EFFECTS OF LIGHT INTENSITY AND COCOPEAT AMENDMENTS ON THE GROWTH AND YIELD OF KULAI CHILLI (*Capsicum annuum L. var.* Kulai)

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ABSTRACT

Capsicum (*Capsicum annuum L. var.* Kulai) is becoming increasingly popular as a spice and food colourant. The objectives of this study were to determine the effect of different light intensity (50%, 70% and 100%) and different types of amended cocopeat (cocopeat only, cocopeat with EM, cocopeat with biochar and cocopeat with EM and biochar) on the growth and yield of Kulai Chilli (*Capsicum annuum L. var.* Kulai).The experiment was carried out at School of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan Campus, Sandakan, Sabah, Malaysia. The study was a field and laboratory study. A Random Complete Block Design (RCBD) was used with seven treatments replicated three times. Parameters were the leaf number, plant height (cm), fruit length (cm), number of matured fruits per plant, circumference of fruits (cm), wet weight of fruits (g), and dry weight of fruits (g). Probability test (Two-way ANOVA) was used to analyse the data collected at 0.05 significant level. There were significant effect of light intensity towards the growth, production and quality of Kulai Chilli. The growth of Kulai Chilli plant increased with the increase of light intensity. 100% light showed the highest mean for plant height (32.58 cm) and number of leaf per plant (31.00). The production of number of matured fruits per plant also showed the highest mean at 100% light intensity (2.92). The quality of fruits produced in terms of length of fruits (12.21 cm), circumference of fruits (5.42 cm), wet weight of fruits (15.79 g), and dry weight of fruits (3.16 g) also showed the highest mean at 100%. There were also significant effect of different types of amended cocopeat towards the growth, production and quality of Kulai Chilli. The best combination for amended cocopeat is cocopeat with EM and biochar which showed the highest mean for plant height (33.73 cm), number of leaf per plant (35.67), number of matured fruits per plant (2.22), length of fruits (10.34 cm), circumference of fruits (5.47 cm), wet weight of fruits (12.79 g), and dry weight of fruits (2.56 g). There was no significant interaction between light intensity and cocopeat amendments towards plant height, number of leaf per plant and number of matured fruits per plant. There were significant interaction between light intensity and cocopeat amendments towards the length of fruits, circumference of fruits, wet weight of fruits, and dry weight of fruits.

KESAN KEAMATAN CAHAYA DAN PERAPI SABUT KELAPA KEATAS PERTUMBUHAN DAN HASIL TANAMAN CILI KULAI
(*Capsicum annuum L. var.* Kulai)

