



UNIVERSITI PUTRA MALAYSIA

**EFFECTS OF N AND K CONCENTRATIONS ON NUTRIENT UPTAKE,
PHOTOSYNTHETIC CAPACITY AND GROWTH OF BELL PEPPER
(*CAPSICUM ANNUUM* VAR. *GROSSUM*) GROWN UNDER RAIN
SHELTERS IN THE LOWLANDS**

**NORHANANI AHMAD
FP 2009 31**



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SHELTERS IN THE LOWLANDS**

By

NORHANANI AHMAD

**Thesis Submitted to the School of Graduate Studies, Universiti Putra
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Science**

October 2009



Dedication,

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

EFFECTS OF N AND K CONCENTRATIONS ON NUTRIENT UPTAKE, PHOTOSYNTHETIC CAPACITY AND GROWTH OF BELL PEPPER (*CAPSICUM ANNUUM* VAR. *GROSSUM*) GROWN UNDER RAIN SHELTERS IN THE LOWLANDS

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October 2009

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Faculty : Agriculture

Effects of different concentrations of N and K in the nutrient solutions on nutrient uptake, photosynthetic capacity and growth of bell pepper (*Capsicum annuum* var. *grossum*) cv. 'Canape' under rainshelters in the lowland were evaluated. This study was carried out under rainshelter in randomized complete block design (RCBD) with three replications from February until July 2005 at Institut Latihan Pertanian Ayer Hitam (IPAH), Johor. Bell pepper plants were grown in 9L pots containing cocoa peat and burnt rice husk at 1:1. Except for N and K concentrations, a complete nutrient solution based on the Cooper nutrient formulation was supplied using fertigation system. The concentrations of N:K at 250:350 mgL⁻¹=S1, 250:300 mgL⁻¹=S2, and 200:300 mgL⁻¹=S3 were applied from the first to 124 day after transplanting (DAT).

The percentage of leaf N, P, K, Ca and Mg concentration, nutrient uptake and leaf gas exchange were measured at 7, 38 and 124 DAT. Plant height, stem diameter and leaf area index were measured at 7 (vegetative stage), 14 (early reproductive stage), 21, 28, 38 (first fruiting stage) and 124 days after transplanting (DAT). Total leaf area, leaf, stem and root dry weight at 7, 14, 28, 38 and 124 DAT. While, flower and fruit dry weights were measured start at 14, 28, 38 and 124 DAT.

Results showing significant differences were observed in percentage of leaf N, P, K at vegetative stage and Mg concentration at fruiting stage. This showed that the N and K concentrations in the nutrient solution influenced the nutrients uptake and accumulated in the plants leaf. Higher total of K followed by N, Ca, and P and Mg uptake showed the importance of N and K for bell pepper growth. Higher maximum assimilation rate of photosynthesis (A_{max}), net photosynthesis (P_N) and transpiration rate (E) at vegetative stage in 250:350 mgL⁻¹ of N:K indicated that the photosynthetic capacity would increase with higher N and K concentration. Lower of F_v/F_m ratio at 7 DAT in all treatments indicated that the plants were under short term environmental stress. However, this condition was improved at 38 and 124 DAT. Plant growth especially plant height, stem diameter, total leaf area, fruit weight and number of fruits per plant increased with the increasing of N and K concentration in the nutrient solution. These indicated the importance of N and K in increasing the growth of bell pepper.

This study was basically to obtain higher fruit production of bell pepper under rainshelter in the lowland. Results suggested using lower concentrations of N and K at 200:300 mgL⁻¹ in the nutrient solution on the first day after transplanting until the fruits were first harvested (57 DAT). Then, these N and K concentrations need to be increased at 250:350 mgL⁻¹ afterwards. This was to ensure that the plant will receive enough N and K to support fruit development and plant growth, due to some of N and K have been removed from the plant after the fruits were harvested.

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

KESAN KEPEKATAN N DAN K KE ATAS PENGAMBILAN NUTRIEN, KEUPAYAAN FOTOSINTESIS DAN PERTUMBUHAN POKOK CILI BENGGALA (*CAPSICUM ANNUUM VAR. GROSSUM*) DI BAWAH STRUKTUR LINDUNGAN HUJAN DI TANAH RENDAH

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Kesan perbezaan kepekatan N dan K di dalam larutan nutrien ke atas pengambilan nutrien, keupayaan fotosintesis dan pertumbuhan pokok cili benggala (*Capsicum annuum* var. *grossum*) cv. 'Canape' di tanah rendah dinilai. Kajian ini dijalankan bermula pada Februari hingga Julai 2005 di Institut Latihan Pertanian Ayer Hitam (IPAH), Johor, di bawah struktur lindungan hujan pada rekabentuk rawak lengkap dengan tiga replikasi. Pokok cili benggala ditanam di dalam pasu yang berisipadu 9L, mengandungi hampas sabut kelapa dan sekam padi bakar pada nisbah 1:1. Baja dan air dibekalkan menggunakan sistem fertigasi bersama larutan nutrien yang lengkap kecuali N dan K yang mempunyai kepekatan yang berbeza. Kepekatan N:K pada $250:350 \text{ mgL}^{-1}$ =S1, $250:300 \text{ mgL}^{-1}$ =S2 dan $200:300 \text{ mgL}^{-1}$ =S3 dibekalkan sepanjang pertumbuhan pokok bermula dari hari pertama hingga hari ke 124 selepas diubah tanam.

