EFFECT OF *TRICHODERMA* INOCULATED COMPOST IOFERTILIZER ON THE GROWTH AND YIELD OF BRINJAL

Thet Su Min[1], Nyo Nyo Win[2]

Abstract

The present work deals with the study on the effect of *Trichoderma* inoculatedcompost biofertilizer on growth and yield of Brinjal (*Solanum melongena*). Tthe processing of compost biofertilizer was carried out by utilization of *Trichoderma* substrate (Yezin Isolate)based on farm waste bedding materials namely rice straw, cow dung and rice bran. Physicochemical properties of cow dung, rice straw and prepared compost biofertilizer were determined by conventional method and modern technique. Field experiment was conducted at Water Utilization Research Section, Department of Agricultural Research, Yezin and laid out in Randomized Complete Block (RCB) design with four treatments and five replications. Four treatments were T1 (chemical fertilizer), T2 (30% biofertilizer), T3 (chemical fertilizer with 30% biofertilizer), T4 (control without fertilizer). Analytical assays of the untreated soil and the prepared fertilizer treated soil were also carried out before sowing and after harvesting. The effect of prepared fertilizers on the growth of brinjal plant was studied on the basis of growth parameters and total yield were estimated. Among these treatments, T3(chemical fertilizer with 30% biofertilizer) was able to produce the highest yield of 8995.58 kg/ha compared with other treatments including control without fertilizer, the lowest yield of 6290.38 kg/ha. According to this study, 30% compost biofertilizer treatment produced the second highest yield of brinjal (7458.13 kg/ha).This study indicated that a combination treatment of biofertilizer and chemical fertilizer had significant effect on the yield and growth of brinjal. Therefore, *Trichoderma* inoculated compost can also be used as biofertilizer to reduce on chemical inputs in the perspective of sustainable agriculture and conservation of natural resources.

Keywords: *Trichoderma* inoculated compost biofertilizer, brinjal, growth and yield

Introduction

Plant nutrients are essential for the production of crops and healthy food for the world's expanding population. Plant nutrients are therefore a vital component of sustainable agriculture. Increased crop production largely relies on the type of fertilizers used to supplement essential nutrients for plants. The nature and the characteristics of nutrient release of chemical, organic and biofertilizers are different, and each type of fertilizer has its advantages and disadvantages with regard to crop growth and soil fertility. For optimum plant growth, nutrients must be available in sufficient and balanced quantities.

Soils contain natural reserves of plant nutrients, but these reserves are largely in forms unavailable to plants, and only a minor portion is released each year through biological activity or chemical processes. This release is too slow to compensate for the removal of nutrients by agricultural production and to meet crop requirements. Therefore, fertilizers are designed to supplement the nutrients already present in the soil. The use of chemical fertilizer, organic fertilizer or biofertilizer has its advantages and disadvantages in the context of nutrient supply, crop growth and environmental quality. The advantages need to be integrated in order to make optimum use of each type of fertilizer and achieve balanced nutrient management for crop growth (Chen, 2007).

[1] Dr, Associate Professor, Department of Chemistry, Myitkyina University
[2] Dr, Associate Professor, Department of Chemistry, Myitkyina University

Chemical fertilizer also reduces the protein content of crops, and the carbohydrate quality of such corps also gets degraded. Excess potassium content on chemically overfertilized soil decreases vitamin C, carotene content and antioxidant compounds in vegetables. Vegetables and fruits grown on chemically overfertilized soil also more prone to attacks by insects and disease. Although chemical fertilizers have been claimed as the most important contributor to the increase in world agricultural productivity over the past decades, the negative effects of chemical fertilizer on soil and environment limit its usage in sustainable agricultural systems. Weakening soil quality requires increasing inputs to maintain high yields. This in turn, threatens future food security and raises production costs for often already poor farmers (Kochakinezhad *et al.*, 2012)

Composting is the transformation of organic material through decomposition into a soil-like material called compost. Invertebrates (insects and earthworms) and microorganisms (bacteria and fungi) help in the transformation. *Trichoderma* spp. is a fungal genus found in many regions of the world and widely used because of the multiple beneficial effects on plant growth and disease resistance, in other words it is widely used as biofertilizers and biopesticides (Alkadious and Abbas, 2012). In recent years, biofertilizers, the products containing living cells of different types of microorganisms, are also used in the integrated nutrient supply system. Biofertilizers can convert nutrionally important elements from unavailable to available form through biological processes leading to crop yields (Hedge *et al*., 1999). The present work deals with the study on the effect of *Trichoderma* inoculated compost biofertilizer on the growth and yield of eggplant.

