# Efficacy of Coco Peat Mulch treated with Aqueous Curry Leaves Extract on control Woody Borreria (*Hedyotis verticillata* (L.) Lam.) at the Vegetative Stage

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**F15A0174**

**A thesis submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Agrotechnology) with Honours**

**Faculty of Agro Based Industry**
**Universiti Malaysia Kelantan**

**2019**

## DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

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I certify that the report of this final year project entitled "Efficacy of Coco Peat Mulch treated with Aqueous Curry Leaves Extract on control Woody Borreria (*Hedyotis verticillata* (L.) Lam.) at the Vegetative Stage" by Nurshamimi Binti Zaini, matric number F15A0174 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Agriculture Technology) with Honours,

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## ACKNOWLEDGEMENT

First, I would like to express my deepest gratitude and sincere thanks to my supervisor, Dr Norhafizah Md Zain, for her encouragement, assistance and guidance to complete this final year project successfully. Besides, I also would like to express my gratitude to my co-supervisor Dr. Ch'ng Huck Ywih for his guidance, ideas and opinion especially during the process of completing my proposal. In addition, I would like to express my thanks to all technical staffs of University Malaysia Kelantan for their assistance during the practical and experiment assessment. My sincere gratitude is extended to my family for their financial support in complete my final year project. Not to be forgotten to my friends for their invaluable help and cooperation during practical and writing times. Lastly, I would like to appreciate whoever contributed for this project.

**Efficacy of Coco Peat Mulch treated with Aqueous Curry Leaves Extract on control Woody Borreria (*Hedyotis verticillata* (L.) Lam.) at the Vegetative Stage**

## ABSTRACT

Introduction of new weed management strategy for plantation in Malaysia is crucial since the present weed control methods are less effective and highly herbicide dependent, thus leading to development of herbicide resistance in weeds as well as environmental and human health concerns. The present study was undertaken to investigate the efficacy of coco peat mulch treated with aqueous curry leaves extract on control woody borreria (*Hedyotis verticillata*) under nursery condition. The bioassay weed species were treated with different application rate of coco peat mulch (4 t $ha^{-1}$ and 8 t $ha^{-1}$) and aqueous curry leaves extract (20% and 40%). There were 6 treatment application were used in this study. Coco peat mulch treated with aqueous curry leaves extract exhibited markedly variable herbicidal activites against the target weed species. The mean value (% of control) of the weed growth (except the root length) significantly inhibited with an increase of coco peat mulch rate and aqueous curry leaves extract from 4 t $ha^{-1}$ to 8 t $ha^{-1}$ to 20% and 40% respectively. The weed emergence was strongly inhibited by 90% when the bioassay species were treated at 8 t $ha^{-1}$ coco peat mulch + 40% aqueous curry leaves extract (**T6**). Similar trend of inhibition on shoot fresh weight and root length also was observed at this application rate. The shoot fresh weight and the root length of *H. verticillata* were reduced by 80-90% respectively. There was no significant inhibition on the weed emergence, shoot fresh weight and root length at application rate of 8 t $ha^{-1}$ coco peat mulch + 20% aqueous curry leaves extract (**T5**). This result suggested that coco peat mulch and aqueous curry leaves extract have synergistic effect in suppressed the *Hedyotis verticillata*.

Keyword: Curry leaves, inhibition, coco peat mulch, *Hedyotis verticillata*

**Keberkesanan Sungkap Sabut Kelapa yang dirawat dengan Ekstrak Akueus Daun Kari untuk mengawal Woody Borreria (*Hedyotis verticillata*(L.) Lam.) pada Peringkat Vegetatif**

## ABSTRAK

Pengenalan strategi pengurusan rumpai baharu untuk ladang di Malaysia adalah penting memandangkan kaedah kawalan rumpai sedia ada kurang berkesan dan sangat bergantung kepada racun rumpai, sekaligus membawa kepada pembangunan daya tahun racun rumpai ke atas rumpai serta kebimbangan kepada alam sekitar dan kesihatan manusia. Kajian ini dijalankan untuk mengkaji keberkesanan sungkup sabut kelapa yang dirawat dengan ekstrak akueus daun kari untuk mengawal woody borreria (*Hedyotis verticillata*) pada peringkat vegetatif di bawah keadaan nurseri. Spesies rumpai bioassai telah dirawat dengan kadar aplikasi yang berbeza dari sungkup sabut kelapa (4 t $ha^{-1}$ dan 8 t $ha^{-1}$) dan ekstrak akueus daun kari (20% dan 40%). Terdapat 6 jenis perawatan yang diaplikasikan di dalam kajian ini. Sungkup sabut kelapa yang dirawat dengan ekstrak akueus daun kari dengan jelas mempamerkan aktiviti herbisid yang berbeza terhadap spesies rumpai yang disasarkan. Nilai purata (% kawalan) bagi pertumbuhan rumpai (kecuali panjang akar) direncatkan dengan signifikan seiring peningkatan kadar sungkup sabut kelapa dan ekstrak akueus daun kari dari 4 t $ha^{-1}$ hingga 8 t $ha^{-1}$ dan 20% hingga 40%. Pertumbuhan rumpai direncatkan hampir 90% apabila spesies bioassai dirawat pada 8 t $ha^{-1}$ sungkup sabut kelapa + 40% ekstrak akueus daun kari (**T6**). Corak perencatan yang sama dapat diperhatikan pada berat segar pucuk dan panjang akar pada kadar aplikasi ini. Berat segar pucuk dan panjang akar *H. verticillata* dikurangkan sebanyak 80-90%. Tiada perencatan yang ketara pada kemunculan rumpai, berat segar pucuk dan panjang akar pada kadar aplikasi 8 t $ha^{-1}$ sungkup sabut kelapa + 20% ekstrak akueus daun kari (**T5**). Hasil kajian ini mencadangkan bahawa sungkup sabut kelapa dan ekstrak akueus daun kari mempunyai kesan bersinergi dalam merencatkan spesies rumpai yang disasarkan.

Kata kunci: Daun kari, perencatan, sabut kelapa, *Hedyotis verticillata*

## TABLE OF CONTENT

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF SYMBOLS

| | | |
|---|---|---|
| g | - | Gram |
| mg | - | Milligram |
| µg | - | Microgram |
| w/v | - | Weight per volume |
| % | - | Percent |
| g/L | - | Gram per liter |
| g $mL^{-1}$ | - | Gram per milliliter |
| t $ha^{-1}$ | - | Tan per hectare |
| cm | - | Centimeter |
| $cm^2$ | - | Centimeter square |
| ml | - | Milliliter |
| °C | - | Degree Celsius |

## LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| ANOVA | - | Analysis of variance |
| B.C | - | Before century |
| SPSS | - | Statistical Product and Service Solution |
| HSD | - | Honest Significance Different |
| Df | - | Degree of freedom |
| F | - | F-test |
| Sig | - | Significant |
| SD | - | Standard Deviation |
| ° N | - | North |
| ° E | - | East |
| Rpm | - | Revolution per minute |
| PDA | - | Potato Dextrose Agar |
| NA | - | Nutrient Agar |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of research

Weeds infestations are the oldest crisis and pose a major threat to the productivity in agriculture and horticulture crop since about 10000 B.C. and have represented one of the major restrictive factors in profitable crop production (Gaddeyya & Ratnakumar, 2014). Weed infestation become a severe problem in crop field where it is frequently hard to control and disturb schedule plantation management system such as fertilizer application and harvesting the crop (Dilipkumar et al.2017). Weeds that present in crop field tend to compete with crop plants for light, moisture and other vital nutrients which cause decrease in yield and quality of crops. In Malaysia, the plantation mostly encompass on oil palm and rubber. During the immature phase of plantation crops, weed management were carried out up to 15-20 times during the 3 years immature period for oil palm and 19-25 times during the 5 year period for rubber. Therefore, a lot of the annual budget were spend on weeding in order to reduced the weed competition on these crops (Lim, 1997).

