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Preventative Weed Management Strategies in Arkansas Tomato Production

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Cover Page Footnote

Gracie E. Morrison is a May 2022 honors program graduate with a major in Environmental, Soil, and Water Science. Matthew Bertucci, the faculty mentor, is an Assistant Professor in the Department of Horticulture.

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Meet the Student-Author

Gracie E. Morrison

After completing my Honors project, I graduated with Honors from the Bumpers College of Agricultural, Food, and Life Sciences in May 2022. I attended Little Rock Central High School, where I took an AP Environmental Science course that inspired a passion for environmental studies. I was also a member of the Boy Scouts of America, and the Girl Scouts, both of which allowed me to get a familiarity with the outdoors. I majored in Environmental Soil and Water Science. During my time in college, my interest in environmental advocacy and research has grown. I had the opportunity to intern for a nonprofit advocating for reduction of agricultural waste in the Buffalo river watershed, and was part of a campaign to reduce neonicotinoid pesticide use, as it harms bees. After these internships, I helped found an environmental awareness Registered Student Organization called Students Advocating for the Environment, which I was an officer in during sophomore year. I would like to thank my mentor, Dr. Bertucci, for helping with this project. I would also like to thank my committee, comprised of Dr. Popp, Dr. Savin, and Dr. Miller, for their feedback on the project.

Gracie in the high-tunnel at the Milo J. Shult Research and Extension Center, Fayetteville, planting tomatoes in landscape fabric plots.

Research at a Glance

- Tomatoes were treated with several weed suppression methods: Landscape fabric, preemergent herbicide, straw mulch, weekly hand weeding and two-week hand weeding, and untreated weedy controls. The material and labor cost were recorded.
- Economic analysis was performed to determine which method had the highest partial profit returns according to the costs versus the revenue
- The preemergent herbicide had the highest partial profit in all scenarios explored. The organic methods cannot compete with the preemergent unless sold at a premium. This is significant in the ongoing debate surrounding organic versus conventional systems, showing that conventional systems are currently more economically viable.

Preventative Weed Management Strategies in Arkansas Tomato Production

Gracie E. Morrison and Matthew Bertucci†*

Abstract

Cost-effective weed suppression is an important consideration for tomato growers. Growers often choose methods which minimize hand labor, as hand weeding can be prohibitively expensive. This project determined the economic viability of high tunnel tomatoes treated with several methods of weed control, both organic and chemical. These methods included: 2-week hand weeding, 1-week hand weeding, preemergent herbicide application (plots sprayed with herbicide prior to weed emergence), straw mulch (plots bedded with straw), landscape fabric (plots covered in fabric), and untreated weedy control plots. These six treatments were applied to randomized blocks in a high tunnel. Weeding, planting, and harvesting were all timed to determine time costs of weed management strategy implementation. After harvest, marketable and cull yield were measured. Means separation analysis using Tukey's test was used to compare data, indicating differences in the management strategies. The data showed that the preemergent herbicide-treated plots tended to be similar to the organic treatments in terms of yield, weed coverage, and implementation time, but not preparation time. Landscape fabric was especially suppressive of weeds. The 1-week and 2-week hand-weeded plots had similar values for yield, weed coverage, and implementation time. As expected, 1-week and 2-week hand weeding took more weeding time overall than the other treatments. These results are relevant to growers in that the results can be used to adjust their weed management practices based on their available material, labor resources, and yield expectations.

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† Matthew Bertucci, the faculty mentor, is an Assistant Professor in the Department of Horticulture.

Introduction

In the agricultural field, weeds can damage specialty crop yields. Many previous studies have investigated the harmful effects of weed interference on tomato production (Chaudhari et al., 2016; 2017; Ghosheh et al., 2010; Jennings 2010). Developing strategies to minimize weed interference is a crucial part of managing crop health and ensuring an economically viable yield. In market garden production, activities such as transplanting, harvesting, and weeding must be conducted by hand. Many production practices are implemented to minimize the labor hours required for weeding, including those examined in this research such as the use of landscape fabric or straw mulch, and application of preemergent herbicides.

