BIBLIOGRAPHY

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ABSTRACT

The study was conducted to determine: 1) the effects of vermicompost on the growth and tuber yield performance of potato (Solibao var.), 2) some physical and chemical properties of the soil under protected environment; 3) economic analysis of potato applied with vermicompost under protected environment at the Certified Organic Demo Farm, Benguet State University, La Trinidad, Benguet.

The height of potato plants were influenced by the application of different rates of vermicompost. The number of super extra large tubers, extra large tubers, big and small tubers increased with increasing rates of vermicompost application from 10, 15 and 20 t ha^{-1}. Conversely, the super extra large, extra large, big potato tubers decreased on plots applied with 25 t ha^{-1} except that small tubers was greater in number. The same trend was observed on the weights of potato tubers.

The bulk density, total porosity, and water holding capacity of the soil were improved by vermicompost application. Likewise, increasing application of vermicompost from 10 to 25 tha^{-1} increased the soil pH, %OM and % Nitrogen content of the soil.

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INTRODUCTION

Potato (*Solanumtuberosum L.*) isa herbaceous annual crop grown for its edible tubers. It is mostly used as a vegetable as a source of starch and for other commercial purposes. This crop becomes the world's most important tuber crop and it is considered as the fourth most important of food energy after rice, wheat, and maize. Farmers and gardeners grow them worldwide. Growers cultivate thousand of different varieties of potato (Mosley 2003) as cited by Faustino (2011).

FNRI (2006) as cited by Faustino (2011), potatoes are best suited in highlands like Benguet and Mountain province because of their similar climate conditions. Thus it became a major source of income to growers in the Cordillera.

An Egyptian study, published in March 2009 in the journal of "Food Chemistry and Toxicology," reported that conventionally grown potatoes had almost two times the amount of pesticides and heavy metal contamination than those organically grown ones.Crinnion (1982), states that measurements taken by the USDA and other consumer agencies produced data showing that organically grown foods had no amount of chemical residues found unlike in conventionally raised foods (Denholm, 2010).

The production of organically produce potato needs to be supplied with the right kind of organic fertilizer inputs. The main problems of today's farmers are the degraded soil qualitiesmaterials due to indiscriminate and improper use of synthetic fertilizers. Likewise improper use and handling of chemical pesticidesdo not only kill the beneficial microorganisms inherent in the soil but also the health of the farmer is badly affected. Using organic inputs helps bring back the original conditions of the degraded soil for its ability to improve the physical, biological and chemical properties of the soil.

Composting organic materials is one of the best methods in the production of organic fertilizer inputs. It is a process allowing the biodegradable materials to be composted under natural or controlled environment to produce end-products essential for the improvement of soil's physical, chemical and biological properties desirable for the plants to grow. There are many ways on how to produce compost. Vermicomposting is one. It is a process of composting using earthworms to convert organic biodegradable materials into very high quality of compost called vermin cast or the combination of cast plus compost. Vermicompost is one of the best organic fertilizers by improving the soil qualities like increasing microbial activity, decreases plant and soil susceptibility to pest and diseases and lessen compaction leading to better aerated soils and higher nutrient levels for the nutrition of the plants.

Generally, the study was conducted to determine the effects of vermicompost application the growth and tuber yield performance of potato (Solibao var.) under protected environment. Specifically, the study aims to determine; 1)the best rate of vermicompost on the growth of organic potato grown under protected environment; 2) the best rate of vermicompost on the yield of organic potato; 3) the effects of vermicompost on some physical properties of the soil; and 4) the effects of vermicompost on some chemical properties of the soil; and 4) the economic analysis of growing potato applied with vermicompost under protected environment.

The research study was conducted under protected environment at the newly Certified Organic Demo FarmBenguet State University Organic Demo Farm, Balili, La Trinidad,Benguet from November 2011 to February 2012.

REVIEW OF LITERATURE

Potato Crop

In terms of nutrition, the potato is best known for its carbohydrate content (approximately 26 grams in a medium potato). The predominant form of this carbohydrate is starch. A small but significant portion of this starch is resistant to digestion by enzymes in the stomach and small intestine, and so reaches the large intestine essentially intact. This resistant starch is considered to have similar physiological effects and health benefits as fiber: It provides bulk, offers protection against colon cancer, improves glucose tolerance and insulin sensitivity, lowers plasma cholesterol and triglyceride concentrations, increases satiety, and possibly even reduces fat storage. The amount of resistant starch in potatoes depends much on preparation methods. Cooking and then cooling potatoes significantly increases resistant starch. For example, cooked potato starch contains about 7% resistant starch, which increases to about 13% upon cooling (FAO 2009).

FNRI (2006) cited by Faustino (2011) stated that potato has a high nutritive value. It contains carbohydrates, proteins, minerals and vitamins in moderate amounts. Mendel (1997) stated that potato contains vitamins and minerals, as well as an assortment of phytochemicals, such as carotenoids and natural phenols. Chlorogenic acid constitutes up to 90% of the potato tuber natural phenols. Others found in potatoes are 4-O-caffeoylquinic (crypto-chlorogenic acid), 5-O-caffeoylquinic (neo-chlorogenic acid), 3,4-dicaffeoylquinic and 3,5-dicaffeoylquinic acids. A medium-size 150 g (5.3 oz) potato with the skin provides 27 mg of vitamin C (45% of the Daily Value (DV)), 620 mg of potassium (18% of DV), 0.2 mg vitamin B_6 (10% of DV) and trace amounts of thiamin, riboflavin, foliate, niacin, magnesium, phosphorus, iron, and zinc. The fiber content of a potato with skin (2 g) is equivalent to that of many whole grain breads, pastas, and cereals.

