Cover Crop and Plastic Mulch Integration into Vegetable Production

Steve Li. Extension Weed Scientist. Auburn University.

Introduction

Weed management in vegetable production is challenging due to limited herbicides registered for use. Many herbicides even registered for use in vegetable can still injure these crops due to variety sensitivity and environment responses. Herbicide applications are usually restricted to row middles or post-directed applications once the target crop is established with the exception of grass control. Vegetable crops that grow into row middles such as melons or cucumbers further complicate weed management as no postemergence herbicides are currently registered for use to control broadleaf weeds. Cover crop implementation is one way to use integrated weed management practices to suppress weeds. Cover crops are grown from the fall until spring then terminated and residual biomass remains on the soil surface to inhibit weed germination and growth (Reddy 2001; Teasdale and Mohler 1993; Teasdale and Mohler 2000). Weed resistance continues to challenge producers to utilize more diverse weed management programs to reduce yield loss. These programs could include a combination of plastic mulch, herbicides, and/or cover crops.

Plants grown in close quarters often experience a declination of growth (Swanton et al. 2015). Proposed mechanisms for this response may be attributed to 1) competition for water, nutrients and light, 2) allelopathic chemical interference, and 3) disturbing disease and insect pressure (Halligan 1976). Allelopathy is a species specific phenomena where chemicals released by plants can suppress weeds (Purvis et al. 1985). Cover crops may interfere with the microenvironment through manipulation of temperature and available moisture (Creamer et al. 1996). In additional to weed suppression, cover crop use can improve soil texture, increase soil microbial activity, recycle nitrogen, and conserve other nutrients (Hartwig et al. 2002). Furthermore, cover crop mixtures have been shown to increase these benefits when compared to monocultures (Brainard et al. 2011; Finney and Kay 2017). Grasses are capable of rapid growth and efficient nitrogen scavenging and legumes are known for slow growth and commonly used in cover crop mixtures (Finney and Kaye 2017). A combination of grasses and legumes could provide a more desirable carbon to nitrogen ratio that optimizes slow degradation and nitrogen recycling (Creamer et al. 1997). The increased weed suppression of mixtures could be due to an increase in biomass on soil surfaces (Lawson et al. 2015). An alternative theory is niche exploitation where additional species habit niches that weeds would normally occupy.

High residue cover crops such as cereal rye (*Secale cerale* L.) and oats (*Avena sativa* L.) have been well studied for weed suppression capabilities (Culpepper et al. 2010). In a study by Palhano et al. (2018), cereal rye and wheat (*Triticum aestivum* L.) were shown to provide 100% control of Palmer amaranth up to 2 weeks after planting with biomasses of 4,860 and 4,040 kg ha^{-1}. In this same study, leguminous cover crops did not achieve adequate control of Palmer amaranth and were no different from the non-treated control by 4 weeks. This difference in weed suppression is likely due to a low carbon to nitrogen ratio in legumes. High residue cover crops typically have a high carbon to nitrogen ratio and microbes have to obtain more nitrogen to break them down. For this reason, leguminous cover crop residues decompose very quickly and have a shorter window of weed control (Touchton et al. 1984). Cereal rye can also germinate at very low temperatures (-1 to 2 °C) and vegetative growth can begin at 4°C meaning cover crops could be established well before weeds begin to germinate and produce enough biomass before the target crop is planted (Miville and Leroux 2018).

Cover crops are often terminated before the subsequent crop growing season, either physically or chemically. Physical termination is often achieved through mowing or rolling to keep the biomass on the soil surface. Chemical means often involve glyphosate applications; however, these have been shown to decrease groundcover up to 11% eight weeks after subsequent crop emergence (Milville and Leroux 2018). Vegetable responses when grown in cover crops have been shown to vary. In a study by Putnam and Defrank (1983), cucumbers, peas, and snap bean yields were not reduced when grown in cover crops; however, barley, corn, oats, rye, sorghum, and sudangrass were shown to be toxic to lettuce and tomato stands were also reduced. A study by Knavel and Herron (1985) showed that cabbage yields were decreased with taller sudangrass (30 cm) while yields were not affected by shorter sudangrass (15 cm). In another study by Leavitt et al. (2011), hairy vetch (*Vicia villosa* Roth), winter rye, and a mixture of both were shown to lower weed densities; however, tomato, zucchini, and bell pepper yields were decreased up to 89%, 79%, and 92% when planted directly into cover crop residues. Alternatively, tomato yields were shown to increase when grown in hairy vetch mulch even when compared to polyethylene plastic mulch in another study by Abdul-Baki et al. (1996). It is likely that vegetables grown on raised beds with adequate distance from cover crop residues would not be effected; however, more research is needed.

