EFFECTS OF ORGANIC FERTILIZERS AND AXILLARY SHOOTS REMOVAL ON THE GROWTH AND YIELD OF BIRD'S EYE CHILIES (*Capsicum frutescens* L.) PLANTED IN BRIS SOIL

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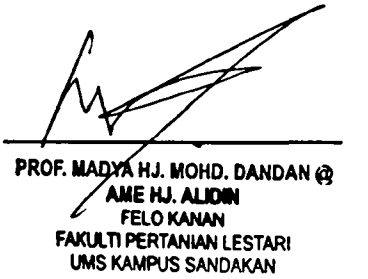

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ABSTRACT

This study was carried out at the Faculty of Sustainable Agriculture, Rainshelter B in Sandakan campus, Universiti Malaysia Sabah from 27th April 2015 until 20th October 2015 to evaluate the effects of organic fertilizers (fermented plant juice, effective microorganism) and axillary shoots (0, 3, 5) removal on the growth and yield of bird's eye chilies (*Capsicum frutescens* L.) planted in BRIS soil. Fertilizer set A and B was used as the control for the fertilizer factor while 0 axillary shoot was used as the control for axillary shoot factor. Three different fertilizers treatments with three different numbers of axillary shoot were each replicates for three times. There were 27 experimental units in total (3 x 3 x 3) and Randomized Complete Block Design (RCBD) was used as the experimental layout. Fertigation system was used for the fertilizer application. The parameters on vegetative growth and yield were recorded and analyzed by using two-way ANOVA at 5% significant level. Of all the parameters that had been studied, only plant height (cm) gave significant effect while the other parameters showed no significant effects. The results showed that for vegetative growth of bird's eye chilies plants, treatment S3 and H3 (fertilizer A and B with 5 axillary shoots) had the highest plant height (S3 =53.28 cm, H3 =46.67 cm). Treatment S2 and H2 (effective microorganism with 3 axillary shoots) had the highest stem diameter which were 7.66 mm and 7.64 mm respectively. The best treatment for canopy width was S3 and H2 (Fertilizer A and B with 3 axillary shoots); S3 = 36.33 cm and 35.44 cm respectively. For the yield components of bird's eye chilies, treatment S3 and H3 (Fertilizer A and B with 5 axillary shoots) gives the highest number of fruits per plant (S3 = 25, H3 = 22), total yield per plant (S3 = 12.22 g/plant, H3 = 10.91 g/plant), and total dry weight of fruits (S3 = 2.85 g, H3 = 2.59 g). As for the fruit evaluation, S1 and H1 (fermented plant juice with 0 axillary shoot) was found to be the best treatment with highest value of weight per fruit (S1 = 0.28 g, H1 = 0.29 g), length per fruit (S1 = 1.37 cm, H1 = 1.41 cm), pedicel length per fruit (S1 = 1.28 cm, H1 = 1.36 cm), and girth per fruit (S1 = 0.99 cm, H1 = 1.04 cm). Treatment S3H2 (fertilizer A and B with 3 axillary shoots) gave the highest dry weight of plant (S3 = 18.29 g, H2 = 17.84 g). Based on the chemical properties of BRIS soil, treatment S2H1 (effective microorganism with 0 axillary shoot) and S2H3 (effective microorganism with 5 axillary shoots) increased the most soil pH value (S2= 4.53, H1 and H3 = 4.47). Meanwhile, treatment S1, H2 and H3 (fermented plant juice with 3 and 5 axillary shoots) were contributing more total nitrogen to the soil (S1 =0.24 %, H2 and H3 = 0.23 %). Treatment S1 and H3 also gives the highest available P to the soil in this study (S1 = 15.24 ppm, H3 = 17.43 ppm). The highest increment of soil organic matter was contributed by treatment S3 and H2 (fertilizer A and B with 3 axillary shoots) (S3 = 1.26%, H2 = 1.30 %). Based on the study, treatment fertilizer A and B with 5 axillary shoots (S3H3) was recommended for further study because it gave the tallest plant height, highest number of fruits per plant, total yield per plant and dry weight of fruits. The second recommended treatment was fermented plant juice with 5 axillary shoots (S1H3). This is due to its ability in improving the BRIS's soil properties especially for the total nitrogen and available phosphorus in soil.