Vermicompost

Vermicompost (also called worm compost, vermicast, worm castings, worm humus or manure) is the end product of the breakdown of organic matter by some species of earthworm. Vermicompost is a nutrient rich, organic fertilizer and soil conditioner, the process of producing vermicompost is called vermicomposting. The earthworm species or composting worm most often used are Redwinglers (Eiseniafetida) or Red Earthworm (Lumbricusrubellus), the species are commonly found in the organic rich soil throughout Europe and North America and especially prefer the special condition in rooting vegetation compost and manure piles as cited by Aboen Jr. (2009).

Vermicompostshave a fine particulate structure, low C:N ratio, with the organic matter oxidized and stabilized and converted into humic materials. They contain nutrients transformed into plant-available forms and are extremely microbially-active. Additions of low rates of substitution of vermicomposts into greenhouse soil less plant growth media or low application rates to field crops have consistently increased plant germination, growth, flowering, and fruiting, independent of nutrient availability; This can be at least partially, attributed by the greatly increased microbial populations, of plant growth regulators, including plant hormones, such as indole-acetic acid, gibberellins and cytokinins and also humicacids, which simulate the effects of hormones. Vermicompostscan suppress the incidence of plant pathogens such as Pythium, Rhizoctonia andVerticillium significantly, by general or specific suppression mechanisms. Vermicompost applied to soils have considerable influence on the trophic structure of nematode populations, significantly suppressing plant parasitic organisms. Greenhouse experiments have shown thatlow substitutions of vermicomposts into soil-less plant growth media can decrease the amounts of feeding and nutrition for crops (Edwards , Dominguez and Arancon 2011).

Effects of Organic Fertilizer on Plant growth

Kinoshita (1970) revealed that organic fertilizers turn heavy soil lighter, more crumbly,friable and they hold light soil particles together to act as an anchor against erosion and to increase water holding capacity of the soil. They provide some of the large quantities needed by the plants and released nutrients present in the soil by turning them into soluble compounds that can be absorbed by the roots of the plants. Finally, they carry considerable quantity of elements, often insufficient into the soil and provide readily available microelements, both activities that promote plant growth.

Brady and Weil (2002) tabulated that some humic substances directly influenced plant growth by accelerating water uptake and enhance germination of seeds (humic acid), stimulating root initiation and elongation (humic and fulvic acid), enhance root cell elongation (humic acid), and enhance growth of plants shoots and roots (humic and fulvic acids).

Effects of OM on Soil Properties

Agriculture Technologies, Inc. (2010) reported that vermicompost is beneficial for soil in many ways by improving the physical structure of the soil, the biological properties of the soil, the water holding capacity of the soil, and the root growth and structure of the plant. It also attracts deep-burrowing earthworms already present in the soil, enhances germination, plant growth and yield. In addition vermicompost also increases microbial activity, decreases plant and soil susceptibility to pest and diseases and lessen compaction leading to better aerated soils and higher nutrient levels and availability of nutrients to the plants.

In the study conducted by Azarmi in 2008, addition of 5, 10 and 15 tons/ha of vermicompost in soil has significant positive effect on the uptake of element nutrients such as P, K, Fe and Zn.Vermicompost also had improved the bulk density and porosity of the soil.

Physical Properties of Soil as
Influenced byOrganic Matter

Brady and Weil (2002) stated that the humic fraction help reduce the plasticity, cohesions, and stickiness of clayey soils, making those soils easier to manipulate. Soil water retention is also improved, since organic matter increases both infiltration rate and water-holding capacity.

Physical Properties of Soil as
Influenced by Vermicompost

Vermicompost has a very high water holding capacity. It has a good structure which makes it desirable component of potting mixes (Lacay 2008) as cited by Cabading (2010).Vermicompost also had improved the bulk density and porosity of the soil (Asarmi 2008).

Chemical Properties

Addison and Hiraga (2010) stated that worm cast also contains five times more nitrogen, seven times more phosphorous, and eleven times more potassium than ordinary soil. These are main minerals needed for plant growth, but the large numbers of beneficial soil micro-organism in worm casts have at least as much to do with it, the casts are also rich in humic acids, which conditions the soil, have a perfect pH balance and contain plant growth factors similar to those found in sea weeds.

Singh (2001) stated that vermicompost has a pH of 7-7.5% and a C:N ratio of 12-15.1. Through chemical analysis, it contains 1.75-2.5% N, about 1.25-2% K, calcium, magnesium, sulfate which are 3-5% times better than farm manure.

Chemical Characteristic
of Vermicompost

Bohn et al. (1998) as cited by Lagman (2003) stated that organic matter of vermicompost supplies nitrogen, phosphorus, and sulfur for plant growth, serves as energy source for soil microfloral and macro faunal organisms, and promotes good soil structure. It indirectly affects the plant uptake of micronutrients and heavy metal cat ions, and the performance (availability) of herbicides and other agricultural chemicals. It supplies nearly all the nitrogen, 50 – 60% of the phosphate, perhaps as much as 80% of sulfur, and a large part of the boron and molybdenum absorbed by plants from fertilized, temperate region soils. Indirectly, it affects the supply of mineral nutrients from other sources. The onions of vermicompost also combined with toxic ions such as cadmium and mercury, as well as with micronutrients cat-ions at high concentrations, and reduce their availability. Whether the metals are strongly absorbed by the solid-phase soil organic matter or complex by high molecular weight humic acid is not known. Organic amendments, however often decrease cat-ion toxicities in acid soils.

Biological Properties

Arancon and Edwards (2005) cited that vermicompost have many outstanding biological properties. They are rich in bacteria, actinomycetes, fungi and cellulose-degrading bacteria. In addition earthworm castings, obtained after sludge digestion, were rich in microorganisms, especially bacteria. The vermicompost had much larger population of bacteria (5.7×10^7), fungi (22.7×10^4) and actinomycetes (17.7×10^6) compared with those in conventional composts. The outstanding physic-chemical chemical and biological properties of vermicompost make the excellent materials as additives to greenhouse container media, organic fertilizers or soil amendments for various horticultural crops.

