Application of Different Fertilizer Types and Levels on Vegetable Production: A Critical Review

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ABSTRACT

The aim of this paper is to review the effects of organic compost, inorganic fertilizers, and foliar feeding to various vegetable crops. At present, increasing crop production for food security is a target worldwide. An approach to achieve this target relies on the types and levels of fertilizers' application which will not affect the environmental sustainability and will boost growth and yield attributes. The use of organic compost and foliar fertilizer is an effective solution to achieve improved food production. Organic fertilizer helps sandy soils by increasing their water- and nutrient-holding capacity, stores nutrients but makes them more available for plant use, increases the CEC of the soil, provides C and energy source (food) to soil microbes, and improves soil aggregation. Moreover, Foliar fertilizer is also an alternative to improve food production and is reported by several scientists to help reduce environmental damage. So far, crop production fertilizer studies focused both on organic and inorganic types. Limited studies had been made comparing reactions of plants to solid and liquid fertilizers. This review found out that the primary concern in agriculture are sustainability, health impact of food production, and food security. Hence, the application of organic compost and foliar fertilizer may be an effective measure in the fulfilment of sustainable agriculture and food security.

Keywords : Organic Fertilizers, Inorganic Fertilizers, Foliar Application, Organic Matter (OM), Cation Exchange Capacity (CEC)

1 INTRODUCTION

Types and levels of fertilizer applied to crops are very important in crop production and play an important role in cropping systems. Relying on inorganic or chemical fertilizers is a major constraint due to its prohibitive cost though identified as an important factor in meeting the food requirements of a growing population.

In recent years there is a growing trend to reduce the use of mineral fertilizers, especially soil applied nutrients such as nitrogen (N), phosphorus (P) and potassium (K) and their use had decreased by seven times. Moreover, there is also increasing demand for organically-grown farm products. These create preconditions to recognize the importance of foliar fertilization and the use of organic fertilizers as an alternative to meet plant nutrient demand during the growing season [25].

Foliar fertilization is an important tool for the sustainable and productive management of crops. In recent years, foliar fertilizers, especially organic ones, have proliferated in the agricultural fertilizer market [15]. Interest on foliar fertilization has risen because of the many advantages of the methods of application of foliar nutrients, such as rapid and effective response to plant needs, regardless of soil conditions [25]. However, few studies have been conducted to compare the effects of both ground and foliar application of fertilizers.

According to [44], combined soil and foliar applications should be recommended to increase both plant productivity and yield quality. [26] also emphasized that foliar application of fertilizers is becoming more prevalent as practice in agricultural crop production because it is more directly targeted and potentially more friendly to the environment in contrast to soil fertilization. In fact, [23] suggested that supplying N to peach trees using a combination of soil and foliar N fertilizers leads to optimal plant responses and limited environmental pollution risks.

This paper aimed to provide detail information regarding the effects of fertilizers' application to the growth and yield performance of crops.

2 History of Plant Mineral Nutrients

For the plants to complete a normal growth, seventeen (17) elements are required. C, H and O are taken from water and air. Other nutrients are

obtained from soil. Primary nutrients are used by plants in comparatively large quantity and often complemented as fertilizers (Nitrogen, Phosphorus and Potassium). On the other hand, secondary nutrients like Ca, Mg and S are also utilized in large quantity but sufficiently supplied and are normally readily available. Micronutrients (trace elements) are required in minute quantity. Micronutrients nutrients are Fe, Zn, Mo, Mn, B, Cu, Co and Cl [41]. Glimpses of early history for research starting on essential nutrients for plant growth emerged in literature, which demonstrate that crop nutrition experiments were carried out by a Greek Philosopher Theophrastus during 287-372 BC. Later on several scientists performed a long chain of experiments to be familiar with the significance of mineral nutrients for normal growth of plants. Hence, it appears that plant nutrition is possibly one of the earliest phases of quantitative study of plant physiology [22].

3 Organic, Inorganic, and Foliar Fertilizers Application

[16] stated that foliar fertilization is an agricultural practice of increasing importance. In theory, application of nutrient sprays may indeed be an environmentally friendly fertilization method since the nutrients are directly delivered to the plant in limited amounts, thereby helping to reduce the environmental impact associated with soil fertilization. However, response to foliar sprays is often variable and not reproducible due to the existing lack of knowledge of many factors related to the penetration of the leaf-applied solution.

