Response of Radish to Phosphorus and Potassium Fertilization on Histosols

C.A. Sanchez, M. Lockhart, and P.S. Porter

University of Florida, Everglades Research and Education Center,
Institute of Food and Agricultural Sciences, P. O. Box 8003, Belle Glade,
FL 33430

Additional index words. soil testing, plant analysis, critical nutrient concentration, organic soils, *Raphanus sativus*

Abstract. Five field experiments were conducted from 1986 through 1988 to evaluate the response of radish (*Raphanus sativus* L.) to rate and source of P (triple superphosphate and phosphoric acid) and to rate of K (KC1) on Histosols. Marketable radish root yields increased with P fertilization when the soil tested <13 mg P/dm³ using a test for water-soluble P. No significant differences were due to P source. Results of leaf tissue analysis suggested that the critical concentration of P in radish leaves was 0.45%. Radish did not respond to K fertilization in any of the five experiments, even though preliminary soil-test K levels ranged from 20 to 102 K/dm³. Histosols used for crop production in Florida rarely test below 20 mg K/dm³; thus, radish rarely would require supplementary K fertilization for optimal yield.

About 20,000 ha of radish are grown on organic soils (Histosols) in Florida, Michigan, Ohio, and New York (Lucas, 1980). Crops grown on organic soils generally require supplementary P and K fertilization for optimal yield and quality (Sanchez, 1990; Warncke et al., 1985). Most organic soils mineralize large amounts of N as a result of rapid biological oxidation when these soils are drained and cultivated (Reddy, 1982; Terry, 1980). Therefore, supplementary N is generally not needed for radish production on Histosols in Florida.

In many areas, radish is grown in rotation with other vegetable crops that require large and frequent fertilizer additions. Therefore, no further fertilizer applications appear to be needed for one or more successive crops of radish. However, in other areas, radish is grown in rotation with agronomic crops that usually receive less fertilizer than certain vegetable crops, and supplementary P and K may be required for optimal radish yield and quality. About 55% of the radishes marketed in the United States from Oct. to June each year are produced on Florida Histosols (Federal-State Market News Service, 1984). In these soils, radish often is grown in rotation with sugarcane, which receives little or no P and only modest amounts of K fertilizers (Sanchez, 1990). Limited information is available concerning the P and K fertilizer requirements of radish produced on Histosols. We were unable to identify relevant research reports from outside Florida, and P and K fertilizer recommendations for radishes produced on Histosols in Florida are

based on a single, 1-year study conducted 25 years ago (Burdine and Guzman, 1967).

Five studies were conducted from 1986 through 1988 to evaluate the response of radish to P and K fertilization on Everglades Histosols. The planting dates, harvest dates, and soil test results before fertilization are

shown in Table 1. In Spring 1986, separate P and K response studies were conducted on a Pahokee muck (euc hyperthermic Lithic Medisaprist), a Histosol being 90 to 130 cm deep over limestone bedrock. The P rates were 0, 70, 110, and 150 kg·ha⁻¹ and the K rates were 0, 112, 224, and 336 kg·ha⁻¹. All remaining studies were P × K factorial experiments conducted on a Terra Ceia muck (euc hyperthermic Typic Medisaprist), a Histosol with depth >130 cm over limestone bedrock. The P rates were 0, 110, and 220 kg·ha⁻¹ and the K rates were 0 and 110 kg·ha⁻¹. The K source for all experiments was KC1. Triple superphosphate (TSP) and phosphoric acid (PA) were used in all experiments to compare P sources. Micronutrients were applied to all experiments to supply Zn, B, and Mn at 9.0, 1.1, and 9.0 kg·ha⁻¹, respectively. Individual plots were 6.0 × 6.9 m and were arranged in randomized complete-block designs with four replications. All granular fertilizers were applied uniformly to the soil surface by hand; PA was applied uniformly to the soil surface using a CO₂-charged backpack sprayer. All fertilizers were disked into the soil before seeding.

'Red Baron' radish was seeded with a between-row spacing of 23 cm and a within-row spacing of 2.5 cm to give a population of 165 plants/m². Subsurface irrigation was provided from field ditches. Radish yields were measured by removing four 3-m sections of row from each plot. The radishes

Fig. 1. Relative radish root yields across five experiments as affected by soil-test P levels midseason. R^2 value is for entire model; CL = critical level.

Table 1. Planting dates, harvest dates, and soil-test data before fertilization for each experiment.