Analyzed Raw Materials

BSWM (2011) analysis of raw materials with a substrate of banana trunk, water lily, grass mixtures and cow manure has 4.33% nitrogen content, 0.96% phosphorus, 2.09% potassium, 2.62% calcium, 1.04% magnesium, 7.2 pH, 53.39% moisture content, 145ppm zinc, 2,719ppm manganese, 21,358ppm iron and 24.69% organic carbon.

MATERIALS AND METHODS

The materials used are potato tubers (Solibao var.), vermicompost derived from water lily, cow manure, banana trunk, and grass mixtures, green house, farm implements like grab hoe, watering cans, cultivate and bolo, ruler and meter stick, plastic bags and laboratory equipments and chemicals.

The materials with a ratio of 2:2:2:1 are; banana trunk (200 kg), water lily (200 kg), grass mixtures of (200 kg) and cow manure (100 kg) were gathered, shredded, mixed thoroughly and piled into the compost pit and composted for one and a half month. The pile was turned once a week after a month for proper aeration. After a month of decomposition, vermin (earthworms) were introduced in the compost pile for further decomposition. Vermicompost (cast + compost) were gathered after a month of worm inoculation.

An area of 4.5m x 22m were sampled before and after the start and final conduct of the trial for initial and final soil physical and chemical analysis. The area were cultivated thoroughly before seeding and prepared with three (3) blocks having each treatment dimension of 0.9m x 7m. The amounts of vermicompost were applied and incorporated thoroughly in each treatment plot following the different treatments. Potato seed pieces were planted with a distance of 30 x 30 cm between hills and rows. The different treatments were laid out in the experimental site following Randomized Complete Block Design (RCBD) with three (3) replications (Figure 1).

Figure 1.Field Layout of the Experimental Area at BSU Organic DemoFarm, La Trinidad, Benguet. Area was thoroughly Preparedbefore planting.

The following treatments were as follows:

M_1-Control (No Fertilizer)

M_2- 10 tons/ ha

M_3- 15 tons/ ha

M_4- 20 tons/ ha

M_5- 25 tons/ ha

Cultural management practices were employed equally to all the treatments such as weeding, watering, hilling-up, insects and disease control and nutrient supplementation by applying liquid organic fertilizer extract (Sunflower + Banana + Molasses) done every other week during the conduct of the study. Compost tea was also appliedin 1:2 dilutions.This was applied at every 2 weeks interval.

The data gathered were the following:

A. Agronomic Parameters

1. Plant Height (cm)

1.1. Initial height (cm). The initial height of the plant was taken 10 days after germination. Ten sample plants were randomly tagged for the measurement.

1.2. Final height (cm). The final height of the plants were taken a week before harvest. The same sample plants used in gathering the initial height were used in determining the final heights of potato.

2. Tuber Yield

2.1 Numbers of classified tubers. The total numbers of classified tubers wereobtained using NPRTC classification.Tubers were classified according totuber weight as follows:

Description	Size (g)
A. Small	< 20
B. Big	20-55
C. Extra Large	56-85
D. Super Extra Large	>85

3. Dry matter content of the tubers was determined by oven–dry method. The DMC of tubers were measured using the formula:

$$\% \, DMC = 100 - \% \, MC$$

$$\% MC = \frac{FW - ODW}{FW} \times 100$$

Where: MC= percent moisture content

FW= fresh weight of tubers

ODW= oven dry weight of tubers

3. Return on Cash Expenses. This was obtained through the following formula:

$$ROCE = \frac{\text{Gross Sales - Total Expenses}}{\text{Total expenses}} \times 100$$

Where: ROCE= Return of Cash Expense

4. Physical Properties of the Soil

4.1 Bulk density (Db) of the Soil (g cm^{-3}). This was obtained by paraffin clod method. The bulk density was obtained with the following formula.

$$Db \, (g \, cm^{-3}) = \frac{\text{wt. of the soil bulk (g)}}{\text{Bulk volume of soil } (cm^3)}$$

4.2. Water holding capacity (WHC) of the soil (%). This wasdetermined through Saturation method, wherein core samplers was filled with soil then the bottom of the cylinders was soaked in water saturated through capillarity.

$$\% \, WHC = \frac{\text{Wt. of saturated Soil – Oven Dry Soil (g)}}{\text{Oven Dry Soil (g)}} \times 100$$

4.3. % Porosity of the Soil was determined by PCCARRD StandardMethod of Analysis.This is obtained using the following formula:

$$\text{Pore Space (\%)} = 1 - \frac{Db}{Dp} \times 100$$

Where: Db = bulk density, g cm^{-3}

Dp = particle density, g cm^{-3}

5. Chemical properties

5.1. Soil pH. The initial and final pH of the soil was determinedusing the 1:2.5 $CaCl_2$ solutions. The samples were read in a pH meter.

5.2. Organic matter content of the soil (%). The soil organicmatter was analyzed using Walkey-Black Method.

5.3. Total nitrogen content of the soil (%). This was computed usingthe formula:

N (%) = % OM x 0.05

Where: (%) OM = value of the organic matter computed

0.05 = constant.

RESULTS AND DISCUSSIONS

Growth Parameters of Potato as Influenced by the Rates of Application of Vermicompost

Initial Height

Vermicompost application affected the initial heights of plants 10 days after emergence (Table 1). Vermicompost applied at the rates of 10 to 25 tha^{-1} increased the initial heights by 29.90%, 36.13%, 38.88% and 31.88%, respectively over the control plants. There was a decrease of 0.74 cm on the height of plants as the amount of vermicompost was applied from 20 tha^{-1} to 25 tha^{-1}. Likewise, plants grown in plots applied with the different rates of vermicompost did differs from each other as to initial height is concern. This observation can be attributed to the influence of vermicompost on the growth of potato plants by improving the chemical properties of the soil (Singh, 2001, Adison and Hiraga 2010).