ABSTRAK

Cili Kulai (Capsicum annuum L. var. Kulai) menjadi semakin popular sebagai rempah dan pewarna makanan. Objektif kajian ini adalah untuk menentukan kesan keamatan cahaya yang berbeza (50%, 70% dan 100%) dan jenis perapi sabut kelapa (cocopeat sahaja, cocopeat dengan EM, cocopeat dengan biochar dan cocopeat dengan EM dan biochar) terhadap pertumbuhan dan hasil Cili Kulai (Capsicum annuum L. var. Kulai). Eksperimen telah dijalankan di Sekolah Pertanian Lestari, Universiti Malaysia Sabah, Kampus Sandakan, Sandakan, Sabah, Malaysia. Kajian ini adalah satu kajian ladang dan kajian makmal. 'Random Complete Block Design' (RCBD) telah digunakan dengan tujuh rawatan dengan tiga replikasi. Parameter yang diukur adalah bilangan daun, ketinggian tumbuhan (cm), panjang buah-buahan (cm), bilangan buah-buahan matang setiap tumbuhan, lilitan buah-buahan (cm), berat basah buah-buahan (g), dan berat kering buah-buahan (g). Ujian kebarangkalian (Two-way ANOVA) telah digunakan untuk menganalisis data yang dikumpul pada aras kesignifikanan 0.05. Terdapat kesan ketara keamatan cahaya terhadap pertumbuhan, pengeluaran dan kualiti Cili Kulai. Pertumbuhan Cili Kulai meningkat dengan peningkatan keamatan cahaya. 100% cahaya menunjukkan min tertinggi bagi ketinggian tumbuhan (32.58 cm) dan bilangan daun sepokok (31.00). Pengeluaran bilangan buah-buahan matang setiap tumbuhan juga menunjukkan min tertinggi pada keamatan cahaya 100% (2.92). Kualiti buah-buahan yang dihasilkan dari segi panjang buah-buahan (12.21 cm), lilitan buah-buahan (5.42 cm), berat basah buah-buahan (15.79 g), dan berat kering buah-buahan (3.16 g) juga menunjukkan min tertinggi pada 100% . Terdapat juga kesan yang ketara bagi jenis perapi sabut kelapa terhadap pertumbuhan, pengeluaran dan kualiti Cili Kulai. Kombinasi yang terbaik bagi perapi sabut kelapa adalah sabut kelapa dengan EM dan biochar yang menunjukkan min tertinggi bagi ketinggian tumbuhan (33.73 cm), bilangan daun sepokok (35.67), bilangan buah-buahan matang sepokok (2.22), panjang buah-buahan (10.34 cm), lilitan buah-buahan (5.47 cm), berat basah buah-buahan (12.79 g), dan berat kering buah-buahan (2.56 g). Tiada interaksi yang ketara antara keamatan cahaya dan perapi sabut kelapa terhadap ketinggian tumbuhan, bilangan daun setiap tumbuhan dan bilangan buah-buahan matang sepokok. Terdapat interaksi yang ketara antara keamatan cahaya dan perapi sabut kelapa terhadap panjang buah-buahan, lilitan buah-buahan, berat basah buah-buahan, dan berat kering buah-buahan.

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LIST OF SYMBOLS, UNITS AND ABBREVIATIONS

g	Gram
mg	Milligram
µg	Microgram
N_2O	Nitrogen oxide
CO_2	Carbon dioxide
pH	Potential of hydrogen
EM	Effective microorganism
mm	Millimeter
^0C	Degree celcius
%	Percentage
M	Meter
"	Feet
kg	Kilogram
L	Litre
cm	Centimeter
m	Meter
kg ha^{-1}	Kilogram per hactare
ANOVA	Analysis of variance
UMS	Universiti Malaysia Sabah

CHAPTER 1

INTRODUCTION

1.1 Introduction

Capsicum annuum L. var. Kulai or Kulai Chilli is a Malaysian variety. The plant height is 70-80 cm, fruit length is 10-15 cm and fruit weight is 7-10 gm. The taste of the chilli is very spicy. The plants are moderately resistant to anthracnose and virus and also resistant to Bacterial Leaf Blight. Kulai chilli is becoming increasingly popular as a spice and food colorant. It is a crop that requires sunlight at specific stages of growth as this affects not only the yield but most importantly the quality of the crop. Yield of chilli has been found to increase with relative increase in light intensity. Chilli plants are well known as light-loving plants which need light in sufficient amount of sunlight to produce fruits. This also will affect the uniformity of the fruit ripening for the plants. (Jabatan Pertanian Perak, 2010)

Temperature is acknowledged as the major environmental factor influencing fruit set of chilli (Aloni et al., 1991; Wien et al., 1992). Reports clearly indicated that low temperature is detrimental to pollination and fertilization (Noto, 1989; Rylski and Spigelman, 1982; Rylski, 1974), leading to the formation of parthenocarpic fruits that tend to abscise easily. Temperature is mainly influence by the amount of sunlight that reaches the planting area. Temperature, relative humidity, sunshine hours and wind speed are important factors influencing water loss from the soil surface and from the crop through transpiration (*Mwendera, 2000*).

Medium is also one of the important factors that did affect the uniformity of the fruit ripening. The medium did affect the water and nutrient supply for the plants to survive. The ratio and types of amended cocopeat was important for the plants to ensure the optimum supply and uptake of water and nutrient and also for the disease control. The amount of organic materials and beneficial microorganism in the medium was important for determining the growth and productivity of Kulai Chilli. The study of nutrient will help the farmers in determining the suitable medium for the chilli plant to increase growth rate and produce fruits uniformly.

