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Performance of Onion *(Allium cepa* L.*)* in Organic System Using Combined Organic Fertilizer and *Trichoderma* in Split Application

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Abstract

Conventional onion production in Nueva Ecija, Philippines requires excessive application of inorganic fertilizer and pesticides for maximum yield and protection from pests. In an effort to develop an alternative farming practices that is environment friendly, the research aimed to determine the response of onion on the combined use of organic fertilizer and *Trichoderma* in split application.The following were the treatments carried out in an organic area in a completely randomized block design: Treatment 1= Organic fertilizer alone (8t/ha) applied at planting; Treatment 2= Organic fertilizer (8t/ha) applied twice (basal and at 30 DAT); Treatment 3= Organic fertilizer (8t/ha) applied twice (basal and at 30 DAT) plus *Trichoderma* applied once at planting; Treatment 4= Organic fertilizer (8t/ha) applied basal and at 30DAT + *Trichoderma* applied twice at planting and at 30 DAT ; and Treatment 5= Organic fertilizer (8t/ha) applied twice at planting and at 30 DAT + *Trichoderma* applied thrice at planting, 30 DAT and during bulb formation Results indicate that the combined application of organic fertilizer (8t/ha) applied twice (basal and at 30 DAT) + *Trichoderma* applied thrice at planting, 30 DAT and during bulb formation consistently recorded the highest yield of 15.33 t/ha and 14.50 t/ha, during the first and second year trials, respectively. The combined use of organic fertilizers and *Trichoderma* applied in split application could successfully produce onion in organic system.

Keywords: organic onion, *Trichoderma*, organic fertilizers, split application, red creole variety

1. Introduction

Farming system in the Philippines is generally characterized by intensive farm production using synthetic fertilizers and pesticides. Onion (*Allium cepa* Linn.) is one among the different crops cultivated under conventional system with too much application of inorganic fertilizer and use of pesticides to obtain desirable yield.

Central Luzon is the biggest onion producer in the Philippines, and undoubtedly, onion growing is one of the major factors attributing to increased income among farmers in the region, particularly, in Nueva Ecija (DA-PRDP Luzon A Cluster Report, 2014). Onion is grown as a secondary crop after rice and recognized to boost the income of many farmers, particularly in Nueva Ecija.

However, most farmers growing onion in the region are dependent on chemical inputs to ensure high yield (Galindez, 2012) which entails high input cost. Besides, excessive application of chemical inputs such as inorganic fertilizers and pesticides imposes health hazard and environmental problem such as soil salinity, heavy metal accumulation, water eutrophication and accumulation of nitrate that resulted to air pollution and emission of other greenhouses gases that could aggravate the effect of climate change (Savci, 2012).

With this scenario, alternative farming practices that are ecologically sustainable should be developed to promote soil health, ensure sustainability of production and ensure the stability of the environment. In this case, organic farming could be the best option to abate this problem, since organic farming practices avoid the use of chemical inputs and call for sound ecological processes, biodiversity and safe food production (Manzanilla, 2012). Organic fertilizer is a good source of essential nutrients from plants as well as for the improvement of soil productivity (Gajete, 2000). The Central Luzon State University-Ramon Magsaysay Center for Agricultural Resources and Environment Studies (CLSU RM-CARES) was able to isolate *Trichoderma* species that can be used both as a biofertilizer and bio control agent. Hence, it is the interest of this research to find out the response of the combined use of organic fertilizers and *Trichoderma* in split application in the hope of developing an organic production protocol for onion.

2. Methodology

Experiment on the performance of onion in pure organic system using combined organic fertilizer with *Trichoderma* was established in a fully converted and third party certified organic area. The two *Trichoderm*a isolates were molecularly identified as *Trichoderma longibrachiatum* and *Trichoderma asperellum.*

The following treatments were used:

Treatment 1= Organic fertilizer alone (8t/ha) applied at planting
Treatment 2= Organic fertilizer (8t/ha) applied twice (basal and at 30 days after transplanting (DAT)
Treatment 3= Organic fertilizer (8t/ha) applied twice (basal and at 30 DAT) plus *Trichoderma* applied once at planting
Treatment 4= Organic fertilizer (8t/ha) applied basal and at 30DAT + *Trichoderma* applied twice at planting and 30DAT
Treatment 5= Organic fertilizer (8t/ha) applied twice at planting and at 30 DAT + *Trichoderma* applied thrice at planting, 30 DAT and during bulb formation

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Onion variety

Red creole variety was used and tested for two growing seasons.