Table 1.Initial height of the plant 10 days after emergence as influenced by the different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN (cm)
Control	10.57^{b}
10	13.73^{a}
15	14.46^{a}
20	14.68^{a}
25	13.93^{a}

Means with the same letter/s are not significantly different at 5% level of DMRT.

<u>Final Height</u>

Similar trend were observed on the final height of potato plants grown in plots applied with different rates of vermicompost (Table 2). Vermicompost applied at the rates of 10 to 25 t ha^{-1}increased the final height by 27.12%, 32.03%, 39.87% and 39.87% respectively over the control plants. There were increases on the height of plants as the amounts of the vermicompost applied were increased. Likewise, plants grown in plots applied with different rates of vermicompost did differ from each other as to the final heights is concerned. This observation attributed to the component of humic substances probably act as regulators of specific plant-growth functions (Brady and Weil, 1996), and the nutrients from the vermicompost (Adison and Hiraga 2010, Signh, 2001).

Table 2. Final height of the plant 80 days after emergence as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN (cm)
Control	30.6^{b}
10	38.9^{a}
15	40.4^{a}
20	42.8^{a}
25	42.8^{a}

Means with the same letter/s are not significantly different at 5% level by DMRT

Yield Parameters of Potato as Influenced by the Application Rates of Vermicompost

Number of Super ExtraLarge-size Potato Tubers

Table 3 shows the super extra-large size potato tubers as influenced by the different rates of vermicompost application. Application of vermicompost from 20 t ha^{-1} to 25 tha^{-1} gave corresponding increases of super extra-large tubers from 150%, 450%, 450%, and 300%, respectively over the control. However, potatoes grown in plots applied with 25 t ha^{-1} vermicompost registered identical decreases by 27.27% over those plants grown in plots applied with 15-20 t ha^{-1}, respectively. This observation can be attributed to the effects of vermicompost by improving the physical, chemical and biological properties of the soil that enhance growth and tuber development.

Table 3. Number of super extra large-size potato tubers as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN
Control	2^{d}
10	5^{c}
15	11^{a}
20	11^{a}
25	8^{b}

Means with the same letter/s are not significantly different at 5% level by DMRT

Number of Extra Large-size Potato Tubers

Application of different rates of vermicompost influenced the extra large-size potato tubers (Table 4.) Application of vermicompost from 10 t ha^{-1} to 25 t ha^{-1} gave the differences to each other. It gave the corresponding increases by 33.33%, 66.67%, 100% and 16.67% over the control respectively. Application of 20 t ha^{-1} of vermicompost registered the highest produced extra large-size of potato tuber. These observations correspond to the contribution of vermicompost on the yield of potato (Edwards and Bohlen 1996, Edwards 1998, Lavelle and Spain 2001).

Table 4. Number of extra large-size potato tubers as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN
Control	6^{c}
10	8^{bc}
15	10^{ab}
20	12^{a}
25	7^{bc}

Means with the same letter/s are not significantly different at 5% level by DMRT

Number of Big-size Potato Tubers

Table 5 shows the big-size potato tubers as influenced by the different rates of vermicompost application. Application of vermicompost from 25 t ha^{-1} gave corresponding increases of big-size tubers by 33.33%, 11.11%, and 55.56%, respectively over the control. Application of 10 t ha^{-1} did not differ from the control.

This observation maybe attributed due to the rates of vermicompost applied in the soil that affects the yield of potato (Edwards, Dominguez and Arancon, 2011).

Table 5. Number of big-size potato tubers as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN
Control	9^{c}
10	9^{c}
15	12^{b}
20	10^{c}
25	14^{a}

Means with the same letter/s are not significantly different at 5% level by DMRT

Number of Small Size Potato Tubers

Table 6 shows the number of small size potato tubers as influenced by the different rates of vermicompost application. Application of 10 t ha^{-1} and 25 t ha^{-1} gave corresponding increase by 18% and 63.64% respectively over the control. However, application of 20 t ha^{-1} vermicompost did not differ over the control. Moreover application of 15 t ha^{-1} vermicompost decreased by 36% from the untreated plot. This implication shows that different rates of vermicompost application has its own corresponding effects for the yield of potato.

Table 6. Number of small-size potato tubers as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN
Control	11^{bc}
10	13^{b}
15	7^{d}
20	11^{c}
25	18^{a}

Means with the same letter/s are not significantly different at 5% level by DMRT

Weight of Super Extra Large-size Potato Tubers

Weight of super extra-large potato tubers as influenced by the different rates of vermicompost application is shown in table 7. Vermicompost applied at the rates of 10-25 t ha^{-1} increased the weight of super extra-large size potato tubers by 213.98%, 470.50%, 520.08% and 197.17% respectively over the control. However, 25 t ha^{-1} had decreased at about 79.92% from the highest mean. On the other hand this shows that application of vermicompost in increasing rates affects the weights of the tubers. This conform to the statement of Addison and Hiraga (2010) that vermicompost contain plant growth factor. Likewise they stated that worm cast five times nitrogen, seven times phosphorous and eleven times potassium more than ordinary soil. These are main minerals needed for plant growth and yield.

Table 7. Weight of super extra large-size potato tubers as influenced by differentrates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN (g)
Control	201.7[c]
10	633.3[b]
15	1,150.0[a]
20	1,250.0[a]
25	600.0[b]

Means with the same letter/s are not significantly different at 5% level by DMRT

Weight of Extra Large-size Potato Tubers

Table 8 shows the weight of extra large size potato tubers as influenced by the different rates of vermicompost application. Application of vermicompost by 10 to 25 t ha^{-1} gave corresponding increases by 93.74%, 106.49%, 168.73% and 43.72% respectively over the control. However, potatoes grown in plots applied with 25 t ha^{-1}registered a decrease of 125.01% from the highest result (20 t ha^{-1}). On the one hand, this observation agree with the report that vermicompost improved the root growth and structure of the plant (Agricultural Technologies, Inc. (2011) by improving the physical, chemical and biological structure of the soil that benefits the potato plants for their growth and yield.