1.2 Justification

Chilli (*Capsicum annuum L. var.* Kulai) is becoming increasingly popular as a spice and food colorant. The supply for chilli in Malaysia is still not enough that we still have to import the product from other countries. One of the problems of the chilli production in Malaysia is the uniformity of the fruit ripening. This will affect the amount of fruits produce per harvest and also time consumption for every harvesting session. This will also increase the demand and the production is relatively low. Chilli plants are crops that require sunlight at specific stages of growth as this affects not only the yield but most importantly the quality of the crop.

In nature, the two things that help chilli peppers ripen are a constant warm temperature and long sunny days (lot of light). The uniformity of the fruits produced by the plants is mainly depends on the amount of light intensity that the plants receive during the fruiting stage. By determining the optimum amount of light intensity requirement for the chilli plants to produce mature fruits uniformly for every plant, this will increase the production of chilli and lower the cost and the lost during the post-harvest process. Medium is also one of the important factors that will affect the uniformity of the fruit ripening. The medium will affect the water and nutrient supply for the plants to survive. The ratio and types of medium is important for the plants to ensure the optimum supply and uptake of water and nutrient and also for the disease control. The study of nutrient will help in determining the suitable medium for the chilli plant to increase growth rate and produce fruits uniformly.

1.3 Objectives

Objectives of this study were to determine the effect of different light intensity on the growth and yield of Kulai Chilli (*Capsicum annuum L. var.* Kulai) and to determine the effect of different types of amended cocopeat on the growth and yield of Kulai Chilli (*Capsicum annuum L. var.* Kulai).

1.4 Hypothesis

H_0 = The growth and yield of Kulai Chilli (*Capsicum annuum L. var.* Kulai) is the same by applying different light intensity and different types of amended cocopeat.

H_1 = The growth and yield of Kulai Chilli (*Capsicum annuum L. var.* Kulai) is different by applying different light intensity and different types of amended cocopeat.

CHAPTER 2

LITERATURE REVIEW

2.1 Kulai Chilli (Capsicum annuum L. Var. Kulai)

It is estimated that 30,000 tonnes and 700 tonnes of capsicum is annually produced in the world trade, with Spain, Hungary and Morocco being exporters mainly to Europe (ASTA, 1995). Regionally, South Africa and Zimbabwe are major producers (Anonymous, 1997). Capsicum is a spice and is also famous for its use as an orange-red food colourant, in addition to which it also has medicinal value in remedy of asthma, colic, arthritis and other ailments (Anonymous, 2004). According to Wierenga (1983), the pigments in capsicum are a mixture of carotenoids in which capsanthin and capsorubin dominate.

Chili (Capsicum annum) belongs to the family Solanaceae to which some other important vegetables such as potato, tomato, brinjal, etc. belong. It is a very popular vegetable, not only in India but allover the world. The chili includes a large number of horticultural varieties. The fruit varies in size from 1-20 cm in length from thin, long to conical and thick fleshed blocky shapes. It includes both pungent and non-pungent varieties but most of the varieties grown in our country are pungent varying from very pungent to mild-pungency. (K.T. Chandy, 2009)

Table 2.1 Nutrient value of Kulai Chilli for every 100 g.

Element	Amount
Protein (g)	2.8
Carbohydrate (g)	9.5
Fat (g)	0.7
Fiber (g)	0
Calcium (g)	15.0
Iron (g)	1.8
Phosphorus (g)	80.0
Kalium (g)	0
Sodium (g)	0
Beta carotene (ug)	2,730.0
Vitamin B1 (mg)	0.2
Vitamin B2 (mg)	0.1
Vitamin C (mg)	175.5
Niacin (mg)	0.7

Source: MARDI (1990)

2.2 Effect of light intensity on plant growth

Light is important factor for the growth and development of chilli plant. According to Das (1997), light is an integral part of the photosynthetic reaction as it provides the energy for the combination of carbon dioxide and water in the formation of manufactured compounds. The greater the amount of light available, the greater the rate of gross photosynthesis and the amount of carbohydrates. Light plays an important role in transpiration, dormancy and germination of chilli plants. Total quantity of light that a plant receives during illumination has a direct impact on photosynthesis, plant growth and yield. The impact can be measured in terms of plant growth, plant reproduction and quality of products. Plants have an optimal intensity of light (Neri et al.).