Experiment	Dates of cropping		Soil test		
	Planting	Harvest	pH ^z	P ^y (mg·dm ⁻³)	K ^x (mg·dm ⁻³)
Spring 1986	27 Feb. 1986	31 Mar. 1986	6.2	2.1 ± 0.25	20 ± 7
Winter 1986	16 Dec. 1986	19 Jan. 1987	5.7	6.0 ± 2.25	35 ± 5
Spring 1987	1 Feb. 1987	4 Mar. 1987	5.9	12.1 ± 1.87	35 ± 5
Winter 1987	18 Dec. 1987	20 Jan. 1988	6.1	14.4 ± 2.13	98 ± 12
Spring 1988	2 Feb. 1988	3 Mar. 1988	6.0	20.6 ± 5.00	102 ± 22

^z1 soil : 2 water (v/v) with glass electrode while stirring.

^y1 soil : 12.5 water (v/v) extraction.

^x1 soil :2.5 solution (v/v) extraction with 0.5 N acetic acid.

Received for publication 23 June 1989. Univ. of Florida Expt. Sta. Journal Series no. 10019. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

Table 2. Effects of P and K fertilization on soil P and K levels and marketable radish root yields.

Experiment	Fertilizer applied (kg·ha ⁻¹)	Soil test ^a		Marketable yield (Mg·ha ⁻¹)
		P (mg·dm ⁻³)	K (mg·dm ⁻³)	
Spring 1986	P			
	0	2.2	---	6.01
	70	2.9	---	6.19
	110	3.7	---	6.53
	150	4.4	---	7.34
	Significance	L**	---	L**
	K			
	0	---	29.4	6.19
	110	---	60.3	6.34
	220	---	72.8	6.51
Winter 1986	340	---	69.9	5.83
	Significance	---	L**Q*	NS
	P			
	0	7.7	---	7.50
	110	18.7	---	8.34
	220	18.9	---	8.29
	Significance	L**Q*	---	L**Q*
	K			
	0	---	39.8	8.01
	110	---	58.6	8.08
Spring 1987	Significance	---	L**Q*	NS
	P			
	0	11.9	---	9.69
	110	20.4	---	10.10
	220	27.3	---	9.98
	Significance	L**	---	NS
	K			
	0	---	36.1	9.95
	110	---	54.7	9.98
	Significance	---	L**Q*	NS
Winter 1987	P			
	0	19.7	---	5.53
	110	35.6	---	5.22
	220	52.8	---	5.51
	Significance	---	L**	NS
	K			
	0	---	135.2	5.47
	110	---	182.4	5.35
	Significance	---	L**Q*	NS
Spring 1988	P			
	0	23.9	---	8.48
	110	44.2	---	8.38
	220	54.0	---	8.59
	Significance	L**	---	NS
	K			
	0	---	144.3	8.38
	110	---	164.6	8.58
	Significance	---	L**Q*	NS

^aMeasured on soil samples collected midseason.

***, NS Significant linear (L) or quadratic (Q) response at $P = 0.05$ and 0.01 or not significant, respectively.

were graded using standard marketing criteria (USDA, 1968). Marketable yields were determined after excluding undersized and oversized radishes and those with growth cracks or discoloration. Leaf samples were taken from all plots to determine P and K concentrations except in Spring 1986. After digesting 0.3 g plant material with H₂SO₄ and H₂O₂ (Wolf, 1982), P and K were determined by inductively coupled plasma spectroscopy.

Soil samples were taken from each plot before fertilization, 15 days after fertilization, and immediately after harvest for all experiments. The soils were analyzed for pH, water-soluble P, and 0.5 N acetic-acid-extractable K using the methods of the Univ. of Florida Everglades Soil Testing Laboratory (Sanchez, 1990). Analysis of variance

and regression analysis were performed using SAS (SAS Institute, Inc., 1982). Critical levels were determined using the linear response and plateau (LRP) procedure described by Nelson and Anderson (1977). This procedure is an iterative statistical analysis for separating relative yield into two classes based on the maximization of the class sum of squares in a one-way analysis of variance. Coefficients of determination (R^2) values are obtained by dividing class sum of squares by the total corrected sum of squares. By this iterative process, a series of R^2 values is obtained for divisions at various levels of x . The critical level of x is taken as the level at which R^2 is maximum.

Marketable radish root yields ranged from 5.22 to 10.01 Mg·ha⁻¹ (Table 2). Growth cracking caused low marketable yields in

Winter 1987. The amount of growth cracking, expressed as a percentage of total radish root mass average, was 2% in Spring 1986, 8% in Winter 1986, 17% in Spring 1987, 47% in Winter 1987, and 18% in Spring 1988. The percentage of growth cracks and discoloration was not affected by P and K fertilization and probably was related to weather conditions.

Source of P (data not shown), rate of K, and interactions were not statistically significant in any of the five experiments, even at $P = 0.10$. Phosphorus rates increased radish yields only in Spring and Winter 1986 (Table 2). The critical soil-test P level was 13 mg·dm⁻³ as determined by relating relative yields (calculated within experiment) to soil P levels 15 days after fertilization over all experiments (Fig. 1). This observation is generally consistent with the preplant soil-test P levels (Table 1), where only sites used in Spring and Winter 1986 had soil-test P levels appreciably <13 mg·dm⁻³. In Spring 1986, the soil P level after fertilization was only 4.4 mg·dm⁻³; this low level explains the large linear response of radishes to P in this experiment. Generally, only fields previously cropped to sugarcane and sweet corn on Florida Histosols have soil P levels <13 mg·dm⁻³ (Sanchez, 1990).