Peratus kepekatan N, P, K, Ca dan Mg dalam daun, pengambilan nutrien dan pertukaran gas diukur pada hari ke 7, 38 dan 124 selepas diubah tanam. Tinggi pokok, diameter batang dan indeks luas daun diukur pada hari ke 7 (peringkat vegetatif), 14 (peringkat awal reproduktif), 21, 28, 38 (peringkat pertama pokok berbuah) dan hari ke 124 selepas diubah tanam. Jumlah luas daun, berat kering daun, batang, akar diukur pada hari ke 7, 14, 28, 38 dan 124 selepas diubah tanam. Manakala, berat kering bunga dan buah diukur pada hari ke 14, 28, 38 dan 124 selepas diubah tanam.

Keputusan menunjukkan perbezaan yang bererti di dalam peratus kepekatan N, P, K pada peringkat vegetatif dan Mg pada peringkat pokok berbuah. Ini menunjukkan kepekatan N dan K di dalam larutan nutrien mempengaruhi pengambilan dan pengumpulan nutrien oleh tanaman. Jumlah pengambilan K dan N yang tinggi diikuti Ca, P dan Mg menunjukkan kepentingan N dan K di dalam pertumbuhan tanaman. Kadar asimilasi maksimum fotosintesis (A_{max}), fotosintesis bersih (P_N) dan kadar transpirasi (E) yang tinggi pada N:K, 250:350 mgL^{-1} di peringkat vegetatif menunjukkan N dan K mempengaruhi keupayaan fotosintesis bagi pokok cili benggala. Nilai F_v/F_m yang rendah pada hari ke 7 selepas diubah tanam bagi semua rawatan menandakan bahawa pokok berada di dalam segahan sementara akibat persekitaran. Walaubagaimanapun keadaan ini tidak berlanjutan pada hari ke 38 dan 124 selepas diubah tanam. Pertumbuhan pokok seperti ketinggian, diameter batang, jumlah luas daun, berat dan jumlah buah bagi sebatang pokok meningkat dengan peningkatan kepekatan N dan K di dalam

larutan nutrien. Ini menunjukkan N dan K adalah penting di dalam meningkatkan pertumbuhan pokok cili benggala.

Tujuan kajian ialah untuk memperolehi pengeluaran hasil buah yang tinggi di bawah struktur lindungan hujan di tanah rendah. Keputusan mencadangkan kepekatan N dan K yang lebih rendah digunakan iaitu pada 200:300 mgL⁻¹ pada hari pertama selepas anak pokok diubah tanam sehingga kali pertama buah dituai (hari ke 57 selepas diubah tanam). Kemudian, kepekatan N dan K ini perlulah dipertingkat kepada 250:350 mgL⁻¹ sehingga keakhirnya. Ini bagi memastikan pokok menerima N dan K yang cukup bagi menyokong perkembangan buah dan pertumbuhan pokok, disebabkan sebahagian N dan K telah hilang dari tanaman selepas buah dituai.

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I certify that an Examination Committee met on 20 October 2009 to conduct the final examination of Norhanani Ahmad on her Master of Science thesis entitled “Effects of N and K Concentrations on Nutrient Uptake, Photosynthetic Capacity and Growth of Bell Pepper (*Capsicum annuum* var. *grossum*) Grown Under Rain Shelters in The Lowlands” in accordance with Universities and Universities and Collages Act 1971 and Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommendeds that the student be awarded the Master of Science.

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I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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LIST OF ABBREVIATIONS

F_v/F_m	Ratio of variable to maximum fluorescence
A_{max}	Maximum assimilation rate of photosynthesis
P_N	Rate of photosynthesis
g_s	Stomatal conductance
WUE_i	Photosynthetic water use efficiency
ϕ	Quantum yield
PS I	Photosystem I
PS II	Photosystem II
E	Transpiration rate
N	Nitrogen
P	Phosphorus
K	Potassium
Ca	Calcium
Mg	Magnesium
CO ₂	Carbon dioxide
>	Greater than
<	Less than
=	Equal to
%	Percentage
°C	Degree-Celsius
EC	Electrical conductivity

CHAPTER 1

INTRODUCTION

In the past, organic fertilizer was applied to the crops by farmers to increase growth and yield. Organic fertilizer such as chicken waste was among the fertilizers that were frequently used to supply nutrient in the plants. However, when technology was introduced in the 80's, farmers began to use inorganic fertilizer such as nitrogen, potassium and phosphate. The use of these fertilizers increased dramatically until in 90's. After this period, concerns about movement of fertilizers especially nitrogen and herbicides into underground water was express as well as significant concentration of these elements was detected on water surface. Death and decomposition of phytoplankton in the rivers that polluted the water and environment have made people recently very concern over the use of excessive amount of fertilizer that will cause effect on water supplies.

