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EVALUATION OF INSECT ATTRACTANT ON POLLINATION AND FRUIT SET OF CUCUMBER (*Cucumis sativus* L.)

SANTY BINTI KARIM

DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF AGRICULTURE SCIENCE WITH HONOURS

HORTICULTURE AND LANDSCAPING PROGRAMME
SCHOOL OF SUSTAINABLE AGRICULTURE
UNIVERSITI MALAYSIA SABAH
2010

DECLARATION

I hereby declare that this dissertation is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that no part of this dissertation has been previously or concurrently submitted for a degree at this or any other university.

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ABSTRACT

This research was conducted at School of Sustainable Agriculture Field Laboratory in Universiti Malaysia Sabah, to evaluate the effect of insect attractant on pollination and fruit set of cucumber (*Cucumis sativus* L.). The objectives of this study were to evaluate the effectiveness of insect attractant in attracting pollinators and to examine the effect of the attractant on pollination and fruit set of cucumber. The experimental design was Completely Randomized Design. There were three treatments; plants sprayed with sugarcane juice at 10% concentration (v/v), jaggery solution at 10% concentration (w/v) and a control (no spray); each replicated five times. The attractants were sprayed at 7.00 am in the morning, five times and at two day intervals. Number of insect visit, percentage fruit set, individual fruit weight, length, circumference, fruit shape and seed numbers were measured. Data were then analyzed using One-way ANOVA. The results showed that, sugarcane juice at 10% concentration (v/v) significantly increased insect visit by 44±4.92 times, individual fruit weight (4.35±17.03 g), circumference (19.5±0.27 cm), seed number (181 seeds) and improved fruit shape (12% of defective fruits) compared to the control. Meanwhile, jaggery solution at 10% concentration (w/v) only increase insect visit by 37±2.86 times, seed number (123 seeds) and fruit shape (15% of defective fruits) with compared to the control. This study clearly demonstrated that the yield and quality of cucumber crops can be enhanced by using pollination attractant under conditions of low population of pollinators. A further investigation is required to make appropriate recommendations for an optimum concentration of the attractants and time of application.

PENILAIAN TERHADAP BAHAN PENARIK SERANGGA DALAM PENDEBUNGAAN DAN PEMBENTUKAN BUAH TIMUN (*Cucumis sativus* L.)

ABSTRAK

Satu kajian dijalankan di Makmal Ladang, Sekolah Pertanian Lestari, Universiti Malaysia Sabah, untuk menilai kesan penggunaan bahan penarik serangga terhadap pendebungaan dan pembentukan buah bagi tanaman timun (*Cucumis sativus* L.). Objektif kajian ini adalah untuk menilai keberkesanan bahan penarik serangga dalam menarik agen pendebunga dan mengkaji kesan bahan tersebut terhadap pendebungaan dan pembentukan buah timun. Reka bentuk eksperiman yang digunakan ialah Rekabentuk Rawak Lengkap dan mempunyai tiga rawatan iaitu; semburan dengan menggunakan air tebu dengan kepekatan 10% (v/v), larutan jaggery dengan kepekatan 10% (w/v) dan kawalan (tanpa semburan); Setiap rawatan mempunyai lima replikasi. Penyemburan dilakukan pada jam 7.00 pagi, dengan bilangan semburan sebanyak lima kali dan setiap selang dua hari. Bilangan lawatan serangga, peratus pembentukan buah, berat, panjang, ukur lilitan, bentuk buah dan bilangan biji benih bagi setiap buah diukur. Data dianalisis dengan menggunakan ANAVA satu hala. Keputusan menunjukkan air tebu dengan kepekatan 10% (v/v), meningkatkan kadar lawatan serangga sebanyak 44±4.92 kali, berat (4.35±17.03 g), ukur lilitan buah (19.5±0.27 cm), bilangan biji benih (181 biji), dan memperbaiki bentuk buah (12% buah tidak sempurna) berbanding dengan kawalan. Manakala, larutan jaggery dengan kepekatan 10% (w/v) hanya meningkatkan kadar lawatan serangga sebanyak 37±2.86 kali, bilangan biji benih (123 biji) dan bentuk buah (15% buah tidak sempurna) jika dibandingkan dengan kawalan. Kajian ini jelas menunjukkan bahawa hasil dan kualiti buah timun boleh ditingkatkan dengan menggunakan bahan penarik serangga. Kajian terperinci perlu dilakukan untuk menentukan kepekatan optimum yang perlu digunakan dan masa penyemburan yang berkesan.

