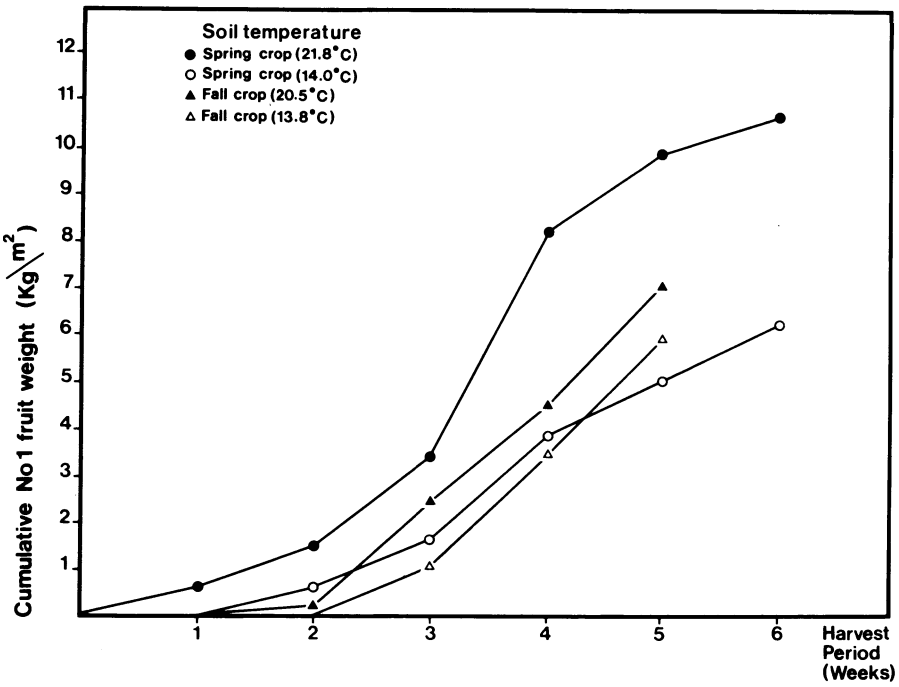

Fig. 1. Influence of soil temperature on the cumulative yield of tomato number 1 fruit weight grown under normal air temperature conditions.

spectively) with an increase in soil temperature. These large differences resulted from small yields obtained in the unheated plots and a 66% reduction in the number of fruits affected by gray mold in the heated parcels.

Warming the soil was shown to improve the productivity of greenhouse tomato. Our experiments have clearly demonstrated that an increase in soil temperature had a greater influence in the spring than in the fall when light intensity was not the limiting factor and soil temperature was lower. In the fall, warming the soil had an important effect only under low air temperature conditions.

The use of plastic tunnels for the production of tomato has been limited because of low yield and a lack of earliness as compared to the field crop. With an increase in soil temperature, it was possible to obtain yields as high as under normal greenhouse conditions and with sufficient earliness to command high prices. Moreover, under these low air temperature conditions, energy cost has been estimated to be only 20 to 25% of a conventional greenhouse. These data on effect of soil temperature in conventional greenhouse raise the possibility of growing 3 short crops of tomato a year using high density planting of 2 or 3 cluster plants. Such a low canopy could easily be covered with thermal blankets and allow additional energy savings. More work is needed to determine the profitability of these new cultural practices.

Table 2. Effect of soil temperature on the yield of greenhouse tomato grown under reduced air temperature conditions in a plastic tunnel.

Season	Soil temp[z] (°C)	No. 1 fruit size (g/fruit)	Yield No. 1 fruit (kg/m²)	Total yield (kg/m²)
Spring	13.8	162	8.7	10.0
	23.9	175*	12.2*	13.6*
Fall	13.0	161	2.5	5.2
	22.0	158	3.9*	7.4**

[z]Avg seasonal temp.
*,**Significantly higher than paired comparison at 10% (*) or 1% (**) level.

