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FLORAL CHARACTERISTICS AND FLOWERING BEHAVIOUR OF SARAWAK PEPPER (Piper nigrum L.) USING EXAGENOUS HORMONES

FIDELIA JOHNY

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By

FIDELIA JOHNY

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Chair : Assoc. Prof. Noorasmah binti Saupi, PhD
Faculty : Agricultural Science and Forestry (Bintulu Campus)

Piper nigrum L. is important cash crops in Sarawak and recently the productivity has been consistently low due to low yield production. Inconsistent of blooming time due to the morphology and heredity of functional male, female, and hermaphrodite flowers in a single spike became one of the factors affected harvesting. As for the exploitation of maximum production, detailed of flower development and composition are important factors to consider. Therefore, the study aims to (i)evaluate the status of pepper farming and flower composition in pepper cultivar varieties in Sarawak, (ii)evaluate the phenology of Sarawak pepper and, (iii)determine the effect of different concentrations of exogenous hormones on berries production. To record farming practices, field surveys were undertaken at 20 pepper farms in Sarawak, and spike samples were selected at random from three pepper vines for each pepper cultivar, namely "Kuching," "Semongok Aman," and "Semongok Emas" then were observed under microsope. Phenology study on "Kuching" cultivar was to identified floral development and two exogenous hormones, then Auxin NAA and Gibberellic acid GA3, were used to increase the hermaphrodite flowers of the "Kuching" cultivar. Four concentrations, i.e., 0 ppm, 10 ppm, 25 ppm, and 50 ppm then applied in a single application during pre-blooming stages. Study found 21% of farmers reported the un-synchronization of berries production in each harvesting time was one of the major constraints in their farming. The composition of flowers found to be varied between cultivar and supported previous pepper farm status where "Kuching" cultivar had less hermaphrodite flower compared to "Semongok Aman" and "Semongok Emas". Nine main stages of inflorescence development (ID) in "Kuching" cultivar and flower sex begin to emerge during the sixth stage with ranged of full berry development takes between 103-150. As for the application of exogenous hormone, GA3 at 25 ppm has the higher percentage of hermaphrodite with 76.62% after 2 weeks of application. The observation continued and showing that vine applied with 25 ppm of NAA up to 83.13% of hermaphrodite. Further, observation continued until week 12 and both GA3 and NAA reported to produce more synchronize berries with 96.01% and 91.87% respectively. Hence, study on the effects of hormones to the growth of hermaphrodite flowers can discover the best types and concentrations hormones to continuously enhance pepper production. Therefore, future

studies on economic management including cost assessment of exogenous hormone application, are aspects that need to be considered to describe the economic aspects for small pepper farmers especially in Sarawak to obtain maximum yield through more evenly ripe berry production.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Master Sains

CIRI-CIRI FLORA DAN SIFAT PEMBUNGAAN LADA SARAWAK (*Piper nigrum* L.) MENGGUNAKAN HORMON EKSOGEN

Oleh

FIDELIA JOHNY

Disember 2021

Pengerusi : Prof. Madya. Noorasmah binti Saupi, PhD
Fakulti : Sains Pertanian dan Perhutanan (Kampus Bintulu)

Piper nigrum L. merupakan satu tanaman kontan yang penting di Sarawak dan baru-baru ini, produktiviti *P.nigrum* secara konsisten rendah disebabkan oleh pengeluaran hasil yang rendah. Tempoh masa bunga mekar yang tidak konsisten kerana morfologi dan bawaan bunga jantan, betina, dan hermafrodit yang berfungsi dalam satu "spike" menjadi salah satu faktor yang mempengaruhi penuaian. Bagi mengeksploitasi pengeluaran maksimum, perincian mengenai perkembangan dan komposisi bunga adalah faktor penting untuk dipertimbangkan. Oleh itu, kajian bertujuan untuk (i) menilai status penanaman lada dan komposisi bunga dalam varieti kultivar lada di Sarawak, (ii) menilai fenologi lada Sarawak dan, (iii) menentukan kesan kepekatan berbeza hormon eksogen terhadap pengeluaran buah beri. Untuk merekodkan amalan pertanian, tinjauan lapangan telah dijalankan di 20 ladang lada dalam Sarawak, dan sampel "spike" dipilih secara rawak daripada tiga pokok lada untuk setiap kultivar, iaitu "Kuching," "Semongok Aman," dan "Semongok Emas" seterusnya diperhatikan di bawah mikroskop. Peringkat perkembangan bunga ditentukan dengan menjalankan kajian fenologi ke atas kultivar "Kuching" dan Auxin NAA dan Asid Gibberellic GA3, digunakan untuk meningkatkan bunga hermafrodit kultivar "Kuching". Empat kepekatan berbeza, iaitu, 0 ppm, 10 ppm, 25 ppm, dan 50 ppm kemudiannya digunakan dalam satu aplikasi semasa peringkat pra-mekar. Kajian menemukan 21% petani melaporkan ketidakseragaman pengeluaran beri dalam setiap masa penuaian merupakan salah satu kekangan utama dalam penanaman mereka. Komposisi jenis bunga didapati berbeza antara kultivar, dan menyokong status ladang lada sebelumnya dimana kultivar "Kuching" mempunyai bunga hermafrodit yang lebih rendah berbanding "Semongok Aman" dan "Semongok Emas". Sembilan peringkat utama perkembangan perbungaan (PP) dalam kultivar "Kuching", dan jantina bunga mula muncul semasa peringkat ke-enam, dengan julat perkembangan bunga kepada buah beri mengambil masa di antara 103-150 hari. Bagi penggunaan hormon eksogen, GA3 pada 25 ppm mempunyai peratusan hermafrodit yang lebih tinggi iaitu 76.62% selepas 2 minggu penggunaan. Pemerhatian berterusan menunjukkan bahawa pokok lada yang disembur dengan 25 ppm NAA sehingga 83.13% hermafrodit. Selanjutnya, pemerhatian diteruskan sehingga minggu ke-12 dan kedua-dua GA3 dan NAA dilaporkan menghasilkan lebih banyak keseragaman beri dengan masing-masing

