



UNIVERSITI PUTRA MALAYSIA

***GROWTH AND NUTRITIONAL QUALITY OF *Cosmos caudatus* Kunth AS
AFFECTED BY RATES OF ORGANIC AND INORGANIC FERTILIZERS AND
POST HARVEST COOLING***

SALUMIAH BINTI MIJIN

FP 2014 12



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**MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA**

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By

SALUMIAH BINTI MIJIN

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

March 2014

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DEDICATION

This thesis is dedicated to my beloved husband and son, Abdul Sadar Abuda and Abdul Arief Anaqiey, who taught me to hope, believe and have faith



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

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By

SALUMIAH BINTI MIJIN

March 2014

Chairman: Associate Professor Siti Aishah Hassan, PhD
Faculty: Agriculture

A study was conducted to determine the effects of fertilizer sources and rates on growth, physiology and phytonutritional quality of *Cosmos caudatus*, a herbal species that is normally consumed fresh as a salad. A factorial experiment was conducted in randomized complete block design with three replications. Two types of fertilizer namely inorganic compound fertilizer (15%N: 15%P₂O₅: 15%K₂O) and organic based fertilizer (8%N: 8%P₂O₅: 8%K₂O) were applied at five different rates based on nitrogen rate ranging from 0, 30, 60, 90 and 120 kg N/ha. Growth and physiological data were collected during vegetative stage and phytochemical content were measured at harvest.

The vegetative growth of *C. caudatus* was significantly affected by rates and sources of fertilizer used. Plants receiving inorganic compound fertilizer were taller and had higher biomass, more branches and greater total leaf area as compared to organic fertilized plants. Fertilizer sources had no significant effect on the leaf nutrient content. However, increasing amount of fertilizer applied increased the macronutrient content. Photosynthetic rate was significantly increased with increasing fertilizer rates. For plants treated with organic fertilizer, the ascorbic acid content increased with fertilizer rates but decreased at the highest fertilizer rate. Fertilizer rate 90 kg N/ha appeared to be sufficient for optimum biomass production. Inorganic fertilizer resulted in leaves containing higher nitrate and lower antioxidant activity.

Based on the identified optimum fertilizer rate, postharvest shoots during storage of organically and inorganic fertilized plants was carried out. The young shoots of 12 weeks old plants were harvested and divided into two groups. Comparisons were made between samples that were hydro-cooled and were left non-precooled at ambient temperature after harvest. Fertilizer sources did not show differences in water loss, visual appearance, pH and

total chlorophyll content of *C. caudatus*. However, vitamin C and carotenoids contents of organic-fertilized plants were significantly higher than inorganic-fertilized plants. Hydro-cooling treatment has significant effect on the young shoot quality where less water loss, better visual appearance and higher content of vitamin C, total chlorophyll and carotenoids in hydro-cooled shoot as compared to control. The quality of *C. caudatus* shoot decreased as storage day progressed. In short, organic fertilizer could enhance richer vitamin C and carotenoids content in *C. caudatus* which is essential while consuming salad. Hydro-cooling is essential to retain postharvest quality of this shoot.

Different rate and sources fertilizer application had effects on growth performances and phytonutritional content of *C. caudatus*. In conclusion, organically grown *C. caudatus* were higher in phytonutritional content compared those applied with inorganic fertilizer. For growth and physiological performance, inorganic fertilizer was superior than organic fertilizer. However, considering nitrate is harmful whereas mineral and vitamin contents as well as antioxidant activity are priority in fresh herbs, organically grown produce may benefit human health better than corresponding conventionally grown produce. Higher fertilizer applied can cause decreasing phytonutritional content of *C. caudatus*. Therefore, it is suggested that, fertilizer rates should be limited to 90 kg N/ha for *C. caudatus* production to increase phytonutritional content. To maintain the freshness, prolong the shelf life and retain phytonutritional quality of *C. caudatus*, hydro-cooling treatment must be applied after harvest.