Abundant of plant species are considered as weeds in agronomic cropping systems due to their destructive effects in agricultural fields (Gaddeyya & Ratnakumar, 2014)

for example such as *Hedyotis verticillata* Lam or generally known as woody borreria is a types of creeping perennial weeds that belong to *Rubiaceae* family. This weed was first discovered being evolved around the oil palm area in Malaysia on 2005 (Chuah, 2014). It is a type of broadleaved weeds with dark green leaves that being considered as one of the troublesome weeds that usually can be found on the farm area such as oil palm and rubber field. This is because, once the *H. verticillata* weed is matures, the stem will turn into woody and hard to managed (Chuah et al. 2005). Therefore, it will become a trouble to the farmer in order to control and manage the weed problem.

Later on, according to Chuah and Ismail (2010), *H. verticillata* weed were reported as a herbicide resistance weed toward a few types of herbicides in the market such as paraquat, glyphosate and metsulfuron in numerous states in Malaysia such as Kedah, Perak, Kelantan, Pahang, Johor and Sarawak. Herbicide resistance weed is a type a weed species that consist of genetic composition that permits them to endure a meticulous herbicide application. When the herbicide was applied on the crop filed, the susceptible biotype would died. However, there a few resistant biotype would survived, maturde and developed the seed. When the similar type of herbicide was being applied constantly plus resistance biotype were reproduce, the population of of weed that were resistance will rises.

Therefore, the introduction of weed management strategy on the crop field is vital as the existing weed control practice nowadays are less efficient and extremely depend on the chemical herbicide application. This crisis have a propensity to lead into the future effect of the chemical in the herbicide on the human health and environment plus the development of herbicide resistance in weed (Dilipkumar et al.2017). Consequently, the application of mulching helpful in controlled and reduced the number of weeds development. Mulching is any material that is spread or laid over the surface of the soil as a covering. It assists in

preventing the growth of the weeds and sustaining the consistent level of moisture in the soil (Vanderlinden, 2017). There are many different types of mulching available to the garden and crop such as coco peat, chipped bark, chopped leaves, straw and compost. Coco peat mulching is a natural by-product obtained within the coconut shell after the extraction of fiber from the coconut husk. It is firmly packed blocked which expand when exposed to water. It able to hold water and drains well besides by covering all the bare soil with this mulch, nearly all the weeds will never able to come into contact with the soil (Vanderlinden, 2017).

Futhermore, the application of the plant extract as an alternative on managing and controlling the weed emergence on the crop field assist in reducing the dependence on the chemical herbicide. Plant extract refers to utilize of suitable solvent from plant as raw material extraction or processing of substances that can be used to improve health or other purposes (Yvon, 2012). There are many types of plants extract that being used for a research. For example, such as aqueous curry leaves extract. This extract is known as allelopathic plants extract. This is because, it tend to release a chemical or known as allelochemical from the plants that effect to another plant in term of growth and biological system (Ferguson, Rathinasabapathi, & Chase, 2003). According to the study conducted by Indracanti & Dash, (2015) , the application of the aqueous curry leaves extract on mixed culture of two rice cultivars which is a basmati (cv. Kasturi) and a non-basmati (cv. Pant Dhan11) tend to give inhibitory effect on dry matter in both cultivar. The root and shoot dry weight ratio tend to decreased significantly in all treatments after the application of the aqueous curry leaves extract for both cultivars. These results show that the presence of the allelochemical in the extract tend to give negative effect on the shoot and root dry weight.

## 1.2 Problem statement

Generally, the weed control strategies that being implemented by the farmers are cultural, physical, chemical and biological. Meanwhile, a chemical herbicide application is one of the most effective methods to control the weeds species. Nevertheless, nowadays this application is becoming extra and costly and also contribute to environmental pollution. Furthermore, continuous application of chemical herbicides can result the weed population tend to become tolerant or resistance toward the herbicide (Gaddeyya & Kumar, 2014). Every techniques of weed control have its own benefits and weakness. Thus a new weed control strategy is needed to overcome these problems.

For examples such as the non- chemical control by the application of mulching on the crop field provides abundance of benefits such as conserving the soil moisture, increase the organic matter content, sustaining the soil fertility plus inhibiting the weed emergence (Dilipkumar et al.2017). This technique assist in reducing the dependence on the chemical herbicide to supresss the weeds on the crop field. The weed suppression by mulching are due to the action of phytotoxic compound in the mulching (Verdu & Mas, 2007). According to Jodaugiene et al. (2012) , it is stated that the main benefit of mulch application is nutrient contribution. This is because, organic mulch tend to supplied and enhanced the amount of P and K in the soil. However, the release of the nutrients compoud from organic mulch are gradually and required time as it slowly decomposed. Besides, the particle size of the plant residue also affects its decomposition (Halde & Martin, 2015). Consequently, the application of the aqueous curry leaves extract with the mulching tend to accelerated and improved the inhibitory effect of the mulching on the weed as the curry leaves extract also consist of allelopathic effect that tends to assist in controlling the weeds species. Therefore, the

combination of both mulching and curry leaves extract will double the inhibitory effect on the weed species.

### 1.3 Hypothesis

H0: Coco peat mulch treated with aqueous curry leaves extract cannot improved the inhibition of the woody borreria (*Hedyotis verticillata).*

H1: Coco peat mulch treated with aqueous curry leaves extract can improved the inhibition of the woody borreria (*Hedyotis verticillata).*

### 1.4 Objective

The objective of this study is to:

1. Determine the effect of the coco peat mulch treated with aqueous curry leaves extract on the growth performance of woody borreria (*Hedyotis verticillata)*.

### 1.5 Scope of study

This study was conducted in order to determine the effect of the coco peat mulch treated with aqueous curry leaves extract on the growth performance of *H. verticillata* under nursery condition on weed emergence, shoot fresh weight and root length. This study including the preparation of series of aqueous curry leaves extract concentration to be treated with coco peat mulching on *H. verticillata.* Different rates of coco peat mulch and aqueous curry leaves extract concentrations treatment were used to calculate the inhibition level on seed germination and growth of target weed species.

### 1.6 Significance of study

The application of chemical herbicide is one of the most effective methods on controlling the weeds growth. However, the continuous applications of the chemical herbicide tend to make the weeds species resistance toward the herbicide. This resistance of the weeds will expands herbicide costs for farmers and will result a huge amount of herbicide accumulation in the soil. In addition, although herbicides are aimed to target plants, it also can be toxic that effect the humans health.

Therefore, the weed control strategies can be improved through the application of mulching and by addition of the plant extract in order to reduce on the dependence of the chemical herbicide on the crop field. This is because muching functions to suppress the weed on the crop field. But, it takes times as it is slowly decomposed (Halde & Martin, 2015). Hence, addition of the aqueous curry leaves extract with mulching will to assist to fasten the weed inhibition process where aqueous curry leaves extract will induce the releasing process of phytochemical in the muching. As a result, this study hepful in introduced the new approach of weed control strategy by the application of the organic method.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Curry Leaf (*Murraya koengii*)

### 2.1.1 Origin and Distribution of Curry Leaves

*Murraya koenigii* is native to India, Sri Lanka and other south Asian countries. It is dispersed all over India and is plentifully originated from Sikkim to Garhwal, Bengal, Assam, Western Ghats and Kerala. Furthermore, it reached to Malaysia, South Africa and Reunion Island from India along with South Indian immigrants (Gahlawat, Jakhar, & Dahiya, 2015).

### 2.1.2 Taxonomic status

| | |
|---|---|
| Kingdom | : Plantae |
| Sub Kingdom | : Tracheobionta |
| Division | : Magnoliophyta |
| Class | : Magnoliopsida |
| Subclass | : Rosidae |
| Order | : Sapindales |
| Family | : Rutaceae |
| Genus | : *Murraya* |
| Species | : *koenigii* |

Figure 2.1.2: Taxonomy of curry leaf (Disegha & Izionworu, 2014)

### 2.1.3 Uses

**Benefit as Antifungal**

Curry leaf tree is frequently used as spice due to the natural pungent of leaves. The main components of the plants, which is carbazole alkaloids are acknowledged to control of cytotoxic, antioxidative, antimutagenic and anti-inflammatory activities. In addition, the curry leaves consists of abundance of mono-terpenoids and SES quiterpenoids which demonstrated antifungal activities (Malwal & Sarin, 2011).

