Yield and Nitrogen Uptake of Lettuce (*Lactuca Sativa* L.) as Influenced by Different Rates of Vermicast Grown in Sandy Soil

Dhenber C. Lusanta[1], Warren Kim Siarot[1,2], Zenaida C. Gonzaga[3]

Ecological Farm Resource and Management Institute (EcoFARMI), Visayas State University, Visca, Baybay City, Leyte 6521-A, Philippines[1]
Science Education Institute, Department of Science and Technology, Philippines[2]
Department of Horticulture, Visayas State University, Visca, Baybay City, Leyte 6521-A, Philippine[3]
[1]Corresponding email: dhenber.lusanta@vsu.edu.ph

ORCID ID: [1]0000-0003-1593-8037, [2]0000-0002-5215-5632

Abstract

The study was conducted to evaluate the different rates of vemicast on the yield and N uptake of lettuce grown in sandy soil (1) and to determine the best rate of vermicast on the yield and N uptake of lettuce grown in sandy soil (2). Lettuce grown in sandy soil incorporated with vermicast was more vigorous than control especially plants treated with the highest level of vermicast which is 7.5 g/kg soil while control plants have yellowish leaves. Treatments with lower rates of vermicast (5.0 and 2.5 g/kg soil) as well as the control were not successful in developing head of lettuce while the highest rate of vermicast (7.5 g/kg soil) clearly produced head. Incorporating 7.5 g vermicast/kg soil obtained the heaviest fresh weight and total dry matter yield of 88.20 g/plant and 7.86 g/plant respectively. Moreover, application of vermicast regardless of varying rates evidently improved sandy soil pH.

Keywords: nitrogen uptake, lettuce, vermicast, sandy soil

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INTRODUCTION

Lettuce (*Lactuca sativa* L.) which belongs to the *Asteracae family* is considered one of the most important high value vegetables in the Philippines. It can either be leaf or head type salad vegetable that is commonly grown in temperate countries and in some favored localities particularly in elevated part of the country. It is an important component of Filipino diets because it contains high quantities of vitamins, especially vitamin C (Kapoor, 2010).

Increasing lettuce production due to increase in demand tend to source out additional land area. Thus, sandy soils can be a good area to venture lettuce production since alluvial sandy soils (Tropepts suborder) found to be 46.7 % among all other soil types in the Philippines (BSWM).

Although sandy soils are chemically exhausted and highly sensitive to erosion and demand cautious management if used for crop production due to its course texture a low water holding capacity and high infiltration rate (Bationo, 2005), one and very popular practice to mitigate this main production constraint is amending the soil with organic materials.

Organic amendments are regarded as an alternative practice to improve soil moisture and nutrient retention, lowers soil bulk density, and improves overall soil structure and increasing the efficiency of crop production and irrigation (Haynes, 2008). Additionally, soil amendments can not only change the characters of sandy soil, but enhance yield, quality (Chen *et al*., 2005) and stress resistance (Giri *et al*., 2003), promote the growth of horticultural plants. And one of the potential organic amendments are now being promoted is the vermicompost or vermicast.

Vermicast improves water retention capacity of soil due to its high organic matter content. It also promotes better root growth and nutrient absorption and improves nutrient status of soil, both macro-nutrients and micro-nutrients (Punjab State Council for Science and Technology, 2010). Moreover, vermicast has been used in sustainable agriculture and was found to stimulate plant growth (Lazcano, 2011). Vermicast has been applied to several plants including strawberries (Lazcano, 2011), tomato (Manyuchi et al., 2012), rice (Ramasamy, 2011) and maize (Arancon, 2006). At present, there is limited information about the application of vermicast on the growth and yield of lettuce in sandy soil. The study aims to evaluate the different rates of vemicast on the yield and N uptake of lettuce grown in sandy soil and to determine the best rate of vermicast on the yield and N uptake of lettuce grown in sandy soil.

