The Effect of Vermicompost of *Perionyx excavatus* to Growth of *Brassica integrifolia* in hydroponic solutions

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Received:- 05 May 2022/ Revised:- 13 May 2022/ Accepted:- 22 May 2022/ Published: 31-05-2022

Abstract— *This study was conducted to evaluate the effect of vermicompost on the growth of Brassica integrifolia. The experiment was arranged in a completely randomized design with hydroponic solutions supplemented with inorganic nutrients and vermicompost with the ratios of 100:0, 75:25, 50:50, 25:75, 0:100, respectively. The agronomic, microbiological criteria and the change of the hydroponic solution were collected and processed to evaluate the effectiveness. The results showed that the treatment with 100% vermicompost solution gave the best agronomic criteria in the studied treatments and was equivalent to the control treatment. Microbiological density conformed to quality standards TCVN 6505-2:1999 on food hygiene and safety. After 30 days to stabilize the nutrient solution, the stability indicators of the hydroponic solution showed that the vermicompost solution (100%) could be used as a substitute for the inorganic nutrient solution.*

Keywords— Brassica integrifolia, hydroponic method, Perionyx excavatus, vermicompost.

I. INTRODUCTION

Green vegetables are an indispensable food source in human's daily life. However, the problem of environmental pollution makes the quality of vegetables not to be guaranteed, while the demand for safe vegetables of people is increasing. With the desire to apply simple techniques for safe vegetable products on a family scale, the hydroponic vegetable method is very suitable with the following advantages: growing a variety of off-season vegetables, without having to work the soil, weeding, no need to use pesticides, the product is completely clean and homogenous... so growing hydroponic vegetable is more and more widely used in modern life today [1].

Earthworms (*Perionyx excavatus*) are commonly used in waste metabolism in the Philippines, Australia and other countries [2]. Currently, earthworm (*Perionyx excavatus*) is increasingly being applied in many fields such as food, medicine, fertilizer. Earthworm manure helps to provide nutrients to plants, increase the germination rate of seeds, promote root development, increase plant weight, contain beneficial microorganisms that contribute to resist plant's disease. In addition, it also restores the fertility of the soil, helping the soil to be loose and aerated. Earthworm manure can be packed and transported in large quantities easily without any loss of quality, and at the same time do not affect the air environment because they have the earthy odor [3]. In addition, earthworms play an important role in organic waste management [4]. The use of vermicompost as fertilizer has been quite widespread, but combined with hydroponic methods is still very little. The application of earthworm manure as vermicompost into hydroponics is a solution to limit the use of chemical nitrogen fertilizers, towards an absolutely safe vegetable growing technique.

II. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

2.1 Material

Kitchen waste and manure were used as food for the earthworms in a ratio of 1:1 volume:volume. Both kitchen waste and manure were precomposted for 21 days before being used as food for the earthworms. 1 kg of vermicompost + 1 liter of water, put in a bag to soak in an air tank overnight to get cheese clot settled for 30 days and got - vermicomposting solution

- Seeds: *Brassica integrifolia* seeds of Trang Nong Co., ltd.

Substratum: coconut fiber is soaked in water, every 12 hours, the water is drained, soaked for 4 days to reduce tannin. Then take it out to dry.

Styrofoam containers are covered with black nylon inside to reduce light intensity and avoid leakage of nutrient solution to the outside. Styrofoam lid is perforated with a plastic pipe (with the same diameter as the mouth of a plastic gabion), punched 6 holes on each foam box lid. Plastic baskets are made with small holes so that when the vegetables grow, they can root out and keep the substrate moist, then stuff the coconut fiber medium into the plastic basket and place it in the pre-punched holes on the lid of the styrofoam box.

Seeds: soak in water for 3-4 hours, then take out to drain, incubate for one night and then sow seeds in a nursery tray with available coir mixed with rice husk ash, sow 3-4 seeds in each tray. After sowing the seeds, water a little and place in a cool place with light sunshine. When *Brassica integrifolia* has real leaves, sow 2-3 seeds in a plastic basket at a depth of about 1cm. Place the lid of the container with the seeded plastic basket on top of the styrofoam container containing the nutrient solution, so that the bottom of the basket is submerged in the solution by 1-2cm

2.2 Experimental details

2.2.1 Arrangement treatments

The experiment was arranged in a completely randomized design consisting of 5 treatments with three replications, each replicate consisted of a styrofoam bin with six sprouted vegetable plants. the treatments are arranged according to Table 1.