Area preparation

Organic experimental area located at CLSU RM-CARES and certified organic by the Organic Certification Center of the Philippines was utilized in this study. The area was prepared thoroughly using small tractor to cultivate the area and to attain good tilth.

Seedling production

Seedlings of onion were grown in a raised seedbed measuring 1 x 10 m^2. One (1) bag of organic fertilizer was broadcasted in a prepared seedbed. Line sowing of seeds was followed for easy management of weeds. Seeds were covered with carbonized rice hull after sowing to cover the seeds and rice straw was used as mulch to maintain soil moisture and easy germination of seeds.

Application of vermicast and manure tea was employed two weeks after seed emergence to enhance vigorous growth of seedlings.

Transplanting

Thirty day-old seedlings were transplanted in prepared plots measuring 2 x 5 m^2 with a planting distance of 15 x 15 cm. Before transplanting, the area was irrigated to soften the soil.

Organic fertilizer application

The computed amount of organic fertilizer per plot for each treatment was applied based on the scheduled time of application called for each treatment. The organic fertilizer used are produced at the RM-CARES with guaranteed analysis of N=1.5%, P2O5=2.0% and K2O=2.0%.

Irrigation

Since the experimental plot was moist during planting, succeeding irrigation was done at one week interval. Irrigation was done following the flooding system using water pump.

Weed control

Weeding was employed when there are sprouted weeds in the experimental plots by cultivating the area using hand trowel. Succeeding cultivation was done at weekly interval to maintain and ensure cleanliness of the experimental area.

Insect pests and diseases management

Insect pests and diseases were controlled using biopesticides from the extracts of kakawate (*Gliricidia sepium* L.) leaves, hot pepper (*Capsicum frutescens* L.) fruits and rhizome of ginger (*Cucurma longa* L.) and fermented acapulco (*Cassia alata* L.) leaf extract following the recommended rate of 100 ml/liter of water.

Harvesting

Harvesting was done when the neck tissue had softened and closed and when the leaves had fallen.

Data gathered/analysis

1. Plant height at 30 DAT and at harvest
   The average plant height was taken 30 days after transplanting and during harvest. Ten (10) randomly selected sample plants in each treatment was taken and measured from the ground level up to the highest leaf.
2. Bulb diameter
   Ten (10) randomly selected bulbs was collected and measured for the bulb diameter using vernier caliper.
3. Number of marketable bulb/kg
   Total Number of marketable bulb/kg was taken by counting the total marketable bulb per kg.
4. Yield (marketable and nonmarketable) t/ha
   Weight of marketable and nonmarketable bulb was taken from the harvest area of 1x3m^2 and converted into a per hectare basis.

All data gathered was analyzed statistically using analysis of variance (ANOVA) for Randomized Complete Block Design (RCBD). Comparison among means was done using DMRT to determine significant differences among treatment means at 5% level of probability.

3. Results and Discussion

Growth and Yield Performance of Onion (red creole variety)

Table 1 shows the performance of onion red creole variety under pure organic system.

Plant height at 30 DAT

Performance of red creole variety in terms of plant height during the first trial (year 1) showed that all treatments applied with organic fertilizer in combination with *Trichoderma* significantly produced comparable plant height over the treatment applied with organic fertilizer alone (T1). However, plant height at 30 DAT during the second trial (year 2), showed no significant differences observed among the treatments evaluated.

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Plant height at harvest

Applications of different treatments significantly affect plant height of red creole during harvest. In Year 1, plants applied with recommended rate of organic fertilizer (8t/ha) applied at planting and at 30 DAT plus *Trichoderma* (526 kg/ha) applied at planting and at 30 DAT (T4) significantly produced taller plants (37.6 cm) while application of recommended rate of organic fertilizer alone at planting and at 30 DAT (T2) recorded the shortest plants height of 30.9 cm.

Second year results showed that application of recommended rate of organic fertilizer (8t/ha) at planting and at 30 DAT plus *Trichoderma* (526 kg/ha) applied at planting and at 30 DAT (T4) consistently produced the tallest plants with 60.16 cm while application of organic fertilizer alone at planting (T1) and twice application at planting and at 30 DAT plus *Trichoderma* applied only at planting (T3) significantly produced comparable plant height of 51.76 cm and 51.19 cm, respectively. The shortest among the different treatments evaluated.

