hectare (Department of Agriculture, 2016).

Trichoderma were mass-produced in Ramon Magsaysay-Center for Agricultural Resources and Environment Studies (RM-CARES) A laboratory using pure rice bran and soil at a ratio of 1:1, water was added to attain 30% moisture content.

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After the preparation of the substrate, it was placed in polypropylene bag and sealed with a rubber band. Sterilized at 15psi or 121˚C for 45 minutes and allowed it to cool. Inoculated the pure culture of *Trichoderma* on the substrate at room temperature in 7 days.

The experiment was laid out following the Randomized Complete Block Design (RCBD) with four replicates, the area was subdivided into an equal block for replication and each block was further subdivided into four plots representing the different treatments. Each plot was measured 4 m x 5 m with a distance of 0.5 m between plots and blocks. The following treatments were evaluated: T1 = Recommended rate of organic fertilizer (RROF) at 4.5 t ha^{-1}; T2 = Recommended rate of *Trichoderma plus* (RRTP) at 250 kg ha^{-1}; T3 = ½ RROF + ½ RRTP; T4 = Full RROF + Full RRTP.

A total of 500 m^2 was utilized in this study, the area was prepared by alternate plowing and harrowing using hand tractor until good soil tilth was obtained. Before planting healthy cloves of garlic, the area was covered with rice straw as mulch to conserve moisture and reduces weed growth. After the preparation of mulch, cloves were planted with a distance of 20 cm x 20 cm between hills and rows. The required amount of organic fertilizer was converted to a kilogram per plot and applied before planting of garlic. Application of *Trichoderma plus* were split into three applications, the first application was done before planting, second application was at 30 DAP and the last application was done during bulb formation.

Immediately after plating the cloves, irrigation was done to ensure availability of moisture for germination of cloves. This was done by flooding the experimental plots by using the water pump. Succeeding irrigation was done at 7 days interval and if it is necessary. Irrigation was stopped two weeks before harvesting. Weed seeds that grew in the experimental plots were removed by regular hand pulling to reduce weed population and maintain the cleanliness of the experimental plots.

To control the insect pests it is required to spray extracted hot pepper and kakawate leaf (*Gliricidium sepium*) at a rate of 100 ml of the stock solution per liter of water and sometimes sprayed by OHN (Organic Herbal Nutrients) weekly.For diseases, acapulco leaves (*Senna alata*) were extracted and sprayed twice a week. Preparations of plant extract were done at the RM-CARES biopesticide laboratory.

Harvesting was done when maturity indices appeared in 93 days, that was lower leaves began dried and 75% of the leaves turned yellow and began folded over. Harvesting was done by pulled the bulbs manually from the soil.

All data gathered in this study were analyzed statistically using Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD) to determine the effect of treatments evaluated. A comparison among means was done using Least Significant Difference (LSD). Analysis of data was done by using Statistical tools for Agricultural Research (STAR).

Results and Discussion

Soil Fertility Status Analysis

Table 1 showed the fertility status of the experimental area before the establishment of the study in the experimental area. The result showed that the area has very low nitrogen content with 0.134% which is limited and most deficient in the soil, while Phosphorous has 36.31 ppm and the Potassium level is 180 ppm. The area has pH of 6.80 which is considered as a favorable level for most vegetable crops.

Table 1. NPK content of soil from experimental area

CHEMICAL PROPERTY	VALUES
pH	6.80
Total Nitrogen	0.134
Phosphorous (ppm)	36.31
Potassium (ppm)	180

Percent Germination

Percent Germination was taken at 30 days after planting cloves. Percent germination ranges from 96.35% to 97.70% and the lowest germination was recorded in the control plants (T1) which is the application of pure organic fertilizer while the highest germination rate was obtained from plots applied with full RROF + full RRTP (T4) with 97.70%.

Plant Height at 30 DAP

Results showed that application of Recommended Rate of Organic fertilizer + Recommended Rate of *Trichoderma* plus (T4) significantly obtained the tallest plants at 30 days after planting with 38.95 cm while application of the Recommended Rate of *Trichoderma plus* (T2) significantly obtained the second tallest plants of 38.11 cm (Table 2). This result confirmed the result of Chowdappa *et al.*, (2013) that *Trichoderma* spp.are able to enhance growth components including plant height, leaf number, root length and root fresh weight and have the ability to produce phytohormones which is the key factor in the increase of plant height also Cai et al., (2013) reported that harzianolde produced by *Trichoderma* spp. can improve the early stage of plant development through the enhancement of root length. These morphological modifications are possible because of the ability of these species to act through several mechanisms such as environmental buffering (against pH, drought, water logging, cold and heat), phosphorous solubilization, OM decomposition, chelation and sidephore production.