MATERIALS and METHODS

Soil Sampling, Collection, and Analyses

Bulk samples of alluvial sandy soils from a depth of 0-20 cm were collected randomly from an agricultural farm in Lilo-an, Ormoc City. The bulk soil samples were air-dried for 4 days, pulverized and were passed through a 4-mm sieve. Subsamples were subsequently taken for initial chemical analyses and the rest were prepared for bagging. The subsamples for initial chemical properties were passed through a 2-mm sieve for the following analyses:

Soil pH

This was determined using potentiometric method (PCARR, 1980). A 10g air dried soils that passed through a 2 mm sieve or no. 10 mesh screen was placed into a 50 ml beaker. The soil was added with 10 ml distilled water, stirred thoroughly and allowed to stand 15 minutes after mixing. Immediately before placing the electrode of calibrated pH, the soil suspension was again stirred thoroughly.

The pH meter was calibrated using the standard buffer solution of pH 4.0 and 7.0 and soil pH was determined to the nearest 0.1 unit. The electrode was rinsed with distilled water and blot dried with tissue paper before proceeding to the next sample.

Organic Matter (OM)

This was determined using modified Walkley and Black Method (Nelson and Sommers, 1982) a 0.5g air-dried soil that passed through a 0.425mm sieve was weighed and then transferred into a 500 mL Erlenmeyer flask. Subsequently, 10 mL of 1N $K_2Cr_2O_7$ was added to the soil in the flask after which the flask was swirled gently to dispense the soil in the solution. Under the hood, 10mL of concentrated H_2SO_4 was added to soil $K_2Cr_2O_7$ mixture and mix rapidly. The mixture is allowed to stand for 1 hour after which, 200 mL of distilled water was added. Four drops of O-phenanthroline indicator was then be added to the mixture. It was stirred using magnetic stirrer and titrated with 0.5N $FeSO_47H_2O$ until the color of the solution changes from greenish to dark green. A blank solution was prepared and determination was done in the same manner. The %OM was calculated using the formula:

$$\%OM = 1 - \frac{S}{B} \text{ x } 0.69 \text{ x } \frac{1}{w}$$

Where;
OM = organic matter
S = mL of $FeSO_47H_2O$ in soil sample titration
B = mL of $FeSO_47H_2O$ in blank titration
W = weight of soil sample (g)

Total N

This was determined using the Kjeldahl method (USDA, 2004). One soil sample that was passed through a 0.425 mm sieve was weighed and placed into 100 mL digestion flasks. Then 1 g of selenium reagent mixture was added to the soil and mixed thoroughly by swirling. Under the fume hood, 6mL of concentrated H*2*SO*4* was added to the soil selenium mixture. The flask was placed onto the buchi digestion unit inside the hood and heated. Heating was regulated and the flask was rotated at 20 minutes interval to facilitate the digestion of the sample. The digestion was stopped when frothing or charring ceased leaving a white precipitate. Then the flask was removed from the digester and was allowed to cool. Prior to distillation, approximately 30 mL distilled water was slowly added to the digest and the flask was swirled. The digest was transferred into Buchi distilling flask after which 50 mL of 40% NaOH was added while holding the flask at about 45^o angle. The flask was attached to the distillation set up. For the receiver of the distillate, a 125mL Erlenmeyer flask with 25 mL of 2% H3BO3 and three drops of mixed indicator was placed on the stand beneath the condenser tip. Distillate was collected up to the 75 mL mark of the Erlenmeyer flask.

The distillate was titrated with 0.05 N H_2SO_4 until the color of the solution mixture changed to pink. The total N was determined using the formula:

$$\%N = \frac{(a-b)xNx0.014}{W} \; x \; 100$$

Where:

N = normality of H_2SO_4
a = mL of H_2SO_4 in soil sample
b = mL of H_2SO_4 in the blank
W = weight of soil

