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High Tunnel Tomato Production

Henry G. Taber
Iowa State University, taber@iastate.edu

Bernard J. Havlovic
Iowa State University, bhavlovi@iastate.edu

Nicholas P. Howell
Iowa State University, nhowell@iastate.edu

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Abstract
High tunnels for Iowa tomato production are used for earliness rather than late-season extension beyond the fall frost period. This is probably due to price decline and lower per capita in the fall as consumers change their buying habits. Typically, transplanting in high tunnels is initiated about 4 to 5 weeks before field planting or about early-to mid-April for central Iowa. Our objective was to maintain a steady supply of fresh market tomatoes throughout the growing season by evaluating a combination of cultural practices: proper variety selection (adaptable varieties for early and main season); sequence of planting dates; and the use of high tunnels, row covers, and selective wavelength polyethylene mulches (increased soil temperature compared with black plastic).

Disciplines
Agricultural Science | Agriculture | Horticulture

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Henry G. Taber, professor
Department of Horticulture
Bernard Havlovic and Nick Howell,
farm superintendents

Introduction

High tunnels for Iowa tomato production are used for earliness rather than late-season extension beyond the fall frost period. This is probably due to price decline and lower per capita in the fall as consumers change their buying habits. Typically, transplanting in high tunnels is initiated about 4 to 5 weeks before field planting or about early- to mid-April for central Iowa. Our objective was to maintain a steady supply of fresh market tomatoes throughout the growing season by evaluating a combination of cultural practices: proper variety selection (adaptable varieties for early and main season); sequence of planting dates; and the use of high tunnels, row covers, and selective wavelength polyethylene mulches (increased soil temperature compared with black plastic).

Materials and Methods

The project was established at the Armstrong Research Farm (southwestern Iowa, in a well-drained silt loam soil) and the Horticulture Research Station (central Iowa, in a well-drained loam soil). The previous crop at Armstrong was field corn and at the Horticulture Station, sod. Both sites were fertilized according to soil test recommendations. The cultural system consisted of SRM-olive wavelength plastic mulch and trickle irrigation. Transplants were set 18-in. in-row and rows 4.5 ft on center for the high tunnels and 6-ft on center for field production. All plants were staked, tied, and pruned to the first flower cluster. Irrigation scheduling was via tensiometers. Pest management practices for field production included necessary herbicide, insecticide, and fungicide applications. High tunnel production included only two insecticide applications for cutworms and tomato hornworm control. Selected varieties and their characteristics are listed in Table 1. There were two replications of each variety at each site.

Transplant dates were: Armstrong high tunnel on April 17 and field transplant dates of May 17 and June 8; Horticulture high tunnel on April 12 and field transplant dates of May 18 and June 12.

Yield data consisted of a weekly harvest at the Horticulture Station and twice a week at the Armstrong farm with fruit sorted into marketable and culls. Culls included very small fruit and fruits with rots, radial and concentric cracks, and ripening disorders. The marketable category was graded into four sizes: extra large (>2⅞ in.), large (2⅞ to 2½ in.), medium (2½ to 2¼ in.), and small (<2¼ in.).

Results and Discussion

Sunstart variety was the first to begin production from the high tunnel planting at both sites (Table 2). Early production began six days earlier at the Armstrong Farm compared with the Horticulture Station, even though plants were set five days later, reflecting the more southern location. Also, early yield was generally higher at Armstrong and the cullage was less compared with the Horticulture station. Sunchief produced unacceptably high cullage at both sites.

There was a stark contrast between the two sites for total high tunnel season yield. Although both sites were planted at similar times and the harvest season almost identical, Armstrong had higher total and marketable yields, with some varieties >1.5 times that of the Horticulture Station (Table 3). A large part of the difference was in percentage of culls with the Horticulture Station almost three times Armstrong. The higher daytime temperatures in the tunnel, and perhaps the sod ground, led to much more non-uniform color (blotchy ripening) development at

the Horticulture Station. Temperatures >92°F will lead to considerable blotchy ripening and high temperatures ≥104°F, for three hours or more, results in blossom abortion. The Horticulture Station tunnel exceeded these values for many days. The high temperature also reduced the percentage of extra large fruit, but soil fertility levels may also have affected fruit size. Varieties that performed similarly for total yield at both locations were Sunstart and Sunshine, the two earliest varieties.