Bulb diameter

Bulb diameter as affected by treatment application during the first year showed that plants applied with organic fertilizer applied twice during planting and at 30 DAT plus *Trichoderma* applied at planting, 30 DAT and at bulb formation (T5) significantly produced the biggest bulb with the diameter of 37.6 mm while plants applied with the recommended rate of organic fertilizer alone whether applied once during planting or twice during planting and at 30 DAT (T1 & T2) produced comparable bulb of 34 mm and 34.7 mm, the smallest bulb obtained among the treatments evaluated.

Second year trial showed that no significant differences on bulb diameter were observed among the treatments evaluated. Application of organic fertilizer alone applied at planting and at 30 DAT produced the smallest bulb of 44.02 mm, the smallest bulb diameter among the treatments evaluated.

Number of bulb to a kilogram

Number of onion bulb per kg is also a very important factor in determining the size of the bulb. First year of the trial showed that the number of bulb to a kilogram as affected by the application of different treatment indicates that application of recommended rate of organic fertilizer alone applied at planting and at 30 DAT (T2) and the application of the same rate of organic fertilizer plus *Trichoderma* applied at planting, 30 DAT and at bulb formation (T5) significantly produced more number of bulbs with 24 and 23 bulbs, respectively. The second trial

(Year 2) showed that application of organic fertilizer at recommended rate plus *Trichoderma* applied both twice at planting and at 30 DAT (T4) significantly produced the highest number of bulb per kg with 18 bulbs while lesser number of bulb per kg was produced by the application of organic fertilizer (8t/ha) applied twice (basal and at 30 DAT) plus *Trichoderma* applied at planting (T3) with 14 bulbs/kg. All other treatments produced comparable number of bulbs per kilogram.

Non-marketable yield

Non-marketable yield on the other hand was also recorded. Application of organic fertilizer (8t/ha) applied basal and at 30 DAT plus *Trichoderma* applied at planting and at 30DAT (T3) recorded the highest non-marketable bulbs at 4.87 t/ha in Year 1, while the application of organic fertilizer (8t/ha) applied twice (basal and at 30 DAT) (T2) recorded non-marketable bulbs at 2.67 t/ha, the highest in Year 2.

Marketable yield

Marketable yield as affected by the application of different treatment during the first and second year of the trial is also shown in Table 1. Comparable yield was recorded from the application of the recommended rate of organic fertilizer alone applied during planting (T1) and treatment applied with same amount of organic fertilizer applied at planting and at 30 DAT plus *Trichoderma* applied at planting, 30 DAT and during bulb formation (T5) during the first trial with 15 t/ha and 15.33 t/ha, respectively. The highest yield among the treatments evaluated. In the second trial (Year 2), Treatment 5 consistently produced the highest yield of 14.50 t/ha while the lowest yield was obtained from the application of organic fertilizer (8t/ha) applied twice (basal and at 30 DAT) plus *Trichoderma* applied at planting (T3) with 11.83 t/ha.

The consistent performance of red creole variety of onion in organic system using combined application of organic fertilizer (8t/ha) applied twice (basal and at 30 DAT) + *Trichoderma* applied thrice at planting, 30 DAT and during bulb formation in all the growth and yield attributing parameters used can be attributed on the combined effect of using organic fertilizer and *Trichoderma*. Results also indicate that the combined use of organic fertilizers and *Trichoderma* applied in split application could successfully produce onion in organic system.

In a comprehensive review made by S.S.Dhaliwala *et al*, 2019, different organic materials such as plant residues, manures and waste materials application is recognized as an effective means to improve nutrient use efficiency and fertility of soil. Under several cropping systems, application

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of organic sources is found helpful for sustaining high crop productivity since organic sources affects the soil physical and chemical properties which in turn affect the micronutrient nutrition of crops by providing better environment for root growth as well as by adding some additional micronutrients to soil also.

Ahmed A. Kandil *et al*, 2013, in their research on the effect of fertilization treatments on onion (farmyard manure, chicken manure, compost and mineral NPK fertilizers) showed significant effect on all studied characters (plant height, number of leaves/plant, foliage fresh weight and bulbing ratio at 90 and 120 days from transplanting, total yield, marketable yield, total culls, average bulb weight in both seasons, total soluble solids, dry matter and total weight loss percentages of onion bulbs every month after harvesting till end of storability) in two growing seasons.

