UNIVERSITI PUTRA MALAYSIA

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BUNGA RAYA KETAREN

FP 2013 51

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By

BUNGA RAYA KETAREN

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

January 2013

Abstract of thesis is presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

INFLUENCE OF ALLELOPATIC MULCH ON WEED GROWTH AND POSTHARVEST QUALITY OF LEAF LETTUCE (*Lactuca sativa* L.)

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January 2013

Chairman : Siti Hajar Ahmad, PhD

Faculty : Agriculture

Today, there is a high demand for our food supply to be free of potentially toxic substances including those used in the production of raw products. During the production and processing of agricultural commodities, various chemicals and foreign substances such as pesticide may enter food commodities. Most pesticides are acutely toxic and can produce adverse health effects in humans and animals when ingested at low levels over long periods of time. A study was conducted to identify allelopathic mulch for sustainable weed control of leaf lettuce and determine its effect on postharvest quality characteristics. A quantitative survey was done to investigate major weeds selected leafy vegetable fields in Selangor. Ten weed species were recorded. *Cyperus rotundus and Ageratum conyzoides* were the most abundant weeds followed by *Eleuthranthera ruderalis*, *Amaranthus spinosus*, and *Cyperus kyllingia.* **S**electing allelopathic mulch to inhibit weed seeds germination was studied using extracts of sorghum, paddy straw and empty oil palm fruit bunch (EFB) in a growth chamber. Total germinated seeds were recorded every 24 hour. Shoot and root lengths were measured on germination day 20. Allelopathy residues were detrimental to germination percentage, germination speed, mean germination time and relative hypocotyl and root length of weed species studied. Cucumber, cabbage and sunflower allelochemicals inhibited 100% germination of *C.*

rotundus, A. conyzoides, E. ruderalis, A. spinosus and *C. kyllingia*. Sorghum, paddy straw and EFB caused 30-50% germination for *C. kyllingia*, Seed germination of *C. rotundus, A. conyzoides, E. ruderalis* and *A. spinosus* was 10-30% when treated with extract sorghum, paddy straw and EFB. Germination of *E. ruderalis* was lowest when treated with EFB than other weeds. Final seed germination and seedling growth was reduced 0-50% with sorghum, paddy straw and EFB mulch residues. Effectiveness of sunflower and cucumber mulch on leaf lettuce was studied on vegetable field plot. Types and rates of mulching did not affect soils moisture content and total N, P, K, Mg and Ca. Higher total phenolic content and phenolic soluble concentration occurred in soils with cucumber mulch residue compared to control. Seventeen weed species belonging to six families was observed in Leaf lettuce crop. Unmulched plot had 14 weed species of family Poaceae, three Cyperaceae, two each of Euphorbiaceae and Asteraceae and one each of Amaranthaceae and Portulacaceae. Sum dominance ratio showed five most dominant weed encountered were *C. rotundus*, *C. distans*, *A. spinosus*, *C. kyllingia* and *A. conyzoides*. Sunflower (5 ton/ha) and cucumber (15 ton/ha) mulched plots caused reduction to five weed species. Highest reduction was for *A. spinosus*. Sum dominance ratio of weeds with sunflower mulch residues (10 and 15 ton/ha) was high for *C. rotundus*, and similar to 10 ton/ha cucumber mulch. Cucumber mulch at 5 ton/ha successfully suppressed *C. rotundus* in leaf lettuce plots. Mulching did not affect postharvest quality of Leaf lettuce. All characteristics measured (firmness, pH, TA and AA) were not different from unmulched treatment. Mulch rates did not affect quality characteristics and soil nutrients of leaf lettuce. Cucumber and sunflower mulching controlled weeds effectively and has potential as alternative chemical herbicides. Studies should be conducted for longer period for optimum mulch residues effectiveness.

Abstrak tesis yang dikemukakan kepada Senat of Universiti Putra Malaysia sebagai memenuhi keperluan ijazah Master Sains

PENGARUH SUNGKUPAN ALLELOPATIK KE ATAS PERTUMBUHAN RUMPAI DAN KUALITI LEPAS TUAI SALAD DAUN (*Lactuca sativa* L.)

