Yield and Fruit Quality of Tomato as Affected by Rates and Ratios of K and Ca in Water Culture System

B. Nzanza, Diana Marais, and Andries S. Claassens

Department of Plant Production and Soil Science, University of Pretoria, 0002 Pretoria, South Africa. E-mail: andries.claassens@up.ac.za.

Abstract

A water culture experiment in a greenhouse investigated the effects of K:Ca ratios and rates on yield and quality of tomato. A factorial experiment included two levels of K (6 and 10 $mmol_c/l$), two levels of Ca (12 and 16 $mmol_c/l$) and four K:Ca $mmol_c/l$ ratios (6:12, 6:16, 10:12, 10:16). Treatments were replicated four times in a fully randomized design with tomato cv. "Money Maker" as the test crop. The total marketable yield of tomato decreased, mainly because of a high incidence of physiological disorders, including small fruits. High K rates in the nutrient solution decreased fruit pH, and increased titratable acidity (TA) and total soluble solid (TSS). High Ca (16) rates combined with low K (6) decreased the K content of tomato fruits. Low K in the nutrient solution increased the incidence of blotchy ripening (BR), whereas low Ca increased the incidence of blossom end rot (BER). There was no evidence that these plant nutrients influenced the occurrence of fruit cracking (FC) or cat facing (CF).

Keywords: calcium, fruit quality, potassium, tomato, yield, water culture.

Introduction

Fruit quality is a crucial factor in the production of greenhouse tomatoes, and it is strongly influenced by K. Potassium plays a key role in charge balance and certain metabolic and transport processes, as well as turgor regulation (Dorais *et al*., 2001); it influences fruit shape, reduces ripening disorders, and enhances acid concentration (Adams *et al*., 1978). With adequate K nutrition, the fruit is generally higher in total solids, sugars, acids, carotene, and lycopene, and has a better keeping quality (Munson, 1985).

Potassium accumulates to a greater extent than other nutrient elements, which leads to considerable demands for this mineral (Williams and Kafkaffi, 1998; Voogt and Sonneveld, 1997). A main cause for concern in elevating K in the nutrient solution is its antagonistic effect on the uptake of other nutrients, such

as Ca, N, or Mg. A high K:Ca ratio has been reported to increase BER (Bar Tal and Pressman, 1996).

The aim of this experiment was to investigate the effects of K and Ca rates and ratios on yield and quality of tomato under certain South African conditions.

Materials and methods

A greenhouse experiment was conducted at the experimental farm of the University of Pretoria. The factorial experimental design included two levels of K (6 and 10 $mmol_c/l$), two levels of Ca (12 and 16 $mmol_c/l$) and four K:Ca $mmol_c/l$ ratios (6:12, 6:16, 10:12, 10:16); there were four replications. Tomato cv. "Money Maker" seedlings were transplanted into 10-l pots on a rotating table. The main stems were trained and allowed to grow to five trusses. Lateral shoots were removed but fruit was not thinned. Treatment combinations were prepared by modifying a Hoagland no. 2 solution. The nutrient solutions were monitored regularly for pH and EC, and replaced fortnightly. At harvest, fruits were collected to determine yield and quality factors, such as physiological disorders, size, pH, TSS, TA, EC, dry matter. Leaf and fruit samples were chemically analysed for K, Mg, Ca, N, and P. Analysis of variance (ANOVA) was applied to each parameter at $P < 0.05$. In case of significance Turkey's LSD test was applied.

Results

Table 1 presents the response of tomato to K: Ca ratios, as expressed in fruit disorders and effects on marketable yields. There were no significant differences in marketable yields, though the treatment supplied with high K and Ca (10:16) showed the highest marketable yield, and the low K and Ca (6:12) treatment the lowest. High Ca (16) reduced the incidence of BER. Blotchy ripening occurred only in low-K treatments. FC and CF were not affected by treatments.

Table 2 summarizes the effects of K:Ca ratios on tomato fruit quality. Fruit pH and EC were significantly higher at low K:Ca ratios. Titratable acidity, TSS, and fruit dry matter (DM) were not significantly affected by rates and ratios of K and Ca in the nutrient solution.

Table 1. Effects of K:Ca ratios on fruit disorders (g/fruit) and marketable yield of tomato.

