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# Potential of Vermicompost Drippings and Other Vermicomposting Products on the Growth and Yield of Lettuce

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**Abstract**

Vermicompost drippings (VD), one of the by-products of vermicomposting, have been largely ignored in the Philippines as an organic fertilizer for economically important vegetable crops. Several reports mention that using vermicompost drippings/leachates have significantly improved crop growth, which had been attributed to its large amounts of plant nutrients, growth hormones, and presence of beneficial organisms. This study aims to look into the potential of vermicompost drippings as a possible foliar fertilizer for lettuce. The application of vermicompost drippings, vermitea, and vermicompost significantly improved growth, yield and nutrient uptake of lettuce grown in acidic soil conditions, which is comparable with those fertilized by synthetic fertilizers. Further improvement in yield was recorded when vermicompost was supplemented with a foliar application of vermicompost drippings. In terms of nutrient uptake, a tripled increase from plants treated with at least two vermicomposting products was recorded while highest phosphorus uptake was manifested by the application of vermicompost drippings. The same trend exists in potassium plant uptake, where there was an observed increase of about four times potassium content in tissue compared to the control. This increased nutrient resulted in taller and heavier plants with bigger and more developed leaves, dramatically increasing yield. Hence, lettuce could be grown organically using vermitea, vermicompost, and vermicompost drippings, but further improvement of growth and yield could be done using a combined application of vermicompost and drippings.

**Keywords:** vermicompost leaches, organic lettuce, African night crawlers, growth hormones, acidic soil

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Most vegetable growers in the Philippines indiscriminately use synthetic fertilizers and pesticides over organic input; use of chemical fertilizers in the Philippines has been found to have increased by 1000% from 1960 to 2005 (FAOSTAT 2007 as cited by Reyes and Bedoya, 2008). Synthetic fertilization, a common agricultural practice, has been used due to its dramatic effects on the yield of high-value vegetable crops. However, it has been reported that long-term fertilization of synthetic fertilizers, especially nitrogenous fertilizers, resulted in soil acidification (Barak, et al, 1997; Qiao, et al, 2018) which resulted in nutrient imbalance, making the soil less fertile and limiting plant growth and biochemical ingredient formation (Li and Xia, 2005). Other drawbacks in using chemical fertilizers include low efficiency on delivery system due to surface run off, leaching, and volatilization, which further leads to low farm productivity.

To address the issues of impaired soil quality, crop nutrient deficiencies, and other forms of environmental pollution, as well as the high cost of fertilizer application, it is important to consider emerging alternatives to conventional fertilizers, like employing organic-based fertilizer technology.

An organic approach towards agriculture can address these problems by reducing the adverse effects of synthetic fertilizers on soil health and environment. This approach is affordable and often readily available because it uses natural fertilizers, such as manure, compost, and vermicompost and its by-products vermicompost, vermitea, and vermicompost drippings. Of the three, the latter has not been given much importance in the Philippines.

Vermicompost drippings (VD), a leachate from watering substrates during vermicomposting, is rich in macro and micronutrients (Sundaravadivelan, et al 2011), vitamins (Zrazhevsky, as cited by Chattopadhyay, 2015; Atlavinyte, Daciulyte, and Luganska, 1971), beneficial microorganisms (Zambare, et. al, 2008), phytohormones such as gibberillic acid and auxins (Gopal, et al 2010), and enzymes such as protease and amylase (Shivasubramanaian and Ganeshkumar, 2004; Zambare, et al 2008). These phytohormones, beneficial microorganisms, and enzymes present in VD are crucial for high crop yields. Thus, this study hypothesizes that the application of VD could improve lettuce production due to the presence of nutrients, phytohormones such as auxin and gibberellins, enzymes, vitamins, essential nutrients, and other beneficial organisms.

## Materials and Methods

### *Location of the study*

The study was conducted at the University of Southeastern Philippines (USeP) Tagum-Mabini Campus, Pindasan, Davao De Oro, Philippines.

Soil pH was 5.2 and type of soil belonged to Cambangan clay loam.

