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Effect of Potassium on Growth, Fruit Quality Improvements and Resistance to Anthracnose in Field Grown Capsicum (*Capsicum Annum* L. Cv. 'Hungarian Yellow Wax')

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ABSTRACT

Postharvest losses of capsicum crop accounts for 30-40% of total crop production. It has been shown that postharvest losses of capsicums can be reduced significantly with the application of potassium due to improvements in disease resistance and fruit quality. The objective of this study was to investigate the effect of higher doses of potassium (K) on plant growth, yield and fruit quality parameters and resistance to anthracnose disease of capsicum cv. 'Hungarian Yellow wax'. Three different levels of potassium, Department of Agriculture (DOA) recommended level [180g per bed (control)], double the level (360g per bed) and three times of the level (540g per bed) were applied to the soil in a Randomized Complete Block design. The same experiment was repeated in three farmer fields of Naula Grama Niladhari (GN) division in Dambulla Divisional Secretariat of Matale district of the central province of Sri Lanka. Plant growth parameters were measured at two week intervals, and fruit quality parameters (TSS, Ph, %TA), fruit physical parameters (length, width, pericarp thickness, fresh weight, firmness and cell wall thickness) were recorded. Finally the resistance to diseases of capsicum fruits was also tested by inoculation of Colletotrichum capsici *to the fruits. This study concludes that application of higher doses of potassium improves some plant growth parameters (height and plant diameter at base), fruit physical parameters (fruit length, width , fresh weight, firmness and cell wall thickness). The tripled and doubled the dose of potassium application reduced anthracnose disease by over 75% and 95% respectively indicating that higher level of K could have a significant impact in reducing postharvest losses of capsicum in local conditions*

KEYWORDS: *Potassium application, capsicum anthracnose, fruit quality*

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1. INTRODUCTION

Capsicum (*Capsicum annum* L.) is a vegetable which has a high demand both in local and export market.

Anthracnose is one of the major diseases in capsicum which occurs both at pre-harvest and postharvest stages. *Colletotrichum,* the causative organism of anthracnose causes a significant economic damage to crops in tropical, subtropical, and temperate regions. Number of fruits, vegetables, ornamentals legumes and cereals are affected by *Colletotrichum* species (Bailey *et al*., 1992). Generally anthracnose is controlled by the application of fungicides which poses high monetary costs to agriculture and can be environmentally hazardous. Meanwhile, there is an increasing demand for no or less chemical applied fresh produce and many researches have been laid on substituting pesticides with non-hazardous and cheaper controlling methods. Pre-harvest application of high doses of potassium (K) has been proven to be effective in decreasing the incidence of many pests and/or diseases in crops (Fuchs and Grossmann, 1972) and thus farmers are advised to apply K fertilizers to improve crop health (Imas and Magen, 2007; Amtmann *et al*., 2008). In addition, potassium is involved in yield and quality improvements of fresh produce (Amtmann and Rubio, 2012).

This study was conducted to investigate the impact of application of higher doses of K on growth and fruit quality of capsicum.

2. BACKGROUND/ LITERATURE SURVEY

Capsicum (*Capsicum annum* L.) is one of the most consumed vegetable crop in Sri Lanka grown in 3287 ha with an annual production of 14406 mt. It has a good demand in the export market as well being 5.7% of the production is exported annually (DOA, 2010). The genus *Capsicum* is counted for a massive postharvest loss due to the disease anthracnose which is caused by *Colletotrichum* species in both tropical and sub-tropical regions (Pereira et al., 2011; Park et al., 2012). In Sri Lanka, the post harvest loss of capsicum cultivation due to anthracnose disease is estimated around 21-47% (Rajapakse, 1999). The disease is caused by mainly five *Colletotrichum* species: *C. acutatum*, *C. capsici*, *C. gloeosporioides*, *C. nigrum* (Don et al., 2007) and *C. coccodes* (Johnston and Jones, 1997) in the world while *C. gloeosporioides and C. capsicii* (Rajapakse and Ranasighe, 2002) are the commonly found species in Sri Lanka.The control of disease is currently achieved by application of fungicides, which is costly and environmentally hazardous. In addition, growing capsicum in the field involves extensive labor and a high cost of agrochemicals such as, mineral fertilizers and fungicides in order to assure good yield and quality. Numerous studies have proven that K is effective in controlling many fungal diseases, anthracnose in particular. The incidence of anthracnose (*C.olletotricchum higginsianum*) in flowering Chinese cabbage (*Brassica parachinensis*) was found to be reduced with increased levels of potassium (Guo et al., 2012). In tomato cv. ‘Maheshi‘ and ‘Thilina‘, the disease was effectively redused by application of extra dose of potassium (Weerahewa and David, 2015). Moreover, anthacnose, stalk-end rot and freckle disease in banana could effectively suppressed by twice the recommended dosage of K (Weerakoon et al., 2005). Further, application of thrice the recommended dose of potassium had shown a significant reduction of stem-end rot in mango variety ‘Karuthacolomban’ by over 45% compared to the recommended dosage (Karunanayake, 2008).

