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IMPORTANCE OF WATER CONTROL FOR TOMATO PRODUCTION USING THE GRADIENT MULCH SYSTEM[1]

C. M. Geraldson
University of Florida, IFAS,
Agricultural Research & Education Center,
5007 - 60 Street East, Bradenton, FL 33508

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Abstract. **Limited field observations along with an understanding of the gradient-mulch system supports the concept that moisture—both level and control—could be a primary limiting factor in the functional efficiency of the system. Within a commercial tomato field, moisture gradient variations were associated with yields from 24 to 42 lbs/plant. The % moisture contained in the 0-2, 2-4, and 4-8 inch depths of the soil bed at Site A was 7.5, 10.5, and 14.8, respectively. Levels at Site B were 9.9, 12.2, and 18.3, and at Site C were 10.8, 12.9, and 19.0. Yields at Site B were 42 lbs/plant, 24.2 at Site A, and 31.6 at Site C. After rains, Site C tended to retain an excess of moisture whereas Sites A and B were relatively stable. The 42 lbs/plant or 1,960 30-lb units/acre reflects an intensity of production that is associated with the best in water use efficiency, as well as production efficiency.**

Concept

The gradient-mulch system has been presented as a sophisticated gathering of technology which can be used to increase production (2, 3, 4, 5). Most tomato growers in Florida now use a full bed mulch and average yields have increased about 60% to a level of 800 marketable units/acre (1). However, it is possible to attain yield levels of 2000/acre by exploiting the full potential of the concept (5). In order to identify limiting factors, the gradient-mulch system should be evaluated with relevance to the integration of the functional components.

Gradient-Mulch System

The system is designed to provide a minimal stress root environment, stabilized as such for the entire growing season. This is accomplished by placing a reservoir of nutrients at the soil bed surface with a constant water table serving as a moisture reservoir and covering with a full bed mulch (Fig. 1).

(A) *Nutrient gradient*: By this procedure it is possible to establish a range of concentrations decreasing gradientwise with distance from the surface source (3, 4, 5). The balance of ions contained in these gradients is altered by equilibration with both soluble and insoluble ions in the soil. The composition of the gradient is relevant to the composition of the applied fertilizer as well as the ionic components in the soil. Gradient steepness tends to be maintained by the upward movement of moisture. A variance in moisture movement can alter stability of the gradient.

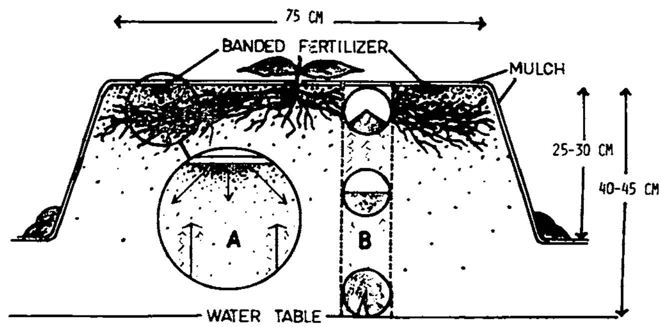

Fig. 1. Gradient-mulch system, minimal stress root environment. A. Nutrient gradient (3-dimensional). 1. Salts diffuse outward from level of highest concentration. 2. Salts move upward with moisture. B. Moisture-air gradient (2-dimensional). 1. Moisture movement upward.

(B) *Moisture gradient*: Moisture seeps upward from the water table providing a moisture/air ratio which increases gradientwise with depth. Moistures range from saturation (28-30%) in the subsoil to a minimal at the surface. A measure of the % moisture in the top 2 inches of the soil bed has been found to vary from 5 to 15% in research plots as well as growers' fields or portions thereof. Evaluation of such variations with regard to crop response has been rather broad and, for the most part, limited. Fluctuation of the water table during the growing season might change the direction of water movement through the soil profile and thus alter the composition of both the nutrient and moisture gradients.

(C) *Root environment*: Roots will develop in that portion of the soil bed where the most favorable increments (rootwise) of both gradients coincide.

Functional Design Concept

Nutrients removed by the root from the root environment are replaced by diffusion from the soil surface or by equilibration with ions distributed throughout the soil (3, 4, 5). Moisture similarly moves from the water table to replace that removed by the roots. When the system is functioning normally the root can obtain nutrients and moisture from one portion of the soil without significantly altering the composition of the soil solution (3, 4, 5). Thus, this design provides functional stability, theoretically, for the entire season.

The key to root environment stability is the constant water table. In Florida with periodic rains, a constant water

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table is often difficult to maintain. Fluctuations are not only associated with rains, but also drainage and irrigation management.

Observations Relevant to Soil Moisture Changes

In early studies (2) it was established that a water table 16 to 18 inches below the soil bed surface was satisfactory for production systems using a full bed mulch. This close-row system, 4.5 ft between rows, 7 rows/land, provided 7,360 linear ft/acre. Rows were 400 ft long with a slope of 4 inches/100 ft. This degree of slope is considered relatively steep, but does favor good drainage. Distance to the water table in combination with the soil type, degree of compaction, length of row, field slope and the row spacing are relevant factors affecting water control.