adalah 96.01% dan 91.87%. Oleh itu, kajian tentang kesan hormon terhadap pertumbuhan bunga hermafrodit telah menemui jenis dan kepekatan hormon terbaik untuk meningkatkan pengeluaran lada secara berterusan. Oleh itu, kajian pada masa depan mengenai pengurusan ekonomi termasuk penilaian kos aplikasi hormon eksogen, merupakan aspek yang perlu diberi perhatian untuk menerangkan aspek ekonomi bagi petani lada kecil khususnya di Sarawak untuk memperoleh hasil maksimum melalui pengeluaran beri yang lebih masak sekata.

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I certify that a Thesis Examination Committee has met on 13 December 2021 to conduct the final examination of Fidelia Johny on her thesis entitled "Floral Characteristics and Flowering Behaviour of Sarawak Pepper (*Piper nigrum* L.) using Exagenous Hormones" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra 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:

Patricia King Jie Hung, PhD
Professor
Faculty of Agricultural and Forestry Sciences (Bintulu Sarawak Campus)
Universiti Putra Malaysia
(Chairman)

Phebe Ding, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Internal Examiner)

Asmah Awal, PhD
Professor Ts.
Faculty of Plantation and Agrotechnology
Universiti Teknologi MARA
Malaysia
(External Examiner)

SITI SALWA ABD GANI, PhD
Associate Professor ChM. and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 1 August 2022

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

Noorasmah binti Saupi, PhD
Associate Professor
Faculty of Agricultural Science and Forestry
Universiti Putra Malaysia, Bintulu Campus
(Chairman)

Shiamala Devi a/p Ramaiya, PhD
Senior Lecturer
Faculty of Agricultural Science and Forestry
Universiti Putra Malaysia, Bintulu Campus
(Member)

_____
ZALILAH MOHD SHARIFF, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

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Signature: _____
Name of Chairman of Supervisory Committee : Assoc. Prof. Noorasmah Binti Saupi

Signature: _____
Name of Member of Supervisory Committee : Dr. Shiamala Devi a/p Ramaiya

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

2,4-D	2,4-Dichlorophenoxyacetic acid
BA	Benzyl Adenine
GA3	Gibberellin acid
IAA	Indole-3-acetic acid
IBA	Indole-3-butyric acid
K	Potassium
MPB	Malaysian Pepper Board
N	Nitrogen
NAA	1-Napthaleneacetic acid
P	Phosphorus