KESAN BAJA ORGANIK DAN PENYIMPANAN TUNAS AIR TERHADAP PERTUMBUHAN DAN HASIL CILI PADI (Capsicum frutsencs L.) DI TANAH BRIS

ABSTRAK

Kajian ini telah dijalankan di Rumah Teduhan Hujan B Fakulti Pertanian Lestari, kampus Sandakan, Universiti Malaysia Sabah (UMS) bermula pada 27 April 2015 hingga 20 Oktober 2015 untuk mengkaji kesan baja organik (MOL kangkung dan mikroorganisma efektif) dan penyimpanan tunas air terhadap pertumbuhan dan hasil cili padi (Capsicum frutsencs L.) di tanah BRIS. Baja kimia A dan B digunakan sebagai kawalan untuk faktor baja manakala tiada penyimpanan tunas air sebagai kawalan untuk faktor tunas air. Tiga rawatan baja dan tiga rawatan penyimpanan tunas air mempunyai tiga unit replikasi. Secara keseluruhannya, 27 replikasi telah digunakan dan disusun dalam reka bentuk blok rawak lengkap (RCBD). Sistem fertigasi digunakan untuk aplikasi pembajaan. Parameter berkaitan dengan pertumbuhan dan hasil direkod dan dianalisis dengan menggunakan ANAVA dua-hala. Berdasarkan hasil kajian, hanya ketinggian pokok (cm) memberi kesan perbezaan seerti manakala parameter yang lain menunjukkan tiada kesan perbezaan seerti. Keputusan pertumbuhan bagi cili padi menunjukkan rawatan S3 dan H3 (Baja kimia A dan B dengan 5 tunas air) memberi hasil paling tinggi dari segi ketinggian pokok iaitu 53.28 sm untuk rawatan S3 dan 46.67 sm untuk rawatan H3. Rawatan S2 dan H2 (mikroorgsnisma efektif dengan 3 tunas air) memberi hasil diameter batang tertinggi iaitu 7.66 mm dan 7.64 mm. Rawatan S3 dan H2 (Baja kimia A dan B dengan 3 tunas air) menghasilkan kanopi yang lebih lebar iaitu 36.33 sm dan 35.44 sm masing-masing. Bagi keputusan hasil cili padi, rawatan S3 dan H3 (Baja kimia A dan B dengan 5 tunas air) memberi hasil bilangan buah tertinggi(S3= 25 biji , H3 = 22 biji), jumlah hasil berat yang tertinggi (S3= 12.22 g/pokok, H3 = 10.91 g/pokok) dan jumlah berat kering buah tertinggi (S3 = 2.85 g, H3 = 2.59 g). S1 dan H1 (MOL kangkung dengan 0 tunas air) memberi keputusan terbaik dari segi kualiti fizikal buah iaitu berat basah (S1 = 0.28 g, H1 = 0.29 g), panjang buah (S1 = 1.37 sm, H1 = 1.41 sm), panjang tangkai (S1 = 1.28 sm, H1 = 1.36 sm), dan ukuran keliling (S1 = 0.99 cm, H1 = 1.04 cm). Rawatan S3H2 (baja kimia A dan B dengan 3 tunas air) memberi jumlah berat kering pokok tertinggi (S3 = 18.29 g, H2 = 17.84 g). Untuk sifat kimia tanah BRIS, rawatan S2H1 (mikroorganisma efektif dengan 0 tunas air) dan S2H3 (mikroorganisma efektif dengan 5 tunas air) memberi peningkatan tanah pH yang tertinggi (S2= 4.53, H1 and H3 = 4.47). Rawatan S1 dan H2 (MOL kangkung dengan 3 dan 5 tunas air) memberi jumlah nitrogen yang tertinggi kepada tanah (S1 =0.24 %, H2 dan H3 = 0.23 %). Rawatan S1 dan H3 juga memberi jumlah tertinggi untuk kandungan fosforus dalam tanah (S1 = 15.24 ppm, H3 = 17.43 ppm). Bahan organik tanah dijumpai paling tinggi hasil dari rawatan S3 dan H2 (Baja kimia A dan B dengan 3 tunas air) iaitu S3 = 1.26% dan H2 = 1.30 %. Berdasarkan kajian yang telah dijalankan, rawatan kombinasi baja kimia A dan B dengan 5 tunas air (S3H3) adalah disyorkan untuk penyelidikan masa depan. Ini kerana rawatan tersebut memberi hasil tertinggi untuk ketinggian pokok, hasil bilangan buah, jumlah hasil berat dan jumlah berat kering buah. Satu lagi rawatan yang disyorkan ialah rawatan MOL kangkung dengan 5 tunas air (S1H3). Rawatan tersebut berupaya untuk meningkatkan sifat tanah terutama pada peningkatan nutrisi nitrogen dan fosforus dalam tanah.

