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Eggplant Yield in Response to Potassium Fertilization on Sandy Soil

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Abstract. **'Classic' eggplant *(Solanum melongena* L.) responses to K fertilization were evaluated in Spring and Fall 1991 at Live Oak, Fla., on soils testing low in Mehlich-1 extractable K. Total season yield leveled off at 51.1 t·ha^{-1} with 94 kg K/ha fertilization in spring and at 53.3 t·ha^{-1} with 60 kg K/ha in fall. Critical K concentrations (in grams per kilogram) in whole leaves were ≈45 at first flowering, 35 at early fruiting, 30 during harvest, and 28 at the end of seven harvests. Fresh petiole-sap K critical concentrations (in milligrams per liter) were ≈4500 to 5000 before harvest and 4000 to 4500 during harvest. Less than 3500 mg K/liter in fresh sap indicated K deficiency in fruiting plants. The Mehlich-1 soil extractant procedure predicted similar responses at the two sites; however, yield responses showed that the two sites differed in fertilization requirements. Fertilizer recommendations for K at both sites exceeded eggplant K requirements.**

Eggplant is produced on 800 ha annually in Florida. In 1989–90, average yield was 12 t·ha^{-1} and crop value was $13.5 million (Florida Agricultural Statistics Service, 1991). Since eggplant is a minor crop compared to other solanaceous crops such as tomato and pepper, little research has been conducted on fertilizer requirements. Growers generally fertilize eggplant similar to tomato because of the lack of research data.

Past Florida recommendations (Montelaro, 1978) for K fertilization of eggplant were based on early work with mixed fertilizers. Work by Robertson and Young (1964) showed that eggplant yield was depressed as fertilizer application (in kilograms per hectare) increased to > 145N–90P–120K (applied in two equal portions each to spring and fall crops). The soil contained 60 mg ammonium acetate (pH 4.8)-extractable K/kg. Since mixed fertilizers were used, it is difficult to determine the nutrient factors responsible for yield responses. In a later study, nonmulched eggplant responded to up to 250 kg K/ha (Sutton and Albregts, 1970). The fertilizer was applied in three split applications during the growing season. In New Jersey, eggplant yield responded positively to seven drip irrigation injections of a mixed fertilizer that resulted in applying (per hectare) 156N-67P-130K to eggplant growing on sandy loam soil that tested medium in K (Paterson, 1981).

Current Florida recommendations (Hochmuth and Hanlon, 1989) for K fertilization are based on the Mehlich-1 (double-acid) (Mehlich, 1953) soil test index (Kidder et al., 1989). Maximum K recommendations (150 kg·ha^{-1}) are made for soils with <36 mg extractable K/kg soil.

Early research on eggplant K requirements produced conflicting results. Furthermore, no results are available for calibrating the Mehlich-1 extractant, which is used widely in the southeastern United States. Therefore, two studies were conducted to determine eggplant K requirements and evaluate the current calibration of the Mehlich-1 soil extractant.

Experiments were conducted at the Suwannee Valley Agricultural Research and Education Center near Live Oak, Fla., on a Lakeland fine sand (thermic, coated Typic Quartzipsamment) during Spring and Fall 1991. The K treatments ranged from 0 to 225 kg·ha^{-1} in 45-kg increments. Nitrogen from ammonium nitrate was applied uniformly to all plots at 135 kg·ha^{-1} in spring and at 180 kg·ha^{-1} in fall. Phosphorus from concentrated (triple) superphosphate was applied at 25 kg·ha^{-1} each season. Potassium was supplied as potassium magnesium sulfate in spring and as potassium chloride in fall. Magnesium sulfate was used to help equilibrate Mg and S each season.

Soil was prepared by plowing and rototilling. Fertilizer mixtures were broadcast on 28 Feb. and 31 July for spring and fall crops, respectively, on a 0.9-m-wide area and rototilled into the bed area. The soil was bedded, pressed, and fumigated with 98 methyl bromide: 2 trichloronitromethane (chloropicrin) at a broadcast rate of 400 kg·ha^{-1}. Drip tubing (0.25-mm wall thickness, 30-cm emitter spacing, and 63-ml·min^{-1}·m^{-1} flow rate) was positioned 2.5 cm deep 8 cm from the bed center during bedding. Beds were covered with black polyethylene mulch in spring and white-on-black co-extruded mulch in fall. Beds were 60 cm across the top and arranged on 1.5-m centers.

