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**Soil Quality, Crop Growth, and Productivity of *Ipomoea aquatica* Forssk. and *Brassica rapa* L. Using Different Growing Media Mixtures for Square-Foot Gardening in Malaybalay City, Bukidnon, Philippines**

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*Abstract*

Organic manures have long been used by farmers for the availability of nutrients for plant growth, and to improve soil quality. But the kind and amount of organic media most beneficial to the growth of kangkong (*Ipomoea aquatica* Forssk.) and pechay (*Brassica rapa* L.) are uncertain. This study investigated the effects of growing media mixtures (GMM) with different amounts of chicken manure and vermicast on the growth and productivity of the selected vegetables. The study aimed to assess the quality of the GMM with different amounts of chicken manure and vermicast in terms of pH, organic matter, total nitrogen, extractable phosphorus, and exchangeable potassium, determine the effect of different GMM on the growth and productivity of *I. aquatica* and *B. rapa* in terms of average plant height, leaf width, the number of leaves, and fresh weight of plants, and determine the best-growing media mixtures for the growth and productivity of the experimental plants. Results show that the growing media mixture with optimum pH range, high OM, N, P, and K contents have biological and nutrient essential for plant growth and productivity. T<sub>10</sub> yielded kangkong with the broadest leaf width, the greatest number of leaves, and heaviest fresh weight, while T<sub>9</sub> produced the tallest, broadest leaf, greatest number of leaves, and heaviest pechay. Overall, T<sub>10</sub> is the best growing media for kangkong. Whereas T<sub>9</sub> is optimum for cultivating pechay. Results indicated that chicken manure and vermicast enriched growing media mixture build healthy soil for improved growth and productivity of kangkong and pechay.

*Keywords:* Soil quality, plant growth, crop productivity, organic urban gardening, square-foot gardening

## Introduction

How cities have grown, characterized by air and water pollution, lack of green spaces, large energy consumption, unsustainable waste production, long-distance industrialized food chains, and an overall disproportionate footprint, have led to several public health issues. It is imperative to consider some actions that can ensure improved urban environmental management and sustainability measures.

For the most sought-after environmental sustainability, urban agriculture must not be underestimated, being a source of healthy and diversified food. Urban gardening has become popular every year as urban dwellers develop innovative ways to use small available spaces to grow vegetables or flower gardens. Vegetables are grown in cities as a very important food commodity. Aside from playing a major role in meeting the vitamins, minerals, and protein requirements of humans to boost the immune system, vegetables are relatively higher than other crops because growers can produce more vegetables from a small area in a shorter period (Torrefiel, 2006). Venturing in urban agriculture increases physical activities (Van de Berg et al., 2010), improves health (Mejias Moreno, 2013; Wakefield et al., 2007), allows socialization (Infanto, 2005; Milligan et al., 2004), provides additional income (Espinosa Segui et al., 2017; Pourias et al., 2020; Corcoran et al., 2017), promotes nutritional benefits (Pourias et al., 2016; Ruggeri et al., 2016), and enhances one's food knowledge, skills, and awareness (Hardman et al., 2018).

In the Philippines, RA 100068, otherwise known as the Organic Agriculture Act of 2010, advances, disseminates, improves, and enforces the practice of organic agriculture in the country. Further, the act stipulates initiatives to enrich the soil, boosts farm productivity, lessens pollution, preserves the environment, averts natural resources reduction, safeguards the farmers', consumers', and the community's health, and advances communal agriculture

systems. Organic agriculture (AO), as stipulated in the act, reduces the use of synthetic fertilizers, pesticides, and pharmaceuticals, and utilizes animal manure and vermicast. The principles and policies of the above-mentioned act ensure the economic productivity of food and fibers while maintaining soil quality and fertility and ascertain safety for farmers, consumers, and the environment (ATI, 2011).

Organic gardening has greater potential in building healthy soil. Compared to conventional farming, harmful chemicals and pesticides are eliminated from the food produced, thus preventing diseases and promoting human health. At present, there are notable sources of organic matter which can contribute to the attainment of a higher level of organic fertility to the soil. Farm manures are highly recommended for crop production due to their nutrient content, ensuring good yield to vegetable crops (Tagotong & Corpuz, 2015). Abbey et al. (2001) reported that various stages of decomposition of animal and plant litters constitute soil organic matter. They added that soil comes from dead plant roots, crop residues, green manure, dead soil microorganisms, and farmyard manure.

Organic manures like farmyard manure, compost, and cow manures have long been used by farmers for the availability of nutrients, especially nitrogen, for plant growth and to improve soil quality (Zaman et al., 2004). Shaheen et al. (2014) reported that using organic manure increases the yield of spinach and nutrient levels of nitrogen, phosphorus, and potassium in the soils. *I. aquatica* and *B. rapa* were chosen since these plants are short-term crops. However, as to which kinds and levels of organic fertilizer are more beneficial to kangkong and pechay, vegetable growers are still uncertain. Thus, the researchers in this study investigated the effects of growing media mixtures with different amounts of chicken manure and vermicast on the growth and productivity of the vegetables under investigation.