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LIST OF UNITS AND ABBREVIATION

AEM	Activated Effective Microorganism
ANOVA	Analysis of Variance
BRIS	Beach Ridges Interspersed with Swales
CEC	Cation Exchange Capacity
EM	Effective Microorganism
FPJ	Fermented Plant Juice
MOL	*Mikro Organisme Lokal*
UMS	Universiti Malaysia Sabah

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$$\frac{\text{Number of strongly germinating seeds} \times 100}{\text{Total number of seeds tested}} = \text{Percent germination}$$

CHAPTER 1

INTRODUCTION

1.1 Introduction

Bird's eye chili (*Capsicum frutescens*) is classified as one of the most pungent chilies in the world, next to the habanero (*Capsicum chinensis*). The pods of bird chili are small and elongated. They are normally referred to as 'cili padi' or 'cili api' or 'cili burung' interchangeably in Malaysia (Melor, 2003). Unlike fresh chilli (*C. annuum*), *cili padi* remains less in importance and is not grown on a large scale in this country. Locally, *cili padi* is normally grown as backyard crop until lately when the erstwhile steady negligible area of *cili padi* suddenly increased to 205 ha and the import values showed a sharp rise to about RM39 million, mainly from Thailand. The sudden increase in demand of *cili padi* appeared to coincide with the rise in demand for this commodity as raw material in sauce industry (Melor, 2003). Needless to say, the existing varieties/land races of *cili padi* are poor yielding and late maturing. With these inferior varieties, it is doubtful that the local *cili padi* production is able to meet the growing local demand for this commodity (Melor, 2003).

Changes in agriculture policies started around 1960 in Malaysia during the green revolution, inducing farmers to be fully dependent on chemical fertilizers for plant growth. However, nowadays, factors such as soil degradation, chemical pollution, the demand for safe food and more importantly, the rising cost of petroleum have forced farmers to seek other alternatives. Organic fertilizer is one of the ways that are used by the farmers in order to solve this problem. An organic fertilizers compose of anything biodegradable that is found in nature, which releases nutrients as it decays (van Haute, 2007).

Fermented bio-solution, such as Fermented Plant Juice is a carbon-based compound that increases the productivity of soil. Thus, it will directly increase the growth and yield quality of plants as well. The use of Fermented Plant Juice will be able to boost the plant resistance, provide faster yield and extend the shelf life of chili planting. Fresh vegetables and sugar are combined and fermented to take advantage of high levels of plant hormones in the cells of the plants, as well as, secondary/ supplemental nutrients, lactic acid producing bacteria and yeast. *Ipomoe aquatica*, one of worst weed around the world is suitable for the making of Fermented Plant Juice.

Effective microorganism is one of the organic fertilizers that has brought revolution in the environmental aesthetic value. Effective microorganism consists of a wide variety or multi-culture of effective, beneficial and non-pathogenic microorganisms coexisting together (EM Trading, 2000). Essentially, it is a combination of aerobic and anaerobic species commonly found in all ecosystems. Effective microorganism application includes sustainable agricultural, industrial, health (livestock, pets and human), odor control, waste management and recycling, environmental remediation and eco-friendly cleaning (EM Technology, 1998). The benefits of effective microorganism in increasing crop yields, improving crop quality and protecting plants from pests and disease have been demonstrated for a wide range of crops and soil condition.

Chili pepper is typically dripped or furrow irrigated. With drip irrigation, growers use either one or two drip lines per bed. Precision agriculture uses inputs most efficiently and judiciously to maximize productivity and profitability with minimum impact on soil and environment. Precision in terms of both time and quantity of inputs and agronomic practices, envisages a prospect, which can help in decreasing the cost of production and not having any adverse effect on soil and environmental health. Thus, the intent of precision farming is to match agricultural inputs and practices to localized conditions within a field to do the right thing in the right place, at the right time and in the right way (Abdul Hakkim, 2014).