Furthermore, a study conducted by Singh et al. (2017) demonstrated that *Murraya koenigii* (curry leaves) can inhibit the fungi growth (*Aspergillusniger, Fusarium oxysporum*,

*Penicillium notatum* and *Trichoderma viride*). Inhibition of fungal growth were investigated using PDA and NA well diffusion method. The study resulted totals flavonoid content in crude methanolic, ethanolic and acetonic extracts and minimum inhibitory, minimum fungicidal and obtained *from M. koenigii* leaves.

**Benefit as Anti oxidant**

Curry leaves contain higher amounts of chlorophyll. Chlorophyll has been recommended as an effective antioxidant since it scavenges free radicals (Kirupa & Kavitha, 2015). In addition, curry leaves assists body defend from free radicals which are in charge for aging and damage of body cells including that of heart, kidney and liver.

A study conducted (Debosree et al. 2012) demonstrated the property of curry leaves in protection of liver and kidney from oxidation. It has been stated that curry leaves can avoid liver diseases like hepatitis and cirrhosis. In addition, curry leaves also can be used to thicken the hair, strengthen the roots hair and also reduce the hair loss (Meenal, 2017). Besides, the curry leaves are rich in protein and beta-carotene that reduce the hair fall and increase growth of hair. Hair loss can occur due to lack of protein (Mahendiratta, 2016). Therefore, frequent intake of curry leaves is necessary for the hair growth. This is because it is rich in antioxidants that provide moisture to the scalp and helps to remove the dead scalpel follicles and prevent the dandruff.

**Benefit to boosts digestion and promote weight loss**

Curry leaves intake is good for the digestive system as it stimulates the digestive enzymes and helps break the food more easily by soothing the intestinal walls, preventing various indigestion problems (Amritjude, 2011). Besides the curry leaves are conventionally utilized to treat diarrhoea and nausea efficiently. Regular consumption of curry leaves will assist to cleanses and eliminates the harmful toxins in the body.

Moreover, it also assists the body to detoxify naturally, burn extra calories, and prevent from fat accumulation, which can consequence in weight gain.This is because curry leaves consist of mahanimbine, an alkaloid that has anti-obesity and lipid-lowering effects (Quick weight loss tips: How to lose weight with curry leaves or kadi patta in 1 month, 2018). Therefore by intake of curry leaves it will assists to decreased the total cholesterol and triglyceride levels and lower body weight. Furthermore, the uptake of curry leaves not only causes the loss of fat, however it will also aid to avoid from a variety of health risks by cleansing your body of harmful substances. In addition, as the curry leaves consists of anti-diabetic properties, it can decreased the blood sugar levels as the high blood sugar levels can consequence in weight gain (Quick weight loss tips: How to lose weight with curry leaves or kadi patta in 1 month, 2018).

## 2.2 Weed management

### 2.2.1 The application of Mulching

Mulching is any material that is spread or laid over the surface of the soil as a covering. It is utilized as defense against weeds species ever since the mulch forms a protective layer between the sun and the soil, therefore, it tend to be very tough for the weeds to develop. In addition mulch also helps to improve the fertility of the soil. This is because; organic types of mulch decay eventually and gradually add to the nutrients in the soil. There are a lot of types of the mulch that can be applied to the garden such as shredded hardwood mulch, cypress mulch, fresh wood chips and compost materials (Venderlinden, 2018).

### 2.2.2 Effect of mulching on the weed growth

The application of mulch can assist crop, bed and garden in numerous methods. Mulches such as coco peat can helps to decrease weed growth by making states unfavorable for germination of weed seeds and by providing a physical obstacle for emerging weeds. A very well mulch layer can save a lot of time for laborious weeding. While, a thick layer of mulches material is particularly efficient in decreasing the number of annual weeds in the garden and bed. This is because; the weeds have difficulty for penetrating the thick layer of mulches (Relf, 2015).

There are a lot of types of mulching that frequently being used as a weed suppressed in the previous studies. Therefore, table 2.2.6 show the application of different

types of mulching alone and mulching that treated with herbicide also their effect on the bioassays species.

### 2.2.3 The types of mulches

**Shredded or chipped bark mulch**

There are variety types of mulches that available on the market nowadays. Every type of mulch having its own advantages and disadvantages and will work better in some situations than in others. For example such as shredded or chipped bark mulch. This type of mulch usually do not break down easily and will not supply a lot of nutrient on the soil (Venderlinden, 2018). According to ferguson et al. 2008, this type of mulch had not only reduced the weed emergence that being planted in the pot at the nursery but it also can decreased the level on nitrogen accessibility due to the high carbon nitrogen ratios. In addition, the herbicide treated chipped bark able to provide almost 150% raises in weed control efficacy on the preemergent herbicide and decreased the nursery plant phytotoxicity.

**Wood chips mulch**

Wood chips is a type of mulch that was obtained from numerous diverse hardwood and softwood species. It also frequently reachable from municipalities or service companies involved in pruning or clearing trees. Commonly, wood chip mulch consist of high amount of carbon nitrogen ratio. This indicate that in the process of decomposing this mulch might momentarily diminish the delivered of soil nitrogen fertilizer to mulched

plants (Rakov, 1998). The ability of the wood chips mulch from a few types of woody perennials such as Southern Redcedar and Southern Magnolia to supressed the weed is due to the possibility of it containing water-soluble natural product with phytotoxic activity which could be utilize to inhibit the weed. However, this type of mulch having it own disadvantage. For example, the infection of fungus called shotgun due to rotting of wood may causes a lot of problem to the farmer. Therefore, it is recommended to not utilize the wood chips mulch alone, but cover it with a layer of another type of mulch as alternative strategy (Rakov, 1998).

**Sawdust mulch**

Sawdust mulch is a type of mulch that frequently suggested to blueberries crop and other type of acid- loving evergreen crop. This is because this type of mulch having a capability to acidified the soil as it decomposed. Besides, sawdust mulch having as similarity with the wood chips mulch as both of the mulches having an abilty to deprives the nitrogen in the soil (Rakov, 1998). According to Ferguson et al. (2008), this type of mulch had not only reduced the weed emergence that being planted in the pot at the nursery but it also can decreased the level on nitrogen accessibility due to the high carbon nitrogen ratios.

**Straw mulch**

Straw mulch is a type of mulch that can be derived from wheat, rye, oat or barley. This type of mulch is widely used as winter mulch around tree or shrub roots and summer

mulch in vegetable gardens and strawberry plantings. However, this type of mulch having a weakness as it essentially made up of carbon.This is because the process of development of plant required adequate amount of nitrogen, while in order to break down the high-carbon plant also involved nitrogen. If the soil consist of least amount of nitrogen, the plant will be robbed of nutrient rather than being fertilized by the straw mulch. Therefore, it is recommended to applied compost to the crop field before applied the straw mulch in order to avoid the robbed of nitrogen (Baley, 2018). Conversely, this type of mulch is inexpensive and efficiently inhibit the weeds and lessens soil water losses. Moreover, as a winter mulch, it guard the tender roots from cold temperature damage (Rakov, 1998).

**Black plastic film mulch**

Black plastic film mulch is a type of synthetic mulch that commonly being used in the crop field. It is made up non renewable sources which is petroleum (Schonbeck, 2012). It is generally utilized in vegetable and small fruit plantings and is regularly applied as a layer under wood, bark, or mineral chips (Rakov, 1998). Black plastic film mulch function in order to suppressed most of the weed and sustained the soil moisture. Therefore, it will decreased the labor and cost for the weed management. However, due to the synthetic properties of this mulch, it will not provide any organic matter to the soil compared to other organic mulches.

