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Efficiency Comparison of Different Compositions of Effective Microorganisms (EM) Fertilizer Stock Dilutions on Growth and Yield of Green Onion in Tbongkhmum District, Tbongkhmum Province, Cambodia

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ABSTRACT

The environment is very important in the modern way of life of people, whether rural or urban, in which the connection with nature really improves the well-being of the people. Microorganisms are biologically diverse organisms that are recommended to be used to preserve the natural environment and increase crop yields. Many farmers are interested in reducing the use of chemical fertilizers to reduce the impact on the environment and the contamination of agricultural products that can harm the environment and consumers. Reducing the use of imported chemical fertilizers and preferring to use naturally processed fertilizers makes farmers more profitable in terms of agricultural expenses, especially by increasing the recycling capacity of waste. The purpose of this study is to find out which types of Effective Microorganisms (EM) fertilizer is the most effective for growth and yield of green onions in Tbongkhmum province. As methodology, the experimental study was divided into 4 replications with a total of 4 treatments and a total of 16 plots. The first treatment uses EM fertilizer mixed with rice water; the second treatment uses EM fertilizer mixed with Siam weed; the third treatment uses EM fertilizer mixed with yellow fruit; and the fourth treatment uses EM fertilizer mixed with fish waste. As a result, after using different EM fertilizers in the experiment, the use of EM fertilizers mixed with fish waste has the best effect on the growth of green onions in terms of the number of stems per clump, the number of leaves per clump, the weight per clump, and the weight of green onions per plot.

INTRODUCTION

The technology of Effective Microorganisms (EM) does not harm the environment and have many benefits in increasing the diversity of soil microorganisms, reducing soil degradation, and reducing environmental degradation (Anibal *et al.*, 2007). It stimulates growth, increases plant nutrient uptake, changes soil structure, and changes plant root growth (Marcello *et al.*, 2019).

Vegetables are the second-most important crop after rice. Most vegetables are grown in the lowlands, especially along the riverbanks, because they are highly nutritious. The types of vegetables that farmers like to grow are tuberous vegetables and leafy vegetables, and most of them are family-owned, depending on the size of the land and their availability. In vegetable production, it requires much attention to cultivation techniques, including the use of animal manure such as cow manure, chicken manure, and pig manure. Pest control techniques are an important basis for increasing yields (General Department of Agriculture, 1992). Green onion is a vegetable that is unique from other crops because it can be used in many ways, both in tubers and leaves. Based on the many flavors and nutrients contained in the stems, leaves, and tubers, it is used as a vegetable, a spice (which makes food more delicious), and, more importantly, it can be used as medicine (it can be used as an antiseptic, milk booster, antibacterial agent, painkiller, bloating, flu medicine, insect repellent, and can be grown as an insect repellent plant). If looking at the role of natural EM fertilizer, it has many benefits for the efficient use of microorganisms in agriculture (Urmi & Sariah, 2006). Plants can grow well, especially in soils covered by these powerful microorganisms (Sun *et al.*, 2014). Professor Teruo Higa created the initial theory of effective microorganisms (Higa, 1991; Higa & Wididana, 1991a). EM contains a variety of beneficial microorganisms, such as photosynthetic bacteria, for example, Rhodopseudomonas palustris, Rhodobacter spheaeroides, Lactobacillus plantarum, and yeasts (Saccharomyces spp.).

For the cultivation techniques of farmers, it is shown that farmers do not have much understanding of the techniques, especially the lack of attention to the processing of various wastes, preferring to use chemical fertilizers that are easy to use and to buy. Therefore, farmers need to understand more new techniques in order to grow crops with high yields and good quality without compromising the environment, soil quality, or human and animal health. Seeing all these problems, an experiment on the use of different compositions of EM fertilizer stock dilutions on growth and yield of green onion in Tbongkhmum district, Tbongkhmum province has been conducted.

The objectives of this experiment are to discover which types of natural EM fertilizer is most effective for growing and obtaining the highest green onion yields, and to learn about the economics of using natural compost EM fertilizer on green onion yields.