This fact causes farmers to shift to either organic fertilizers or inorganic fertilizers. [9] reported that organic fertilizer increases the cation exchange capacity of the soil. Aside from its ability to supply nutrients, organic fertilizers are also capable of improving the physical, chemical, and biological properties of soil which could significantly improve the growth and development of plants. [37] pointed out that organic matter is an excellent source of plant-available nutrients and their addition to soil could maintain high microbial populations and activities.

3.1. Organic Fertilizer Application

Vermicompost is worm castings or digested excretions, and is largely used by gardeners and landscapers as a soil amendment. These castings originate from organic materials, which the worms feed on [42]. Once ingested the organic material undergoes enzymatic digestion along with several other processes to ultimately create a casting. Vermicompost contains many plant available nutrients, and research indicates castings improve soil structure by enhancing soil porosity, aeration, and moisture holding capacity resulting in enhanced plant growth [42], [6], [20], [18]. Aging of vermicompost has been studied focusing on microbiological or physical/chemical changes for up to 60 days of aging [2], [21], [36].

Vermicompost is finely divided peat-like materials with high porosity, aeration, drainage, water-holding capacity [42]. [20] reported that vermicompost tended to have pH values near neutrality which may be due to the production of carbon dioxide and organic acids produced during microbial metabolism. They also reported that their moisture content was reduced progressively during vermicomposting giving final moisture contents between 45% and 60%, the ideal moisture contents for land-applied composts [42].

[4] studied the agronomic impacts of vermicompost and inorganic (chemical) fertilizers on strawberries when applied separately and in combination. Vermicompost was applied at 10 tons/ha while the inorganic fertilizers (nitrogen, phosphorus, potassium) at 85 (N)-155 (P)-125 (K) kg/ha. While there was not much difference in the dry shoot weight of strawberries, the yield of marketable strawberries and the weight of the largest fruit was greater on plants in plots grown on vermicompost as compared to inorganic fertilizers in 220 days after transplanting. In addition, there were more runners and flowers on plants grown on vermicompost. Also, farm soils applied with vermicompost had significantly greater microbial biomass than the one applied with inorganic fertilizers. This is due to the fact that vermicompost contains several plant available nutrients [20]and [18]. In addition, research revealed that vermicompost improves soil structure resulting in enhanced plant growth [42], [6]. The use of vermicompost in food production showed that growth and yield both display a surprising increase in production.

Vermicompost has demonstrated consistently beneficial effects on plant growth independent of nutrient transformations and availability [13]. [43] found that vermicompost contained plants nutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B, the uptake of which had positive effects on plant nutrition, photosynthesis, chlorophyll content of the leaves and improves the nutrient content of the different plant components (roots, shoots and the fruits).

Similarly, Studies made by [7] found that application of *T. harzianum + E. fetida* compost produced comparable results as to the number of leaves, leaf width, leaf length, fresh weight and dry weight with the positive control (synthetic organic fertilizer (Urea) at 0.65 grams' plant-1) indicating that it is a good alternative to application of inorganic fertilizer to the growth of *Pechay*. Compost derived from the application of *T. harzianum* + Vermi worms is highly recommended to produce *Pechay*. Result of the study by [7] may also be effective to other similar crops under the same family. Also, compost is deemed effective and will enhance soil porosity, aeration, and moisture holding capacity [42], [6], [20], [18]. The application of compost in growing high value crops will not only make foods available, but also assures sustainable agriculture. Soils, in addition, will have improved soil structure and available nutrients for the next cropping.