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^{0}C	degree of celsius
>	more than
<	less than
%	percentage
=	equal to
cm	centimeter
g	gram
kg	kilogram
m	meter
mg	miligram
mm	milimeter
ANOVA	Analysis of variance
CRD	Completely Randomized Design
IPM	Intregated Pest Management
MARDI	Malaysia Agriculture Reserch and Developemenr Institute
SSA	School of Sustainable Agriculture
SPSS	Statistical Package of Social Science
UMS	Universiti Malaysia Sabah

LIST OF FORMULAE

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Almost all cultivated crops including the staples are obtained from flowering plants (angiosperms) which, by their very nature, require the deposition of pollen (containing the male genetic material) onto the female reproductive floral structures (containing the ovules) to produce seed. It is through seeds that virtually all angiosperms perpetuate themselves; and cross-pollination, through its effects on increased seed vigor and recombination of diverse genetic material within a given plant species. Cross pollination is also responsible for the ability of angiosperms to adapt, establish and diversify under unique, often changing and sometimes formidable environmental conditions. Pollination, accomplished through various means, is thus responsible for much of earth's present biodiversity. The two major agents of pollination are wind and insects.

For many crops, the need for insect pollination arises from the spatial isolation of the sexual reproductive structures. For example, most cucurbits are monoecious, bearing separate male (staminate) and female (pistillate) flowers. Insects are needed to transfer pollen from the male flowers to the stigma of female flowers for pollination and ovule fertilization to occur. Some crops such as apple and almond have prefect or hermaphroditic flowers that contain both male and female reproductive structures within the same flower; but these crops also require insect's pollination as most cultivars are self-infertile and therefore rely on cross-pollination to form viable seeds which then triggers fruit development. Yet, other crops produce flowers that are both hermaphroditic and self-fertile, but still need insect visitation under certain conditions to set fruit or because of the highly adhesive nature of the pollen grains.

The need for an abundance of insect pollinations is very easily demonstrated with cucurbit (Cucurbitaceae) crops. Almost all cucurbits are monoecious and all of them produce relatively large, sticky pollen grains; and also require the active transfer of pollen from male to female flowers for fruit set to occur. For most cucurbits, pollination must occur within a relatively short time period, as pollen viability and stigmatic receptivity of individual flowers are typically less than 24 hours (Free, 1993). Under growing conditions in some places such as Carolina, floral receptivity may only last a matter of hours, thereby requiring numerous and efficient pollinators to pollinate the flowers while they are still receptive.

Cucumber (*Cucumis sativus* L.) is a member of Cucurbitaceae and highly cross-pollinated crop. Pollination is mainly by honey bees, solitary bees, wasps and other insects. Any material that increases honey bee visit to the crop would be of great practical value to harvest the benefit of cross pollination. Thus, insect attractant is a promising way to increase insect visitation and the pollination process.

Local insect attractants have been used to boost the yield of pear, peach, blue berry, watermelon and apple. However, the study was managed in India and other countries in Europe (Pateel and Sattangi, 2007). In Malaysia, farmers do not use any insect attractant to attract pollinating agent to their farm; orchard or vegetables. Crops are planted in the open and pollination is allowed to occur naturally. Unavailability of insect attractants in the market and lack of information about their effects on crop quality and productivity are some of the reasons for this situation.

Some studies have been done on pollination of cucumber but no attempt has been made to explore the possible use of insect attractant to boost the productivity of cucumber in Malaysia. Hence, this study was conducted to evaluate the efficiency of locally available insect attractants to attract more number of bees and other pollinators to cucumber flower and the effect of pollination on fruit set of cucumber.

1.2 Justification

Cucumber was chosen as the planting material because it is a pollinated crop and has a short shelf life. This crop is also easy to plant and has high adaptability to most soil types and various environmental conditions.