The axillary shoot is a shoot that develops in the axil of a leaf of a plant. An axillary shoot develops from the nodes which then becomes a new stem. In chili cultivation, these axillary shoot make the plant grow short and bushy. Therefore, it has been a cultural practice for the farmers to remove the axillary shoot in order to allow taller growth. However, there are controversies arising from this practice as it causes the

chili plant to growth tall with only one main stem supporting the upper part. So often that the plants fall apart due to heavy burden and stacking is required. As a result, this practice has cause controversial for the chili grower as this task required more labor cost for the axillary shoot pruning and stacking installation. The manipulation of a number of axillary shoots being kept and removed are able to increase the yield of *C. frutescnes* (Yaseer Suhaimi *et al.*, 2013).

BRIS soil is a problematic soil available in Malaysia. Since these soils (BRIS) in the coastal region of Malay Peninsula are known to be successful in growing tobacco, with the combination of waste products like chicken manures and palm oil extracts etc. can improve on the soil fertility. Soil health is fundamental to profitable and sustainable production. Soils are one of the most important resources a farmer has (Bandyopadhyay, 2010). At Tuaran area, the BRIS soil areas are utilized by the local/ foreign farmers to plant various types of vegetables and crops such as loofah, brinjal, bird's eye chili, maize, watermelon, cucumber, okra and coconut (Appendix A). To improve on the soil fertility, plant wastes can be applied as mulching and as well manure when decomposed, while controlling the soil water loss (evaporation process). However plastic mulching can be used as well but with the introduction of fertigation to manage the nutrients and irrigation process (Ishaq *et al.*, 2013).

1.2 Justification

This study was conducted to achieve the aim for improving chili growth and yield using the organic fertilizers and manipulating the numbers of axillary shoots. Organic fertilizer are easily bio-degradable thus are able to conserve our environment and soil. Furthermore, organic fertilizers help in maintaining the soil structure and increasing its nutrient-holding capacity. Fermented plant juice and effective microorganism are types of organic fertilizer that are widely used for organic farming. The use of fermented plant juice and effective microorganism in chili production may significantly save the expensive cost of synthetic fertilizer which are commonly used. In fertigation system, synthetic fertilizer set A and B are used widely for planting various types of crops. However, the cost of synthetic fertilizer set A and B are expensive and might become a burden for the small scale farmer.

Chili farmers' often tends to remove all the axillary shoot of chili plants in order to allow greater vegetative growth. However, this action might indirectly reduce the yield of chili plants due to the lack of branches for flowering and fruiting. Moreover, the removing of axillary shoot reduce branches number thus makes the chili plants unstable because it only has one main stem to support all the upper part.

BRIS soil was used as the soil medium for planting chili. In general, BRIS soil is not suitable for crop planting. However, with aid of soil amendment, it is found out that BRIS soil is suitable for chili planting.

The modern technology of fertigation system is able to produce more consistent yield and make work more efficient for the local farmer. As far as we are concern, the sandy soil has limitation as it has low capacity of holding water and nutrient properties. The use of fertigation, which, it penetrate the water and fertilizers direct to the root zone may has led to better performance. The root zone of chili plant then can absorb the water and nutrient more efficiently.

1.3 Significance of the Study

The significance of this study is to increase the yield of bird's eye chili in order to meet the growing local demand for this commodity. Other than that, it will also help small scale farmers interested in fertigation system farming to save the cost in purchasing the costly synthetic fertilizer. The study of manipulating the number of axillary shoots will help improve in better yield of chili production. Moreover, by incorporating organic fertilizers, BRIS soil can gain its soil fertility and thus can be converted into vegetable cultivation land. This way, the farmers in coastal area are able to utilize their land without leaving it idle. With these area of BRIS soil being utilized, land area for vegetables cultivation can be increased and thus solving the food security issues in our country.

1.4 Objectives

The objectives of this study were:

i. To compare the effects of Fermented Plant Juice, Effective Microorganism with Fertilizer A and B on the growth and yield of bird's eye chili planted in BRIS soil.

ii. To determine the numbers of axillary shoots for better growth and yield of bird's eye chili planted in BRIS soil.

iii. To determine the nutrient contents of the BRIS soil series after the experiment.

