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Research Article

Effects of Calcium with and without Surfactants on Fruit Quality, Mineral Nutrient, Respiration and Ethylene Evolution of 'Red Spur Delicious' Apple

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Abstract

Calcium (Ca) plays an important role in apple fruit quality. Only portion of Ca spray that lands on the surface of apple fruit can penetrate in the tissue and influence fruit quality and maturity. Thus, selection of an appropriate surfactant in a spray solution would be extremely crucial in the success of Ca and other nutrient absorption. In this study, effects of Ca spray with or without Regulaid and KALO surfactants on fruit quality, ethylene and respiration of 'Red Spur Delicious' apple was studied. No significant difference in fruit quality attributes or mineral nutrients were found between the two surfactants. However, fruits receiving a combination of KALO surfactant and Ca had significantly lower respiration and ethylene evolution, suggesting that KALO could be a preferred surfactant if fruit growers wish to postpone fruit maturity. The reason of this phenomenon is not clear and deserves further investigation.

Introduction

Foliar fertilization is a common practice to supply crops with mineral nutrients, especially under limited soil nutrient availability conditions [1]. However, foliar-applied nutrients must overcome the barrier properties of leaf surface to be absorbed by plants. Various pathways are reported to explain the penetration of foliar nutrients through the leaf tissues. Meanwhile, beveled that air humidity is one of the main controlling factors in this process since it controls both the actual nutrient concentration on the leaf surface [1] as the driving force of absorption and the permeability of the leaf surface. Postharvest and pre-bloom foliar nitrogen sprays are applied to enhance flower bud vigor, and calcium (Ca) is applied directly to fruit during the growing season to reduce fruit susceptibility to physiological disorders. The cuticle serves as the prime barrier to penetration of different solutes [2], and numerous studies have focused on cuticle structure, composition and penetration by components [3-6]. Epicuticular waxes are known to reduce cuticular penetration by a wide range of solutes [7]. However, growing evidence suggests that cracks might provide a pathway for Ca penetration into apple fruit [5, 8-10]. Therefore, modifying the epicuticular wax without altering its protecting properties may allow increased and more uniform Ca uptake. Surfactants alter energy relationships at interfaces, thereby reducing surface tension [11] and enhancing foliar absorption of biologically active compounds [12]. In this experiment, we studied the effect of calcium with and without two surfactants on fruit quality, fruit minerals, ethylene evolution and respiration of 'Red Spur Delicious' apple.

Materials and Methods

Eighteen years old 'Red Spur Delicious' apple trees on M.7 rootstock, planted at 3.65 x 6.71 m spacing at the University of Idaho Parma Research and Extension Center were used for this study. The experimental arrangement was a complete randomized design with four treatments, each with five single tree replications. Four different treatments in this experiment were as follows: control (no spray), Calcium (Ca) alone as 1.17% Calcium Metalosate) (v/v), 1.17% Calcium Metalosate plus 0.8% Regulaid (v/v), and 1.17% Calcium Metalosate plus 0.8% KALO surfactant (v/v).

For fruit mineral analysis, fruits were randomly sampled from each tree on October. Samples were washed with a mild solution

of Ligui-Nox detergent (Alocnox, Inc., New York, NY), rinsed in deionized water. Each fruit was peeled and cut longitudinally to collect flesh and peel tissues. They were dried at 65 °C, and ground in a grinder (Cyclotec 1093, Teactor, Inc., Hoganas, Sweden) to pass through a 40-mesh screen. Nitrogen concentration of each sample was measured by LECO (FP-528, LECO Corp., St. Joseph, MI). The concentrations of calcium (Ca) and magnesium (Mg) were measured by atomic absorption spectrophotometry (Perkin-Elmer 1100 B, Norwalk, Connecticut) as described by Chaplin & Dixon [13].

To determine fruit qualities, fruits were harvested on October 3, weighed, and their color was rated visually on a scale of 1 = 20% pinkish-red progressively to 5 = 100% pinkish-red. Soluble solids concentrations (SSC) were measured by temperature-compensated refractometer (Atago N1, Tokyo, Japan). Fruit firmness was measured by Fruit Texture Analyzer (Guss, Strand, Western Cape, South Africa). After fruits were cut equatorially, they were dipped in I-KI solution and the starch degradation pattern (SDP) of each fruit was recorded by comparison with the SDP standard chart developed for apples [14].

To measure the effects of treatments on postharvest characteristics of fruits, apples were weighed and then placed in the closed chambers (Postharvest lab in Pomology Lab, Parma, Idaho) for 23 days. Each day, concentrations of evolved ethylene and carbon dioxide (respiration) were measured by Gas Chromatograph (Hewlett Packard 5890 Series II, Lionville, PA) using Flame Ionization Detector (FID) and a packed column (HayeSep Q, 80/100, Alltech Inc., Deerfield, IL). Data was analyzed by SAS statistical package and means were separated at 5% level, using LSD test [15].

Results and Discussion

Kalo surfactant did not have effects on any of the fruit quality attributes of 'Red Spur Delicious' apples (Table 1). Also, mineral concentrations of flesh and peel of the fruit had no statistically differences among treatments (Table 2).

