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Performance of Red Onion (Bulb Type) in Fully Converted Organic Area as Affected by Frequency of Organic Fertilizer Application Combined with *Trichoderma* spp.

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Abstract: The study was conducted to determine the viability of producing organic onion under the fully converted area of Ramon Magsaysay Center for Agricultural Resources and Environment Studies (RMC-ARES), Central Luzon State University, Philippines. Specifically, the study aimed to establish the frequency of organic fertilizer and *Trichoderma* spp. application, employing split application, and determine the yield performance of red onion (bulb type). The research was conducted for two consecutive dry seasons (2014 and 2015). Red Creole variety was used with the following treatments: T1—organic fertilizer alone (8 ton/ha) at planting; T2—organic fertilizer (8 ton/ha) applied twice (at basal and 30 d after transplanting (DAT)); T3—organic fertilizer (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied at planting; T4—organic fertilizer at 8 ton/ha rate + *Trichoderma* spp. at the rate of 526 kg/ha, both applied twice (at planting and 30 DAT); T5—organic fertilizer at 8 ton/ha rate applied twice (at planting and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied thrice (at planting, 30 DAT and during bulb formation). Results of the study showed that application of the recommended rate of organic fertilizer twice (at planting and 30 DAT) + three times application of *Trichoderma* spp. (at planting, 30 DAT and during bulb formation) consistently produced bigger bulb during the first and second trial of the study, compared to other treatments evaluated. Consequently, higher marketable yield was produced with 15.33 ton/ha during the first trial and 14.50 ton/ha on the second trial.

Key words: Organic onion, *Trichoderma* spp., organic fertilizer, split application.

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 to obtain desirable yield. Onion is one of the most important and profitable horticultural crops grown worldwide. Based on global review of the major vegetables, onion ranks the second after tomato in area under cultivation [1]. The demand for onion is increasing, as the disposable income of the population increases. However, the local production of onion does not meet consumption needs in spite of large increase in production during the past decade, due to low productivity of land under cultivation and pest problem [2]. The Philippine government is exporting thousands of tons of onions in fresh and chilled forms costing millions of dollars. In Philippines, Central Luzon is the biggest onion producer in the country, and undoubtedly, onion growing is one of the major factors in increased income among farmers in the region, particularly, in Nueva Ecija. Onion is grown as a secondary crop after rice. It is a multiple crop grown after rice that boosted

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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, but persistent use of chemicals imposes high production cost and threat to the environment, particularly to soil health, such as acidity and nutrient imbalance [2].

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 [3]. Organic fertilizer is a good source of essential nutrients from plants as well as for the improvement of soil productivity [4]. Organic agriculture has developed rapidly worldwide during the last few years and is now practiced in approximately 120 countries in the world [5]. Its share of agricultural land and farms is growing everywhere. The market for organic product is growing at past rate, not only in Europe, Japan and North America, but also in many other countries, including many developing countries including Philippines.

Trichoderma species are free living fungi that are common in soil and root ecosystem. Some strains enhance plant growth and development, crop productivity, uptake of nutrients and resistance to abiotic stresses. *Trichoderma* species can antagonize and control a wide range of economically important plant pathogenic fungi, viruses, bacteria and nematodes [6]. *Trichoderma* is one of the most popular genera of fungi commercially available as a plant growth promoting (bio-fertilizer) fungi and biological control agent. Bio-fertilizers are becoming increasingly popular in many countries and for many crops [7]. Effective bio-fertilizer reduces not only the load of chemical fertilizers in crop production, but also minimizes the pollution by excessive uses of the latter [8].

A number of organic vegetable farmers in Central Luzon, Philippines grow organic vegetables year round in large quantity during dry season because of favorable dry and cool weather. However, most of them usually apply the required amount of organic fertilizer only once during planting. Hence, nutrient requirement of vegetables during vegetative or reproductive stages is no longer available. This condition seriously affects the growth and development of vegetables and subsequently affects the yield performance [2].

