Influence of K and Ca on Quality and Yield of Watermelon

F.J. Sundstrom and S.J. Carter
Department of Horticulture, Louisiana State University, Baton Rouge, LA 70803

Abstract. Fertilizer K supplied as KCl, and Ca supplied as gypsum, interacted in their effect on yield and tissue composition of 'Calhoun Gray' watermelon [Citrullus lanatus (Thunb.) Matsum. & Nakai]. Increased rates of K significantly affected yield in a curvilinear manner. Response for K at varying levels of Ca had linear and either cubic and/or quadratic relationships. Increased rates of Ca reduced K uptake and yield. There was a highly significant inverse relationship between tissue K and tissue Ca. Although there was a significant K × Ca interaction on yield, individual element correlation coefficients with yield also were significant. Increased rates of fertilizer K increased rind thickness at watermelon equator, which was found to be related to watermelon rupture pressure. Ca and blossom-end rind thickness had no influence on rupture pressure. K and Ca did not influence blossom-end rot, redness of flesh, or soluble solids of watermelon.

Watermelons grown in the southeastern United States for early season production are often grown on sandy soils that warm rapidly in the spring. Because of high regional rainfall and low cation exchange capacities, nutrient leaching in these sandy soils is a major problem.

Research concerning the influence of K and Ca availability on watermelons has been documented, but with dissimilar conclusions. It generally has been observed that increasing rates of fertilizer K stimulate watermelon yield (1, 2, 20, 23). Increasing rates of Ca, supplied as lime, have been observed to decrease (16, 23), increase (12, 17, 20, 30), or not affect (15) watermelon yield.

Studies on watermelon fruit quality have been numerous (9, 15, 19, 24, 25, 26, 27, 29), but observations on the effect of nutrition on quality have been limited (1, 3, 10, 30) with variable results.

Rind resiliency has been found to be of greater importance than rind thickness. The Magness-Taylor fruit tester has been employed by some (18, 28) as a measure of rind toughness. Use of an instron to measure product firmness or resiliency has only been reported on a limited basis (8).

The purpose of this study was to determine the influence of K and Ca, independent of soil acidity interaction, on fruit quality, fruit rind thickness, fruit rupture pressure, and yield of watermelon grown on a sandy soil.

Materials and Methods

This study was conducted on a Ruston sandy loam soil (fine-loamy, siliceous, thermic-type, Paledults) near Colfax, La. in Spring and Summer 1981 and 1982.

The experimental design was a randomized complete block with 3 replications. Treatments were arranged factorially and consisted of 4 rates of K as KCl (0, 70, 139, and 209 kg K/ha) and 4 rates of Ca as gypsum (0, 560, 1120, and 1680 kg Ca/ha). K treatments were applied each year 50% banded preplant and 50% as a sidedress at layby. Ca plots were established in 1981 by incorporation of a 1.2-m-wide band of gypsum in each plot to a depth of between 15 and 32 cm. No additional gypsum was applied in 1982. Indigenous soil K and Ca values were 35 and 325 ppm, respectively. Both years, soil pH values of all plots ranged between 5.4 and 5.7. All plots received P banded preplant according to soil test recommendations. N was applied to all treatments at a rate of 139 kg N/ha, 50% banded preplant and the remainder at layby. 'Calhoun Gray' watermelon was seeded in hills with 1.2 m in-row spacing and 3.1 m between rows. Each plot was 9.8 m in length. Seedlings were thinned to 2 plants per hill.

Soil and tissue samples were taken at early fruit set both years. Six soil samples were taken from the center of each plot at a depth of 0–15 cm. Samples were analyzed for K and Ca by the LSU Soil Testing Laboratory as described by Brupbacher et al. (7). Tissue samples containing 20 to 24 of the youngest, fully mature leaves and petioles were taken at the same time as soil samples. Tissue was digested with a 3 : 1 HNO₃ : HClO₄ acid mixture and analyzed on a Perkin-Elmer Model 5000 Atomic Absorption Spectrophotometer for K and Ca by the Louisiana Department of Agriculture Laboratory.