Another study by [1] on the effect of vermicompost on growth, yield, and quality of vegetable crops showed that growth of vegetable transplants was positively affected by addition of vermicompost, perhaps by altering the nutritional balance of the medium. Result of the study also revealed that there were no significant differences in field performance. Hence, vermicomposting is a sustainable technique for solid waste disposal. [33] studied the yield and quality of cabbage (*Brassica oleracea* L.var. *capitata*) under organic growing media using vermicompost and earthworm *Pontoscolex*

corethrurus inoculation. Results showed that the application of vermicompost combined with inoculation of earthworm *P. corethrurus* significantly increased total biomass, marketable weight, crop diameter, and harvest index compared with the cabbage grown in inorganic media as well as the quality of cabbage which was determined by sugar and vitamin C content and storage loss. Each vermicompost provided the highest yield and quality at different earthworm population. Vermicompost made from the mixture of cow manure and vegetables residue gave a high yield and quality cabbage with population of *P. corethrurus* by 0-25 indiv.m-2. Moreover, vermicompost made from the mixture of cow manure and leaf litter with population of *P. corethrurus* by 50 indiv.m-2 gave a high yield and quality cabbage. Lastly, vermicompost made from the mixture of cow manureza, vegetable residue, and leaf litter gave a high yield cabbage without inoculation earthworm *P. corethrurus* and with population of *P. corethrurus* by 75-100 indiv.m-2 for a high-quality cabbage. [1] on their study showed that transplant quality was improved in peppers and eggplants while tomato transplant quality was slightly reduced when applied by vermicompost. Studies by [33] and [1] prove that the use of vermicompost is an effective approach to improve yield and an efficient measure in the attainment of food security and sustainable agriculture.

Table 1: Average Nutrient Content of Organic Manures

Amendment	***Percentage Content (dry wt)***		
	Nitrogen	**Phosphoric Acid (P_2O_2)**	**Potash (K_2O)**
Bulky Organic Manures			
Farmyard Manure	0.95	0.62	2.20
Rural Compost	0.75	0.63	1.05
Urban Compost	1.35	0.62	1.43
Sewage Sludge	2.75	0.75	0.35
Sewage Sludge Activated.	5.41	3.15	0.62
Vermicompost	1.80	0.22	0.40

Source: [40]

The effect of vermicompost and vermiwash on growth of vegetables found that organic waste material processed by the naturally occurring earthworm should be used to produce vermicompost which will supply nutrients and other soil stimulants for plant growth and improve soil quality. Vermiculture provides the best answer for ecological agriculture, which is synonymous with “sustainable agriculture” [24]. Vermicompost will not only improve vegetable production, it has good impact to the maintenance of good soil quality and to the environmental sustainability as well.

[4] studied the effects of vermicompost on plant growth and found that when used at lower substitution rates, vermicompost can increase growth, flowering and yields of vegetable and ornamental crops. Similarly, vermicompost applied at very low rates e.g. 2.5 t/ha or 5 t/ha can significantly increase growth and yields of highly valuable vegetable and fruit crops in the field. The effects of vermicompost on plants are not solely attributed to the quality of mineral nutrition provided but also to its other growth regulating components such as plant growth hormones and humic acids. Moreover, the application of vermicompost in the field enhances the quality of soils by increasing microbial activity and microbial biomass which are key components in nutrient cycling, production of plant growth regulators and protecting plants soil-borne disease and arthropod pest attacks.

The effect of the application of vermicompost is not limited to vegetable crops. Fruit trees applied with vermicompost also showed significant result. Webster et al. (2005) studied the agronomic impact of vermicompost on cherries and found that it increased yield of cherries for three (3) years after single application. Application of vermicompost in soil builds up fertility and restore its vitality for long time and its further use can be reduced to a minimum after some years of application in farms. [8] found that worm-worked waste (vermicompost) boosted grape yield by two-fold as compared to chemical fertilizers. Hence, vermicompost may be an effective measure to increase cherries and grapes production.

Inorganic fertilizer is known as an effective fertilizer in terms of production and is used by most of the farmers to have an immediate increased production. This is partly due to the fact that there is a need to balance the demand for foods and food production. Thus, a study by [28] on the growth and yield responses of four leafy vegetables to organic fertilizer showed that organic fertilizer as the sole source of nutrients can give yields that are higher or comparable to inorganic fertilizer. Organic grower need not fear reduced yields, if the correct rate of organic fertilizer is applied. The optimum responses of leafy vegetables to organic fertilizer rate was about 30t/ha of poultry manure for leaf mustard, kangkung and lettuce and 36 t/ ha for chinese spinach.