In order to reduce the potential effect of nutrient deficiency on organic vegetable production, farmer's practice of applying organic fertilizer was done usually during planting. However, a study conducted on split application of organic fertilizer using native bittergourd and tomato significantly obtained higher yield and higher return on expenses. This finding is very important to establish frequency of organic fertilizer application in organic vegetable production, so that practitioners and organic enthusiasts will have a guide to follow [2].

The study was conducted to determine the viability of producing onion in the fully converted organic area. Specifically, the study aimed to establish the frequency of organic fertilizer and *Trichoderma* spp. application, employing split application, and determine the yield performance of onion.

2. Materials and Methods

2.1 Experimental Area

The area utilized in this study is a certified organic area by the Organic Certification Center of the Philippines, located at the Ramon Magsaysay Center for Agricultural Resources and Environment Studies (RMC-ARES), Central Luzon State University, Philippines. The area is being utilized for experiment and organic vegetable production.

The initial soil analysis of the area prior to the start of the experiment showed pH of 5.23, organic matter of 1.86%, total N of 0.08%, available P of 21.4 ppm and exchangeable K of 170.0 ppm.

2.2 Setting-Up of Experiment

Red Creole variety of onion was utilized in this experiment. The research was conducted for two consecutive dry seasons in 2014 and 2015.

The following treatments were established using organic fertilizer + *Trichoderma* spp. in a fully converted organic area:

T1 = organic fertilizer alone (8 ton/ha) at planting;

T2 = organic fertilizer (8 ton/ha) applied twice (at basal and 30 DAT);

T3 = organic fertilizer (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied at planting;

T4 = organic fertilizer at 8 ton/ha rate + *Trichoderma* spp. at the rate of 526 kg/ha. Both are applied twice at planting and 30 DAT;

T5 = organic fertilizer at 8 ton/ha rate applied at planting and 30 DAT + *Trichoderma* spp. at the rate of 526 kg/ha applied thrice at planting, 30 DAT and during bulb formation.

The experiment was laid out following the randomized complete block design (RCBD) with three replications. The experimental area was divided into three blocks representing the replication and further subdivided into five plots (2 m × 6 m) representing the treatments. Distance between blocks is 1 m, while the distance between beds is 0.5 m. Raised beds (20 cm) were prepared and utilized.

2.3 Management Practices

2.3.1 Land Preparation

The experimental area was prepared by cutting/removing rice stubbles and weeds, plowed and harrowed twice to obtain good tilth. After the initial land preparation, the area was irrigated to allow weeds to germinate, and at one week before transplanting, the area was plowed and harrowed again to cultivate the soil and remove the germinated weeds. Plots were prepared in raised bed with the length of 5 m long and 1 m width at 5 cm high. Preparation of plots was done prior to transplanting of onion seedlings.

2.3.2 Organic Fertilizer and *Trichoderma* spp. Application

The required amount of organic fertilizer and *Trichoderma* spp. applied per treatment in the experiment was done following the scheduled time of application as indicated in the treatments. The organic fertilizer used in the experiment was produced by RMC-ARES with guaranteed analysis of N 1.5%, P_2O_5 2.00% and K_2O 2.00%. *Trichoderma* spp. was isolated from Carabao manure and mass produced in the laboratory using pure rice brand and soil as the substrate at a ratio of 1:1.

2.3.3 Transplanting

Transplanting of 30-day-old onion seedlings was done during the first week of December, with one seedling per hill spaced at 15 cm × 15 cm.

2.3.4 Irrigation

Irrigation was done immediately after transplanting, while succeeding irrigation was done two weeks after transplanting or depending on soil moisture and condition of the crop during the last few weeks of crop growth. Deep well irrigation was used during irrigation time.

2.3.5 Weeding

Weeding was done as soon as there are weeds in the area to avoid growth and competition between plants and weeds. Weeding was done anytime as the need arises.

2.3.6 Pest and Disease Management

Bio-pesticides made from natural sources, such as Kakawate leaves, hot chili, yellow ginger and Acapulco (*Senna alata*) leaves were extracted and used to control insect pest and diseases. Application rate was followed at the recommended rate of 100 mL/L water. Weekly application was done to prevent or limit the development of pest population and disease occurrence.