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MATERIALS AND METHODS

Location of study

This experiment was conducted in Trapeang Kou village, Sralop commune, Tbong Khmum district, Tbong Khmum province. The village has a total population of 159 families, and about 80% of the population is engaged in agriculture, including 20 vegetable growers, especially green onions.

Type of Soil for Experimentation

The type of soil in the research site is in Kampong Siem soil group. The soils in this group are those with very weak slopes and around the Basal plateau and are black or hazel clay on the plains or foothills. The soil is relatively deep and easy to irrigate, especially during the rainy season when there is a lot of rain, and in the deeper part of the soil there may be large basalt rocks. The variability of waterlogging depends on the drainage system and the topography (CARDI, 2007). This type of soil is fertile but generally lacks nitrogen (N), phosphorus (P), and zinc (Zn), as well as a high iron content and viscosity when wet. This type of soil, when dehydrated, becomes hard, which makes it difficult to plow when cultivating and is suitable for growing both rice and other crops (General Department of Agriculture, 2020). Fertilizers used in this experiment include the chicken manure (for bottom layering), natural EM fertilizer and some separation materials.

Experimental Methods and Design

In order for the experimental work to be accurate with the minimum level of bias, Randomized Complete Block Design (RCBD) has been organized in this research work, which has 1 experimental factor divided into 4 replications, 4 treatments, and a total of 16 plots. The four treatments are described as follows:

- T1= EM + rice washed water (EM+RWW)
- T2= EM + Siam weed (EM+CO)
- T3= EM + yellow fruit (EM+YF)
- T4= EM + fish residual waste (EM+FRW)

Process of Cultivation

Varieties are important factors related to yield composition and market economy characteristics. Therefore, before planting, one must understand the conditions of his growing area, combined with the needs of the market. For instance, planting in the rainy season, he has to choose varieties that have hard leaves and are resistant to raindrops and can also increase self-resistance to many environmental variables. Soil preparation is an important factor that can affect the cultivation of green onion. It should not use wet soil during planting, sowing, or transplanting, so before planting, growers must prepare the soil properly. After plowing and weeding, growers need to prepare the land as follows:

- The length of row with 2 meters wide and 3 meters long
- In the rainy season, rows should be built a little higher, between 15 and 30 cm
- In the dry season, rows should not be built too high, only 10 to 15 cm high
- Rows should be in a straight line to facilitate the management, maintenance, and alignment of the pole line
- A tape measure or measuring stick should be used to accurately measure by purposes.

Method of Mixing EM Fertilizer with Rice Washed Water

- Take 18 liters of rice washed water, 1 liter of molasses, and 1 liter of EM fertilizer
- Mix in a plastic container with a lid and a capacity of 30–50 liters hold
- Stir the mixture thoroughly and close the lid
- Store it in a dry, dark place at a temperature of 20–30 degrees Celsius
- Open the lid once a day, stir thoroughly to release the gas, and leave it for about 7–14 days before using it
- Can keep it for 3–6 months by placing it in a dry, shady place away from sunlight
- Take 10 ml of split EM or EM fertilizer mixed with 10 liters of clean water to water on the sub or vegetable nursery or in the field of 1 square meter every day to repel pests and make the soil more fertile.
- Do not use split EM or EM fertilizer to save it to be further split or take for animals to drink or eat.

Method of Splitting EM Fertilizer with Fruits

- Take fruits to chew or pound, stuff it in a cloth and tie it tightly, and put it in a plastic container with 18 liters of clean water, 1 liter of molasses, and 1 liter of EM-1 fertilizer and stir all the mixture together completely.
- Keep in the shade or in a house that is not exposed to sunlight; open the lid once a day.
- Store it about 10–15 days before being filtered into a bottle; keep it for 3-6 months.
- Take 5 ml of EM fruit hormone fertilizer mixed with 2.5 liters of clean water and spray it on the crop once every 1-2 months to nourish the plants, support the roots, and increase the stimulation of the plants.
- For leafy crops such as lettuce, bak choy, water spinach, we can apply 10 ml of EM fertilizer mixed with 10 liters of clean water and spray or water the crop every 5-7 days. When transplanting roots, EM fertilizer can be applied to the cross-sectional area to speed up the growth of the roots.