As to the effect of *Trichoderma*, Mostafa, Abdelrahman *et al*, 2016 in their research indicated that *Trichoderma* spp. are versatile opportunistic plant symbionts that can cause substantial changes in the metabolism of host plants, thereby increasing plant growth and activating plant defense to various diseases. In the said research, it was found out that using the metabolite profiling approach, *Trichoderma longibrachiatum* isolated from desert soil can confer beneficial agronomic traits to onion and induce defense mechanism against *Fusarium oxysporum* f. sp. *cepa* (FOC), through triggering a number of primary and secondary metabolite pathways. Their findings also demonstrated the contribution of *T. longibrachiatum* to the accumulation of key metabolites, which subsequently leads to the improvement of onion growth, as well as its resistance to oxidative stress and FOC.

Roberto N.Silva *et al* 2019, indicated in their research that *Trichoderma* are friendly microorganisms to plant and improve crop production. Further, some *Trichoderma* spp. are considered potential agents in the control of fungal plant diseases and that they can interact directly with roots, increasing plant growth, resistance to diseases, and tolerance to abiotic stress.

K.K. Sharma 2018, pointed out that the use of microorganisms that antagonize plant pathogens (biological control) is a risk-free approach and the species of *Trichoderma* are well recognized as agents for plant disease control in addition to its promontory effect on plant growth.

In terms of the importance of split application of inputs, R.R. Rukmowati *et al* 2017, in their research on application of granular organic fertilizer to improve yield of red onion treated with

granular organic fertilizer applied in 3 split applications, significantly produced higher yield than those treated inorganic fertilizers and suggested the use of granular organic fertilizer to supply nutrient in organic cultivation of red onion local variety.

Patel, A,J, and Patel K.G. 2017 in their research on the effect of different organic manures on yield and quality of onion indicate the very importance of using organic matter in split application on the yield of onion. For getting higher bulb yield and net profit from onion grown organically, application of biocompost, nadep compost and castor cake in equal proportion in two equal splits i.e. at the time of transplanting and one month after transplanting is necessary.

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Table 1. Performance of red creole onion variety applied with organic fertilizer and *Trichoderma* at different frequency of application in fully converted organic area.

TREATMENT	PARAMETERS											
	Plant Height (cm)				Bulb Diameter Marketable (mm)		Number of Marketable Bulb/ kg		Yield (t/ha)			
	30 DAT		At harvest						Marketable		Non- Marketable	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
T1 = Organic fertilizer (OF) alone (8t/ha) applied at planting	24.0^{b}	27.2^{a}	36.2^{bc}	51.76^{d}	34.0^{c}	56.92^{a}	22.0^{b}	16.0^{b}	15.0^{a}	13.0^{ab}	2.02^{d}	2.20^{b}
T2= Organic fertilizer (8t/ha) applied twice (basal and at 30 DAT)	26.1^{a}	27.0^{a}	30.9^{d}	52.93^{c}	34.7^{c}	44.02^{b}	24.0^{a}	15.0^{b}	12.73^{c}	13.17a^{b}	2.9^{c}	2.67^{a}
T3= OF (8t/ha) applied twice (basal and at 30DAT) plus *Trichoderma* applied once at planting	25.4^{a}	27.5^{a}	35.3^{c}	51.19^{d}	35.2^{bc}	57.14^{a}	22.0^{b}	14.0^{c}	14.0^{b}	11.83^{b}	2.37^{cd}	2.25^{ab}
T4= OF (8t/ha) applied basal and at 30 DAT plus *Trichoderma* applied twice at planting and at 30DAT	24.1^{a}	27.7^{a}	37.6^{a}	60.16^{a}	36.4^{ab}	56.84^{a}	22.0^{b}	18.00^{a}	13.5^{b}	13.83^{ab}	4.87^{a}	0.93^{c}
T5= OF (8t/ha) applied twice (basal and at 30 DAT) + *Trichoderma* applied thrice at planting, 30 DAT and during bulb formation	25^{a}	27.8^{a}	36.3^{b}	56.07^{b}	37.6^{a}	59.62^{a}	23.0^{a}	15.0^{b}	15.33^{a}	14.50^{a}	4.2^{b}	2.42^{ab}

Means followed by the same letter(s) are not significantly different at 5% level of significance using DMRT.

3. Conclusion

Performance of red creole onion in organic system was generated and results indicate that the combined application of organic fertilizer (8t/ha) applied twice (basal and at 30 DAT) + *Trichoderma* applied thrice at planting, 30 DAT and during bulb formation consistently recorded the highest yield of 15.33 t/ha and 14.50 t/ha, during the first and second year trials, respectively. Results also indicate that the combined use of organic fertilizers and *Trichoderma* applied in split application could successfully produce onion in organic system.

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