Proc. Fla. State Hort. Soc. 106:199-201. 1993.

CARROT AND SWEET CORN YIELDS WHEN FERTILIZED ACCORDING TO SOIL TEST RESULTS

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Additional index words. Zea mays var. *rugosa, Daucus carota,* phosphorus, ammonium poly-phosphate, Histosols.

Abstract. **Fertilizer recommendations based upon University of Florida, IFAS, Extension Soil Testing Laboratory, Gainesville, results were utilized to produce carrots (*Daucus carota* L.) and sweet corn (*Zea mays* var. *rugosa* Bonaf.) on Histosols. Two P rate studies on carrots and three P rate studies on sweet corn were conducted near Zellwood, FL, to evaluate yield response. Application rates of P were based upon soil test results and amounts the cooperative grower applied. For carrots, there were no significant differences among P rates expressed as yield for culls, fancy, jumbo, or total marketable roots. Yields for marketable carrots ranged from 621 to 700 48-lb units per acre in 1992 and from 288 to 332 in 1993. For sweet corn, there were no significant differences among fertilizer treatments for yield expressed as crates per acre for two of the three locations. Grower fertilizer rates had a greater yield at one location, but response was not due to P. Yields for marketable ears of sweet corn ranged from 123 to 233 crates per acre. Yield at the other two locations ranged from 225 to 285 crates per acre. The overall results of these studies validate the use of calibrated soil testing to determine the amount of P fertilizer to apply to carrots and sweet corn grown on muck soils in the Zellwood, FL, area.**

Introduction

Florida is the third leading state in the nation in fresh market carrot production and first in sweet corn production (Freie and Young, 1993). Approximately 90% of the carrots and 25% of the sweet corn are grown in the central Florida production area around Zellwood.

The Histosols used for vegetable production near Zellwood drain into Lake Apopka. The water discharged from the farms to the lake is of poor quality, containing high concentrations of P and other nutrients, and has been blamed for contributing to the highly eutrophic condition of the lake (Conrow, 1989).

A cooperative project was initiated in 1991 between Florida Cooperative Extension Service, Soil Conservation Service, and the Agricultural Stabilization and Conservation Service. The objectives were to help farms improve nutrient and water management practices for vegetable production within the Lake Apopka drainage basin to reduce nutrient loading to the lake (Neal et al., 1992). The use of calibrated soil testing is a key to the nutrient management aspects of this project. Although most producers were utilizing soil testing prior to this project, the majority of samples were being analyzed by a private lab which recommended fertilizer amounts in excess of University of Florida, IFAS, recommendations.

A series of field trials were conducted in 1991-93 to confirm the reliability of calibrated soil testing as performed by the University of Florida, IFAS, Extension Soil Testing Laboratory (ESTL), Gainesville, for the crops grown in the Zellwood area. Previous studies have confirmed that crops grown on soils testing high to very high in P do not respond to additional P fertilization (Hochmuth and Hanlon, 1989). Most of the calibration work for Histosols has been performed in the Everglades agricultural area, however, using a different extraction method and interpretation of results (Sanchez, 1990). The objectives of these experiments were to confirm that the Mehlich-1 extractions used by the ESTL result in recommendations which satisfy the crop nutrient requirement for vegetable production in the Zellwood area. Utilization by producers of ESTL or similar recommendations would result in a reduction in the amount of P fertilizer applied to vegetables in the Lake Apopka basin, which in 1991 totaled 273,000 pounds (unpublished survey data, 1991).

Materials and Methods

The trials were conducted over a period of two years and in four locations on commercial farms. There were two locations of carrot trials, one in 1991 and one in 1992. There were three locations of sweet corn, two in 1992 and one in 1993. Site 1a was used for a carrot trial in the fall of 1991, followed by a sweet corn trial in the spring of 1992.

The experimental design for all trials was a randomized complete block design with four or five blocks in each trial. Treatments were based on ESTL soil test recommendations, grower rate of P, half grower rate of P, and a banded treatment of liquid ammonium poly-phosphate. Four of the five trials included a complete fertilizer treatment at the rate used by the grower in the surrounding field.

Soil samples were taken after field preparation but before fertilizer was applied. All but one site tested very high in P, K, Mg, and Ca and had a pH between 6.0 and 6.2. ESTL recommendations for these sites were 0 N-0 P-0 K lb per acre for both carrots and sweet corn. These sites are typical of the Lake Apopka Histosols which have been in vegetable production for many years. Site 1c, however, was a field previously not used for vegetables and consequently tested very low in P, low in K, and high in Mg and Ca. The

Florida Agricultural Experiment Station Journal Series No. N-00821.

pH was 5.3. The ESTL recommendation for this site was 0 N-52.4 P-100 K lb per acre for sweet corn. All fertilizer treatments except the banded P were broadcast by hand prior to planting. The banded P was applied as a drench to a 3 to 4 inch band directly over the row 1 to 4 days after planting.