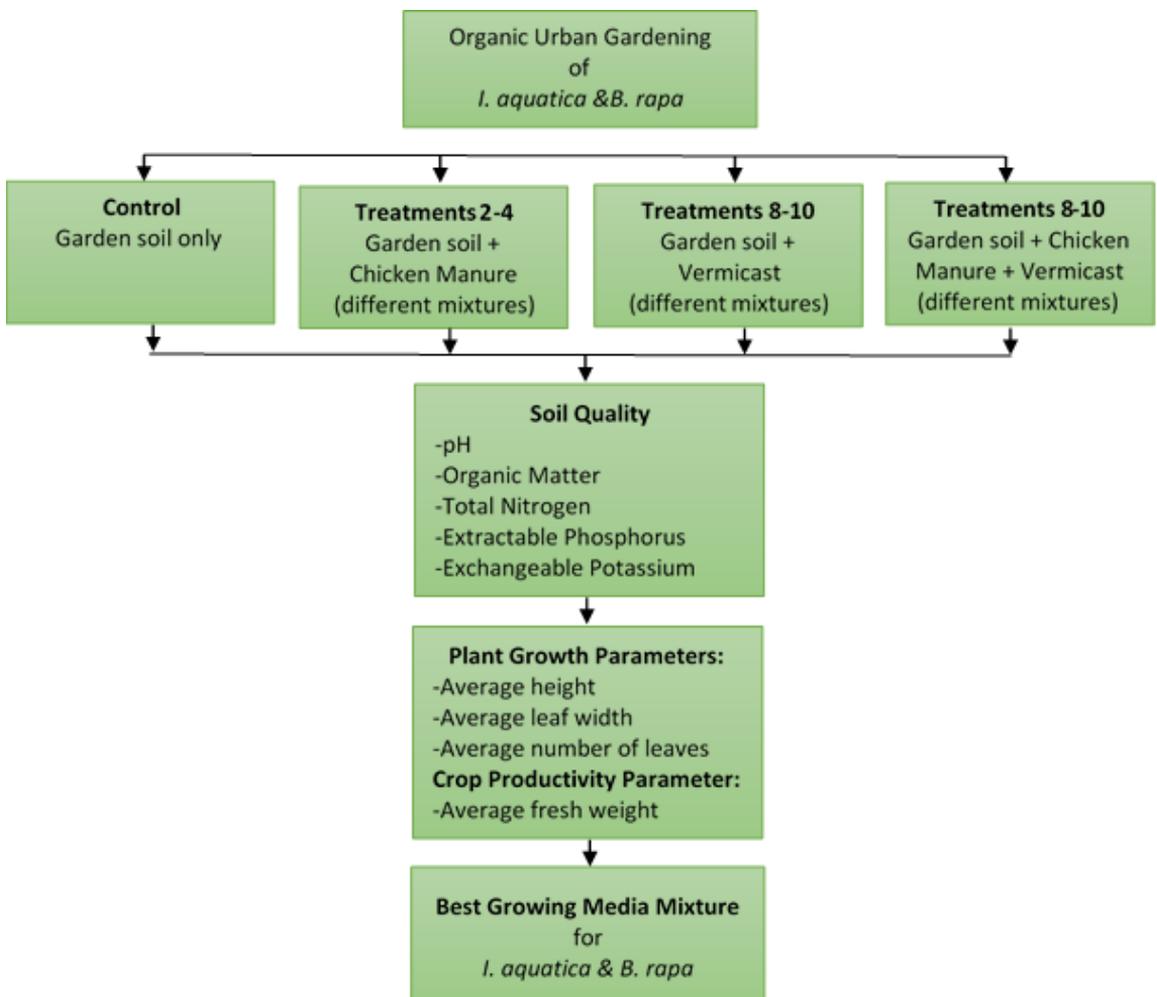
## Conceptual Framework

Organic urban gardening uses fertilizers of organic origin such as chicken manure and vermicast that improve soil health. Soil quality is the overall fitness or effectiveness for supporting plant growth, managing water and responding to environmental stresses (Lewandowski et al., 1999). Soil being a finite non-renewable and dynamic living resource is needed to sustain biological productivity, maintain or enhance the quality of air and water, and promote plant, animal and even human health (Doran & Zeiss, 2000). The good indicator of soil quality (SQ) is the soil organic matter (SOM)-related properties (Islam & Weil, 2000; Wander &

Bollero, 1999). The SOM beneficially reduces erosion and run-off, improves infiltration, movement and retention of water in soil, soil aggregation, and nutrient cycle (Woomer & Swift, 1994). The supplementation of organic manure maintains soil health, improves soil quality, increases nutrients which are important for improving growth and productivity of crops (Meena et al., 2015). Moreover, researches in the past five decades on SOM have emphasized the importance of mineral nutrients for crop growth and productivity yet the crop yields effect of SOM is difficult to demonstrate (Karlen et al., 1992; Seybold et al., 1996). In

**Figure 1**

Conceptual Framework of the Study Showing the Parameters



addition, the application of manure such as chicken manure and/or vermicast have altered the SOM levels which in turn affects plant growth and productivity (Strickling, 1975).

As presented in Figure 1, the different growing media mixtures served as control and treatments with variable amounts of garden soil, chicken manure, and vermicast in growing *I. aquatica* and *B. rapa*. The soil quality mixtures were analyzed, and the plant growth and productivity were measured to determine the best growing media mixtures for enhanced growth and productivity of the two plants.

### *Objectives of the Study*

The study aimed to:

1. assess the quality of growing media mixtures with different amounts of chicken manure and vermicast in terms of pH, organic matter, total nitrogen, extractable phosphorus, and exchangeable potassium;
2. determine the effects of different growing media mixtures on the growth and productivity of *Ipomoea aquatica* and *Brassica rapa* in terms of average plant height, average leaf width, average number of leaves, and average fresh weight of plants; and
3. determine the best growing media mixtures for the growth and productivity of *Ipomoea aquatica* and *Brassica rapa*.

