



STUDY ON THE POTENTIAL OF *Melaleuca cajuputi* AS A  
NATURAL HERBICIDE AGENT TO SUPPRESS WEED  
GROWTH

BY

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## ABSTRACT

Weeds are diverse in their habit and habitats throughout the world. In landscape maintenance, weeds are of concern because they compete with other plants for growth factors. Modern management nowadays relies on the importance of synthetic chemicals to control weeds as unwanted plants in order to reduce the weed management cost. The use of herbicides does not represent an appropriate tool for the control of some weeds developing but leading negatively affect to the environment. Managing the landscape and natural resources are not only designing good views and environment but also upgrading and maintaining it through a good consideration to ensure the living environment. Therefore, this study aimed to explore *Melaleuca cajuputi* of heath forest species as potential natural herbicides agent in sustainable landscape management. To achieve this aim, we examine the allelochemical compound in plants, as well as analysis of physico-chemical properties in soil and water, and demonstrated this species as having allelopathic potential as natural herbicides, in order to determine their effectiveness towards suppressing weeds growth without degrading the environmental quality index. The result revealed that allelochemical contents only detected in plant and not in the soil properties as well as in the water bodies. Interestingly, total phenolic content was found substantially highest in the semi-mature plants stage. The overall analysis of the heath forest soil was recorded as extremely nutrient poor due to the high level of sand texture in the soil. In addition, the Water Quality Index (WQI) for heath forest is 41 or Class IV which can be used for irrigation and recreation purposed only. On the other hand, to examine the efficiency of allelopathy effect, the model system was conducted over four different periods, ranging from one to four weeks and at three different concentrations: 0.5 g, 2.5 g and 5.0 g. The results revealed that the higher the concentration the better the weed suppression mechanism. The significance outcome of this research is cost-effective and eco-friendly technology of herbicides to mitigate environmental pollution in suppressing the weed growth from landscape ecological perspective. The plants used as a natural herbicides agent which can creates new habitats with balances ecosystem, improve the soil structure, enhance the visual aesthetic of landscape scenic and provide a healthy living environment to all.

## خلاصة البحث

الأعشاب الضارة متنوعة في عاداتها وبيئتها في جميع أنحاء العالم. لصيانة المناظر الطبيعية ، تشكل الأعشاب الضارة مصدر قلق لأنها تتنافس مع النباتات الأخرى على عوامل النمو. تعتمد الإدارة الحديثة في الوقت الحاضر على أهمية المواد الكيميائية الإصطناعية للسيطرة على الحشائش كنباتات غير مرغوبة فيها من أجل تقليل تكلفة إدارة الحشائش. لا يمثل استخدام مبيدات الأعشاب أداة مناسبة للسيطرة على بعض الحشائش النامية ولكنه يؤدي إلى التأثير السلبي على البيئة. لا تقوم إدارة المناظر الطبيعية والموارد الطبيعية بتصميم وجهات نظر وبيئة جيدة فحسب، بل تعمل أيضًا على تحسينها وصيانتها من خلال مراعاة جيدة لضمان البيئة المعيشية. لذلك، تهدف هذه الدراسة إلى استكشاف *Melaleuca cajuputi* (مالالوكا كاجوبوتري) من الأنواع النباتية الصحية من الغابات، كعامل مبيدات عشبية طبيعية محتملة في الإدارة المستدامة للمناظر الطبيعية. لتحقيق هذا الهدف، نقوم بفحص مركب الأليلوكيميائي في النباتات ، وكذلك تحليل الخواص الفيزيائية والكيميائية في التربة والمياه ، وأظهرت النتائج أن هذا النوع له إمكانات مسبب الإلتهاب كمبيدات عشبية طبيعية، من أجل تحديد فعاليتها نحو قمع نمو الأعشاب الضارة دون تحطيم مؤشر الجودة البيئية. وكشفت النتيجة أن محتويات allelochemical تم اكتشافها فقط في النبات وليس في خواص التربة وكذلك في المسطحات المائية. ومن المثير للإهتمام، تم العثور على محتوى الفينول الكلي أعلى بكثير في مرحلة النضج النصف للنباتات. تم تسجيل التحليل الشامل للتربة الحرجية الفقيرة كمواد مغذية للغاية بسبب ارتفاع مستوى الطبيعة الرملية في التربة. بالإضافة إلى ذلك ، فإن مؤشر جودة المياه (WQI) للغابات الصحية هو 41 أو الفئة الرابعة والتي يمكن استخدامها لأعراض الري والاستجمام فقط. من ناحية أخرى ، لدراسة كفاءة تأثير allelopathy ، تم إجراء النظام النمذجي على مدى أربعة فترات مختلفة ، تتراوح من أسبوع إلى أربعة أسابيع وبثلاث تركيزات مختلفة: 0.5 غ، 2.5 غ و 5.0 غ. أظهرت النتائج أنه كلما زاد التركيز كلما كانت آلية قمع الحشائش أفضل. نتيجة هذا البحث تتمثل في أنها تقنية فعالة من حيث التكلفة و عدو الإضرار بالبيئة لمبيدات الأعشاب للتخفيف من التلوث البيئي في قمع نمو الأعشاب الضارة من منظور بيئي طبيعي. النباتات المستخدمة كعامل مبيدات الأعشاب الطبيعية التي يمكن أن تخلق موائد جديدة مع التوازن البيئي، وتحسين بنية التربة ، وتعزيز الجمالية البصرية للمناظر الطبيعية الخلابة وتوفير بيئة معيشية صحية للجميع.

