Field Production

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Section Editor

High Tunnel Multi-Cropping: Cut Flowers and Tomato

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Significance to Industry: The purpose of this study was to evaluate the yield of 6 high value crops for high tunnel production. Tomato, zinnia, delphinium, gomphrena, sunflower, and gerbera daisy were grown in a high tunnel during the spring of 2011 in northern Mississippi. Tomato pruning or suckering severity was also trialed. Suckering may reduce vine growth and promote earlier and larger fruit (1). It has also been reported that determinate tomatoes need no pruning other than removing all suckers below the first flower cluster (2).

High tunnels can increase marketing opportunities, improve early cash flow, and yields are often higher than field-grown crops. The primary crops for high tunnel production, worldwide, in order of economic importance are tomato, sweet pepper, cucumber, muskmelon, lettuce, summer squash, and eggplant. The other major horticultural crops produced in high tunnels include small fruits, tree fruits, and cut flowers (3).

Nature of Work: During the spring of 2011 cut flowers and tomatoes were grown in northern Mississippi in a high tunnel 96 ft long x 30 ft across. The experimental design was a randomized complete block with three replications. The treatment for the cut flowers was a cultivar evaluation with number of stems, stem length, and bloom diameter measured. The treatments for the tomatoes compared yield with no pruning of suckers, pruning the suckers up to the second true leaf axils, and pruning the suckers up to the leaf axils below the first bloom.

In February of 2011 raised beds were formed in the high tunnel 6 in high and 30 in across the top with a press-pan-type bed shaper. Black plastic mulch and low flow drip irrigation tubing was applied following the bed shaper. Beds were spaced 7 ft apart, center-to-center. A soil test was done prior to bed formation, which recommended 80 lbs/ac of P and K (0-20-20) and 120 lbs/ac of N to amend the soil. Amendments for the P and K and 60 lbs/ac of N (NH_4NO_2) were applied pre-plant. The remaining N was applied when ~1 in sized fruit first appeared, by injecting greenhouse grade calcium nitrate ($CaNO_3$) through the drip tape to apply 5 lbs of N/ac/week.

The tomato cultivar ‘Applause’, a hybrid determinate plant, was seeded in the greenhouse 3 February 2011 and transplanted to the high tunnel beds 14 March 2011. Plants were planted in the beds by hand through holes made in the plastic. The 14 March 2011 planting date is a full month earlier than the recommended planting date for our location in northern Mississippi. Tomato plants were spaced 2 ft apart in the row and each replication consisted of 8 plants. A tomato stake was driven into the row between every two plants and the Florida weave trellising technique was used. The cut flowers were spaced 1 ft apart in the row and staggered on each side of the row with each replication consisting of 20 plants. The cut flowers trialed were Diamond Blue Delphiniums (*Delphinium chinensis)*, Flashing Light Gomphrena (*Gomphrena haageana)*, Futuristic Mix Gerber Daisies (*Gerbera jamesoni)i*, Pro-Cut Mix Sunflowers (*Helianthus annus)*, and 3 cultivars of Zinnias: ‘Benary Giant Scarlet’, ‘Zowie Yellow Flame’ and ‘State Fair Mix’ (*Zinnia elegans)*. The flowers were seeded in the greenhouse 14 March 2011 and transplanted by hand to the high tunnel beds 28 April 2011. Plants in the greenhouse were watered with a soluble fertilizer (Peters 20-20-20) injected at the concentration of 200 ppm twice weekly and once immediately prior to planting. Pentachloronitrobenzene (Terraclor, Uniroyal Chemical Company) was applied to the tomato transplants as a drench at transplanting for systemic fungal control. Spinosad (Spintor, Dow AgroSciences) was mixed with chlorothalonil (Bravo Weather Stik, Syngenta) or azoxystrobin (Quadris, Syngenta) and sprayed, with a backpack sprayer, as needed for insect and disease control. An advantage to early tomatoes was realized as no insect problems occurred. Two applications of copper hydroxide (Kocide, Dupont) were sprayed for bacterial spot symptoms.

