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# EFFECTS OF FOLIAR POTASSIUM FERTILIZATION ON MUSKMELON FRUIT QUALITY AND YIELD[1]

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## Abstract

Sugar content, aroma, and texture are key quality traits that influence consumer preference of many fruits and vegetables, such as muskmelon [*Cucumis melo* L. (Reticulatus Group)]. These quality traits are directly related to potassium (K)-mediated processes. However, soil-derived K alone is seldom adequate to satisfy these fruit quality processes. Controlled environment studies have shown that supplemental foliar K applications can overcome this apparent deficiency. However, the suitability of potential K salts as foliar sources is still uncertain. We studied the effects of six foliar K sources (potassium chloride—KCl, potassium—$KNO_3$, monopotassium phosphate—MKP, potassium sulfate—$K_2SO_4$, Potassium thiosulfate—KTS, and Metalosate® Potassium) on fruit quality parameters of field-grown muskmelon 'Cruiser' over two growing seasons, 2006 and 2007 in Weslaco, south Texas. Weekly foliar K applications were initiated at fruit set and continued to fruit maturity. Although pre-plant soil K concentrations were very high, supplemental foliar K treatments resulted in higher K concentrations in plant tissues, suggesting that plant K uptake from the soil solution was not sufficient to saturate tissue K accumulation. In 2006, fruit yields were not affected by supplemental foliar K spray but in 2007, yield differed significantly among the foliar K sources with treated plots generally having higher yields than the control plots. Fruit from plots receiving supplemental foliar K had higher external and internal fruit tissue firmness than control fruit and this was associated with generally higher soluble solids concentrations (SSC) in both years. All the foliar K sources studied had positive effects on fruit quality parameters except for $KNO_3$, which tended to result in less firm fruit, lower SSC values. The results are consistent with previous controlled environment findings that supplementing soil K supply with foliar K applications during fruit development and maturation can improve muskmelon fruit quality by

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increasing SSC, firmness, and sugar contents.

## Introduction

Potassium (K) is an essential plant nutrient involved in numerous physiological processes that control plant growth, yield, and quality parameters such as taste, texture, and nutritional/health properties (Marschner, 1995; Lester, 2005). The majority of K in plant tissues is taken up by roots from the soil solution in its ionic form ($K^+$). Even though K is abundant in most soils in Texas, the bulk of soil K is unavailable to plants, as both plant and environmental factors can limit adequate plant K uptake (Mengel and Kirkby, 1980). In many species, K uptake occurs mainly during the vegetative stages of plant growth when root growth is not inhibited by carbohydrate supply (Fisher et al., 1970). During reproductive development, competition for photoassimilates between developing fruits and vegetative organs may limit root activity and nutrient uptake (Ho, 1988). Therefore, soil derived K, which is essential for sugar transport and unloading into fruit during fruit growth and development, is not always optimal during the critical fruit development period and this is partly responsible for poor fruit quality and yield.

Previous controlled environment studies (Lester et al., 2005, 2006) have shown that supplementing soil K supply with foliar K applications during fruit development and maturation can improve muskmelon fruit quality parameters such as fruit firmness, sugar content, ascorbic acid and beta-carotene levels. For field-grown plants, increasing soil fertilizer inputs may not be enough to alleviate the developmentally-induced K deficiency, partly because of reduced root activity during reproductive development and also because of competition for binding sites on roots from cations, such as calcium and magnesium (Clarkson, 1989; Engels and Marschner, 1993). Data of Lester et al. (2005) indicated that the beneficial effects of supplemental foliar K application on fruit quality were greater when an organic form of K (Metalosate® Potassium) was used, compared to an inorganic (e.g. potassium chloride, KCl) source. Potassium chloride is the most widely used source of fertilizer K, however, its relatively high salt index (~120, Mortvedt, 2001) and its high point of deliquescence (POD, 86%, Schönherr and Luber, 2001) limits its use for foliar nutrition. A high POD increases the risk of crystallization following foliar sprays.

The objective of this 2-year study was to evaluate the effectiveness of different K salts for foliar K fertilization on muskmelon fruit yield and quality parameters.