TABLE 1
EXPERIMENTAL ARRANGEMENT

Treatment	Inorganic nutrition (%)	Vermicomposting of *Perionyx excavatus* manure solution (%)
Treatment 1(Control)	100	0
Treatment 2	75	25
Treatment 3	50	50
Treatment 4	25	75
Treatment 5	0	100

2.3 Methodology

Nutrient solution mixed with the ratio for each treatment, each treatment 12 liters of solution. The nutrient solution is put in a styrofoam container and left for 30 days to start growing vegetables.

Harvesting *Brassica integrifolia* after 30 days of planting. Harvesting by removing the plastic basket from the styrofoam, removing the plastic basket and growing medium from the vegetables. Cut across the stem to get the product which is the stem and leaves of *Brassica integrifolia*.

2.4 Criteria follow-up assessment

Hydroponic environment: record the criteria every 5 days, starting from the time of growing vegetables to harvesting, including the following criteria: pH, protein content in the hydroponic solution when harvesting *Brassica integrifolia*. (Kjeldahl method)

Agronomic criteria: record the criteria once every 5 days, all *Brassica integrifolia*, starting from the time *Brassica integrifolia* has true leaves for harvesting, including the following criteria: plant height (cm), leaf length (cm), leaf width (cm), root length (cm), number of leaves (leaves/plant).

Harvesting: including the following criteria: total weight (g), trade weight (g); Trade weight/total weight ratio (%)= (trade weight / aggregate weight) x 100.

Determination of density of heat-resistant *Coliforms* and *E. coli* present in vegetables by MPN method.

2.5 Data processing

The data was entered and processed by excel software. The program Minitab 16.0 is used for statistical analysis.

III. RESULTS AND DISCUSSION

3.1 Effect of vermicompost (*Perionyx excavatus*) on the height of *Brassica integrifolia*

The results of Table 2 show that at the time of 10 days after planting, the height of Treatment 5 (100% vermicompost) (10.23 cm) was not significantly different from that of Treatment 1 (100% inorganic nutrient solution) (11.87 cm). Treatment 5 with the result was better than Treatment 2, Treatment 3, Treatment 4 and the difference was statistically significant (P<0.05).

TABLE 2
HEIGHT OF *Brassica integrifolia* IN ALL TREATMENTS

Treatments	Height (cm) of *Brassica integrifolia* in days after planting						
	0 day	5 days	10 days	15 days	20 days	25 days	30 days
Treatment 1 (Control)	1,65a	5,61a	11,87a	21,26a	24,73a	30,56a	37,16a
Treatment 2	1,72a	2,45b	3,16b	4,23b	5,32b	6,27b	7,64b
Treatment 3	1,65a	2,92b	4,07b	5,67b	7,55b	9,84b	12,17b
Treatment 4	1,68a	2,66b	3,7b	4,44b	5,29b	6,52b	8,12b
Treatment 5	1,17a	4,67ab	10,25a	19,35a	22,86a	26,03a	30,72a
Average	0,13	0,93	1,05	2,04	1,85	2,32	3,38
Cv (%)	8,45	25,44	15,87	18,59	14,05	14,63	17,62
P	0,948	0,007	0,00	0,00	0,00	0,00	0,00

Note: Mean values in column followed by different letters are statistically significant differences (P < 0.05)

This result showed that *Brassica integrifolia* can adapt to hydroponic environment with 100% vermicompost and grow equivalent to Treatment 1. Particularly, the height (*Brassica integrifolia*) of Treatment 2 was the lowest (2.45 cm) among the treatments. At the time of 20 days after planting, the *Brassica integrifolia* in Treatment 2, Treatment 3, Treatment 4 grew very slowly, after 10 days from the time of 10 days after planting, the height of *Brassica integrifolia* in Treatment 2, Treatment 3 and Treatment 4 only increased respectively by 2.16 cm, 3.48 cm and 1.59 cm; while the height of *Brassica integrifolia* in Treatment 5 (12.60 cm) and Treatment 1 (12.87 cm) were still developed well.

