subdivision of the TR_2 substage might enhance plant description for pest management practitioners.

The principal application of the proposed system of phenology is to aid in the assessment of pest populations as they relate to specific crop stages. For instance, using data from Keulart's (4) study of tomato defoliation, 20% defoliation of lower plant leaves at stages equivalent to TV_1 through TV_2 did not alter mean yield per plant. Twenty percent defoliation of upper plant leaves at a stage equivalent to TR_2 caused yield reduction. This nomenclature can apply to single 'Flora Dade' plants or to entire crops. Further testing is needed to determine if it can be applied readily to other cultivars and in other geographical regions.

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Semi-mechanically Harvested Fresh-market Tomato Yields as Influenced by Harvest Date and Cultivar

Peter J. Stoffella[1]

Agricultural Research and Education Center, IFAS, University of Florida, P.O. Box 248, Fort Pierce, FL 33454

Mark Sherman[2]

Vegetable Crops Department, IFAS, University of Florida, Gainesville, FL 32611

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Abstract. **Three jointless tomato (*Lycopersicon esculentum* Mill.) cultivars, 'MH-1', 'Hayslip', and 'Burgis', were evaluated for fruit yields using a semi-mechanical fresh-market tomato harvester. Harvest dates were 85 or 99 days after transplanting in Fall 1980, and 88 or 95 days after transplanting in Fall 1982. Total fruit yields of the late harvest were significantly higher than the early harvest in 1982, but not in 1980. An increased percentage yield (weight basis) of colored fruit occurred during the late harvest in both trials. 'Burgis' and 'Hayslip' had significantly higher green fruit yields and lower ripe fruit yields than 'MH-1' in both years. Yields of semi-mechanically harvested fruit were reduced by an average of 25% and 47% when compared with manually harvested fruit yields during 1980 and 1982, respectively.**

Nearly all of Florida's fresh-market tomatoes are harvested by hand. Seasonal labor for manual harvesting will undoubtedly increase the cost of fresh-market tomato production. In past years, growers have directed their interest primarily toward mechanical harvesting of mature-green tomatoes. Mechanical harvesting was reported to reduce energy requirements by 45% per acre and 58% per pound of tomato when compared to manual harvesting (5). Florida's projected share of U.S. winter fresh-market tomato production will increase from 49% in 1979 to 51% in 1985 (10). The likelihood of an increasingly competitive market may force growers to consider mechanical harvesting to reduce production costs.

In an attempt to improve the yield and quality of machine-harvested tomatoes, a modified semi-mechanical harvester was designed and tested (8). The purpose of this investigation was to evaluate semi-mechanically harvested fruit yields of 3 tomato cultivars at 2 harvesting dates. Yields obtained from semi-mechanically harvested plots were compared to those obtained from manually harvested plots of unstaked tomatoes grown with standard, full-bed, plastic mulch (6).

Three jointless tomato cultivars, 'MH-1' (4), 'Burgis' (2), and 'Hayslip' (1) were grown during the fall seasons of 1980 and 1982 at the Agricultural Research and Education Center, Fort Pierce, Fla. Dolomitic limestone (2.24 MT/ha) was preplant incorporated into an Oldsmar fine sand. Raised beds, 109 cm wide, were spaced at 2.1 m on center. A 4N–7P–3.3K fertilizer at 1570 kg/ha was preplant incorporated into the beds. An additional application of 8N–5.2P–16.6K fertilizer at 2350 kg/ha was banded under a 25-cm, black plastic strip offset from the center of each bed. The strip-mulch technique (7) was used to decrease fertilizer leaching, since heavy rainfalls occur frequently during the growing seasons.

Tomato seedlings were transplanted 61 cm apart in the center of each bed on 8 Oct. 1980 and 13 Sept. 1982. Each plot was 15.2 m in length. Pest control and cultural practices conformed with production recommendations for the Fort Pierce area. The Institute of Food and Agricultural Sciences (IFAS) semi-mechanical harvester was used 85 or 99 days after transplanting during 1980 and 88 or 95 days after transplanting during 1982. Prior to harvesting, plants were undercut using a rotating square bar attached to a tool bar. Conveyer belts of the harvester elevated the plants to a platform where 2 persons manually shook fruit from the plants into a chlorinated water tank. Fruits from the tank were conveyed to a 6-person sorting crew. The sorting crew removed culls and separated green fruit from those showing red color (breakers and above). Culls included fruit less than 54 mm in diameter, severely misshapen, or otherwise damaged fruits.