### *Experimental design and treatments*

The experiment was laid out in a single factor experiment arranged in completely randomized design (CRD) with eight treatments replicated three times. The experimental treatments were as follows:

T1- Control
T2- Inorganic Fertilizer (RR) alone
T3- Vermicompost drippings (VD) alone
T4- Vermicompost alone
T5- Vermitea alone
T6- Vermicompost +Vermitea
T7- Vermicompost + VD
T8- Vermicompost + Vermitea + VD

### *Soil and plant tissue analyses*

Soil analysis was conducted to determine the actual nutrient contents of the soil media and fertilizer requirements of the experimental crops. The composite soil sample was brought to the Regional Soil Laboratory of the Department of Agriculture (DA), Davao City to determine the organic matter, pH, nitrogen, phosphorus and potassium contents of the soil, while plant tissue analysis was conducted to determine plant nutrient contents prior to the termination of the study. Collected plant samples were oven dried for three (3) days at 70°C. The dried samples were then pulverized using a Wiley mill before submitting to the plant tissue laboratory of the DA for plant nutrient uptake determination.

### *Collection, application of vermicompost drippings (VD)*

Freshly harvested VD was collected from the vermicomposting facility of the USeP Mabini Unit and immediately placed in a clean container. Six liters of VD were collected from the newly harvested VD and subsequently mixed into four liters of water to make a 60% VD solution, which was chosen based on the result of the primary author's preliminary studies. The prepared solution was applied using an atomizer on a weekly interval, starting from transplanting up to the termination of the study.

***Preparation and application of vermitea***

A 30-liter container was filled with 25 liters of non-chlorinated water and aerated for 30 minutes. After aeration, a teabag containing 1.5 kg of vermicast was placed inside the container, followed by two hundred fifty (250) ml of molasses. The container was then covered and aerated for 24 hours.

The newly harvested vermitea was sprayed at a rate of 20 ml/L of water using an atomizer in a weekly interval, starting from transplanting up to the termination of the study.

***Application of RR synthetic fertilizer and vermicompost***

Vermicompost (a product from mixed legumes and grasses added with cow manure) was prepared at a ratio of 3:1 and applied at the base prior to transplanting of experimental plants at the rate of 100 grams per plant. The earthworm species used in the vermicomposting of the substrate was the African Night Crawler, *Eudrilus eugeniae*.

Fertilizer application was done using the recommended rate based from the result of the soil analysis which was applied in split application. The first application was applied at the base of the experimental plants, and the second application was applied two weeks after transplanting.

***Cultural management practices for lettuce***

Three to five seeds were sown in prepared propagation cells. The cell was placed under a shaded area. Thinning was done one week after seedling emergence, leaving only one healthy seedling per cell. A starter solution (urea at the rate of 1 tablespoon per gallon of water) was applied a week after thinning. The seedlings were hardened for one week before transplanting.

Seedlings were transplanted three weeks after sowing. Transplanting was done late in the afternoon to avoid transplanting shock and allow the seedlings to recover faster.

Watering was done as often as necessary using a hand-held sprinkler to ensure that the water requirement of lettuce plants was sufficiently provided. Weeding, by hand pulling, was done to avoid any competition for sunlight and soil nutrients from unwanted plants.

Insect pests and diseases were controlled by spraying with organic pesticides such as oriental herbal nutrients two weeks after planting. In the case of any pest recurrence, an immediate spraying of the organic pesticide was done at a rate of 20 ml/L of water using a hand-held sprayer to ensure that test crops were protected from pest and disease infestation.

Harvesting of lettuce was done by cutting the leaves from the base. Trimming the leaves and cleaning through washing was done in order to remove adhering dirt.

### *Data Gathered*

Horticultural characteristics of lettuce. Four horticultural characteristics such as plant height, leaf length, leaf width, and number of leaves were collected to determine the effect of vermicompost drippings and other vermi products on lettuce. Plant height (cm) was obtained from 10 sample plants per treatment per replication by measuring the height of the plants from the surface of the soil up to the longest leaf. Leaf length (cm) was taken from the same sample plants by measuring the longest leaf from the base of the leaf up to the tip using a ruler. For leaf width (cm), the most expanded leaves were measured from 10 sample plants per replication using a ruler, starting from mid-length to the edge. Finally, the number of leaves was taken by counting the numbers of fully developed leaves from 10 sample plants per treatment and replication.