Materials and Methods

Sample Collection and Preparation

Farm waste materials such as cow dung, rice straw and rice bran were collected from Sein Sar Pin Village, Maeutaw village group, Zaeyarthiri Township, Nay Pyi Taw. Cow dung, rice straw, rice bran, bioinoculant *Trichoderma* substrate (10^7 cfu/g) (200:40:4:1) and water (18 L) were to be used in composting process for preparation of biofertilizer by open heap layering method. Size of box used in composting was 8ft x 4 ft x 2.5 ft. After about 75 days, germination percent is 82% and then the inoculated compost biofertilizer were ready to be used. By using inoculated compost fertilizer, the brinjal (*Solanum melogena* L.) were grown in a research field at Water Utilization Research Section, Department of Agricultural Research, Yezin, Nay Pyi Taw. The experiment was arranged in a randomized complete block design and comprised four different fertilizers, namely chemical fertilizer (83N- 37P- 64K kg/ha), 30 % (w/w) *Trichoderma* inoculated compost biofertilizer, chemical fertilizer with 30 % (w/w) *Trichoderma* inoculated compost biofertilizer and unfertilized plots as control. The size of each experimental plot was (6x3) square feet. Each treatment had five replications with 6 plants in each replicate. There were 3 rows in each plot. Weeding, irrigation and other intercultural operation were done when necessary.

Weekly plant height measurements were taken from two weeks after transplanting and the shoot fresh and dry weight, root fresh and dry weight and fruity-yield per plant were recorded after the harvest. Land preparation was done by cutting the vegetation of scraping the soil surface.

Methods

All samples were subjected to physical and chemical analyses using conventional and modern techniques. And also four treatments were analysed before sowing and after harvesting. Standard methods of analyses were followed. Some part of this research work was done in Water Utilization Research Section, Department of Agricultural Research, Yezin, Nay Pyi Taw. Soil texture was determined by international pipette method. Measurement of moisture content was determined by oven drying method and soil pH was measured with a glass electrode using a 1:2.5 soil to water ratio. Organic carbon was determined Tyurin's method, electrical conductivity was determined by conductivity meter, available nitrogen content was determined by alkaline permanganate method and available phosphorous content by Olsen's method. Available potassium, exchangeable calcium, magnesium and potassium were determined by AAS. In the analytical procedures of the experiments, recommended methods and techniques were applied (FAO, 2008; AOAC, 2009). Statistical analysis was carried out using International Rice Research Institute (IRRISTAT version 5.0) in this study.

Results and Discussion

Some Physicochemical Properties and Nutrients of Raw Materials

Table.1 represents the moisture, bulk density, pH and organic carbon of raw materials. Some physicochemical properties of cow dung, rice straw and rice bran were moisture content (15.64 %, 10.37 %, 12.29 %), bulk density (0.43 g/mL, 0.18 g/mL, 0.47 g/mL), pH value (7.63, 7.27, 5.51) and organic carbon (12.42 %, 46.82 %, 53.05 %). Rice bran has higher bulk density and organic carbon than that of cow dung and rice straw. It indicated that the pH values of cow dung and rice straw are suitable to prepare natural fertilizer.

The nutrient contents of the raw materials (cow dung, rice straw and rice bran) are presented in Table 2. Cow dung contains 1.79 % of N, 1.43 % of P, 0.26 % of K, rice straw contains 1.02 % of N, 0.33 % of P, 0.13 % of K and rice bran contains 2.03 % of N, 3.43 % of P, 1.58 % of K. The most common element contents in cow dung, rice straw and rice bran were iron (967.50 ppm, 133.40 ppm and 152.30 ppm), manganese (798.40 ppm, 914.00 ppm and 117.00 ppm), copper (20.02 ppm, 16.38 ppm and 14.46 ppm) and zinc (68.23 ppm, 28.33 ppm and 73.32 ppm) respectively. The sufficient amount of N, P, K and micronutrients were found to be present in raw materials.