CHAPTER 1

INTRODUCTION

1.1 Study background

Piper nigrum. L is mainly cultivated for its fruit and is widely known as the "King of Spices" or "Black Gold" and one of the most wildly used spices in the world (Ravindran, 2005; Zhang *et al*., 2015) and known for the value in its constituent part of its essential oil (Abdulazeez *et al*., 2016). Scientifically, *P. nigrum* has two main components which is the volatile oil, and a pungent component, commonly known as piperine (Parthasarathy *et al.,* 2007). Therefore, this perennial vine that belong to family of *Piperaceace* (Izzah and Wan Asrina, 2019) is particularly well-known for its vast culinary applications and has been widely employed in food seasoning since the flavour and pungency integrate well with most savoury meals (Khew *et al.,* 2019). Khew *et al.* (2019) also mentioned in their study that pepper spices also play a role in the pharmacological industry and as for Malaysia, the cultivation of the pepper area and the export value are increasing and become part of Malaysia's economic profit, where *P. nigrum* price is the significant determinant of the total revenue of Malaysia, particularly for the state of Sarawak as *P. nigrum* or pepper cultivating is one of source of livelihood for majority pepper farmers in the state (Kiong *et al.,* 2010). In addition, although few countries are well known for pepper production globally, Malaysia is currently placing in the fifth world largest producers of peppers by representing 5.9% of total production in the world with 31,7073 tonnes during the year 2018 (Malaysian Pepper Board, 2018), and this proves that Malaysia is a potential country for Pepper production where, covered about 16,300 ha in 2015 and showed 33% growth compared to 12,235 ha in the year 2006 (International Pepper Community, 2017). As Geographical Index (GI), *P. nigrum* grown in Sarawak has been known and patented as Sarawak pepper. Sarawak pepper comes in three high-yielding varieties, *i.e.*, "Kuching", "Semongok Emas", and "Semongok Aman". However, various important issues are occurring in pepper industry, resulting in a decline of pepper yields in Sarawak. As for example, due to staggered and delayed spiking in *P.nigrum* , lack of hermaphrodite (bisexual) flowers, diseases problems such as anthracnose, and spike shedding, *P. nigrum* have poor fruit set or spike intensity in Sarawak.

In inflorescence development, the first inflorescence in the form of spike start to emerge after six months of planting (Malaysian Pepper Board, 2011). However, the first inflorescence or spike will be pruned to enhance the growth of the vegetative component or plant canopy. The flowers are protogynous but in the absence of an active pollen transfer mechanism, protogyny becomes inefficient in ensuring outbreeding (Ravindran *et al.,* 2000). Malaysian Pepper Board (MPB) recommended practices encourage flowering in January and fruit sets collected before July each year, but it always depends on timing of *P. nigrum* were planted. Therefore, various cultural practices need to be timed in relation to their critical stages of growth, especially during flowering and fruit set to achieve high productivity of pepper. Studies done by DeWard and Zeven (1969) found that hermaphroditism varies from cultivar to cultivar and determines productivity to a large extent and this character is genetically controlled. In addition, Venugopal *et al.*

(2013) found that the cultivars that shows great variability in the composition of hermaphrodite, female and male flowers in their spikes affecting the final yield as highly packaged inflorescences or larger anther primordial per flower cause the reduction in anther number (Manos and Jaramillo, 2001).

Apart from that, Satheeshan, (2000) statement also support that the productivity of *P. nigrum* is highly dependent on the growth and behaviour of the vine, where the critical stages in determining the yields of pepper occur during flowering stages. Hence, to exploit the maximum production potential in pepper, a detailed and deep understanding of growth and the flowering pattern is indeed important. A previous study was done by Ravindran *et al.* (2000) stated that a high percentage of hermaphrodite which is the bisexual flower, is essential for effective pollination and fruit set development. Therefore, the study of flowering composition, which is the number of hermaphrodites, male and female flowers in a spike considered important to determine the yield in *P. nigrum* and Sarawak pepper, respectively. Previously, *P. nigrum* production has been declining since the early 1980s, potentially arise to pest and disease outbreaks as well as labour constraints (Chen *et al*., 2018; Paulus, 2007) but according to Khew *et al.* (2019), one of the critical constraints in pepper output is the non-synchronous maturity of flower growth and non-uniform fruit ripening. This is related to the shape and heredity of functional male, female, and hermaphrodite flowers, which affect pepper productivity.

Low fruit set or spike intensity in *P. nigrum* is due to staggered and delayed spiking, lower bisexual flowers, and spike shading causing the flower of each spike are not synchronized to develop, which will affect the full formation of berries in pepper spike and several methods for improving pepper flowering and yield production have been documented where pruning is one way to enhance the creation of main shoots and induce the development of lateral shoots that include flowers and fruits (Thangaselvabal *et al*., 2008). In India, spraying 1% complex fertilizers 19:19:19 (N:P:K) three times at three-week intervals from primordial flower initiation to flowering period can increase the yield (Krishnamurthy *et al*., 2013). Thus, the objectives of this study were to 1) evaluate the status of pepper farming and flower composition in pepper varieties in Sarawak, 2) evaluate the phenology of "Sarawak pepper" in cultivar "Kuching", and 3) determine the effect of different concentrations of exogenous hormones on berries production.

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BIODATA OF STUDENT

Fidelia Johny was born on September 16, 1992, in Papar, Sabah. She began studying with an agricultural background in 2009 at Sekolah Menengah Teknik Lahad Datu in Farm Management courses, and she was interested in agricultural studies at the time. Previously, she was a Diploma student at Kolej RISDA Melaka, where she earned a Diploma of Agriculture in 2014, and then pursued her Bachelor's degree at Universiti Putra Malaysia (UPM) Bintulu Campus, where she earned a Bachelor of Science in Bioindustry in 2017. Botany and ethnobotany were her interested field to study.