Yield and yield components. The yield (ton/ha) was taken by weighing all harvested lettuce plants per treatment per replication and converted per hectare basis. The yield component (grams per plant) was taken by weighing all plant samples and divided to the total sample plants per treatment and replication.

## Results and Discussion

### *Effects of vermicompost drippings and other vermicomposting products on the horticultural characteristics of lettuce*

Significant improvements of the horticultural characteristics of lettuce were observed with the application of different vermicomposting products. A single application of either vermicompost, vermitea, and vermicompost drippings produced taller plants with bigger and more developed leaves comparable to those plants with synthetic fertilizer application but growth of lettuce was further improved by combined application of vermicompost and vermicompost drippings (see Figures 1 and 2).

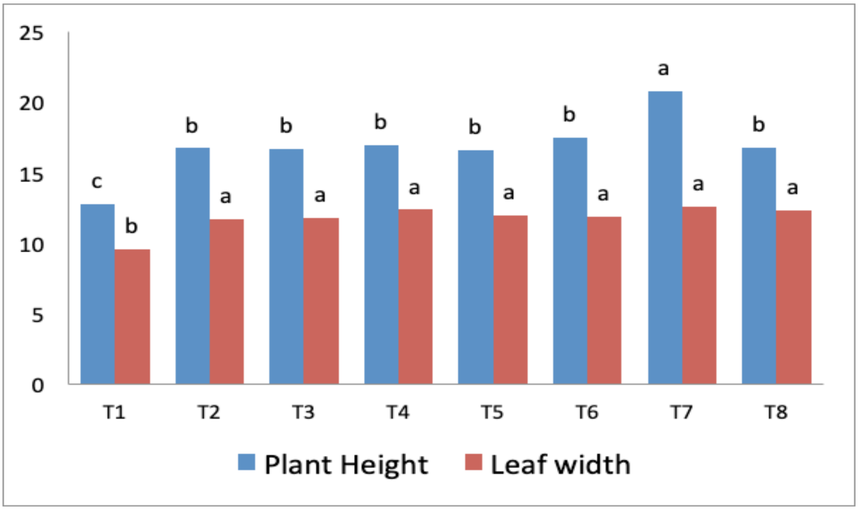



Figure 1. Plant height (cm) and leaf width (cm) of lettuce as affected by the application of vermicompost drippings and other vermicomposting products

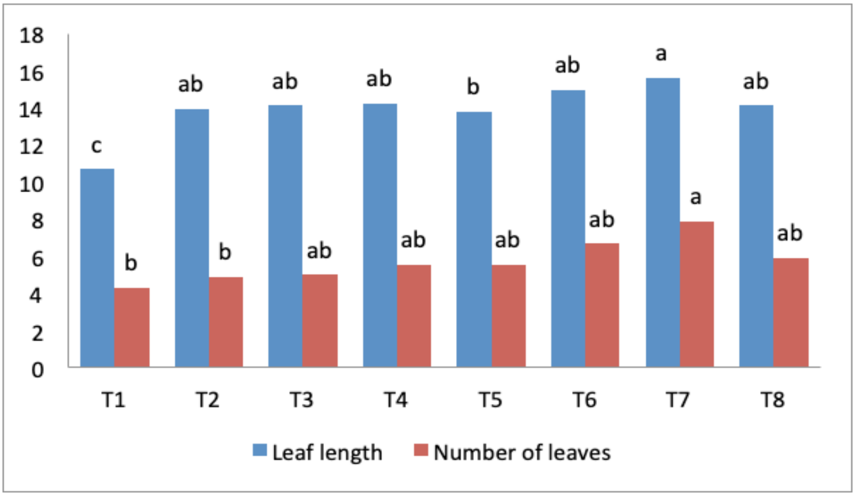



Figure 2. Leaf length (cm) and number of leaves of lettuce as affected by the application of vermicompost drippings and other vermicomposting products

This finding showed the importance of the nutrients present in both inorganic and organic fertilizers, as fertilizer application significantly improved experimental plant growth and yield compared to the unfertilized treatment. This is in line with the result of a study done by Buckerfield, et al. (1999), who reported that several plant growth hormones like cytokinins, gibberellins, and vitamins, along with macro and micronutrients, were present in vermicompost drippings.