Radishes grow fast and diagnosis of nutrient deficiencies from leaf analysis would be largely postmortem for the crop sampled. However, multiple crops of radish are often grown in succession, and diagnosis of a nutrient deficiency in any given crop could aid in making fertilizer-use decisions for subsequent crops. Based on the relationship between relative yield and leaf P concentration at maturity over all experiments, radish appears to be deficient in P if the leaf tissue concentration is <0.45% (Fig. 2). This percentage is only slightly higher than the critical level of 0.4%, estimated using growth rate analysis (Beverly, 1984).

Growers in southern Florida often use liquid P sources, rather than dry ones, for radish production because they believe that a more uniform distribution of applied fertilizers is achieved and, subsequently, a more uniform grade of radish is harvested. In our field experiments, TSP or PA was applied uniformly to the plots, and under these conditions, both P sources produced similar yields. Because our method of application may not have simulated commercial application, additional work should evaluate the P fertilizer distribution patterns achieved by dry and liquid fertilizer applicators used in commercial radish operations.

The K concentration in radish leaves ranged from 4.5% to 6.4% across all experiments, consistently above the critical concentration of 2.0% proposed by others (Beverly, 1984; Burdine, 1976). The initial soil test levels ranged from 20 to 102 mg K/dm³ (Table 1). The Univ. of Florida Everglades soil testing laboratory currently recommends K fertilization of radish if the soil tests <110 mg K/dm³ (Sanchez, 1990). Clearly, this critical soil test level is too high and an adjustment in recommendations is in order. Histosols

Fig. 2. Relative radish root yields across four experiments as affected by leaf-tissue P concentration. R^2 value is for entire model; CL = critical level.

used for crop production in southern Florida rarely, if ever, test below 20 mg K/dm³ using acetic acid in analysis. Beverly (1984), in a nutritional survey, found that all radish leaves collected from Histosols in Florida had K concentrations greater than the critical level of 2.0%. The results of experiments reported here suggest that radish grown on Florida Histosols rarely should require supplementary K fertilization for optimal yield and quality when grown in rotation with crops

that received K fertilizer applications.

Literature Cited

- Beverly, R.B. 1984. Nutritional survey of the Everglades vegetable industry. *Proc. Fla. State Hort. Soc.* 97:201-205.
- Burdine, H.W. 1976. Plant analysis for vegetable crops on Everglades organic soils. Everglades Agr. Res. Educ. Ctr. Res. Rpt. EV-76-9.
- Burdine, H.W. and V.L. Guzman. 1967. Radish response to phosphorus and potassium fertilizers on Everglades organic soil. Everglades Agr. Res. Educ. Ctr. Res. Rpt. EV-67-12.
- Federal-State Market News Service. 1984. Marketing Florida vegetables. Summary 1983-1984. Fla. Dept. Agr. Consumer Serv., Tallahassee.
- Lucas, R.E. 1980. Organic soils (Histosols). Formation, distribution, physical and chemical properties and management for crop production. Michigan State Univ. Res. Rpt. 435.
- Nelson, L.A. and R.L. Anderson. 1977. Partitioning of soil-test response probability, p. 19-38. In: T.R. Peck, J.T. Cope, Jr., and D.A. Whitney (eds.). *Soil testing: Correlation and interpreting the analytical results*. ASA Spec. Publ. 29. Amer. Soc. Agron., Madison, Wis.
- Reddy, K.R. 1982. Mineralization of nitrogen in organic soils. *Soil Sci. Soc. Amer. J.* 46:561-566.
- Sanchez, C.A. 1990. Soil-testing and fertilizer recommendations for crop production on organic soils in Florida. Univ. Fla. Tech. Bul. 376.
- SAS Institute, Inc. 1982. SAS user's guide: Statistics. 1982 ed. SAS Institute, Inc., Cary, N.C.
- Terry, R.E. 1980. Nitrogen mineralization in Florida Histosols. *Soil Sci. Soc. Amer. J.* 44:747-750.
- U.S. Department of Agriculture. 1968. United States standards for grades of radishes. U.S. Dept. Agr. Agr. Mktg. Serv., Washington, D.C.
- Warncke, D. D., D.R. Christenson, and M.L. Vitosh. 1985. Fertilizer recommendation: Vegetable and field crops in Michigan. Michigan State Univ. Ext. Bul. E-550.
- Wolf, B. 1982. A comprehensive system of leaf analysis and its use for diagnosing nutrient status. *Commun. Soil Sci. Plant Anal.* 13:1035-1059.