**Clear, Translucent, and Colored Plastic Films**

Moreover, aside black plastic film mulch, there is also clear and translucent film that available in the market. However, this type of mulch only warm the soil into a superior degree but do not suppressed the weed effectively compared to the black plastic film mulch (Schonbeck, 2012). In addition, the development of colored plastic mulch such as translucent green, brown, olive, and IRT (infrared-transmitting) plastic films provide superior soil warming compared to black plastic, with fair weed suppression.This is because this type of mulch tend to absorbed the red and blue light wavelengths that utilized by all plants in photosynthesis and transmit mostly infrared (heat) wavelengths and some green light, these materials will decrease the weed germination, emergence, and growth compared to clear film or bare soil (Schonbeck, 2012).

### 2.2.4 Allelopathy

According to the Vargas, Ulguim, Agostinetto, Margo, & Thurmer, (2013). allelopathy is a phenomenon that occurs in nature, in which chemical substances are released by plants in the environment and can cause inhibitory effects in germination, growth and development of other nearby plants, which may interfere in many life processes of plants as the use of water and nutrient assimilation, growth of the roots, in the expansion of leaves, in photosynthesis, synthesis of proteins, in cellular respiration and cell membrane permeability. However, the application of the allelopathic plants is considered as a mother nature's own weed killer. "Allelopathy is a biological phenomenon where one plant inhibits the growth of another plant by release of allelochemicals through leaching,

root exudation and decomposition that can result beneficial and harmful effect." (Nooralvandi, 2016). Moreover, curry leaves is considered as a allelopathic plants because during the study conducted by (Kakati & Baruah, 2013) it shows that the curry leaves aqueous tend to inhibit the seed germination and root growth of mung bean (*Vigna radiata* (L.) Wilczek.). Therefore, this result proved that there is a proof of allelopathic potential on curry leaves extract on seed germination and radical growth of Mung bean (Kakati & Baruah, 2013).

Furthermore, there are a lot of plant extracts that usually being used as a natural herbicide for suppressed the weed development. Therefore, table 2.2.5 below shows the application of different types of plant extracts and its effect on the bioassays species.

### 2.2.5Others plant extraction

Table 2.2.5: The types of plant extract and its effect on the bioassays species

| Types of plant extract | Active Concentration | Bioassay species | Percentage of inhibition | References |
|---|---|---|---|---|
| Sunflower leaf extract | 10-15% (w/v) | Barnyard grass *(Echinochloa crus-galli)* | Inhibit the weeds emergence by 80-90% | Dilipkumar and Chuah, (2013) |
| Aqueous sunflower leaf extract (Megasun cv) | 100% | Wild barley (*Hordeum spontaneum*)<br>Annual ryegrass (*Lolium rigidum*)<br>Red-root amaranth (*Amaranthus retroflexus*) | Inhibit the weeds emergence by 80% | Nikneshan et al. (2011) |
| Musk rose *(Rosa moschata) leaves* extract | 10% | Basmati (cv. Kasturi)<br>Non-basmati (cv. Pant dhan11) | Enhanced the shoot fresh weight by 24.2 mg | Indracanti & Dash, (2015) |
| Aqueous curry (*Murraya koenigii*) leaves extract | 10% | Basmati (cv. Kasturi)<br>Non-basmati (cv. Pant dhan11) | Reduced the shoot fresh weight by 17.5 mg | Indracanti & Dash, (2015) |
| Aqueous napier grass (*Pennisetum purpureum*) extracts | 0.07 g $L^{-1}$ and 0.47g $L^{-1}$ | Woody borreria *(Hedyotis verticillata)*<br>Chinese sprangletop *(Leptochloa chinensis)* | Inhibit the weed emergence by 50% | Norhafizah et al.( 2013) |

| | | | | |
|---|---|---|---|---|
| Aqueous *Rapanea umbellata* (Mart.) Mez (Primulaceae) leaves extract | 10% and 5% (g mL $^{-1}$) | Barnyard grass (*Echinochloa crus-galli*)<br><br>Wild poinsettia (*Euphorbia heterophylla)*<br><br>Morning glory (*Ipomoea grandifolia*) | Inhibit the development of the root part more than 60%-80% for all species in both concentration | Novaes et al. (2013) |
| Aqueous barley (*Hordeum vulgare*) root extract | 4,8,12,16 and 20 g per 100 ml of water | Quack grass (*Agropyrum repens*) | Inhibit the radical length at the lowest compared to other parts of tissue extract. | Ashafi et al. (2009) |
| Aqueous carrot weed (*Parthenium Hysterophorus* L.) root extract | 5% | Maize (*Zea mays* L.) | Root extract possessed least germination (58.78%) compared to the whole plant (75.82%) and shoot (62.62%) extract from the same plant. | Awan et al. (2017) |

### 2.2.6 Application of other types of mulching and herbicide

Table 2.2.6: The application of other types of mulching and herbicide and its effect on the bioassays species.

| Types of mulching | Active concentration | Bioassay species | Effect | References |
|---|---|---|---|---|
| Oil palm mulches (frond, leaflet and rachis) | 3 tan/ $ha^{-1}$ | Goosegrass (*Eleusine indica*) | 85 – 100% inhibition | Dilipkumar et al. (2015) |
| Rice (husk) residues | 3 tan/ $ha^{-1}$ | Goosegrass (*E. indica*) | 70 – 80% inhibition | Dilipkumar et al. (2015) |
| Oil palm residues (frond, leaflet and rachis) + Imazethapyr | 1.4 – 1.8 t $ha^{-1}$ + 12 g ai $ha^{-1}$ | Goosegrass (*E. indica*) | 90-100% inhibition | Dilipkumar et al. (2017) |
| Oil palm residues (frond, leaflet and rachis) + imazethapyr | 3.4 t $ha^{-1}$ + 24 g ai $ha^{-1}$ | Panicgrass *(Panicum* sp) Bhui-amla (*Phyllanthus amarus)* Chinese violet *(Asystasia gangetica)* | 90% inhibition | Dilipkumar et al. (2017) |
| Wheat straw shredded | 5.08 cm thick | Zinnia *(Zinnia elegans)* | Had the lowest mean of weeds cover (34159.33$cm^2$) | Mutalleb, (2018) |
| Santa-Maria *(Parthenium hysterophorus)* mulch | 5 t $ha^{-1}$ | Soybean (*Glycine max*) | Gave strong reduction on shoot fresh weight | Siddiqui et al. (2018) |
| Southern Magnolia ( Magnolia grandiflora) wood chip mulch | 5 to 10 mm thick | Lettuce (*Latuca sativa*) | Gave strong reduction on radical length | Ferguson et al. (2008) |

| | | | | |
|---|---|---|---|---|
| Southern Redcedar (*Juniperus silicicola*) wood chip mulch | 5 to 10 mm thick | Crabgrass (*Digitaria sanguinalis*) | 80 - 90% inhibition | Ferguson et al. (2008) |

# CHAPTER 3

# MATERIALS AND METHODS

## 3.1 Materials

### 3.1.1 Mulching

Coco peat were bought from the Secret Garden Nursery, Tanah Merah, Kelantan (5.8397° N, 102.1593° E) in September 2018.

### 3.1.2 Plant Materials

The seeds of *Hedyotis verticillata* were collected from paddy field of Kampung Pantai Prai, Padang Serai, Kedah (5° 32' 53" N, 100° 36' 10" E) in June 2018. The curry leaves were collected from the Kampung Manik Urai, Kuala Krai, Kelantan (5° 32' 2" N, 102° 11' 58" E) in September 2018.

## 3.2 Method

### 3.2.1 Preparation of curry leaves extract

Curry leaves were left under the sun to let it dry and then were prepared by grind it to a fine powder by using a blender. The leaves powder obtains then were weighed at 100g and let to dissolved in 100ml of distilled water to provide 100% of stock solution. These mixing were agitated vigorously by using an orbital shaker at 25°C at 200 revolutions per minute (rpm) for at least 1 day (24 hours) ( Norhafizah, Yew, Ismail & Chuah, 2013). Then, the extracts were filtered through muslin cloth followed by Whatman No. 1 filter paper. Then the extract were dilute with distilled water to get different concentration of 20% and 40% of aqueous curry leaves extract. These prepared extracts were stored in chiller at 4°C before until it were be used.