## Materials and Methods

Six K sources and a control were evaluated in field studies during the spring growing seasons of 2006 and 2007 in Lower Rio Grande Valley region of Texas, an area with a semiarid climate averaging approximately 500 mm (2 in.) rainfall. Soil type at the study site was a Hidalgo sandy clay loam. Standard commercial practices for spring muskmelon production including irrigation, nutrient management, and pest control were followed. In both years, plots were established in a completely randomized design and replicated four times. Starting at fruit set, and continuing till fruit maturation, the following weekly foliar K treatments were established:

(1) control (sprayed with de-ionized water)

(2) potassium chloride (KCl)

(3) potassium nitrate ($KNO_3$),

(4) monopotassium phosphate (MKP – Mora-Leaf® P&K 30% $K_2O$, Rotem BKG LLC, Ft Lee, NJ)

(5) potassium sulfate ($K_2SO_4$),

(6) potassium thiosulfate ($K_2S_2O_3$; KTS®, 25% $K_2O$, Tessenderlo Kerley Inc., Phoenix, AZ)

(7) a glycine amino acid-complexed K (Metalosate® Potassium 24% $K_2O$; Albion Laboratories, Inc, Clearfield, Utah)

A non-ionic surfactant (Silwet L-77; Helena Chem. Co., Collierville, TN) was added to all spray treatments at 0.3% (v/v). All foliar K solutions were formulated according to manufacturer recommendations and calibrated to supply ~ $K_2O$ at 4.0 lbs per acre (4.4 kg per Ha) during each foliar application. All treatments were applied between 0500 and 0800 HR on each spray event. A total of 5 foliar K applications (total ~ $K_2O$ at 20.0 lbs per acre or 22.4 kg per Ha) per treatment were made each year. At maturity, uniform fruits (7-10 per treatment) were harvested from each plot and analyzed for fruit sugars, fruit firmness, K concentration, soluble solids concentration, ascorbic acid, and β-carotene following the procedures previously described by Lester et al. (2005).

**Results and Discussion**

Pre-plant soil tests indicated moderate to very high potassium (624 mg/kg or 624 ppm) levels, so no K was added to the soil. Phytotoxicity problems were not observed with any of the foliar K sources and concentrations used. The pH levels of spray solutions ranged from 6.5 to 7.7. Unbuffered solutions of most K sources tend to have alkaline pH levels that can cause leaf burns and this is more pronounced when applied during dry, hot weather conditions (Swietlik and Faust, 1984). In the present study, all treatments were applied between 0500 and 0800 when air humidity (>80%), temperatures (< 25°C or < 77°F), and wind speeds (<1.0 mph or <1.6 kg/hr) were less favorable for leaf burn development.

Plant tissues from plots receiving supplemental foliar K treatments generally had higher K concentrations than those from control plots, suggesting that soil K supply alone was not sufficient to saturate tissue K accumulation (Table 1). However, differences in tissue K concentrations among the foliar K sources were not highly significant except for $KNO_3$ treatments, which generally had the least beneficial effect on tissue K concentrations, perhaps a dilution effect resulting from $NO_3$-enhanced vegetative growth.

Soluble solids concentrations also differed significantly among the foliar K treatments in both years and were generally lower in 2007 than in 2006. With the exception of KCl and $KNO_3$, all the other foliar K sources significantly increased fruit SSC levels compared to the control treatment. Although SSC values were generally lower in 2007 than in 2006, the relative benefit from supplemental foliar K was observed in 2007. Unseasonable weather conditions (cold fronts) during the 2007 growing season delayed vegetative development and as a consequence there was a substantial overlap between canopy development and fruit maturation. This is a probable reason for the marginal SSC values observed in 2007. Nevertheless, a positive and more pronounced response to foliar K treatments was recorded in 2007. In 2006, similar trends were also observed for total and component sugars (glucose, sucrose and fructose; data not shown) but variability in individual observations resulted in inconsistent trends among the K sources. The general trend of increased SSC and sugar contents in fruit form of K-treated plots is consistent with, but less dramatic than our previous observations with supplemental foliar K application in controlled environment studies (Lester et al., 2005).

While foliar K applications generally increased firmness in both years, no significant differences were found among the K sources except for $KNO_3$, which tended to result in less firm fruit compared to controls (Table 2). Firmness measurements are a good indicator of fruit texture and shelf life. In a previous study it was found that fruit firmness was closely correlated with fruit tissue pressure potential ($\psi_p$; Lester et al., 2006), with fruit from K-treated plants having significantly higher $\psi_p$ values than those of control plants. Fruit yields averaged 6,000 lb/acre (6,725 kg/Ha) based on a once-over harvest during peak fruit maturity in 2006, and 20,100 lb/acre (22,529 kg/Ha) in 2007 based on harvests over a two-week period. Significant yield differences between supplemental foliar K treatments and the control were observed only in 2007 and consistent with SSC results, yields from KCl-treated plots were not significantly different from those of control plots. Individual fruit fresh weights of K-treated fruit did not differ significantly from those of fruit from control plots. However, fruit counts from treated plots were slightly greater than those from control plots (data not shown), potentially accounting for the increased yields. Studies of yield responses to K are mixed. Hartz et al. (2005) reported increased yields and fruit quality of fertigated tomatoes even when exchangeable soil K concentration was high; they found no effect of foliar applied K on yield and quality, perhaps due to confounding factors related to soil processes and climatic conditions.

