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Responses of Watermelon Yield and Whole Leaf and Petiole Sap K Seasonal Profiles to K Fertilization 96-04

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Abstract

Watermelon, 'Royal Sweet' transplants were planted at Live Oak, FL on a sandy soil and fertilized with potassium at 0, 50, 100, and 150 lbs K_2O/acre, all applied under the mulch before planting. Early and total season yield responded in quadratic fashion to K fertilization, with yields maximized with 100 lbs K_2O/acre. Whole-leaf K and petiole fresh sap K concentrations correlated positively for three sampling dates during the season. Sap K measurements made early in the season correlated best with final seasonal yield.

Introduction

Watermelons are one of the most important vegetable crops in Florida with about 40,000 acres planted in 1993-94 season (Freie and Pugh, 1995). Average yield in Florida is 230 cwt per acre. Preharvest production costs are 1400 dollars per acre with about 8% of that attributed to fertilizer (Smith and Taylor, 1995). Average fertilization rates for melons and watermelon in Florida were 160 N, 140 P_2O_5, and 210 K_2O (lb/acre) (USDA, 1990), even though the maximum rates recommended as of 1995 for soils low in P or K are 150 lbs/acre each for N, P_2O_5, and K_2O (Hochmuth and Hanlon, 1995a).

Fertilization rates of K for watermelons in Florida are based on results of a Mehlich-1 soil test with maximum K_2O rate at 150 lbs/acre (Hochmuth and Hanlon, 1995b). The fertilization recommendation includes information on fertilizer management so that applied nutrients are used efficiently by the watermelon crop.

The amount of fertilizer K to apply was derived from considerable research spanning almost 40 years. Early work with watermelon fertilization was conducted at Immokalee (Everett, 1960), Leesburg (Brinen et al, 1979, Elmstrom et al, 1973), Live Oak (Locascio et al, 1973; Nettles and Lundy, 1958), and Gainesville (Brinen et al, 1979; Halsey, 1959; Fiskell et al, 1967; Locascio et al, 1973). These early studies were largely done with mixed N-P-K fertilizers so that yield responses cannot be conclusively attributed to N, P, or K. Most studies showed that maximum yields were realized with 2000 to 2400 lbs

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per acre of 6-8-8 (N-P_2O_5-K_2O), or equivalent. More recent work with N, P, and K on watermelons showed that yield rarely responded to more than 150 lbs/acre of each N, P_2O_5, or K_2O (Hochmuth and Hanlon, 1989; Hochmuth et al, 1994).

K fertilization programs can be monitored by plant tissue testing (Hochmuth et al, 1991), however, carefully calibrated techniques and accurate nutrient sufficiency ranges must be developed and field tested. Most plant tissue testing laboratories have techniques and nutrient sufficiency ranges developed for whole-leaf analyses (Hochmuth et al, 1991), but recently, analytical procedures and sufficiency ranges have been developed for petiole sap N and K testing (Hochmuth et al, 1991; Hochmuth, 1994). The sap testing procedures were first field-tested for tomato in Florida (Hochmuth et al, 1988) but have since been expanded to other vegetables including watermelon (Hochmuth et al, 1994; Vann et al, 1993). Sufficiency ranges for petiole sap nitrate-N and K concentrations were recently summarized (Hochmuth, 1994).

The purposes of this potassium research were to field-test current University of Florida K fertilization recommendations for watermelon and to gather more field data on watermelon leaf petiole sap N and K testing to use to revise current petiole testing recommendations.

Materials and Methods

Fertilization studies were conducted during the spring of 1994 on a Lakeland fine sandy soil at the Suwannee Valley Research and Education Center near Live Oak, FL. The purpose of the research was to provide data to calibrate the fresh leaf petiole sap potassium testing procedures. Soil was plowed and disked, ad unfertilized soil was sampled to 6-inch depth, extracted with Mehlich-1 solution, and analyzed for P, K, Ca, Mg, Cu, Mn, and Zn (Hanlon et al, 1994).

Potassium fertilization treatments were 0, 50, 100, and 150 lbs K_2O per acre supplied from potassium chloride. Maximum recommendation for K was 120 lbs K_2O per acre (Hochmuth, 1992), but this recommendation has been revised recently to 150 lbs K_2O per acre (Hochmuth and Hanlon, 1995). The soil tested high in P, so no P fertilizer was applied. Nitrogen was supplied from ammonium nitrate and applied at 150 lbs N/acre. Magnesium was applied at 20 lbs Mg/acre from magnesium sulfate. Micronutrients were supplied from a micronutrient mix applied at 50 lbs/acre to supply 1, 5, 2, and 1 lbs/acre of copper, manganese, zinc, and boron.