K:Ca ratio	BER	BR	FC	CF	Small fruit	Marketable yield
	---------- % ----------					
6:12	2.75 a	0.42 a	2.14 a	0.89 a	3.19 a	90.62 a
6:16	0.93 b	0.96 a	2.20 a	0.91 a	3.23 a	91.77 a
10:12	2.32 a	0 b	2.18 a	0.53 a	3.35 a	91.62 a
10:16	0.41 b	0 b	2.59 a	0.40 a	3.28 a	93.32 a

Means followed by the same letter in a column are not significantly different according to Turkey's test at P <0.05.

Table 2. Effects of K:Ca ratios on tomato fruit quality.

K:Ca ratio	pH	TA	TSS	EC	DM
		nmol/L	*%*	*dS/m*	*%*
6:16	4.1875 a	67.50 a	4.92 a	4.765 ab	5.355 a
6:12	4.1625 a	66.75 a	4.902 a	4.6875 b	5.5725 a
10:16	4.075 b	72.25 a	5.075 a	4.8275 a	5.4025 a
10:12	4.0775 b	71.75 a	5.0675 a	4.7875 ab	5.59 a
LSD	0.038	4.28	0.1409		0.2625
CV	0.751	5.648	2.593	1.701	0.262

Means followed by the same letter in a column are not significantly different according to Tukey's test at P <0.05.

The effects of K:Ca ratios on the mineral contents of fruit are presented in Table 3. The data revealed no significant differences among treatments, in the mean contents of N, Ca, and Mg the fruit, whereas the P and K contents were highest at a K:Ca ratio of 6:12 and lowest at a ratio of 6:16.

Table 3. Effects of K:Ca ratios on mineral contents of tomato fruits.

K:Ca ratio	N	P	Ca	K	Mg
	---------- % ----------				
6:16	2.125 a	0.35 b	0.14 a	2.995 b	0.115 a
6:12	2.425 a	0.475 a	0.147 a5	3.575 a	0.1225 a
10:16	2.25 a	0.4 ab	0.1325 a	3.145 ab	0.1175 a
10:12	2.525 a	0.425 ab	0.18 a	3.4425 ab	0.1225 a
LSD	0.40009	0.0943	0.06092	0.5003	0.0162
CV	11.161	14.875	26.352	9.948	8.802

Means followed by the same letter in a column are not significantly different according to Turkey's test at $P < 0.05$.

Discussion

The results showed that tomato yield was most affected by physiological disorders such as BER. BR was observed only in low-K treatments, which indicates that K deficiency plays a key role on the incidence of this disorder. No relationship has been found for FC and CF that affected the marketable yield (Table 1). This study showed the beneficial effect of elevated K levels in improving fruit quality. High K rates increased TA, TSS and EC, and decreased fruit pH. High Ca combined with low K decreased the percentage of K in the fruit (Table 3). Based on these findings it seems clear that proper K nutrition improves fruit quality of tomato.

References

Adams, P., J.N. Davies, and G.W. Winsor. 1978. Effects of nitrogen, potassium and magnesium on the quality and chemical composition of tomatoes grown in peat. Journal of Horticultural Science 53:115-122.

Bar Tal, A., and E. Pressman. 1996. Root restriction and potassium and calcium solutions concentrations affect dry-matter production, cation uptake and blossom-end rot in greenhouse tomato. Journal of the American Society for Horticultural Science 121:649-655.

Dorais, M., A. Papadopoulos, and A. Gosselin. 2001. Greenhouse tomato fruit quality. Horticultural Review 26:239- 350.

Munson, R.D. 1985. Potassium in Agriculture. ASA-CSSA-SSSA, Madison, Wisconsin, USA.

Voogt, W., and C. Sonneveld. 1997. Nutrient management in closed growing systems for greenhouse production. *In*: Goto, E. (Ed.). Proc. Intl. Symp. on plant production in closed ecosystems. Aug. 26-29, 1996. Narita, Japan. Kluwer Academic Publishers, Dordrecht, The Netherlands. pp 83-102.

Williams, L., and U. Kafkafi. 1998. Intake and translocation of potassium and phosphate by tomatoes by late sprays of KH_2PO_4 (MKP). *In*: Proceedings of the Symposium on Foliar Fertilization: A Technique to Improve Production and Decrease Pollution, Cairo, Egypt, 10-14 December 1995. NRC, pp. 85-90.