Weed management strategies are chosen with the goal of minimizing negative interference on production while maximizing yield value and weed suppression (Smeda and Weston, 2017). Each method examined in this study has unique characteristics that affect its yield and cost. Hand weeding has improved plant growth, yield, and yield quality in tomatoes while reducing weed density (Ijaz et al., 2017). In another study on tomatoes, hand weeding was more successful in decreasing weed density than preemergent herbicides or mulching (Bakht and Khan, 2014). However, hand weeding has a greater labor cost than other management strategies (Deese, 2010). Organic mulches improve growth, yield, and quality of yield (Sinkevičienė et al., 2009). Past studies found that mulch requires a concentrated early season workload of labor, because mulching an area takes time (Brown et al., 2019). However, mulching also reduces labor later in the season (Brown et al., 2019). The use of landscape fabric requires relatively little labor to install but more labor to plant and remove (Strader and Dawson, 2018). It is designed to exclude light to prevent weed growth under the fabric (Hammermeister, 2016). Preemergent herbicides are designed to kill germinating seeds (Bakht and Khan, 2014). The application of *S*-metolachlor, the preemergent herbicide used in this project, required less labor than hand weeding (Zewdie and Yohannes, 2019). Application of *S*-metolachlor also improved tomato yield (Bakht and Khan, 2014).

There is debate regarding the economic viability of conventional versus organic systems of food production (Posner et al., 2008). Modern agriculture has greatly contributed to nonpoint source pollution in waterways, which has led to some growers adopting organic systems (Mateo-Sagasta et al., 2017). Organic agriculture is largely considered more sustainable than conventional systems in terms of environmental degradation but less economically viable because of the yield gap (De Ponti et al., 2012). However, if growers use the USDA market standard for Organic product, the product could be more attractive to wholesalers and could be sold at a premium (USDA-AMS, 2022a). The objective of this research was to make comparisons between several weed control strategies for high tunnel tomatoes: landscape fabric, preemergent herbicide, hand weeding, and straw mulch. Each method was used alongside hand weeding to ensure effective weed suppression. Plots with no passive weed management and no active weeding served as controls.

Materials and Methods

Celebrity variety tomato was sown in 72-cell seed planter trays until plants reached 2 to 3 true leaf stage. Over the next three days, plants were taken outside for several hours in the middle of each day to harden off plants prior to transplanting. Tomato seedlings were transplanted in late summer into a high-tunnel structure into 0.762-m wide preformed beds at the Milo J. Shult Agricultural Research and Extension Center in Fayetteville, Arkansas. Preemergent herbicide, landscape fabric, and straw mulch were applied. The preemergent herbicide used was *S*-metolachlor (Dual Magnum, Syngenta) applied at 1.68 kg active ingredient per hectare, using a CO_2 powered backpack sprayer calibrated to deliver 187.03 liters per hectare. Landscape fabric and straw mulch (4.08 kg per plot) were applied to beds immediately after bed formation. An experimental unit was a 3.66-m long plot with plants spaced at 0.46 m resulting in 8 tomato plants/plot. All treatments were replicated 4 times and plots were arranged in a randomized complete block design according to known variation in the site. Alleys (0.91 m in length) were spaced between plots in each bed.

Data were collected on cumulative time spent for dedicated hand-weeding of each plot to keep the site free of weeds under each management practice. Data were also collected on visual ratings of weed control, assessed as a percentage of coverage every 2 weeks. Alleys between plots were also hand weeded but this was not timed.

In mid-October through early November, four harvests were conducted and timed. To harvest, two people stood on either side of the plot and picked all visible ripe tomatoes. The tomatoes were sorted as marketable or cull based on USDA market standards of size and appearance (USDA-AMS, 2022b). Tomatoes that were visibly smaller, extremely discolored, rotting, or showing signs of worms or deficiencies, were marked as cull. Ripe, healthy tomatoes were marked as marketable. Mature tomatoes were counted and weighed in crates on a scale to determine the marketable fruit number and weight in litres per plot.

At season's end, cumulative hours spent for dedicated hand-weeding were calculated for each plot to quantify the labor costs required for keeping each site free of weeds under each management practice.

Following execution in the field, analysis of variance) was conducted in SAS using the GLIMMIX procedure to compare response variables, and means separation was conducted according to Tukey's honestly significant difference at a 0.05 significance level. Weed management strategy was treated as a fixed effect, and replication was treated as a random effect.