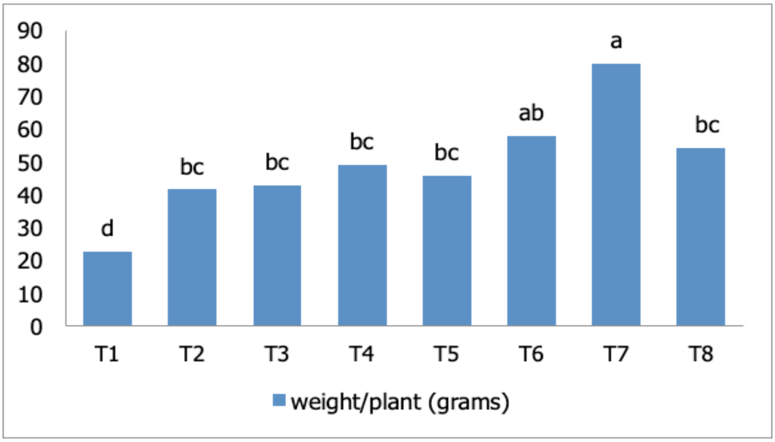
The same was also the case with vermitea application, where Saheed, et al. 2017 reported that the application of vermitea showed a positive response on plant growth. Meanwhile, studies done by Keeling, McCallum, and Beckwith (2003), Edwards. Arancon, and Greytak (2006), and Arancon et al. (2017) posit that the extracted formulation of vermitea, such as soluble mineral nutrients, organic acid and water-soluble plant growth regulators have a positive effect on the plant growth with both foliar and soil applications.

The results of this study also coincide with several reports indicating that vermicompost by-products had significantly improved crop plants, especially in further improving lettuce yield with the foliar application of dripping. For instance, Samadhiya et al. (2013) reported that a significant improvement was observed on the horticultural characteristics of tomato, and plant growth stimulation and development was also observed in sorghum with the application of leachate, but maximum growth was observed further when it was combined with nitrogen, phosphorus, and potassium fertilization (Gutierrez-Miceli et al. 2008). Ismail (2005) also reported that the foliar spray of vermiwash improved okra growth and yield.

Vermicompost leachate and spraying with beneficial microorganisms have also been tested on lettuce with a direct positive effect on physiological parameters, total nitrogen content, and organoleptic quality (Devasinghe and Kularathna, 2016). Fathima and Sekar (2014) even described vermiwash as a potent bio-fertilizer that improves germination and survival rate of seedlings growing on nutrition depleted soil, paving the way for sustainable agriculture in organic farming practices.

***Effects of vermicompost drippings and other vermicomposting products on the yield and yield components of lettuce***

Figure 3 presents the yield and yield components of lettuce as affected by the application of the different vermicomposting by-products, as well as the yield difference of the treatments versus the control group. Data revealed that the application of vermicompost, vermicompost drippings, vermitea, and the combination of vermicompost and vermitea resulted in the significant improvement of weight and yield of lettuce which is relative to synthetically fertilized plants but had higher yields compared to unfertilized treatment. These treatments produced heavier plants and consistently higher yields, with a slight yield improvement observed from the application of a vermitea-vermicompost combination compared to the synthetically fertilized plants and those with only a single application of organic fertilizers. However, a three-fold increase in yield (255%) was observed when VD was combined with vermicompost.