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

**PERTUMBUHAN DAN KUALITI PEMAKANAN *Cosmos caudatus* Kunth
YANG DIPENGARUHI OLEH KADAR BAJA ORGANIK DAN INORGANIK
SERTA RAWATAN RENDAMAN SEJUK LEPASTUAI**

Oleh

SALUMIAH BINTI MIJIN

Mac 2014

Pengerusi : Profesor Madya Siti Aishah Hassan, PhD
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Satu kajian telah dijalankan untuk mengkaji kesan sumber dan kadar baja terhadap pertumbuhan, fisiologi dan fitonutrisi kualiti *Cosmos caudatus*, yang biasanya dimakan segar sebagai salad. Kajian faktorial dijalankan dengan mengikut rekabentuk penuh rawak berblok dengan 3 replikasi. Dua jenis baja dinamakan baja inorganik kompaun (15%N, 15%P₂O₅, 15%K₂O) dan baja organik (8%N, 8%P₂O₅, 8%K₂O) telah digunakan pada lima kadar yang berbeza mengikut kadar nitrogen dari 0, 30, 60, 90 and 120 kg N/ha. Data fisiologi dan pertumbuhan dikumpul semasa pertumbuhan vegetatif dan kandungan fitokimia diukur selepas dituai.

Pertumbuhan vegetatif *C. caudatus* dipengaruhi secara signifikan oleh kadar dan sumber baja yang digunakan. Tanaman yang menerima baja inorganik kompaun mempunyai tinggi dan berat kering yang lebih tinggi, lebih bercabang dan mempunyai daun yang lebih luas berbanding dengan tanaman yang dirawat dengan menggunakan baja organik. Sumber baja tidak memberi kesan secara signifikan terhadap kandungan nutrien dalam tanaman. Walaubagaimanapun, tinggi jumlah penggunaan baja yang digunakan meningkatkan kandungan makronutrien. Kadar fotosintesis meningkat secara signifikan bila dibaja dengan kuantiti yang banyak. Bagi tumbuhan yang dirawat dengan baja organik, kandungan asid askorbik meningkat dengan peningkatan kadar baja tetapi menurun pada kadar baja yang sangat tinggi. Kadar baja 90 kg N/ha adalah lebih sesuai untuk mengoptimumkan penghasilan berat kering. Baja inorganik memberikan keputusan dimana mengandungi nitrat yang dan rendah antioksidan aktiviti pada daun.

Berpandukan kepada kadar baja optimum yang telah ditentukan, kajian lepas tuai pucuk yang dibaja secara organik dan inorganik dikaji terhadap jangka hayat semasa penyimpanan. Pucuk muda dituai pada minggu ke-12 dan dibahagikan kepada 2 kumpulan. Perbandingan dilakukan diantara sampel

yang dilakukan rawatan rendaman air sejuk dan sampel yang tidak dilakukan rawatan rendaman air sejuk pada suhu bilik selepas dituai. Sumber baja yang digunakan tidak mempengaruhi kehilangan air, keadaan visual, pH dan kandungan klorofil *C. caudatus*. Walaubagaimanapun, kandungan vitamin C dan karotenoid yang di baja dengan menggunakan baja organik adalah tinggi secara signifikan berbanding dengan menggunakan baja inorganik. Rawatan air sejuk memberi kesan secara signifikan ke atas kualiti pucuk muda dimana kurang kehilangan air, keadaan visual yang lebih baik dan tinggi kandungan vitamin C, klorofil dan karotenoid berbanding dengan rawatan kawalan. Kualiti pucuk *C. caudatus* menurun apabila disimpan lama. Ringkasnya, baja organik boleh meningkatkan kandungan vitamin C and karotenoid di dalam *C. caudatus* dimana ia adalah penting apabila dimakan sebagai salad. Rawatan rendaman air sejuk adalah penting untuk mengekalkan kualiti lepas tuai pucuk.

Perbezaan kadar dan sumber baja yang digunakan memberi keputusan yang pelbagai pada pertumbuhan dan mempengaruhi kandungan fitonutrien *C. caudatus*. Kesimpulannya, *C. caudatus* yang ditanam secara organik tinggi kandungan fitonutrien berbanding dengan menggunakan baja inorganik. Bagi pertumbuhan dan perkembangan fisiologi, baja inorganik menunjukkan prestasi yang baik dari menggunakan baja organik. Walaubagaimanapun, dengan mempertimbangkan kandungan nitrat adalah berbahaya dimana mineral dan vitamin termasuklah antioksidan aktiviti diutamakan dalam tanaman herba, penanaman organik adalah lebih memberi kebaikan pada kesihatan manusia berbanding dengan reaksi tanaman yang ditanam secara konvensional. Tinggi penggunaan baja akan menyebabkan kandungan fitonutrien *C. caudatus* menurun. Dengan itu, dicadangkan agar, kadar baja boleh dikurangkan kepada 90 kg N/ha bagi pengeluaran untuk meningkatkan kandungan fitonutrien *C. caudatus*. Bagi mengekalkan kesegaran, memanjangkan jangka hayat dan mengekalkan kualiti fitonutrien *C. caudatus*, rawatan rendaman air sejuk mesti digunakan selepas menuai.