The best performing varieties at both sites were Mtn Spring, Mtn Fresh Plus, Fla91, and FL47R. At Armstrong, the indeterminate greenhouse variety Blitz performed well but fruit size was more in the large category as opposed to extra large. Blitz and Trust are greenhouse varieties that are not as well adapted to the culture of high tunnel production as early field fresh market types.

The high tunnel effect on daily maximum and minimum temperatures is illustrated in Figure 1. Early in the growing season, a high tunnel advantage lies in elevating daily temperature to hasten plant growth and development. But, as early summer approaches (June) it is critical that maximum ventilation be provided (rolling up sides and ends) to avoid extreme heat (Figure 1). Conversely, high tunnels do not provide much protection against low temperatures near freezing. The nights of April 27, May 6, and May 12 all recorded 37°F outside at the Armstrong site. The high tunnel minimum temperatures on those nights were 39, 40, and 37°F, respectively. At the Horticulture Station, the outside low temperature of 33°F was recorded May 6. The corresponding high tunnel low temperature was 34.5°F. Also note that throughout the early season the minimum air temperature in the high tunnel was close to outside minimum air temperature.

Field plantings were established with the same nine varieties in mid-May once the danger of frost passed. The field location was adjacent to the high tunnel at both sites. First harvest occurred for all varieties, except Fla91, on July 19 at Armstrong. The corresponding date for the Horticulture Station was August 3. However, Sunstart and Sunshine produced substantial fruit a week earlier, July 26. Unlike the high tunnel results, both sites produced similar total yields for most varieties (Table 4). The best performing varieties were the same as in high tunnel production–Mtn Spring, Mtn, Fresh Plus, Fla91, and FL47R. However, the Horticulture Station had almost twice the cullage as the Armstrong Farm. This may be related to more stringent sorting techniques and/or cultural practices such as lower fertility level on the Horticulture sod site.

A second field planting was established in June to maintain continuous supply—June 8 at the Armstrong Farm and June 12 at the Horticulture Station. At both locations the varieties performed similarly for total yield and equivalent to the mid-May planting over the same time period (Table 5). However, the fruit quality was lower at the Horticulture site as reflected in nearly 50% cull fruit, almost twice that of the mid-May planting. Mtn Fresh Plus also had twice the cull fruit compared with the mid-May planting at Armstrong. Frost occurred the night of September 20, terminating harvest.

To maintain uniform fruit production Sunstart and/or Mtn Fresh could be planted in a high tunnel followed by a mid-May and early-June planting of Mtn Fresh (Figure 2). If Sunstart was used in the high tunnel followed by two plantings of outdoor Mtn Fresh this would yield 26 to 35 lb/10 plants per week from July 10 to September 15, except for July 31 when only 8 lb were produced and August 14 where the two plantings overlapped and 91 lb produced. If Mtn Fresh was used for all three plantings, weekly yield would fluctuate considerably, from a high of 101 lb/10 plants on July 24 to 34 lb/10 plants on September 7.

Table 1. Tomato varieties used in high tunnel and field trials, 2006.

Variety	Days to harvest	Fruit size (oz)	Seed cost, per 1M	Comments
Sunshine	67	8	$41.00	very early, smooth fruit
Sunstart	67	8–11	41.00	First early, poor foliage cover, concentrated set for ~ 2 weeks
Sunchief	70	10	47.25	Large vine, good foliage, sunshine maturity with larger fruit size
Mtn. Spring	70	10	27.25	Standard commercial variety
Florida 91	80	10	51.25	Extra large, attractive fruit, sets well under high temps, vigorous vine
Mtn. Fresh +	72	10	25.35	Good flavor, large vine
Florida 47R	75	10–12	47.00	Main season, firm, high quality fruit
Trust	main	7–8	278.00	Standard greenhouse variety
Blitz	main	8	278.00	Newer greenhouse type, higher yield
Sun Leaper	80	7–8	25.00	Sets well under high temperatures

All are determinate growth habit, except Trust and Blitz. All are resistant to Fusarium wilt race 1 and 2, Verticillium wilt, Gray leaf spot (except Mtn. Spring, Mtn. Fresh), and Alternaria stem canker (except Mtn. Spring and Mtn. Fresh). Mtn. Fresh is also resistant to nematodes. Sun Leaper only at Horticulture Station in second outdoor planting to replace Mtn. Spring.