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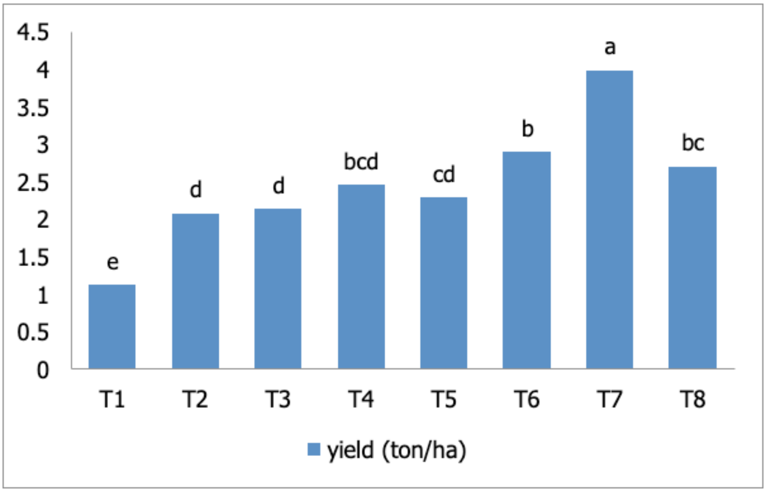


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**Figure 3. Weight/plant (A) and Yield (B) of lettuce as affected by the application of vermicompost drippings and other vermicomposting by-products**

Sundararasu (2016) reported that the application of VD played a vital role on plant growth by contributing to the developing roots as well as promotion of growth which had helped plants to forage more nutrients that resulted to better crop yield. They added also that VD is rich source of vitamins, hormones, enzymes, macronutrients such as nitrogen, and 84% higher in phosphorus compared to compost and micronutrients that, when applied to the plants, helped for efficient growth.

However, treatment with a combined application of vermicompost, vermicompost drippings, and vermitea showed lower yield (a yield decrease) compared to a combined application of vermicompost and vermicompost drippings, but had better yield compared to lettuce fertilized with synthetic fertilizer. Adding vermitea to the combined application of vermicompost and drippings did not further improve lettuce yield, but this treatment still had better effect with those treatments with organic fertilization. While there are no reports on the detrimental effect of vermitea to crop plants, there are several reports that say vermicomposting leachates had a scorching effect on crop plants. Quaik et al. (2012) reported on this scorching effect; Sundararasu (2016) suggested that 10% (v/v) was found to be the optimum amount in a hydroponic system, with 50% reported to be better for growth and yield in chili.

***Nutrient uptake of lettuce as affected by the application of vermicompost drippings and other vermicomposting products***

The nutrient uptake of lettuce based on the application of different vermicomposting products is presented in Table 1 (see next page). Nitrogen uptake was significantly affected by the application of different vermicomposting products. For instance, single applications of vermicompost drippings, vermitea, and vermicompost have higher nutrient uptake compared to unfertilized lettuce, but have a similar uptake to those plants fertilized with synthetic fertilizer. The highest nitrogen uptake could be observed in those plants treated with a combination of vermicompost-vermitea and vermicompost-drippings. It is also interesting to note that the highest phosphorus uptake was manifested by the application of vermicompost drippings alone, though it is slightly different from the rest of the treatments except for the unfertilized plants.

**Table 1. Plant nutrient uptake (g/plant) of lettuce as affected by the application of vermicompost drippings and other vermicomposting by-products**

| TREATMENT | Plant Nutrient Uptake (g/plant)** | | |
|---|---|---|---|
| | N | P | K |
| T1- Control | 0.78$^{d}$ | 0.09$^{b}$ | 0.82$^{e}$ |
| T2- RR Synthetic | 1.37$^{c}$ | 0.16$^{ab}$ | 1.76$^{cd}$ |
| T3- VD alone | 1.48$^{c}$ | 0.18$^{a}$ | 1.5$^{5d}$ |
| T4- Compost alone | 1.65$^{bc}$ | 0.20$^{a}$ | 2.15$^{bc}$ |
| T5- Vermitea alone | 1.57$^{bc}$ | 0.15$^{ab}$ | 1.83$^{cd}$ |
| T6- Compost+Vermitea | 1.95$^{a}$ | 0.09$^{b}$ | 2.31$^{b}$ |
| T7- Compost+VD | 2.77$^{a}$ | 0.14$^{ab}$ | 3.40$^{a}$ |
| T8- Compost+Vermitea+VD | 1.78$^{bc}$ | 0.10$^{ab}$ | 2.10$^{bc}$ |

**= significant
Means in column having common letter are not significantly different at 1% level of probability using Tukey's HSD.