Plots were 1.5 × 7.5 m in spring and 1.5 × 6 m in fall. 'Classic' eggplant transplants were placed in one row in the center of the bed with 45 cm between plants. Transplanting dates were 14 Mar. in spring and 8 Aug. in fall. The design was a randomized complete block with five replications.

Irrigation was used to maintain a tensiometer reading of –8 to –12 kPa 20 cm deep in the bed. Pests were controlled by applying labeled pesticides based on field scouting.

On five dates in spring and four dates in fall, 20 most-recently matured whole leaves, including petioles, were analyzed for N and K. One-half of these whole leaves (including petioles) was dried, ground, and analyzed for K by atomic absorption spectroscopy and for N by Kjeldahl digestion followed by rapid-flow calorimetry (Hanlon et al., 1990). From the remaining leaves, fresh petioles were excised and chopped and the sap was expressed. Fresh-sap nitrate-N and K concentrations were determined by battery-operated, hand-held, ion-specific electrodes (Horiba, Kyota, Japan). Nitrogen was analyzed to ensure that N was not limiting during the season.

Eggplants were harvested seven times each season starting on 29 May and ending on 8 July in spring and starting on 27 Sept. and ending on 4 Nov. in fall. Fruit were graded according to U.S. Dept. of Agriculture (USDA) grade standards (USDA, 1953), counted, and weighed.

Data were subjected to analysis of variance and regression techniques (SAS Institute, 1982). Orthogonal contrasts were used to compare no K vs. K fertilizer and also to test yield responses among eggplants receiving K fertilizer. These comparisons were made to determine a K fertilizer application above which no further yield response resulted. Further, total yield data were analyzed more precisely using

Table 1. Prefertilization Mehlich-1 soil test indexes for eggplant K studies at Live Oak, Fla., 1991.

		Extractable nutrient (mg·kg^{-1})						
Season[z]	pH[y]	P	K[x]	Mg	Ca	Zn	Cu	Mn
Spring	5.5	57	21	16	191	1.14	0.05	7.69
Fall	6.0	50	31	27	335	0.30	0.02	1.69

[z]Average of 30 samples both seasons.
[y]pH measured in a 1 soil : 2 water mixture.
[x]K indexes were on opposite ends of the low range in spring and fall.

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the linear-plateau method (Dahnke and Olson, 1990; Nelson and Anderson, 1977).

Spring and fall sites differed in prefertilization Mehlich-1 soil test results, but both sites tested low (20 to 35 mg K/kg) (Table 1). Therefore, responses to K were expected at both sites, and the K recommendation for each site was 150 kg·ha^{-1}.

Early yield. Potassium fertilization did not affect the spring crop's early yield of USDA no. 1 large (>10 cm in diameter) or cull (Table 2) fruit. Yield of small (6 to 8 cm), medium (8 to 10 cm), or USDA no. 2 fruit also was not affected. Yields were 0.3, 0.9, 0.7, and 1.1 t·ha^{-1} for USDA no. 1 small and medium and USDA no. 2 small and medium fruit, respectively. Early total marketable eggplant yield from the first two harvests in spring increased by 4.5 t·ha^{-1} as K rate increased from 0 to 225 kg·ha^{-1} (Table 2). Although there was a linear trend, increases in early yield at >90 kg K/ha were negligible. In the fall crop, there were few fruit produced in the early USDA no. 1 or no. 2 small or medium categories. Early USDA no. 1 large, cull, or total marketable yield for the fall crop was not affected by K rate (Table 2). The difference in response between the two crops probably was due to the differences in soil K at the two sites. The extractable soil K was higher at the fall than at the spring site (Table 1). Average early fruit weight (0.52 kg for spring and fall) was not affected by K fertilization.

Total season yield. Potassium fertilization did not affect average total yield (in tons per hectare) of USDA no. 1 small (0.4), or medium (4.9) or USDA no. 2 small (0.8) or medium (2.2) fruit for the spring crop or USDA no. 1 small (3.1) or medium (5.7) or USDA no. 2 small (1 .8) or medium (3.0) fruit for the fall crop. Increasing K fertilization resulted in quadratic increases in yields of large fruit in both seasons (Table 2). Total marketable yields from seven harvests increased significantly when K was applied in both seasons (Table 2). Yield responses (total marketable) were quadratic, with apparent maximum yields of 55.2 and 60.0 t·ha^{-1} in spring and fall, respectively, at an application rate of 135 kg·ha^{-1} (Table 2). The total yield responses were due to the effect of K rate on USDA no. 1 large (most valuable) grade fruit. Average fruit weight (0.49 kg for spring and 0.48 kg for fall) was not affected by K fertilization.