The production of *Capsicum* for spice and vegetables daily use has increased every year. In 2006, FAO reported that Asia was the largest producer of *Capsicum* in the world, with China leading the production of 12,531,000 mt in 2005 (FAO, 2006). In Malaysia, *Capsicum* was ranked as the second major vegetable after leaf mustard and reported that the production of *Capsicum* was to be 115,513.36 mt in 2002 (Department of Statistic, 2006). Although the consumption of bell pepper was not as popular as hot chili, bell pepper has created its own market potential particularly by restaurants and hotels as parts of cooking ingredients. Due to this potential



with local demand outweighed its production by 98%, the cultivation of bell pepper in Malaysia is increasing every year (Hawa *et al.*, 1992).

The bell pepper production in Malaysia was mostly established in highland areas such as in Cameron Highlands, Pahang. This situation is due to environmental condition especially air temperature that is more suitable for the production. Higher air temperature in the lowlands area that is between 21-32 °C, as compared to highland area between 14.6-23.4 °C make the production of this particular vegetable less suitable. Bell pepper is grown in soilless culture and under rainshelter structure to protect the plants from heavy rainfall.

Limitation of land for agriculture is among the issues faced by vegetable producers to expand the production of temperate vegetable in highlands (Ministry of Agriculture, 1998). Thus, to ensure the production of these vegetables continually expanding, government has encouraged the producers to shift the production of highland vegetables to the lowlands via technology improvements. These technologies hopefully, will enable the production of temperate vegetables in the lowlands and at the same time helps in reducing off the usage of highland area.

Currently, in modern agricultural systems soilless culture is commonly used and fertigation technique is applied by producer. Water and nutrient are mixed together in the main tanks and supplied with drip irrigation device to media culture (Bar Yosef, 1999; Hagin *et al.*, 2002). Soilless culture has

given the advantages to vegetable producers because the amount of nutrient supply can be controlled base on the crop requirement (Bar Yosef, 1999). A study by Bar Yosef and Sagiv (1982) proved that fertigation in tomato increase the yield and lead to fertilizer saving compared to the one without fertigation.

Tomato and cucumber are mostly produced in highland area, but currently it is extensively produced in lowland such as in Batu Pahat and in Kluang, Johor. These plants have been produced by local commercial producer (Utusan Malaysia, 2004) using soilless culture with fertigation technique under rainshelter. Due to this circumstance, it indicates that the bell pepper productions in lowlands can also been done. Due to lack of information on bell pepper grown in lowlands, this study hopefully will show the growth trend and yield of bell pepper along with the nutrient requirement of plant growth.

In Malaysia, many studies have been carried out to estimate the nutritional requirement for tomato and hot chilies. However, there was very little research has been conducted for bell pepper especially in lowland. Currently, fertilizer that is supplied to the bell pepper is based on nutritional requirements of other Capsicum species or other crops such as tomato or muskmelon. Therefore, it is important to study the nutrient requirement of this plant so that specific nutritional requirement can be estimated.

Nutrients such as nitrogen and potassium were among the elements that affect the yield and quality of vegetables grown in soilless cultivation

(Johnson and Decoteau, 1996; Silber *et al.*, 2005). According to Miller (1961) and Leigh and Jones (1984), N is among the nutrient that has been manipulated by farmers due to the relations of N to reproduction development in peppers especially fruit quality. While K is the important aspect to maintain N metabolism in plants and as an activator for a number of enzymes, mostly those involved in photosynthesis and respiration process (William and Norman, 2004). Increased in N has been shown to increase the number and size and overall yield (Johnson and Decoteau, 1996; Gill *et al.*, 1974) while increase K rate increase the number of fruits per plant and seed yield (Osaman and George, 1984). The proper use of N and K fertilizers in the soilless culture and fertigation are important due to their relations to the stage of plant growth and environmental condition (Grattan and Grieve, 1999). Fertilization above plant requirements not only increases the costs but also detrimental to the environment such as salt accumulation in soil and ground water contamination due to leaching (Villa-Castorena *et. al*, 2003). For that reason, it is necessary to carry out studies on different N and K concentration in the nutrient solution, using fertigation technique under rainshelters in the lowland condition for higher production of bell pepper and to estimate the potential yield.

This study will observe the influence of N and K concentrations in the nutrient solution on bell pepper production under rainshelters in lowland conditions. A variety that is known to be heat resistant was chosen for this study to determine the potential of bell pepper production for the lowland using