[47] studied the effects of organic and inorganic fertilizers on the growth of NH-Ae 47-4 variety of okra. Results obtained from the experiment showed that the effect of the treatments were significantly different from the control for all the parameters accessed with urea fertilizer having least effect. Plants treated with poultry litters have best performance by recording the highest fresh and dry weight (0.39g) at 4 weeks after planting (WAP); highest stem height 29.33cm for all the concentrations applied. Another study by [12] on the growth, yield, and quality of vegetables under chemical and organic farming showed that in the final measurement, both two vegetables in organic fertilization treatments grew better and resulted in a final higher total yield, shoot length and branches than those in chemical fertilizer treatments, which was attributed to the high nutrient sustainability of organic fertilizer and the improved biological properties of the soil. Organic fertilizer contains many plant available nutrients, and research shows that it improves soil structure by enhancing soil porosity, aeration, and moisture holding capacity resulting in improved and plant

growth and yield [42], [6], [20], [18]. Macronutrients Nitrogen (N), Phosphorous (P), Potassium (K) and Carbon (C) were increased by the application of organic manure as shown in the study by [12]. Result of the study by [12] revealed that total microbial count increases by using the organic fertilizers, shown the indication of healthy soil. Moreover, results of the experiment by [12] showed that chemical fertilizers were less suitable as compared to organic fertilizers. It is recommended that vegetables can be grown successfully with supplementation of organic fertilizers.

Subler and Edwards (undated) reported that the best plant growth responses are when organic fertilizer and traditional fertilizers are used together. In addition, [38] studied the response of *Pechay*, (*Brassica rapa*) to organic fertilizer under DMMMSU-NLUC condition, La Union, Philippines. *Pechay*, when applied with organic inputs for its growth, has comparative advantage over that of the farmers' practice of using urea. Although statistically insignificant in the ANOVA test, the differences in values favor the use of organic inputs. Likewise, raw recipes for *Pechay* are more nutritious, hence safer if organically grown due to the absence of chemicals. Moreover, growing organically is helping maintain a clean and safe environment to live in. At present, the focus of studies on fertilizers should not be limited to address shortage of food supplies in the market. There is a need to emphasize health and environmental impact of food production.

For leafy vegetables, leaf area and fresh weight are considered vital and should be measured to determine the effectivity of fertilizers applied. A study conducted by [17] on the response of *Pechay* (*Brassica napus* L.) to different levels of compost fertilizer concluded that the application of 75% Pure Garden Soil: 25% Pure Compost provided the best growth and yield performance in terms of leaf area and fresh weight. The result of the study showed that application of organic fertilizer greatly enhanced growth and yield performance. The application of organic fertilizer in *Pechay* specifically, compost is recommended since it influences its growth and yield, especially on the leaf area and fresh weight. Thus, compost play an important role in vegetable production. In a study by [32] on the effect of organic and inorganic fertilizers application on soil and cucumber (*Cucumis sativus* L.) plant productivity, results showed that the application of compost improved the soil characteristics; increased soil productivity and organic matter content. The experimental results confirmed that the use of organic fertilizers increased the crop productivity.

The application of organic fertilizer, therefore, showed that vegetable production may be effective in improving soil quality, environmental sustainability, achieving food security, and sustainable agriculture.

3.2. Inorganic Fertilizer Application

The use of inorganic fertilizer to vegetable production and other crops was proven effective and significantly increase yield. [14] studied the effects of inorganic fertilizer on the yield of two varieties of cucumber (*Cucumis sativus* L.). Results revealed significant differences ($P<0.05$) among the varieties in terms of vine length, number of branches and leaf area. The growth and yield attributes of cucumber including the vine length, number of leaves per plant, number of branches, leaf area, number of fruits per plant, fruit length, fruit girth, fruit weight per plant, fruit number per plant and total yield per hectare increased significantly ($P < 0.05$) with increase in inorganic fertilizer application up to the highest level. According to [37], to produce high yield, most growers use synthetically-based products, thus, the possibility of pesticides and chemical residue accumulation is very serious that poses threat to human health.

Synthetically-based fertilizers are the most common fertilizers used by the farmers. However, its use incurs a high cost and its supply is sometimes limited that many farmers now are still adapting the idea of using organic fertilizers no matter how long and laborious is the preparation [17].