Vermicast Collection, Preparation, and Analyses

Vermicast was collected from the vermicomposting site of VSU near Molave Hills, Visca, Baybay City, Leyte. The moisture content was determined by oven drying 100 g sample of vermicast in forced drat oven set at 105ºC for five days. After oven drying, the percent moisture content (%MC) was calculated using the following formula:

$$\%\,MC = \frac{FW - ODW}{FW}\,x100$$

Where: FW = fresh weight of Vermicast

ODW = oven dry weight of Vermicast
MC = moisture content

The actual amount of vermicast that was applied per bag was adjusted to its moisture content (%MC) using the formula below:

$$FW = \frac{RR}{1 - \frac{\%MC}{100}}$$

Where: FW = fresh weight of fresh vermicast incorporated per pot
RR = application rate of vermicast per bag (g/kg soil)
MC = moisture content

For the analysis of manure, a sub sample was air dried and set aside for pH, OM, and total N, content determination. The pH, OM, and total N were determined following the methods used for determining pH, OM, and total N of soil.

Experimental Design and Layout

A total of 80 pots were used and placed in shed house structure located at the GULAYAN NG MASA demo area of the Department of Horticulture. These were laid out in Randomized Complete Block Design (RCBD) having 5 sample pots per treatment with 4 replications. The following treatments were used: T_0 – Control, T_1 – 2.5 g Vermicast/ kg soil (5 t/ha), T_2 - 5 g Vermicast/ kg soil (10 t/ha), and T_3 – 7.5 g Vermicast/ kg soil (15 t/ha).

Vermicast Application

The amendment was mixed thoroughly with the soil prior to bagging at one week before planting. On the other hand, Urea as source of inorganic N was applied after two, three and 4 weeks after sowing through drenching at the rate of 10 g dissolved in a gallon of water in all treatment pots.

Care and Maintenance

Weeds were removed regularly to avoid competitions for nutrient and moisture. Watering was done regularly to maintain needed moist condition. Manual picking was done to prevent spread leaf-borers attacking the plant.

Harvesting, Preparation and Analysis of Plant samples

Harvesting was done at 45 days from planting. The head was cut close to the soil surface and roots was uprooted. The soil adhering to the roots was removed carefully. The different plant parts were washed with tap water and rinsed with distilled water. The shoot and roots were separately placed in properly labeled paper bags and placed in a forced drafts oven set at 70°C for four days. The oven dried samples were weighed and ground in Wiley Mill grinder to a particle size less than 1 mm. prior to weighing plant samples for analysis, the ground shoot and roots were placed overnight in a forced draft oven set at 70°C.

Data Gathered

The following parameters were gathered: Fresh weight (g) – this was determined by weighing each lettuce plant at harvest, Dry matter yield (g) – This was obtained by taking the dry weight of the shoots and roots after drying them in forced draft oven set at 70°C for four days. The dry weight of each plant was combined to obtain the total dry weight, and N uptake (mg/kg) – this was quantified by taking the product of total N contents of the shoots and roots multiplied with their total dry matter yield.

RESULTS and DISCUSSION

General Observation

Lettuce seedlings with uniform growth were transplanted two weeks after emergence from seedling trays. One week after transplanting, lettuce looper/worm infestation was observed but controlled through manual picking and chemical spraying with a carbaryl insecticide (Sevin). After 2 weeks from transplanting, visible difference on the growth was observed. Lettuce grown in sandy soil incorporated with vermicast was more vigorous than control especially plants treated with the highest level of vermicast which is 7.5 g/kg soil while control plants have yellowish leaves.

Initial soil chemical properties

Table 1 shows the initial sandy soil and vermicast chemical properties used in the experiment. The soil used in the experiment was slightly acidic and had low amount of OM and total N compared to vermicast with neutral pH and very high OM but lower Total N. Organic matter values of <2% and total N values of <0.2% are low (PCARR, 2000).

The low content of OM and N on the other hand, could partly explain the observed yellowing of control lettuce leaves.