Method of Mixing EM Fertilizer with Siam Weed

- This method is to help the plant to grow young green leaves, fruit, heat resistance, and will be able to repel a large number of pests.
- Chew the plants finely in a 30- to 50-liter plastic container with a mixture of powdered molasses, EM fertilizer, and clean water and stir together and close the lid to keep the shade out of the sun.
- Open the lid once a day and keep it for about 10–15 days before filtering it into a bottle to use.
- Store for 3–6 months in a shady place away from sunlight.

- For leafy crops such as water spinach, cabbage, lettuce, kale, etc., take 10 ml of EM fertilizer mixed with 5 liters of clean water, and spray or water the crop every 5-7 days.

Method of Mixing EM Fertilizer with Fish Residual Waste

- Put the fish head or fish residual waste in a plastic container with a capacity of 30 to 50 liters, then pour the molasses, EM fertilizer and water together, stir the mixture well, and close the lid tightly to prevent flies or worms.
- Keep in a shady place away from heat for a day or two
- Open the lid and stir once; leave it for 10 to 15 days.
- The fish head or fish residual waste will rot and we can use the water, but it smells a little bad.
- It can be stored for 3–6 months in a shady place away from sunlight.
- For vegetable crops such as lettuce, cabbage, water spinach, green onion, etc. we can use 10 ml of EM fertilizer mixed with 10 liters of clean water to spray or water the crop every 5-7 days.

Data Collection

Data is a source of information and figures derived from observations of crop variability, and it is very important for researchers to assess any issues. Data collection takes place at harvest time. For every measurement of the stem height of each green onion leaf, we randomly select 5 samples of onion in each treatment. Measuring the height of this green onion stem, we are from the base next to the ground to the end of the longest leaf in centimeter.

RESULTS AND DISCUSSION

Height of Green Onion Stem at Harvesting Stage

The results showed that the first treatment (using EM mixed with rice washed water) had an average stem height of 30.43 cm, and the second treatment (using EM mixed with Siam weed) had an average stem height of 29.68 cm, while the third treatment (using EM mixed with yellow fruit) has an average stem height of 32.25 cm, and the fourth treatment (using EM mixed with fish residual waste) has an average stem height of 33.16 cm.

Table 1: Height of green onion stem at harvesting stage

SV	d.f.	SS	MS	F value	F-table	
					5%	1%
Treatment	3	25.050	8.016	2.55 ns	3.86	6.99
Replication	3	15.691	5.230	1.66 ns	3.86	6.99
Error	9	28.260	3.140			
Total	**15**	**68.002**	**4.533**			

CV =4.2%

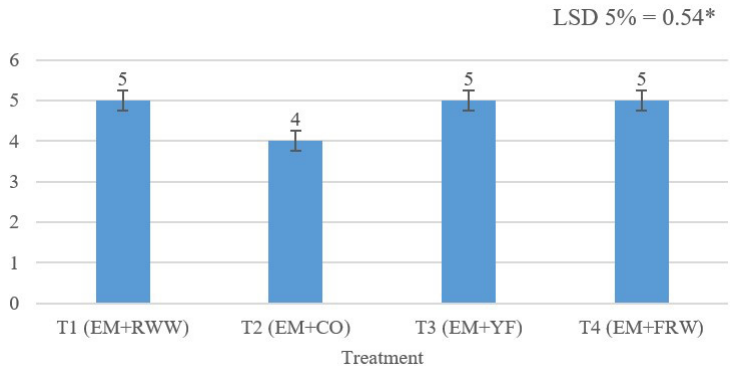

Figure 1: Height of green onion stem at harvesting stage (cm)

Number of Green Onion Stems Per Clump at Harvesting Stage

The results showed that the first, third, and fourth treatments had an average of five stems at harvesting time, while the second treatment had an average of only four stems per clump. From this result, it is observed that the first, third, and fourth treatments have an average number of stems per clump more than other treatment due to the effect of all these fertilizers having a higher effect on the growth and performance of green onion, while the second treatment (using EM mixed with Siam weed) has the lowest partial growth of stems per clump.