2.3 Biochar

Biochar is a solid material obtained from the carbonisation of biomass. Biochar may be added to soils with the intention to improve soil functions and to reduce emissions from biomass that would otherwise naturally degrade to greenhouse gases. Biochar also has appreciable carbon sequestration value. Biochar also improves water quality and quantity by increasing soil retention of nutrients and agrochemicals for plant and crop utilization. More nutrients stay in the soil instead of leaching into groundwater and causing pollution. Pre-Columbian Amazonians are believed to have used biochar to enhance soil productivity. They produced it by smoldering agricultural waste (i.e., covering burning biomass with soil) (Solomon et al., 2007) in pits or trenches. The term "biochar" is charcoal used as a soil improvement (Peter, 2009). These positive qualities are dependent on the properties of the biochar and may depend on regional conditions including soil type, soil condition (depleted or healthy), temperature, and humidity. Modest additions of biochar to soil reduce nitrous oxide N_2O emissions by up to 80% and eliminate methane emissions, which are both more potent greenhouse gases than CO_2 (Lehmann, 2007).

2.4 Cocopeat

Coco peat (cocopeat), also known as coir pith, coir fibre pith, coir dust, or simply coir, is made from coconut husks, which are byproducts of other industries that use coconuts. Coir waste from coir fiber industries is washed, heat-treated, screened and graded before being processed into coco peat products of various granularity and denseness, which are then used for horticultural and agricultural applications and as industrial absorbent. Usually shipped in the form of compressed bales, briquettes, slabs or discs, the end user usually expands and aerates the compressed coco peat by the addition of water. A single kilogram of coco peat will expand to 15 litres of moist coco peat. Trichoderma is a naturally occurring fungus in cocopeat, it works in symbiosis with plant roots to protect them from pathogenic fungi such as pythium. It is not present in sterilized coco peat. Trichoderma is also destroyed by hydrogen peroxide. Coco peat is used as a soil additive. Due to low levels of nutrients in its composition, coco peat is usually not the sole component in the medium used to grow plants. When plants are grown exclusively in coco peat, it is important to add nutrients according to the specific plants' needs. free of bacteria and most fungal spores, and is sustainably produced without the environmental damage caused by peat mining. Coco peat is mixed with sand, compost and fertilizer to make good quality potting soil. Coco peat generally has acidity in the range of pH - 5.5 to 6.5. It is a little on the acidic side for some plants, but many popular plants can tolerate this pH range. Coco peat can be reused up to three times with little loss of yield. Coco peat from diseased plants should not be reused. (MAF Biosecurity New Zealand, 2009).

2.5 Effective Microorganism

Effective Microorganisms or EM is a mixed culture of beneficial microorganisms (primarily photosynthetic and lactic acid bacteria, yeast, actinomycetes, fermenting fungi) that can be applied as an inoculant to increase the microbial diversity of soils. This in turn, can improve soil quality and health, which enhances the growth, yield, and quality of crops. The concept of inoculating soils and plants with beneficial microorganisms to create a more favorable microbiological environment for plant growth has been discussed for decades by agricultural scientists. However, the technology behind the concept of Effective Microorganisms and it is practical application was developed by Professor Teruo Higa at the University of the Ryukyus in Okinawa, Japan. Professor Higa has devoted much of his scientific career to isolating and selecting different microorganisms for developing beneficial effects on soils and plants. He has found microorganisms that can coexist in mixed cultures and are physiologically compatible with one another. When these cultures are introduced into the natural environment, their individual beneficial effects are greatly magnified in a synergistic fashion. EM cultures do not contain any genetically modified microorganisms. EM is made up of mixed cultures of microbial species that are found in natural environments worldwide. Benefits of EM are promotes germination, flowering, fruiting and ripening in plants, improves physical, chemical and biological environments of the soil and suppresses soil borne pathogens and pests, enhances the photosynthetic capacity of crops, ensures better germination and plant establishment and increases the efficacy of organic matter as fertilizers. (Mayer et al., 2010)

