CALIFORNIA

Tomato Yield Variability Related to Soil Texture and Inadequate Phosphorus Supply

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Little research has been conducted on within-field spatial variability of irrigated crops grown in a Mediterranean climate such as exists in the Central Valley of California. Where the land is sufficiently level, gravity irrigation systems are common. In such systems, the soil serves as both a medium for root growth and a surface over which water is transported. Therefore, the relationship between soil properties and crop performance is more complex than in rain-fed and sprinkler-irrigated cropping systems.

Processing tomato is an important crop in California, with an annual gross farm value of $750 million, averaging $2,400 per acre. Irrigation and soil physical management are often the controlling factors in establishing the crop, preventing disease, and achieving high fruit yield and quality. What is the magnitude of spatial variation of tomato yield within individual fields? Is it possible to infer the causes of within-field variation from yield maps and conventional crop monitoring techniques. The research reported here was designed to answer those questions. It was supported by the University of California, the California Department of Food and Agriculture Fertilizer Research and Education Program, and the California Tomato Research Institute.

Yields and crop and soil conditions in two irrigated tomato fields of 106 and 78 acres were monitored at the Button & Turkovich Ranch in Winters, California in 1997. Soils are mapped as Capay silty clay, Marvin silty clay loam, and Rincon silty clay loam...all rated Class II due to slow permeability...and Brentwood silty clay loam and Yolo silt loam...both Class I soils. Each field contains areas of Class I and II soils. Fields have been graded to uniform slopes for furrow irrigation and have been in agronomic and vegetable crops for several decades. They were disked and bedded up on a 5-foot spacing following wheat harvest in 1996. Weeds were controlled during the 1996-97 winter. Processing tomatoes were either direct seeded (Field 1, 2/24/97) or transplanted (Field 2, 4/3/97) in a single row on each bed. The fields were managed by the grower using standard practices for the region and were harvested in late July (Field 1) and early August (Field 2).

Irrigation and soil physical management are often controlling factors in establishing processing tomatoes, preventing disease, and achieving high fruit yield and quality. Understanding spatial variation within individual fields may offer unique insights leading to more precise and, therefore, successful management.

Soil and plant tissue were sampled on a

Mechanical harvesting of processing tomatoes in the Sacramento Valley of California.

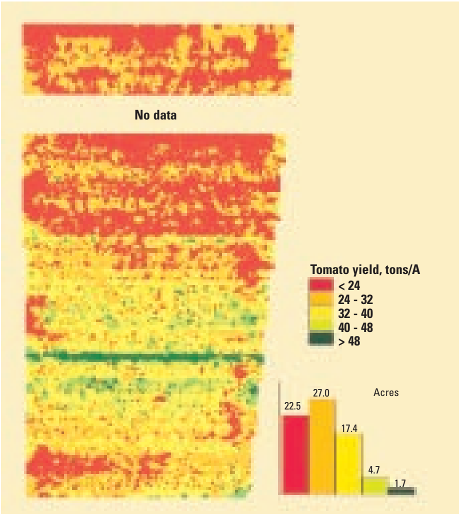

Figure 1. Yield map of processing tomato in Field 2. Field area is 78 acres. High yielding strip one-third of distance from southern boundary represents harvest of beds where field was "opened up" and plants from two beds were thrown onto adjacent beds to clear a lane for truck-trailer receiving harvested fruit.

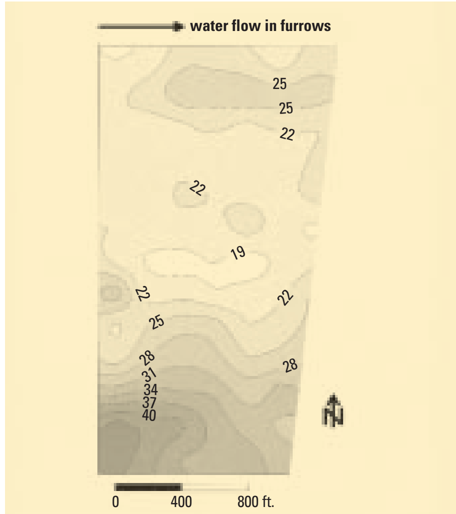

Figure 2. Sand content (%, 0-6 inch depth) of soil in Field 2.

200 x 200-ft. grid spacing. Samples were obtained in a 15 x 15-ft. area at each grid intersection. Plant samples consisted of petioles of the fourth leaf from the top of 15 plants. Each soil sample was a composite of 10 to 15 cores (0-6 inch depth) collected from bed tops.

Yield was measured with a prototype weighing monitor/global positioning system (GPS) mounted on one of the grower's mechanical harvesters which straddles a single row of tomatoes. Spacing between adjacent yield points in the final data set ranged from 10 to 40 feet in the direction of travel. Yield data were converted to a 30 x 30-ft. grid using inverse distance squared weighting of the nearest 12 neighboring data points. All data were entered in ArcView geographic information system (GIS) software.