Physicochemical Properties and Nutrients of Compost Biofertilizer

The physicochemical characteristics such as moisture content (4.28%), bulk density (0.45 g/mL), water holding capacity (57.00%), pH value (7.20), organic carbon (18.17%), organic matter (31.33), C/N ratio (17.47) and electrical conductivity (3.88 dS/m) were found in prepared biofertilizer (Table 3). Organic carbon plays a very important and sometimes spectacular role in the maintenance and improvement of soil properties.

The prepared biofertilizer was found to contain 1.04 % of N, 0.20% of P, 0.86 % of K, 0.69 % of Ca, 0.15 % of Mg and 0.05 % of S. The most common trace elements in biofertilizer were iron, manganese and zinc. The contents of NPK are essential to maintain and sustain the soil fertility. In the present work, the calcium contents were higher than that of magnesium and sulphur in raw materials. Iron is necessary for chlorophyll formation. Manganese has several functions in the plant. Copper is probably associated with some of the plant enzyme systems and zinc is one of the most widely used micronutrient. So, the sufficient amount of N, P, K and macro and micronutrients were present in compost biofertilizer (Table 4). Toxic metals of the biofertilizer were described in Table 5. No toxic metals analysed by AAS were found in prepared biofertilizer.

Table 1 Some Physicochemical Properties of Raw Materials

Properties	Cow Dung	Rice Straw	Rice Bran
Moisture (%)	15.64	10.37	12.29
Bulk Density (g/mL)	0.43	0.18	0.47
pH	7.63	7.27	5.51
Organic Carbon (%)	12.42	46.82	53.05

Table 2 Nutrients of Raw Materials

Macro and Micronutrients	Cow Dung	Rice Straw	Rice Bran
Total N (%)	1.79	1.02	2.03
Total P_2O_5 (%)	1.43	0.33	3.43
Total K_2O (%)	0.26	0.13	1.58
Total Ca (%)	1.32	0.48	1.20
Total Mg (%)	0.71	0.03	0.68
Total S (%)	0.03	0.04	0.04
Fe (ppm)	967.50	133.40	152.30
Mn (ppm)	798.40	914.00	117.00
Cu (ppm)	20.02	16.38	14.46
Zn (ppm)	68.23	28.33	73.32

Table 3 Physicochemical Properties of Compost Biofertilizer

Properties	Content
Moisture (%)	4.28
Bulk Density (g mL^{-1})	0.45
Water Holding Capacity (%)	57.00
pH	7.20
Organic Carbon (%)	18.17
Organic Matter (%)	31.33
C/N ratio	17.47
Electrical Conductivity (dS/m)	3.88

Table 4 Macro and Micronutrients in Prepared Biofertilizer

Macro and Micronutrients	Composition (%)
Total N	1.04
Total P_2O_5	0.20
Total K_2O	0.86
Total Ca	0.69
Total Mg	0.15
Total S	0.05
Fe	0.0908
Mn	0.0074
Zn	0.0098
Cu	ND

ND = Not Detected

Table 5 Toxic Metal Contents in Compost Biofertilizer by AAS

Toxic Metals	Content (ppm)	Concentration limits (ppm)*	German Standard (ppm)**
Lead	ND	300	150
Nickel	ND	420	50
Cadmium	ND	35	3
Chromium	ND	-	150
Arsenic	ND	41	-
Mercury	ND	7.8	3

* (Ohio Enviromental Protection Agency, 2012) ND-Not Detected

** (European Commission Orbit Association, 2008)

Analysis of the Soil Treated with Chemical Fertilizer and Biofertilizer before Sowing

Table.6 shows the physical parameters and chemical compositions in terms of N, P, K, Ca and Mg of farm soil media before sowing of the Brinjal. These soils were subjected to different treatments by using prepared chemical fertilizer, biofertilizer and chemical fertilizer with biofertilizer and also the soil, without any fertilizer treatment, which was kept as a control.