2.4 Data Analysis

Data gathered were analyzed using randomized complete block design (RCBD). Comparison among means was done using Duncan's multiple range test (DMRT).

Cost and return analysis was undertaken to determine the profitability of 1,000 m^2 organic onion production.

3. Results and Discussion

The performance of red Creole variety grown under pure organic system at different frequency of application of organic fertilizer and *Trichoderna* spp. during the first and second year of experimentation is reflected in Table 1.

3.1 Plant Height at 30 DAT and at Harvest

3.1.1 Plant Height at 30 DAT

Performance of red Creole variety in terms of plant height during the first trial (2014) showed that all treatments applied with organic fertilizer in combination with *Trichoderma* spp. significantly produced comparable plant height compared to treatment with organic fertilizer alone (T1). However, all treatments produced comparable plant height at 30 DAT regardless of the treatment applied in the second trial (2015).

3.1.2 Plant Height at Harvest

Plant height at harvest showed that application of different treatments significantly affected the plant height of red Creole.

In first year trial, plants applied with the recommended rate of organic fertilizer (8 ton/ha) applied at planting and at 30 DAT + the application of *Trichoderma* spp. (526 kg/ha) during planting and at 30 DAT (T4) significantly produced taller plants (37.6 cm) compared to the treatments without *Trichoderma* spp. application. *Trichoderma* spp. is reported to increase plant growth in a range of crops plants [9]. However, the application of organic fertilizer at planting and 30 DAT (T2) recorded the shortest plant height of 30.9 cm.

In year two trial, application of the recommended rate of organic fertilizer (8 ton/ha) at planting and 30 DAT + *Trichoderma* spp. (526 kg/ha) during planting and at 30 DAT (T4) consistently produced the tallest plants with 60.16 cm. While organic fertilizer alone applied at planting (T1) and organic fertilizer applied twice + *Trichoderma* spp. applied only during planting (T3) significantly produced comparable plant height of 51.76 cm and 51.19 cm, respectively, the shortest plant height among all treatments evaluated.

3.2 Bulb Diameter

Bulb diameter as affected by treatment application during the first year of the experiment showed that plants applied with organic fertilizer twice during planting and at 30 DAT + *Trichoderma* spp. applied at planting, 30 DAT and during bulb formation (T5) significantly produced the biggest bulb diameter of 37.6 mm, which could be attributed to the combined effect of split application of the recommended rate of organic fertilizer and split application of *Trichoderma* spp.. Split (two times) application of organic fertilizer was proved to be the best frequency [10]. As explained by Espanto [11], the mineralization of organic fertilizer lasts for 30 d, hence, the second application of organic fertilizer at 30 DAT coincides with the findings of the researchers, and the second application is very timely during the bulb formation. More so, *Trichoderma* spp. enhances growth of the plant [12]. On the other hand, plants applied with organic fertilizer basally or twice during planting and at 30 DAT (T1 and T2) produced bulb with diameter of 34 mm and 34.7 mm, respectively, the smallest bulb diameter among the treatments evaluated.

Results of the second year experiment showed that bulb diameter was significantly comparable in all treatments, except with the application of organic fertilizer during planting and at 30 DAT (T2) which recorded a bulb diameter of 44.02 mm, the smallest bulb diameter recorded among the treatments.