Table 8. Weight of extra large-size potato tubers as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN (g)
Control	266.7^{d}
10	516.7^{b}
15	550.0^{b}
20	716.7^{a}
25	383.3^{c}

Means with the same letters are not significantly different at 5% level by DMRT

Weight of Big-size Potato Tubers

Table 9 shows the weight of big-size potato tubers as influenced by the different rates of vermicompost application. Application by 10 to 25 t ha^{-1} vermicompost affect the weight of the tubers over the control having a corresponding increases by 21%, 115.76%, 21% and 68.39% respectively. However it was registered that 15 t ha^{-1} produce the highest weight as far as big-size is concerned. This observation maybe caused by the rates of vermicompost applied to the potato to its corresponding capacity as far as producing big-size tubers is concerned. Furthermore, in the study of Azarmi (2008), addition of 5, 10, 15 t ha^{-1} of vermicompost in soil has positive effect on the uptake of element nutrients as P, K, Fe and Zn.

Table 9.Weight of big-size potato tubers as influenced by different rates vermicompost applicayion.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN (g)
Control	316.7[c]
10	383.3[c]
15	683.3[a]
20	383.3[c]
25	533.3[b]

Means with the same letter/s are not significantly different at 5% level by DMRT

Weight of Small-size Potato Tubers

Table 10 shows the weight of small-size potato tubers as influenced by the different rates application of vermicompost. Application of 10 t ha^{-1}, 20 t ha^{-1} and 25 t ha^{-1} differed over the control by 2.47%, 81.21%, 93.74% respectively. However a decreased was observed in treatment 3 applied with the rate of 15 t ha^{-1} of vermicompost. This observation maybe due to the rates of vermicompost to its superiority of producing big-size tubers shown in table 9. Likewise application of 25 t ha^{-1}vermicomposthas registeredthe highest weight as far as small-size potato tuber is concern. This may be considered as the issue caused its shortage to produce bigger tubers as shown in the previews table.

Table 10. Weight of small-size potato tubersas influenced by different rates of vermi-compost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN (g)
Control	266.7[b]
10	273.3[b]
15	133.3[c]
20	483.3[a]
25	516.7[a]

Means with the same letter/s are not significantly different at 5% level by DMRT

Dry Matter Content

Table 11 shows the dry matter content of potato tubers as influenced by the different rates of vermicompost application. Application of 10 t ha^{-1} to 25 t ha^{-1} vermicompost affect the dry matter content of tubers by 1.02%, 5.51%, 2.51% and 3.52% respectively. This implies that increasing application rates of vermicompost increases dry matter content of potato tubers (Solibao var.). Furthermore, this result shows that growing organic potato with the use of vermicompost as organic fertilizer can improve the quality of potato specially Solibao variety for food processing. From 18.76%, it was increased up to 19.42%. The dry matter content of tubers ranged from 19-22% meeting the required dry matter content of above 19% for processing (Kuntz, 1996). Dry matter is influenced mainly by the genetic characteristics of the entry, but may also be affected by environmental factors (Ratsovski et al., 1981) as cited by Tad-awan et al., (2008).

Table 11. Dry matter content of tubers as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	MEAN (%)
Control	18.76^{b}
10	18.95^{ab}
15	19.23^{ab}
20	19.23^{ab}
25	19.42^{a}

Means with the same letter/s are not significantly different at 5% level by DMRT

Some Physical Properties of the Soil as Influenced by the Application Rates of Vermicompost

Water Holding Capacity of the Soil

The water holding capacity of the soil as affected by the different application rates of vermicompost is shown in Table 12. Plots applied with the rate of 10, 15, 20 and 25 tha^{-1} increased the water holding capacity by 36.51%, 59.12%, 65% and 71.99% respectively over the initial value of 41.05%. Brady and Weil (1996) as cited by Ocampo (2011) said that organic matter improves the soil structure which influences water retention, drainage and release of nutrient.

Table 12. Water holding capacity of the soil as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST (t ha^{-1})	WHC (%)
Control	55.44^{d}
10	64.65^{c}
15	65.32^{c}
20	67.77^{b}
25	70.60^{a}
Initial	41.05

Means with the same letter/s are not significantly different at 5% level by DMRT.

Bulk Density of the Soil

Table 13 showed the bulk density of the soil as affected by the different application rates of vermicompost. Application rates of vermicompost from 10 to 25 tha^{-1} influenced the bulk density of the soil over the control. Bulk density of plots treated with 25, 20, 15, and 10 tha^{-1} decreased at about 4.55%, 12.12%, 15.19% and 17.42 % respectively over the control. This shows that increasing the rates of vermicompost application tend to decrease the bulk density of the soil.Azarmi (2008)said that vermicompost improved the bulk density of the soil. Smith *et.al*. (1999) as cited by Ocampo (2011) reported that the bulk density tend to decrease with the addition of both compost and vermicompost.

Table 13. Bulk density of the soil as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST ($t\ ha^{-1}$)	Db ($g\ cm^{-3}$)
Control	1.32^{a}
10	1.26^{ab}
15	1.16^{bc}
20	1.11^{c}
25	1.09^{c}
Initial	1.34

Means with the same letter/s are not significantly different at 5% level by DMRT.

Total porosity of the Soil

Application of different rates of vermicompost influenced the total porosity of the soil. Table 14 shows that application of 10 tha^{-1} to 25tha^{-1} of vermicompost increased the porosity of the soil by 11.88%, 19.06%, 27.63% and 30.25% respectively over the initial value. This shows that as the rates of application for vermicompost is increasing, the pore space tend to increase. This attributed to the report of the Agriculture Technologies, Inc (2010) that vermicompost increases microbial activity that lessen compaction leading to better aerated soils.

Table 14. Total porosity of the soil as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST ($t\ ha^{-1}$)	TOTAL POROSITY (%)
Control	56.33^{b}
10	56.67^{b}
15	60.33^{ab}
20	64.67^{a}
25	66.00^{a}
Initial	50.67

Means with the same letter/s are not significantly different at 5% level by DMRT.