For both seasons, the contrast of no K vs. K fertilizer was significant ($P \leq 0.01$); however, there was no significant effect of K at ≥45 kg·ha^{-1}. In spring, the total yield linear-plateau critical K rate (where yield leveled off) was 94 kg·ha^{-1} (Fig. 1). In fall, the critical K value was 60 kg·ha^{-1} (Fig. 2). Quadratic equations were maximized at151 kg K/ha in spring and at 130 kg K/ha in fall (Figs. 1 and 2).

The linear-plateau model identified the critical fertilizer K rate above which yield leveled off. Quadratic maxima seemed to overestimate the point of no response to K. This result has been observed for corn *(Zea mays* L.) (Cerrato and Blackmer, 1990) and watermelon *[Citrullus lanatus* (Thunb.) Matsum. & Nakai] (Hochmuth et al., 1993). The slight

Table 2. Effect of K fertilization on early and total season yield of eggplant in two seasons at Live Oak, Fla., 1991.

K applied (kg·ha^{-1})	Yield (t·ha^{-1}) USDA no. 1 large[z] Spring	USDA no. 1 large[z] Fall	Cull Spring	Cull Fall	Total marketable Spring	Total marketable Fall
	Early (first two harvests)					
0	6.0	4.2	0.1	0.4	9.0	6.2
45	5.9	3.1	0.0	0.7	11.0	4.2
90	7.3	2.6	0.2	0.3	13.1	3.3
135	6.5	4.6	0.1	1.0	12.0	4.8
180	7.3	2.7	0.0	0.2	11.9	3.9
225	7.5	2.5	0.1	0.3	13.5	3.2
Significance	NS	NS	NS	NS	L*	NS
	Total season (seven harvests)					
0	20.6	26.8	2.4	3.3	34.4	45.5
45	27.3	35.5	2.2	4.0	42.0	51.8
90	34.3	34.8	1.2	3.4	51.2	51.8
135	37.3	37.6	2.3	4.2	55.2	60.0
180	34.6	35.7	2.4	3.3	50.1	53.0
225	32.3	33.8	0.4	3.2	48.1	48.9
Significance	L**, Q**	L**, Q**	NS	NS	L**, Q**	L**, Q*

[z]USDA = U.S. Dept. of Agriculture; large fruit were >10 cm in diameter.
NS,*,**Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively; L = linear and Q = quadratic.

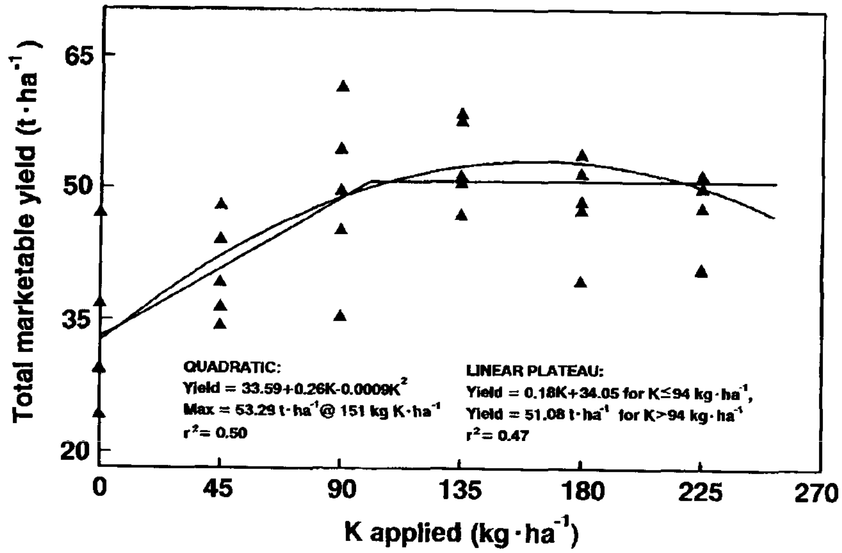

Fig. 1. Eggplant yield response to K fertilization in Spring 1991.