After planting, the trials were treated identically to the grower's field in which they were located, being sprayed for pests as needed and the water table maintained at a level determined by the producer. Plots were harvested by hand. Crop response data were analyzed by the General Linear Models procedure (SAS Institute, Inc., Cary, NC). Individual crop and site information is as follows.

Carrot trials

Site 1a was planted to 'Apache' on 9 Oct. 1991 and harvested 119 days later on 3 Feb. 1992. Beds were 46 inches on center with a band of 3 rows on each side of the bed. Plots were 30.7 ft. wide by 140 ft. long. Subsamples 1 bed wide by 15 ft. long were harvested for records. The soil type was a Terra Ceia muck with a pH of 6.2 and P tested very high (170 P ppm).

Site 1b was planted 29 Oct. 1992 and harvested 126 days later on 4 Mar. 1993. Plots were 60 ft. wide by 61 ft. long. All other items were the same as outlined above.

Sweet corn trials

Site 1a was planted to 'Billy No. 1' on 9 Mar. 1992 and harvested 78 days later on 26 May 1992. Rows were 3 ft. on center. Plots were 30.7 ft. wide by 140 ft. long. Three subsamples 3 ft. wide by 25 ft. long were harvested for records in 5 treatments which were replicated 5 times. The soil type was a Terra Ceia muck with a pH of 6.0 and P tested very high (72 P ppm).

Site 2 was planted to 'Super Sweet 8701' on 26 Feb. 1992 and harvested 84 days later on 20 May 1992. Plots were 30 ft. wide and 120 ft. long. Two subsamples 3 ft. wide by 25 ft. long were harvested for record in 5 treatments which were replicated 4 times. The soil type was a Gator muck with a pH of 6.0 and P tested very high (150 P ppm). The grower side-dressed the entire field with 32 lb per acre N on 2 Apr. 1992.

Site 1c was planted to 'Showcase' on 2 Apr. 1993 and harvested 74 days later on 15 June 1993. Plots were 45 ft. wide by 50 ft. long. Three subsamples 3 ft wide by 25 ft long were harvested for record in 6 treatments which were replicated 4 times. The soil type was Terra Ceia muck with a pH of 5.3 and P tested very low (5 P ppm).

Results and Discussion

Carrot trials

There was no effect of any P treatment on culls, fancy, jumbo, or total marketable carrot yield (Tables 1 and 2). Tissue testing results for P from both site 1a and 1b taken during the growing season and at harvest were in the adequate or high (Hochmuth et al., 1991) range and support our findings that P applied according to calibrated soil tests is sufficient to produce carrots.

Yields for marketable carrots ranged from 621 to 700 48-lb units per acre in 1992 while the grower recorded 628 units. In 1993, the carrot yields were much lower, ranging from 288 to 332 48-lb units per acre and the grower recorded 297 units. The lower yields were attributed to more culls due to heavy rains.

Table 1. Carrot yield results when fertilization was based on Mehlich-1 soil test results, grower fertilizer application, and additional phosphorus, site 1a, Zellwood, FL, 1992.

	Rate (lb/A)			Yield (48 lb units/A)			
Treatment	N	P	K	Fancy	Jumbo	Total	Culls
Mehlich-1	0	0	0	466 a	155 a	621 a	220 a[z]
0.5 × Grower P	0	26	0	530 a	169 a	699 a	157 a
Grower P	0	52	0	478 a	211 a	689 a	159 a
Liquid N-P	17	26	0	502 a	198 a	700 a	139 a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 2. Carrot yield results when fertilization was based on Mehlich-1 soil test results, grower fertilizer application, and additional phosphorus, site 1b, Zellwood, FL, 1993.

	Rate (lb/A)			Yield (48 lb units/A)			
Treatment	N	P	K	Fancy	Jumbo	Total	Culls
Mehlich-1	0	0	0	263 a	25 a	288 a	302 a[z]
0.5 × Grower P	0	13	0	299 a	16 a	315 a	301 a
Grower P	0	26	0	279 a	37 a	316 a	302 a
Grower	30	26	50	309 a	23 a	332 a	258 a
Liquid P	28	42	0	309 a	13 a	322 a	292 a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Sweet corn trials

At site 1a, the average ear weight and length increased significantly with the grower rate of P as compared to no P and 12 lb per acre P. Ear width or diameter was not affected by rate of P applied (Table 3). Total crates per acre were higher for the growers complete fertilizer rate. The field was uneven with areas of poor drainage and high soluble salts. Comparing treatment 35N-24P-209K with treatment 0N-24P-0K indicates the yield response was due to N or K rather than P. Conclusions from this site should be used cautiously.

At site 2, the average ear weight, width, length, and total marketable crates per acre were not significantly different (Table 4). The field was uniform in growth and appearance.

At site 1c, the average ear length and yield in crates per acre did not show a response to additions of P (Table 5). The average ear weight increased with an increase from 0 P to 33 lb P per acre. As with carrots, tissue testing results indicated adequate or high P at harvest time for all treatments.