Fertilizer rates were calculated based on beds on 8-ft centers to conform to standardized fertilization practices (Hanlon and Hochmuth, 1990). Fertilizer materials were blended, applied in a 30-inch swath in the bed area, and rototilled to incorporate fertilizer into soil uniformly. Plots consisted of a single bed 35 ft in length with 7.5 ft between bed centers. The four fertilization treatments were arranged in four randomized complete blocks.

On 14 March, fertilized soil was bedded, fumigated with a mixture of methyl bromide and chloropicrin (98:2%) at 400 lbs/acre (broadcast rate), pressed, and covered with black polyethylene mulch (Sonoco Film Products, Hartsville SC). Drip irrigation tubing (Roberts Ro-Drip) was placed in the center of the bed in a one-inch-deep groove in the soil. Beds were 24 inches wide and six inches tall. The tubing had 8-mil thick walls with emitters on 12-inch spacing with a flow rate of 0.4 gallons per minute per 100 ft at 8 psi pressure.

On 25 March, 'Royal Sweet' watermelon transplants were placed in a single row in each bed at 36-inch spacing in the row. Drip irrigation was operated as needed to maintain a tensiometer gauge at -8 to -12 centibars at the 12-inch depth between two plants in a row, three inches from the drip tubing. Diseases and insects were controlled by timely applications of labeled pesticides based on pest scouting of the crop.

On three occasions (22 Apr, 2-inch vines; 5 May, 30-inch vines with small fruits; 19 May, fruits near full grown), whole leaves plus petioles were collected for N and K analyses. From four leaves, petioles were excised, chopped, and pressed with a hydraulic press to remove the sap. Fresh (same day after field collection) sap was analyzed for nitrate –N and K concentrations with hand-held, battery-operated, ion-specific meters (Cardy meter, Kyota Japan) (Hochmuth, 1994). Petioles awaiting pressing were held on ice and warmed to room temperature before pressing.

At least six remaining whole leaves were dried in a forced-air oven at 140^{o}F, ground in a Wiley mill, and wet-ashed in sulfuric acid and hydrogen peroxide. Leaf N and K concentrations were determined by rapid-flow colorimetry and by plasma emission spectroscopy, respectively (Hanlon et al, 1994).

Watermelon fruits were harvested three times on 3, 9, and 13 June 1994. Fruits were weighed and all fruits of uniform shape and greater than 12 lbs were considered marketable. All data were analyzed by analysis of variance and K rate trends were evaluated with regression analysis.

Results and Discussion

The sandy soil used for this test was 18 ppm Mehlich-1 K, 98 ppm P, and 32 ppm Mg. These were interpreted as low, high, and high, respectively (Hochmuth and Hanlon, 1995). A yield response to 150 lbs K_2O was expected.

Early (first harvest) fruit yield was affected in quadratic fashion by K fertilization (Table 1). Numbers of fruits, yield, and fruit weight responses to K leveled off after 100 lbs K_2O/acre. The regression equation for yield was $Y=19.2+3.9K-0.02K^2$ ($R^2=0.80$) where Y is yield in cwt/acre and K is potassium rate in lbs/acre. The yield equation was maximized with 98 lbs K_2O/acre.

Total season yield (3 harvests) was likewise affected by K fertilization in quadratic fashion (Table 1) with yield leveling off after 100 lbs K_2O/acre. The yield equation was $Y=183+5.45K-0.03K^2$ ($R^2=0.80$), where Y is yield in cwt/acre and K is potassium rate in lbs/acre. The yield equation was maximized at 105 lbs K_2O/acre.

These yield responses are similar to responses previously (Brinen et al, 1979; Elmstrom, et al, 1973; Everet, 1960; Fiskell et al, 1967; Halsey, 1959; Hochmuth et al, 1994; Locascio et al, 1973; Nettles and Lundy, 1958). These yield responses were in support of the current maximum K recommendations for watermelon of 150 lbs K_2O/acre (Hochmuth and Hanlon, 1995).

Fresh petiole sap potassium concentrations were increased in quadratic fashion (first date), and increased in linear fashion (second and third dates) by K fertilization (Table 2). Petiole N concentrations were mostly not affected by K fertilization. Petiole potassium concentration profile for the 100-lbs K_2O treatment was 3700 ppm, 3500 ppm, and 3000 ppm for the early, mid-season, and harvest stages. These were slightly lower compared to published sufficiency ranges for the same stage of growth (Hochmuth, 1994).

Whole-leaf K concentrations for plants with K fertilization were usually near those published sufficiency ranges (Hochmuth et al, 1991). Whole leaf N was always within the adequacy ranges. Correlation coefficients (r) for sap-K and leak-K were 0.97, 0.67, and 0.64 for 22 Apr, 5 May, and 19 May respectively (Table 3). Measurements of sap K made on 22 April (early) had the best correlation with yield compared to other sap testing dates.