### *Materials and Methods*

#### *Locale and Materials*

The study was conducted at the Science Garden of Bukidnon State University, Malaybalay City, Bukidnon, the Philippines, from October to November 2017. Certified plant seeds were purchased from a local agricultural supplier, East-West Seed Philippines. In this study, two short-term crops, *Ipomoea aquatica*

(kangkong) and *Brassica rapa* (pechay) were considered.

#### *Experimental Design*

The study employed the experimental research method using complete randomized block design (CRBD) in four replicates. CRBD is the simplest experimental design in which the subjects are randomly assigned to treatments. The design relies on randomization to control the effects of extraneous variables. The experimenter assumes that, on average, extraneous factors will affect treatment conditions equally, so any significant differences between conditions can fairly be attributed to the independent variable. The one-way analysis of variance for completely randomized block design (CRBD) was used to analyze the data.

#### *Acquisition of Seeds and Other Materials*

Certified seeds and other materials needed for planting were purchased from the local agricultural supply and hardware stores in Malaybalay City, Bukidnon, Philippines.

#### *Crop Establishment*

The certified seeds of two vegetables were planted in two distinct plots four feet by four feet square foot raised bed divided into 16 plots with four-inch spaces between each plant. The square footbeds were elevated two feet from the ground and were placed inside a net to prevent destruction by animals and insects, as adapted from the square-foot gardening of Bartolomew (FAO, 2020). The garden soil, chicken manure, and vermicast were purchased from local agricultural suppliers. These garden media were air-dried, weighed, and mixed for the different growing media mixture which served as the treatments. Four replicates per growing media mixtures were used in the study. Various growing media mixtures (Table 1) were prepared as follows:

**Table 1**  
*Different Growing Media Mixtures of Organic Materials*

Growing Media Mixtures (T <sub>1</sub> -T <sub>10</sub> )	Soil Formulation
T <sub>1</sub>	8 kg Garden Soil
T <sub>2</sub>	6 kg Garden Soil, 2 kg Chicken Manure
T <sub>3</sub>	4 kg Garden Soil, 4 kg Chicken Manure
T <sub>4</sub>	2 kg Garden Soil, 6 kg Chicken Manure
T <sub>5</sub>	6 kg Garden Soil, 2 kg Vermicast
T <sub>6</sub>	4 kg Garden Soil, 4 kg Vermicast
T <sub>7</sub>	2 kg Garden Soil, 6 kg Vermicast
T <sub>8</sub>	4 kg Garden Soil, 2 kg Chicken Manure, 2 kg Vermicast
T <sub>9</sub>	2 kg Garden Soil, 3 kg Chicken Manure, 3 kg Vermicast
T <sub>10</sub>	4 kg Chicken Manure, 4 kg Vermicast

After mixing the different amounts of soil, chicken manure, and vermicast for the different growing media mixtures, one kilogram of each well-mixed growing media mixture was taken, placed in airtight containers, and submitted to the Soils and Plant Tissue Testing Laboratory of the Soils Department of the College of Agriculture at Central Mindanao University, Musuan, Bukidnon, the Philippines, for soil quality analysis after the square foot beds were established.

#### *Determination of Soil Quality*

In this study, the soil quality parameters, namely pH, organic matter, total nitrogen,

extractable phosphorus, and exchangeable potassium content of the various growing media mixtures enriched with chicken manure and vermicast at various amounts, were determined. The growing media mixtures were analyzed for pH using a benchtop pH meter with the combined electrode, while organic matter (OM) using a loss of weight by ignition. The same samples were also tested for total nitrogen (N) using the Kjeldahl digestion method (Saez-Plaza, 2013), total extractable phosphorus (P), and total exchangeable potassium (K) using wet digestion (Di-acid digestion method) (Prasad et al., 2006).

#### *Plant Growth and Development*

Plant growth parameters include average plant height, average leaf width, average number of leaves, and the parameter on average fresh weight for plant productivity. A meter stick was used to measure the plant height and leaf width in centimeters, the leaves were counted, and an analytical balance was utilized to measure the plant weight in grams. Monitoring plant growth parameters was done every six days from planting to 33 days during harvesting, while for plant productivity, the weighing of the whole plant was conducted during harvest time at 33 days. This study hypothesized that soil quality based on various formulations could affect plant growth and productivity.

#### *Results and Discussion*

##### *Quality of Different Soil Formulations*

Chicken manure and vermicast were used in varying amounts to prepare the soil formulation and grow kangkong and pechay. One control soil and nine (9) growing media mixtures were prepared as presented in Table 2, and soil parameters (pH, OM, total N, P, & K) were determined. Table 2 presents the control and different treatments with the corresponding soil quality parameters.

