18. Rutger, J. N. and L. S. Beckham. 1970. Natural hybridization of *Phaseolus vulgaris* L. x *Phaseolus coccineus* L. *J. Amer. Soc. Hort. Sci.* 95:659-661.
19. Tucker, C. L. and J. Harding. 1975. Outcrossing in common bean *Phaseolus vulgaris* L. *J. Amer. Soc. Hort. Sci.* 100:283-285.
20. Weinstein, A. I. 1926. Cytological studies on *Phaseolus vulgaris*. *Amer. J. Bot.* 13:248-263.
21. Zaumeyer, W. J. 1972. Snapbeans. p. 234-244. *In* Genetic vulnerability of major crops. Nat. Acad. Sci., Washington, D.C.

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Influence of Subsoil Acidity on Tomato Yield and Fruit Size[1]

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Abstract. **'Tropic' and 'Walter' tomatoes (*Lycopersicon esculentum,* Mill.) were grown in central Alabama on a Lucedale fine sandy loam soil (Rhodic Paleudult) with uniform 0- to 15-cm surface soil pH of about 6.0 and subsoil pH ranging from 4.4 to 6.2. Depth and amount of soil water extraction and plant heights increased as subsoil pH increased. Marketable tomato yields were influenced by subsoil pH, with maximum yields occurring at pH 5.6 to 5.8. Marketable yields ranged from 10,400 to 55,500 kg/ha for 'Tropic' and from 14,000 to 39,400 kg/ha for 'Walter'. Yield of large size fruit of 'Tropic' was greater above pH 5.0 than below pH 5.0. Fruit size distribution for 'Walter' was not affected by subsoil pH.**

Low soil pH restricts root and shoot growth of many plants, often resulting in a limited root system and reduced drought tolerance. This is believed to be the reason why plants often fail to develop deep, vigorous root systems in highly-weathered and leached acid subsoils (7). The detrimental effect of low subsoil pH on root growth has been clearly demonstrated to be intimately associated with exchangeable or solution aluminum (1). Tomato plants have been reported to be sensitive to aluminum and have been suggested for use as an indicator of aluminum availability in acid soils (3, 6). Jones and Overman (4) reported that adjusting soil pH to 6.0 to 7.0 reduced the incidence of fusarium wilt and increased yields. Highest yields were obtained with a combination of soil fumigation and increased soil pH. Other investigations (2, 5) have demonstrated control of fusarium wilt of tomato by elevating the soil pH as well as numerous other factors associated with acid soils.

The purpose of this experiment was to determine the effect of subsoil acidity on plant growth and yield of 2 tomato cultivars.

Materials and Methods

Field studies were conducted with 'Tropic' and 'Walter' tomatoes during 1975 and 1976 in central Alabama on a Lucedale fine sandy loam soil. These cultivars were used because 'Tropic' is an indeterminate plant and 'Walter' is semideterminate. The surface soil (0 to 15 cm) was uniformly limed to about pH 6.0, whereas the subsoil (15 to 30 cm) varied between pH 4.4 and 6.2. All plots were adequately fertilized according to soil test recommendations, and plants were set in mid-April. Plants were staked, and tied with twine when about 45 cm high and as needed as they grew taller. Plants were sprayed weekly throughout the season with insecticide (dimethoate and carbaryl) and fungicide (zinc-ion-maneb complex). Plant heights were measured at 2-week intervals during the season. Soil samples were obtained at weekly intervals during the peak water-use period for gravimetric determinations of soil water extraction. Fruits were harvested weekly from early July to mid-August. Excavations of root systems were made after the last harvest, and rooting patterns were observed in representative plots with subsoil pH ranging from 4.4 to 6.2.

The long-time average rainfall from mid-April to mid-August at this location is 50 cm. Rainfall during the test period was about 126% of normal in 1975 and 100% in 1976. Relative rainfall during the critical growth period of June and July (normal is 26 cm) was 134% in 1975 and 49% in 1976.