Table 2: Number of green onion stems per clump at harvesting stage

SV	d.f.	SS	MS	F value	F-table	
					5%	1%
Treatment	3	1.467	0.489	4.22 *	3.86	6.99
Replication	3	0.607	0.202	1.75 ns	3.86	6.99
Error	9	1.042	0.115			

Total	**15**	**3.117**	**0.207**			

CV =7.0%

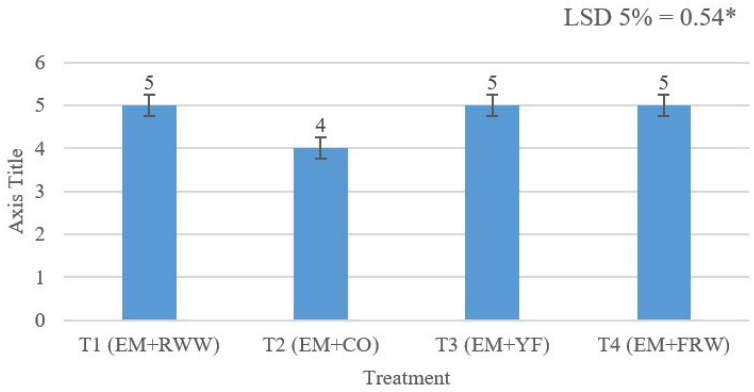

Figure 2: Number of green onion stems per clump at harvesting stage

Number of Green Onion Leaves Per Clump at Harvesting Stage

The results showed that the first treatment (using EM mixed with rice washed water) had an average leaf count of 6.5 leaves per cluster, and the second treatment (using EM mixed with Siam weed) had an average leaf count of 6.25 leaves per cluster, while the third treatment (using EM mixed with yellow fruit) had an average leaf count of 6.75 leaves per cluster, and the fourth treatment (using EM mixed with fish residual waste) had an average leaf count of 7.75 leaves per cluster

Table 3: Number of green onion leaves per clump at harvesting stage

SV	**d.f.**	**SS**	**MS**	**F value**	**F-table**	
					5%	**1%**
Treatment	3	17	5.666	4.85 *	3.86	6.99
Replication	3	8.5	2.833	2.42 ns	3.86	6.99
Error	9	10.5	1.166			
Total	**15**	**36**	**2.40**			

CV =8.0%

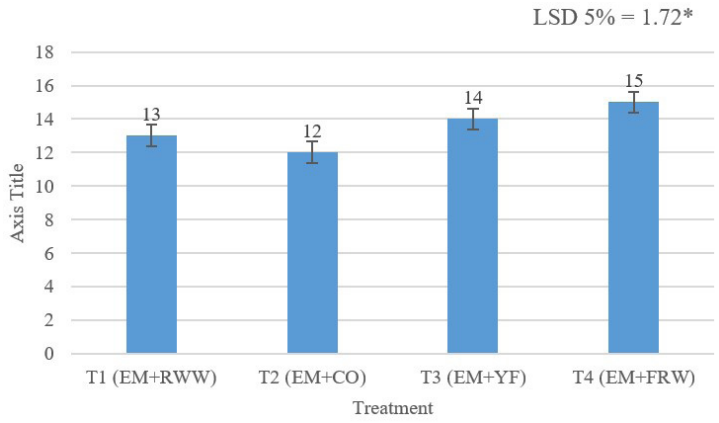

Figure 3: Number of green onion leaves per clump at harvesting stage

Weight of Green Onion Per Plot at Harvesting Stage (kg)

The results showed that the fourth treatment received the highest average weight at the harvesting stage, up to 7.07 kg per plot, while the third treatment received an average harvest weight of 6.69 kg. The second treatment had an average harvest weight of 6.34 kg per plot, while the first treatment had the lowest average harvest weight of 6.28 kg per plot. From this result, it is observed that the fourth treatment (using EM mixed with fish residual waste) had the best effect on the original weight of the green onion, followed by the third treatment (using EM mixed with yellow fruit), and the second treatment (using EM mixed with Siam weed) had little effect on the original weight of the green onion, while the first treatment (using EM mixed with rice washed water) was the lowest compared to other treatments.