Potassium uptake was also observed to be significantly higher in plant tissue from plants treated with a vermicompost-drippings combination, which was about four times compared to the control. This uptake of nutrients among treated plants could be attributed to the significant changes of growth and development of test plants. Lettuce treated with inorganic and organic fertilizers have improved growth, which may further develop good rooting performance to forage more nutrients from the soil media.  According to Arancon et al. (2003) and Atiyeh, et al. (2002), certain components of vermicompost drippings, such as humic acids and plant growth regulators, stimulated plant growth. Humic acids present in VD increased the number of roots (Alvarez and Grigera, 2005), and plays a different role in the plant development process by regulating the absorption of macro and micronutrients (Gutierrez-Miceli, et al. 2008).

## Summary and Recommendations

The application of vermicompost drippings, vermitea, and vermicompost products significantly improved growth, yield and nutrient uptake of lettuce, which is comparable with those plants fertilized wtih synthetic fertilizers.

But further improvements on growth and yield were generally observed when vermicompost at the rate of 100 grams per plant was supplemented with foliar application of vermicompost drippings (60% v/v). Thus, with the recent trend of practicing sustainable agriculture, it is but imperative to use organic production technologies that will benefit our local farmers specifically in the utilization of vermicompost and its by-products vermitea and vermicompost drippings.

In addition, this production practice has great potential in solving problem in soils through neutralizing soil acidity, a factor for reduction of yield.

To improve the current study, there is a need to include in further studies the micronutrient status in the tissue, as well as profitibility in lettuce production.

## References

Alvarez, R. and S. Grigera. (2005). Analysis of soil fertility and management effects on yields of wheat and corn in the rolling pampa of Argentina. J. Agron. Crop Sci., 191(5):321-329.

Arancon, N.Q., Edwards, C.A., Dick, R. and L. Dick (2007). Vermicompost tea production and plant growth impacts. Bio Cycle, 48, 51-52.

Arancon, N.Q., Edwards, C.A., Bierman, P., Metzger, J.D., Lee, S. and C. Welch. (2003). Effects of vermicomposting on growth and marketable fruits of field grown tomatoes, peppers and strawberries. Pedobiologia. 47:731-735.

Atiyeh, R.M., S. Lee., C.A Edwards, N.Q. Arancon and J.D Metzger. (2002). The influence of humic acids derived from earthworm-processed organic wastes on plant growth. Bioresource Technology. 84 (1): 7-14

Atlavinyte O, J. Daciulyte, A. Luganska. (1971). Correlation between the number of earthworm, microorganisms and B12 in soil fertilized with straw. Liet TSR Moksulu Akad Darb Ser B 3:43–56

Barak, P., Jobe, B., Krueger, A., Peterson, L., and D. Laird. (1997). Effects of long-term soil acidification due to nitrogen fertilizer inputs in Wisconsin. Plant and Soil, 197(1), 61-69.

Buckerfield JC, T. Flavel, K.A. Lee, and KA. Webster. (1999). Vermicompost soil and liquid form as plant growth promoter. Pedobiologia, 42:753-759

Chattopadhyay, A. (2015). Effect of vermiwash of Eisenia foetida produced by different methods on seed germination of green mungbean, Vigna radiate. Int. J. Recy Org Waste Agricult 4, 233-237.

Devasinghe, U and L. Kularathna. (2016). Effect of effective microorganism and Vermiwash on the Yield and Quality of Lettuce (*Lactuca sativa L.*) in hydroponic cultivation. International Journal of Chemical, Environmental & Biologic Sciences. 4(1).