Results and Discussion

Labor time (Table 1) required for the use of preemergent herbicide, straw much, and landscape fabric were greater than other treatments in the preparation stage. The use of the landscape fabric required the most labor time for preparation followed by the use of straw and the use of preemergent herbicide. Landscape fabric treated plots had longer planting times, while the other plots had values similar to each other. This is because the fabric had to be cut and the seedlings had to be placed into the holes in the fabric, rather than straight into the ground. Fabric-treated plots took significantly less time than the other plots for weeding, given that few weeds could survive under the fabric. Hand-weeded plots required the most maintenance, while the weedy control treatment required the least, although weedy control plots did not differ from fabric-treated plots. Weedy control plots and 1-week hand-weeded plots had lower harvest total hours, which included values from all harvests, compared to plots treated with preemergent herbicide, which had the greatest harvest labor time total. For the green harvest, where remaining green tomatoes were harvested prior to ripeness at the end of the trial, the 2-week hand-weeded and preemergent herbicide treated plots took longer as compared to the weedy plots, which took the shortest number of hours, with other treatments intermediate. In total, the weedy control plots took a shorter time to plant, maintain, weed, and harvest as compared to all treatments with the exception of the landscape fabric treated plots. The hand-weeded plots took the longest time, but those treatments did not differ from the labor time spent for the preemergent and the straw treatments. In the individual harvests, the times were statistically indistinguishable for all treatments.

Cull yield, cull fruit size, and cull fruit count (Table 2) were indistinguishable between treatments ($P > 0.05$). Marketable yield and marketable fruit count for the weedy control plot were smaller ($P < 0.05$) than all treatments except the 1-week hand treatment, meaning the weedy control treatment had less fruit, though size was similar to other treatments.

At the beginning of the season, plots had not yet been weeded and early emerging weeds were able to germinate. Interestingly, weedy control plots initially had comparable weed coverage to other treatments, except for landscape fabric plots with fewer weeds, and 2-week hand weeded plots with more weeds (Table 3). As time progressed at different weekly intervals, it quickly became apparent that weedy control plots had excessive weed coverage, with very little difference among the other weed treatments. Weed coverage never exceeded 15% of the plot, even in 2-week hand-weeded plots. Common weeds were carpetweed, thistle, morning glory, oxalis, clover, carpetweed, and various grasses (data not shown).

The results of the experiment are generally consistent with similar research on the observed effects of weed management strategies. Hand weeded plots tended to be the most different from weedy control plots. Preemergent treated plot yielded fruit larger in size than weedy control plots, as has been observed in past studies such as the Bakht and Khan 2014 study that also indicated no significant difference between the average weed density in plots given 1-week hand weeded, 2-week hand weeded, or preemergent herbicide treatments. However, the Bakht and Khan study did note a lower minimum weed density in hand-weeded plots than all other treatments; whereas in this study, fabric consistently had the minimum weed density though was not statistically different from the other treatments except for 2-week hand weeded plots and weedy control plots.

The 2-week hand weeded treatments fluctuated in weed density more than the 1-week hand weeded plots, which makes sense given that weeds had more time to grow before being weeded. However, the overall time taken to weed was not statistically different between the two hand-weeded treatments, nor was the yield, fruit size, or fruit count. This suggests that 1-week hand weeding does not offer significant benefits over 2-week hand weeding, and the additional time for weeds to grow does not negatively impact the crop output or make the weeding take longer.

Past research such as the Brown et al. 2019 study has shown that straw mulch takes an early season workload and reduces labor later in the season, and though the amount of time for planting, weeding and maintenance were not significantly different from the other treatments, the time spent tended to be on the lower end, with the only shorter weeding time being the landscape fabric treated plots.

The analysis was limited in scope, as effects of weed management strategies on yield, time spent, and weed coverage were observed over a single season and a single location. Given that growers might utilize weed management strategies over a number of years, the research could be expanded further through more trials. The results might change over time; for example, once landscape fabric is installed, it can be reused, cutting down on time and making it potentially more appealing to growers than other treatments in the long run. Weed density might differ across years or regions because of the weed seedbank, and if the trial were repeated in a different area, different

Table 1. Time spent for weed management strategy implementation.