1.5 Hypotheses

i. H_0 : There was no significance difference between the effects of Fermented Plant Juice and Effective Microorganism and those of synthetic fertilizer A and B on the performance (growth and yield) of bird's eye chilies grown in BRIS soil.

H_A : There was significance difference between the effects of Fermented Plant Juice and Effective Microorganism and those of synthetic fertilizer A and B on the performance (growth and yield) of bird's eye chilies grown in BRIS soil.

ii. H_0 : Different number of axillary shoots have no significant effects on the performance (growth and yield) of bird's eye chilies planted in BRIS soil.

H_A : Different number of axillary shoots have significant effects on the performance (growth and yield) of bird's eye chilies planted in BRIS soil.

iii. H_0 : There was no significance difference of the nutrient contents of the BRIS soil series after the experiment.

H_A : There was significance difference of the nutrient contents of the BRIS soil series after the experiment.

CHAPTER 2

LITERATURE REVIEW

2.1 *Capsicum frutescencs*

Pepper (*Capsicum frutescens* L.), is a perennial herb or shrub with many branches, belongs to the Solanaceae family. The unripe fruits are green or purple in color but turn red, orange, yellow or brown when ripe (Udoh *et al.*, 2005). Pepper is an important crop species in the world. It is one of the most important vegetables grown in Nigeria and other parts of the humid and semi-arid tropics (Aliyu, 2000). It is commonly used as condiments (Alabi, 2006) and the non-pungent species (*Capsicum annum*) are eaten raw as salad while the stronger flavoured types (chilies) are popular in all kinds of cookery as pungent species. It is also used in seasoning sauces and soup and other dishes. As a medicinal plant, chili is used in the prevention and treatment of cold and fever (Udoh *et al.*, 2005). Chili like other vegetables crops contributes nutritiously with nutrients that may be lacking in other food materials hence improve food intake (Grubben, 1997).

The climate conditions that are suitable for chili planting are annual rainfall between 1500-2000 mm, temperature range from 20 - 33 °C and up to 500 m above the sea level. Chili can grow well in various types of soils including marginal soils such as peat, BRIS and tin-tailings. It requires deep soil >25 cm for better root development. High organic matter content promotes better growth performance for chili. Good drainage is required. Chili is prone to pest attack and various diseases infestation when it is in high humidity condition. Last but not least, the suitable pH is 5.5 - 6.8 (Russo, 2012).

2.2 Nutrient Requirement for Chili Growth

The Solanaceous group of vegetables generally takes up large amounts of nutrients. The amount of nutrients they take up depends on the quantity of fruit and dry matter they produce, which in turn is influenced by a number of genetic and environmental variables. Chili and bell peppers need 3 to 3.5 kg N, 0.8 to 1 kg P, and 5 to 6 kg K (Hedge, 1998).

Fruit and fruiting parts in this group of vegetables contain 45 to 60% of total N, 50 to 60% of total P, and 55 to 70% of total K absorbed by the plants. The major proportions of the nutrients in fruit are absorbed from the time of flowering. The proportion of nutrients found in fruit declines with an increase in nutrient applications. A small proportion of the N and still smaller proportions of the P and K, found in fruit are translocated from the vegetative parts (Hedge, 1998).

The period of greatest nutrient requirements for N, P and K is from about ten days after flowering to just before the fruit begins to ripen. There is diurnal variation in nutrient absorption. A higher proportion of P tends to be absorbed during the night than N or K (Hedge, 1998).

2.3 Organic Fertilizers

Organic fertilizers are fertilizers derived from animal matter or vegetable matter. Organic fertilizers are carbon-based compounds that increase the productivity and growth quality of plants. It helps to improve the soil structure and contribute nutrients into the soil which increases the fertility of the soil available for the plants.

2.3.1 Fermented Plant Juice (FPJ)

Fermented Plant Juice is produced by the fermentation of plant leaves, grasses, thinned crop plants, axillary buds and/or young fruits and flowers (Jensen *et al.,* 2006). FPJ is used in solutions for seed and soil treatments and plant nutrition (Miller *et al.*, 2013). It consists of the young shoots of vigorously growing plants that are allowed to ferment for about approximately seven days with the use of brown sugar. The brown sugar draws the juices out of the plant material via osmosis and also serves as a food source for the microbes carrying out the fermentation process (Miller *et al.*, 2013). The weak alcohol

produced during fermentation extracts chlorophyll (soluble in ethanol) and other plant components (Miller *et al.*, 2013).