At the time of harvesting 30 days after planting, the height of in Treatment 5 (30.72 cm) was not statistically different from that of Treatment 1 (37.16 cm) and was significantly higher than that of Treatment 2, Treatment 3, Treatment 4. the growth in height of in *Brassica integrifolia* Treatment 2, Treatment 3, and Treatment 4 were quite slow, with the average height in Treatment 2 (0.19cm/day), Treatment 3 (0.35cm/day), and Treatment 4 (0.21cm/day). While the height growth in Treatment 5 was 0.98 cm/day, and this growth was not different from the control treatment (1.18 cm/day) (table 2).

Tripathi *et al.* [5] showed that unlike NPK levels vermicompost had no effect on plant height of Pak choi but it had significantly increased the leaf number. Vermicompost at 15 t/ha produced highest number of leaf but not significantly different from other levels of vermicompost. But at 45 DAT vermicompost had significantly increase the leaf number per plant

3.2 Effect of vermicompost (*Perionyx excavatus*) on the number of leaves of *Brassica Integrifolia*

Table 3 shows the results in 10 days after planting, the number of leaves in Treatment 5 (100% vermicompost of *Perionyx excavatus*) reached 7.62 leaves/plant, which is higher differently with statistical mean than Treatment 2, Treatment 3, Treatment 4 (P < 0.05), however leaves of *Brassica Integrifolia* in Treatment 5 and Treatment 1 (Control) have the similiar result in statistical mean.

The growth rate of the tree is similar to the height of *Brassica Integrifolia*, by the time of 30 days after planting, the number of leaves in Treatment 2 increased from 3 leaves/plant to 5.67 leaves/plant (average increase of 0.09 leaves/plant/day), Treatment 3 increased from 3 leaves/plant to 6.56 leaves/plant (average increase of 0.11 leaves/plant/day), Treatment 4 leaf count increased from 3 leaves/plant to 5.78 leaves/plant (average increase of 0.09 leaves/plant/day). The growth rate of leaf number of Treatment 2, Treatment 3, Treatment 4 was lower and different from that of Treatment 5 (average increase of 0.29 leaves/plant/day) ($P < 0.05$).

The number of leaves on a plant also plays an important role in the weight of the plant because leaves are the main organ for photosynthesis.

TABLE 3
NUMBER OF LEAVES OF *Brassica integrifolia* IN TREATMENTS

Treatment	Number of leaf (leaf / tree) of *Brassica Integrifolia* in the days after planting						
	0 day	5 days	10 days	15 days	20 days	25 days	30 days
Treatment 1- Control	3	5,21a	7,89a	9,28a	10,68a	12,52a	14,61a
Treatment 2	3	3,22b	4,22b	4,39c	4,84c	5,27c	5,67c
Treatment 3	3	3,4b	4,19b	4,67c	4,94c	6,29c	6,56c
Treatment 4	3	3,15b	4,18b	4,22c	4,89c	5,28c	5,78c
Treatment 5	3	5,39a	7,62a	8,77b	9,22b	10,12b	11,56b
Average		0,38	0,32	0,17	0,36	0,50	0,52
Cv (%)		9,22	5,77	2,74	5,26	6,36	5,86
P value		0,00	0,00	0,00	0,00	0,00	0,00

**Note: Mean values in column followed by different letters are statistically significant differences ($P < 0.05$)*

Tripathi *et al.*[5] noted that chemical fertilizers release nutrients rapidly and plant utilizes them quickly resulting in significant change in growth and development of a plant. Hence they are more efficient than vermicompost in short run. But in long run or after one month the effects of vermicompost are more favorable than chemical fertilizers. Chemical fertilizers (NPK) were efficient than the organic manures in the short run [14]. In other leafy crops such as cabbage maximum number of loose leaf was found when organic and chemical fertilizers were applied in combination [15,16].