Fertilizer application using either inorganic or organic fertilizer sources is one of the most common cultural management practices in vegetable production. According to [30], commercial and subsistence farming has been and is still relying on the use of inorganic fertilizers for growing crops. This is because they are easy to use, quickly absorbed and utilized by crops. However, these fertilizers are believed to contribute substantially to human, animal, food intoxication and environmental instability or degradation [30].

Though inorganic fertilizers contribute to food intoxication and environmental degradation, [17] said that it is still the most common fertilizers used by farmers because it is less laborious. [35] conducted a study entitled "Assessing the Impacts of Inorganic and Organic Fertilizer on Crop Performance Under a Microirrigation-Plastic Mulch Regime". Results showed that the inorganic fertilizer had higher yields (lbs/acre) than organic fertilizer. The addition of microbes to the inorganic fertilizer significantly increased the numbers of cucumbers and okra per acre. Overall, the "Farmer mix" with or without the addition of microbes significantly increased yields for all crops compared to the organic-based fertilizer.

In a study by [27] on the effects of different proportions of inorganic fertilizer and organic fertilizer on yield and quality of amaranth revealed that inorganic fertilizer is a kind of fast, high nutrient chemicals, but too much inorganic fertilizers will lead to high levels of nitrate in vegetables, affecting the quality of vegetables. Organic fertilizers can provide a more comprehensive and lasting nutrients that needed for crop growth and development, but too much also to cause a decline in quality of vegetable. Many studies have shown that organic and inorganic fertilizer can complement each other, which can provide continuous, comprehensive nutrients to the growth of crops to increase crop yield and quality.

[34] studied the growth and fruit yield of tomato as influenced by combined use of organic and inorganic fertilizer in Kabba, Nigeria. Result obtained from parameters studied (plant height, leaf numbers, branch number, stem girth, fruit number per plant and fruits weight) revealed that tomato performed better ($P<0.05$) with the application of 125kg/ha NPK+3t/ha poultry manure application. The study showed that use of inorganic and organic fertilizer had better effects on growth and yield of tomato. Therefore, for good yield and better productivity of tomato, a combination of 125kg/ha NPK fertilizer + 3t/ha poultry waste is recommended for tomato production in the study area.

For easier and fast effect, inorganic fertilizers are suggested. However, safe and nutrient quality of vegetables are compromised.

3.3. Foliar Fertilizer Application

Fertilizer types applied to vegetable crops are very important in crop production. It plays an important role in the cropping systems as well. A study by [48] on the yield quality of melon (*Cucumis melo* L.) showed that foliar-fertilized plants deliver high yields of good quality at lower rates of mineral fertilization. In horticultural practice, foliar fertilization is also recommended as the most effective method of supplying plants with nutrients under deficiency conditions. Study by [48] also revealed that the application of the foliar fertilizers reduced the total sugar and monosaccharides content in melon fruit. Regardless of the kind of foliar feeding, driest matter in the fruit was produced by 'Pacstart', total sugar and monosaccharides by 'Yupi' and ascorbic acid by 'Legend'.

[39] studied "Review of Foliar Feeding in Various Vegetables and Cereal Crops Boosting Growth and Yield Attributes". Results showed that foliar application of macro and micro nutrients play an important role in the production of good crop and higher yield. A study by [29] on the effect of foliar fertilization on soybean grain yield revealed that foliar fertilizers significantly increased the values for all quantitative traits. Ferticare I is more effective than Wuxal super in soybean because this fertilizer has higher concentration of macronutrients. Foliar fertilization of soybean reduced the negative impact of small amounts of rainfall during the summer months on grain yield. Because foliar fertilizer is directly absorbed, rainfall will not have negative impact to production of vegetable crops. Thus, foliar fertilizer is fast, effective and show less negative impact to the environment.

[10] studied the effect of foliar application of water-soluble fertilizers on growth, yield, and quality of tomato *(Lycopersicon esculentum* L.). Results showed that the application of 5 foliar sprays of water-soluble fertilizers significantly increased the plant height, number of branches, Number of fruits, average fruit weight, fruit length, fruit diameter, TSS, yield and the net profit of tomatoes. The maximum plant height, number of branches/plant, fruit length, yield, net profit along with maximum C:B ratio were recorded by 5 foliar sprays of water soluble liquid fertilizers 19:09:19 followed by NPK 19:19:19. The minimum values in all the parameters were recorded in the control having only recommended dose of fertilizer. Result of the study is similar to the study by [48] and [39] which revealed significant increase in yield.