By

BUNGA RAYA KETAREN

Januari 2013

Chairman : Siti Hajar Ahmad, PhD

Faculty : Agriculture

Pada masa kini, terdapat permintaan yang tinggi bagi bekalan makanan yang bebas daripada bahan toksik termasuk yang digunakan untuk pengeluaran produk mentah. Semasa pengeluaran dan pemprosesan komoditi pertanian, pelbagai jenis bahan kimia dan bahan-bahan asing seperti racun perosak boleh mencemari bahan makanan. Kebanyakan racun perosak adalah toksik secara akut. Walaupun tercemar pada kadar yang rendah/minima namun pendedahan dalam tempoh masa yang panjang boleh mengakibatkan kesan buruk terhadap kesihatan manusia dan juga haiwan. Kajian dijalankan untuk mengenalpasti sungkupan allelopati untuk kawalan rumpai lestari bagi salad daun dan menentukan kesannya ke atas kualiti cirian lepas tuai. Tinjauan kuantitatif dijalankan untuk mengenalpasti rumpai utama di ladang sayur berdaun di Selangor. Sepuluh spesies rumpai dicatatkan. *Cyperus rotundus* dan *Ageratum conyzoides* adalah rumpai terbanyak, diikuti *Eleuthranthera ruderalis, Amaranthus spinosus dan Cyperus kyllingia*. Kajian memilih sungkupan allelopati penghalang percambahan biji-benih rumpai, rawatan ekstrak sekoi, jerami padi, tandan kosong sawit digunakan. Jumlah benih yang bercambah direkodkan dalam tempoh 24 jam. Panjang hipokotil dan radikal diukur pada hari percambahan ke-20. Sisa allelopati menjejaskan peratusan percambahan biji benih, kecepatan percambahan, min masa

percambahan dan panjang relatif hipokotil dan radikal rumpai yang dikaji. Allelopati timun, kobis dan bunga matahari merencatkan 100% percambahan *C. rotundus* L., *A. conyzoides* L., *E. ruderalis, A. spinosus* L., and *C. kyllingia*. Sekoi, jerami padi dan tandan kosong sawit menyebabkan 30-50% pecambahan biji benih *C. kyllingia*. Hasil percambahan *C. rotundus, A. conyzoides, E. ruderalis* and *A. spinosus* adalah 10-30% dengan rawatan sekoi, jerami padi dan tandan kosong sawit. Percambahan *E. ruderalis* paling rendah apabila dirawat dengan tandan kosong sawit berbanding rumpai lain. Percambahan akhir biji benih dan pertumbuhan anak benih berkurangan 0-50% dengan sungkupan sekoi, jerami padi dan tandan kosong sawit. Kajian keberkesanan sungkupan bunga matahari dan timun dilakukan pada salad daun ditanam di ladang. Jenis dan kadar sungkupan tidak memberi kesan kepada % kelembapan tanah dan jumlah N, P, K, Mg dan Ca tanah. Jumlah kandungan fenolik dan kepekatan fenolik terlarut menunjukkan kesan tertinggi dengan sungkupan timun berbanding kawalan. Sejumlah 17 species rumpai daripada 6 keluarga terdapat dalam tanaman salad daun. Dalam plot tanpa sungkupan, terdapat sebanyak 14 species rumpai dari keluarga Poaceae, tiga species Cyperaceae, dua species Euphorbiaceae dan Asteraceae dan satu species Amaranthaceae dan Portulacaceae. Berdasarkan sum dominance ratio, lima species rumpai yang dominan djumpai ialah *C. rotundus, C. distans, A. spinosus, C. kyllingia* dan *A. conyzoides*. Sungkupan bunga matahari (5 tan/ha) dan timun (15 tan/ha) menyebabkan penurunan kepada lima jenis species rumpai. Penurunan tertinggi adalah bagi *A. spinosus*. Jumlah nisbah dorminan rumpai yang disungkup sisa bunga matahari (10 dan 15 tan/ha) adalah tinggi bagi *C. rotundus*, dan sama dengan sungkupan sisa timun pada kadar 10 tan/ha. Sungkupan timun pada kadar 5 tan/ha berjaya menghalang *C. rotundus* dalam kawasan tanaman salad daun. Sungkupan tidak mempengaruhi kualiti lepas tuai salad daun. Kesemua cirian (pH, asid tertitrat dan asid askorbik) salad daun tidak menunjukkan perbezaan berbanding rawatan tanpa sungkupan. Kadar setiap sungkupan juga tidak mempengaruhi kualiti cirian dan nutrient tanah.