Some Chemical Properties of the Soil as Influenced by the application rates of vermicompost

Soil pH

Application of increasing rates vermicompost from 10, 15, 20, 25 tha^{-1} increases the soil pH (Table 15). Vermicompost applied at the rates of 10 to 25 tha^{-1} increased the pH of the soil near to its neutral by 3.49%, 4.60%, 5.51%, and 5.87% respectively over the control. It confirms to the statement of Singh (2001) that vermicompost has a pH of 7-7.5%. Addison and Hiraga (2010) also said that worm casts are rich in humic acid, which conditions the soil, have a perfect pH balance and contain plant growth factors. Arancon et al. (2005) as cited by Ocampo (2011) stated that vermicompost tend to have pH values near neutrality which may be due to the production of CO_2 and organic acids produce during microbial metabolism.

Table 15.Soil pH of the soil as influenced by different rates of vermicompost application.

RATE OF VERMICOMPOST ($t\ ha^{-1}$)	(SOIL pH)
Control	6.3^{d}
10	6.52^{c}
15	6.59^{b}
20	6.65^{a}
25	6.67^{a}
Initial	6.30

Means with the same letter/s are not significantly different at 5% level by DMRT.

Organic Matter Content of the Soil

Application of vermicompost as shown in table 16 influenced the organic content of the soil. Increasing rates of vermicompost increased the organic matter content of the soil by 62.5%, 84.38%, 117% and 134% over the initial value of 1.94%. Application of 25 tha^{-1} registered the highest amount of organic matter with a mean of 2.62. This shows that increasing the application rates of vermicompost from 10 to 25 tha^{-1} increased the organic matter content of the soil. This observation can be attributed to the influence of vermicompost on the organic matter content of the soil (Betayan, 2009). Arancon and Edwards (2005) cited that vermicompost have many outstanding biological properties. They are rich in bacteria, actinomycetes, fungi and cellulose-degrading bacteria.

Table 16. Organic matter content of the soil as influenced by different rates ofvermicom-postapplication.

RATE OF VERMICOMPOST (t ha^{-1})	OM (%)
Control	1.28^{d}
10	2.08^{c}
15	2.36^{b}
20	2.45^{ab}
25	2.62^{a}
Initial	1.94

Means with the same letter/s are not significantly different at 5% level by DMRT.

Nitrogen Content of the Soil

Table 17 shows the Nitrogen content of the soil as influenced by the different rates of vermicompost application. Application of vermicompost from 10 to 25 tha^{-1} gave corresponding increase of Nitrogen content by 1%, 140%, % and 160% respectively over the initial value. This shows that as the rate of vermicompost is increased, nitrogen content also increases. This confirms with the statement of Bohn et al. (1998)that organic content of vermicompost supplies nitrogen. The same with Addison and Hiraga (2010) who stated that worm cast contains five times nitrogen more than ordinary soil.

Table 17. Total nitrogen content of the soil as influenced by different rates of vermicom-postapplication.

RATES OF VERMICOMPOST (t ha^{-1})	TOTAL (%)
Control	0.06[b]
10	0.11[ab]
15	0.12[ab]
20	0.12[ab]
25	0.13[a]
Initial	0.05

Means with the same letter/s are not significantly different at 5% level by DMRT.

Economic Importance

Return on Cash Expenses

Table 18 shows that different rates of vermicompost influenced the (ROCE) return on cash expense. It increased the yield of potato. Application of 20 tha^{-1} of vermicompost were superior over 25 tha^{-1} much the more to the untreated plot. This showed that application of vermicompost from the rate of 10 to 20 tha^{-1} increased the yield of potato that results to high return on cash expense. However application of 25 tha^{-1} rate of vermicompost resulted to a decrease of 28.21% net return lower than 10 ton ha^{-1} application of vermicompost. This could be due to high production cost resulting to a low net return.

Table 18. Return on cash expense of potato as influenced by different application rates of vermicompost.

TREATMENT	Yield /Plot (kg/plot)	GROSS INCOME (Php)	COST OF PRODUC-TION (Php)	NET INCOME (Php)	%ROCE
Control	2.94	176.40	182.75	-6.35	-3.47
10 tons/ha	5.42	325.20	230.35	94.85	41.18
15 tons/ha	7.55	453.00	254.15	198.85	78.24
20 tons/ha	9.00	540.00	277.95	262.06	94.28
25tons/ha	6.00	360.00	301.79	58.21	19.29

Price used in the computation of gross income was Php 60/kg.

SUMMARY, CONCLUSION AND RECCOMENDATION

Summary

The study was conducted at the newly certified Organic Demo Farm at Benguet State University, La Trinidad, Benguet under protected Environment from November 2011 to February 2012 using RCBD. Application rates of 10 tha^{-1}, 15 tha^{-1}, 20 tha^{-1} and 25 tha^{-1} were studied. The study was conducted to 1) determine the best rate of vermicompost on the growth of organic potato grown under protected environment, 2) the best rate of vermicompost on the yield of organic potato, 3) the effects of vermicompost on some physical and chemical properties of the soil and 4) the economic analysis of growing potato applied with vermicompost under protected environment.

The different rates of vermicompost affect the growth and yield of potato as well as some of the physical and chemical properties of the soil. The bulk density was improved as the different rates of vermicompost were applied, the higher the rates, the lower the bulk density. Likewise with the pore space and water holding capacity of the soil in which the higher the rates, the higher increase in percent.

On the other hand, growth of potato with the rates 20 and 25 tha^{-1} registered the tallest plants. However, they did not differ much, 20 tha^{-1} is a little superior over 25 tha^{-1} application of vermicompost. Same to the yield of potato, vermicompost with the rate of 20 tha^{-1} gave the highest yield over the other treatment.

The dry matter content of the potato tuber was influenced by different rates of vermicompost application. The increasing application rate of vermicompost raised the dry matter content meeting the requirement for processing.