**Table 2**  
Soil Quality of Control and Growing Media Mixtures

Treatment	Growing Media Ratio	pH	OM (%)	Total N (%)	P (ppm)	K (ppm)
T <sub>1</sub>	8 kg Garden Soil	6.17	0	0.4744	82.10	1,787.50
T <sub>2</sub>	6 kg Garden Soil, 2kg Chicken Manure	6.86	9.280	0.9412	107.76	4,400.00
T <sub>3</sub>	4 kg Garden Soil, 4kg Chicken Manure	6.64	11.345	1.2079	104.06	7,425.00
T <sub>4</sub>	2 kg Garden Soil, 6kg Chicken Manure	6.19	12.722	1.7172	113.61	11,137.50
T <sub>5</sub>	6 kg Garden Soil, 2kg Vermicast	7.32	4.461	0.5982	81.94	2,337.50
T <sub>6</sub>	4 kg Garden Soil, 4kg Vermicast	7.26	6.526	1.2544	80.44	2,200.00
T <sub>7</sub>	2 kg Garden Soil, 6kg Vermicast	6.74	10.656	1.7406	109.97	3,575.00
T <sub>8</sub>	4 kg Garden Soil, 2kg Chicken Manure, 2kg Vermicast	6.84	0.000	0.8066	100.92	3,575.00
T <sub>9</sub>	2 kg Garden Soil, 3kg Chicken Manure, 3kg Vermicast	6.56	11.345	1.7817	108.12	7,975.00
T <sub>10</sub>	4 kg Chicken Manure, 4 kg Vermicast	6.58	9.280	2.2773	97.75	7,975.00

### Soil pH

Results show that the pH values within the optimum range are those for treatments 1, 2, 3, 4, 7, 8, 9, and 10. The ones with values beyond pH 7.0 are treatments numbers 5 and 6, with pH 7.32 and pH 7.26 values, respectively.

The pH of the soil is vital because it affects many soil factors that affect plant growth like the presence of soil bacteria, the availability of nutrients, the presence of toxic elements, and the soil structure that impacts the fertilizer nutrients' availability. The release of nitrogen from organic matter from bacterial activity and the particular use of fertilizer is affected by soil pH because bacteria function optimally in the pH range of 5.5 to 7.0. Perry (2020) added that when the pH is below 5.0, the plant nutrients are leached out more quickly than soils with optimum pH range and may limit its growth.

Despite the variable amount of chicken manure, the vermicast added and the crop considered in related studies, the increased pH with the addition of chicken manure conformed with results of the study of Dikinya and Mufwanzala (2010); Amara and Mourad (2013); and Han, An, Hwang, Kim, and Park (2016). This increase in soil pH is due to the exchange of reactions happening in the terminal OH<sup>-</sup> of Al or Fe<sup>2+</sup> hydroxyl oxides replaced by organic anions produced from the decomposition of manure such as malate, citrate, and tartrate. Moreover, the presence of basic cations in the chicken manure released upon decarboxylation explains the rise in the soil pH (Dikinya & Mufwanzala, 2010).

### Organic Matter (OM)

The table further shows that T<sub>4</sub> has the

highest OM content with a value of 12.722, followed by T<sub>3</sub> and T<sub>9</sub> (11.45); while T<sub>5</sub> and T<sub>6</sub> have OM content lower than 7, and T<sub>1</sub> has zero (0) OM value. Results revealed that growing media mixture with a greater amount of chicken manure and vermicast had high OM content, which included T<sub>4</sub> (2 kg garden soil, 6 kg chicken manure); T<sub>3</sub> (4 kg garden soil, 4kg chicken manure); T<sub>9</sub> (2 kg garden soil, 3 kg chicken manure, 3 kg vermicast); T<sub>7</sub> (2 kg garden soil, 6kg vermicast); T<sub>10</sub> (4 kg chicken manure, 4 kg vermicast); and T<sub>2</sub> (6 kg garden soil, 2kg chicken manure).

Most productive and agricultural soils have between 2 - 6% organic matter (Fenton et al., 2020). There are two natural sources of nutrients for plants: organic matter and minerals. Through the process of decomposition, the plant and animal manure yield soil rich in organic matter. Aside from furnishing nutrients and home to organisms in the soil, organic matter can clump soil particles and increase the water-holding capacity of the soil. Most soils contain 2 - 10% organic matter. However, even in small amounts, organic matter is very important (FAO, 2020). Chicken manure and vermicast are sources of organic matter, and their breakdown results in the delivery of nutrients. The application and incorporation of organic materials in animal manure can increase stable soil organic levels. Fenton et al. (2020) stated that the quickest increases in OM are acquired from compost or semi-solid manure that is rich in carbon.

The addition of organic compost such as chicken manure and vermicast had similar results with the study of Hoover et al. (2019), which posited that long-term application of chicken manure significantly increased the organic matter content of the growing media mixtures. In addition, the results of the vermicast supplementation in the current study support the idea of vermicast as good organic fertilizer that increases the nutrient content of the growing media resulting in improved growth and productivity of the plants (Hussain & Abbasi, 2018), although the related studies

utilized different crops such as corn and potato.

### Total Nitrogen (N)

T<sub>10</sub> got the highest total N and this could be attributed to the organic matter from two organic sources – 50% chicken manure and 50% vermicast. The five highest total N were for T<sub>10</sub>, T<sub>9</sub>, T<sub>7</sub>, T<sub>4</sub>, and T<sub>7</sub>. It is followed by T<sub>9</sub> with 2 kg garden soil, 3 kg chicken manure, and 3 kg vermicast, and T<sub>7</sub> with 2 kg garden soil, and 6 kg vermicast. The high N content in these treatments was due to the additional organic matter, which was contributed with either chicken manure or vermicast. According to Fenton et al. (2020), both organic and inorganic forms of nitrogen are found in soils, and 90% of them are associated with soil organic matter. This study takes into consideration chicken manure and vermicast as sources of organic matter.

Compared to carbon (C), hydrogen (H), and oxygen (O), nitrogen (N) ranks behind in the total quantity needed for plant growth, but is the mineral element most demanded by plants. The quantity of nitrogen in soils is intimately associated with organic matter levels. Residue from plants that do not have fix atmospheric nitrogen provides small amounts of soil nitrogen. Typically, approximately 5% of organic matter is nitrogen. Nevertheless, within a growing season only a small quantity of the total nitrogen is available to plants. Returning crop residues to the soil or introducing other organic matter to the soil, such as animal manure or animal bedding, replenishes organic matter (Oldham, 2020).