Table 4: Weight of green onion per plot at harvesting stage

SV	d.f.	SS	MS	F value	F-table	
					5%	1%
Treatment	3	1.618	0.539	4.70 *	3.86	6.99
Replication	3	0.192	0.064	0.55 ns	3.86	6.99
Error	9	1.031	0.114			
Total	**15**	**2.842**	**0.189**			

CV =5.1%

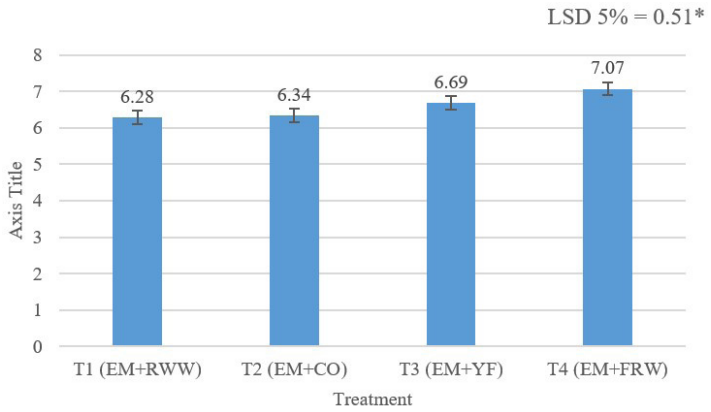

Figure 4: Weight of green onion per plot at harvesting stage

Yield of Green Onion Per Hectare (tons)

The results show that the fourth treatment had an average yield weight of 8.84 tons/ha, while the third treatment has an average yield weight of 8.36 tons/ha, the second treatment has an average yield weight of 7.92 tons/ha, while the first treatment has the lowest average yield weight of only 7.85 tons/ha. From this result, it is observed that the fourth treatment (using EM mixed with fish residual waste) has the best effect on the average yield weight per hectare, while the treatment that achieved the next best result is the third treatment (using EM mixed with yellow fruit). However, the treatment using EM mixed with Siam weed and the treatment using EM mixed with rice washed water has little effect on the yield weight of the green onion.

Table 5: Yield of green onion per hectare (tons)

SV	d.f.	SS	MS	F value	F-table	
					5%	1%
Treatment	3	2.528	0.842	4.70 *	3.86	6.99
Replication	3	0.300	0.100	0.55 ns	3.86	6.99
Error	9	1.612	0.179			
Total	**15**	**4.441**	**0.296**			

CV =5.1%

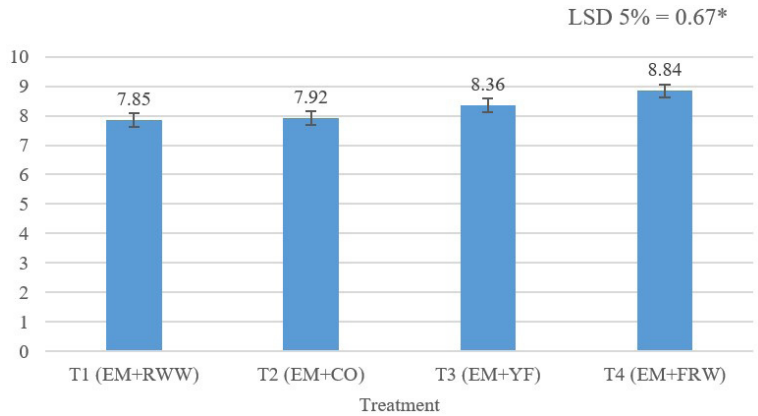

Figure 5: Yield of green onion per hectare (tons)