The return on cash expense (ROCE) that obtained the highest percentage was noted from plots applied with 20 tha^{-1} vermicompost with a corresponding return on cash expense of 94.28%.

Conclusion

The best rate of vermicompost application appeared to be 20 tha^{-1} for the growth and yield of organic potato under protected environment.

Application of vermicompost increased the physical properties of the soil like, bulk density, pore space and water holding capacity.

Likewise, the chemical properties like pH, soil organic matter and total nitrogen content of the soil was increased.

Application of vermicompost with 20 t ha^{-1} registered to be the best based on the economic importance.

Recommendation

It is therefore recommended based on the results and conclusions that application of 20 t ha^{-1} vermicompost is the best rate for the production of organic potato (Solibao var.) under protected environment.

In addition, a follow-up study is recommended to verify the results for the controlled and open field condition.

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APPENDICES

Appendix Table 1.Initial height of the plant 10 days after emergence (cm)

TREATMENT	BLOCKS				
	I	II	III	TOTAL	MEAN
M_1	11.55	10.40	9.76	31.66	10.57
M_2	14.28	15.20	11.70	41.18	13.73
M_3	13.95	15.23	14.21	43.39	14.46
M_4	13.2	15.15	15.68	44.03	14.68
M_5	14.00	12.85	14.96	41.81	13.94
Total	53.28	68.83	66.31	202.07	13.28

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	0.681	0.341	0.1932		
Treatment	4	33.409	8.352	4.7365*	3.84	7.01
Error	8	14.107	1.763			
Total	14	48.197				

* = significant CV= 9.85%

Appendix Table 2. Final height of the plant 80 days after planting (cm)

TREATMENT	BLOCKS				
	I	II	III	TOTAL	MEAN
M_1	33.30	28.50	30.00	91.80	30.60
M_2	41.10	38.10	37.50	116.70	38.90
M_3	42.30	40.50	38.40	121.20	40.40
M_4	41.30	45.80	41.30	128.40	42.80
M_5	40.50	44.80	43.10	128.40	42.80
Total	198.50	197.70	190.30	586.50	39.1

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	8.176	4.088	0.7819		
Treatment	4	304.080	76.020	14.5409**	3.84	701
Error	8	41.824	5.228			
Total	14	354.080				

** = highly significant CV= 5.85 %

Appendix Table 3.Number of super extra large-size tubers

TREATMENT	BLOCKS I	II	III	TOTAL	MEAN
M_1	2	2	3	7	2
M_2	5	6	4	15	5
M_3	10	11	11	32	11
M_4	12	10	10	32	11
M_5	9	7	7	23	8
TOTAL	38	36	35	109	7.4

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F 0.05%	0.01%
Replication	2	0.933	0.467	0.4828		
Treatment	4	158.267	39.567	40.9310*	3.84	7.01
Error	8	7.733	0.967			
Total	14	166.933				

*= significant CV=13.53%

Appendix Table 4.Number of extra large-size tubers

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	6	5	6	17	6
M_2	9	8	8	25	8
M_3	8	10	12	30	10
M_4	14	11	11	36	12
M_5	7	8	7	22	7
TOTAL	44	42	44	130	8.6

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	0.533	0.267	0.1379		
Treatment	4	71.333	17.833	9.2241**	3.84	7.01
Error	8	15.467	1.933			
Total	14	87.333				

** = highly significant CV= 16.04%

Appendix Table 5.Number of big-size tubers

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	10	10	8	28	9
M_2	10	9	9	28	9
M_3	13	11	11	35	12
M_4	10	10	9	29	10
M_5	13	16	14	43	14
TOTAL	56	56	51	163	10.8

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	3.333	1.667	1.6667		
Treatment	4	56.400	14.100	14.1000**	3.84	7.01
Error	8	8.00	1.000			
Total	14	67.73				

** = highly significant CV = 9.20%

Appendix Table 6.Number of small-size tubers

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	10	13	10	33	11
M_2	12	12	13	37	12
M_3	6	7	7	20	7
M_4	10	10	12	32	11
M_5	18	17	18	53	18
TOTAL	56	59	60	175	11.8

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	2.800	1.400	1.2174		
Treatment	4	192.400	48.100	41.8261**	3.84	7.01
Error	8	9.200	1.150			
Total	14	204.400				

** = highly significant CV = 9.09%

Appendix Table 7.Weight of superextra large-size tubers (g $plot^{-1}$)

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	175	180	250	605	201.7
M_2	650	700	550	1,900	633.3
M_3	1,150	1,150	1,150	3,450	1,150.0
M_4	1,250	1,500	1,500	4,250	1,250.0
M_5	700	500	600	1,800	600.0
TOTAL	3,935	4,030	4,050	12,005	767

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	25470.000	12735.000	0.7563		
Treatment	4	2236006.667	559001.667	33.1965**	3.84	7.01
Error	8	1134713.333	16839.167			
Total	14	2396190.00				

** = highly significant CV =16.92%

Appendix Table 8.Weight of extra large-size tubers (g $plot^{-1}$)

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
T_1	250	250	300	575	226.7
T_2	550	500	500	1,550	516.7
T_3	500	500	650	1,650	550.0
T_4	750	700	700	2,150	716.7
T_5	400	400	350	1,150	383.3
TOTAL	2,450	2,350	2,500	7,075	478.68

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	2333.333	1166.667	0.4828		
Treatment	4	350666.667	87666.667	36.2759**	3.84	7.01
Error	8	19333.333	2416.667			
Total	14	372333.333				

** = highly significant CV = 10.10%

Appendix Table 9.Weight of big-size tubers (g $plot^{-1}$)

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
T1	350	350	250	950	316.67
T_2	400	350	400	1,150	383.33
T_3	750	650	650	2,050	683.33
T_4	400	400	350	1,150	383.33
T_5	500	600	500	1,600	533.33
TOTAL	2,400	2,350	2,150	6,900	459.99

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	7000.000	3500.000	1.7143		
Treatment	4	262666.667	65666.667	32.1633**	3.84	7.01
Error	8	16333.333	2041.667			
Total	14	286000.000				

** = highly significant CV = 9.82%

Appendix Table 10.Weight of small-size tubers (g plot^{-1}).