On the other hand, application of ½of the Recommended Rate of Organic Fertilizer +½ of the Recommended Rate of *Trichoderma plus* (T3) and Recommended Rate of Organic Fertilizer (T1) obtained comparable plant height of 37.17 cm and 36.67 cm. Shorter plant height obtained from these treatment could be attributed to fact that organic fertilizer alone is not enough to sustained the nutrient requirement of garlic. The same with the application of ½ Recommended Rate of Organic Fertilizer + ½ of the Recommended Rate of *Trichoderma plus*, reducing the recommended rate of both organic fertilizer and *Trichoderma plus* affect the growth performance of garlic.

Plant Height at Harvest

Based on the result of plant height at harvest (Table 2), similar trend as the plant height during 30DAP was observed. Result showed that application of Recommended Rate of Organic fertilizer + Recommended Rate of *Trichoderma plus* (T4) consistently obtained the tallest plants of 41.09 cm followed by the application the Recommended Rate of *Trichoderma plus* (T2) with 40.12 cm while of ½ of the Recommended Rate of Organic Fertilizer + ½ of the Recommended Rate of *Trichoderma plus* (T3) and Application of Organic Fertilizer alone (T1) obtained comparable a plant height of 39.00 cm and 38.46 cm, respectively. Application of *Trichoderma* as mentioned by Gravel et al., 2007; Losane and Kumar, 1992; Patten and Glick, 2002; Shayakhmetov, 2001 increases the plant growth continuously until its maturity by producing plant growth hormones containing auxins which are key hormones affecting plant growth and development

that can be produced by this fungi in both symbiotic and pathogenic interactions with plants.

Percent survival rate (%)

As observed, there is no significant difference among the treatments evaluated. However, percent of survival ranges from 94.65% to 96.60 %. Based on the result presented in Table 2, the highest percent survival was recorded from the plot treated with the Recommended Rate of Organic fertilizer + Recommended Rate of *Trichoderma plus* (T4) with 96.60 % followed by the application of the Recommended Rate of *Trichoderma plus* (T2) with 95.55%. Application ½ of the Recommended Rate of Organic Fertilizer + ½ of the Recommended Rate of *Trichoderma plus* (T3) obtained 95.25% and the lowest survival rate was recorded from the application of organic fertilizer alone (T1) with 94.65%.

Average Bulb Diameter (mm)

Result of bulb diameter as an influence by the application of organic fertilizer and *Trichoderma plus* applied alone or in combination with organic fertilizer showed that plants applied with the Recommended Rate of Organic fertilizer + Recommended Rate of *Trichoderma plus* (T4) significantly obtained largest bulbs, this could be the effect of the *Trichoderma plus* and organic fertilizer as mentioned by Kleifield and Chet (1992) that *Trichoderma* enhances root growth and development to uptake more nutrients thereby, improving bulb during its formation. *Trichoderma* releases cellulases which degrade cellulose and enhance the organic matter and nutrients in the rhizosphere. (Jiang et al., 2011) solubilization and chelation of the mineral can enhance nutrient availability which is engaged in plant metabolism leading to the enhancement of plant physiological activity (Harman, et al., 2004). On the other hand, application of *Trichoderma plus* alone (T2) obtained the second largest bulbs with 26.84 mm. Organic fertilizer alone (T1) obtained the smallest bulb diameter of 24.88 mm.

Number of bulbs per kilogram (kg)

The number of bulbs per kilogram was also recorded. Number of bulbs per kilogram reflects the size of bulbs produced per plants. The more numbers of bulbs per kilograms the smaller the size of bulbs. The result showed that the application of the Recommended Rate of Organic fertilizer + Recommended Rate of *Trichoderma plus* T4) obtained the least number of bulbs per kilogram with an average of 90.50 pieces. This result also confirmed the findings of Galindez et al., (2016) that onion applied with organic fertilizer and the recommended rate of *Trichoderma plus* obtained bigger sizes of onion bulb that resulted to a lesser number of bulb per kilogram. The highest numbers of bulbs per kilogram was obtained from the application of the recommended Rate of Organic fertilizer (T1) with 131 bulbs per kilogram. On the other hand, the application of *Trichoderma plus* alone (T2) obtained 110.25 bulbs per kilogram, the second-lowest number obtained.