Fruits from the green group were weighed after removal from the harvester, and fruits with color were separated further into "turning" and "ripe" fruits, counted, and weighed. The "turning" classification includes USDA color classifications 2, 3, and 4 (9). The "ripe" classification includes USDA color stages 5 and 6. Mean fruit weight (g/fruit) was determined by dividing the total weight of the fruit with color by the number of fruits with color for each plot. Both experiments were arranged in a randomized complete block with 3 replications. Analysis of variance was performed on all collected data by the Sta-

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[1]Assistant Professor, Vegetable Crops.

[2]Assistant Professor, Extension Vegetable Specialist.

Table 1. Main effects of cultivars and harvest date on marketable tomato fruit yields when harvested with the IFAS semi-mechanical fresh-market harvester.

	Fall 1980					Fall 1982				
	Marketable fruit yield (MT/ha)					Marketable fruit yield (MT/ha)				
Main effects	Green	Turning[z]	Ripe[z]	Total	Fruit[y] wt (g/fruit)	Green	Turning[z]	Ripe[z]	Total	Fruit[y] wt (g/fruit)
Cultivars (C)										
Burgis	28.2 a[x]	13.7 a	4.7 b	46.6 a	150 a	10.2 b	9.9 a	8.5 b	28.1	150 a
Hayslip	29.3 a	7.2 b	2.5 c	39.0 b	160 a	15.0 a	8.9 a	6.8 b	30.6	160 a
MH-1	16.2 b	12.4 a	6.8 a	35.4 b	123 b	5.5 c	7.1 b	15.5 a	28.0	137 b
Harvest date (HD)										
Early	31.9	5.4	1.2	38.5	141	11.7	10.2	5.1	27.1	150
Late	17.3	16.8	8.1	42.2	145	8.8	6.9	15.3	31.1	148
	**[w]	**	**	NS	NS	**	**	**	*	NS
Interaction										
C × HD	NS	*	**	NS	NS	NS	**	NS	NS	NS

[z]Turning classification includes USDA color classes 2, 3, and 4. Ripe classification includes USDA color classes 5 and 6.
[y]Fruit size based on turning and ripe fruit.
[x]Mean separation by Duncan's multiple range test, 5% level.
[w] Significant at 5% (*), 1% (**), or nonsignificant (NS) by F test.

tistical Analysis System (SAS), a computer software package (3).

Fruit yields for the 3 cultivars obtained from semi-mechanically harvested plots were compared to those from a manually harvested cultivar performance trial for each year. 'MH-1' was not included in the 1982 manually harvested comparisons. A full-bed, black, plastic mulch system similar to those used by Florida's commercial tomato growers was used for manually harvested plots. Fertilizer rates were identical to those of the semi-mechanical trial, but the 8N–5.2P–16.6K fertilizer was placed into 2 bands, 30 cm to each side of the center of the bed. Other cultural practices, i.e., planting dates, pest control, and plant population were identical to the semi-mechanical trials. The trials were arranged in a randomized complete block design with 4 replications. Fruit meeting USDA color classification 2 to 6 (turning to ripe) were harvested manually at weekly intervals for 4 weeks.

Semi-mechanical harvester trials. 'Burgis' and 'Hayslip' had significantly lower turning fruit yields than 'Burgis' and 'Hayslip' in 1982. 'MH-1' had a significantly higher percentage (weight basis) of turning and ripe fruit than the other cultivars (Table 2). This advantage was expected since 'MH-1' is an early-maturing cultivar when compared to 'Burgis' or 'Hayslip'. No differences in total fruit yields among cultivars occurred in 1982; however, 'Burgis' had significantly higher total fruit yields than 'Hayslip' or 'MH-1' in 1980. 'MH-1' had significantly smaller fruit than 'Hayslip' or 'Burgis' in both trials.