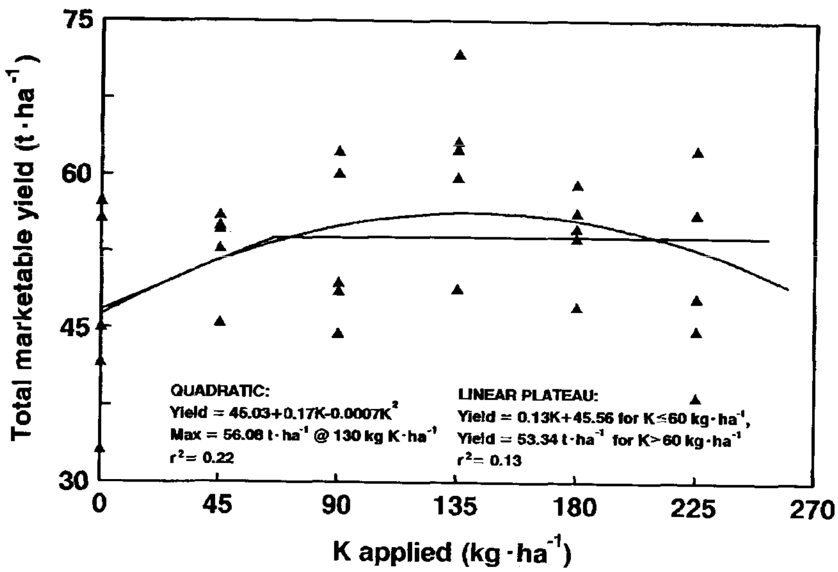

Fig. 2. Eggplant yield response to K fertilization in Fall 1991.

differences in yield response to K fertilization at the two sites probably were due to the slight differences in Mehlich-1 extractable K. Using the linear-plateau critical value and the quadratic maximum sets lower and upper limits on possible K fertilizer recommendations for these sites. Based on the midpoints between these limits, realistic recommendations for K would be 120 and 100 kg K/ha for crops grown on soils similar in Mehlich-1 extractable K to those of the spring and fall crops, respectively.

Potassium and N concentrations in time. In the spring crop, leaf K concentrations in all treatments were above the adequate level of 35 $g \cdot kg^{-1}$ at early fruit set (Hochmuth et al., 1991b) for only the first sampling date (Table 3). After 30 Apr., leaves of plants receiving 0 or 45 kg K/ha had K concentrations <35 $g \cdot kg^{-1}$. After 7 June, leaves of plants in most K treatments had K concentrations ≤35 $g \cdot kg^{-1}$.

Yield responses were absent at >93 kg K/ha. The leaf K concentration profile through the season at 90 kg K/ha is, therefore, representative of adequate K fertilization. These tissue data, viewed in relation to yield responses, showed that adequate K concentrations (in grams per kilogram) were ≈45 at first flower (30 Apr.),35 at early fruiting, and 30 during most of the harvest season, falling to <30 after seven harvests.

Petiole-sap K concentrations on five dates increased with increasing K application (Table 3). Petiole-sap K concentrations >4000 $mg \cdot liter^{-1}$ until harvest began and >3500 mg. liter' during harvest were associated with optimum yields.

In the spring crop, whole-leaf N concentrations were 53, 51, 45, 40, and 34 $g \cdot kg^{-1}$ for the 30 Apr., 23 May, 7 June, 18 June, and 2 July sampling dates, respectively. Plant-sap nitrate-N concentrations were 1500, 1270, 1050, 420, and 140 $mg \cdot liter^{-1}$ for the same dates. These values indicated that N was in the adequate range for eggplant (Hochmuth et al., 1991a, 1991b).

For the fall crop, leaf K concentrations fell to, or below, the adequate level of 35 $g \cdot kg^{-1}$ by early harvest (1Oct.) for the 0 and 45 kg K/ha rates (Table 4). Leaves of plants receiving 90 kg K/ha had K concentrations ≥35 $g \cdot kg^{-1}$ during harvest, falling to slightly <35 $g \cdot kg^{-1}$ near the final harvest (Table 4).