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## LIST OF SYMBOLS

°C	Degree
=	Equal
>	more than
<	less than
%	percent
±	standard deviation

## LIST OF ABBREVIATIONS

µg/L	microgram per litre
µmol	micromolar
AE	Allelochemical Effectiveness
Al	Aluminium
BCF	Bioconcentration factor
BOD	Biological Oxygen Demand
Cd	Cadmium
CEC	Cation Exchange Capacity
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
DO	Dissolved Oxygen
Fe	Iron
mg/kg	miligram per kilogram
mg/L	miligram per litre
Mn	Manganese
NWQSM	National Water Quality Standards for Malaysia
N	Nitrogen
NH <sub>3</sub>	Ammonia
NH <sub>4</sub>	Ammonium
Ni	Nickel
NO <sub>2</sub>	Nitrite
NO <sub>3</sub>	Nitrate
P	Phosphorus
pH	power of hydrogen
Pb	Lead
TOC	Total Organic Carbon
TDS	Total Dissolve solid
Zn	Zinc

# CHAPTER ONE

## INTRODUCTION

### 1.1 RESEARCH BACKGROUND

Maintaining landscape is like an investment while proper management and care probably make up to 50 percent of a successful landscape investment. The practice of maintenance in landscape management is not only by the use of the land, but it also contributes in the making of good built environment through natural resources such as plantations that require special care to achieve their full potential. In landscape management, maintenance is divided into two groups:

- i. **Plants** maintenance
  - Pruning, irrigation, mowing, planter beds, fertilizing and chemical application.
- ii. **Ground** maintenance
  - pH and nutrient of soil maintenance, amending, mulching, soil humidity control and weeds control maintenance (the major activity in landscape areas).

Weeds are diverse in their habit and habitats where it thrives in disturbed habitats and creates an abundance of areas that is meaningless to mankind in any production (Manning, 2004). In 1967, the Weed Science Society of America defined weed as a plant growing where it is not desired or known as unwanted and undesirable plant that may affect human welfare through the utilization of the land biodiversity and water resource. Although they account for not more than 1% of the total plant

species on earth, they cause great problems to human by interfering in food production, economic stability, health and welfare (Qasem and Foy, 2001). They decrease productivity and are a setback for the management and harvest of the given culture which leads to an annual loss of approximately U\$95 billion (FAO, 2009).