 Marketable watermelons (>6.8 kg) were harvested once from the center 6 hills of each plot in July of both years. The number of fruit, their respective weight, and blossom-end-rot (BER) number were determined. Four representative and uniform fruit per treatment were selected for immediate quality testing.

The stem end of each watermelon was placed on the pressure cell of a tabletop Instron, Model No. 1101. The increase in pressure applied by the pressure head descending at a rate of 51 cm/min on the blossom-end of each fruit was recorded until rind rupture occurred. The maximum amount of pressure the watermelon was able to withstand before cracking was determined.

Each cracked watermelon was cut longitudinally and the flesh was sampled for soluble solids and redness by removal and homogenization of 5 to 8 cm³ of tissue from the heart section. The homogenate was filtered through Whatman No. 6 filter paper and tested for total soluble solids on a Bausch and Lomb Refractometer, Model No. ABBE-3L. A portion of the homogenate
was also tested for redness on a Gardener Color Difference Meter, Model No. XL 10. The standard plate values were: total reflectance, \( L = 24.4 \); redness, \( a = 21.8 \); and yellowness, \( b = 6.2 \). The "\( a \)" value as reported by Nip et al. (25) was used as an index of red flesh color. Rind thickness at the blossom-end and equator of each watermelon was measured by means of a centimeter scale.

**Results and Discussion**

Treatment influences were similar in both seasons; therefore, all data reported herein are means of 1981 and 1982 results. Fertilizer K and Ca interacted in their effect on watermelon yield. In treatments where K was supplied at 70 or 139 kg K/ha, the effect of Ca rate was significant in a curvilinear manner. At these levels of K, addition of 560 kg/ha of Ca resulted in highest crop yields (Table 1). Levels of Ca greater than 560 kg/ha consistently reduced fruit yields. Because Ca was supplied in the form of gypsum, soil pH values within Ca treatments were not influenced appreciably by Ca rate.

In those treatments which received lower rates of K, application of Ca substantially decreased yield. In those plots receiving the highest rate of K, the depressive influence of Ca was not as apparent. This observation is possibly explained by the antagonism found to exist between the 2 elements. There existed a highly significant (\( r = 0.63 \)) inverse relationship between tissue K and Ca (Fig. 1), as previously reported by Elmstrom et al. (11). High rates of fertilizer K resulted in high concentrations of K and low concentrations of Ca in watermelon leaf-petiole tissue.

Increasing fertilizer K influenced yield in a curvilinear manner. Rates of fertilizer K at either 70 or 139 kg/ha appeared to be optimum (Table 1). This positive response of K on watermelon yield supports the work of others (1, 2, 20, 23).

Correlations between foliar mineral analyses and crop response have been studied by many (3, 6, 14, 21, 22). Low correlations between foliar composition and yield (3, 14, 21, 22) have been explained by nutrient interaction influences. In this study, although there was a significant K \( \times \) Ca interaction on yield, the main effect correlation coefficients (\( r = 0.29 \) and \( r = 0.23 \) for K and Ca, respectively) were still significant at 1% and 5% levels, respectively. These results are only in agreement with Brinen et al. (6), who found leaf K level at early fruit set to be correlated with yield/plant. Increased levels of fertilizer K from zero to 209 kg/ha were significantly correlated with tissue K (\( r = 0.29 \)) and watermelon yield (\( r = 0.33 \)) at the 1% level.

### Table 1. Influence of fertilizer K and Ca on watermelon yield, 2-year average (1981 and 1982).

<table>
<thead>
<tr>
<th>Potassium (kg/ha)</th>
<th>0</th>
<th>70</th>
<th>139</th>
<th>209</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (kg/ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>43.8</td>
<td>44.5</td>
<td>47.4</td>
<td>45.8</td>
</tr>
<tr>
<td>560</td>
<td>37.4</td>
<td>56.5</td>
<td>54.8</td>
<td>49.2</td>
</tr>
<tr>
<td>1120</td>
<td>31.7</td>
<td>45.0</td>
<td>37.1</td>
<td>43.5</td>
</tr>
<tr>
<td>1680</td>
<td>35.6</td>
<td>30.3</td>
<td>33.6</td>
<td>43.5</td>
</tr>
<tr>
<td>Significance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L<strong>Q</strong></td>
<td>43.8</td>
<td>44.5</td>
<td>47.4</td>
<td>45.8</td>
</tr>
<tr>
<td>L<strong>Q</strong></td>
<td>37.4</td>
<td>56.5</td>
<td>54.8</td>
<td>49.2</td>
</tr>
<tr>
<td>L<strong>Q</strong></td>
<td>31.7</td>
<td>45.0</td>
<td>37.1</td>
<td>43.5</td>
</tr>
<tr>
<td>L<strong>Q</strong></td>
<td>35.6</td>
<td>30.3</td>
<td>33.6</td>
<td>43.5</td>
</tr>
</tbody>
</table>