Harvested yield (kg/ha)

Plots applied with the combination of the Recommended Rate of Organic Fertilizer at 4.5 t ha^{-1} with the recommended rate of *Trichoderma plus* at 250 kg ha^{-1} produced the highest yield of 18 t ha^{-1}. Application of *Trichoderma plus* alone produced the second highest yield of 16.66 t ha^{-1} which was comparable with the yield of plants applied with ½ of the Recommended Rate of Organic Fertilizer + ½ of the Recommended Rate of *Trichoderma plus* (T3) with 16.25 t ha^{-1}. Plots treated with pure organic fertilizer alone was disclosed as the lowest yield of 14.88 tha^{-1}. This showed that garlic treated the Recommended Rate of Organic fertilizer+Recommended Rate of *Trichoderma plus* (T4) influenced the growth and yield. This results confirmed the findings of Haque et. al., (2012), Katatny and Idres (2014), Naznin et. al., (2015), Shrivastava et.al., (2006), Tucci et. al., (2011), Idowu etal.,(2016) that *Trichoderma* spp. has effect on plant morphology and physiology leads to better field stand and it also accelerates the vegetative and reproductive growth of plants. It enhances plant height, flowers, bulbs and fruits per plant. In many cases, the average weight of each crop is also comparatively higher caused by the application of *Trichoderma* species. In addition by Bal and Altinas, (2006) proved that the *Trichoderma* spp. was effective in the promotion of growth and yield of crops.

Summary, Conclusion and Recommendation

A field experiment utilizing *Trichoderma plus* and organic fertilizer as a source of nutrients for garlic production under pure organic cultivation was evaluated. The study aims to evaluate the influence of *Trichoderma plus* in garlic production specifically to: determine the growth and yield performance of garlic applied with *Trichoderma plus* alone or in combination with organic fertilizer; and determine the best combination of *Trichoderma plus* and organic fertilizer for organic garlic production.

The study was conducted at the Ramon Magsaysay Center for Agricultural Resources and Environment Studies, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines from February 2018 to May 2018. The experiment was laid out using Randomized Complete Block Design (RCBD) with four replications. The area utilized in this experiment was a certified organic area. Treatments were: T1=Recommended rate of organic fertilizer (RROF) at 4.5 t ha^{-1}, T2=Recommended rate of *Trichoderma plus* (RRTP) at 250 kg ha^{-1}, T3= ½ RROF + ½ RRTP, T4 = Full RROF + Full RRTP.

Based on the result, application of *Trichoderma plus* at a full recommended rate plus a full recommended rate of organic fertilizer significantly influence the plant height of garlic at 30 DAP and at harvesting with 38.95 cm and 41.09 cm, the tallest among the plants applied with the different treatments. In terms of bulb diameter, the biggest diameter was recorded with 28.94 mm and this was recorded from the plots applied with the full recommended rate of *Trichoderma plus* and organic fertilizer. On the other hand, the number of bulbs per kilogram was taken and results showed that plants applied with the full recommended rate of *Trichoderma plus* and organic fertilizer obtained the lesser number of bulbs per kilogram, this implies that the bulb has a

Table 2. Agronomic performance of garlic (Allium sativum L.) as influenced by Trichoderma and organic fertilizer application.

Treatment	Percent germination (%)	Plant height (cm)		Percent Survival (%)	Ave.bulb diameter (mm)	Ave.number of bulbper (kg)	Harvested yield?ha (t/ha)
		30DAT	At Harvest				
T1=Recommended rate of Organic fertilizer at 4.5 tha-1	96.35	36.67c	38.46d	94.65	24.88d	131a	14.88c
T2=Recommended rate of Tricho derma (RRTP) at 250 kg ha-1	97.40	37.86b	40.12b	95.55	26.84b	110.25b	16.66b
T3=1/2 RROF+1/2RRTP	97.35	37.17c	39c	95.25	25.85c	128a	16.25b
T4=Full RROF+Full RRTP	97.70	38.95a	41.09a	96.60	28.94a	90.50c	18.00a

bigger size compared to other treatments and so T4 obtained the highest yield of 18 t ha-1.

Considering the result of the study, it can be recommended that *Trichoderma* combined with organic fertilizer could be an effective source of nutrients for garlic production under the pure organic system.

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