Table 2. Early[1] season yield (lb/10 plants) of tomatoes planted in high tunnels.[2]

	Armstrong			Hort Station		
Variety	Marketable	Total	Cull, %	Marketable	Total	Cull, %
Sunstart	19.9	23.2	14.2	13.6	16.7	18.6
Sunshine	8.8	11.3	22.1	2.3	3.2	28.1
Sunchief	1.0	2.4	58.3	1.2	1.8	33.3
Mtn. Spring	1.4	1.9	26.3	0	0	--

[1]Early equals the first two weeks of harvest.
[2]Harvest commenced June 23 at Armstrong and June 29 at the Horticulture Station. Planting date was April 17 at Armstrong and April 12 at the Horticulture Station.

Table 3. Total[1] season yield (lb/10 plants) of tomatoes planted in high tunnels.[2]

	Armstrong				Hort Station			
Variety	Mktable	Extra large[3]	Total	Cull, %	Mktable	Extra large[3]	Total	Cull, %
Sunstart	109	90.2	140	22.5	61	73.8	140	56.2
Sunshine	122	88.9	174	29.7	60	76.7	162	63.2
Sunchief	142	95.4	188	24.4	35	88.6	122	71.1
Mtn Spring	208	91.6	229	9.2	90	88.9	148	39.0
Mtn Fresh	198	93.8	221	10.6	105	92.3	160	34.5
Fla91	208	94.4	227	8.5	100	85.0	154	35.0
FL47R	224	86.0	238	8.5	85	79.4	139	38.7
Blitz	194	77.3	233	16.6	70	65.7	163	57.2
Trust	171	81.4	201	15.0	66	56.1	149	55.4

[1]Total equals eight weeks of harvest.
[2]Harvest for high tunnel ended August 14 at Armstrong and August 17 at the Horticulture Station.
[3]Extra large equals percentage of marketable fruit >2 7/8 in. diameter.

Table 4. Total[1] season yield (lb/10 plants) of tomatoes field planted.[2]

	Armstrong				Hort Station			
Variety	Mktable	Extra large[3]	Total	Cull, %	Mktable	Extra large[3]	Total	Cull, %
Sunstart	104	82.5	129	19.9	83	77.1	123	31.9
Sunshine	89	67.4	117	24.2	84	75.0	151	44.6
Sunchief	105	80.0	138	23.6	28	100.0	109	73.9
Mtn Spring	116	86.2	141	17.6	97	93.4	134	28.1
Mtn Fresh	172	78.5	192	10.5	166	81.3	212	22.2
Fla91	138	89.1	154	10.0	108	96.3	143	24.5
FL47R	133	85.0	156	14.7	89	83.1	133	33.0
Blitz	81	70.4	109	25.9	75	56.0	152	51.0
Trust	75	68.0	116	35.9	87	62.1	150	42.2

[1]Total equals seven weeks of harvest.
[2]Transplants set May 17 at Armstrong and May 18 at the Horticulture Station. Harvest began July 19 at Armstrong and July 26 at Horticulture Station.
[3]Extra large equals percentage of marketable fruit >2 7/8 in. diameter.

Table 5. Total season yield (lb/10 plants) of tomatoes field planted.[1]

	Armstrong				Hort Station			
Variety	Mktable	Extra large[2]	Total	Cull, %	Mktable	Extra large[2]	Total	Cull, %
Mtn Spring	93	67.6	108	13.9	--	--	--	--
Mtn Fresh +	94	91.8	117	20.3	66	98.5	116	43.2
Fla91	95	93.5	117	19.1	53	99.1	106	49.8
FL47R	92	80.5	111	17.7	66	96.0	131	49.8
Sun Leaper	--	--	--	--	71	95.0	130	45.4

[1]Transplants set June 8 at Armstrong and June 12 at the Horticulture Station.
[2]Extra large equals percentage of marketable fruit >2 7/8 in. diameter.