Results and Discussion

Plant growth during the first 30 days after planting was unaffected by subsoil pH. During the second 30 days, however, plants grew 15 to 30 cm taller on the higher subsoil pH plots than on the lower pH plots. Plant ht for both cultivars at first harvest increased as subsoil pH increased (Fig. 1). Final plant ht ranged from 61 to 117 cm for 'Tropic' and 46 to 79 cm for 'Walter'. Marketable tomato yields of both cultivars were significantly correlated with plant ht at the beginning of harvest (Fig. 2).

Marketable tomato yields varied within a subsoil pH range, especially at the lower pH, but were correlated with pH when the entire pH range was considered (Fig. 3). Yields of 'Tropic' varied more at a particular subsoil pH than did those of 'Walter'. Marketable yields for 'Tropic' ranged from about 10,000 kg/ha at the lower subsoil pH to 56,000 kg/ha at the higher pH. Yields for 'Walter' ranged from 14,000 to 39,000 kg/ha. 'Tropic' outyielded 'Walter' during the 2-year period by an average of about 7,000 kg/ha. Yields of both cultivars were higher in 1975 than in 1976, which was due mainly to the greater rainfall during the critical growth period of June-July, when rainfall was 134% of normal as compared with 49% of normal for the same period in 1976. Also, there was more disease present in 1976 than in 1975. No disease count was made either year, but based on observation at the end of the harvest season, it was estimated that 50% or more of the plants were dead in 1976 and 20% in 1975. There were more diseased plants on low subsoil pH plots

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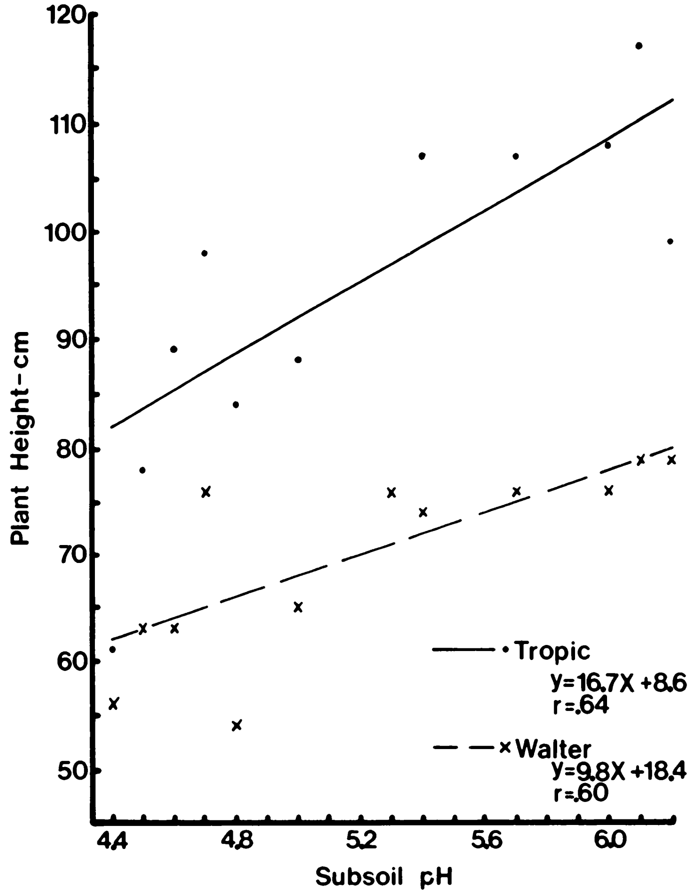

Fig. 1. Effect of subsoil pH on tomato plant ht prior to first harvest (average 1975-76).