The farm soil T4 as control (before sowing) shows sand 70.92 %, silt 16.04 %, and clay 13.00 %. The category of this type of soil falls in the sandy loam. The sand and silt in the soil take only a small active part in the plant growth. Soil pH may influence nutrient absorption and plant growth. The pH values of treated soils (T1 to T4) were found to be in the range of 6.34 and 6.44 and thus, it can be considered as a slightly acidic type of soil. A degree of salinity can be measured by determining the electrical conductivity (EC) of soil (FAO, 2008). It has been found that the electrical conductivity of control soil was 0.59 dS/m. By treating the soil with fertilizers the value of EC of soil was higher (0.64 -1.07) than that of the original free soil. The EC values of all treated soils were ranged from 0 to 2, and thus all soil samples were salt free (salinity effect negligible). Chemical compositions of the prepared soil were organic carbon, humus, total nitrogen, available phosphorous and available potassium together with exchangeable calcium and magnesium. These elements are the macronutrients for plant growth.

Humus is a potential soil food for plant growth and yield. The microbes become a part of the soil humus along with materials that have partially or entirely resisted the process of decomposition. The continuous slow release of plant nutrients from decomposing humus is a very important part of the ability of the soil to supply the needs to plant. If there is plentiful supply of humus or organic carbon, the decay of these by microorganisms liberates carbon dioxide, which may be converted to increase the biomass (Teakle and Boyle, 1958).The humus content of treated soil were higher than that of original control soil.

The content of available nitrogen in the farm soil was 42.00 ppm. The available phosphorous and potassium in the farm soil were 43.70 meq/100g and 150.93 meq/100g, respectively. The amounts of exchangeable Ca, Mg and K were about 7.50 me/100 g, 1.38 meq/100 g and 0.29 meq/100 g respectively. On the context of what has been described above, low N, P and K contents were found in the farm soil. Hence, the fertilizer treated soils would have more pronounced effect on the plant growth.

Table 6 Analysis Data of the Soil before Sowing Brinjal

Analytical Item	**T1**	**T2**	**T3**	**T4**
Texture-Sand (%)	69.40	69.64	70.28	70.92
Silt (%)	16.92	16.44	17.32	16.04
Clay **(%)**	13.68	13.92	12.36	13.00
Moisture (%)	1.52	0.58	0.40	1.01
pH	6.40	6.34	6.39	6.44
Electrical Conductivity (dS/m)	0.78	0.64	1.07	0.59
Organic Carbon (%)	1.08	1.15	1.14	1.06
Humus (%)	1.86	1.98	1.96	1.83
Total N (%)	0.25	0.19	0.21	0.17
C/N ratio	4.32	6.05	5.43	6.24
Available N (ppm)	45.78	44.03	52.30	42.00
Available P (ppm)	48.23	34.90	34.92	43.70
Available K (ppm)	228.25	225.28	230.43	150.93
Exchangeable Ca (meq/100g)	8.97	8.23	9.95	7.50
Exchangeable Mg (meq/100g)	0.67	1.25	0.93	1.38
Exchangeable K (meq/100g)	0.24	0.32	0.39	0.29

T1 = Chemical fertilizer, T2 = 30% compost (biofertilizer),
T3 = Chemical fertilizer + 30% compost (biofertilizer), T4 = Control

(a) Brinjal (two months after sowing) (b) Brinjal (three months after sowing)