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

No.	Treatments	Parameters											
		Plant height (cm)				Bulb diameter marketable (mm)		Number of marketable bulb/kg		Yield (ton/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	OF alone (8 ton/ha) applied at planting	24.00^{b}	27.20^{a}	36.20^{bc}	51.76^{d}	34.00^{c}	56.92^{a}	22.00^{b}	16.00^{b}	15.0^{a}	13.00^{ab}	2.02^{d}	2.20^{b}
T2	OF (8 ton/ha) applied twice (at basal and 30 DAT)	26.10^{a}	27.00^{a}	30.90^{d}	52.93^{c}	34.70^{c}	44.02^{b}	24.00^{a}	15.00^{b}	12.73^{c}	13.17^{ab}	2.90^{c}	2.67^{a}
T3	OF (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied at planting	25.40^{a}	27.50^{a}	35.30^{c}	51.19^{d}	35.20^{bc}	57.14^{a}	22.00^{b}	14.00^{c}	14.00^{b}	11.83^{b}	2.37^{cd}	2.25^{ab}
T4	OF (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied twice at planting and 30 DAT	24.10^{a}	27.70^{a}	37.60^{a}	60.16^{a}	36.40^{ab}	56.84^{a}	22.00^{b}	18.00^{a}	13.50^{b}	13.83^{ab}	4.87^{a}	0.93^{c}
T5	OF (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied thrice at planting, 30 DAT and during bulb formation	25.00^{a}	27.80^{a}	36.30^{b}	56.07^{b}	37.60^{a}	59.62^{a}	23.00^{a}	15.00^{b}	15.33^{a}	14.50^{a}	4.20^{b}	2.42^{ab}

OF: organic fertilizer. Means with common letters within the column are not significantly different from each other at 5% significance level.

Fig. 1 Onion produced in T5 in fully converted organic area.

3.3 Number of Bulbs to 1 kg

Number of onion bulbs per kg is also a very important factor in determining the size of the bulb. Number of bulb to 1 kg is affected by the application of different treatments. Application of organic fertilizer at planting and 30 DAT (T2) and organic fertilizer + *Trichoderma* spp. applied at planting, 30 DAT and at bulb formation (T5) significantly produced more number of bulbs with 24 and 23 bulbs, respectively, during the first trial. Results in the second year trial showed that application of organic fertilizer at recommended rate + *Trichoderma* spp. both applied twice at planting and 30 DAT (T4) significantly produced the highest number of bulbs/kg with 18 bulbs/kg. While the least number of bulbs/kg (14 bulbs/kg) was produced in the application of organic fertilizer (8 ton/ha) applied twice at basal and 30 DAT + *Trichoderma* spp. applied at planting (T3). All other treatments have comparable number of bulbs/kg.

3.4 Marketable and Non-marketable Yield

3.4.1 Marketable Yield

Marketable yield as affected by treatment application can also be seen in Table 1. In first year trial, comparable yield was obtained from the application organic fertilizer alone (T1) and organic fertilizer at recommended rate applied at planting and 30 DAT + *Trichoderma* spp. applied thrice at planting, 30 DAT and during bulb formation (T5) with 15 ton/ha and 15.33 ton/ha, respectively, the highest yield among the different treatments evaluated. In the second year trial, T5 consistently produced the highest yield of 14.50 ton/ha, which coincides with the findings that two split application of organic fertilizer in native bittergourd and tomato [13, 14] is sufficient for plant to sustain the nutrient requirement for its growth and development to produce the maximum yield. Fig. 1 shows the kind of onion produced in T5.

The lowest yield, however, was obtained with the application of organic fertilizer (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. applied at planting (T3) with 11.83 ton/ha.

3.4.2 Non-marketable Yield

Non-marketable yield, on the other hand, was recorded high during the first trial in the application of organic fertilizer (8 ton/ha) applied at basal and 30 DAT + *Trichoderma* spp. applied at planting and 30 DAT (T4) with 4.87 ton/ha. Non-marketable yield on the second trial with the application of organic fertilizer (8 ton/ha) applied twice at basal and 30 DAT (T2) was lower (2.67 ton/ha).

3.5 Insect Pests and Disease Incidence

Weekly monitoring of insect pests was done during the whole duration of the crop life to avoid development of pest population and implement immediate action. Cutworm was the most observable insect pest in the experiment, however, even the very low pest population will cause economic damage to the crop. Observation was done using 40 sample plants per treatment replication.

Disease occurrence was monitored weekly. Bulb rot was the most observable disease during the period in the experimental area. Observation on the occurrence of disease started one week after transplanting of the crop and was repeated at weekly interval. Data were obtained from 40 sample plants per replication.

Severity of bulb rot was gathered using the rating scale shown in Table 2.

Disease occurrence, particularly bulb rot, was monitored and recorded weekly to monitor disease progression and to develop effective control measures.