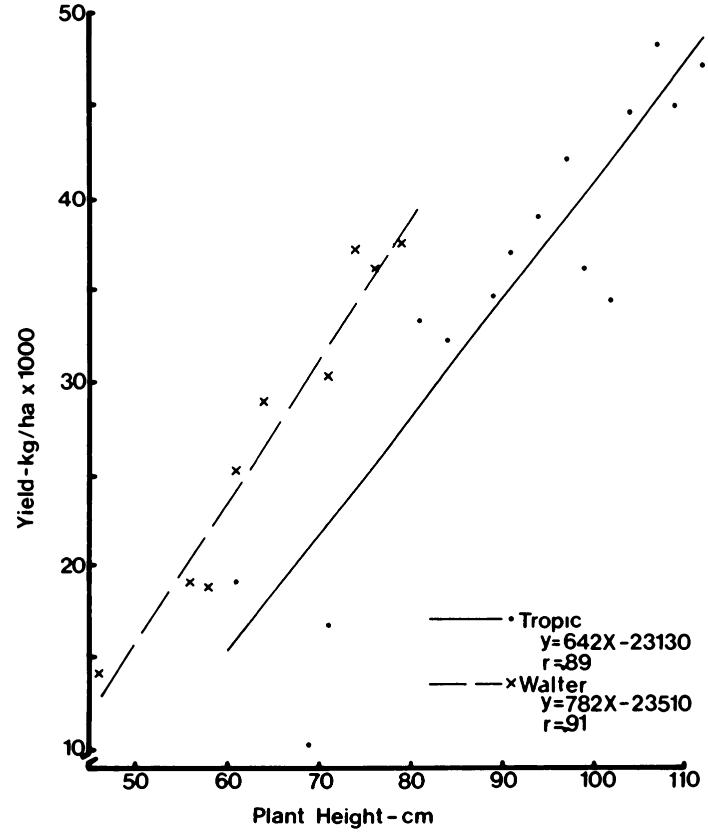

Fig. 2. Relationship of tomato plant ht to marketable yields (average 1975-76).

than on high pH plots. Fewer harvests were made in 1976 than in 1975 as a result of disease, with only 5 harvests of 'Tropic' in 1976 as compared with 7 in 1975.

Average yields for the 2 cultivars ranged from about 21,000 to 43,000 kg/ha, with maximum yields obtained at subsoil pH 5.6 to 5.8. Average yields at subsoil pH 6.0 to 6.2 were less than yields at pH 5.6 to 5.8. The reason for this decrease in yield at the highest pH is not known, but the decrease occurred in both years. An average of all pH levels for both years showed that 63% of marketable 'Tropic' tomatoes were large size (5x6 = ⩽ 6.8 cm diam) 21% were medium (6x6 = 6.4 to 7.3 cm diam) and 16% were small (6x7 = 5.7 to 6.7 cm diam). Values for 'Walter' were 38% large, 27% medium, and 35% small. Subsoil pH did not affect the size distribution for 'Walter', but above pH 5.0 the percentage of large-size 'Tropic' fruit was higher than below pH 5.0 (Fig. 4).

Cull tomato yields were little affected by subsoil pH. The overall average showed that culls made up about 23% of the total yield for 'Tropic' and 35% for 'Walter'. Most cull fruit for 'Tropic' was from catfacing, which apparently is not greatly affected by subsoil pH. A high percentage of 'Walter' culls was fruits that were too small for the small-size grade (6x7).

Root observations made at the end of each growing season showed that plants grown on subsoil pH below about 5.0 had a high concn of roots in the surface 15 cm but had few roots below 15 cm. It appeared that the taproot died and a branch root developed and grew laterally at about the 15-cm depth. Plants grown on subsoil with pH 5.6 and higher had a lower concn of roots in the surface 15 cm, but had many roots below 30 cm with the taproot extending to 45 to 50 cm. There was no difference in observed rooting between cultivars. The decrease in depth of rooting in the more acid subsoils probably