Tomatoes were first harvested 20 May 2011 and every three to four days thereof until the final harvest of 20 June for a total of 10 harvests. Yield was calculated on a per plot basis. Cut flowers were harvested bi-weekly or as bloom maturity required starting 11 May and ending 5 July.

Results and Discussion: There were no significant differences among all tomato treatments except for the extra large fruit weight (Table 1), which was significantly reduced by treatment 3 (pruning the suckers up to the node below the first bloom). Under the conditions we experienced, in the spring of 2011 in north Mississippi, pruning determinate tomatoes in a high tunnel may not be necessary.

Field grown cut flowers are a high value crop when compared to field crops on a per acre profit basis. Growers have the potential to make $25,000-$30,000 per acre (4). The value of field grown cut flowers in the United States was $375 million in 2010 (5). Zinnia and gomphrena produced several stems, but are of lower value than delphinium, gerbera daisy, and sunflowers. Gomphrena is considered a filler cut flower and is sold in bundles of 10 to 15 stems for $1.30-1.50 a bundle. Zinnias are sold in bundles of 15-20 stems for $5.00-8.00 a bundle or $0.25-0.50 a stem. Sunflowers, gerberas, and delphiniums command a market price of $0.85-1.50 a stem (5,6).

This study shows that multiple crops can be grown in high tunnel production: vegetables as well as cut flowers. To maximize plastic use, cut flower varieties were planted in the high tunnel into the same holes in the plastic as an earlier spring crop of broccoli, cauliflower, and four leaf lettuce varieties (data not shown) at 1 ft. spacing, which was also the spacing for the cut flowers. High tunnel production can create earlier marketing potential by being able to produce marketable stems earlier than growers who produce in open field conditions. However there is a risk, as early spring storms may damage or destroy your high tunnel and/or your crop.

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Table 1. Marketable yield and cull number of 'Applause' tomato grown in a north Mississippi high tunnel in the spring of 2011.

Pruning Treatment	USDA Size Grade	Fruit Number[z]	Fruit Weight[z] (kg)
No Pruning	Jumbo	55 a	19.9 a
Up to 2nd Node	" "	55 a	18.5 a
Up to 1st Bloom	" "	48 a	15.8 a
No Pruning	Extra large	93 a	21.0 a
Up to 2nd Node	" "	84 a	18.4 ab
Up to 1st Bloom	" "	62 a	13.7 b
No Pruning	Large	37 a	5.6 a
Up to 2nd Node	" "	33 a	4.9 a
Up to 1st Bloom	" "	27 a	4.0 a
No Pruning	Medium	27 a	2.9 a
Up to 2nd Node	" "	19 a	2.0 a
Up to 1st Bloom	" "	13 a	1.4 a
No Pruning	Small	23 a	1.6 a
Up to 2nd Node	" "	19 a	1.3 a
Up to 1st Bloom	" "	12 a	0.8 a
No Pruning	Culls	23 a	-
Up to 2nd Node	" "	28 a	-
Up to 1st Bloom	" "	19 a	-

[z] Each replication consisted of 8 plants. Values represent numbers and weight of tomatoes per 8 plant plots. Least significant difference (LSD) at *P*=0.05. Entries sharing the same letter were not significantly different. Culls were not weighed.

Table 2. Average number of stems, stem length, stem diameter, and bloom diameter of 7 cultivars of flowers in a north Mississippi high tunnel in the spring of 2011.