3.3 Effect of vermicompost on the size of leaves at harvest *Brassica integrifolia*

By the time of 10 days after planting, the width of *Brassica integrifolia* leaves in Treatment 1 (Control) and Treatment 5 (100% vermicompost of *Perionyx excavatus*) was not statistically significant. However, the leaf length of Treatment 5 (2.05 cm) was shorter and different from the leaf length in Treatment 1 (5.1cm), while in Treatment 2, Treatment 3 and Treatment 4 has not yet developed the sixth leaf. (Table 4)

At the time of 25 days after planting, Treatment 3 had just started to develop the sixth leaf with leaf length (4.22 cm) and leaf width (0.62cm) much lower than that of Treatment 1 (Control) and Treatment 5 ($P<0.05$). At the time of harvest (30 days after planting), the largest leaf length of *Brassica integrifolia* was found in Treatment1. Leaf length and leaf width were lowest in Treatmnet 2 (1.5 cm and 0.62 cm), although Treatment 3 and Treatment 4 had leaf length and leaf width better than Treatment 2, but there was no difference statistically between these 3 Treatment.

TABLE 4
THE SIZE OF *Brassica integrifolia* LEAVES AT HARVEST IN ALL TREATMENTS

Treatments	The length of leaf (cm)	The width of leaf (cm)
Treatment 1- Control	11,84a	4,08a
Treatment 2	1,50b	0,63b
Treatment 3	6,03ab	1,53b
Treatment 4	2,14b	0,62b
Treatment 5	9,61a	4,33a
Average	2,21	0,75
Cv (%)	35,56	33,42
P	0,001	0,00

****Note: Mean values in column followed by different letters are statistically significant differences ($P < 0.05$)***

3.4 Effect of vermicompost on root length of *Brassica integrifolia*

At the time of harvest, the root length of *Brassica integrifolia* roots reached 16.38 cm in Treatment 5, this value was not statistically different from that in the Treatment 1 (Control) (18.68 cm). Treatment 2, Treatment 3 and Treatment 4 had root lengths of 7.83 cm, 3.35 cm and 4.99 cm, respectively, 2.4 to 5.5 times lower than that of the control Treatment 1 ($P<0.05$) and The results of Treatment 5 and Treatment 1 root lengths were not statistically significant. (Table 5)

TABLE 5
ROOT LENGTH AT HARVEST OF *Brassica integrifolia* IN ALL TREATMENTS

Treatment	Root length (cm)
Treatment 1- Control	18,678a
Treatment 2	7,825b
Treatment 3	3,349b
Treatment 4	4,99b
Treatment 5	16,358a
Average	1,946
Cv (%)	19,004
P	0,00

***Note: Mean valuesin column followed by different letters are statistically significant differences ($P < 0.05$)**

Tripathi et al. [5] found vermicompost significantly increased the root length of *Pak choi*. Maximum root length was obtained in vermicompost at 15 t/ ha. However, vermicompost at 10 t/ha and 5 t/ha was at par with control. The humic acids in humus stimulate root growth. In a similar study, Tomati et al. [6] and Canellas et al. [7] found that humic acids isolated from vermicompost enhanced root elongation and formation of lateral roots in maize roots

3.5 Effect of vermicompost on the total weight and commercial weight of *Brassica integrifolia*

Among the plants supplemented with vermicompost solution of *Brassica integrifolia*, Treatment 5 had the highest total weight of *Brassica integrifolia* (336.09 g), this result is equivalent to the weight of *Brassica integrifolia* in Treatment 1 Control (369.65 g) statistically significant similar at 5% level (Table 6).

TABLE 6
MASS OF *Brassica integrifolia* AT HARVEST IN ALL TREATMENTS

Treatment	Total Weight (gram)	Trade Weight (gram)	Ratio of Trade Weight/ Total Weight (%)
Treatment 1 Control	369,65a	353,88a	95,71a
Treatment 2	5,84b	3,26b	52,63b
Treatment 3	22,08b	19,43b	87,09a
Treatment 4	27,47b	25,04b	91,43a
Treatment 5	336,09a	325,86a	96,93a
Average	20,32	20,62	10,02
Cv (%)	13,35	14,17	11,82
P	0,00	0,00	0,002

***Note: Mean values in column followed by different letters are statistically significant differences ($P < 0.05$)**

The ratio of Trade Weight/Total Weight of *Brassica integrifolia* in Treatment 5 reached 96.93%,it was 1.22% higher than that of the control Treatment. In Treatment 2, the weight of *Brassica integrifolia* reached the value of 5.84 g lower than that of Treatment 3 (22.08 g) and Treatment 4 (27.47 g), but Treatment 2, Treatment 3, Treatment 4 had different results without statistical significance, but significant difference 5% compared with Treatment 5 and Treatment 1.