### 3.2.2 Seedling growth test

The experiment was done in nursery of University Malaysia Kelantan, Jeli Campus (5.7445°N, 101.8642° E) with humidity rate at 78-80% also the temperature between 28-30°C. The seeds of *H. verticillata* were scarified with sand papers first in order to slightly break the outer coat to allow water to penetrate the seeds (Hodgson, 2016). A cup was filled

with 146 g of top soil and were placed in a 40 x 30 x 5 cm tray. For growth test, 20 *H. verticillata* seeds were sowed for each plastic cup (4 cm diameter x 8.3 cm height) with holes at the bottom. The water were applied from the bottom of the cup to stimulate moist condition for proper growth of *H. verticillata* seedling under nursery conditions ( Dilipkumar et al.2017). One day after sowing, the coco peat mulch treated with aqueous curry leaves extract were applied onto the soil surface as follows

**Table 3.1**: No of treatments and application rate of coco peat mulch (t $ha^{-1}$) + curry leaves extract (%)

| **Treatment** | **Application rate of coco peat mulch (t $ha^{-1}$) + aqueous curry leaves extract (%)** |
|---|---|
| Control | 0 t $ha^{-1}$ coco peat mulch + 0% aqueous curry leaves extract |
| Treatment 1 | 4 t $ha^{-1}$ coco peat mulch + 0% aqueous curry leaves extract |
| Treatment 2 | 4 t $ha^{-1}$ coco peat mulch + 20% aqueous curry leaves extract |
| Treatment 3 | 4 t $ha^{-1}$ coco peat mulch + 40% aqueous curry leaves extract |
| Treatment 4 | 8 t $ha^{-1}$ coco peat mulch + 0% aqueous curry leaves extract |
| Treatment 5 | 8 t $ha^{-1}$ coco peat mulch + 20% aqueous curry leaves extract |
| Treatment 6 | 8 t $ha^{-1}$ coco peat mulch + 40% aqueous curry leaves extract |

The spraying volume for aqueous curry leaves extract was 450 L/ha ( Mohammad, Ghahraei, Ahmad, Reza & Mohammad, 2014). Hence, based on the spraying volume, 0.88ml of aqueous curry leaves extract were applied on the soil surface of each tested seedling according its respected concentration by using micropipette. The distilled water were applied as a control. The cups were placing under nursery and the humidity were maintained with 78-80% also the

temperature between 28-30°C. The data were collected 2 weeks after the treatments application. The number of emerged weed seedlings, the shoot fresh weight and the root length were measured and data were expressed as % of control.

### 3.2.3 Statistical Analysis

All the treatments were arranged in completely randomized design with three replications. The data that obtained were statistically elaborate further by using SPSS Statistic V21 and One way of Anova. Turkey test HSD were used to compare the mean between the treatments ($P< 0.05$).

### 3.3 Research flow chart

Curry leaves aqueous extract was prepared by dissolving 100g of curry leaves leaflet powder in 100ml distilled water to provide 100% of stock solution. The stock solution then were diluted with distilled water to a series of concentration which are 20% and 40%.

↓

20 seeds of *H. verticillata* were sowed for each cup with diameter of 4cm x 8.3cm height that formerly was filled with 146g of top soil as growing medium.

↓

The treatments were applied to the soil one day after sowed the seeds as follows;

- **T0** (0 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract) ( control )
- **T1** (4 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract)
- **T2** (4 t $ha^{-1}$ coco peat mulch + 20% curry leaves extract)
- **T3** (4 t $ha^{-1}$ coco peat mulch + 40% curry leaves extract)
- **T4** (8 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract)
- **T5** (8 t $ha^{-1}$ coco peat mulch + 20% curry leaves extract)
- **T6** (8 t $ha^{-1}$ coco peat mulch + 40% curry leaves extract)

0.88 ml of the curry leaves aqueous extract were applied according to the spraying volume; 450 L/ha by using 1000µL of micropipette to all the treatments except control.

↓

All the parameters were measured after 2 week of treatment application. The number of emerged weeds, the shoot fresh weight and the root length were measured.

↓

All the measurement were done in three replicates. Then, the data were analyzed using SPSS and One Way ANOVA.

**Figure 3.3**: Research flow chart

# CHAPTER 4

# RESULT AND DISCUSSION

4.1 Effect of coco peat mulch treated with aqueous curry leaves extract on control the *Hedyotis verticillata* weeds under nursery conditions

### 4.1.1 Weed emergence

Figure 4.1 shows the effect of coco peat mulch treated with aqueous curry leaves extract on weed emergence of *Hedyotis verticillata.* It was found that the mean value (% of control) of weed emergence of the bioassay species was significantly reduced with an increase of coco peat mulch rate from 4 t $ha^{-1}$ to 8 t $ha^{-1}$ as indicated in **T1** (4 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract) and **T4** (8 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract) (Appendix B.3). However, there was no significant inhibition on weed emergence when coco peat mulch at 4 t $ha^{-1}$ treated with 20% **T2** or 40% of curry leaves aqueous extract. At these concentrations, the weed emergence was inhibited by 50 – 65 %. Similar trend of inhibition was also observed when coco peat mulch at 8 t $ha^{-1}$ treated with 20% **T5** and 40% **T6** of aqueous curry leaves extract.

At these concentrations, the weed emergence was strongly inhibited by 80 – 90 %. From this result, it is interesting to note that application of aqueous curry leaves extract together with coco peat mulch at **T3** and **T6** significantly reduced the emergence of *H. verticillata* as compared to the application of coco peat mulch alone at **T1** and **T4**.

Based on the study conducted by Nikneshan et al. (2011) the application of 100% concentration of the aqueous sunflower leaves extract from the Megasun sunflower cultivar strongly suppressed several types of the weeds species such as Red-root amaranth *(Amaranthus retroflexus),* Annual ryegrass *(Lolium rigidum),* and Wild barley *(Hordeum spontaneum)* with 80% inhibition. Conversely, Dilipkumar & Chuah (2013) reported that the application of sunflower leaf extract at 10-15% concentration possesses 80-90% of inhibition level of on the emergence and seedling growth of barnyard grass (*Echinochloa crus-galli*) emergence and seedling growth. Later on, Dilipkumar et al. (2015) stated that the application of the mulch from oil palm residues (frond, leaflet and rachis) and rice husk at an application rate of 3 t $ha^{-1}$ gave strong inhibition to goosegrass (*Eleusine indica*) with 85-100% and 70-80% inhibition respectively.

Recently, Dilipkumar et al. (2017) found that the application of oil palm residues (frond, leaflet and rachis) at an application rates of 1.4 – 1.8 t $ha^{-1}$ which treated with 12 g ai $ha^{-1}$ of imazethapyr gave significant inhibition on *E. indica* emergence with 90-100% inhibition under glasshouse condition. They also documented that oil palm residues at an application rate of 3.4 t $ha^{-1}$ that treated with 24 g ai $ha^{-1}$ imazethapyr provide outstanding control on other types of weed species such as Panicgrass *(Panicum sp),* Bhui-amla *(Phyllanthus amarus)* and Chinese violet *(Asystasia gangetica)* with 90% inhibition on weed emergence under field condition. Furthermore, incorporation of S-metolachlor at 10 g a.i. $ha^{-1}$

and hairy vetch (*Vicia villosa*) residue at 5 t ha$^{-1}$ gave synergistic interaction by inhibiting smooth pigweed emergence by 86%, compared with single S-metolachlor at 1000 g a.i. ha$^{-1}$ to achieve the same inhibitory effect (Teasdale et al. 2005). In addition, Mathers and Case (2010) demonstrated that a single application of acetolachlor at 2.8 kg a.i. ha$^{-1}$ or hardwood gave 46% and 0% weed control, respectively. Interestingly acetolachlor-treated hardwood provided 100% weed control at 110 days after treatment.