\( ^* \)Interaction of K \( \times \) Ca significant at 1% level.

\( ^{NS} \) Linear (L), quadratic (Q), or cubic (C) nonsignificant (NS) or significant at 5% (*) or 1% (**) level.

**There was no relationship between exchangeable soil Ca and crop yield. Plant uptake of Ca and gypsum rate were not related, supporting earlier work of Fiskell et al. (13). There was a significant negative correlation (\( r = 0.29 \)) between tissue Ca and yield at the 5% level. Depressed watermelon yields as a result of increasing rates of lime-supplied Ca have been reported previously (16, 23). As found by others (10, 18, 30), tissue Ca was not related to blossom-end rot incidence (data not shown).

Increased rates of K resulted in greater rind thickness at fruit equator (Table 2). Rind thickness at fruit equator was correlated significantly (\( r = 0.59 \)) at the 1% level with the pressure that the blossom-end of a watermelon could tolerate before the rind cracked (Table 2). Data from watermelon-shipping studies (4, 5) indicate a 56% reduction in external bruising and a 50% reduction in cracked watermelons when the thin blossom end of...

### Table 2. Influence of fertilizer K averaged over Ca levels on watermelon fruit quality, 2-year average (1981 and 1982).

<table>
<thead>
<tr>
<th>Potassium (kg/ha)</th>
<th>Diameter rind thickness (cm)</th>
<th>Melon rupture pressure (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.6 b</td>
<td>150 b</td>
</tr>
<tr>
<td>70</td>
<td>3.7 ab</td>
<td>164 ab</td>
</tr>
<tr>
<td>139</td>
<td>4.1 a</td>
<td>167 a</td>
</tr>
<tr>
<td>209</td>
<td>4.0 a</td>
<td>166 a</td>
</tr>
</tbody>
</table>

\( ^{K \times Ca} \) Interaction on quality not significant.

\( ^{\text{Mean separation within columns by Duncan's multiple range test, 5% level.}} \)
the fruit was protected in a crosswise load. The advantage of crosswise loading and shipping of watermelons is that lengthwise impact forces transmitted to the load are taken on the thicker, tougher sides of the melons, rather than the thin blossom-ends. Even more important, the force of lengthwise impact on a crosswise load is distributed over a greater surface area of the melon, therefore substantially reducing the pressure/cm² of rind. This research indicates that even when pressure is applied on the thin blossom-end of the fruit, it is rind thickness at the equator of the watermelon which is of greatest significance. In all cases, however, cracking initiated at the blossom-end and proceeded towards the diameter of the fruit. Increased K resulted in increased rind thickness at the equator of the fruit. Blossom-end rind thickness was not influenced significantly by fertilizer K and was not related to watermelon rupture pressure. This would suggest rind resiliency and thickness measurements would be of greater value if taken at the equator rather than the blossom-end of the watermelon.

Ca availability as influenced by gypsum rate did not influence rind thickness at the blossom-end or equator of the watermelon, an observation different than that of Waters and Nettles (30). Ca had no effect on fruit rupture pressure values.

The effect of fertilizer treatment on watermelon flesh redness and soluble solids was studied. Mean red flesh color difference meter values ranged from 20.4 to 20.7, and were not significantly influenced by K or Ca rate. The lack of a significant fertilizer treatment effect on flesh redness has not yet been reported. Results that neither K nor Ca influenced soluble solids were consistent with earlier studies (10, 30). Fruit heart soluble solids values fluctuated from 8.9 to 9.3%, independent of treatment effects. There was no significant relationship between flesh redness and soluble solids.

Literature Cited