This study is important to determine the potential use of insect attractants in attracting pollinating agents and their effect on fruit set, quality and yield. If successful, it will help farmers to increase their cucumber production without additional planting space. This would generate income and thus, increase profit. By using local insect attractants which are easily prepared, the cost of production will be minimized compared to imported products.

Evaluation of insect attractants using sugarcane juice and jaggery solution can be done by examining its effectiveness in attracting pollinators. However, further study needs to be conducted for different compounds as a means to produce more effective insect attractants.

Hence, this study is very important because it will provide a guide for further researches to study about the use of insect attractants to boost pollination and improve fruit set as well as fruit quality.

1.3 Objectives

This study was therefore conducted with the following objectives:

1. To evaluate the effectiveness of insect attractants in attracting pollinators to cucumber crops.
2. To examine the effect of insect attractants on pollination and fruit set of cucumber.

CHAPTER 2

LITERATURE REVIEW

2.1 Cucumber

Cucumber is one of the most important cucurbit vegetables, primarily grown for its tender fruits for salad purposes and for pickling. Fruits are also used as cooked vegetables. Fruits have cooling effect and are used by patients suffering from jaundice, constipation and indigestion. The seed oil has antipyretic properties while the fruits contain 0.4 g protein, 0.3 g minerals, 0.4 g fiber, 10 mg calcium, 0.6 mg iron, 423 mg chloride and 2 mg vitamin C per 100 g (Gopalakrishnan, 2007).

2.1.1 Taxonomy

The family Cucurbitaceae comprises about 117 genera and 825 species in warmer parts of the world (Gopalakrishnan, 2007).

Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Cucurbitales

Family: Cucurbitaceae

Genus: *Cucumis*

Species: *C. sativus*

2.1.2 Origin and Distribution

Cucumber is a native of India and the crop has been cultivated for 3000 years in the country. Most of the local types grown in the country are cultivated types. Wild forms under *Cucumis sativus* are scanty. A wild type, *C. hardwickii* with small bitter fruits having sparse and stiff hairs is found in foothills of Himalayas. This wild species, considered as the progenitor of *C. astivus*, crosses freely with cultivated forms (Gopalakrishnan, 2007).

2.1.3 Botany

The cucumber is a creeping vine that roots in the ground and grows up trellises or other supporting frames, warping around ribbing with thin, spiraling tendrils. The plant has large leaves that form a canopy over the fruit. The fruit is nearly cylindrical, elongated, with tapered ends, and may be as large as 60 cm long and 10 cm in diameter. Cucumbers are usually over 90 % water. Having an enclosed seed and developing from a flower. Botanically speaking, cucumbers are classified as fruits. However, much like tomatoes and squash they are usually perceived, prepared and eaten as vegetables (Gopalakrishnan, 2007).

2.1.4 Growing Condition

According to Gopalakrishnan (2007), cucumber is a warm season crop and cannot withstand even light frost. It prefers dry climate with bright sunshine. Compared to other cucurbits, cucumber comes up well in slightly lower temperature of 18-24 ^{0}C. Above 30 ^{0}C, female flower production is reduced considerably. Under high humid conditions, incidence of diseases like powdery mildew, downy mildew, anthracnose and pests like fruit fly, serpentine leaf miner will be severe.

Cucumber prefers a well drained sandy loam for early crop and clay for heavy yield. The crop cannot withstand water stagnation. The ideal soil pH is 5.5 to 6.7.

2.2 Bees

Bees are flying insects closely related to wasps and ants, and are known for their role in pollination and for producing honey and beeswax. Bees are found on every continent except Antarctica, in every habitat on the planet that contains insect-pollinated flowering plants.

2.2.1 Taxonomy

Bees are monophylectic lineage within the superfamily Apoidea, presently classified by the unranked taxon name anthophila. There are nearly 20,000 known species of bees in seven to nine recognized families, though many are undescribed and the actual number is probably higher (Delaplane and Mayer, 2000).