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I certify that a thesis Examination Committee has met on **20 March 2014** to conduct the final examination of Salumiah binti Mijin on her Master of Science thesis entitled “Growth and Nutritional Quality of *Cosmos caudatus* As “Affected by Rates of Organic and Inorganic Fertilizers and Post Harvest Cooling” 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.

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DECLARATION

Declaration by graduate student

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LIST OF ABBREVIATIONS

%	percentage
*	significant at $p \leq 0.05$
**	significant at $p \leq 0.01$
°C	degree Celsius
ANOVA	analysis of variance
BHT	Butylated hydroxytoluene
FTC	ferric thiocyanate
g	gram
LSD	least significant different
M	molar
ml	milliliter
ml/L	milliliter per liter
nm	nanometer
ns	non-significant
PE	polyethylene
rpm	rotations per minute
TBA	Thiobarbituric acid
WAT	week after transplanting

CHAPTER I

GENERAL INTRODUCTION

Herbs have been used for centuries to improve the health and well being of entire civilizations (Lidley, 1981). Medicinal herbs are used globally in various complementary alternative therapies (WHO, 2003). According to the world health organization (WHO), more than 5 billion people, or 80% of the world's population, still depend on herbs and traditional methods of healthcare (Wan Hassan, 2006).

Malaysia is rated as one of the 12 countries in the world with a wide 'mega-diversity' of plants (Herbal Medicine Research Group, 2002). Malaysia, being in a tropical rain forest zone, has rich sources of medicinal herbs and plants. The total value of herbal products in Malaysia is estimated to be RM 4.55 billion and the rate of growth of the sector is approximately 15% annually (Wan Hassan, 2006). However, the industries that utilize medicinal herbs in their health products are still at the infancy stage in Malaysia though the numbers are expected to increase and estimated to reach up to 20%. The value of total consumption of herbs and herbal products locally is estimated at RM3.2 billion of which only an estimated RM 500 million is from local sources. A large percentage of the nation's herbs supplies are imported from Thailand, China, India, and Indonesia (Wan Hassan, 2006).

More than 2,000 herb species in Malaysia have been reported to have medicinal properties. In addition to native species, some plants were brought in by the Chinese, Indians and others when they migrated into Malaysia centuries ago (Wan Hassan, 2006). Herbs can be consumed fresh as salad, processed or cooked (Norhanom et al., 1999). Some are consumed fresh because of their taste, which adds variety and flavour to the human diet in addition to having health benefits.

One local herb with potential to be developed commercially is *Cosmos caudatus*, known locally as 'ulam raja'. Although it originated from Tropical Central America it is now found in almost all tropical regions. This herb is found to contain antimutagen and antifungal compounds such as custonoid, stigmesterol, lutein and 4, 4-bipyridine (Ragasa et al., 1999). Huda-Faujan et al. (2007) also reported that the *C. caudatus* contains very high levels of amino acid and protein. Further, more than twenty antioxidants have been also identified in the *C. caudatus* (Guanghou et al., 2005).

Local demand for herbs in the production of traditional medicines is on the rise. However, less than 10% the herbs used in the production of local traditional medicines is cultivated locally. The rest are imported or collected from the wild. Over-dependence on imported raw materials can expose the local industry to problems of inconsistency in supply, price instability and adulterated and low quality materials.

In the last decades, interest in the medicines and nutritional application of this herb has increased dramatically. Due to its functional properties, it has also been demonstrated to support the bone formation and aid blood circulation (Abas et al. 2003). This plant is widely grown and can be readily established at low cost. *Cosmos caudatus* could become a novel antibiotic agent due to the significant antimicrobial. However, the lack of information regarding cultural practices in the cultivation of local herbs, especially in terms of fertilization, is probably one of the attributing factors for the problem of low local supplies. For herbal crops such as *C. caudatus*, where the leaf is the major plant part used, promotion of vegetative growth is a priority. In relation to this fertilizers are known to have pronounced influence on plant growth and development. Improvements in foliar production through proper management of plant inputs are thus a major concern for large scale production. Since biomass production of plants grown in no limiting conditions will depend upon the available nutrients in the growing medium, all important cash crops should follow recommended fertilizer rates for optimal yield. Therefore, this herb was selected for this study.