Over a period of time it has been observed that some commercial fields or portions thereof are associated with yields that range 2 to 3 times more than the average (800 marketable units/acre (1)). It was decided to obtain some measures of the moisture levels and the associated yields in a grower's field (Hunsader Brothers, Manatee County) where the components have been selectively integrated to take full advantage of the gradient-mulch system (Fig. 1). A precise field level was basic in providing a water furrow with a constant slope that was 17 inches below the soil bed surface. Rows for the most part were 1200 ft long with a desired slope of 1 inch/100 ft. This was a wide row culture with a ditch between each row and 12.5 ft row spacing. The wide row culture is used in varying degrees, especially by growers in the Manatee-Ruskin area, to provide better water control and improve production efficiency (5). This cultural procedure provided 3,400 linear ft/acre with a plant population of 1400/acre. Three areas within the field were selected by the grower for comparison: Site A on the dry side where the soil contained minimal organic matter; Site B as adequate; and Site C on the wet side where the field slope was slightly negative. Fertilizer was applied as a standard procedure to provide an optimal nutrient gradient (1400 lbs 18-0-25/acre or 38 lbs banded/100 linear ft + 475 lbs 2-18-4 broadcast). Irrigation was applied as a constant water table and shut off only when at rained. Soil samples were obtained 4 times (3/2, 4/10, 5/12, and 5/28) during the growing season at 3 depths and 2 locations in the soil bed. The moisture % in these samples was used to determine the moisture gradients. Results presented in Tables 1 and 2 indicate that a measured level of moisture can be associated with a substantial variance in yield.

Observations and Discussion

Before rains on 5/9, Sites B and C from visual appearances were equivalent, with large full bushes that grew above the stakes. Site A plants were smaller and never did reach the top of the stakes. Before any rain, moisture gradients at Sites B and C were relatively equivalent and stable (Table 1). At Site A the moisture gradient was stable but during the entire season contained a lower level of moisture. After the 2 inch rain on 5/9, the irrigation water was turned off for approximately 24 hours. All plots indicated above normal moisture (normal 4/10) levels on May 12—a fluctuation in the moisture gradient that varied with the site. Site C_1 tended to retain an excess of water indicated by the high levels of moisture and wilting. Compared to Site B, portions of the soil bed at Site C contained higher levels of moisture—probably due to a drainage lag. Tomato plants at Site C did not wilt, but yields were 31.5 lbs/plant compared to 42 from Site B (Table 2). Moisture levels were lowest at Site A with a yield of 27.2 lbs/plant. These comparisons serve to indicate the magnitude of effect on yield that can be associated with moisture variations. They must also serve as a guide to further research. With 42 lbs/plant or 1,960 30-lb units/acre, the composition of the root environment at Site B could serve as a guide in a search for the optimal. The total results indicate that a water level just under an excess could favor the highest yield levels. In order to achieve this balance, a highly efficient system of water control must be maintained.

Table 1. Percent moisture content in 6 fractions of the soil bed at 3 different sites sampled 4/20 and 5/12 during the 1980 growing season.

		Fertilizer band			Plant row		
		Soil depth			Soil depth		
Date	Depth	0-2	2-4	4-8	0-2	2-4	4-8
4/10[z]	A Dry	7.2	9.1	15.9	7.8	11.9	13.9
	B Opt	9.6	12.1	20.4	10.2	12.3	16.1
	C Wet	11.0	12.7	20.1	10.5	13.0	16.8
5/12[y]	A Dry	7.7	10.8	17.1	11.9	14.2	16.9
	B Opt	8.4	13.1	21.4	14.7	17.9	21.6
	C Wet	13.9	18.5	23.3	15.3	20.2	23.1
	C_1 Wettest	18.2	23.5	25.6	17.9	23.7	26.2

[z]Normal when the moisture was supplied by seepage from a constant water table.
[y]A 2″ rain occurred on 5/9/80.

Table 2. Tomato production (3 harvests) from plots located in those areas of moisture variation indicated in Table 1.

	I[z]	II	III	Total		
	lbs/plant	lbs/plant	lbs/plant	lbs/plant	lbs/fruit	units/A[y]
A (Duke)[x]	11.03	10.84	2.28	24.15	0.34	1127
B (Duke)	17.77	13.71	10.30	41.78	0.34	1950
B (Tempo)	16.11	15.32	10.75	42.18	0.33	1968
C (Tempo)	12.99	16.99	1.57	31.55	0.31	1472
C_1 (Tempo)	13.75	3.88	—	17.63	0.30	823

[z]The first 3 plots (24′ — 10 plants/plot) were harvested on 5/6, 5/19, and 6/2, the last 3 on 5/12, 5/27, and 6/5. A 2.0″ rain occurred on 5/9 and a 3″ rain on 5/26.
[y]Yields (30 lbs/unit) were calculated for a wide row culture (3400 linear feet and 1400 plants/A).
[x]Variety.

These limited field observations, along with an understanding of the gradient-mulch system, supports the concept that moisture—both level and control—could be a primary limiting factor in the functional efficiency of the system.

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