Sungkupan sisa timun dan bunga matahari mengawal rumpai dengan berkesan dan boleh digunakan sebagai alternatif kepada racun rumpai. Akan tetapi, kajian perlu dijalankan pada jangka masa panjang untuk mendapat keberkesanan sisa sungkupan yang optimum.

ACKNOWLEDGEMENTS

In the name of Almighty ALLAH, Who provided me with the strength, wisdom and will to complete my master study. May His name be glorified and praised.

First and foremost, I would like to offer my heartfelt appreciation and utmost gratitude to my supervisor Associate Professor Dr. Siti Hajar Ahmad for her continuous support and invaluable guidance for my Master study, for her patience, motivation and enthusiasm. During my master study, she provided sound advice, good teaching and friendly company, and shared a lot of her expertise, research insight and best ideas. I simply could not imagine having a better advisor and friendlier mentor for Master study. I believe that one of the main gains of my master study was working with Associate Professor Dr. Siti Hajar Ahmad.

With a great deal of luck, I got an excellent Supervisory Committee. I owe an immense debt to the rest of my supervisory committee, Professor Dr. Abdul Shukor Juraimi, and Associate Professor Datin Dr. Rosenani Abu Bakar for their encouragement, insightful comments and critical review. This thesis could not have been done without their strong supervision.

I am deeply indebted to my dear family (Mr. Gembira Ketaren and Mrs Tiran Ginting), who deserve special mention for their inseparable support. To my sisters (Nurnyatalina Ketaren, Nur Dewi Eslina Ketaren), brother (Natangsa Ketaren and M. Firman Ketaren), nephew (Alvin Ginting, Hagai Ginting and Jaya Ketaren) also my brother and sister in law (Christian Ginting and Nuryanti Sasmita), thank you for being supportive and caring siblings.

I would like to thank UPM for providing Graduate Research Fellowship (GRF) and research facilities to conduct my master study.I consider it an honor to work with all the administrative and technical staffs of the Faculty Agriculture Mr. Azhar Othman. And I would like to say thank you very much to friend who help me to finished all my works and writing. Miss Nor Elliza Tajidin, Miss Azimah Hamidon, Miss Surisa Phornvillay, Miss Munirah, Miss Hamizah, Miss Fathimatul, Miss Fairuz, Miss Farah Farhana, Aisyah, Humam and Zakhwan

Bunga Raya Ketaren

I certify that a Thesis Examination Committee has met on September 2012 to conduct the final examination of Bunga Raya Ketaren on his thesis entitled "Influence of Allelopatic Mulch on Weed Growth and Postharvest Quality of Leaf Lettuce (*Lactuca sativa* L)" in accordance with the Universities and Univesity Colleges Act 1971 and the Constitution of the Pertanian Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Siti Aishah binti Hassan, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Mahmud bin Tengku Muda Mohamed, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Izham bin Ahmad, PhD
Associate Professor
Faculty of Graduate Studies
Universiti Putra Malaysia
(Internal Examiner)

Azmi bin Man, PhD
Rice and Industrial Crops Center
MARDI
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School Of Graduate Studies
Universiti Putra Malaysia

Date: 07 Januari 2013

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree Master of Science. The members of Supervisory Committee were as follows:

Siti Hajar Binti Ahmad, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Chairman)

Abdul Shukor Juraimi, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Rosenani Binti Abu Bakar, PhD
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

_____
BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

_____

BUNGA RAYA KETAREN

Date: 07 January 2013

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LIST OF ABBREVIATIONS

CEC	: Cation exchange capacity
N	: Nitrogen
P	: Phosphorus
K	: Potassium
USA	: United States of America
HPLC	: High Performance Liquid Chromatography
ATP	: Adenosine Tri-Phosphate
DNA	: Deoxyribonucleic acid
RNA	: Ribonucleic Acid
TA	: Titratable acidity
SSC	: Soluble solids concentration
TPC	: Total phenolic content
R^2	: Coefficient determination
F	: Frequency
FU	: Field uniformity
D	: Field density
MFD	: Mean field density
RA	: Relative abundance
RFMD	: Relative mean field density
EFB	: Empty fruit bunch
FGP	: Final germination percentage
AS	: Speed of accumulated germination
MGT	: Mean germination time