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Water-soluble Calcium in Ca-efficient and Ca-inefficient Tomato Strains[1]

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Additional index words. nutrient efficiency, *Lycopersicon* spp., acid soil tolerance

Abstract. **Seedlings of 5 strains of tomato (*Lycopersicon* spp.) were grown in low-Ca nutrient solutions in a greenhouse for 4 weeks in order to determine whether Ca-efficient and inefficient strains differed in concentrations of water-soluble Ca. Aqueous extracts from dried tissues of efficient strains were lower in percent of Ca and in electrical conductivity than were extracts from inefficient strains. Efficient strains may suffer less than inefficient strains from precipitation or displacement of Ca from functional sites in tissues by other ions.**

Calcium appears in many forms in plants, ranging from water soluble to insoluble. The soluble portion occurs in the cytoplasm as ionic Ca or as relatively soluble Ca salts, and the less soluble forms include Ca in cell walls, Ca associated with enzymes, and relatively insoluble Ca salts. Researchers have estimated the occurrence of the various forms of Ca by using analysis of juice (3), extraction with water, salt solutions, or acids (6), and microscopic identification of Ca oxalate crystals (9). These methods are often imprecise, and Ferguson et al. (7) believe that Ca oxalate is the only cellular fraction that currently can be measured reliably. They argue that mea-

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Table 1. Strains of tomato plants used in study (5).

Experimental no.	Strain	Plant intro. no.
Ca-efficient		
10	*L. esculentum* cv. Yellow Peach	205040
35	*L. esculentum* x *L. pimpinellifolium*	129021
Ca-inefficient		
16	*L. esculentum*	340909
20	*L. esculentum*	341984
21	*L. esculentum*	341988

surable water-soluble Ca is really that which is extracted in acid or salt solutions, because of dissolution of salts and acids inherent to the plant tissues, and that salts and acids may influence the amount of Ca that is dissolved from tissues.

In this study, we compared the concentrations of water-soluble Ca in Ca-efficient and Ca-inefficient tomato strains (Table 1) to determine whether efficiency was related to water-soluble Ca concentrations. In previous experiments using Ca-deficient media (4, 5), inefficient strains contained more total Ca than efficient strains, but the former grew less and exhibited more severe deficiency symptoms than the latter. These observations suggested that inefficient strains used less Ca for structural and metabolic roles and that they might have higher concentrations of water-soluble Ca than efficient strains. We also measured in this study the conductivity and pH of the extracts to determine whether all tissues were being extracted with similar solutions.

Seeds of Ca-efficient and Ca-inefficient tomato strains (Table 1) were sown in acid-washed sand in plastic flats on Feb. 23, 1981. Flats were subirrigated with deionized water as required for 2 weeks, and then for 1 week with a solution of 2.5 mM KNO_3, 2.5 mM $NaNO_3$, 0.25 mM $MgSO_4$, 0.5 mM KH_2PO_4, 0.25 mM $CaCl_2$, and micronutrients at half the concentration suggested by Hoagland and Arnon (8). On March 13, seedlings at the first true-leaf stage were transplanted to containers holding solutions twice as concentrated as above. Each seedling was provided with 1.8 liters of nutrient solution in individual containers, and 4 replications of single plants were arranged in a randomized block design.

Solutions were replenished with deionized water, and on March 20, 14 mg of Ca were added to each pot. Plants ranging from 4 to 8 g dry weight were harvested on April 10, and dried at 70°C for 3 days. The tissues were ground to pass a 20-mesh screen. For 1 hr, 0.5 g of tissue in 50 ml of distilled water was shaken mechanically in a 125-ml Erlenmeyer flask. Extracts were prepared by filtration through paper. Conductivity and pH were measured electrometrically. Soluble Ca in the filtrate and total Ca in the wet-ashed (HNO_3 and H_2O_2) tissues were analyzed by atomic absorption spectrophotometry.