Effects of vermicast on horticultural attributes, yield, N concentration and N uptake

Vermicast application significantly affected the horticultural attributes, yield, N concentration and N uptake of lettuce grown in sandy soil (Table 2 and 3). Treatments with lower rates of vermicast (5.0 and 2.5 g/kg soil) as well as the control were not successful in developing head of lettuce while highest rate of vermicast (7.5 g/kg soil) clearly

Table 1. Initial chemical properties of soil and vermicast used in pot experiment

Soil Property	Soil	Vermicast
pH	5.57	7.00*
OM (%)	0.86	39.39
Total N (%)	0.08	1.63

*- ratio 1:5

Table 2. Means of horticultural attributes of lettuce var. General grown in sandy soil with varying vermicast application

Treatment (g/kg soil)	Number of Days to Head Formation	Head Size (cm)	
		Polar	Equatorial
T_0 - Control	0.00b	0.00b	0.00b
T_1 – 2.5	0.00b	0.00b	0.00b
T_2 – 5.0	0.00b	0.00b	0.00b
T_3 – 7.5	12.67a	11.37a	12.97a
CV%	3.17	2.84	3.24

Means in a column followed by a common letter and those without letters are not significantly different from each other based on 5% level of significance, using FPLSD.

Table 3. Means of yield, N concentration and total N uptake of lettuce var. general grown in sandy soil with varying vermicast application

Treatment (g/kg soil)	Yield (g)		Plant N	
	Fresh weight	Total dry matter	Concentration (%)	Uptake (mg/kg)
Control T_0 -	65.83c	5.23c	2.90a	151.67b
T_1 – 2.5	68.87bc	5.84bc	2.52ab	147.17.99b
T_2 – 5.0	85.83ab	7.13ab	2.24b	159.07a
T_3 – 7.5	88.20a	7.86a	2.10b	165.06a
CV%	77.18	6.51	2.45	6.65

Means in a column followed by a common letter and those without letters are not significantly different from each other based on 5% level of significance, using FPLSD.

produced head (Figure 1). These results suggest that lower doses of vermicast (5.0 and 2.5 g/kg soil) are not suitable for the formation of lettuce head if grown in sandy soil. Moreover, lettuce yield was significantly affected by vermicast application. Increasing rate of vermicast obtained considerable increase in yield. The highest rate of 7.5 g vermicast/kg soil obtained the heaviest fresh weight and total dry matter yield of 88.20 g/plant and 7.86 g/plant respectively. Similarly, this observation supports the claim of Ouda and Mahadeen (2008) that application of the highest dose of organic fertilizer (60 kg ha-1) with the highest dose of organic manure (80 t ha-1) produced the highest yield of broccoli main heads (3.16 t ha^{-1}).

On the other hand, contrasting trend was observed on plant N concentration. Increasing rate of vermicast resulted to decreasing plant N concentration with the highest is on the control. This observation was actually caused by dilution effect during the process of digestion in determining N.

Higher N concentration in control plants is due to lower dry matter yield which had more concentrated N per unit mass than with vermicast having considerably high dry matter yield and less concentrated N or more diluted N per unit mass. N uptake however resulted to have significantly increasing trend as rate of vermicast increases. This result agreed to Murmu et al., 2013 that tomato-sweet corn applied with vermicompost in combination to inorganic fertilizer resulted to an increase nitrogen use efficiency due to lower nitrogen losses caused by binding of mineral nitrogen with compost in the soil (Kasperczyk & Knickel, 2006).