Edwards, C.A., N.Q. Arancon , and S. Greytak. (2006). Effects of vermicompost teas on plant growth and disease. Bio Cycle. 47: 28-31.

Fathima, M. and M. Sekar. (2014). Studies on growth promoting effect of vermiwash on the germination of vegetable crops. International Journal of Current Microbiology and Applied Science. 3:564-570.

Gopal M., Gupta, A., Palaniswami, C., Dhanapal, R. and G.V. Thomas. (2010). Coconut leaf vermiwash: a bio-liquid from coconut leaf vermicompost for improving the crop production capacities of soil. Curr Sci 98(9):1202–1210

Gutiérrez-Miceli FA, García-Gómez RC, Rincón Rosales R, Abud-Archila M, María Angela OL, Cruz MJ, and L. Dendooven. (2008). Formulation of a liquid fertilizer for sorghum (*Sorghum bicolor (L.) Moench*) using vermicompost leachate. Bioresour Technol. 99(14): 6174-80.

Ismail, S.A. (2005). The Earthworm Book. Ausa, Goa: Other India Press. Pp. 101.

Keeling, A. A., McCallum, K. R., and C. P. Beckwith. (2003). Mature green waste compost enhances growth and nitrogen uptake in wheat (*Triticum eastivum L.*) and oil seed rape (*Brassica napus L.*) through the action of water extractable factors. Bio-resource technology. 90: 127-132.

Li, J. and J. Xia. (2005). Summary on nitrogen (N), phosphorus (P), potassium (K) and tea quality. Chinese Agricul Sci Bull. 21:62–65.

Qiao, C., Xu, B., Han, Y., Wang,J., Wang, X., Liu, L., Liu, W., Wang, S., Tan, H., Liu, Y., and Zhao, X. (2018). Synthetic nitrogen fertilizers alter the soil chemistry, production and quality of tea. A meta-analysis. Agron. Sustain. Dev. 38 (10). https://doi.org/10.1007/s13593-017-0485-z.

Quaik, S, Embarandir, A., Rupari, P.F., Singh, R., and Ibrahim, MH. (2012). Effect of Vermiwash and Vermicomposting Leachate in Hydroponics Culture of Indian Borage (*Plectranthus ambionicus*) Plantlets. Terranganu, Malaysia: UMT 11th International Annual Symposium on Sustainability Science and Management.

Reyes, T. and D. Bedoya. (2008). Agrochemical use in the Philippines and its consequences to the environment. Phils: Greenpeace Southeast Asia. Pp 12.

Saheed, M., K. Njoki, C. Ndribe and F. Oke. (2017). The Effect of Vermitea on the Growth Parameters of *Spinacia oleracea L.* (Spinach). Journal of Environmental Science and Pollution Research. 3(4): 236-238.

Samadhiya, H., Dandotiya, P., Chaturvedi, J. and O.P. Agrawal. (2013). Effect of vermiwash on the growth and development of leaves and stem of tomato plants. International Journal of Current Research. 5 (10): 3020-3023.

Sundaravadivelan, C, Isaiarasu, L. Manimuthu, M., Kumar, P., Kuberan, T. and J. Anburaj. (2011). Influence of vermiwash on biological productivity of marigold. Madras Agric. J., 91 (4-6) : 221-225.

Sundararasu, K. (2016). Effect of vermiwash on growth and yielding pattern of selected vegetable crop Chilli, (*Capsicum annuum*). Int. J. Adv. Res. Biol. Sci. 3(9): 155-160.

Sundaravadivelan, C, Isaiarasu, L. Manimuthu, M., Kumar, P., Kuberan, T. and J. Anburaj. (2011). Impact analysis and confirmative study of physico-chemical, nutritional and biochemical parameters of vermiwash produced from different leaf litters by using two earthworm species. Journal of Agricultural Technology 7(5): 1443- 1457.

Zambare, V.P., Padul, M.V., Yadav, A.A., and T.H. Shete. (2008). Vermiwash: Biochemical and microbiological approach as ecofriendly soil conditioner. ARPN J. Agric. & Biol. Sci., 3(4): 1-5.