CHAPTER 3

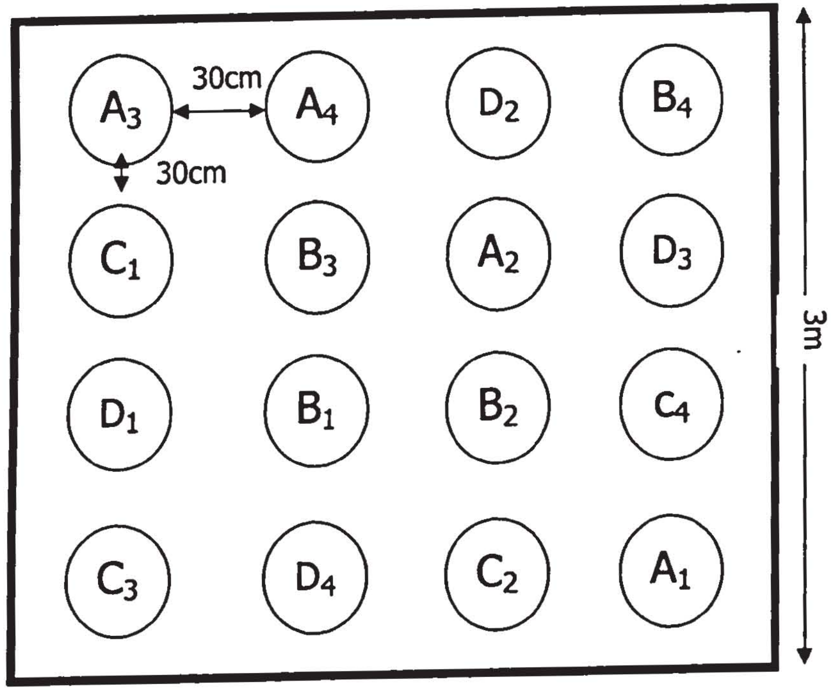
METHODOLOGY

3.1 Location and duration of study

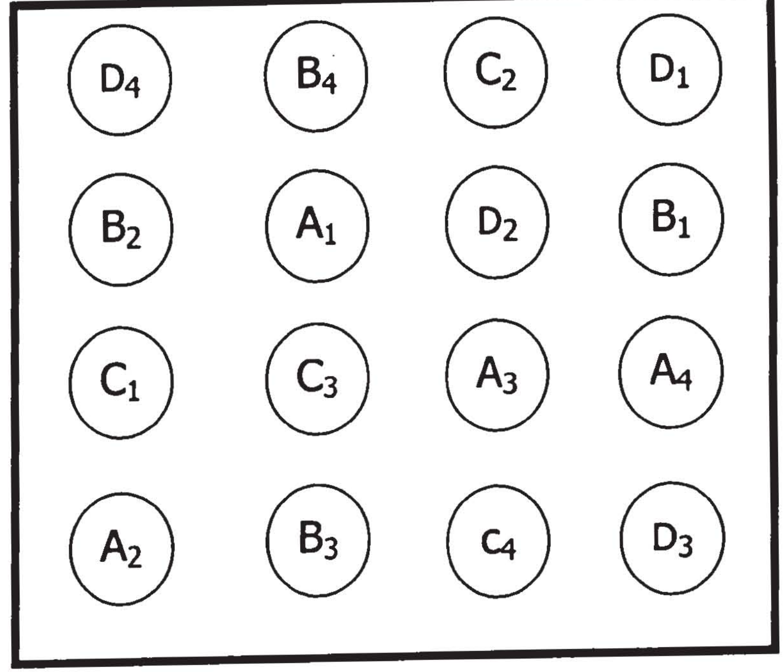
The experiment was carried out at School of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan Campus, Sandakan, Sabah, Malaysia. Sandakan has a tropical rainforest climate. The city sees heavy precipitation throughout the year, with the heaviest precipitation seen from November through January. Temperatures are relatively constant throughout the course of the year with average high temperatures around 31^0C and average low temperatures of 24^0C. Sandakan averages approximately 3100 mm of precipitation per year. The parent materials of the soil in Sandakan consist mainly of mudstone and minor sandstone, sandstone and minor mudstone, limestone and miscellaneous rocks. The experiment was conducted from April until July 2012. The period was 4 months for the field study. Another 1 month was for laboratory study and 1 month for data analysis.