In global agriculture, weed represents one of the main problems. Competition from weeds can have serious effects on growth, survival and maintenance cost of landscape plants. Weeds are therefore just as much a part of our domestic culture as the crops. Revolutionized weed control in the global agricultural sector and landscape management system today cleared that it depends on the ability of people to control the unwanted plants that might compete with crops for light, nutrients and water in many forest ecosystems throughout the world. The earliest known weed control technology was hand-weeding and ploughing (which includes hand-pulling, cutting with a knife, hoes and mattocks). For most agronomists and weed scientists in the 20<sup>th</sup> century, the history of technology in weed control is the history of herbicides. For some it didn't begin until the introduction of synthetic herbicides in era 2000 and above. According to Carl (May, 2005), the revolution of weed control from time to time is being illustrated as shown in Figure 1.1.

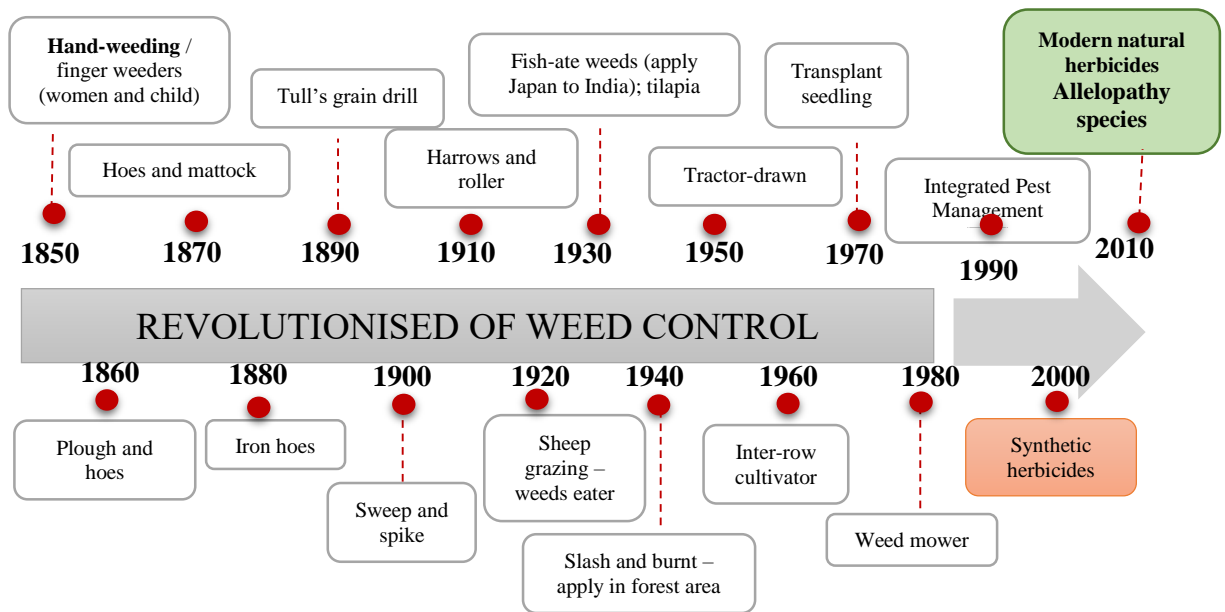


Figure 1.1: Historical view of weed control technology (Carl E.Bell, May 2005).  
Sources: <http://croplifefoundation.files.wordpress.com/2012/05/solving-africas-weed-problem-report1.pdf>

In this figure, a few important things were also highlighted that is the range of different control methods. However, successful weed control requires the combination or sequential use of several methods (called integrated weed management). For example, cutting followed by herbicide applications has been used successfully in many programs and prescribed fires followed by many spot-applications of herbicides. By considering all available control options: manual, mechanical, promoting competition from native plants, grazing, biocontrol, herbicides, prescribed fire and other techniques; all of these methods have their own advantages and disadvantages in terms of their effects against the target weeds, impacts to untargeted plants and animals, risks to human health and safety, and costs (as shown in Table 1 to show their successful and some cases of unsuccessful usage in landscape areas).

Table 1.1: Weed control effects of different types of implementations (Lundkvist and Fogelfors, 2004).