Treatments	Prep.	Planting	Weeding	Maintenance	Harvest 1	Harvest 2	Harvest 3	Harvest 4	Green Harvest	Harvest Totals	Total
	hours/ha										
1-week Hand	0.00	32.42 b	810.28 a	890.39 a	25.80	38.00	50.83	27.40	116.00 ab	258.89 b	1149.00 a
2-week Hand	0.00	29.09 b	764.07 ab	835.96 a	31.14	45.22	51.08	32.27	149.00 a	309.20 ab	1145.00 a
Preemergent	1.73 c	31.61 b	502.44 ab	582.28 ab	31.41	63.16	80.24	35.51	151.00 a	362.16 a	944.00 ab
Straw	36.74 b	27.53 b	451.73 b	556.51 ab	26.04	52.71	57.67	24.66	118.00 ab	280.07 ab	836.00 ab
Fabric	130.69 a	58.99 a	62.67 c	339.10 bc	36.13	57.06	63.90	25.03	135.00 ab	317.18 ab	656.00 bc
Weedy	0.00	31.61 b	0.00	78.11 c	36.87	38.13	68.77	30.64	85.00 b	260.13 b	338.00 c
P-value	<0.0001	0.0089	0.0002	<0.0001	0.2938	0.1100	0.5040	0.5528	0.0117	0.0331	<0.0001

Notes: 1-week Hand refers to weekly hand-weeded treatments. 2-week Hand refers to bi-weekly (every 2 weeks) hand-weeded treatments. Prep refers to preparation. Green refers to green harvest, wherein remaining unripe green tomatoes were harvested at the conclusion of the trial. Maintenance refers to time spent on day-to-day maintenance.

Table 2. Yield values.

Treatments	Marketable Fruit Count	Cull Fruit Count	Marketable Yield	Cull Yield	Marketable Fruit Size	Cull Fruit Size
	fruit/ha		kg/ha		kg/fruit	
1-week Hand	320,675 ab	21,080	65,168 ab	3,444	0.22 ab	0.22
2-week Hand	389,294 a	15,248	79,701 a	2,626	0.24 ab	0.24
Preemergent	380,324 a	19,733	75,859 a	3,220	0.32 a	0.23
Straw	347,135 a	14,801	71,027 a	1,981	0.23 ab	0.21
Fabric	357,002 a	25,115	70,034 a	3,409	0.21 ab	0.20
Weedy	178,501 b	12,110	36,568 b	1,542	0.20 b	0.21
P-value	0.0059	0.4881	0.0096	0.4339	0.0371	0.0858

Notes: 1-week Hand refers to weekly hand-weeded treatments. 2-week Hand refers to bi-weekly (every 2 weeks) hand-weeded treatments.

weed species might present themselves, having different effects on the yield, different density based on their prolificness, and different difficulty of removal, altering the weeding time. A continuation of this project is underway to examine the same high tunnel over several years, allowing insight into the effects of the weed seedbank and other potentially important factors.

Conclusions

Overall, the preemergent herbicide-treated plots tended to be similar to the organic treatments in terms of yield, weed coverage, and implementation time, other than preparation time. Landscape fabric was especially suppressive of weeds. The 1-week and 2-week hand weeding had similar values for yield, weed coverage, and implementation time and, as expected, had a greater labor cost. These results showcase some of the factors influencing the profitability of weed management strategies. The information presented here can be used by growers to inform them of the potential barriers and benefits to the weed management strategies explored in this project, so they can make informed decisions.

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Literature Cited

Bakht, T. and I.A. Khan. 2014. Weed control in tomato (*Lycopersicon esculentum* Mill.) through mulching and herbicides. Pak. J. Bot. 46(1):289-292.

Brown, B., A.K. Hoshide, and E.R. Gallandt. 2019. An economic comparison of weed management systems used in small-scale organic vegetable production. Organic Agriculture. 9(1):53-63.

Chaudhari S., K. Jennings, D. Monks, D. Jordan, C. Gunter, F. Louws. 2016. Critical period for weed control in grafted and nongrafted fresh market tomato. Weed Science. 64(3):523-530.

Chaudhari S., K. Jennings, D. Monks, D. Jordan, C. Gunter, F. Louws. 2017. Response of drought-stressed grafted and nongrafted tomato to postemergence metribuzin. Weed Technology. 31(3):447-454.

Deese, S.D. 2010. Economic Analysis: Weeding Techniques for Organic Farms. Digital Undergraduate Research Commons at California Polytechnic State University. Accessed 14 March 2021. Available at: https://digitalcommons.calpoly.edu/agbsp/14

De Ponti, T., B. Rijk, and M.K. Van Ittersum. 2012. The crop yield gap between organic and conventional agriculture. Agricultural systems. 108:1-9.