These results generally support our previous controlled environment findings that supplementing soil K supply with foliar K applications during fruit development and maturation can improve muskmelon fruit quality by increasing firmness, sugar content, and perhaps yield under unfavorable environmental conditions. The current data also provide additional evidence of differences among potential foliar K sources, with $KNO_3$ consistently emerging as a less desirable source of K during fruit development.

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Table 1 shows the effects of foliar potassium (K) sources on tissue K concentrations and fruit soluble solids concentrations (SSC) of field-grown muskmelon ('Cruiser') fruit in south Texas. Weekly foliar K applications were made between fruit set and fruit maturity during the spring growing season in 2006 and 2007.

**Table 1**
**Effects of Foliar Potassium (K) Sources on Tissue K Concentrations and Fruit Soluble Solids Concentrations (SSC)**

| Treatment | Leaf | | Petiole | | Stem | | SSC | |
|---|---|---|---|---|---|---|---|---|
| | K mg/gdw | | K mg/gdw | | K mg/gdw | | % | |
| | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 |
| Control | 11.9cd | 12.9b | 48.2d | 54.3b | 42.9d | 46.1c | 9.2b | 8.1b |
| KCl | 11.6d | 14.1a | 55.2bc | 63.4a | 49.3c | 53.7b | 10.0ab | 9.3ab |
| $KNO_3$ | 10.7d | 13.1b | 47.6d | 54.9ab | 41.6d | 47.8bc | 9.7ab | 8.7b |
| MKP | 13.2bc | 15.9a | 51.6cd | 59.4ab | 46.7cd | 53.7b | 10.6a | 10.1a |
| $K_2SO_4$ | 14.7a | 14.9a | 50.2cd | 58.7ab | 64.0a | 69.6a | 10.5a | 9.7a |
| KTS | 13.9ab | 16.8a | 64.2a | 73.9a | 55.4b | 63.7a | 10.7a | 10.4a |
| Metalosate® Potassium | 14.7a | 15.4a | 57.8b | 66.5a | 48.1c | 53.5b | 10.3a | 9.8a |

| **Abbreviation** | **Foliar Potassium (K) Sources** |
|---|---|
| gdw | ground dried weight |
| KCl | potassium chloride |
| $KNO_3$ | potassium nitrate |
| MKP | monopotassium phosphate |
| $K_2SO_4$ | potassium sulfate |
| KTS | potassium thiosulfate |

[z] *Means with the same letter, within a column and location are not significantly different at Duncan's MRT 95% probability level (n=6-16).*

Table 2 shows the effects of foliar potassium (K) sources on the yield, average fruit weight and fruit firmness of field-grown muskmelon (‘Cruiser’) fruit.

Weekly foliar K applications were made between fruit set and fruit maturity during the spring growing season in 2006 and 2007.

**Table 2**
**Effects of Foliar Potassium (K) Sources on the Yield, Average Fruit Weight and Fruit Firmness of Field-Grown Muskmelon (‘Cruiser’) Fruit**

| Treatment | Yield | | Fruit Weight | | External Fruit firmness | | Internal Fruit firmness | |
|---|---|---|---|---|---|---|---|---|
| | 40-lb. boxes/acre (45-kg boxes/Ha) | | (g) | | (N) | | (N) | |
| | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 |
| Control | 144.5a[z] | 455.9b | 1826.3a | 2148.4a | 41.7b | 41.2a | 10.2bc | 8.9b |
| KCl | 148.8a | 506.2a | 1867.5a | 2295.7a | 43.0b | 44.7a | 10.6abc | 9.9ab |
| $KNO_3$ | 136.1a | 429.9b | 1770.9a | 2191.3a | 39.6b | 39.9a | 9.8c | 8.4b |
| MKP | 160.2a | 530.0a | 1763.7a | 2384.7a | 43.3b | 46.1a | 11.2abc | 10.9a |
| $K_2SO_4$ | 155.8a | 517.0a | 1977.8a | 2298.1a | 57.8a | 45.2a | 12.8ab | 10.3ab |
| KTS | 166.9a | 573.9a | 1805.2a | 2496.0a | 51.8ab | 46.8a | 13.1a | 11.1a |
| Metalosate® Potassium | 151.4a | 521.9a | 1936.3a | 2337.4a | 43.6b | 45.7a | 11.2abc | 10.7a |

| Abbreviation | Foliar Potassium (K) Sources |
|---|---|
| KCl | potassium chloride |
| $KNO_3$ | potassium nitrate |
| MKP | monopotassium phosphate |
| $K_2SO_4$ | potassium sulfate |
| KTS | potassium thiosulfate |

[z] *Means with the same letter, within a column and location, are not significantly different at Duncan’s MRT 95% probability level (n=6-16).*

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