Tripathi et al. [5] noticed that after harvesting of the crops, the rate of respiration reduced under both chemical fertilizer and vermicompost application indicating decreased activities of soil microorganism. However 15t/ha vermicompost treated plot showed the higher respiration rate as compared to chemical fertilizers.

3.6 Density of heat-resistant *Coliforms* and E. coli in *Brassica integrifolia* in all treatments

Heat-resistant coliforms appeared in Treatment 1 with $0.64x10^2$ (MPN/g) lower than Treatment 2 ($4.3x10^2$ MPN/g), Treatment 3 ($4.62x10^2$ MPN/g) and Treament 5 ($3.74x10^2$ MPN/g). However, compared with the limit specified by "Vietnam Standard" (TCVN 6505–2:1999), these values are within the allowable limit. In NT4, there was no presence of heat-resistant coliforms. According to the results (Table 7), *E. coli* was not present in all vegetable samples of all 5 treatments (Table 7)

TABLE 7
DENSITY OF HEAT-RESISTANT COLIFORMS AND E. COLI IN *Brassica integrifolia*

Treatment	heat-resistant Coliforms (MPN/g)	*E. coli* (MPN/g)
Treatment 1 Control	$0,64x10^2$	0
Treatment 2	$4,3x10^2$	0
Treatment 3	$4,62x10^2$	0
Treatment 4	$0,00x10^2$	0
Treatment 5	$3,74x10^2$	0

In summary, *Brassica integrifolia* in all treatments were within the allowable limits of TCVN 6505–2:1999 on food hygiene and safety.

3.7 Change of solution hydroponics

3.7.1 pH of hydroponic solution

The hydroponic solution is left for 30 days before it can be used to grow *Brassica integrifolia*. At this time, the pH value of Treatment 5 solution is 7.1, within the pH range suitable for leafy vegetables (5.5-7,5), the pH of Treatment 5 is not different from that of Treatment 2 (7.77), Treatment 3 (7.89) and Treatment 4 (7.35), and four Treatments are higher statistically significant difference at 5% level than the pH of hydroponic solution in the Treatment 1 (P<0.05) (Table 8).

In general, the pH in four Treatments containing hydroponic solution components analyzed had unstable pH changes. In Treatment 2, the pH at the start of planting *Brassica integrifolia* was 7.77. In 5 days after planting, the pH did not increase significantly (7.79), but by the time of 20 days after planting, the pH decreased to 7.52 and increased to the time of harvesting (30 days after planting), pH value reached 7.59. The pH value in Treatment 3 was similar to that in Treatment 2, at the initial point, the pH value of Treatment 3 was 7.89, decreased to 7.56 at the time of 15 days after planting with pH 7.56, but increased to the time of 20 days after planting (7.59) and until 30 days after planting, pH has a value of 7.53. The pH in Treatment 4 had a negligible change and was less volatile than in Treatment 2 and Treatment 3, at the beginning of *Brassica integrifolia* cultivation, the pH was 7.35, when harvesting was improved (30 days after planting), the pH increased value 7.48. Treatment 5 got pH 7.1 by the initial time was lower than that of Treatment 2, Treatment 3, Treatment 4 but no statistically significant differences at the 5% level with pH in Treatment 4 and different from Treatment 2 and Treatment 3 statistically significant meaning (P<0,05). By 30 days after planting, Treatment 5 got pH 7.6 and the difference was not statistically significant compared with Treatment 2, Treatment 3 and Treatment 4, but pH of Treatment 5 was difference from pH of Treatment 1 (P<0.05) (Table 8)