Analysis of Profit (ha)

The profit from the production of green onion is derived from the total revenue (TR) and the total cost (TC) of each treatment in hectare. To calculate a profit, it is needed to use the following formula:

Profit (π)= Total revenue (TR) – Total cost (TC)

The results of the calculation of the average profit per hectare of green onion production show that the fourth treatment with the highest average profit per hectare is the fourth treatment with 19,455,404 riels, followed by the third treatment with a profit of 18,256,000 riels, then the second treatment with a profit of 17,155,789 riels, while the first treatment has the lowest profit with only 16,980,132 riels per hectare.

Table 6: Analysis of profit from each treatment (ha)

No.	Treatment	Total income/ ha (Riel)	Total cost/ha (Riel)	Total revenue/ ha (Riel)
1	T1= EM + rice washed water (EM+RWW)	19,625,000	2,644,868	16,980,132
2	T2= EM + Siam weed (EM+CO)	19,800,000	2,644,211	17,155,789
3	T3= EM + yellow fruit (EM+YF)	20,900,000	2,644,000	18,256,000
4	T4= EM + fish residual waste (EM+FRW)	22,100,000	2,644,596	19,455,404

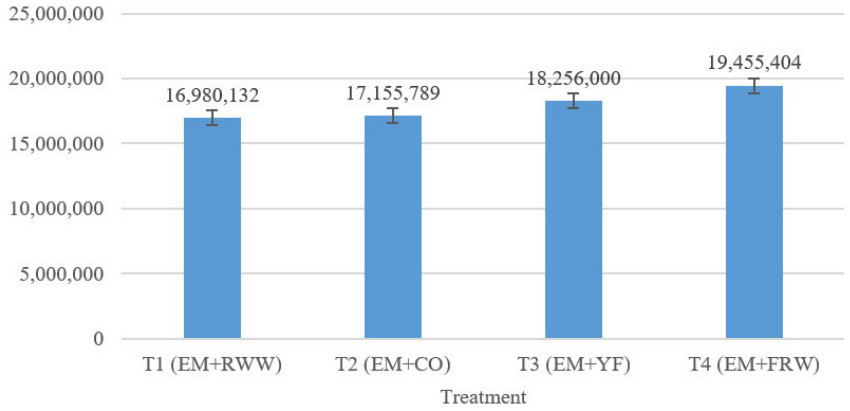

Figure 6: Analysis of profit from each treatment (ha)

CONCLUSIONS

As a result, it is found that the natural EM fertilizers actually contribute to the yield of green onion. The advantages of EM fertilizers contribute to excellent plant protection since they are microbial agents that use helpful microorganisms to regulate the biological control of pests. Fish residual waste is rich in carbohydrates and proteins, which are important nutrients for plants to use for photosynthesis, which helps plants grow well.

According to the interpretation and discussion of the results of experimental research and through the implementation of practical research work on the use of natural EM fertilizer differentiated on the growth and yield of green onion. We can make the following general conclusions:

- After using natural EM fertilizer, it was demonstrated that stem height and number of leaves was influenced by differentiation on the growth and yield of green onion based on data analysis by each treatment. Based on agricultural statistics, the meaning of the leaves varies.

- Calculating the average total cost of each treatment in hectares of green onion yields the following results: 2,644,868 riels for the first treatment, 2,644,211 riels for the second, 2,644,000 riels for the third, and 2,644,596 riels for the fourth. The findings indicate that the average total cost per hectare is similarly costed by the four treatments.

- According to the findings of the profit analysis, the average profit per hectare of green onion production show that the fourth treatment with the highest average profit per hectare is the fourth treatment with 19,455,404 riels, followed by the third treatment with a profit of 18,256,000 riels, then the second treatment with a profit of 17,155,789 riels, while the first treatment has the lowest profit with only 16,980,132 riels per hectare.

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