The uptake of mineral nutrients from foliar fertilization as studied by [46] showed that foliar fertilizer is most effective when soil nutrient availability is low, topsoil dry, and root activity during the reproductive stage is decreased. Foliar fertilization is also successful in increasing content of fruit Ca2+ and cereal grain protein. It is proposed that this treatment should be recommended in the integrated plant production because it is environment friendly and increases productivity and yield quality. Compared to organic fertilizer, foliar feeding is absorbed faster and also show significant impact to the environment.

4 CONCLUSION

Limited studies have been made comparing reactions of plants to solid and liquid fertilizers. So far, crop production fertilizer studies focused both on organic and inorganic types (ground application). This review suggested the application of organic fertilizer in various vegetable production due to its significant health benefits and ecological impact. Organic fertilizer is noted to increase safe food production as reported by several scientists. Moreover, foliar application also plays an important role in producing safe foods as well for human consumption and maintains environmental sustainability. The said fertilizers may be an effective measure in the fulfilment of sustainable agriculture and food security.

REFERENCES

[1] Ahirwar, C. S., & Hussain, A. (2015). Effect of vermicompost on growth, yield and quality of vegetable crops. *International Journal of Applied and Pure Science and Agriculture*, *1*(8), 49-56.

[2] Aira, M., Monroy, F., & Domínguez, J. (2007). Earthworms strongly modify microbial biomass and activity triggering enzymatic activities during vermicomposting independently of the application rates of pig slurry. *Science of the total Environment*, *385*(1-3), 252-261.

[3] Alkurd, A., Takruri, H. R., & Al-Sayyed, H. (2008). Tannin contents of selected plants used in Jordan. *Jordan Journal of Agricultural Sciences*, *4*(3), 265-274.

[4] Arancon, N. Q., & Edwards, C. A. (2005). Effects of vermicomposts on plant growth. *Soil Ecology Laboratory, The Ohio State University, Columbus, OH, 43210*, 16-18.

[5] Arancon, N. Q., Edwards, C. A., Bierman, P., Welch, C., & Metzger, J. D. (2004). Influences of vermicomposts on field strawberries: 1. Effects on growth and yields. *Bioresource technology*, *93*(2), 145-153.

[6] Atiyeh, R. M., Subler, S., Edwards, C. A., Bachman, G., Metzger, J. D., & Shuster, W. (2000). Effects of vermicomposts and composts on plant growth in horticultural container media and soil. *Pedobiologia*, *44*(5), 579-590.

[7] Bercero D. II M., Aranico E. C., Tabaranza A. C. E., Amparado Jr. R. F. (2014). Growth performance of pechay (*Brassica rapa*) in household derived composts. *AAB Bioflux*, *6*(3), 169-175.

[8] Buckerfield, J., & Webster, K. (1998). Worm-worked waste boosts grape yields. *Australian and New Zealand Wine Industry Journal*, *13*, 73-80.

[9] Buckman, H. O., & Brady, N. C. (1974). The Nature and Properties of Soil. Mc Millan Pub. *Inc. New York. 639p*.

[10] Chaurasia, S. N. S., Singh, K. P., & Rai, M. (2005). Effect of foliar application of water-soluble fertilizers on growth, yield and quality of tomato (Lycopersicon esculentum L.). *Sri Lankan J. Agric. Sci*, *42*, 66-70.

[11] Chung, K. T., Lu, Z., & Chou, M. W. (1998). Mechanism of inhibition of tannic acid and related compounds on the growth of intestinal bacteria. *Food and Chemical Toxicology*, *36*(12), 1053-1060.

[12] Dalal, L. P., Mishra, A., & Dhabarde, P. (2014). Growth Yield and Quality of Vegetables under Chemical and Organic Farming. International Journal of Scientific & Engineering Research, *5*(3). https://www.ijser.org/paper/Growth-Yield-and-Quality-of-Vegetables-under-Chemical.html

[13] Domínguez, J., & Gómez-Brandón, M. (2012). Vermicomposting: composting with earthworms to recycle organic wastes. *Mangagemnet of organic waste. Rijeka, Croatia: In Tech*, 29-48.