Postharvest handling of herbs is of prime importance to reduce potential loss of their medicinal properties and yield. All fresh green herbs are fragile when they are in fresh state and can easily deteriorate in short time after harvest. For this reason, appropriate storage temperature and humidity is necessary to lengthen the storage duration of fresh herbs without loss in quality of such produce.

Research confirms that lowering the respiration rate of fresh vegetables is essential to preserve its market quality. In relation to this the most important technology for lowering respiration rates is found to be precooling of produce within hours of harvest (Jones, 2007) whereby pre-cooling is the first step in good temperature management. Proper pre-cooling preserves product quality by inhibiting the growth of decay microorganisms, restricting enzymatic and respiratory activities, inhibiting water loss and reducing ethylene production (Hardenburg et al., 1986). Since *C. caudatus* is commonly eaten raw in Malaysia as a good source of natural antioxidants, minerals and vitamin (Shui et al., 2005), research on preservation of its postharvest quality is essential.

This study will evaluate the effects of using inorganic and organic fertilizer sources at suitable rates for higher production of *C. caudatus* shoots and higher yield. This study will test the validity of claims that plants grown with inorganic fertilizers have less taste and are less healthy as compared to those grown using organic fertilizers. Determination of fertilizer rates is an important aspect of this study in order to determine the optimum fertilizer rates for optimum yield and quality of the *C. caudatus* and to avoid over fertilization which may have a net negative impact on yield and quality.

Hence, the objectives of the study are:

1. To determine the effect of fertilizer sources and rates on growth, physiology and phytonutritional quality of *C. caudatus*;

2. To determine the optimum fertilizer rates for higher yields in production of *C. caudatus*; and
3. To determine the effect of fertilizer sources and hydro-cooling treatment on shelf life and quality of *C. caudatus* shoots during storage.

CHAPTER 2

LITERATURE REVIEW

2.1 *Cosmos caudatus*

2.1.1 Origin, types and uses

Cosmos caudatus is a herbaceous annual plant belonging to the family Compositae. The scientific name for the plant is *Cosmos caudatus* kunth. It originated from tropical Central America and is now widespread in almost all tropical regions (Guanghou et al., 2005). Locally it is known as ulam raja whereby 'Ulam' is a Malay word for fresh herbaceous vegetable salad. Hence when literally translated 'ulam raja' means the 'King salad'.

There are many types of *C. caudatus*. The two main popular types are the ones with pink and white flowers. A more common hybrid of *C. caudatus* is the yellow flowered varieties or *Cosmos sulphureus*, whose shoots can also be eaten as 'ulam' or salad. *Cosmos caudatus* or 'ulam raja asli' is also called 'ulam raja kuning' (Ooi, 2003).

Cosmos caudatus is one of the popular 'ulam' in Malaysia. Its young shoots or the edible young leaves are usually eaten with 'sambal belachan' (shrimp paste-chili), cinalok (fermented shrimp sauce) or with budu (anchovy sauce). As a traditional vegetable, this herb can also be cooked in the 'masak lemak' style or blanched and eaten with rice and it is also used in dishes such as kerabu. This herb is also served as an appetizer and used as food flavoring due to its unique taste and aroma. Today, the ulam raja is featured as part of the Malaysian cuisine in major hotels in the country for tourists and is also a favorite among locals at buffet lunches or dinners (Wan Hassan, 2006).

2.1.2 Botany

Cosmos caudatus is an annual, short-lived perennial aromatic herb. It grows up to between 0.5 to 2 m tall (Wan Hassan, 2006). The fruits or seeds are thin, elongated and dark brown in color (Figure 2.1). The leaves are simple, pinnate or bipinnate, arranged in opposite pairs, soft and aromatic, bright green in colour, measuring between 20 to 30 cm in length (Figure 2.2). At night or in the day, the leaves fold to enclose the terminal buds (Wan Hassan, 2006). The stem is erect, light purpleish green, succulent and hairy (Smith, 1991). The flowers are produced on a single long inflorescent stalk

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