LSD	: Least Significant Difference
RCBD	: Randomized Complete Block Design
RDW	: Relative dry weight
Mg	: Magnesium
SDR	: Summed dominance ratio

CHAPTER I

GENERAL INTRODUCTION

The human population has increased rapidly during later half of the 20th century and dependence on agrochemicals (fertilizers, herbicides and pesticides) has increased to produce the required agricultural products. These agrochemicals, besides polluting the environment, are also hazardous to human and livestock. Hence, such practices are not sustainable and cannot remain in use forever. Poor yield, by repeated cultivation of certain crops and fruit, due to so called 'soil sickness" has been known and investigated since the begining of horticulture. Use of allelopathy is a safe alternative to overcome these problems and to achieve sustainability in agriculture and maintenance of clean environment for our future generations.

Allelopathic strategies are aimed at reducing environmental pollution and maintaining ecological balance especially soil fauna and flora through reduced use of chemical herbicides or substituting them with natural products (plant and microbial products). Allelochemicals and phytochemicals are eco-friendly and free from the problems associated with the present herbicides. Hence, allelopathy is the priority area of research in the world. Phytotoxicity is a very old component of agriculture and it is described as allelopathy by Molisch (1937). Any direct or indirect and harmful or beneficial effect by one plant (including micro-organisms) on another through production of chemical compounds that escape into the environment is called allelopathy (Rice, 1984).

Allelopathy is an important factor in determining vegetation pattern, species diversity and vegetation dynamics. It plays asignificant role in "plant–plant" and "plant–microbe" interactions, which are important in the management of one species by another mainly through biochemical interactions, affecting seed germination and seedling growth of existing species by the intruder species. These chemical compounds (allelochemicals) are released into the environment in appropriate quantities via root exudation, as leachates during litter decomposition and volatilization (Reigosa et al., 2000), are phenolic and allelopathic in nature (Cecchi et al., 2004). Allelopathy inhibition typically results from the combined action of a group of allelochemichals which collectively interfere with several physiological processes of the receiver plants and their growth and development affected. The readily visible effects include inhibited or retarded germination rate, swollen and darkened seeds, reduced root and shoot extension, swelling of root tips (Oliveira et al., 2004), curling of the root axis, discoloration, lack of root hairs and lateral roots (Burgos et al., 2004), increased number of seminal roots, reduced dry weight and lowered reproductive capacity (Rice, 1979).

Alelopathy in plant residue include plant or their parts deliberately left in the field soil for decomposition after the crop has been harvested (Kumar and Goh, 2000). These are considered as natural resource rather than waste because of their usefulness to the fields. Their decomposition by the microbial action improves the physical, chemical and biological properties of the soil and also adds a number of carbon end products and several other nutrients to the soil system. This process of decomposition depends upon the kind of plant residue as several edaphic factors

(Kumar and Goh, 2000). The main concern regarding the crop residues is their allelopathic effect on other or same crop plants (Thorne et al., 1990). The decomposting crop residue releases a variety of allelochemicals, particulary, in the soil causing adverse effects on the other plants (Nelson, 1996). They are known to reduce nodulation and biological nitrogen fixation in legumes (Heckman and Kluchinski, 1995).

Allelopathic effects, strong enough to contribute significantly to weed control in field conditions, have been documented for rye, sorghum and sorghum–sudangrass hybrids, sunflower, cucumber, rapeseed, buckwheat, and subterranean clover (Putnam and Tang, 1986; Rice, 1995; Boydston and Hang, 1995). Hence, there is a need for weed free maintenance during early crop growth. Manual weeding is laborious, time consuming and non-economical. The chemical method of weed control offers pollution and health hazards. As such, onion being vegetable crop use of chemicals has to be discouraged. Allelopathic is an interaction between plant and other organisms that offers alternative uses in agriculture including decreasing dependence on synthetic pesticide for the control of pests, diseases and weeds (Saxena et al., 1996).