[14] Eifediyi, E. K., & Remison, S. U. (2010). Growth and yield of cucumber (Cucumis sativus L.) as influenced by farmyard manure and inorganic fertilizer. *Journal of Plant Breeding and Crop Science*, *2*(7), 216-220.

[15] Eroy, M. (2015). Yield of Pechay (Brassica napus L. var. Black Behi) as Influenced by the Application of Full on Liquid Fertilizer. Bureau of Agriculture and Fisheries Standards. Terminal Report EUP No. 012. https://dokumen.tips/documents/yield-of-pechay-brassica-napus-l-var-black-behi-as-production-however.html

[16] Fernández, V., & Brown, P. H. (2013). From plant surface to plant metabolism: the uncertain fate of foliar-applied nutrients. *Frontiers in plant science*, *4*, 289.

[17] Gonzales, L. M. R., Caralde, R. A., & Aban, M. L. (2015). Response of Pechay (Brassica napus L.) to different levels of compost fertilizer. *International Journal of Scientific and Research Publications*, *5*(2), 1-4.

[18] Grappelli, A., Tomati, U., Galli, E., & Vergari, B. (1985). Earthworm casting in plant propagation. *HortScience*, *20*(5), 874-876.

[19] Hagerman, A. E., Robbins, C. T., Weerasuriya, Y., Wilson, T. C., & McArthur, C. (1992). Tannin chemistry in relation to digestion. *Rangeland Ecology & Management/Journal of Range Management Archives*, *45*(1), 57-62.

[20] Handreck, K. A. (1986). Vermicomposts as components of potting media. *Biocycle*, *27*(9), 58-62.

[21] Hindell, R. P., McKenzie, B. M., & Tisdall, J. M. (1997). Influence of drying and ageing on the stabilization of earthworm (Lumbricidae) casts. *Biology and fertility of soils*, *25*(1), 27-35.

[22] Jabeen, R. and R. Ahmad (2012). Provision of Essential Minerals Through Foliar Sprays, Water Quality, Soil and Managing Irrigation of Crops, Dr. Teang Shui Lee (Ed.), ISBN: 978-953-51-0426-1.

[23] Johnson, R. S., Rosecrance, R., Weinbaum, S., Andris, H., & Wang, J. (2001). Can we approach complete dependence on foliar-applied urea nitrogen in an early-maturing peach? *Journal of the American Society for Horticultural Science*, *126*(3), 364-370.

[24] Kaur, P., Bhardwaj, M. and Babbar, I. (2015). Effect of vermicompost and vermiwash on growth of vegetables. *Research Journal of Animal, Veterinary and Fishery Sciences*, *3*(4), 9-12.

[25] Kerin, V., & Berova, M. (2003). Foliar fertilization in plants. *Videnov & Son, Sofia*.

[26] Kuepper, G. (2003). Foliar fertilization. *NCAT Agriculture Specialist. ATTRA Publication# CT13*.

[27] Lian, H., Ouyang, L., Liu, J., Yang, L. & Zou, P. (2017). Effects of different proportions of inorganic fertilizer and organic fertilizer on yield and quality of amaranth. Proceedings of the 2017 6th International Conference on Energy, Environment and Sustainable Development. *Advances in Engineering Research, 129*, 911-915. https://doi.org/10.2991/iceesd-17.2017.166

[28] Lim, A. H., & Vimala, P. (2012). Growth and yield responses of four leafy vegetables to organic fertilizer. *Journal of Tropical Agriculture and Food Science*, *40*(1), 1-11.

[29] Mandić, V., Simić, A., Krnjaja, V., Bijelić, Z., Tomić, Z., Stanojković, A., & Ruzić-Muslić, D. (2015). Effect of foliar fertilization on soybean grain yield. *Biotechnology in Animal Husbandry*, *31*(1), 133-143.

[30] Masarirambi, M. T., Hlawe, M. M., Oseni, O. T., & Sibiya, T. E. (2010). Effects of organic fertilizers on growth, yield, quality and sensory evaluation of red lettuce (Lactuca sativa L.)'Veneza Roxa'. *Agriculture and Biology Journal of North America*, *1*(6), 1319-1324.