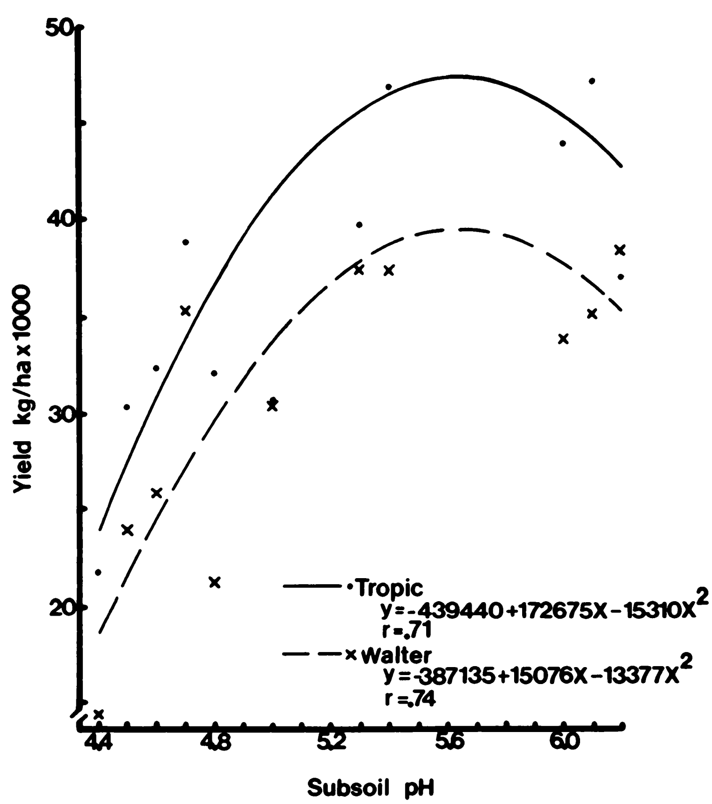

Fig. 3. Relationship of marketable tomato yields to subsoil pH (average 1975-76).

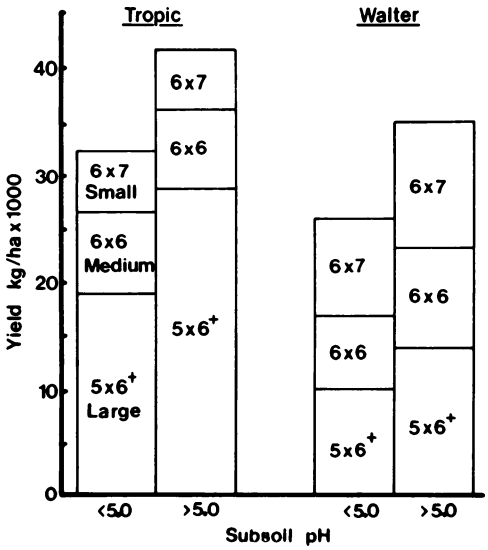

Fig. 4. Marketable tomato yields of 2 cultivars by fruit size as affected by subsoil pH. Refer text for size classification.

resulted from the increase in available Al. The exchangeable Al increased as soil pH decreased, with concn ranging from none at pH 6.0 to 1.25 meq/100g at pH 4.4. This Al concn has been reported to be toxic to cotton roots (1).

Soil water extraction patterns were closely related to root observations. Soil water extraction patterns for the soil profile at 15 to 30 cm at 4 pH ranges for the 1975 date were 5 days after a light rain or 16 days after a rain that recharged the soil profile (Fig. 5). The 1976 date showed water extraction 8 days after soil profile was recharged. The amount of water extracted from the 15- to 60-cm soil depth increased as subsoil pH increased. About 100% of the available water was extracted from the 30- to 60-cm soil depth on plots with subsoil pH above 5.6 as compared with about 55% on plots with pH below 4.6. The deeper root system on high subsoil pH plots enabled plants to extract water from a greater soil depth and obtain adequate water for optimum growth for a longer period of time than that for the plants grown on low subsoil pH plots.