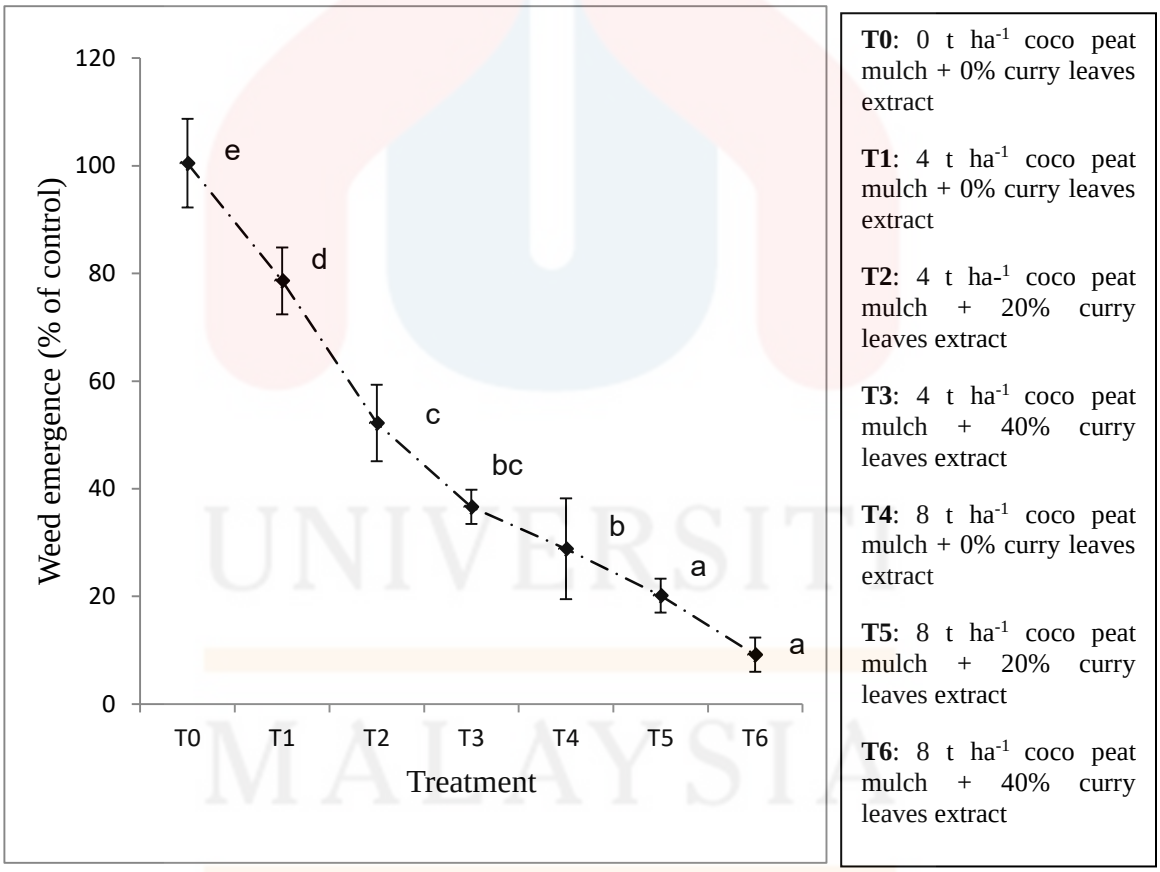



Figure 4.1.1: Effect of coco peat mulch treated with aqueous curry leaves extract on weed emergence of Hedyotis verticillata. Vertical bars represent standard deviation (SD) of the mean.

### 4.1.2 Shoot fresh weight

Figure 4.2 shows the effect of coco peat mulch treated with aqueous curry leaves extract on shoot fresh weight of *H. verticillata.* It was found that there was significant reduction between the mean values (% of control) of shoot fresh weight of the bioassay species with an increase of coco peat mulch rate from 4 t $ha^{-1}$ **T1** (4 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract) to 8 t $ha^{-1}$ **T4** (8 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract) (Appendix B.4). In T1 , coco peat mulch had reduced the shoot fresh weight of *H. verticillata* by 35% meanwhile **T4** exhibit strong phytotoxicity effect by reduced the shoot fresh weight by 50%. Conversely, there was no significant inhibition on shoot fresh weight of *H. verticillata* when coco peat mulch at 4 t $ha^{-1}$ treated with 20% (**T2**) or 40% (**T3**) of aqueous curry leaves extract. Nevertheless, there is an increment on reduction of shoot fresh weight at these two treatments with almost 50% reduction in **T2** and 58% reduction in **T3**. Furthermore, similar trend was also observed when coco peat mulch at 8 t $ha^{-1}$ treated with 20% (**T5**) and 40% (**T6**) of aqueous curry leaves extract. Likewise, the shoot fresh weight reduction was higher in **T6** (80% inhibition) as compared to **T5** with 70% reduction of shoot fresh weight.

These result is accordance with a study conducted by Indracanti & Dash (2015), where the application of 10% aqueous curry leaves extract shows significant effects in shoot fresh weight of mixed culture of two rice cultivars which is a basmati (cv. Kasturi) and a non-basmati (cv. Pant Dhan11). Similarly, the application of 10% aqueous rose musk *(Rosa moschata)* leaves extract tend to decrease the shoot fresh weight of mixed culture of both cultivars. These results show that plant extract exhibit phytotoxicity effect on selected crop species. Besides, Awan et al. (2017) reported that the application of aqueous carrot weed

(*Parthenium Hysterophorus* L.) root extract at 5% concentration strongly reduced the shoot fresh weight of maize (*Zea mays* L.). In addition, according to Siddiqui et al. (2018), the application of Santa-Maria (*Parthenium hysterophorus)* mulch at an application rates of 5 t $ha^{-1}$ tend to gave strong reduction on the shoot fresh weight of soybean (*Glycine max*).

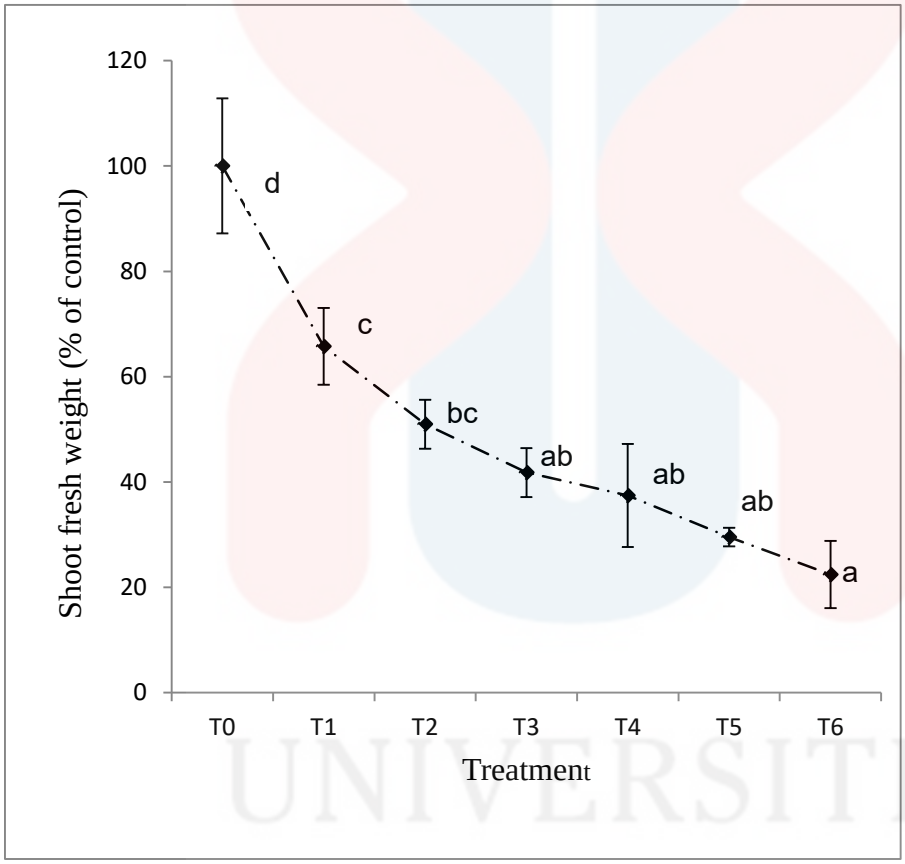



Figure 4.1.2: Effect of coco peat mulch treated with aqueous curry leaves extract on shoot fresh weight of *Hedyotis verticillata*. Vertical bars represent standard deviation (SD) of the mean.