Living cover crop systems can provide similar benefits in addition to an extended period of weed control from sowing until harvest. This weed suppression is likely due to direct competition for light, nutrients and moisture. Weed germination is thought to be difficult in an established crop due to shading, crowding, and reduced surface temperatures (Hartwig and Ammon 2002). Living green manures may have increased weed suppression capabilities as compared to dessicated cover crop residues (Teasdale 1998). Some cover crops such as white clover (*Trifolium repens* L.) and perennial ryegrass (*Lolium perenne* L.) are low growing plants that could be grown at the same time as the target crop. Perennial peanut (*Arachis pintoi*) is a perennial legume that has been used in citrus orchards for weed suppression. As a green, living manure, it is often used as a smother crop for its pest reduction benefits, soil conservation, and nitrogen fixation abilities (Severino and Christoffoleti 2004). Other living mulch systems that have been studied include crabgrass (*Digitaria sanguinalis* L.) in vineyards (Varadu et al. 1989) and broadcast spread purslane (*Portulaca olaceae* L.) in broccoli where crop yield was not affected (Ellis et al. 2000). Living cover crops may have greater weed suppression capabilities due to competition for resources; however, living cover crops may also compete with the target crop (Teasdale 1993). Again, vegetables on raised beds above a low growing cover crop may not be affected.

Correct implementation of cover crops into vegetable production could have the potential to not only reduce crop-weed competition but also reduce weed pressure for crops in subsequent years. Additionally, this system could eliminate the need for a preemergence herbicide, thereby reducing input costs and decreasing selection pressure for resistant weed species (Norsworthy et al. 2012). Both small scale and large scale vegetable producers may be able to benefit from such a system.

Justification

Weed management in watermelon production is challenging due to wide row spacing, highly disturbed soil, and few selective herbicides registered for use. Vegetable weed control can be challenging to both organic and conventional producers alike. Weed suppression from cover crops is achieved through diverse mechanisms that are not well understood and need further investigation. The purpose of this study is to evaluate living and terminated cover crops and cover crop mixtures for use in vegetable production. The design of this experiment is to investigate weed suppression capabilities of certain cover crop species, potential interference between the target crop and cover crop, and possible reduction of herbicide applications. Cover crops and plastic mulch may provide additional weed management tools to vegetable producers. The results of this study could be applicable to both large scale and small scale vegetable production.

Field Trials in 2017/2018

To evaluate watermelon performance in cover crop residues grown with plastic mulch, field trials were conducted in 2017/2018 in Henry and Lee Counties in Alabama (Wiregrass Research and Extension Center, Headland AL, and Hornsby Farm, Auburn AL). The experimental design was a randomized complete block with 4 replications. Plot size was 4.5 by 7.6m. Cover crops tested were daikon radish, crimson clover, cereal rye, and oats planted at seeding rates of 16, 28, 112, and 112 kg ha^{-1} with a seed drill. Additionally, mixtures of crimson clover with cereal rye or oats were also planted. Cover crops were planted in November 2017 and terminated in March 2018 before rototilling 1.5m strips for bed preparation on 4.5m row spacing. Plastic mulch was laid and seedless watermelons of the 'Captivation' variety were planted April 2018 with 46 cm plant spacing with a 3:1 seedless melon to pollinator ratio. No soil herbicides were applied to row middles in any of the treatments. Row middles either remained untreated or received an application of halosulfuron-methyl (52.53 g ai ha^{-1}) + clethodim (136.03 g ai ha^{-1}) 5 weeks after planting (WAP) before vines started to run. Vine length and weed counts were recorded at 4 and 8 WAP as well as yield at harvest in July 2018. Data were subjected to an analysis of variance in SAS 9.4 and means were generated based on Fisher's protected least significant differences.