Figure 1 View of field experiment for brinjal

Analysis of the Soil after Harvesting Brinjal

View of field experiment and vegetative growth stage of brinjal are shown in Figures 1 and 2. The analysis data of soil after harvesting brinjal are described in Table 6. All types of soil are sandy loam and it cannot be any changed before and after harvesting. pH value of treated and untreated soils were 7.01 to 7.11. In addition, in the field work study, the pH of the soil (after harvesting) was found to increase than before the transplanting stage. The effect of organic materials on the increase of pH of the soil has been reported (IRRI, 1979). It is normally due to the reduction of soil materials, but may also be caused by mineralization of organic materials to ammonia. Soil organic carbon and nitrogen are used as indexes of soil quality assessment and sustainable land use management. Soil C/N ratio is often considered as a sign of soil nitrogen mineralization capacity. High soil C/N ratio can slow down the decomposition rate of organic matter and organic nitrogen by limiting the soil microbial activity ability, whereas low soil C/N ratio could accelerate the process of microbial decomposition of organic matter and nitrogen (Wu *et al*., 2001). After harvesting stage, it was found that lowest value of C/N ratio in 30% biofertilizer treated soil (T2) and the highest value of C/N ratio in chemical fertilizer treated soil (T2). After harvesting stage, as for total N, available N, P, K and exchangeable Ca , Mg and K in all treatments, showed the reduced amounts as compared to the treated soils before sowing. It can be ascertained that the plants have taken up N, P, K, Ca and Mg on an enhance way.

(a) Chemical Fertilizer

(b) 30 % Biofertilizer

(c) Chemical fertilizer with

(d) Control 30% Biofertilizer

Figure 2 Vegetative growth stage of brinjal

Table 7 Analysis Data of the Soil after Harvesting Brinjal

Analytical Item	T1	T2	T3	T4
Texture-Sand (%)	65.92	72.28	70.88	69.18
Silt (%)	16.68	13.60	14.40	15.86
Clay **(%)**	17.40	14.12	14.76	14.96
Moisture (%)	0.11	1.52	0.12	0.23
pH	7.09	7.01	7.03	7.11
Electrical Conductivity (dS/m)	0.64	0.48	0.82	0.58
Organic Carbon (%)	1.30	1.40	1.50	1.38
Humus (%)	2.24	2.41	2.59	2.38
Total N (%)	0.14	0.18	0.19	0.16
C/N ratio	9.28	7.78	7.89	8.63
Available N (ppm)	22.78	42.42	48.52	39.11
Available P (ppm)	26.21	33.69	32.91	39.32
Available K (ppm)	97.75	109.68	152.55	102.70
Exchangeable Mg (meq/100g)	0.59	1.13	0.70	1.08

T1 = Chemical fertilizer, T2 = 30% compost (biofertilizer),
T3 = Chemical fertilizer + 30% compost (biofertilizer),
T4 = Control

Effect of Chemical Fertilizer and Biofertilizer on the Growth and Yield of Brinjal

Factors affecting plant growth are air, heat (temperature), light, mechanical supports, nutrients and water. In the field experiment, these external factors except nutrients supplying to soil were same condition for all treated soils and control plot. Growth, yield, and quality of brinjal depend on nutrients availability in soil, which is related to the judicious application of manures and fertilizers. The results are shown in Table 8.

Plants get their nutrients from three sources; air, whereas hydrogen, some oxygen, and possibly some carbon are taken from the air, whereas hydrogen, some oxygen, and possibly some carbon are taken from the soil solution. If a soil is to produce crops successfully, it must have, among other things, an adequate supply of all the necessary nutrients which plants take from the soil. The effect of inoculated compost (biofertilizer) on plant growth was studied in this work. Vegetative growth stages of brinjal in field experiment are shown in Figure 2.

During cultivation, daily determinations of plant height were recorded. The results are shown in Table 8. In this work, plant height was highly significant for brinjal ($p < 0.01$). There was highly significant in root fresh weight, root dry weight, shoot fresh weight and shoot dry weight for brinjal ($p <0.01$). Number of total fruits of T3 was significantly higher than those of T1, T2 and T4 for brinjal ($p <0.01$). After harvesting, the yield components such as the shoot fresh weight(g), root fresh weight(g), shoot dry weight(g), root dry weight(g), number of total fruit per plant and fruit weight per plant (g $plant^{-1}$) were measured and total yield (kg/ha) were calculated. *Trichoderma* inoculated biofertilizer (T3) the highest yield, which was significantly higher than the other treatments T1(chemical fertilizer), T2 (30 % Biofertilizer) and T4 (control).