Mean fruit yields of the two fields were 35.3 ton/acre (Field 1) and 26.9 ton/acre (Field 2). Even though average fruit yields of the two fields were quite different, yield distributions were similar. The least productive 25 percent of the total area in each field yielded 71 to 75 percent of the field average and only 55 to 57 percent of the most productive 25 percent of the total area.

Both fields were harvested with more than one machine. There was more complete coverage by the harvester with the yield monitor in Field 2, allowing examination of yield spatial pattern in greater detail. Yields (**Figure 1**) were lowest in areas of the field with slowly permeable Capay silty clay soil located mainly in the northern half of the field and corresponding to the areas shown in **Figure 2** with lower sand content. Yields were generally higher in the better drained silt loams and loams in the southern half of the field. However, yield in the coarsest-textured southwest corner of the field was relatively low, probably due to under-irrigation.

Such irrigation-induced variability is difficult to avoid in gravity-irrigated systems. If the irrigator had used a longer "set" (i.e., left the water on longer) to accommodate the coarsest-textured soil, the crop would undoubtedly have suffered from prolonged saturated conditions in the areas of the field having finer-textured, less permeable soils. Some possible "precision ag" solutions to this would be (1) apply one or more extra irrigations to the portion of the field with coarser-textured soils, (2) convert the whole field to trickle irrigation, or (3) change to more closely spaced furrows and irrigate on a skip-furrow basis in the poorer-drained areas. Trickle irrigation systems are expensive to install and maintain and have not worked well on the heavy "cracking clay" soils on this farm, and the other two solutions involve unknown, but likely significant, labor and management costs.

In Field 1, soil test P levels were well above the critical level for tomatoes of 15 parts per million (ppm) sodium bicarbonate extractable. In contrast, in Field 2, both plant tissue and soil analysis indicate that the grower's knifed application of 100 lb P_2O_5/A in the fall seven months prior to transplanting of the tomatoes was not effective. Petiole phosphate at early- to mid-bloom in Field 2 ranged from very low to adequate and was related to yields (**Figure 3**). Soil available P of samples collected the previous year (during the wheat crop) was not as well correlated with tomato yield (**Table 1**). However, the mean value (7.7 ppm, sodium bicarbonate extractable) was well below the acceptable level for optimum yield. Both yield and petiole phosphate were related to soil texture (**Table 1**). Therefore, it is uncertain whether the direct cause of low yield was low soil P, or inadequate P uptake due to poor root development in areas with fine-textured soil where the crop was subjected to prolonged saturation.

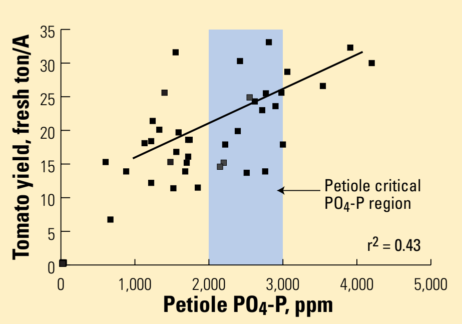

Figure 3. Tomato petiole phosphate level at early bloom vs. fruit yield in Field 2. Fertilizer P (100 lb P_2O_5/A) was knifed into beds in the fall seven months before tomatoes were transplanted in April 1997.

Summary

Tomato yield varied greatly within fields of 78 and 106 acres. Yield spatial patterns suggest the influence both of soil texture and cultural practices. In one field, inadequate P nutrition reduced yield, especially in areas of the field with heavy soil texture. Knifed P fertilizer applied seven months prior to planting apparently was not effective in supplying P to plants. A pop-up P application at planting time would likely be more effective.

In the same field, yield was also reduced in an area of coarse soil texture. The grower practice of optimizing irrigation timing for the finer-textured areas of the field likely resulted in under-irrigating the crop in the coarser-textured areas. Modifications to the furrow irrigation system design and operation are possible, though cost and manageability limitations must be addressed. BC

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TABLE 1. Relationship between tomato fruit yield and soil and plant characteristics in Field 2. Data collected from 79 grid points on a 200 x 200-ft. spacing.

	Yield	Midbloom petiole PO_4
	r	
Midbloom petiole PO_4	0.66	–
Late bloom petiole PO_4	NS	NS
Mid-bloom petiole NO_3	NS	0.53
Sand content	0.43	0.56
Clay content	-0.55	-0.65
Soil P[1]	0.49	0.41
Soil organic matter	NS	NS
Soil pH	NS	NS

r = coefficient of correlation. All significant at 1% level except where NS appears.
[1]sodium bicarbonate extractable