Table 1: Effects of Kalo surfactant on fruit quality of 'Red Spur Delicious' apples.

Treatments	Avg. Fruit Weight (g)	Harvest Color (1-5)	Storage Color (1-5)	Harvest Sugar (°Brix)	Harvest Firmness (kg)	Starch Index	Russet (%)
Control	169.50 aZ	3.64 a	3.42 a	11.47 a	7.46 a	3.31 a	2.96 a
Ca	164.61 a	3.53 a	3.42 a	10.98 a	7.66 a	3.04 a	2.62 a
Ca_Regulaid	181.16 a	3.37 a	3.39 a	11.62 a	7.52 a	3.14 a	1.71 a
Ca_KALO	178.84 a	3.31 a	3.36 a	11.13 a	7.36 a	3.44 a	3.52 a

[z]Mean separation within columns of each year by LSD at $\alpha \leq 0.05$.

Table 2: Effects of Kalo surfactant on fruit minerals quality of 'Red Spur Delicious' apples.

	Element Concentrations (Based on Dry Weight)						
	Fruit Peel				Fruit Flesh		
Treatments	N (%)	Ca (%)	Mg (%)		N (%)	Ca (%)	Mg (%)
Control	0.271 aZ	0.075 a	0.088 a		0.235 a	0.023 a	0.038 a
Ca	0.247 a	0.072 a	0.085 a		0.224 a	0.023 a	0.038 a
Ca_Regulaid	0.267 a	0.074 a	0.088 a		0.221 a	0.023 a	0.037 a
Ca_KALO	0.284 a	0.079 a	0.089 a		0.232 a	0.026 a	0.041 a

[z]Mean separation within columns of each year by LSD at $\alpha \leq$ 5%.

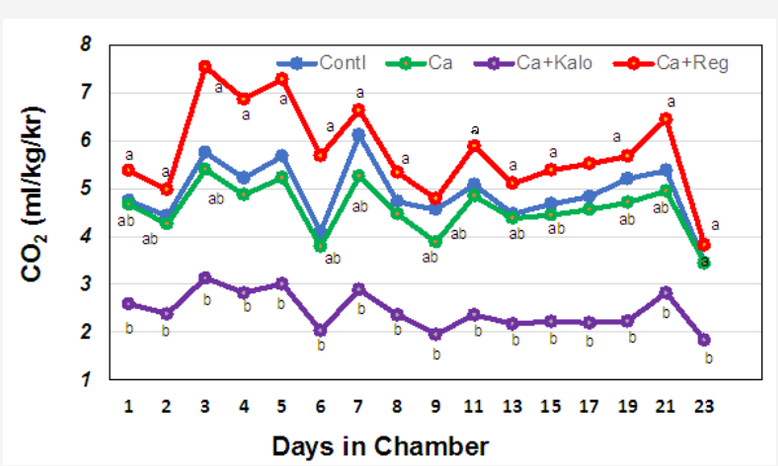

Figure 1: Effects of calcium with and without KALO and Regulaid surfactants on respiration in 'Red Spur Delicious' apple.

Fruits treated with 1.17% Calcium Metalosateplus 0.8% KALO/ surfactant had significantly lower respiration rates (Figure 1) and ethylene evolution (Figure 2) than those on other treatments. Since Ca absorption was not significantly affected by KALO surfactant, the respiration and ethylene differences cannot be due to Ca. By application of KALO surfactant, growers can postpone the harvest to obtain better fruit color without advancing fruit maturity. The reason of this phenomenon it is not clear and deserves further investigation. It is possible that KALO surfactant retards precursor compounds for ethylene synthesis, which is very interesting. This subject deserves further study as slowing ethylene and respiration can have a major positive impact on apple growers.

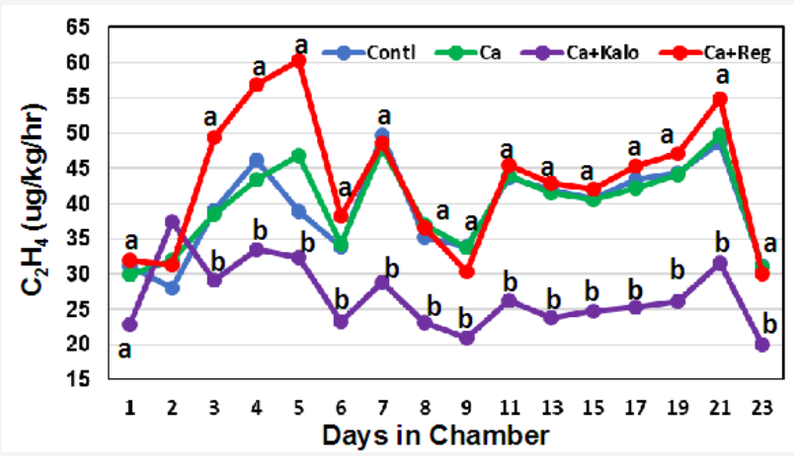

Figure 2: Effects of calcium with and without KALO and Regulaid surfactants on ethylene evolution in 'Red Spur Delicious' apple.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

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