The maximum total yield of about 8995.58 kg/ha for eggplant was obtained by using chemical fertilizer with biofertilizer (T3) (Figure 3). These results implied that yield of brinjal was significantly increased when *Trichoderma* inoculated biofertilizer were combined with chemical fertilizer. The combined treatment gave significantly higher yield of all crops than the treatment T1. i.e., recommended rate of NPK fertilizer.

Generally, the NO_3^- form of N fertilizer could not retain long time to the rhizosphere zone of plants and therefore, split application of N fertilizer was suggested at different stages of crop growth. Conversely, the organic amendments and microbes played a role to slow by release the plant nutrients. The microbial population in soil releases some exudates (organic substances), increases nutrient uptake through enhanced root growth or promotes availability of necessary nutrients and solubilize a number of poorly soluble nutrients, such as Mn^{4+}, Fe^{3+} and Cu^{2+} etc. (Altomare *et al*., 1999). Therefore, in present study the combined treatments enhanced efficient utilization of nutrients than the others which expedited crop growth and yield.

Chemical fertilizer

30% Biofertilizer

Chemical fertilizer with 30% Biofertilizer

Control

Figure 3 Maturity stage of brinjal

Table 8 Effect of Chemical Fertilizer and Biofertilizer on Growth and Yield of Brinjal (Field Experiment)

Treatment	Plant height (cm)	Shoot fresh weight (g)	Root fresh weight (g)	Shoot dry weight (g)	Root dry weight (g)	Number of total fruits $plant^{-1}$	Fruit weight $plant^{-1}$	Total yield (kg/ha)
T1	60.07	73.24	26.40	14.84	8.96	27	1020.30	7407.38
T2	58.43	86.24	29.72	17.08	9.68	28	1027.29	7458.13
T3	62.67	121.28	35.49	23.96	11.8	35	1239.06	8995.58
T4	53.33	53.18	21.64	10.52	7.42	21	866.44	6290.38
F Test	**	**	**	**	**	**	*	*
LSD(5%)	6.64	16.49	2.45	2.23	1.81	6.02	232.43	1687.44
CV(%)	8.20	14.30	6.30	9.70	13.80	15.70	16.20	16.20

T1=Chemical fertilizer,T2=Biofertilizer,
T3=Chemical fertilizer with biofertilizer,T4=Control LSD=Least Significant Difference, CV=Coefficient of Variation
** = significant at 1% ($p<0.01$), * = significant at 5% ($p<0.05$)

Conclusion

In this research work, physicochemical properties of raw materials (cow dung, rice straw and compost biofertilizer) have been studied by conventional methods and modern instrumental techniques. In this process, *Trichoderma* (cellulolytic) was used as composting accelerator for initiation of prepared biofertilizer. Biofertilizer was prepared from the selected waste materials (cow dung, rice straw) by over heap layering method for the composting process with the aid of bioinoculant *Trichoderma*. The prepared biofertilizer was found to contain macro and micro nutrients. And also, there is no detectable values of all toxic metals (Pb, Ni, Cd, Cr, As, Hg) in prepared biofertilizer. In the present study, it was clearly observed that the *Trichoderma* inoculated biofertilizer had positive impact on growth and yield of brinjal.

Based on the field work investigation, the efficacy of *Trichoderma* inoculated biofertilizer accelerated when it was supplemented with chemical fertilizer application. Superior and significant growth and yield were increased by supplementation of chemical fertilizer with *Trichoderma* inoculated biofertilizer. The maximum 8995.58 kg/ha yield increase over control of brinjal was noticed in T3, which was 6290.38 kg/ha in T4. It may be concluded that application of *Trichoderma* inoculated biofertilizer along with chemical fertilizer could save at least 30 % biofertilizer giving higher yields in brinjal compared to T1 (chemical fertilizer).

Undoubtedly, there is a positive and potential of *Trichoderma* inoculated biofertilizer in crop cultivation to achieve attractive yield and reducing chemical fertilizer. With biofertilizer, a low input system can be carried out, and it can be supported achieving outcome for farms. Agriculture wastes recycling can bring tremendous benefits to agriculture and land management in long run. Therefore, this research may contribute to the development of the biofertilizer for agricultural sector in Myanmar.

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