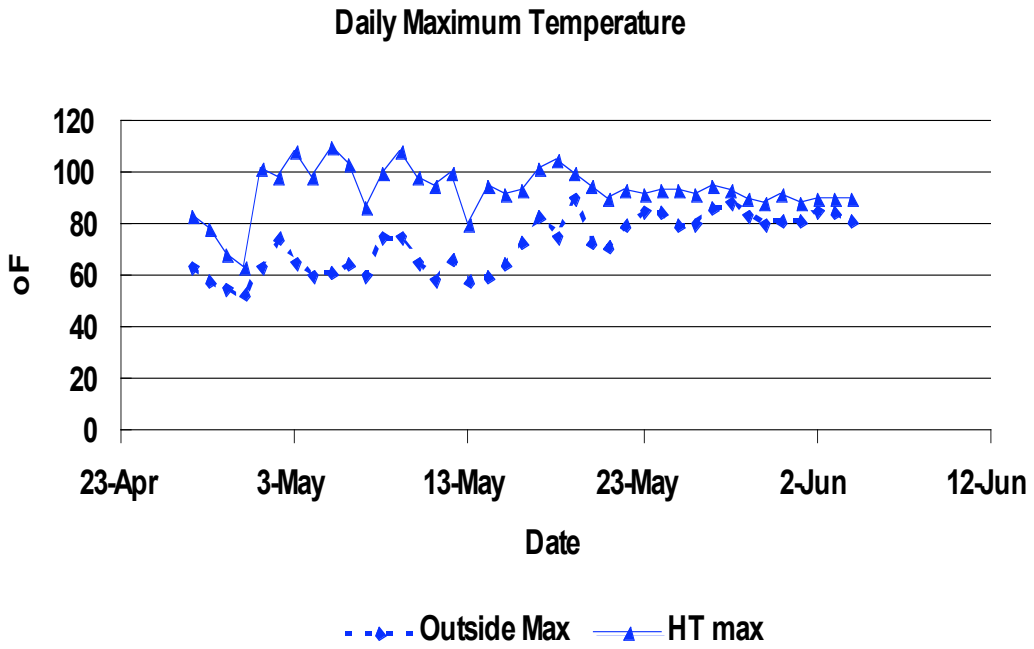

Figure 1. Comparison of outside daily high temperature to high tunnel maximum air temperature. High tunnel temperature probe located between plants at an 8-in. height above the wavelength-selective plastic mulch. Average of three locations. Armstrong Research Farm, Lewis, IA.

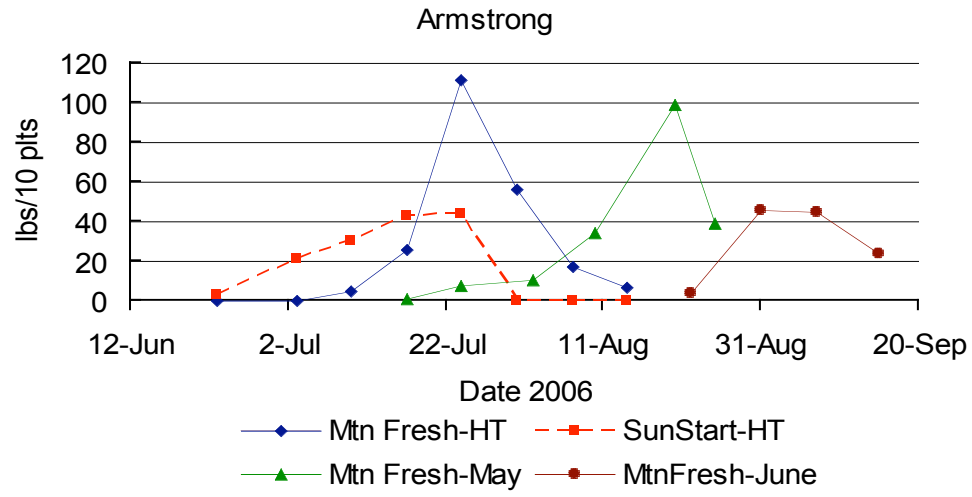

Figure 2. Weekly harvest yields from 10 plants from a planting of SunStart and Mtn Fresh in high tunnel on April 17 and field planting of Mtn Fresh on May 17 and June 8, Armstrong Research Farm.