The escalation of total N with the chicken manure and vermicast supplementation in the current study supports the higher total N of soil mixture with continuous application and the significant increment of vermicast in the study done by Dikinya and Mufwanzala in 2010 and Meena et al. (2015), respectively. Dikinya and Mufwanzala pointed out that the application of chicken manure leads to

substantially high nitrogen content because nitrogenous compounds, such as ammonia, are released during decomposition. Meanwhile, the decomposition of phenolic acids and aliphatic acids increases N availability leading a gain in N due to the increment of vermicompost like vermicast (Meena et al., 2015).

#### *Extractable Phosphorus (P)*

The top five growing media mixtures with the highest P content in ppm were T<sub>4</sub>, T<sub>7</sub>, T<sub>9</sub>, T<sub>2</sub>, and T<sub>3</sub>. Results revealed that growing media mixture with higher P concentration had more amounts of chicken manure and vermicast. The high P content could be traced back to the increasing amount of chicken manure and the added vermicast. As the animal manure in chicken and vermicast undergo decomposition, they also release P into the soil. The additional anthropogenic P sources with the augmentation of chicken manure, vermicast, or its combination is paramount to the accrual of high P contents of these media mixtures. The organic material added enhances the status of the mixtures, microbiological activity and improves the availability of plant nutrients (Dikinya & Mufwanzala, 2010; Meena et al., 2015).

Phosphorus (P), second to nitrogen (N), is the ultimate limiting nutrient for crops and forage making. Phosphorus's chief function in plants is the storage and the energy transfer formed during photosynthesis for the growth and reproduction processes. For phosphorus availability, several methods can be done like adding lime, organic manure, and the proper application of P fertilizers, which affects the efficient assimilation of P by the crops (USDA-NRCS, 2020).

#### *Exchangeable Potassium (K)*

The soil formulation with the five highest P contents is T<sub>4</sub>, T<sub>10</sub>, T<sub>9</sub>, T<sub>3</sub>, and T<sub>2</sub>. Results indicated that those growing media mixtures with more chicken manure and vermicast had higher P content. The use of chicken manure

and vermicast in the study served as a source of potassium. As stressed by Parnes (2020), the use of organic residues of almost any kind supplies enough K with no need for additional inorganic fertilizer. All animal manures and most plant residues are good potassium fertilizers. Consequently, as organic residues decompose, most potassium is quickly released.

The study of Meena et al. in 2015 had analogous findings with the current study, suggesting that the increment of organic matter like vermicast can enrich the availability of K, upgrade the organic matter of the soil, and improve soil physical characteristics. This upscaling of soil quality is due to the solubilizing action of organic acids formed upon decomposition of organic matter from manure with its higher capacity to hold K in available form (Vidyavathi et al., 2011).

#### *Effect of Growing Media Mixtures on the Growth and Productivity of the Selected Plants*

##### *Ipomoea aquatica (kangkong)*

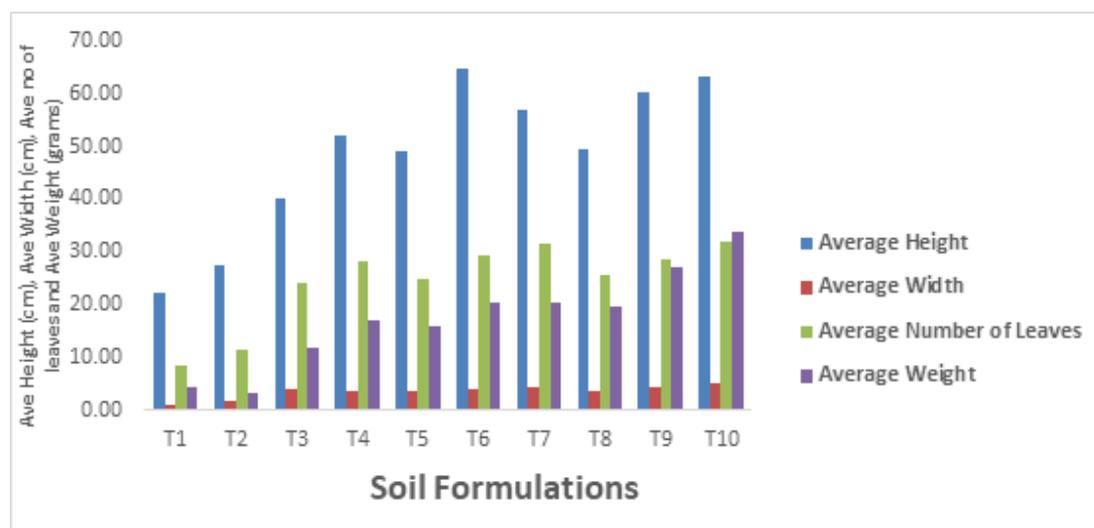
The effects of these various growing media mixtures on the growth and productivity of kangkong are shown in Figure 2.

As shown on the figure, results reveal that average plant height is highest for kangkong grown on T<sub>6</sub> and shortest for T<sub>1</sub>; plant width is broadest for kangkong planted on T<sub>10</sub> and narrowest for T<sub>1</sub>. The treatment with the most number of leaves was found is T<sub>10</sub> and T<sub>7</sub> and the least number was at T<sub>1</sub>, and the heaviest average fresh weight was for T<sub>10</sub>. The lightest wet weight was harvested from T<sub>2</sub>. The overall pattern showed that the control group (8 kg garden soil) was consistently the lowest in all parameters.