[31] Mueller-Harvey, I. (2006). Unravelling the conundrum of tannins in animal nutrition and health. *Journal of the Science of Food and Agriculture*, *86*(13), 2010-2037.

[32] Natsheh, B., & Mousa, S. (2014). Effect of organic and inorganic fertilizers application on soil and Cucumber (Cucumis Sativa L.) plant productivity. *Int. J. Agric. For*, *4*, 166-170.

[33] Nurhidayati, U. A., Ali, U., & Murwani, I. (2016). Yield and quality of cabbage (Brassica oleracea L. var. Capitata) under organic growing media using vermicompost and earthworm Pontoscolex corethrurus inoculation. *Agriculture and Agricultural Science Procedia*, *11*(2016), 5-13.

[34] Ogundare, S. K., Babalola, T. S., Hinmikaiye, A. S., & Oloniruha, J. A. (2015). Growth and fruit yield of tomato as influenced by combined use of organic and inorganic fertilizer in Kabba, Nigeria. *European Journal of Agriculture and Forestry Research*, *3*(3), 48-56.

[35] Omidire, N. S., Shange, R., Khan, V., Bean, R., & Bean, J. (2015). Assessing the impacts of inorganic and organic fertilizer on crop performance under a microirrigation-plastic mulch regime. *Professional Agricultural Workers Journal (PAWJ)*, *3*(174-2016-2179).

[36] Parle, J. N. (1963). A microbiological study of earthworm casts. *Microbiology*, *31*(1), 13-22.

[37] Pascual, P. R., Jarwar, A. D., & Nitural, P. S. (2013). Fertilizer, fermented activators, and EM utilization in pechay (Brassica pekinensis L.) production. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences*, *29*(1), 56-69.

[38] Prado, A. J., & Sampaga, L. O. (2013). Response of pechay, (Brassica rapa) to organic fertilizer under DMMMSU-NLUC condition, La Union, Philippines. *Undergraduate thesis of Don Mariano Marcos Memorial State University*.

[39] Rahman, I. U., Afzal, A., Iqbal, Z., Shah, A. H., Khan, M. A., Ijaz, F., ... & Manan, S. (2015). Review of foliar feeding in various vegetables and cereal crops boosting growth and yield attributes. *American-Eurasian Journal of Agricultural and Environmental Sciences*, *15*, 74-77.

[40] Singh, S. K., Yadav, R. B., Singh, J., & Singh, B. (2017). Organic Farming in Vegetables. IIVR Technical bulletin no. 77, ICAR-II, Varanasi, pp. 47

[41] Tahir, M. (1980). Wheat production manual Pakistan agriculture research council. *Islamabad*', pp: 259.

[42] Tejada, M., Gómez, I., Hernández, T., & García, C. (2010). Utilization of vermicomposts in soil restoration: effects on soil biological properties. *Soil Science Society of America Journal*, *74*(2), 525-532.

[43] Theunissen, J., Ndakidemi, P. A., & Laubscher, C. P. (2010). Potential of vermicompost produced from plant waste on the growth and nutrient status in vegetable production. *International Journal of Physical Sciences*, *5*(13), 1964-1973.

[44] Tiwari, S. C., & Husain, N. I. S. R. E. E. N. (2017). Biological activities and role of flavonoids in human health–A. *Indian J Sci Res*, *12*(2), 193-6.

[45] Tukey, H. B., Marczynski S. (1984). Foliar nutrition-old ideas rediscovered. *Acta Hort.* 145: 205-212.

[46] Wojcik, P. (2004). Uptake of mineral nutrients from foliar fertilization. *Journal of fruit and ornamental plant research*, *12*(Spec. ed.).

[47] Zainab, H., Nurfatirah, N., Norfaezah, A., & Othman, H. (2016, June). Green bio-oil extraction for oil crops. In *IOP Conf Ser Mater Sci Eng* (Vol. 133, p. 12053).

[48] Zaniewicz-Bajkowska, A., Kosterna, E., Franczuk, J., & Rosa, R. (2010). Yield quality of melon (Cucumis melo L.) depending on foliar feeding. *Acta Sci. Pol., ser. Hort. Cultus*, *9*(1), 55-63.

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