Ghosheh H., M. Al-Kawamleh, and I. Makhadmeh. 2010. Weed competitiveness and herbicidal sensitivity of grafted tomatoes (*solanum lycopersicon* mill.). J. Plant Protection Research. 50(3).

Hammermeister, A. M. 2016. Organic weed management in perennial fruits. Scientia Horticulturae. 208:28-42.

Ijaz, A., I. Khan, S. Zareen, M. I. Khan, R. Khan, and M. Haroon. 2017. Yield and yield attributes of tomato (*Lycopersicon esculentum* Mill) cultivars influenced by weed management techniques. Pakistan J. Weed Sci. Res. 23(4):431-438.

Jennings, K.M. 2010. Tolerance of fresh-market tomato to postemergence-directed imazosulfuron, halosulfuron, and trifloxysulfuron. Weed Technol. 24(2):117-120.

Mateo-Sagasta, J., S.M. Zadeh, H. Turral, and J. Burke. 2017. Water pollution from agriculture: a global review. The International Water Management Institute on behalf

Table 3. Weed coverage in percent.

Treatments	Aug 11	Aug 18	Aug 25	Sept 01	Sept 08	Sept 15	Sept 22	Sept 29	Oct 06
	----------%----------								
1-week Hand	3.25 ab	3.75 b	2.75 bc	3.50 b	4.50 b	2.25 bc	3.00 bc	2.50 bc	2.50 cd
2-week Hand	25.25 a	4.00 b	14.50 b	5.75 b	9.50 b	3.00 bc	6.25 b	4.00 b	6.50 b
Preemergent	7.00 ab	2.50 b	8.25 bc	6.00 b	5.00 b	2.50 bc	3.75 bc	2.00 bc	4.700 bc
Straw	20.00 ab	2.50 b	2.75 bc	4.25 b	8.25 b	3.50 b	5.25 b	2.00 bc	3.00 bcd
Fabric	1.00 b	0.00 b	0.75 c	0.50 b	0.25 b	0.00 c	0.50 c	0.50 c	1.00 d
Weedy	11.75 ab	31.25 a	88.25 a	91.25 a	92.50 a	93.75 a	95.00 a	95.00 a	95.00 a
P-value	0.0234	0.0024	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Notes: 1-week Hand refers to weekly hand-weeded treatments. 2-week Hand refers to bi-weekly (every 2 weeks) hand-weeded treatments.

of the Water Land and Ecosystems research program, Colombo.

Posner, J.L., J.O. Baldock, and J.L. Hedtcke. 2008. Organic and conventional production systems in the Wisconsin integrated cropping systems trials: I. Productivity 1990–2002. Agron. J. 100(2):253-260.

Sinkevičienė, A., D. Jodaugienė, R. Pupalienė, and M. Urbonienė. 2009. The influence of organic mulches on soil properties and crop yield. Agron. Res. 7(1):485-491.

Smeda, R.J. and L.A. Weston. 2017. Handbook of weed management systems. Routledge, New York.

Strader, C. and J. Dawson. 2018. Plastic, Fabric, and Marsh Hay Mulch with No-Till Organic Tomatoes. University of Wisconsin--Extension, Cooperative Extension. Accessed 12 March 2022. Available at: https://fyi.extension.wisc.edu/danecountyag/files/2018/05/Mulch-with-No-Till-Organic-Tomatoes.pdf

USDA-AMS. 2022a. United States Department of Agriculture Agricultural Marketing Service. About the Organic Standards. Accessed 10 March 2022. Available at: https://www.ams.usda.gov/grades-standards/organic-standards

USDA-AMS. 2022b. United States Department of Agriculture Agricultural Marketing Service. Tomato Grades and Standards Agricultural Marketing Service. Accessed 11 March 2022. Available at: https://www.ams.usda.gov/grades-standards/tomato-grades-and-standards

Zewdie, K. and K. Yohannes. 2019. Efficacy and Selectivity of Pre-Emergence Herbicide *S*-Metolachlor Against Annual Grass and Broad Leaved Weeds in Faba Bean. International J. Res. Studies Agric. Sci. 5(7):1-6.