Table 2 Severity of bulb rot monitored by using the rating scale below.

Rate scale	Percent infection
0	No infection
1	< 10% infection
2	10%-30% infection
3	31%-50% infection
5	51%-70% infection
7	71%-100% infection

Table 3 Weekly rating of bulb rot infection of red Creole variety applied with organic fertilizer and *Trichoderma* spp. in fully converted organic area.

No.	Treatments	Rating during monitoring period								
		Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Mean rating	Description
T1	OF alone (8 ton/ha) applied at planting	0.7	1.0	1.0	1.3	1.3	1.7	1.0	1.14	< 10% infection
T2	OF (8 ton/ha) applied twice (at basal and 30 DAT)	1.0	0.7	0.7	0.7	2.0	0.7	1.0	0.97	< 10% infection
T3	OF (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied at planting	0.7	0.7	1.0	1.0	2.3	0.7	0.7	1.01	< 10% infection
T4	OF (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied at planting and 30 DAT	1.3	0.7	2.0	1.0	1.7	0.7	1.3	1.06	< 10% infection
T5	OF (8 ton/ha) applied twice (at basal and 30 DAT) + *Trichoderma* spp. at the rate of 526 kg/ha applied thrice at planting, 30 DAT and during bulb formation	2.0	2.0	1.7	1.7	2.7	1.3	1.0	1.77	< 10% infection

Table 4 Cost and return analysis for 1,000 m^2 organic red Creole variety production.

Particulars	Value
Returns	
Yield (kg)	1,491.50
Price/kg (PhP)	25.00
Total sales (PhP)	37,287.50
Expenses (PhP)	
Labor	
Land preparation at 2 man days (PhP350/d × 2)	700.00
Planting at 5 man days (PhP250/d × 5)	1,250.00
Weeding at 6 man days (PhP250/d × 6)	1,500.00
Fertilizer application at 1.5 man days (PhP250/d × 1.5)	
Organic fertilizer application	375.00
Irrigation at 4 man days (PhP250/d × 4)	1,000.00
Harvesting at 5 man days (PhP125/d × 5)	625.00
Material Inputs	
Seeds	1,500.00
Organic fertilizer at PhP200/bag	3,200.00
Trichoderma at PhP30/kg	2,600.00
Total expenses (Php)	12,750.00
Net income (Php)	24,537.50
Return on expenses (%)	192.45

As seen in Table 3, percent disease infection in all treatments showed very low disease occurrence at < 10%. Application of *Trichoderma* spp. and spraying of Acapulco leaf extract was employed regularly to suppress disease incidence. Low incidence of bulb rot could be due to the ability of *Trichoderma* spp. to control pathogen [15].

3.6 Cost and Return Analysis

Cost and return analysis for 1,000 m^2 organic onion production showed a total expense of Php12,750.00 which include expenses on material inputs and labor (Table 4). Based on the results of the study, the 1,000 m^2 will have an average yield of 1,491.5 kg, and at a selling price of Php25.00/kg will give gross sales of Php37,287.50 and a net income Php24,537.50 with high return on expenses at 192.45%. The results are promising and an important incentive to be adopted in terms of lesser expenses with higher income and safe organic produce.

4. Conclusions and Recommendation

Result of the study showed significant differences on plant height at harvest both in the first and second trial of the study. T5 consistently obtained the tall plants during the first and second trial. Bulb diameter of marketable bulb was recorded the biggest on plants applied with T5 in both years. However, the second trial showed comparable bulb diameter between plants applied with T1, T3, T4 and T5. Two split application of organic fertilizer combined with three split application of *Trichoderma* spp. was found to be the best treatment for organic onion production, as this provided sufficient nutrient requirement for its growth and development at different stages of crop growth to produce the maximum yield.

The cost and return analysis for 1,000 m^2 of organic onion production showed positive and generally high profitability, which is an important incentive to be adaptoed in terms of lesser expenses with higher income and safe organic produce.

Further research is recommended to study the best results in other varieties of onion and to include the determination of the physical and chemical properties and storage behavior of organically grown onions.

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