Preplant soil analysis by the ESTL predicted no response to P fertilizer on histosols testing very high in P. Field trials confirmed that yields and quality of carrots and sweet corn were not enhanced by addition of P to these soils, which are typical of the Zellwood production area.

One trial site did test low in P; however, there still was no response to P fertilization of sweet corn. Other factors, including lack of optimal soil moisture may have precluded a P response in this situation.

These trials were conducted as part of a project designed to encourage adoption of management practices which would reduce nutrient loading to Lake Apopka. As a result, vegetable producers have made many changes,

Table 3. Sweet corn yield results when fertilization was based on Mehlich-1 soil test results, grower fertilizer application, and additional phosphorus, site 1a, Zellwood, FL, 1992.

Treatment	Rate (lb/A) N	P	K	Average ear Wt. (g)	Width (cm)	Length (cm)	Yield (crates/A)
Mehlich-1	0	0	0	234 b[z]	4.2 a	17.7 b	138 bc
0.5 × Grower P	0	12	0	230 b	4.2 a	17.5 b	123 c
Grower P	0	24	0	283 a	4.3 a	18.3 a	176 b
Grower	35	24	209	283 a	4.3 a	18.8 a	233 a
Liquid P	6	9	0	256 ab	4.2 a	18.3 a	173 b

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 4. Sweet corn yield results when fertilization was based on Mehlich-1 soil test results, grower fertilizer application, and additional phosphorus, site 2, Zellwood, FL, 1992.

Treatment	Rate (lb/acre) N	P	K	Average ear Wt. (g)	Width (cm)	Length (cm)	Yield (crates/A)
Mehlich-1	0	0	0	307 a[z]	4.4 a	18.7 a	276 a
0.5 × Grower P	0	16	0	303 a	4.4 a	18.4 a	249 a
Grower P	0	32	0	343 a	4.4 a	18.3 a	279 a
Grower	24	32	239	314 a	4.4 a	18.4 a	270 a
Liquid P	6	9	0	329 a	4.4 a	18.4 a	243 a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

including increased use of calibrated soil testing and following P recommendations more closely. The amount of P fertilizer applied to vegetable crops in the Lake Apopka basin has been reduced by 55% in the last two years (unpublished survey data, 1993).

Table 5. Sweet corn yield results when fertilization was based on Mehlich-1 soil test results, grower fertilizer application, and additional P, site 1c, Zellwood, FL, 1992.

Treatment	Rate (lb/A) N	P	K	Average ear Wt. (g)	Width (cm)	Length (cm)	Yield (crates/A)
Control	0	0	100	313 b[z]	4.6 ab	20.0 a	239 a
1	0	33	100	372 a	4.6 ab	19.8 a	258 a
2	0	66	100	386 a	4.5 b	20.0 a	225 a
3	0	98	100	390 a	4.7 a	19.8 a	235 a
Grower	80	79	100	368 ab	4.6 ab	19.6 a	242 a
Liquid P	20	26	100	363 ab	4.6 ab	20.1 a	285 a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

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Proc. Fla. State Hort. Soc. 106:201-202. 1993.

AN OPINION ON THE GRADIENT CONCEPT OF NUTRITION

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Introduction

In the authors opinion the rhizosphere, which can be described as a "black box" that is a dynamic mix of soil borne and applied nutrients is nutritionally undefinable. Darrah (1993) states that "conventionally, nutrient response curves or models include every aspect of plant function, climate, soil types, etc., into a soil-plant-season specific description of yield variation with fertilizer application and therefore have no predictive ability beyond a statistical interpretation based on field trials." This is an empirical description (trial and error) of how plant yield varies with nutrient application. The question is—why not go beyond the trial and error procedure—provide a nutritionally predictable system by defining and stabilizing the ionic composition contained in the "black box."

The Gradient Concept

The Intensity and Balance (I&B) procedure (Geraldson, 1967) was developed to define the ionic composition (concentration and ratios) in the soil solution. The gradient concept (Geraldson, 1962, 1970) was designed to stabilize the ionic composition and thus provide a nutritional predictability that could be held accountable. The stability of the gradient is provided by synchronizing the nutrient/water input with removal. A constant source of water and a separate and constant source of soluble N-K, covered by a full-bed mulch are the basic components of the gradient-mulch system (Geraldson, 1962, 1970, 1990). The concept as a commercial procedure has been most successful using a constant water table with a banded source of soluble N-K at the soil bed surface. The use of fumigants enhanced the potential of the gradient concept by reducing weed competition and soil borne pests and in experimental plots, yields were increased 400 to 500% using a trellis supported non-determinate tomato cultivar (Geraldson, 1970); commercial yields were more than doubled using stake supported determinate cultivars (Van Sickle et al., 1992). It must be emphasized that in-bed N-K or fertigated N-K moves with