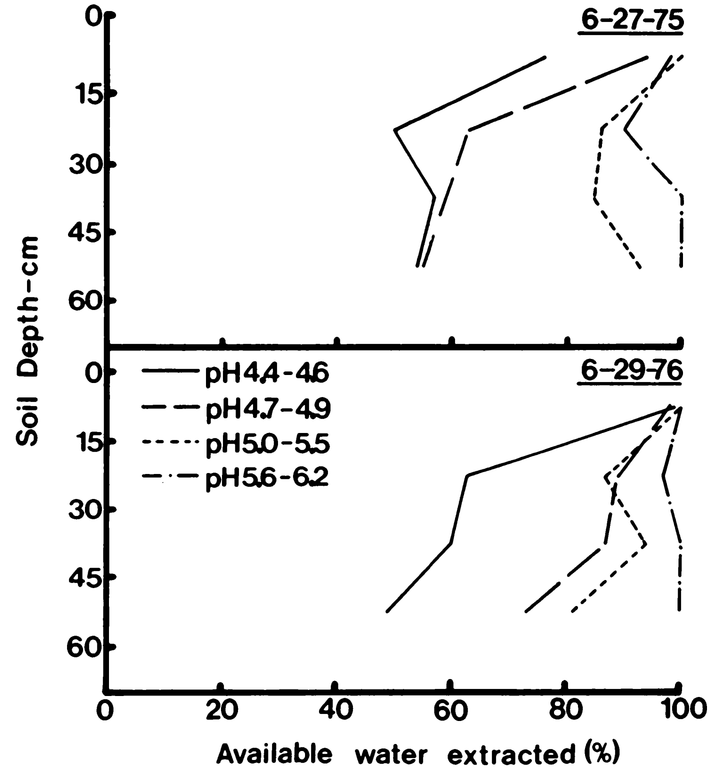

Fig. 5. Effect of subsoil pH on % available water extracted by tomatoes.

Conclusion

Low subsoil pH reduced marketable tomato yields of 2 cultivars. This reduction probably resulted from a combination of a shallow root system which was unable to furnish adequate water for optimum plant growth during the critical water-use period, and the presence of more diseased plants, which shortened the harvest season. Tomato size distribution was affected little by subsoil pH for 'Walter', however, soil pH below 5.0 reduced percentage of large fruit for 'Tropic'.

Literature Cited

1. Adams, Fred, R. W. Pearson, and B. D. Doss. 1967. Relative effects of acid subsoils on cotton yield in field experiments and on cotton roots in growth chamber experiments. *Agron. J.* 59:453-456.
2. Edgerton, C. W. and C. C. Moreland. 1920. Tomato wilt. *LA Agr. Expt. Sta. Bul.* 174.
3. Foy, C. D., G. Gerloff, and W. H. Gabelman. 1963. Differential effects of aluminum on the vegetative growth of tomato cultivars in acid soil and nutrient solution. *J. Amer. Soc. Hort. Sci.* 98:427-432.
4. Jones, J. P. and A. J. Overman. 1971. Control of Fusarium wilt of tomato with lime and soil fumigants. *Phytopathology* 61:1415-1417.
5. ________ and S. S. Woltz. 1968. Field control of Fusarium wilt (race 2) of tomato by liming and stake disinfestation. *Florida State Hort. Soc. Proc.* 81:187-191.
6. Mercado, B. T. and J. R. Velasco. 1961. Effect of aluminum on the growth of coconut and other plants. *Philip. Agr.* 45:268-274.
7. Pearson, R. W. 1966. Soil environment and root development. p. 95-125. *In* W. H. Pierre, Don Kirkham, John Pesek, and Robert Shaw, (eds.) Plant environment and efficient water use. Amer. Soc. Agron. and Soil Sci. Soc. Amer., Madison, Wisc.