Results of this experiment showed that 'Royal Sweet' watermelon response to K fertilization was to no more than about 100 lbs K2O/acre. The new University of Florida recommendations for K fertilization of 150 lbs/K2O/acre are therefore adequate for watermelon on sandy soils. Whole-leaf K analyses showed that current published sufficiency ranges are adequate. Whole-leaf K profile for the minimum amount of K needed in this study to maximize yield was slightly higher than the published sufficiency ranges. For sap potassium concentrations in the leaf petiole, the published sufficiency ranges were on target for early season samples, but slightly high for late season samples.

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Table 1. Effects of potassium fertilization on watermelon fruit yield and fruit weight at Live Oak, FL. Spring 1994.

K_2O application lbs/acre	Watermelon Fruit Yield		Avg. Fruit Wt. lbs
	No./acre	cwt/acre	
	- - - - - - - - - - - - - - - - - Early (first harvest) - - - - - - - - - - - - - - - - -		
0	80	17.4	5.2[y]
50	790	69.1	21.7
100	870	198.7	22.9
150	620	142.1	23.2
Signif.[z]	L**Q**	L**Q**	L**Q**
	- - - - - - - - - - - - - - - - - Total (three harvest) - - - - - - - - - - - - - - - - -		
0	1000	174.9	11.5[y]
50	2075	417.1	16.4
100	2030	441.8	17.5
150	2075	423.9	20.3
Signif.[z]	L**Q**	L**Q**	L**

[z] Regression models contained significant (*5%, **1%) linear (L) and quadratic (Q) terms.

[y] Avg. fruit weight for the zero-K treatment was less than 12 lbs because plants in some replicates for some harvests produced no fruits.

Table 2. Effects of potassium fertilization on watermelon leaf petiole fresh sap nitrate-N and K and leaf N and K concentrations on three dates during season at Live Oak, FL. Spring 1994.

K2O applic. lbs/acre	Sampling date[x]					
	22 April		5 May		19 May	
	NO_3-N(N)	K	NO_3-N(N)	K	NO_3-N(N)	K
	- Sap conc. (ppm) -					
0	1870	1950	1410	2500	850	2175
50	2030	3600	1000	3275	1080	2600
100	1950	3700	970	3525	1040	2975
150	1925	3750	1130	3625	840	3250
Signif.[z]	NS	L**Q**	L**Q**	L**	NS	L**
	- - - - - - - - - - - - - - - - - - - whole-leaf conc. (%)[y] - - - - - - - - - - - - - - - - - - -					
0	6.7 (N)	1.6	4.7 (N)	1.7	4.6 (N)	1.1
50	6.7	3.7	4.4	2.9	5.1	1.5
100	6.7	4.0	4.6	2.7	5.1	1.8
150	6.6	4.1	4.5	2.8	5.0	2.1
Signif.[z]	NS	L**Q**	NS	L*	L*Q*	L**

[z] Regression models contained significant (*5%, **1%) linear (L) and quadratic (Q) terms, or treatment effects were not significant (NS).
[y] Most-recently-matured whole leaf.
[x] Sampling dates were at 12-inch (first), 30-inch vines with small fruits (second), and fruits near full grown (third).

Table 3. Correlation coefficients for watermelon yield and leaf and sap K concentrations, Live Oak, FL. Spring 1994.

	Sap K 22 Apr	**Sap K 5 May**	**Sap K 19 May**	**Leaf K 22 Apr**	**Leaf K 5 May**	**Leaf K 19 May**	**Total Mkt. Yield**
	- -	correlation coefficient, (Prob.) N=16	- -				
Sap K, 22 Apr	1.00	0.82 (0.0001)	0.68 (0.0041)	0.97 (0.0001)	0.69 (0.0030)	0.64 (0.0077)	0.95 (0.0001)
Sap K, 5 May	0.86 (0.0001)	1.00	0.47 (0.0683)	0.86 (0.0001)	0.67 (0.0045)	0.60 (0.0149)	0.90 (0.0001)
Sap K, 19 May	0.69 (0.0041)	0.47 (0.0686)	1.00	0.66 (0.0052)	0.25 (0.3475)	0.64 (0.0075)	0.53 (0.0339)
Leaf K, 22 Apr	0.97 (0.0001)	0.86 (0.0001)	0.66 (0.0052)	1.00	0.69 (0.0033)	0.69 (0.0031)	0.95 (0.0001)
Leaf K, 5 May	0.69 (0.0030)	0.67 (0.0045)	0.25 (0.3475)	0.68 (0.0033)	1.00	0.57 (0.0198)	0.68 (0.0036)
Leaf K, 19 May	0.64 (0.0077)	0.60 (0.0149)	0.64 (0.0075)	0.69 (0.0031)	0.57 (0.0198)	1.00	0.58 (0.0175)
Total Mkt. Yield	0.95 (0.0001)	0.90 (0.0001)	0.54 (0.339)	0.95 (0.0001)	0.68 (0.0036)	0.58 (0.0175)	1.00