Table 7. Evaluation of effect of paper treated with herbicide and/or fungicide on soil salt residues following the paper mulch experiment (1974).

Paper	40 lb	25541a[z]
	60 lb	32860b
Herbicide	No herbicide	23100b
	Herbicide 1	20672b
	Herbicide 2	14629a
Fungicide	No fungicide	23539a
	Fungicide	34862b

[z]Statistically significant at 5% level

(40 lb) paper. This was expected due to less water movement through the 60 lb paper. The addition of herbicide 2 resulted in a lower concentration of salts which indicates that something in the herbicide formulation made the paper more porous. The addition of fungicide (Table 7) made the paper less permeable to water. Thus, the addition of a fungicide which resulted in an improvement in water repellency and durability of the paper as indicated by greater salt retention (Table 6), may be the most important information obtained.

Literature Cited

1. Clarkson, V. A., and W. A. Frazier. 1957. Effect of paper and polythylene mulches and plastic caps on cantaloupe yields and earliness. *Proc. Amer. Soc. Hort. Sci.* 69:400-404.
2. Everett, P. H., H. H. Bryan, and N. C. Hayslip. 1972. Growing fresh market tomatoes for machine harvest. *Proc. Fla. State Hort. Soc.* 85:152-156.
3. Geraldson, C. M. 1962. Growing tomatoes and cucumber with high analysis fertilizer and plastic mulch. *Proc. Fla. State Hort. Soc.* 75:253-260.
4. ————. 1963. Quality and balance of nutrients required for best yield and quality of tomatoes. *Proc. Fla. State Hort. Soc.* 76:153-158.
5. Hutchins, A. E. 1933. Mulch papers in vegetable production. *Minn. Agr. Exp. Sta. Bul.* 298.
6. Jones, J. P., A. J. Overman, and C. M. Geraldson. 1972. The effect of mulching on the efficacy of DD-MENCS for the control of Fusarium wilt of tomato. *Plant Dis. Reptr.* 56(11):953-956.
7. Magruder, R. 1930. Paper mulch for the vegetable garden. *Ohio Agr. Exp. Sta. Bull.* 447.
8. Savage, C. G., and G. B. Barnett. 1934. Paper mulch for pineapple. *Agr. Gaz. N. S. W.* 45:335-336.
9. Smith, A. 1931. Effect of paper mulches on soil temperature, soil moisture, and yields of certain crops. *Hilgardia* 6(6).
10. Thompson, B. D. 1959. Response of strawberries to mulching with plastic. *Proc. Fla. State Hort. Soc.* 72:179-185.
11. Thompson, H. C., and Hans Platenius. 1931. Results of paper mulch experiments with vegetable crops. *Proc. Amer. Soc. Hort. Sci.* 28:305-309.

EVALUATION OF TOMATO PRODUCTION EFFICIENCY WITH RELEVANCE TO CONTRIBUTING COMPONENTS[1]

C. M. Geraldson

IFAS, Agricultural Research and Education Center
Bradenton

Abstract. **During the decade preceding 1973, tomato production efficiency in Florida had deteriorated to the degree that 58% of the tomatoes supplied to the U. S. markets in 1972-73 were imported from Mexico. During the next 2 seasons this deterioration was reversed and Mexico in 1974-75 supplied only 40% of the market. A major factor in this reversal has been the decrease in unit production costs which in turn has been due to greatly increased yields. Average production in Florida had reached a plateau of 500 marketable units per acre during the decade preceding 1973. The average increased to 650 during the 1973-74 season and 800 during 1974-75. These production increases were primarily associated with the use of a gradient-mulch system which provides a minimal stress root environment and a maximum production potential. During this past season more than 80% of all the tomato production area (50% in 1973-74) in Florida had been converted to this system.**

Florida tomato production (state average) fluctuated around 500 marketable units (30 pounds) per acre during the decade ending with the 1972-73 season (12). During the next 2 years (1973-75) production increased markedly to 800 units and that increase was equivalent in quantity to that attained during the previous 50 years. Production and yield increases will be evaluated and discussed with regard to the relevance of contributing components.

[1]Florida Agricultural Experiment Stations Journal Series No. 7087.

Historic Background

Fifty years ago about 200 marketable units per acre was the average tomato yield in Florida (12). From 1955 to 1963, production per acre increased about 50% (340 to 500 marketable units) (4, 12). This could be associated with the rise of the vine ripe industry and concurrent use of improved varieties and improved cultural procedures (6, 12). Although vine ripe tomato yields were generally larger, unit production costs were equivalent to or larger (Table 1) than those associated with other cultural procedures, primarily because production of vine ripe tomatoes requires a large labor input. Mexico, with a supply of comparatively low cost labor, could produce vine ripe tomatoes more efficiently and during the 1960's increased production and exports to the U. S. Florida's competitive position continued to deteriorate as labor costs continued to increase. Florida growers were understandably concerned and many discussions, proposals and devices were initiated by the Florida industry. An emphasis was placed on production, harvesting and packing procedures that might reduce the labor requirements. A special research effort was directed toward machine harvest (5). Packing house mechanization with an emphasis on bulk handling was also stressed, utilizing procedures that were compatible with mature green harvested tomatoes. The variety 'Walter' (13) could be grown at wider spacing with minimal pruning and could be harvested in a mature green stage. The use of ethylene gas for uniform ripening in turn favored mature green harvest. Although labor requirement was reduced, unit production costs continued to increase and by 1972-73, 58% (compared to 30% in 1962-63) of the tomatoes supplied to the U. S. markets (Nov.-June) were imported from Mexico (10, 14).