Table 2. Main effects of cultivars and harvest dates on yield of fruit with color (breakers and above) when harvested with the IFAS semi-mechanical fresh-market harvester.

	Percentage of total yield for fruit with color	
Main effects	Fall 1980	Fall 1982
Cultivars (C)		
Burgis	38 b[z]	64 b
Hayslip	24 c	50 c
MH-1	53 a	80 a
Harvest date (HD)		
Early	18	56
Late	59	73
	**[y]	**
Interaction		
C × HD	**	NS

[z]Mean separation by Duncan's multiple range test, 5% level.
[y]Significant at 1% (**) or nonsignificant (NS) by F test.

Sand damage due to fruit striking or rubbing against the indoor-outdoor carpet used in padding the machine was observed on all fruit regardless of cultivar; however, damage was especially severe in 1980. Most of the damage appeared to occur during the fruit separation stage. After mature-green fruit were allowed to ripen, sand damage was severe enough to detract from fruit appearance. Sand damage may be minimized by replacing the indoor-outdoor carpeting which may contact fruit during the separation stage with another padded material that does not hold sand as readily.

The late harvest date had significantly higher ripe fruit yield and lower green fruit yield than the early harvest date in both trials (Tables 1, 2). No difference in fruit size occurred between harvest dates in either trial. The late harvest date had 10% to 15% higher total fruit yield than the early harvest date during 1980 and 1982, respectively. However, a statistically significant difference occurred only in 1982. The ratio of green fruit vs. fruit with color can be altered by harvesting at different dates. An increased percentage (weight basis) of fruit with color at a late harvest, however, may result in more large fruit thereby increasing total yield.

Significant cultivar × harvest interactions occurred for turning fruit yield, ripe fruit yield, percentage of total yield for fruit with color in 1980, and turning fruit yield during 1982 (Tables 1, 2). For each significant interaction in 1980, a differential rate of response occurred between the harvest dates for 'Hayslip' as compared with the 2 harvest dates for 'MH-1' or 'Burgis'. The cultivar × harvest interaction for turning fruit yield in 1982 occcurred because 'Hayslip' had a higher turning fruit yield in the late harvest rather than the early harvest, and in contrast, 'Burgis' and 'MH-1' had higher turning fruit yields in the earlier harvest.

Comparison of manual vs. semi-mechanical harvest trials. Semimechanically harvested fruit yields were reduced by an average of 25% and 47% compared to manually harvested fruit yields during 1980 and 1982, respectively. In part, this reduction can be attributed to the difference between 1 harvest (semimechanical) and 4 harvests (manual). A 9% and 12% reduction in fruit size (g/fruit) occurred in the semi-mechanically harvested trials when compared to manually harvested trials during 1980 and 1982, respectively. The reason for this reduction is unknown but may be attributed partly to the increased fertilizer efficiency of the full-bed mulch system. Semi-mechanically harvested plots were covered only with a 25-cm mulch strip, and the remaining unmulched portion of the bed was susceptible to fertilizer leaching. Perhaps modification of the harvester to perform on a full-bed plastic mulch system would increase tomato yields and reduce incidence of sand damaged fruit.

The semimechanical harvester appears to be an alternative to hand harvesting for fresh-market tomatoes. Based on fruit color, size, and yield, 'Hayslip' and 'Burgis' appeared to be more adapted than 'MH-1' for mechanical harvest of fresh-market tomatoes.

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Physical and Chemical Characteristics of Fresh and Aged Spent Mushroom Compost

Virginia I. Lohr[1], Sherry Hsiao-lei Wang[2], and Jeffrey D. Wolt
Department of Plant and Soil Science, University of Tennessee, Knoxville, TN 37901-1071

Additional index words. waste utilization, growth medium, salinity, leaching, ammonium toxicity

Abstract. **Selected physical and chemical properties of fresh spent mushroom compost were evaluated and compared to the properties of spent mushroom compost which was aged aerobically for 6 weeks. Bulk density, total pore space, total water at saturation, and percentage air space in fresh and aged spent composts were acceptable for plant growth. Both contained very high levels of soluble salts which were readily leachable. Concentrations of metals were acceptable, but concentrations of K, Ca, and Mg could lead to plant nutrient imbalances. Concentrations of NH_4-N in fresh spent mushroom compost were high.**