Petiole-sap K concentration for plants receiving >45 kg K/ha remained at >3500 $mg \cdot liter^{-1}$ all season. Petiole-sap K concentrations fell to <3500 $mg \cdot liter^{-1}$ for K treatments that did not optimize yield (≤45 $kg \cdot ha^{-1}$). These data confirm results from the spring test in which K deficiency occurred when leaf K during harvest dropped to 30 $g \cdot kg^{-1}$ on a whole-leaf basis or to <3500 $mg \cdot liter^{-1}$ on a fresh petiole-sap basis. In the fall crop, whole-leaf N concentrations were 63, 61, 53, and 44 $g \cdot kg^{-1}$ for 11 Sept., 1 Oct., 16 Oct., and 31 Oct., respectively. Plant-sap nitrate-N concentrations were 1600, 1400, 1440, and 1080 $mg \cdot liter^{-1}$ for the same dates. Nitrogen was not a limiting factor in the fall crop (Hochmuth et al., 1991b, 1991a).

Petiole-sap and whole-leaf K concentrations in spring were highly correlated (Table 5). Petiole-sap K seems to indicate plant K status reliably, as determined by dried whole-leaf analyses. Petiole-sap K tests would be quicker than laboratory whole-leaf analyses and useful in field situations.

The Mehlich-1 soil extractant procedure predicted similar responses to K fertilization at each site. However, yield data, backed up by plant tissue and fresh-sap analyses, showed that K fertilization requirements for eggplant were different at each site and were less than those currently recommended. The calibration curve for Mehlich-1 extractant could be changed so that the Mehlich-1 soil test indexes of 21 and 31 mg K/kg soil appear in different categories (low and medium, respectively) rather than in the same (low) category.

Table 3. Dried whole-leaf K concentrations and fresh petiole-sap K concentrations of eggplant as affected by K fertilization, Live Oak, Fla., Spring 1991.

K applied	Sampling date				
($kg \cdot ha^{-1}$)	30 Apr.	23 May	7 June	18 June	2 July
	Whole-leaf K concentration ($g \cdot kg^{-1}$)				
0	37	16	14	16	17
45	43	28	27	27	26
90	46	38	32	29	27
135	46	41	38	32	31
180	48	44	41	34	34
225	49	44	43	36	33
Significance	L**	L**, Q**	L**, Q**	L**, Q*	L**, Q**
	Petiole-sap K concentration ($mg \cdot liter^{-1}$)				
0	3800	1410	930	1660	2950
45	4340	3360	3460	3020	4080
90	4760	3960	3860	3760	4440
135	4840	4220	4640	4020	4840
180	4920	4860	4600	4640	5140
225	4940	4760	4900	4600	4840
Significance	L**, Q*	L**, Q**	L**, Q**	L**, Q*	L**, Q*

*,**Significant at $P \leq 0.05$ or 0.01, respectively; L = linear and Q = quadratic.

Table 4. Dried whole-leaf K concentrations and fresh petiole-sap K concentrations of eggplant as affected by K fertilization, Live Oak, Fla., Fall 1991.

K applied	Sampling date			
($kg \cdot ha^{-1}$)	11 Sept.	1 Oct.	16 Oct.	31 Oct.
	Whole-leaf K concentration ($g \cdot kg^{-1}$)			
0	39	35	36	26
45	51	30	35	28
90	57	43	41	33
135	59	51	47	32
180	60	47	47	40
225	65	49	47	38
Significance	L**,Q**	L**	L**	L**
	Petiole-sap K concentration ($mg \cdot liter^{-1}$)			
0	2920	3460	3460	2940
45	3620	3720	3460	3360
90	3860	4520	4180	4140
135	4380	4760	4440	4700
180	4220	4920	4500	5020
225	4260	5200	4840	5400
Significance	L**, Q**	L**	L**	L**

**Significant at $P \leq 0.01$; L = linear and Q = quadratic.

Table 5. Correlation of whole-leaf K concentration and petiole-sap K concentration, Spring 1991.

Date	Correlation coefficients (r)[z]				
	Whole-leaf K by date				
measured	30 Apr.	23 May	6 June	18 June	2 July
30 Apr.	0.84	0.79	0.76	0.80	0.80
23 May	0.78	0.96	0.93	0.86	0.81
6 June	0.79	0.87	0.93	0.90	0.80
18 June	0.74	0.86	0.87	0.84	0.79
2 July	0.67	0.64	0.78	0.78	0.69

[z]All correlations were significant at $P \leq 0.0001$.

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