Recent Changes

In the past 2 years (1973-75) Florida's competitive position with Mexico has been reversed. During the 1974-75 season Mexican exports supplied only 40% of the U. S. markets (8). It is most significant that, even with increased costs of labor, fertilizers, energy and other components, the unit production costs have decreased while Mexico's have continued to increase. One large grower in Mexico has stated that he must receive $4.75 per marketable unit at Nogales (production, harvesting and packing house costs plus movement to Nogales). Current and comparable Florida costs would average less than $4.00 (Table 2) and at the higher production levels would approach $3.00. Thus, *the emphasis* is on the combination of components used to attain the decrease in unit production costs.

Two major changes in production procedures have occurred during the past 2 years which were associated with an overall 60% yield increase; from 500 marketable units/acre in 1972-73 to 650 in 1973-74 to 800 in 1974-75 (8). First there was a 33% decrease in acreage, most all of which was ground culture. Staked culture increased from 17,000 to 18,000 acres while ground culture decreased from 28,000 to 12,000. A proportionate shift to stake culture in itself would increase the overall acre yields. In order to estimate the magni-

Table 1. Comparative average yield and production costs for ground and staked tomatoes in Florida (1, 2).

	Yield/A (30 lb units)			Cost Dollars/30 lb unit		
	67-72	72-73	73-74	67-72	72-73	73-74
Ground						
Dade	335	303	530	1.67	1.95	1.87
Ft. Pierce	296	301	384	2.11	2.32	1.85
Immokalee	311	311	-	1.85	2.72	-
Staked						
East Coast[z]	967	729	978	2.32	2.63	2.53
Immokalee*	680	850	955	2.23	2.24	2.18
Manatee-Ruskin	555	625	782	1.61	1.93	1.71

[z] Vine ripe production was concentrated in these areas.

Table 2. Per unit cost of production, picking and packing staked or ground tomatoes at 3 yield levels.

	Marketable Units (30 pounds)		
Staked	500	1000	1500
Costs[z] Ground	250	500	750
Production[z]	\$2.00	\$1.00	\$0.67
Picking	0.50	0.50	0.50
Packing	1.55	1.55	1.55
Total	4.05	3.05	2.72

[z]Production costs of \$1000 for staked and \$500 for ground cultures were arbitrarily used to calculate the per unit production costs. Picking and packing costs were taken from the report by Levins and Geraldson (8).

tude of this increase, average yields for ground and staked culture (Table 1, 1972-73) were projected onto the acreage for 1974-75. Such a calculation indicates an overall average yield of about 550 marketable units per acre or a 10% yield increase/acre due to the proportionate decrease in ground culture.

Second was the shift to the gradient-mulch system of production; approximately 50% of the acreage in 1973-74 and 80% in 1974-75 was devoted to this system. It should also be noted that the weather has also been favorable the past 2 years but similar to many other past seasons. The conclusion is that a major portion of the increased production can be correlated with the conversion to the gradient-mulch concept. This conclusion is based on research results, grower acceptance, and production statistics (3, 6, 7, 8, 10, 11).

Economic Considerations

An economic study of the gradient-mulch system in Manatee County (9) indicated production costs of approximately \$1,000 per acre. Many growers approach and some surpass yields of 1000 marketable units (30 lb) which can be calculated as a production cost of \$1.00 per unit. Production, picking and packing costs are indicated for 3 yield levels in Table 2. It should be noted that production costs/unit decrease as yields increase, while picking and packing costs/unit remain static. In order to maintain a system in which there is an increasing production efficiency, components must be evaluated on the basis that the value of the associated production increase exceeds the cost. For example, greenhouses as a production component for tomatoes in south Florida cannot be justified. In most seasons the return per dollar invested greatly favors the field grown tomato. Consider that the cost of hand harvesting could be reduced to some degree from \$0.50 per unit by machine harvesting. However, machine harvesting cannot be justified because a once-over harvest limits production compared to multiple hand harvests. This in turn means a higher unit cost of production and might be estimated to range upward from \$2.00. Competitive advantage is relevant to the lowest cost per marketable unit. The competitive advantage Florida has attained would probably be destroyed by use of such a component as a once-over machine harvest. The advantages can be further illustrated by calculating the return per dollar invested (Table 3). The magnitude of increasing return at high levels of production greatly minimizes the cost of components that do have a positive contribution in sustaining or increasing those yield levels.

Table 3. Calculated return per dollar invested for 3 levels of production and 3 levels of return.