TABLE 8
PH OF HYDROPONIC SOLUTION FOR GROWING *Brassica integrifolia*

Treatment	pH of hydroponic solution after planting						
	0 day	**5 days**	**10 days**	**15 days**	**20 days**	**25 days**	**30 days**
Treatment 1 Control	6.21c	6.26c	6.28b	6.27b	6.24b	6.16d	6.34b
Treatment 2	7.77a	7.79a	7.58a	7.52a	7.52a	7.68a	7.59a
Treatment 3	7.89a	7.71a	7.57a	7.56a	7.58a	7.52bc	7.52a
Treatment 4	7.35b	7.31b	7.44a	7.4167a	7.4733a	7.42c	7.4767a
Treatment 5	7.10b	7.60ab	7.53a	7.54a	7.5867a	7.63ab	7.6a
Average	0.1100	0.1200	0.1346	0.1876	0.1136	0.0561	0.0474
Cv (%)	1.51418	1.74859	1.848074	2.583076	1.559865	0.770796	0.648604
P	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Note: Mean values in column followed by different letters are statistically significant differences (P < 0.05)

3.7.2 Total nitrogen in hydroponic solution

The initial total protein in the treatments was completely different, the highest amount of protein was in the control treatment (2700ppm), in Treatment 2 the protein value was 2377.8 ppm, Treatment 3 was 2055.6 ppm, Treatment 4 was 1733,4 ppm and the lowest in NT5 is 1411.2 ppm. After 30 days of planting, nitrogen will be absorbed by the plant and reduced in the solution. The residual nitrogen in the control Treatment 1, Treatment 2, Treatment 3, Treatment 4 and Treatment 5 was 1952,1±164.9 (ppm), 2039.6 ±58 (ppm), 1850,0 ± 25 (ppm), 1550.2 ± 43 (ppm) and 1026.6 ± 69.1 (ppm), respectively. Although the amount of protein was completely different, the rate of nitrogen use in Treatment 5 was 27.25%, this value is equivalent to Treatment 1 (27.7%) and the difference is significant statistically compared with Treatment 2 (14.230%), Treatment 3 (10.003%) and Treatment 4 (10.570%) ($P<0.05$) (Table 9)

TABLE 9
PROTEIN CONTENT IN HYDROPONIC SOLUTION FOR GROWING *Brassica integrifolia*

Treatment	The initial total of protein (ppm)	Total of protein after harvesting (ppm)	Used protein (ppm)	Used protein ratio (%)
Treatment 1	2700,0	1952,1a	747,90a	27,70
Treatment 2	2377,8	2039,6a	384,55b	14,23
Treatment 3	2055,6	1850,0a	205,62b	10,00
Treatment 4	1733,4	1550,2b	183,16b	10,57
Treatment 5	1411,2	1026,6c	384,55b	27,25
Average		87,18	87,18	3,88
Cv (%)		5,18	21,27	21,62
P value		0,00	0,00	0,00

Note: Mean values in column followed by different letters are statistically significant differences ($P < 0.05$)

Other researchers also reported similar results in several other crops. Application of recommended dose of fertilizers and vermicompost indicated maximum yield in Potato [8], rice [9] and significantly influenced various growth parameters in Cabbage plant [7]. Combination of Vermicompost at 10 t/ha + NPK at 25:60:50 kg/ha increased nodulation, plant height and yield in Pea [10]. Similarly, 150 kg N/ha and 12 t/ha vermicompost increased the leaf number in Potato [11] and vermicompost at 15 t/ha significantly increase the growth and yield of Okra [12]. Chemical fertilizer was most effective within a month of application in influencing growth performance in amaranths whereas vermicompost was more favorable than chemical fertilizer after a month [13]. Tripathi et al. [14] noticed that chemical fertilizers were effective in increasing plant growth in short run but suppressed significantly the microbial activities of soil. Vermicompost on the other hand was effective in long run through slow release of plant nutrients and improving soil health by increased soil microbial activities

IV. CONCLUSION

The use of 100% vermicompost that is stabilized for 30 days after planting as a hydroponic solution for growing *Brassica integrifolia* gives the yield and quality equivalent to using a hydroponic solution with chemical nutrients. In addition, the use of vermicompost will contribute to reducing the risk of environmental pollution by minimizing the solution containing inorganic compounds in hydroponic for growing vegetable.

ACKNOWLEDGEMENTS

This study is funded in part by the Can Tho University Improvement Project VN14-P6, supported by a Japanese ODA loan

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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