In addition, many studies have reveled the effect of K in increasing plant and fruit quality parameters. Application of higher doses of potassium has resulted significant increase in plant growth parameters such as plant length, number of shoots and leaves in egg plent (Fawzy *et al*., 2007) and in tomato (Nanadal *et al*., 1998) compared to the control. Apllication of higher dose of K resulted increased fruit size, fresh and dry weight of bell pepper (Kaya and Higgs, 2003), egg plant (Fawzy *et al*., 2007) and potato (Khan et al., 2012)

3. MATERIALS AND METHODS

3.1. Study Location

The study was carried out in farmers fields at NaUla GN division in Dambulla Divisional Secretariat of Matale District of the central province of Sri Lanka.This is located at an altitude of about 380.69 m above sea level. The soil was flat, with a clay loam texture and pH of 6.1, 0.85g/cm^{3}bulk density, 25.45% moisture content and 19.85% soil porosity. The average recorded temperature and relative humidity were 31^{o}C and 79% respectively during the period of study.

3.2. Plant Material and Nursery Management

Seeds of capsicum genotype *Capsicum annum* 'cv. Hungarian Yellow Wax' from Polo-seed International, Thailand were used for the experiment. Seeds were sown in a 1:1 mixture of well decomposed farmyard manure and top soil and maintained according to the DOA recommendation (DOA, 2011) until transplantation.

3.3. Treatments and Experimental Design

Mature four week old seedlings were transplanted in 300 ft^2 beds with spacing of 15 cm x 30 cm. The basal fertilizer was applied as recommended by the Department of Agriculture. In the first and second top dressings, three potassium [muriate of potash (MOP)] treatments were applied in fact, DOA recommendation [180g per bed- control (K1)], double the recommendation (360g per bed- K2) and three times of the recomendation (540g per bed- K3) along with DOA recommended doses of triple super phosphate (TSP) and urea. Treatments were arranged in a randomized complete block design (RCBD) with three replicates. The experiment was repeated at three locations.

3.4. Measurement of growth, and fruit quality parameters

Five plants from a plant bed were randomly selected for obtaining plant growth parameters. The shoot length, diameter at base, number of leaves and number of branches per plant were measured at two week interval.

Capsicum fruits were harvested at the colour break stage for obtaining physical parameters. From each replicate, fifteen fruits were used to test fruit quality parameters. Fruit length and fruit fresh weight of each harvested fruit were measured and averaged. Fruit width and fruit pericarp thickness were measured by a vernier caliper. Diameter at the maximum width was taken as the fruit width. Fruits were cross sectioned at the maximum width and 3 measurements of pericarp thickness were taken per cross section. Fruit firmness was measured by penetrometer (Model FT 40, Wagner Instruments, Greenwich CT).

Fruit extracts were prepared by crushing five representative fruits per replicate separately using a blender and squeezing the pulp through a muslin cloth. Total soluble solids (TSS) of fruit extracts were measured by a refractometer (Model WZ-113, China) within the range of 0-32% Brix and pH of the extracts was measured using pH meter (Model IQ150, USA). Aliquots (5 ml) of fruit extracts were titrated against 0.1 M NaOH in the presence of phenolphthalein as an indicator and titratable acidity (%TA) for each sample was determined according to a previously followed procedure (Askar and Trepow, 2013). Three samples from one fruit extract were used to repeat the procedures of measuring TSS, pH and %TA.