As judged by foliar appearance (4), inefficient strains were Ca-deficient and smaller than the efficient strains, which appeared healthy. Inefficient strains had higher concentrations of soluble and total Ca than inefficient strains, especially in leaves (Table 2). The pH of extracts did not differ among strains, but the conductivity of extracts from inefficient strains was greater than that from efficient strains (Table 3).

An accompanying study showed that efficient strains were lower in percent of K and percent of Mg in leaves, stems, and total plant than inefficient strains (4). Other nutrients are known to influence the transport of Ca in plants (1). The partitioning of Ca into the oxalate portion can be affected by cations, since the oxalate contents of plants is increased by elevating levels of Mg^{++}, Na^{+}, and Ca^{++} in plants (10, 11). Hence, Ca is rendered nonfunctional by oxalate precipitation. This phenomenon may be acting to bring about the development of Ca deficiency in the inefficient strains. The higher percentage of soluble Ca in the inefficient strains confounds this interpretation. Perhaps K^{+} and Mg^{++} compete with Ca^{++} for functional (2) sites in the inefficient strains and displace Ca^{++} from metabolic roles, bringing about deficiency symptoms and lesser growth in the inefficient strains.

The greater electrical conductivity of extracts from inefficient strains is most likely due to the higher K^{+}, Mg^{++}, and Ca^{++} in their tissues. Ferguson et al. (7) proposed that differences in conductivity of extracting solutions confound results pertaining to water-soluble Ca, because greater conductivity of the extract would reflect a greater salt content, i.e., K^{+}, Mg^{++}, which would release Ca^{++} from tissues. One may speculate that in living cells a greater intrinsic salt concentration may cause displacement of Ca^{++} from functional sites. Thus, differences in conductivity of extracts may elucidate rather than confound the measurements of water-soluble Ca. However, because of compartmentalization and changes upon drying of the tissues, the precise identity of the sites that are extracted is unknown.

Table 3. Conductivity and pH of extracts from selected strains.

Strain	pH[z] Roots	pH[z] Stems	pH[z] Leaves	Conductivity (mMhos)[z] Roots	Conductivity (mMhos)[z] Stems	Conductivity (mMhos)[z] Leaves
10	5.81	5.90	5.59	1.8 b	2.6 ab	1.5 a
35	5.89	6.03	6.14	1.6 a	2.4 a	1.4 a
16	6.04	6.26	6.25	2.4 d	3.2 c	1.9 b
20	5.98	6.15	6.20	2.4 d	3.2 c	1.8 b
21	6.72	6.57	5.94	2.1 c	2.8 b	1.8 b
	NS	NS	NS			

[z]Mean separation within columns by Duncan's multiple range test, 5% level; NS = no significant difference among strains.

Table 2. Percent of water-soluble and total Ca in dry tissue of selected tomato strains grown in Ca-deficient media.

	Ca (%)								
	Roots		Stems		Leaves		Plant		Plant Sol./Total
Strain	Soluble	Total	Soluble	Total	Soluble	Total	Soluble	Total	× 100
10	0.04 a[z]	0.05 ab	0.04 ab	0.05 ab	0.16 a	0.26 a	0.11 a	0.18 ab	65 a
35	0.05 a	0.04 a	0.05 abc	0.04 a	0.14 a	0.23 a	0.10 a	0.15 a	66 a
16	0.07 b	0.06 b	0.07 c	0.06 b	0.26 c	0.39 bc	0.19 c	0.25 cd	75 a
20	0.07 b	0.06 b	0.06 bc	0.09 c	0.30 d	0.43 c	0.21 c	0.29 d	74 a
21	0.07 b	0.04 a	0.03 a	0.05 ab	0.20 b	0.33 b	0.14 b	0.22 bc	65 a

[z]Mean separation within columns according to Duncan's multiple range test, 5% level.