Return Dollars/ Unit	Marketable Units (30 pounds)		
	500	1000	1500
5	+0.38[z]	+1.30	+1.95
4	-0.01	+0.63	+1.09
3	-0.42	-0.03	+0.25

[z]Calculations:

Return: 500 marketable units at \$3.45 (5.00-1.55) = \$1725

Cost: 500 marketable units at \$2.50 = - 1250

Profit: + 475

Return/dollar invested (475/1250) = + 0.38

Note: Packinghouse costs were considered as non-invested dollars.

Integration of Components

Any biological production system includes cultural procedures to grow a crop which provides a variable quantity of a marketable product which in turn favors a reciprocal variable unit production cost.

In the gradient-mulch system of production, the function of the mulch is to maintain the established root environment. With a protected root environment, the major production components can be integrated into a system that provides minimal stress. With precise application of the gradient-mulch system (7), a minimal stress root environment is provided for the crop during the entire growing season. This includes a concentrated source of nutrients and a constant water table. Trickle irrigation has been used where a controlled water table is not available. Production in the Homestead area has increased greatly with an integration of a different combination of components projected onto the Rockland soil (3). Mulch is basic to the system but the success and maximum potential are dependent on the integration of components into a minimal stress system. Furthermore, the success and maximum potential of the system cannot occur without contributing components that support the basic minimal stress concept. Use of plug mix and containerized seedlings has resulted in improved stands and better, more uniform plantings. Production is proportional to the degree of success of any pest control program (disease, insects, weeds). Fumigation is becoming increasingly more essential as a pest control component. The variety Walter is especially adapted to a system that involves minimal labor requirement. Walter also has resistance to Fusarium wilt (race 2). For any given combination of components the cost of each component or of the total system when calculated per marketable unit, decreases as the maximum production potential is approached. As indicated in Table 2, unit production costs at the 500 yield level are 3 times that at the 1500 level. At the 1500 level the added cost of fumigation might be about 10 cents per unit. Considering the potential return (Table 3) with a 4 or 5 dollar market and the potential benefit favoring maximum production, fumigation is highly justified if an advantage does exist and good insurance if there is any doubt. Similarly, a few more pennies/unit to insure adequate nutrients is much more desirable than decreased production because of a lack of nutrients. The emphasis should be on combinations of components that maintain the high production levels which in turn favors an approach to maximum production efficiency.

By decreasing unit production costs Florida growers have assumed a much more favorable position in the national tomato market. Successful competition is a barometer of efficiency. It is unfortunate that economic pressures have favored a decreased vine ripe production because superior quality remains a desirable end product, both for the consumer and the industry. It is possible that vine ripe quality could be integrated with the gradient-mulch system, considering that an even higher level production—low unit cost concept might help cover the increased costs of handling vine ripe tomatoes.

The magnitude of potential economic advantage of production levels of 3000-4000 marketable units per acre can be estimated by projecting these levels onto Tables 2 and 3. Because optimal production provides incentive, more growers with smaller acreages, utilizing indeterminate varieties, with vine ripe harvest and integrated with the basic concepts of the gradient-mulch system deserves consideration.

Literature Cited

1. Brooke, D. L. 1974. Costs and returns from vegetable crops in Florida, Season 1972-73, with comparisons. *Econ. report* 59.
2. ————. 1975. Costs and returns from vegetable crops in Florida, Season 1973-74, with comparisons. *Econ. Information Report* 22.
3. Bryan, H. H. 1974. Yield response of tomatoes and second cropped butternut squash to Fertilizer rate and placement under plastic mulch on Rockdale soil. *Proc. Fla. State Hort. Soc.* 87:159-164.
4. Conner, Doyle. 1974. Florida Agriculture Statistics—vegetable Summary 1974. *Florida Crop and Livestock Reporting Service.*
5. Everett, P. H., H. H. Bryan and N. C. Hayslip. 1972. Growing fresh market tomatoes for machine harvest. *Proc. Fla. State Hort. Soc.* 85:152-156.
6. Geraldson, C. M. 1962. Growing tomatoes and cucumbers with high analysis fertilizer and plastic mulch. *Fla. State Hort. Soc. Proc.* 75:253-260.
7. ————. 1970. Precision nutrient gradients—a component for optimal production. *Soil Sci. and Plant Analysis* 1(6):317-331.
8. Hawkins, W. 1975. Florida Tomato Committee Annual Report.
9. Levins, R. A. and C. M. Geraldson. 1974. Production costs for Manatee-Ruskin staked tomatoes. *Research Report* AREC-GC1974-10.
10. Peters, J. S. 1974. Florida Tomato Committee Annual Report.
11. Pierce, J. B. (Editor). 1975. Agricultural Growth in an Urban Age. IFAS, University of Florida, p. 57.
12. Rose, C. Norman. 1973. Tomato production in Florida. An historic data series. *Econ. Rept.* 68, p. 5.
13. Strobel, J. W., N. C. Hayslip, D. S. Burgis and P. H. Everett. 1969. Walter. IFAS Circular S202. Univ. of Florida, Gainesville.
14. Upchurch, M. L. 1969. Supplying U. S. markets with fresh winter produce. *Agri. Econ. Rept. No. 154 USDA.*