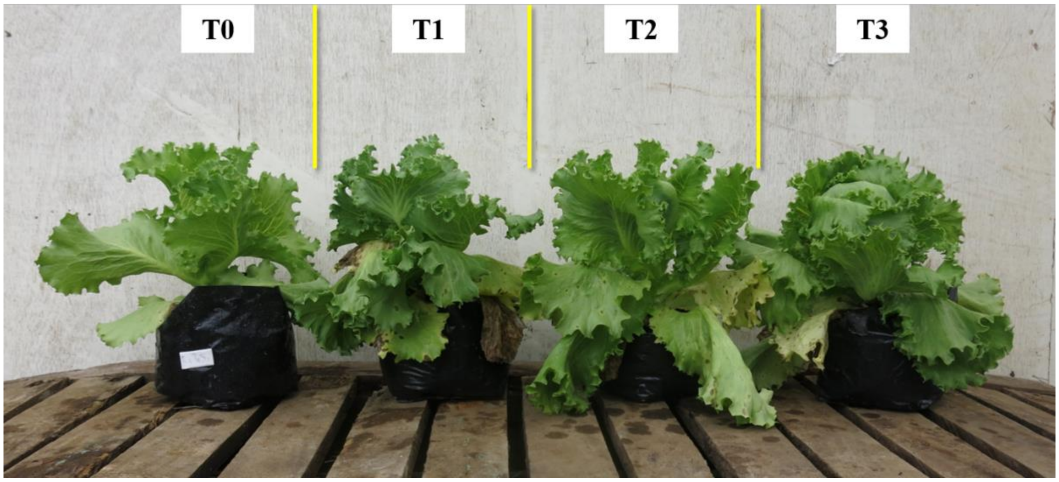

Figure 1. Successful head development of lettuce grown in sandy soil applied with highest rate of vermicast (T3 – 7.5 g/kg soil) while comparable inferior performance of lower vermicast rates (T1- 2.5 g/kg soil and T2- 5.0 g/kg soil) and control.

Effects of vermicast on soil parameters

The soil pH, OM and total N were numerically affected by different rates of vermicast applied (Table 4). These observations imply that generally, vermicast application in sandy soil could improve soil chemical properties. Among soil parameters gathered, only pH was statistically significant which indicate that application of vermicast regardless of varying rates surely improved sandy soil pH. This findings was supported by Albanell et al. (1988) that vermicomposts tended to have pH values near neutrality which may be due to the production of CO2 and organic acids produced during microbial metabolism.

Table 4. Means of soil pH, OM, total N of lettuce var. General grown in sandy soil with varying vermicast application

Treatment (g/kg soil)	pH	OM (%)	Total N (%)
T_0 - Control	5.40b	1.140	0.106
T_1 – 2.5	5.64a	1.290	0.107
T_2 – 5.0	5.78a	1.270	0.120
T_3 – 7.5	5.73a	1.220	0.119
CV%	1.36	8.33	9.71

Means in a column followed by a common letter and those without letters are not significantly different from each other based on 5% level of significance, using FPLSD.

CONCLUSION

The study was conducted at ACIAR-ICM nursery house, Department of Horticulture, College of Agriculture and Food Science, Visayas State University, Visca Baybay City, Leyte from July 18 to August 29, 2014 to evaluate the different rates of vemicast on the yield and N uptake of lettuce grown in sandy soil (1) and to determine the best rate of vermicast on the yield and N uptake of lettuce grown in sandy soil (2). The experiment was laid out in single factor Randomized Complete Block Design (RCBD) having 5 sample pots per treatment with 4 replications. T0 – Control, T1 – 2.5 g Vermicast/ kg soil (5 t/ha), T2 - 5 g Vermicast/ kg soil (10 t/ha) and T3 – 7.5 g Vermicast/ kg soil (15 t/ha). Lettuce grown in sandy soil incorporated with vermicast was more vigorous than control especially plants treated with the highest level of vermicast which is 7.5 g/kg soil while control plants have yellowish leaves. Treatments with lower rates of vermicast (5.0 and 2.5 g/kg soil) as well as the control were not successful in developing head of lettuce while highest rate of vermicast (7.5 g/kg soil) clearly produced head. Incorporating 7.5 g vermicast/kg soil obtained the heaviest fresh weight and total dry matter yield of 88.20 g/plant and 7.86 g/plant respectively. Moreover, application of vermicast regardless of varying rates evidently improved sandy soil pH. Therefore, incorporating vermicast in sandy soil obtained significantly higher dry matter yield and just numerically higher N uptake of lettuce than the control. Amending 7.5 g/kg vermicast to sandy soil is the best rate for producing lettuce head with heavier dry matter yield compared to sandy soil applied with 2.5, 5.0 g vermicast/kg soil and with no vermicast application.

Recommendation

A similar study may be conducted to confirm the result of the present study but additional treatments with higher rate of vermicast to obtain optimum rate in obtaining optimum lettuce yield.

Conflict of Interest

The authors declare that there is no conflict of interest.

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