Harvest Date	Species	Cultivar	Number of Stems	Stem Length	Stem Diameter[z]	Bloom Diameter[z]
5-4-11	Delphinium	Diamond Blue	9	33	0.3	13
5-11-11	Delphinium	Diamond Blue	41	21	0.2	8
5-25-11	Delphinium	Diamond Blue	16	28	0.7	16
6-10-11	Delphinium	Diamond Blue	41	21	0.2	8
6-20-11	Delphinium	Diamond Blue	34	19	0.2	8
6-23-11	Delphinium	Diamond Blue	25	18	0.2	7
5-4-11	Gerbera Daisy	Futuristic Mix	17	33	0.3	12
6-3-11	Gerbera Daisy	Futuristic Mix	17	20	0.7	7
6-20-11	Gerbera Daisy	Futuristic Mix	37	19	0.2	8
6-23-11	Gerbera Daisy	Futuristic Mix	18	33	0.3	13
6-3-11	Gomphrena	Flashing Light	159	29	0.5	n/a
6-10-11	Gomphrena	Flashing Light	318	25	0.3	n/a
6-17-11	Gomphrena	Flashing Light	135	29	0.5	n/a
6-10-11	Sunflower	Procut Mix	7	49	0.9	10
6-17-11	Sunflower	Procut Mix	61	61	1.2	11
6-20-11	Sunflower	Procut Mix	21	18	0.9	8
6-28-11	Sunflower	Procut Mix	12	35	0.7	9
6-3-11	Zinnia	BG Scarlet	1	19	0.6	9
6-10-11	Zinnia	BG Scarlet	36	27	0.5	6
6-17-11	Zinnia	BG Scarlet	55	28	0.4	9
6-20-11	Zinnia	BG Scarlet	22	30	0.5	5
7-5-11	Zinnia	BG Scarlet	75	24	0.5	7
6-3-11	Zinnia	State Fair	6	21	0.6	8
6-10-11	Zinnia	State Fair	38	25	0.5	7
6-17-11	Zinnia	State Fair	13	21	0.6	5
6-20-11	Zinnia	State Fair	24	26	0.5	6
7-1-11	Zinnia	State Fair	52	23	0.4	7
7-5-11	Zinnia	State Fair	74	25	0.5	10
6-3-11	Zinnia	Zowie	88	19	0.7	6
6-10-11	Zinnia	Zowie	40	24	0.5	7
6-17-11	Zinnia	Zowie	13	21	0.6	5
6-20-11	Zinnia	Zowie	27	26	0.5	5
7-1-11	Zinnia	Zowie	61	26	0.4	5

[z]All measurements made in centimeters. Each harvest date was averaged. There were 3 replications consisting of 8 plants.

Tree Response to Fertilizer Formulations in the Field

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Significance to Industry. Fertilizers are commonly applied to field grown liners (often called whips) to decrease production time. The amount that growers actually use varies from nursery to nursery; however, many nurseries in Ohio use excessive amounts of fertilizer. Recommendations are for around 250 lbs actual nitrogen (N)/acre/year in Ohio, based on studies conducted by Elton Smith in the 1970’s and early 80’s (Smith and Treaster, 1981). However, soils are highly variable in Ohio; soils in Lake County (where there are a large number of nurseries) can vary from a very sandy soil close to Lake Erie to a soil with much more clay a few miles further south. Controlled release fertilizers (CRF’s) are widely used and preferred for containerized material since soilless substrates have little nutrient holding capacity. They are easy to apply and manage in a containerized system. Also, fertilization of containerized material with CRF’s is better understood than field fertilization. CRF’s distribute nutrients over a specified range of time, based mostly on temperature of the substrate, which is required for soilless mixes. Field grade water-soluble fertilizers are better suited for soils, but nutrient availability is highly dependent on the aforementioned variables. It is unknown whether CRF’s can be equally suited as field grade water-soluble fertilizers for fertilization of field grown stock. The objective of this study was to compare water-soluble fertilizers with CRF’s for field grown tree production at two locations in Ohio. Included in the study are two experimental CRF’s from the Anderson’s Co. (Maumee, OH) use Advanced Granule Technology® (AGT).

Nature of Work. Three species, *Acer rubrum* ‘Red Sunset’, *Quercus rubra*, and *Pyrus callerana* ‘Chanticleer’, were planted in late April, 2009 at two sites; one site was at Sunleaf Nurseries in Madison, OH, and the other site was at the Waterman Farm of The Ohio State University in Columbus, OH. All plants came as tree liners from J. Frank Schmidt, Boring, OR. Treatments were initially applied within two days of planting. Treatments in 2009 included Scotts (Marysville, OH) Osmocote 33-3-6 (5-6 mo) (2.5 TB/tree), Osmocote 22-3-8 Plus Minors with Poly S (5-6 mo) (3.0 TB/tree), Anderson (AND) (Maumee, OH) AGT formulations of AND 9135, 22-3-8 (3.8 TB/tree) and AND 9136, 33-0-2 (2.7 TB/tree), and the field dry-soluble (standard practice) fertilizer at 100lbs/acre granular 19-19-19 (4.2 TB/tree) supplied by The Anderson Co. All treatments were reapplied in May 2010 and 2011, with the exception of the AND 9136, which was replaced by AND 10182. The rates of application were based on delivery of the same amount of nitrogen for all treatments of 100 lbs N/acre/ 9 sq ft around each tree. There was also an untreated control at OSU, and at Sunleaf, there was also a liquid feed treatment in which plants were fertilized with 100 lbs liquid urea ammonium nitrate (UAN) 28% and 100 lbs potash granular dissolved together in water. Irrigation tape dispersed the liquid feed fertilizer. Twenty-five fertigation events occurred over ten weeks of the growing season to equal 4 lbs of N and K per application, every other irrigation event, M-Fri. Irrigation was applied as needed at OSU.