3.5. Pathogen isolation and identification

Fruits with anthracnose lesions were collected and surface sterilized with 1 % NaOCl for 1 minute followed by washing with sterile distilled water. Tissues from lesion areas were then placed on PDA (Potato Dextrose Agar) media and incubated at 27-30°C. *C. capsici* was identified by its sickle-shaped conidia, the presence of prominent setae (Sutton, 1992), and its brown colony colour (Rajapakse and Ranasighe, 2002).

3.6. Assessment of anthracnose disease resistance

Resistance against anthracnose disease was assessed by artificial inoculation of *C. capsici* on fruits and measuring the lesion area for 10 days. Six fruits from each treatment were used for the inoculation study. A spore suspension (10^5 conidia per ml) was prepared by using 7 days old pure cultures of *C. capsici* and three drops of spore suspension (20 µl) were placed per fruit. Inoculated fruits were maintained in moist chambers (95-100% relative humidity) at 28±2 °C for 10 days. The average lesion area was calculated for each fruit.

4. RESULTS

4.1. Plant Growth Parameters:

A significant increase in some of the plant growth parameters were observed with increasing dosage of MOP. In fact, plant height and diameter at base were signifivcantly increased in plants treated at triple the dose of DOA recomendation than that of the control (Table 1). Similarly, application of higher doses of potassium has resulted significant increase in plant growth parameters in egg plent (Fawzy *et al*., 2007), tomato (Nanadal *et al*., 1998) and potato (Khan *et al*., 2012) compared to the control.

4.2. Fruit Physical Parameters:

Some fruit physical parameters were significantly improved with increasing MOP application (Table 2). Fruit weight, lenght and width were significantly higher in crops treated with thrice the recomended dose of MOP. However, results are not consistent in significance among three treatment levels. Similar results were bought about by Kiviani *et al*., (2004) and Akhtar *et al*., (2010). In addition, Picha and Hall, (1981) has reported that increased application of K resulted in enhanced yield of tomato fruits through larger proportion of fruit forming flowers. In tomato and kidney bean, K application significantly increased harvests bean as a result of increased sugar concentrations (Liu *et al*., 2018). Similarly, the yield and size of tomato, bell pepper, apple and egg plant were improved as a result of soil application of higher doses of potassium (Fawzy *et al.*, 2007; Kaya and Higgs, 2003; Locascio *et al*., 1997; Nava *et al*, 2009; Wojcik, 2005). However, the results of the present study are in contradictory to the findings of Loch and Petho (1992).

4.3. Physicochemical Parameters

The effect of higher doses of K application was not significant on either pH or % titratable acidity. Yet, application of extra doses of K has significantly influenced only on total soluble solids where triple the dosage is significantly different from DOA recommendation (Table 3). TSS levesls were increased with increased levels of MOP though the results were not statistically significant and the results were in agreement with the findings of Delgado *et al* (2004). The increased levels of TSS might be due to induction of sugar synthesis by potassium (Bidari and Hebsur, 2011). However, no significant difference between first and second of application of potassium was observed.

4.4. Resistance to Anthracnose

Day of disease initiation and area of lesion development after challange innoculation with C. *capsici* is given in table 4. Anthracnose disease initiation followed chalanged inoculation with *C. capsici* on capsicum fruits was significantly delayed by the application of extra doses of MOP though there was no significant difference between extra doses of K. The rate of lesion development on fruits of plants treated with higher doses of K was found to be slower than that of the control fruits (Figure 1). Disease initiation was significanty delayed by the application of extra dose of MOP despite there is no significant difference between higher doses of K. Further, application of extra doses of potassium has significantly suppressed lesion development. MOP. The disease reduction measured in area of lesion development at 10 DAI were 95% and 74% in double and triple the recommended levels of application respectively compared to the DOA recommendation.

Nearly 70% of the studies have reported that K is an effective mean of controlling numerous bacterial and fungal diseases in crops (Amtmann *et al*., 2008). The results of the current study provide evidences that soil application of higher doses of K can significantly decrease anthracnose disease development in field grown capsicum caused by *C. capsici*. Similarly the disease caused by *C. gloeosporioides* in tomato, cv. 'Thilina' and 'Maheshi' was effectively controlled by thrise the recomended level of K. (Weerahewa and David, 2015).