<i>Implementation/ Application</i>	<i>POSITIVE weed control effects</i>	<i>NEGATIVE weed control effects</i>
1. Harrows	Destroys/kills small weed plants. Fragmenting root/stem parts of perennial weeds near the soil surface.	Stimulates weed seed germination. May spread viable root/stem parts of perennial weeds.
2. Inter-row cultivator	Covers small weed plants with soil, uproots them or cuts them off.	May damage the non-target plants.
3. Weed mower / tractors	Cuts off weeds in growing crops.	If used after stem elongation, the crop will be damaged.
4. Integrated Pest Management (IPM)	Minimizes weed growth and some other pest problems	Greater labours needed for the transplanti – high cost weeds management.
<b>5. Synthetic / Chemical herbicides</b>	Herbicides have been <b>effectively used</b> in many types of landscape areas and are most often integrated with the cultural practices.	High risk towards the environment. (human beings and animals, water, non-target plants and soil). High cost maintenance due to expensive chemical usage.

In landscape maintenance, weeds are a great concern because they compete with other plants for growth factors. It is more complicated to control weeds in landscape plantation because the landscape areas are usually a mix of annual and perennial ornamental plants. In addition, weeds also hold an incomprehensible place in agriculture, whereas growers need to make considerable efforts to reduce the negative economic impact of weeds. In the view of the fact that, they were compete with other crops in getting resources, thereby affecting crop productivity and quality. Hence, these are ultimately causing many problems in order to sustain agriculture sector in a long term. To get deeper understanding of these issues, weed biology

including the ecology, physiology and population of weed species need to be reviewed more in order to get more information of the weed control management. Moss et al. (2008) has reported that weed biology research consequently aims to generate knowledge that is expected to be applied in the practical control of weeds by integrated research from basic to application with all elements that contributed to the enhancement of weed management.

According to the Qasem and Foy (2001), they reported that to counteract this issue, modern weed management nowadays relies on the important of synthetic chemicals to control weeds as unwanted plants in order to reduce the weed management cost. The discovery of synthetic natural herbicides for weed control in the late 1940s reduced tillage practices, because tillage was not the only method of weed control anymore (Hartwig and Ammon, 2002). In Malaysia, dominant weeds are broad-leaved weeds in rice field (Rezaul et al., 2004). The annual expenditure on herbicides for rice alone is approximately US\$4.10 million which constitutes almost 7% of the total cost on herbicides in Malaysia. The use of herbicides does not represent an appropriate tool for the control of some weed's development but it may lead to negative effects on the environment. Besides, weeds constantly compete with crop plants causing a considerable loss in their productivity and they have been documented as serious plant pests since the ancient times (Zimdahl, 2004).

This research is focused on the weed control approaches by developing a landscape ecological model system using allelopathy plants in order to suppress weed growth in landscape maintenance. This approach allows for profits optimization and preservation of human health and our environment which is also called as the science of weed management. Thus, a systematic study is needed to give a clear explanation on natural herbicides of the allelopathic species from bio-technologies enhancement as

weeds management control. There are a few studies that will be highlighted on the green alternative of screening natural product as potential herbicides to control weeds growth. The application of allelochemicals as natural herbicides for weeds management tool have been reported (Voltarelli et al., 2012; Bhowmik and Inderjit, 2003; Ngoc Bich and Kato-Noguchi, 2012) including their importance and interaction with the environment.

## **1.2 ISSUES**

Weeds are the most visible landscape pest and a major problem either to the professional landscape managers or homeowners. They detract the appearance and function of landscapes itself. The presence of weeds in the landscape area is usually the result of poor site preparation, poor establishment, inappropriate plant selection or improper management (Anaya, 2006). Some important environmental effects are associated with the use of chemical herbicides. These include unintended damage occurring both on the sprayed site and offsite. For example, by changing the vegetation of treated sites, herbicide use also changes the habitat of animals such as mammals and birds (Freedman, 2000). This is especially true for herbicides use in forestry, because biodiverse, semi-natural habitats are involved. It is the indirect effect of herbicide use, because it does not involve toxicity caused to the animal to the herbicide. Nevertheless, the effects can be severe for some species. In addition, not all of the herbicide sprayed by a tractor or aircraft deposits onto the intended spray area. Often there is a drift of herbicide beyond the intended spray site, and unintended, offsite damages may happen to vegetation.