Spent mushroom compost (SMC) is a by-product of the mushroom industry. Mushroom compost is an organic material made from such materials as straw, horse manure, and peat. The fungal mycelia derive their nutrition from this medium and produce the fruiting bodies which are harvested. After about 45 days of growth, when yields drop and an economical crop is no longer being produced, the material is termed "spent" and must be replaced. The SMC generally is resterilized to control mushroom diseases and insects and then is offered for sale or dumped. About 35 million cubic meters of SMC are produced in the United States each year.

Researchers investigating the uses of SMC in potting mixes have advised against using SMC as obtained from mushroom houses (9, 14, 20). These researchers have suggested that the material be aged before use, but they give little information as to why or for how long it should be aged. The use of SMC as a field soil amendment has also been investigated, but the characteristics of the material have not been reported (15, 19).

The purpose of this study was to characterize both fresh and aged SMC, and to determine the potential usefulness of SMC in soilless potting mixes and as a field soil amendment.

Three batches of SMC, consisting of decomposed straw, horse manure, peat, limestone chips, gypsum, cottonseed meal, urea, and residual fungal mycelia, were obtained immediately following resterilization by the mushroom farm. Each batch represented one replication. Samples of "fresh" SMC were collected when each batch was received, and the remaining SMC was placed in four 200-liter drums for aging. To provide aeration, holes were drilled in the bottom of each drum, and each lid was left slightly ajar. To maintain aerobic conditions, the compost was turned by spading it into another drum every 3 days. Sufficient water was added as needed to maintain moisture at about 50% of wet weight, without leaching. This aerobic aging process was continued for 6 weeks, at which time "aged" samples were collected for analysis. Throughout the aging process, samples of SMC were collected as the compost was turned.

Samples were analyzed for 2 M KCl extractable NH_4-N using distillation methods (3). Additionally, electrical conductivity (EC) and pH of saturated paste extracts were measured (4).

To determine the rate at which salts could be leached, plexiglass tubes 20 cm deep and 4 cm in diameter were covered with cheesecloth at the bottom and filled to 16 cm with evenly compacted SMC. One volume (225 ml) of deionized water was poured on each column; the water which drained through was collected. This procedure was repeated weekly for 6 weeks. EC, pH, K, Ca, and Mg were measured in the leachates. After 6 weeks, the depth of the compost was measured, and the percentage of shrinkage was calculated.

Samples of air-dried SMC were digested

Table 1. Total elemental concentrations in fresh and aged spent mushroom composts.

	mmol/kg dry weight	
Element	Fresh SMC	Aged SMC
Nitrogen	1510 ± 170[z]	1580 ± 290
Phosphorus	180 ± 25	180 ± 30
Potassium	320 ± 45	305 ± 55
Calcium	740 ± 210	895 ± 105
Magnesium	275 ± 50	460 ± 60
Aluminum	180 ± 35	215 ± 10
Iron	67 ± 17	71 ± 5
Manganese	7.5 ± 2.3	7.1 ± 0.8
Zinc	1.7 ± 0.2	2.1 ± 0.1
Molybdenum	1.0 ± 0.2	1.4 ± 0.4

[z] ± SD.

Table 2. Physical characteristics of fresh and aged spent mushroom composts.

Physical characteristic	Fresh SMC	Aged SMC
Total pore space (% by vol)	87.1	86.3
Total water at saturation (% by vol)	63.2	65.5
Air space (% by vol)	24.0	20.8
Easily available water (10–50 cm) (% by vol)	12.6	22.6*
Water buffering capacity (50–100 cm)	1.9	2.1
Bulk density (g/cm^3)	0.256	0.293*
Specific gravity	2.05	2.12

*Fresh SMC significantly different from aged at 5% level.

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[1]Present address: Dept. of Horticulture and Landscape Architecture, Washington State Univ., Pullman, WA 99164-6414.
[2]Present address: Dept. of Environmental Science and Engineering, National Chung-hsing Univ., Taichung, Taiwan R.O.C.