3.2 Experimental design

The study was a field and laboratory study. A Random Complete Block Design (RCBD) was used with twelve treatments replicated three times. The shades were act as blocks for the experiment. The polybags within each block were randomly placed. Each block was consisting of four different types of amended cocopeat that replicated three times for each type of amended cocopeat.



20% shade



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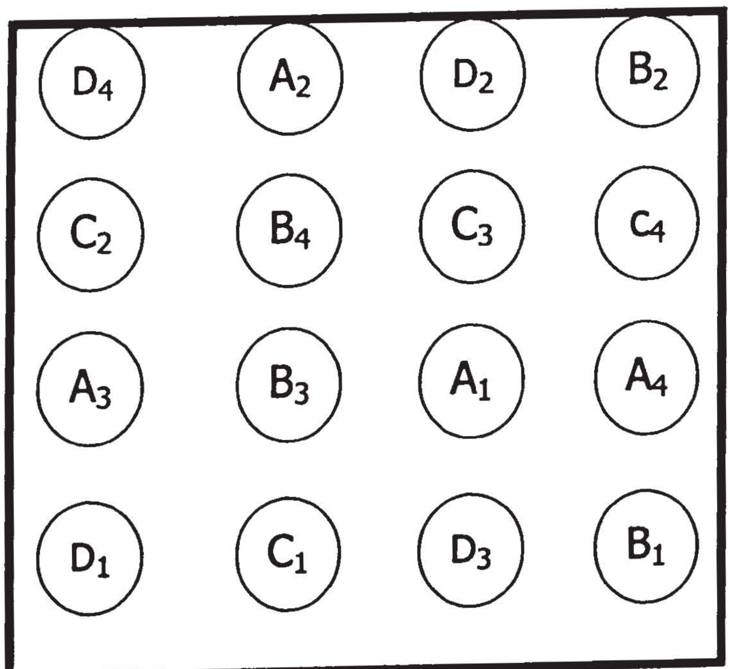

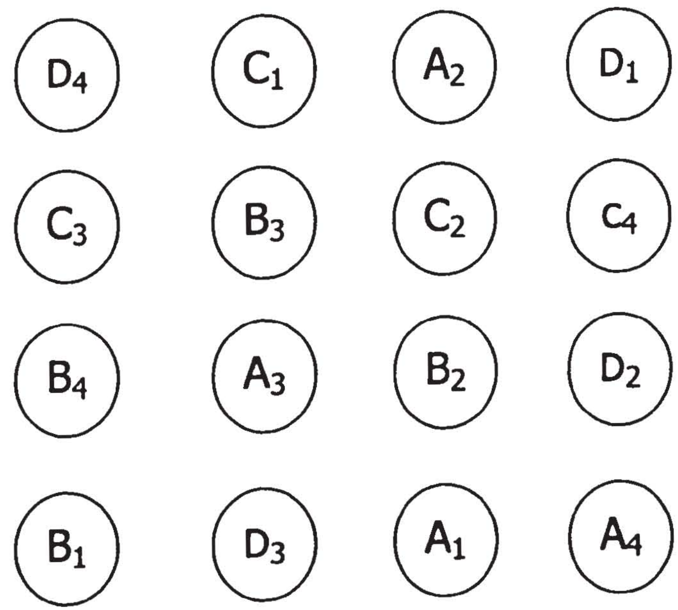

3.3 Treatments

There were two factors that were investigated which were light intensity and amended cocopeat towards the growth and productivity of Kulai Chilli (Capsicum annuum L. Var. Kulai). The treatments are shown in the table below :