The most important requirement when selecting plants for making FPJ is to use the growing tips of plant species that are fast growers (Miller *et al.*, 2013). Vegetable shoots, which are better than lower leaves, should be harvested in the morning when the plants are in respiration mode (before sunrise) and not in photosynthetic mode (during daylight). The plant materials that can be used include water spinach, banana trunks and common purslane. The use of water spinach as the plant material promotes the growth. Water spinach also well known as *kangkung* is a kind of vegetable that typically grows in fresh water. It can also grow in highly moist soil. Its basic characteristic is it grows very fast, similar to the rapid growth of kelp in the seas. Axillary buds of *kangkung* will be good materials to obtain natural growth hormones such as gibberellins, auxins and cytokinins.

2.3.1.1 Chemical Composition in Fermented Plant Juice

Fermented Plant Juice is a fermented extract of a plant's sap and chlorophyll (Reddy, 2011). It is a rich enzyme solution full of microorganisms such as lactic acid bacteria and yeast that invigorates plants and animals (Reddy, 2011). Fresh vegetables and sugar are combined and fermented to take advantage of high levels of plant hormones in the cells of the plants as well as secondary/ supplemental nutrients, lactic acid producing bacteria and yeast.

2.3.2 Effective Microorganisms

Effective Microorganisms (EM), a culture of coexisting beneficial microorganism predominantly consisting of lactic acid bacteria, photosynthetic bacteria, yeast, fermenting fungi and actinomycetes cultured according to a specific method in liquid form (Renuka and Parameswari, 2012). Some of these micro-organisms are known to produce bioactive substances such as vitamins, hormones, enzymes, antioxidants and antibiotics that can directly or indirectly enhance plant growth and protection (Renuka and Parameswari, 2012). Effective Microorganisms has been used widely in nature and organic farming (Diver, 2001).

EM consists of a wide variety or multiculture of effective, beneficial and nonpathogenic microorganisms coexisting together (Renuka and Parameswari, 2012). Essentially it is a combination of aerobic and anaerobic species commonly found in all ecosystems (Renuka and Parameswari, 2012). Teuro higa reported in the 1970s that a combination of approximately 80 different microorganisms is capable of positively influencing decomposing organic matter such that it reverts into a life promoting process. The main species involved are normally the *Lactobacillus plantarum, L. casei* and *Streptoccus lactis* (lactic acid bacteria), *Rhodopseudomonas palustrus* and *Rhodobacter spaeroides*, (photosynthetic bacteria), *Saccharomyces cerevisiae* and *Candida utilis* (yeasts), *Streptomyces albus* and *S. griseus* (actinomycetes), and *Aspergillus oryzae*, *Penicillium* sp. and *Mucor hiemalis* (fermenting fungi) (Renuka and Parameswari, 2012).

2.3.2.1 Benefits of Effective Microorganisms

In crop production, EM serves as a root growth stimulant. EM 1 can improve the biological status of soils, increase soil organic matter, improve germination and root development, increase photosynthesis, and increase plant growth and yield. Other than that, it also encourages growth and maturity in plants and makes plants greener, inhibits the growth of harmful bacteria that carry diseases in the soil, controls the degree of soil moisturization and nutrient absorption, detoxifies residual herbicides and pesticides in the soil and act as insecticides, pesticides and repellent to pests like rats and plant hoppers (Renuka and Parameswari, 2012).

2.3.2.2 Effective Microorganism Activation

EM is available in a dormant state and requires activation before application (Namsivayam *et al.*, 2011). The activation of EM-1 is achieved by adding sugar cane molasses and water which allows the EM to start multiplying (Renuka and Parameswari, 2012). Activation involves the addition of 7 L of chlorine free water and 1.5 kg of brown sugar to 3 L of dormant EM one week prior to application (Namsivayam *et al.*, 2011). These ingredients were mixed together in either a 15 L or 20 L container and stored in area with minimal temperature fluctuations (Namsivayam *et al.*, 2011).

It is fermented to increase the quantity of EM by approximately 20 times. This activated EM or commonly known as AEM is used the same as regular EM. A major

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