Results suggest that the garden soil does not have enough nutrients to sustain good crop yield as compared to the other plots with different soil mixtures enriched with chicken manure and vermicast. Among the different

**Figure 2**

Effect of Growing Media Mixtures on the Growth and Productivity of *Ipomoea aquatica* (kangkong) in Terms of Plant Growth and Productivity Parameters



soil mixtures, the kangkong planted on T<sub>10</sub> containing a mixture of chicken manure and vermicast yielded the broadest average leaf width, the highest average number of leaves, and the heaviest average wet weight, except for the average plant height. From this, the researchers could infer that those plants harvested from T<sub>10</sub> yielded the best plant growth and productivity in terms of average plant height, average plant width, average number of leaves, and average plant wet weight.

The results of the current study is comparable to the a previous study (ACIAR, 2010), which indicated that the water spinach (kangkong) grew well in fertile soil, which was rich in organic contents. According to Attiyeh et al. (2000), kangkong is well adapted to a wide range of climate and soil conditions and requires only relatively high soil moisture for optimum growth. Soils with high organic matter are preferable. In this study, organic matter like vermicomposts had the potential for improving plant growth and productivity when added to the soil. Ordinary garden soil with additional organic matter like chicken manure and vermicast yielded the kangkong with the broadest average plant width, the most number of leaves, and the heaviest average wet weight. On the other hand, the formulation with garden

soil and vermicast yielded the highest average plant height for kangkong.

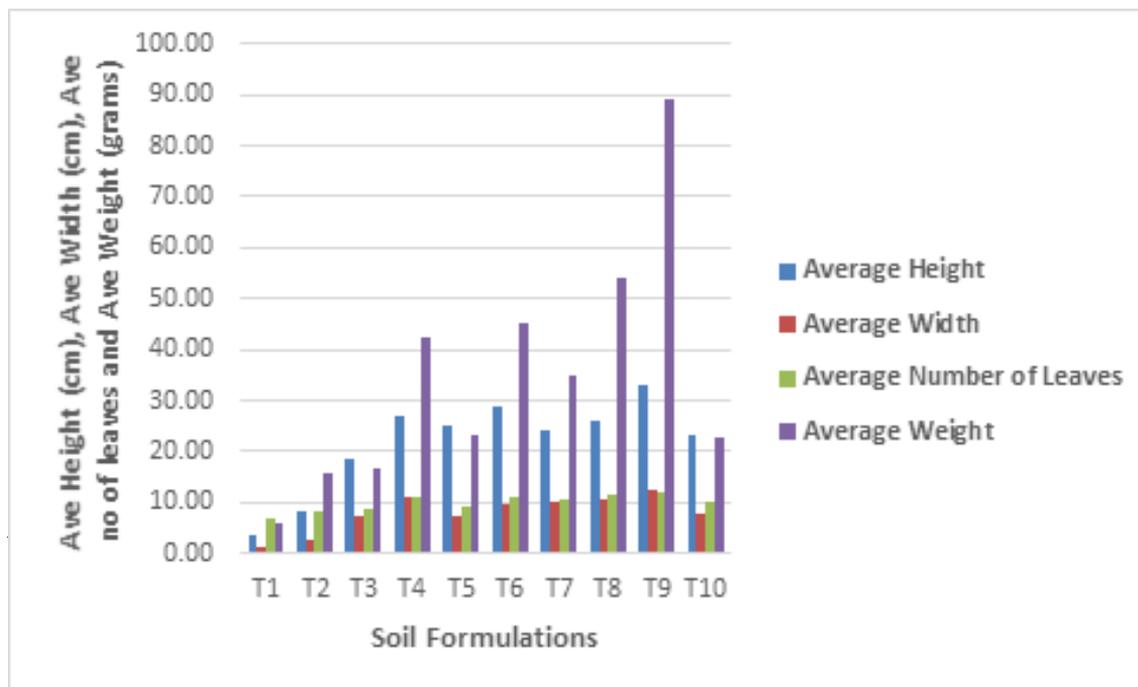
#### *Brassica rapa* (pechay)

Figure 3 shows the effects on the growing media mixtures on the growth and productivity of pechay.

Figure 3 shows the effect of the quality of growing media mixtures on the growth and productivity of *Brassica rapa*. Pechay, when applied with organic inputs for its growth, has a comparative advantage over that of the farmers' practice of using synthetic fertilizer. The result showed that pechay planted on T<sub>9</sub> (2 kg garden soil, 3 kg chicken manure, and 3 kg vermicast) obtained the highest overall plant growth and productivity. On the other hand, the pechay planted on T<sub>1</sub> (8 kg garden soil) had the least growth. The plant growth and productivity are affected by the variable growing media mixtures with animal manure, such as chicken manure and vermicast (Gonzales et al., 2015). This result is supported by the findings of Meena et al. (2015) that applying organic fertilizer improves the essential properties of the soil responsible for the vigorous growth and development of plants.