Table 3.1 Treatments

Treatments		
Light intensity	**Medium**	**Replication**
100%	100% cocopeat	3
	Cocopeat + EM	3
	Cocopeat + Biochar	3
	Cocopeat + EM + Biochar	3
70%	100% cocopeat	3
	Cocopeat + EM	3
	Cocopeat + Biochar	3
	Cocopeat + EM + Biochar	3
50%	100% cocopeat	3
	Cocopeat + EM	3
	Cocopeat + Biochar	3
	Cocopeat + EM + Biochar	3
Total		**36**

3.4 Procedures

3.4.1 Shade house preparation

Shade houses were prepared. Three different shade houses were prepared with different type of shade which has different light penetration percentage. The light intensity percentages were 70%, 50% and 100% which was the one outdoor area which was fully exposed to the sunlight. The area of the shade houses is 3m x 3m each and the height is 2m. Twelve polybags were placed under each of the shades (refer to appendix B).

3.4.2 Seedlings preparation

Chilli seedlings were prepared before transplant into the polybags. Before germination process, the chilli seeds were soaked in water for 6 to 8 hours. Only the seeds that sink in the solution were chosen to be germinated. The seeds are then were soaked in Thiram for a few minutes. The germination tray was filled with cocopeat as a germination medium. The seeds are then were germinated in the germination tray with one seed per cup. The seeds were watered with fungicide for the first watering. The next watering after the seeds germinated was done by mixing the water with fertilizer (chicken dung). The chilli seedlings were transplanted at the 14-leaf stage or 5 to 6 weeks germinated seedlings.

3.4.3 Medium preparation

White UV Polybag (15"X17") were used. Then, the polybags were filled with different types of amended cocopeat. Each polybag was filled with 2 to 2.5 kg of medium. The types of amended cocopeat that were prepared as follows :

Table 3.2 Amended cocopeat specification

Label	Amended cocopeat
A	100% cocopeat
B	Cocopeat + EM
C	Cocopeat + Biochar
D	Cocopeat + EM + Biochar

The medium was filled in the polybags. The weight of the medium filled polybags was 2 to 2.5kg. The ratio of cocopeat to biochar is 3:1 for medium C and D. The Effective Microorganism (EM) which is Bokashi were applied to medium B and D in liquid form. The amount of Bokashi that was applied is 33g per polybags.

3.4.4 Transplanting

The chilli seedlings were transplanted at the 14-leaf stage or 5 to 6 weeks germinated seedlings. The seedlings were transplanted by loosing and make holes for the seedlings (more or less the same size with the size of the cup of the germination tray, the depth was more than the height of the germination tray). The seedlings were transferred by pushing the bottom of the germination tray slightly to loosen the seedlings to be transferred. Then, the base of the seedlings was hold and pulled out slowly. The seedlings were placed into holes that had been made before. The hole was filled with the remaining medium. Lastly, the side of the seedlings were pressed slowly by hand.

3.4.5 Maintenance

i. Fertilizer application

The chilli plants were fertilized using organic fertilizer (chicken dung) 1.6:1.8:2.0 with the same quantity for all the treatments. The fertilizer was applied once every two weeks.

ii. Watering

Every plant was watered with the same water volume which is 3.5L per day. The plants were watered two times per day which is in the morning and in the evening. This was done by manual watering technique using watering can. The volume for each time of watering was 1.75L. This will also depend on the weather. The plants were not watered if it is raining during the watering time.

iii. Pest and disease control

The pest and disease was controlled by applying pesticide Malathion. The top and underside of leaves was sprayed because the pest will lay eggs and form nest under the leaves. Pesticide was only applied if needed.

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