However, fruit firmness and cell wall thickness of exocarp were significantly increased with increasing dosages of MOP though there was no significant difference between the control and the treatment level 2 (Table 5). Adequate supply of potassium results thicker cell walls making it harder for disease organisms to penetrate plant cells and establish an infection (IPNI, 2010) and thus, increased fruit firmness and cell wall thickness might have created a physical barrier against the penetration of *C. capsici*.

Anthracnose is one of the major diseases which reduces the fruit quality causing a concidereble postharvest loss in capsicum. Thus, utilizing increased potassium dosage is a valuble option that may be used as an integrated disease management strategy, especially when the cost of fungicide application needs to be reduced.

Table 1. Plant growth parameters of capsicum as affected by potassium treatments

	Potassium Treatments		
Parameter	K1	K2	K3
Plant height (cm)	55 b	63 a	66 a
Diameter at base (cm)	1.2 b	1.3 a	1.4 a
No. of branches	9 a	8 a	8 a
No. of leaves	68 b	78 a	63 b

Means followed by the same letter in each raw are not significantly different at P≤0.05. (*n* = 45 for plant growth parameters)

Table 2. Fruit physical parameters as affected by potassium treatments

Fruit physical parameter	Potassium Treatments		
	K1	**K2**	**K3**
Length (cm)	7.9 c	10.6 b	13.1 a
Width (cm)	3.1 b	3.1 b	3.5 a
Pericarp thickness (mm)	3.65 b	4.8 b	3.7 a
Fresh weight (g)	24.26 b	25.99 b	30.83 a

Means followed by the same letter in each raw are not significantly different at P≤0.05. (*n*= 45)

Table 3. Physicochemical parameters of fruits as affected by potassium treatments

	Potassium Treatments		
	K1	K2	K3
Total Soluble Solids (°Brix)	4.67 b	4.72 b	5.13 a
pH	5.12 a	5.17 a	5.1 a
% Titratable acidity (g L^{-1} as tartaric acid)	0.05 a	0.06 a	0.06a

Means followed by the same letter in each raw are not significantly different at P≤0.05. (*n*= 27)

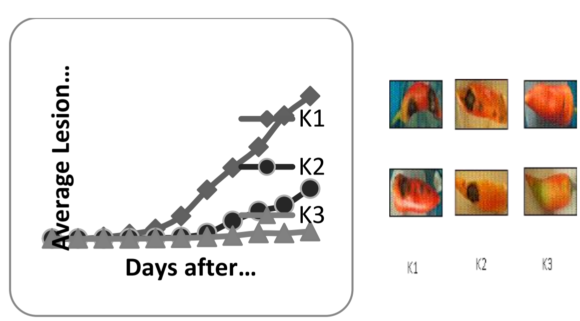

Figure 01: Anthracnose disease lesion development of K treated capsicum for 10 DAI (*n* = 45 for each treatment)

Table 4. Effect of higher doses of MOP on resistance to anthracnose disease of capsicum fruits after challenged inoculation with *C. capsici*

	Potassium Treatments		
	K1	K2	K3
Total lesion area development for 10DAI (mm^2)	149.2^c	39.02^b	7.59^a
Day of disease initiation after inoculation	3^b	5^a	5^a

Means in each column followed by different letters are significantly different at $P \leq 0.05$ (n = 45) according to the DMRT.

Table 5. Effect of higher doses potassium on fruit characteristics of field grown capsicum fruits

Parameter	Potassium Treatments		
	K1	K2	K3
Fruit firmness (N)	16.82^c	18.57^b	20.99^a
Cell wall thickness (µm)	0.21^b	0.26^a	0.25^a

Means in each raw followed by different letters are significantly different at $P \leq 0.05$ (n = 45) according to the DMRT.

6. CONCLUSION/ FUTURE WORK

Potassium was proven to possess beneficial effects on field grown capsicum cv. 'Hungarian Yellow Wax' in some growth parameters, yield and controlling anthracnose disease. Therefore, soil application of increased potassium dosages could be a valuable solution in integrated disease management strategy especially as a substitute for environmentally unsound fungicides. However, potassium does not involve directly in synthesis of physical or chemical components of the plant body. Thus, the reason behind increased fruit cell wall thickness and firmness is quite unclear and might be due to systemically acquired resistance and further studies are required for understanding the exact mechanism.