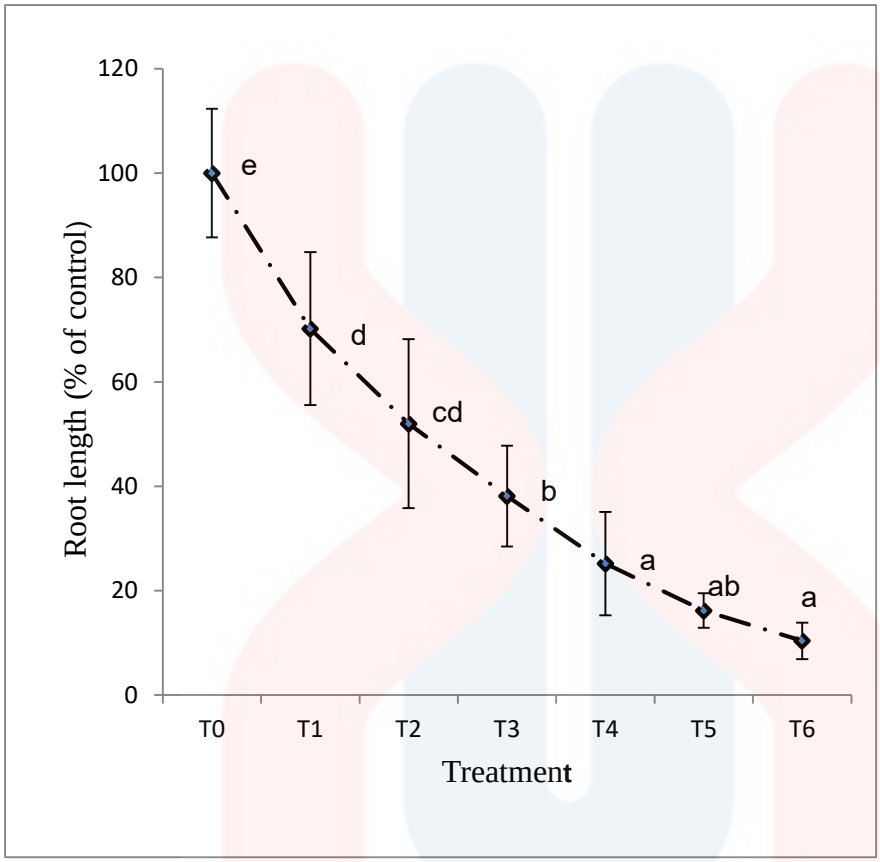
### 4.1.3 Root length

Figure 4.3 shows the effect of coco peat mulch treated with aqueous curry leaves extract on root length of *H. verticillata.* It was found that there was significant inhibition between the mean values (% of control) of root length of the bioassay species with an increase of coco peat mulch rate from 4 t $ha^{-1}$ (**T1**) to 8 t $ha^{-1}$ (**T4**) (Appendix B.5) . It was noted that the inhibition effect was more potent in T4 with more than 70% inhibition as compared to **T1** with 30% inhibition. Therefore, higher rate of coco peat mulch had increased the inhibition level in term of root length.

On the other hand, there was no significant inhibition on root length of *H. verticillata* when coco peat mulch at 4 t $ha^{-1}$ treated with 20% (**T2**) of aqueous curry leaves extract. However, there is an increase in inhibition level of root length at this application rate with almost 50% inhibition. Conversely, coco peat mulch at 4 t $ha^{-1}$ that treated with 40% (**T3**) of aqueous curry leaves extract exhibit significant reduction on root length with more than 60% inhibition as compared to (**T1**). Moreover, it was observed that coco peat mulch at application rate of 8 t $ha^{-1}$ did not give significant effect on the root length of *H. verticillata* regardless of any concentration of aqueous curry leaves extract. Similar to seed emergence and shoot fresh weight, the root length inhibition may more higher in **T6** (90% inhibition) as compared to **T5** with 84% inhibition. These results imply that the combination of coco peat mulch at 8 t $ha^{-1}$ treated with 40% aqueous curry leaves extract possibly contain high level of allelochemicals that leads to a strong reduction in root length.

Norhafizah et al. (2013) documented that aqueous extract of napier grass (*Pennisetum purpureum*) from of culm plus leaves at 0.47g/L had strong inhibitory effect on the radical growth of *H. verticillata* and Chinese sprangletop (*Leptochloa chinensis*) with more than 60%

and 80% inhibition respectively. They also investigate that aqueous root extract from the same plant species at an application rate of 3 to 14g/L gave higher suppression on the root length of both bioassay species with 85 to 95% inhibition. Besides, Novaes et al. (2013) reported that the application of aqueous *Rapanea umbellata* (Mart.) Mez (Primulaceae) leaves extract at 5% and 105 g $mL^{-1}$ on barnyard grass (*Echinochloa crus-galli*), wild poinsettia (*Euphorbia heterophylla*) and morning glory (*Ipomoea grandifolia*). They found that the *R. umbellate* extract inhibit the development of the root part more than 60%-80% for all species in both concentration. Ashafi et al. (2009) stated that the application of aqueous barley (*Hordeum vulgare*) root extract at an application rate of 20 g $mL^{-1}$ inhibit the radical length of quack grass (*Agropyrum repens*). In addition according to Ferguson et al. (2008), the application of 5 to 10 mm thick wood chip mulches from southern magnolia (*Magnolia grandiflora*) gave strong inhibition on radical length of lettuce (*Latuca sativa*).




**T0**: 0 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract

**T1**: 4 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract

**T2**: 4 t $ha^{-1}$ coco peat mulch + 20% curry leaves extract

**T3**: 4 t $ha^{-1}$ coco peat mulch + 40% curry leaves extract

**T4**: 8 t $ha^{-1}$ coco peat mulch + 0% curry leaves extract

**T5**: 8 t $ha^{-1}$ coco peat mulch + 20% curry leaves extract

**T6**: 8 t $ha^{-1}$ coco peat mulch + 40% curry leaves extract

Figure 4.1.3: Effect of coco peat mulch treated with aqueous curry leaves extract on root length of *Hedyotis verticillata*. Vertical bars represent standard deviation (SD) of the mean.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

The objectives of the study have successfully achieved. Based on the result obtained, it can be concluded that the combination of coco peat mulching with the aqueous curry leaves extract possesses a strong inhibition in term of seed emergence, shoot fresh weight and root length for *H. verticillata* weeds. The inhibition rate increases as and the rate of the coco peat mulching and the concentration of aqueous curry leaves extract increases. Therefore, based on the result obtained the recommended rate of the application of the coco peat mulching with the curry leaves aqueous extract was 8 t $ha^{-1}$ coco peat mulch + 40% curry leaves extract. This is because these amounts tend to perform superior inhibitory effect on the weeds emergence and seedling growth. The possibility reason for the inhibitory action of the aqueous curry leaves extract is due to the presence of the allelochemical in the extract.

## 5.2 Recommendation

Further research should be done on isolation and identification of phytotoxic compound that present in the aqueous curry leaves extract. In addition, the mechanism of action of identified phytotoxic compound also needs to be done in order to determine how the phytotoxic compound exerts its effect on weed inhibition. This in turn can provide opportunity for a new natural herbicide discovery. Discovery of new plant-derived products having natural herbicide activities or properties would be a potentially valuable contribution on weed management.