Kingdom: Animalia

Phylum: Arthropoda

Class: Insecta

Order: Hymenoptera

Suborder: Apocrita

Superfamily: Apoidea

Family: Andrenidae,
Apidae,
Colletidae,
Dasypodaidae,
halictidae,
Megachilidae,
Meganomiidae,
Melittidae,
Stenotritidae

2.3 Insect Pollinator of Cucurbitaceae

There are a number of insects which act as pollinating agent for Cucurbitacea. Pollinators are important to assist in transferring pollen grains from the anthers of male flowers to stigmas on female flower. The following sectors describe the numbers of insect taxa that exhibit characteristics amenable to their exploration as pollinators of commercial crops. The general biology and behavior, as they pertain to pollination, are addressed.

2.3.1 Honey Bees (*Apidae: Apinae*)

Honey bees have long dominated the commercial pollination scene. Their ability to pollinate a diversity of crops under a wide range of environmental conditions (e.g., tropical vs. temperate) is well documented (Free, 1993). Although there are several recognized species of *Apis*, only *Apis melifera* L. is the main pollinator used commercially worldwide.

Honey bees are social insects that exist on a perennial basis; therefore, they are available for crop pollination throughout the entire year in the tropics, and most of the year in temperate regions. Due to their large population sizes (30,000 or more individuals per colony), considerable amounts of pollen and honey must be collected and stored for colony growth, maintenance and successful overwintering. This high demand for food results in visitation of millions of flowers over the course of a year by any single colony. All honey bee-pollinated crops produce at least some collectible pollen or nectar, and will thus receive bee visitation. Since honey bees overwinter as a colony, they are also of considerable value in the pollination of early flowering crops, especially since solitary and subsocial bee populations will be minimal during this time of year.

Honey bees are also polylectic; they visit hundreds, if not thousands of different plant species to collect pollen and nectar. In general, being polylectic is an advantageous trait in terms of crop pollination, as honey bees can be used to pollinate a vast number of crop species which possess a diversity of floral architectures. Honey bees, may be less effective on selected plants than other bee types, but over all, they are well adapted to pollinate many crops (Stanghellini, 2000). Honey bees are able to communicate the direction, distance and quality of different floral resources through their so called 'dance language'. As a result of this communication system, crops that provide high quality or an abundance of floral rewards would attract a large proportion of the foraging force within a given colony of bees.

2.3.2 Bumble Bees (*Apidae: Bombinae*)

The role of bumble bee pollination in natural and cultivated crops situations has long been known. Worldwide, 250 to 300 species of *Bombus* are estimated (Prys-Jones and Corbet, 1991). The vast majority thrives in temperate regions, with very few species occurring in the tropics; and even then, they are largely limited to areas of relatively high altitude with low ambient temperatures (Corbet, 1999).

The possibility of using commercial *Bombus* colonies for the pollination of field crops has received attention. Preliminary success has been reported on various crops such as almond, apple, apricot, blueberry, brambles, cherry, cucumber, field bean, raspberry and watermelon (Gooddell and Thomson 1997; Richards and Mayers 1997). There are a number of attributes possessed by *Bombus* spp. that contribute to their efficiency in crop pollination. The commercial availability of their colonies offers a new and reliable alternative to honey bee or mechanical pollination. Once attaining a social state, a single colony may contain enough forage to adequately pollinate some crops under certain conditions very efficiently. Weber (1990) notes that bumble bees have a greater ability to adapt to small flight space compared to honey bees. Commercial availability also allows the colonies to be used on crops that may require higher colony stocking rate per unit area. The polylectic nature of *Bombus* also gives them the potential to serve as pollinators of a large number of crops.

Physical and behavioral attributes also contribute to *Bombus* efficiency. Their larger body size compared to honey bees makes them better pollinators for crops with relatively large flowers (e.g., squash) or long corolla tube (e.g., red clover) (Free, 1993). The combination of larger body size and specific foraging behaviors may also make them more efficient than honey bees on some crops, as demonstrated by Gooddell and Thomson (1997), who showed that apple pollen deposition by *Bombus* was greater than that performed by *Apis melifera* due to body size differences. The ability of bumble bees to forage at faster rates than honey bees has also been reported on a number of crops including alfalfa, raspberry, red clover, sunflower and field bean (Wilmer *et al.*, 1994). Bumble bees floral visitation rates are typically two to three times

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