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Resistance of Sweet Potato Lines to the Sweetpotato Weevil[1]

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Additional index words. host plant resistance, *Ipomoea batatas, Cylas formicarius elegantulus,* mechanism of resistance

Abstract. **Out of 38 lines of sweet potato [*Ipomoea batatas* (L.) Lam.] which had demonstrated some resistance in laboratory tests to the sweetpotato weevil, *Cylas formicarius elegantulus* (Summers), 13 lines had significant levels of resistance, based on weevil free yield in artificially infested fields in Yoakum, Texas. Two lines, W 125 and W 119, previously released as having weevil resistance, maintained a high level of resistance.**

The sweetpotato weevil is the most destructive pest of commercially grown sweet potatos in Georgia, Texas, Florida, Louisiana, Mississippi, and Alabama. In recent years, the development of host plant resistance has received increased attention. Waddill and Conover (9) found some resistance in the white-fleshed lines. Rolston et al. (8) reported that resistance to the weevil existed in a continuous gradient and was polygenetic. Mullen et al. (5, 6) found several lines to be resistant in field tests. Jones et al. (3) released 6 lines with multiple insect and disease resistance, all of which possessed moderate levels of weevil resistance. This study was conducted to determine the resistance levels of sweet potato lines to weevil infestation in artificially infested fields.

We tested 107 sweet potato lines in the laboratory using the method described by Mullen et al. (4). In each test, 23 lines were exposed to 30 sweetpotato weevils for 48 hr, and the number of weevil punctures in the periderm were counted and compared to the controls, 'Centennial' and 'Jewel'. Each line was replicated 5 times and ranked according to the number of weevil punctures. Thirty-eight experimental lines and 2 controls, 'Centennial' and 'Jewel', were selected from the laboratory tests for field testing. Field plots were planted on May 20, 1981, in a randomized complete block design. Each cultivar was replicated 8 times in 10-plant plots. Sweet potato slips from greenhouse beds were planted 30 cm apart with 90 cm between plots and 1.0 m between rows. The field was bordered by 2 guard rows of 'Jewel'. Standard commercial practices were followed in growing the crop. Twelve thousand weevils were released from 4 shelters 66 days after planting as previously described by Mullen et al. (5). Plots were harvested 141 days after plantings, on Oct. 8, 1981.

The criteria used for judging resistance levels were crown infestation, hill infestation, yield, and a subjective severity rating. Each crown was examined for weevil damage and rated on a scale of 1 (no visible infestation on crowns) to 5 (severely infested). The crown index was determined by dividing the total rating points scored for all crowns by the number of crowns examined. Each hill was examined in the field for infestation. One infested root was sufficient to consider a hill infested. Two roots from each plot were selected at random, returned to the laboratory, and held at 23 to 26°C for 30 days and the numbers of weevils emerging from each root determined. Roots were not graded, but total yield was determined for each plot. Weevil free yield was calculated by multiplying the percentage of weevil free hills by the total yield. The severity index (SI) was based on a scale of 1 (no visible damage) to 5 (very heavy damage), and was determined before any of the resistance criteria were measured. Data from only 30 lines are reported, since 5 lines failed to produce sufficient roots in the field.

Five lines were found to be highly resistant to weevil infestation and 8 lines were resistant (Table 1). Two lines, W 119 and W 125, released as having weevil resistance (3) also had a very high weevil free yield. 'Jewel', considered in previous studies as intermediate to susceptible (5.6), had high weevil free yield. 'Centennial' was one of the most susceptible lines studied.

Data on crown damage were not considered in determining resistance levels because few differences were found to exist between the lines tested. The mean crown index was 2.03 ± 0.12 (se). This, however, does not mean that crown damage does not affect yield. Mullen et al. (6) found that crown damage so reduced the vigor of 'Centennial' and other lines that root production was greatly reduced.

Numbers of weevils emerging from roots held in the laboratory were also not considered in determining resistance as variability within the same lines was so great that no significant differences existed. Many lines

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