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
T1	250	300	250	800	266.7
T2	250	270	300	820	273.3
T3	100	150	150	400	133.3
T4	450	450	550	1,450	483.3
T5	550	450	550	1,550	516.7
TOTAL	1,600	1,620	1,250	5,020	334.66

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	4853.333	2426.667	1.4842		
Treatment	4	312440.000	78110.000	47.7737**	3.84	7.01
Error	8	13080.000	1635.000			
Total	14	330373.333				

** = highly significant CV = 12.08%

Appendix Table 11.Dry matter content potato tubers (g)

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	18.48	19.33	18.48	56.29	18.76
M_2	19.33	19.04	19.04	56.85	18.95
M_2	19.04	19.33	19.33	57.70	19.23
M_2	19.33	19.04	19.33	57.70	19.23
M_2	19.33	19.61	19.33	58.27	19.42
TOTAL	94.51	96.35	95.51	286.81	19.12

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	0.094	0.047	0.6189		
Treatment	4	0.714	0.178	2.3482^{ns}	3.84	7.01
Error	8	0.068	0.076			
Total	14	1.416				

ns = not significant CV = 1.44%

Appendix Table 12.Bulk density of the soil (g cm^{-3})

RATES OF VERMICOMPOST	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	1.29	1.30	1.38	3.97	1.32
M_2	1.29	1.25	1.25	3.79	1.26
M_3	1.21	1.14	1.13	3.48	1.16
M_4	1.03	1.19	1.12	3.34	1.11
M_5	1.06	1.01	1.21	3.28	1.09
TOTAL	5.88	5.89	6.09	17.86	1.19

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	0.006	0.003			
Treatment	4	0.118	0.029	6.0966*	3.84	7.01
Error	8	0.039	0.005			
Total	14	0.162				

* = significant CV = 5.84%

Appendix Table 13.Water Holding Capacity of the soil (%)

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	57.60	57.60	51.13	166.33	55.44
M_2	64.91	64.32	64.71	193.94	64.65
M_3	65.27	65.19	65.49	195.95	65.32
M_4	68.06	67.62	67.62	203.30	67.77
M_5	72.09	70.76	68.94	211.79	70.60
TOTAL	327.93	324.73	317.89	971.31	64.76

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	1.836	0.918			
Treatment	4	292.122	73.030	151.7662**	3.84	7.01
Error	8	3.850	0.481			
Total	14					

** = highly significant CV = 1.06%

Appendix Table 14. Total porosity of the soil (%)

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M1	60	55	54	169	56.33
M2	56	61	53	170	56.67
M3	58	62	61	181	60.33
M4	65	63	66	194	64.67
M5	67	70	61	198	66.00

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	26.800	13.400	1.3094		
Treatment	4	237.733	59.433	5.8078*	3.84	7.01
Error	8	81.867	10.233			
Total	14	346.400				

* = significant CV = 5.26%

Appendix Table 15.Soil pH

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	6.30	6.30	6.30	18.90	6.30
M_2	6.50	6.52	6.53	19.55	6.52
M_3	6.64	6.53	6.59	19.76	6.59
M_4	6.67	6.63	6.65	19.95	6.65
M_5	6.62	6.70	6.68	20.00	6.67
TOTAL	32.73	36.68	32.75	98.16	6.55

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	0.001	0.000			
Treatment	4	0.265	0.066	51.5877**	3.84	7.01
Error	8	0.010	0.001			
Total	14					

** = highly significant CV = 0.55%

Appendix Table 16.Total N content of the soil (%)

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	0.06	0.07	0.06	0.19	.06
M_2	0.10	0.11	0.11	0.32	0.11
M_3	0.12	0.11	0.12	0.35	0.12
M_4	0.12	0.12	0.12	0.36	0.12
M_5	0.13	0.14	0.13	0.40	0.13
TOTAL	0.53	0.55	0.54	1.62	0.10

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	0.000	0.000			
Treatment	4	0.008	0.002	75.6471**	3.84	7.01
Error	8	0.001	0.001			
Total	14	0.009				

** = highly significant

CV = 4.93%

Appendix Table 17.Organic matter content of the soil (%)

TREATMENT	BLOCKS			TOTAL	MEAN
	I	II	III		
M_1	1.11	1.35	1.39	3.85	1.28
M_2	2.03	2.12	2.08	6.23	2.08
M_3	2.46	2.26	2.36	7.08	2.36
M_4	2.46	2.41	2.47	7.34	2.45
M_5	2.55	2.70	2.62	7.87	2.62
TOTAL	8.15	10.84	8.3	27.29	2.16

ANALYSIS OF VARIANCE

SOURCE OF VARIANCE	DEGREE OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	COMPUTED F	TABULATED F	
					0.05%	0.01%
Replication	2	0.010	0.005			
Treatment	4	3.337	0.834	91.5409**	3.84	7.01
Error	8	0.037	0.009			
Total	14	3.420				

** = highly significant CV = 4.42%

Appendix Table 18.Return on cash expense (%)

TREATMENTS	TOTAL YEILD (kg/plot)	GROSS INCOME (Php)	PRODUCTION COST (Php)	NET INCOME (Php)	ROCE (%)
Control	2.94	176.40	182.75	-6.35	-3.47
10 tons/ha	5.42	325.20	230.35	94.85	41.18
15 tons/ha	7.55	453.00	254.15	198.85	78.24
20 tons/ha	9.00	540.00	277.95	262.05	94.28
25 tons/ha	6.00	360.00	301.79	58.21	19.29

Price used in the computation of gross income was Php 60/kg.