**Figure 3**

*Effect of Growing Media Mixtures on the Growth and Productivity of Brassica rapa (Pechay) Plant in Terms of Plant Growth and Productivity Parameters*



The one-way analysis of variance (ANOVA) was utilized to determine whether there is a statistically significant difference between the average plant height, leaf width, average number of leaves, and average plant fresh weight. Results demonstrated that there are no significant differences in the plant growth parameters planted on various formulations with  $r$  squared = .978 (adjusted  $r$  squared = .879),  $r$  squared = .981 (adjusted  $r$  squared = .894), and  $r$  squared = .974 (adjusted  $r$  squared = .857), respectively. However, there is a significant difference in the average wet weight with an  $r$  squared = 1.000 (adjusted  $r$  squared = .999).

#### *Best Growing Media Mixture for the Growth and Productivity of the Selected Plants*

##### *Ipomoea aquatica (kangkong)*

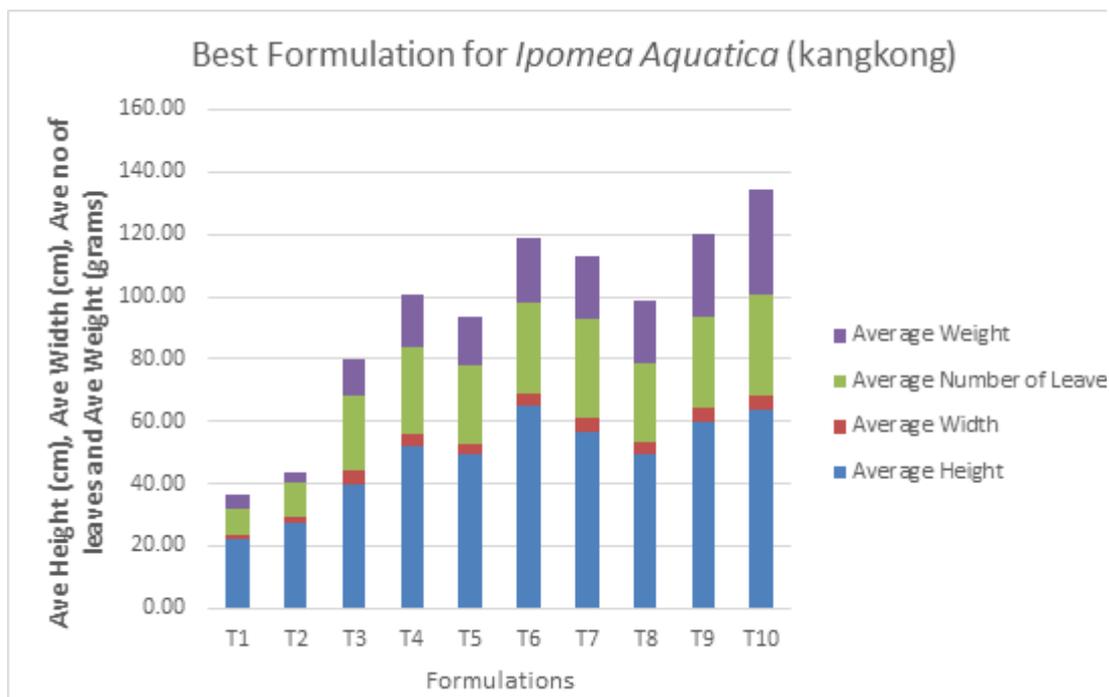
The variable amount of chicken manure and vermicast added to the soil affected the growth and productivity  $T_{10}$  of the *Ipomoea aquatica*. The result in Figure 4 shows that on the harvest day, the chicken manure and vermicast in  $T_{10}$

influence the average plant height, average leaf width, the average number of leaves, and average fresh weight of kangkong.

The data show that the effect of the combination of  $T_{10}$  (4 kg chicken manure and 4 kg vermicast) significantly improved the growth and productivity of kangkong. The control and other formulations showed a statistically significant difference. For kangkong, the measured average plant height was highest for  $T_6$ , the highest value for the average width, the average number of leaves, and the average fresh weight of kangkong were measured from  $T_{10}$ . The growth and productivity of kangkong were affected by several factors, including the quality of soil formulation. The 50% chicken manure and 50% vermicast influenced the vegetative growth in terms of average leaf width, greater number of leaves, and heavier wet weight leading to improved plant growth and productivity of kangkong. This result was ascribed to the high nitrogen and total exchangeable potassium of the soil quality result for  $T_{10}$  available for

**Figure 4**

*Best Growing Media Mixture for Ipomoea aquatica (kangkong) in Terms of Plant Growth and Productivity*



increased plant growth and productivity.

The result of the study suggests that kangkong can thrive in organic matter-rich media (ACIAR, 2010) such as T<sub>10</sub> with 50% chicken manure and 50% vermicast formulation. Kangkong being a resilient crop, adapts well to the wide range of climate, organic matter-rich medium, and requires relatively high soil moisture for optimum growth (Attiyeh et al., 2000) provided by the vermicast. This result suggests that kangkong can grow well in an organic medium without soil.