REFERENCES

AKHTAR ME, KHAN MZ, RASHID MT, AHSAN Z & AHMAD SAGHEER. Effects of potash application on yield and quality of tomato (*Lycopersicon esculentum* Mill.). Pakistan Journal of Botany. 2010; 42: 1695-1702.

AMTMANN A & RUBIO F. "Potassium in plants." eLS. 2012. http://onlinelibrary.wiley.com/doi/10.1002/9780470015902.a0023737/abstract

AMTMANN A, TROUFFLARD S & ARMENGAUD P. The effect of potassium nutrition on pest and disease resistance in plants. Physiologia Plantarum. 2008; 133(4): 682-691.

ASKAR AA & TREPOW H. In: Quality Assuarance in Tropical Fruit Processing, Springer Verlang, Newyork USA. 1993; 9-25.

BAILEY JA, O'CONNELL RJ, PRING RJ, NASH C & JEGER MJ. Infection strategies of *Colletotrichum* species. *Colletotrichum*: Biology, pathology and control. J A Bailey and M J Jeger, eds. CAB International, Wallingford, UK. 1992; 88-120.

BIDARI BI & HEBSUR NS. Potassium in relation to yield and quality of selected vegetable crops. Karnataka Journal of Agricultural Sciences. 2011; 24(1): 55-59.

DELGADO R, MARTÍN P, DELÁLAMO M & GONZÁLEZ MR. Changes in the phenolic composition of grape berries during ripening in relation to vineyard nitrogen and potassium fertilisation rates. Journal of the Science of Food and Agriculture. 2004; 84(7): 623-630.

DOA Capsicum. Retrieved from http://www.agridept.gov.lk/index.php/en/crop-recommendations/988, vol. 2011, Department of Agriculture, Sri Lanka. 2010.

DON LD, VAN TT, PHUONG Vy TT & KIEU PTM. *Colletotrichum* spp. Attacking on

Capsicum Growing in Vietnam. Country Report. In: Oh DG, Kim KT, editors. Abstracts of the First International Symposium on Chilli Anthracnose. Republic of Korea: National Horticultural Research Institute, Rural Development of Administration; 2007. 24.

FAWZY ZF, EL-NEMR MA & SALEH SA. Influence of levels and methods of potassium fertilizer application on growth and yield of eggplant. Journal of Applied Sciences Research. 2007; 3(1): 42-49.

FUCHS WH & GROSSMANN F. Nutrition and resistance of crop plants against pathogens and pests. In: Linser H (ed) Handbuch der pflanzenerna¨hrung und du¨ngung. Springer-Verlag, Vienna. 1972; 1(2): 1008–1107.

GUO JX, LIU YT & YANG X. Effect of Potassium Nutrition on Anthracnose Occurrence and Defense Enzyme Activity in Flowering Chinese Cabbage. China Vegetables. 2012; 14: 23.

IMAS P & MAGEN H. Role of potassium nutrition in balanced fertilization for soybean yield and quality-Global perspective. World. 2007; 92(220.55): 2-38.

International Plant Nutrition Institute. The role of potassium in reducing the incidence of crop diseases. (2010, winter). http://www.ipni.net/ipniweb/pnt.nsf/5a4b8be72a35cd46852568d9001a18da/bc94c4a2c66bdca6852577ec0072616c!OpenDocument

JOHNSTON PR & JONES D. Relationships among Colletotrichum isolates from fruit-rots assessed using rDNA sequences. Mycologia. 1997; 420-430.

KARUNANAYAKE KOL. Natural defense mechanisms in mango fruit and their potential in management of postharvest diseases (Doctoral dissertation), University of Peradeniya, Sri Lanka. 2008; 240.

KAYA C, AK BE & HIGGS, D. Response of salt-stressed strawberry plants to supplementary calcium nitrate and/or potassium nitrate. Journal of Plant Nutrition. 2003; 26(3): 543-560.