Experimental design was a completely randomized design at each location with three subsamples/treatment/species at Sunleaf and five subsamples/treatment/species at OSU. Caliper measurements were taken in May and September at each location in 2009. In 2010 and 2011, calipers (taken at 6” above the ground) were taken in May, July, and September at OSU, and in May and September at Sunleaf.

Results and Discussion. Height and caliper are often discussed as growth parameters; however, total stem growth is the result of the two parameters combined together and sometimes the two are inversely related, as they are in some instances with this trial (Table 1). Stem volume here is expressed as 1/3 (final height x π x (final caliper/2)^2). For many tree species, height is not really a factor in determining when a plant is ready for sale, but for some upright species, like *Pyrus callerya* ‘Chanticleer’, a taller tree may be more saleable. Results indicate that there are differences between formulations for each of the species, and that the mere *presence* of fertilizer has the largest impact on growth (Table 1). At OSU, all species that received no fertilizer were significantly different from the best treatment in one or more measurements. If only fertilizer treatments are considered, in most instances there is not much significance between fertilizers, but there are a few instances that are significant and should be discussed. *Pyrus* showed the least amount of caliper growth and height from the AND9135 at OSU, and at Sunleaf, AND10182 was similar to AND9135, both providing poor caliper growth, significantly different from the liquid feed. The best treatment for *Pyrus* at OSU was the 19-19-19 and the liquid feed at Sunleaf, with 19-19-19 the second best treatment. *Acer* showed the best caliper growth from the AND 10182 at both locations; however, height was compromised by this treatment at each location (Table 1). Osmocote 22-3-8 was the worst treatment at Sunleaf in terms of caliper growth and it was the second worst at OSU for *Acer*. *Quercus rubra* had opposite results from to the other two species. At Sunleaf, the best treatment for *Pyrus* and *Acer* was liquid feed, but with *Quercus*, the liquid feed was the worst treatment. Liquid feed provided the smallest height and caliper growth as well as stem volume for *Quercus* in comparison to all other treatments at Sunleaf. The best treatment at Sunleaf for *Quercus* was the Osmocote 22-3-8, which is possibly the worst treatment for the other two species. There were many *Quercus* plants that died at OSU (data not shown), and growth of the remaining *Quercus* at OSU was minimal. However, the data represents that the best treatment at OSU was the 19-19-19 with all growth parameters. Struve (2) found that liquid feeding provided more growth than slow release fertilizer to *Nyssa sylvatica*, and although not significant, slow release fertilizer provided 31% more growth to *Quercus rubra* than constant liquid feeding. Struve (2) also reported that nutrient use efficiency was much higher for *Quercus rubra* with slow release formulations, as opposed to the *Nyssa sylvatica*, which preferred the liquid feeding. The differences in growth between the two sites could be from the different types of soil at the two locations. At OSU, soil is mostly a Kokomo silty clay with cation exchange capacities (CEC) of around 12-20 and a ph between 6 and 7. At Sunleaf, the soil is mostly a Tyner or Otisville loamy sand with CEC between 2-6 and pH between 4.7 to 6. Nutrients are more readily available (although are more easily leached) in sandy soils right after application of fertilizers, which could explain the higher growth rate the first year at Sunleaf with *Acer* and *Pyrus*. It should also be discussed that the higher growth from the liquid feed can be explained by the higher amount of fertilizer/tree being delivered by this treatment. As explained above, there was a goal of 100 lbs N/ac/treatment; however, if the amount is discussed as lbs/tree, then the liquid feed provided much more N and K. At 100 lbs of N and K/season/ac, and 830 trees/ac (average), this equates to about 54.7 g of N and K/tree possible from the liquid feed treatment. With other fertilizers, the amount was based on a square foot basis (9 ft^2/tree), with each tree receiving only about 9.4 g/tree of N and K ranging from 0.6 g/tree (Osmocote 33-0-2) to 9.4 g/tree (19-19-19).