There are also concerns about the toxicity of some herbicides, which may affect people using these chemicals during the course of their occupation when they are

spraying pesticides, people indirectly exposed through drift or residues on food, and wildlife. For these and other reasons, there are many negative opinions about the broadcast spraying of chemical herbicides and this practice is highly controversial. The chemical and physical properties of the herbicide are of major importance in relation to its effectiveness, but in terms of the hazard that it presents to humans, other animals, non-target plants, microorganisms, and having potential of causing damage and prolonged contamination of the environment including in soil, water and air.

Herbicides are a necessity and their use is now an accepted practice in many areas of the country. However, herbicides offered selective weed control with limited manpower and resources. In the process to control the weeds, the top of weed management needs to pay more on the cost of labours to achieve satisfying result. Two methods of weeds control normally employed on plant sites are bare ground and chemical trimming for control of weeds growing under the fences, under flower beds, along shrubbery borders, along building, and areas where roots of valuable trees extend (Tasawar et al ,2000). Entrepreneurs identified the profit incentive and created a demand for an increasing number of specific weed control chemicals (Kristina, 2013). As a result, an imbalanced weed management system was created. Thus, global agriculture and landscape weed management became dependent upon chemicals and create huge cost maintenance to sustain it in a long-term period.

As studied by Karthikeyan et al. (2003), plant species that are classified as non-target plants will be affected directly or indirectly due to herbicide residues and this leads to significant change in the survival, health or reproduction of non-target plant species or causes a change in plant community attributes. Herbicides are absorbed by non-target plants as well as weeds. However, certain herbicides are completely metabolized while others are not (Hatzios and Penner, 1982; Pline et al.,

2003). The residue of herbicides are most commonly found when herbicides were applied late in weeds and the toxicity is extended on harvested to non-target plant species. Altered susceptibility to disease of either the target or non-target plants may also be one of the unintended effects of herbicides. As a result, it will reduce species richness that has been cited as a consequence of residual herbicides.

### **1.3 PROBLEM STATEMENTS**

Based on the review of contemporary literature and issues, four main problems regarding weed control in landscape management have been identified:

- i. There is high chemical herbicides usage in weed control.
- ii. There is a huge cost maintenance on the labour and this affects economic stability.
- iii. There are many active ingredients in herbicide residues that can affect the non-target plants directly or indirectly.
- iv. There are complications that distract the quality and visual impact of landscape scenically and aesthetically.

### **1.4 RESEARCH QUESTIONS**

From the four problems that have been highlighted, three questions can be raised:

1. How can the allelopathic plant interaction be used as a natural way in weeds management in order to reduce chemical herbicides usage?
2. What are the impacts of *M. cajuputi* species towards the environment?

3. By using the allelochemical interaction between plants, can it be the most effective option in order to suppress weed growth in landscape maintenance?

### **1.5 RESEARCH GAPS**

The different groups of weed will have different control strategies, whether it is natural or chemical herbicides. Until to date, there are many concerns about the toxicity of some herbicides, which may affect people due to many active ingredients in herbicide residues, and also affected the non-target plants directly or indirectly. Unfortunately, very little is known about allelochemical effects towards environment sustainability. Therefore this study aimed to investigate and explore deeply on these matters regarding the environmental and human health impacts. Besides, management needs to pay more on the cost of labours to achieve satisfying result. Worldwide efforts are being made to reduce heavy reliance on chemical herbicides in controlled weed growth and find possible alternatives for achieving sustainable weed management.

### **1.6 RESEARCH HYPOTHESIS**

Heath forest species *M. cajuputi* can be used and integrated in landscape setting to suppress weeds growth as well as to minimize landscape maintenance management cost and creating more environmentally sustainable weeds management.

### **1.7 RESEARCH AIM**

The aim of this research is to explore *M. cajuputi* of heath forest species as a potential natural herbicide agent in sustainable landscape maintenance.