KHAN MZ, AKHTAR ME, MAHMOOD-UL-HASSAN M, MAHMOOD MM & SAFDAR MN. Potato tuber yield and quality as affected by rates and sources of potassium fertilizer. Journal of plant nutrition. 2012; 35(5).

KIVIANI I, BASIRAT MJ & MALAKOUTI. A comparison between the effects of fertigation and soil application of potassium chloride and soluble SOP on the yield and quality of tomato in Borazjan Region of Boushehr. In: Proc. IPI workshop on potassium and fertigation development in West Asia and North Africa, Rabat Morocco. 2004; 24-28s.

LIU ZH, JIANG LH, LI XL, H¨ARDTER R, ZHANG WJ, ZHANG YL & ZHENG DF. Effect of N and K fertilizers on yield and quality of greenhouse vegetable crops. Pedosphere. 2008; 18(4): 496–502.

LOCASCIO SJ, HOCHMUTH GJ, RHOADS FM, OLSON SM, SMAJSTRLA AG & HANLON EA. Nitrogen and potassium application scheduling effects on drip-irrigated tomato yield and leaf tissue analysis. Hort Science. 1997; 32(2): 230-235.

LOCH J & PETHO F. Effect of potassium sulphate on the yield of vegetable: In: roc. Potash in Ecosystem, 23rd Colloquium, Potash Institute. Prague. 12-16. 1992; 407-409.

NANADAL JK, RAMESH V & PANDEY UC. Effect of phosphorus and potassium on growth yield and quality of tomato. Journal of Potassium Research. 1998; 14(1): 44-49.

NAVA G & DECHEN AR. Long-term annual fertilization with nitrogen and potassium affect yield and mineral composition of' Fuji'apple. Scientia Agricola. 2009; 66(3): 377-385.

PARK S, JEONG WY, LEE JH, KIM YH, JEONG SW, KIM GS, BAE DW, LIM CS, JIN JS, LEE SJ & SHIN SC. Determination of polyphenol levels variation in *Capsicum annuum* L. cv. c*helsea* (yellow bell pepper) infected by anthracnose (*Colletotrichum gloeosporioides*) using liquid chromatography-tandem mass spectrometry. Food Chemistry. 2012; 130: 981-985.

PEREIRA MJZ, MASSOLAJÚNIOR NS, SUSSEL AAB, SALA FC, COSTA CP & BOITEUX LS Reação de acessos de *Capsicum* e de progênies de cruzamentosinterespecíficos a isolados de *Colletotrichum acutatum*. Horticultura Brasileira. 2011; 29:569-576.

PICHA DH & HALL CB. Influences of potassium, cultivar, and season on tomato graywall and blotchy ripening. J. Amer. Soc. Hort. Sci. 1981; 106:704–708.

RAJAPAKSE RGAS. Mode of anthracnose development in chili (*Capsicum annum L.*) pods. Annals of the Sri Lanka Department of Agriculture. 1999; 1: 247-266.

RAJAPAKSE RGAS & RANASINGHE JADAR. Development of variety screening method for anthracnose disease in chili. Tropical Agricultural Reseach and Extention. 2002; 5:7-11.

SUTTON BC. The genus *Glomerella* and its anamorph *Colletotrichum*. In: *Colletotrichum* : *Biology, pathology and control*. (Bailey JA & Jeger MJ, Eds.). CAB International, Wallingford, Oxon, UK. 1992; 1-26.

WEERAHEWA D & DAVID D. Effect of silicon and potassium on tomato anthracnose and on the postharvest quality of tomato fruit (*Lycopersicon esculentum* Mill.). J.Natn. Sci. Foundation Sri Lanka. 2015; 43 (3): 271-278.

WEERAKOON WRWMAU, Abayasekara CL & Adikaram NKB. The Effect of Soil Potassium on Postharvest Fungal Diseases of Banana. Proceedings and abstracts of University of Peradeniya Research sessions. 2005; 10, 94.

WÓJCIK P, LIBEK A, KAUFMANE E & SASNAUSKAS A. Effect of foliar potassium sprays on apple tree yielding, and fruit quality under conditions of low soil potassium availability. In Proceedings of the international scientific conference: Environmentally friendly fruit growing, Polli, Estonia,Tartu University Press. 2005; 44-50.