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# APPENDIX A

Figure A.1. *Hedyotis verticillata* weed

Figure A.2. Collected *Hedyotis verticillata* weeds

Figure A.3. Curry leaves powder form

Figure A.4. Curry leaves after extraction

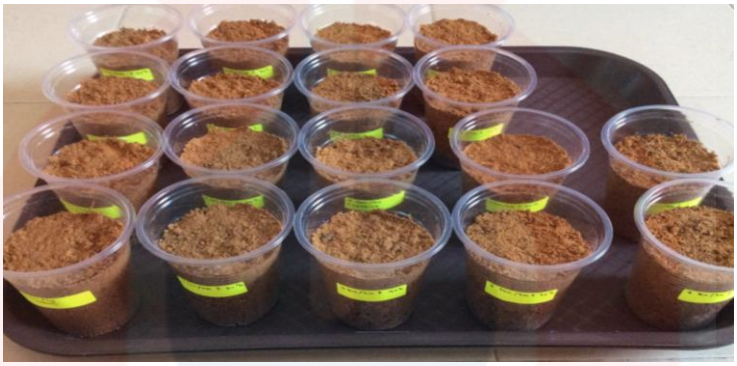

Figure A.5. Sample of seeds in nursery before application of treatment

Figure A.6. Sample of weeds in nursery after application of treatment

Figure A.7. Sample of weeds in nursery after application of treatment

Figure A.8. Sample of weeds in nursery after application of treatment

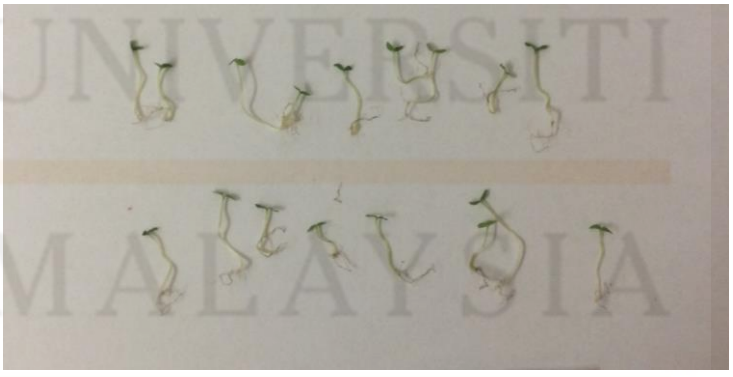

Figure A.9. *Hedyotis verticillata* at 0 t $ha^{-1}$ coco peat mulch and 0% aqueous curry leaves extract after 2 week

Figure A.10. *Hedyotis verticillata* at 4 t $ha^{-1}$ coco peat mulch and 0% aqueous curry leaves extract after 2 week

Figure A.11. *Hedyotis verticillata* at 4 t $ha^{-1}$ coco peat mulch and 20% aqueous curry leaves extract after 2 week

Figure A.12. *Hedyotis verticillata* at 4 t $ha^{-1}$ coco peat mulch and 40% aqueous curry leaves extract after 2 week

Figure A.13. *Hedyotis verticillata* at 8 t $ha^{-1}$ coco peat mulch and 0% aqueous curry leaves extract after 2 week

Figure A.14. *Hedyotis verticillata* at 8 t $ha^{-1}$ coco peat mulch and 20% aqueous curry leaves extract after 2 week

Figure A.15. *Hedyotis verticillata* at 8 t ha-1 coco peat mulch and 40% aqueous curry leaves extract after 2 week

## APPENDIX B

Table B.1. Mean value of different rate of coco peat mulch treated with different concentration of aqueous curry leaves extract and control treatment on weed emergence(%), shoot fresh weight (% of control) and root length (% of control) of *Hedyotis verticillata* under nursery condition. (Mean ± standard deviation)

| Treatments<br>Coco peat mulch (t $ha^{-1}$) + aqueous curry leave extract (%) | No of weed emergence (%) | Shoot fresh weight (mg/plant) | Root length (mm/plant) |
|---|---|---|---|
| 0 t $ha^{-1}$ coco peat mulch + 0% aqueous curry leaves extract | 100 ± 8 | 100 ± 13 | 100 ± 12 |
| 4 t $ha^{-1}$ coco peat mulch + 0% aqueous curry leaves extract | 78 ± 6 | 66 ± 7 | 70 ± 14 |
| 4 t $ha^{-1}$ coco peat mulch + 20% aqueous curry leaves extract | 52 ± 6 | 51 ± 5 | 52 ± 16 |
| 4 t $ha^{-1}$ coco peat mulch + 40% aqueous curry leaves extract | 36 ± 3 | 42 ± 5 | 38 ± 10 |
| 8 t $ha^{-1}$ coco peat mulch + 0% aqueous curry leaves extract | 29 ± 9 | 38 ± 10 | 25 ± 10 |
| 8 t $ha^{-1}$ coco peat mulch + 20% aqueous curry leaves extract | 20 ± 3 | 30 ± 2 | 16 ± 3 |
| 8 t $ha^{-1}$ coco peat mulch + 40% aqueous curry leaves extract | 9 ± 3 | 22 ± 7 | 10 ± 3 |

Table B.2. ANOVA test results for weed emergence shoot fresh weight and root length for *Hedyotis verticilla* under nursery condition.

**ANOVA**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| SFW | Between Groups | 21371.245 | 6 | 3561.874 | 45.745 | .000 |
| | Within Groups | 1557.274 | 20 | 77.864 | | |
| | Total | 22928.519 | 26 | | | |
| WE | Between Groups | 29961.804 | 6 | 4993.634 | 102.956 | .000 |
| | Within Groups | 970.048 | 20 | 48.502 | | |
| | Total | 30931.852 | 26 | | | |
| RL | Between Groups | 31300.040 | 6 | 5216.673 | 40.724 | .000 |
| | Within Groups | 2818.167 | 22 | 128.098 | | |
| | Total | 34118.207 | 28 | | | |

*WE = Weed emergence, SFW = Shoot fresh weight, RL = Root length

Table B.3. Turkey HSD test for shoot fresh weight of *Hedyotis verticilla*

**Shoot fresh weight**

Tukey HSD[a,b]

| Treatment | N | Subset for alpha = 0.05 | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| Treatment 6 | 3 | 22.3333 | | | |
| Treatment 5 | 3 | 30.0000 | 30.0000 | | |
| Treatment 4 | 4 | 37.7500 | 37.7500 | | |
| Treatment 3 | 3 | 42.0000 | 42.0000 | | |
| Treatment 2 | 3 | | 51.0000 | 51.0000 | |
| Treatment 1 | 4 | | | 65.5000 | |
| Control | 7 | | | | 100.1429 |
| Sig. | | .091 | .061 | .345 | 1.000 |

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.542.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table B.4. Turkey HSD test for weed emergence of *Hedyotis verticilla*

**Weed emergence**

Tukey HSD[a,b]

| Treatment | N | Subset for alpha = 0.05 | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| Treatment 6 | 3 | 9.0000 | | | | |
| Treatment 5 | 3 | 20.0000 | 20.0000 | | | |
| Treatment 4 | 4 | | 28.5000 | | | |
| Treatment 3 | 3 | | 36.3333 | 36.3333 | | |
| Treatment 2 | 4 | | | 52.0000 | | |
| Treatment 1 | 3 | | | | 78.3333 | |
| Control | 7 | | | | | 100.4286 |
| Sig. | | .388 | .067 | .086 | 1.000 | 1.000 |

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.542.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Table B.5. Turkey HSD test for root length of *Hedyotis verticilla*

**Root length**

Tukey HSD[a,b]

| Treatment | N | Subset for alpha = 0.05 | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| Treatment 6 | 3 | 10.3333 | | | | |
| Treatment 5 | 4 | 16.0000 | 16.0000 | | | |
| Treatment 4 | 4 | 25.2500 | 25.2500 | | | |
| Treatment 3 | 3 | | 38.0000 | 38.0000 | | |
| Treatment 2 | 4 | | | 52.0000 | 52.0000 | |
| Treatment 1 | 4 | | | | 70.2500 | |
| Control | 7 | | | | | 100.0000 |
| Sig. | | .541 | .144 | .611 | .314 | 1.000 |

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.868.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.