From this trial it is evident that fertilizer is required for proper tree liner growth in Ohio. It is also evident that some tree species, such as *Quercus* can have better growth from a slow release formulation, in this case Osmocote 22-3-8 in comparison to the standard treatment, which at this nursery, is the liquid feed. Probably the best overall treatment over all species is the 19-19-19, which provides good growth for all species in this trial while is also the least expensive. It is also evident that 100 lbs N/ac/tree/year is sufficient for good growth.

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Table 1. The effect of fertilizer formulation on growth of three tree species grown at two locations in Ohio.

Waterman Farm, Columbus, OH

Treatment	*Pyrus calleryana* 'Chanticleer' Final height[z]		Δcal[y]		Stem volume[x]		*Acer rubrum* 'Red Sunset' Final height		Δcal		Stem volume		*Quercus rubra* Final height		Δcal		Stem volume	
And10182 22-3-8	341.9	bc[w]	33.0	ab	156.8	b	367.4	bc	21.0	a	146.4	a	322.3	no diff	14.5	a	97.4	ab
And9135 22-3-8	336.2	bc	30.5	b	149.5	b	364.8	c	19.6	ab	135.3	a	313.6	no diff	12.6	ab	100.4	ab
Osmocote 33-3-6	344.9	ab	32.3	ab	156.8	b	374.4	ab	18.5	b	141.2	a	315.3	no diff	12.3	ab	91.2	ab
Osmocote 22-3-8	340.2	bc	32.8	ab	162.0	ab	377.8	a	18.9	b	141.8	a	325.0	no diff	13.1	a	96.8	ab
19-19-19	355.1	a	35.1	a	177.1	a	381.5	a	19.0	ab	139.8	a	331.7	no diff	16.3	a	111.4	a
No fertilizer	330.1	c	31.8	b	147.7	b	366.9	bc	15.5	c	119.7	b	302.1	no diff	6.6	b	69.3	b

Sunleaf Nursery, Madison, OH

Treatment	*Pyrus calleryana* 'Chanticleer' Final height		Δcal		Stem volume		*Acer rubrum* 'Red Sunset' Final height		Δcal		Stem volume		*Quercus rubra* Final height		Δcal		Stem volume	
And10182 22-3-8	319.7	no diff	20.4	b	121.9	c	397.1	de	37.5	A	248.2	b	374.3	bc	34.5	a	247.8	ab
And9135 22-3-8	325.3	no diff	20.6	b	128.3	bc	422.0	a	30.8	Ab	266.0	ab	388.7	ab	33.5	ab	256.4	a
Osmocote 33-3-6	321.3	no diff	21.1	ab	122.5	bc	415.8	ab	32.0	Ab	265.8	ab	376.4	bc	31.0	b	248.2	ab
Osmocote 22-3-8	310.3	no diff	25.3	ab	126.0	bc	410.9	bc	29.5	B	237.9	b	398.2	a	36.6	a	281.4	a
19-19-19	323.1	no diff	24.0	ab	144.7	ab	402.5	cd	32.8	Ab	260.0	ab	379.6	bc	35.2	a	257.4	a
Liquid Feed	328.8	no diff	26.7	a	162.5	a	391.2	e	35.5	Ab	279.7	a	370.3	c	30.6	b	220.4	b

z = Final height as expressed in cm

y = Δcal is difference in mm between first and last caliper measurements

x = stem volume expressed in in^3 is determined by 1/3 (final height x π x $(\text{final caliper}/2)^2$)

w = data followed by the same letter in the same column are not significantly different, based on lsmeans (α = 0.05)