Allelopathy offers potential for bio-rational weed control through production and release of allelochemicals from leaves, flowers, seeds, stems and roots of living or decomposing plant materials. Under appropriate conditions, allelochemicals may be released in a quantity which suppress the developing weed seedlings and often exhibit selectivity similar to synthetic herbicides (Weston, 1996). Grundy et al;

(1998) reported that crop plant suppressed weed development physiologically through superior vigor by release of phytotoxins or combinations of both allelopathy may have been a factor in few crops that did reduce weed seedling emergence. The suppression of weeds by crops should be exploited to improve weed control.

Lettuce (*Lactuca sativa* L.) is the leading leafy vegetable worldwide with an estimated production of 23 million tons in 2007 (Food Agriculture Organization of the United Nations, 2007). In Malaysia, the planted acreage for vegetables was 53,057 ha, with a production of 874,602 tons in 2010. For lettuce, acerage was 2,297 ha with a production of 38,790 ton (Ministry of Agriculture and Agro-Based Industry Malaysia, 2011). Lettuce is widely eaten fresh and commonly grown as a hydroponic crop. However, only the local leaf lettuce is commonly grown on soils. Naturally, weeds become the main problem of growing crop in soils, and their control by the application of herbicides cause hazard to the environment. For this reason the use of allelopathic mulch to control weed is an alternative to herbicide control.

The research information is in adequate on allelopathic residue effect with potential in controlling common weeds of vegetables. Such information will help to develop organic herbicides which are environmentally safe and cost effective. Identification of suitable botanicals with herbicidal properties and formulations is gaining a special importance in organic farming. Although many botanicals are reported to have allelopathic properties but information on their compatibility with field crops, effective active ingredient, extraction and utilization technology are lacking.

Postharvest priorities across the globe have evolved considerably over the past four decades, from being exclusively technical in their outlook, to being more responsive to consumer demand. Consumer-driven trends which have contributed to this shift include rising incomes in urban areas, changing dietary habits, more women in the work-place, reduced time for meal preparation and growing demand for safety, quality and convenience. Other factors such as globalization, urbanization and the need to achieve efficiencies and reduce costs have also contributed significantly to this shift in priorities and continue to re-shape and restructure the fresh produce sector.

Due to an increasing concern about possible human health risks and undesirable environmental effects associated with the use of synthetic chemicals in conventional apple production, some growers are interested in organic apple production, which does not involve the use of synthetic mineral fertilizers, pesticides, herbicides, fungicides, and growth regulators. Organic production relies on crop rotation, crop residues, manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks, and biological pest control to maintain soil fertility and productivity, supply plant nutrients, control insects and weeds, and other pests (Consumer and Corporate Affairs Canada, 1988).

Much work, however, needs to be done across the region in order to promote quality and safety consciousness, and in particular to assure the use of water of appropriate quality in pre- and postharvest operations, as well as the appropriate use of pesticides, herbicides, fungicides and fertilizers during the production of fruits and

vegetables. The implementation of regulatory frameworks which govern food safety and quality, laboratories and quality assurance services is required in many countries across the region (Rosa, 2006).

The safety of our food supply is important to agribusiness as well as to consumers. Today, there is a high demand for our food supply to be free of potentially toxic substances including those used in the production of raw products. During the production and processing of agricultural commodities, various chemicals and foreign substances may enter food commodities. These chemicals are considered indirect or non-intentional food additives. Pesticides used in the production of raw products are among the most common indirect food additives. Most pesticides are acutely toxic and can produce adverse health effects in humans and animals when ingested at low levels over long periods of time (Smith, 2000). Keeping the above points in view, a study was carried out to identify allelopathic mulch for sustainable weed control of leaf lettuce and determine its effect on growth performance and postharvest quality characteristics. Following specific objectives :

1. To identify common weeds in a vegetable field
2. To select the mulch (plant residue) that inhibit weed seed germination
3. To determine effectiveness of selected mulch in reducing weed competition in a field-cultivated leaf lettuce
4. To determine the allelopathic mulch effect on postharvest quality characteristics of leaf lettuce

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