#### *Brassica rapa*

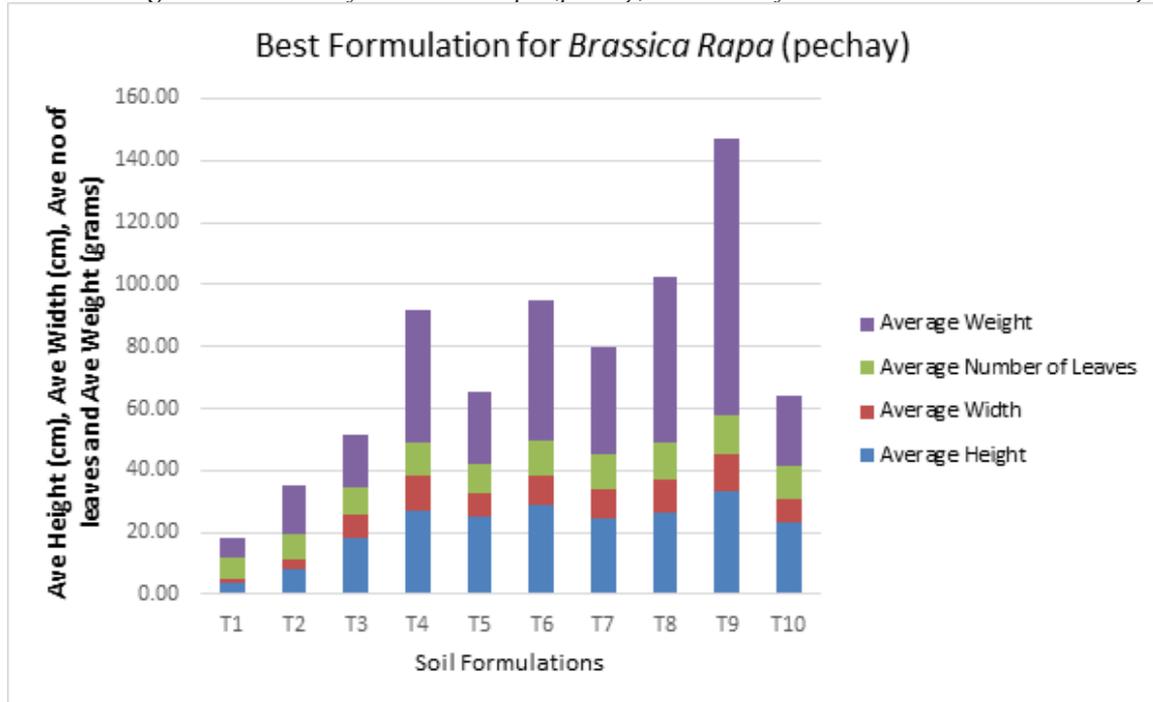
In growing *Brassica rapa* (pechay), different growing media mixtures affect its growth and productivity. Figure 5 shows overall the result of the best growing media mixture for cultivating pechay is formulation T<sub>10</sub>. The highest pechay average height is observed for T<sub>9</sub>, the highest average leaf width for T<sub>4</sub>, the highest average number of leaves for T<sub>5</sub>, and the highest average wet weight for T<sub>9</sub> upon harvest time. The results indicate that combining 2 kg garden soil, 3 kg

chicken manure, 3 kg vermicast yields the best result.

The result of the study proposes that the application of an organic mixture of chicken manure and vermicast to the soil relatively enhances the OM, total nitrogen, the total extractable phosphorus, and total exchangeable potassium content of the soil formulation improving the plant growth and productivity of pechay. Organic matter like chicken manure, and vermicast, even in small amounts, is vital to growing plants (FAO, 2020). As reiterated by Fenton et al. (2020), around 2 - 6% of organic matter is considered the most productive agricultural soil. This organic matter added to the soil can replenish crop residue that provides nitrogen indispensable for plant growth (Oldham, 2020). Theunissen et al. (2010) also added that nitrogen plays a significant role in photosynthesis, cell division and differentiation, growth and somatic embryogenesis, chlorophyll content, ribulose-1,5-bisphosphate carboxylase/oxygenase (rubisco) activity, electron transport rate, photosynthetic rate, and anthocyanin

Figure 5

Best Growing Media Mixture for *Brassica rapa* (pechay) in Terms of Plant Growth and Productivity



production. It is also an important component of proteins required for the metabolic process that takes place during plant growth.

For crop production, one of the most limiting nutrients, next to nitrogen, is phosphorus. The USDA-NRCS in 2020 posited that the basic role of phosphorus in a plant is the storage and transfer of energy produced via photosynthesis. This process increases size and reproductive processes of plants made available by the supplementation of organic matter, i.e., chicken manure and vermicast. As for potassium, the decomposition of all animal manure added quickly releases this essential element as good fertilizer (Parnes, 2020). The unpredictable result in the different parameters- average plant height, average leaf width, average number of leaves, and average plant fresh weight, however, may be attributed to the diameter of the stem, which is excluded as a parameter of the study.

#### Conclusion and Recommendation

The soil quality of growing media mixtures improves with the addition of a variable

amounts of chicken manure and vermicast with the notable increase in pH, organic matter, total nitrogen, extractable phosphorus, and exchangeable potassium, which boosts biological and nutrient availability for plant uptake and decreases potential loss of N and P. The increment of chicken manure and vermicast supplementation provides the growing media mixtures that improved plant growth and productivity of *I. aquatica* and *B. rapa* resulting to increased average plant height, average number of leaves, and heavier fresh weight of plants providing the biological and nutrient needs of the plants. T<sub>10</sub>, composed of a 1:1 ratio of chicken manure to vermicast, is suitable for growing *I. aquatica*, while T<sub>9</sub> is composed of 2:3:3 ratio of garden soil, chicken manure and vermicast is ideal for growing *B. rapa*. Different plant species, therefore, have varying nutrient needs for growth and productivity. From the results, T<sub>10</sub> and T<sub>9</sub> are recommended for urban organic and square-foot gardening in growing *I. aquatica* and *B. rapa*, respectively. Similar studies may be conducted using different short-term or long-term crops. In addition, future studies may include other plant growth and

productivity parameters such as stem diameter and biomass. Other studies may employ different organic growing media such as horse manure, pig manure, among others.

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