Cover crop mixtures of clover + rye and clover + oats resulted in the highest biomass at termination of 4,581 and 4,929 kg ha^{-1}, respectively (Table 1). **Weed densities were significantly reduced by all cover crops 4 WAP compared to bare ground** (Table 2). Clover + oat mixtures consistently suppressed weeds 4 WAP with less than 2 plants per 10 m^2 compared to 20.02 and 11.31 plants per 10 m^2 in bare ground plots in Henry and Lee counties, respectively. Rye, clover + rye, and clover + oat cover crops significantly reduced weed densities at least 50% compared to bare ground 8 WAP in Lee County. After receiving herbicide applications, all cover crops with the exception of daikon radish had significantly lower weed densities than bare ground 8 WAP in Henry County. Herbicide applications reduced weed densities to 1.5 plants per 10 m^2 or lower 8 WAP regardless of cover crop residue in Lee County.

Watermelons grown in oat, clover + rye, and clover + oat residues had longer vine lengths 4 WAP compared to bare ground with increases of 24, 23, and 45% in Henry County, respectively (Figure 1). No significant differences were observed for watermelon vine lengths 4 WAP in Lee County or either county 8 WAP. Yield response did not differ across locations and was not affected by herbicide application in row middles (Figure 2). **Yield increases of 58 and 63% were observed for watermelons grown with oat and clover + oat residues compared to bareground treatment due to less weed competition.**

Data indicate high residue cover crops are likely to decrease early-season weed competition in watermelon production and may lead to increased yields. Combinations of plastic mulch, cover crops, and herbicide applications before watermelons vine into row middles can extend weed control and provide additional tools for weed management programs. However, several aspects of this research trial needed to be addressed. Cover crop seeding methods warrant adjustment for subsequent research to account for space adjacent to row middles. Planting cover crops prior to laying plastic mulch required tillage where beds were formed. Therefore, areas directly adjacent to vegetable beds had no cover crop residue to prevent weed establishment watermelon growth and development may have been negatively affected. Seeding methods for field trials conducted in 2018/2019 were modified by laying plastic mulch in the fall and broadcast seeding cover crops. Row middle size also required alteration to examine practicality of cover crop seeding methods for commercial production. The addition of preemergent herbicides could further suppress early-season weed competition. The concept of competition could also be exploited by using a living mulch versus terminated cover crop residues. Cover crop interactions may vary based on the vegetable crop in production and additional evaluations are needed. These challenges were addressed in the following year to be discussed below.

Table 1. Cover Crops, Seeding Rates, and Biomass at Termination

Cover Crop	Seeding Rate (kg ha^{-1})	Biomass at Termination [ab] (kg ha^{-1})
Daikon radish	16	3060 b
Crimson clover	28	3591 ab
Cereal Rye	112	2351 b
Oats	112	3500 ab
Crimson clover + cereal rye	28 + 112	4581 a
Crimson clover + oats	28 + 112	4929 a

[a] Means followed by the same letter in a column do not differ significantly at $P = 0.05$
[b] Cover crop biomass did not differ across locations, therefore data were combined

Table 2. Weed Density (plants/10 m^2)[ab]

Cover Crop	4 WAP [c]		8 WAP [d]			
	Henry County	Lee County	Henry County		Lee County	
			Non-treated	Treated	Non-treated	Treated
Bareground	20.04 a	11.31 a	14.51 ab	17.51 a	14.24 a	0.74 a
Radish	17.80 b	7.72 b	25.99 a	8.32 ab	12.17 abc	1.19 a
Clover	3.30 c	2.59 cd	16.23 ab	4.95 b	13.56 a	0.40 a
Rye	3.95 c	0.99 d	8.03 b	2.45 b	3.79 c	0.10 a
Oats	2.50 cd	4.00 c	19.56 ab	1.73 b	9.55 abc	0.86 a
Clover/rye	3.04 cd	0.95 d	19.56 ab	3.49 b	6.38 bc	0.26 a
Clover/oats	1.47 d	1.82 cd	9.08 b	1.86 b	5.75 bc	0.46 a

[a] Weed densities were combined for *Amaranthus* spp., *Cyperus* spp., and *Digitaria* spp.
[b] Means followed by the same letter in a column are not significantly different at $P = 0.05$
[c] Location x cover crop interaction observed 4 WAP (P<0.0001)
[d] Location x cover crop x row middle treatment interaction observed 8 WAP (P= 0.0009)

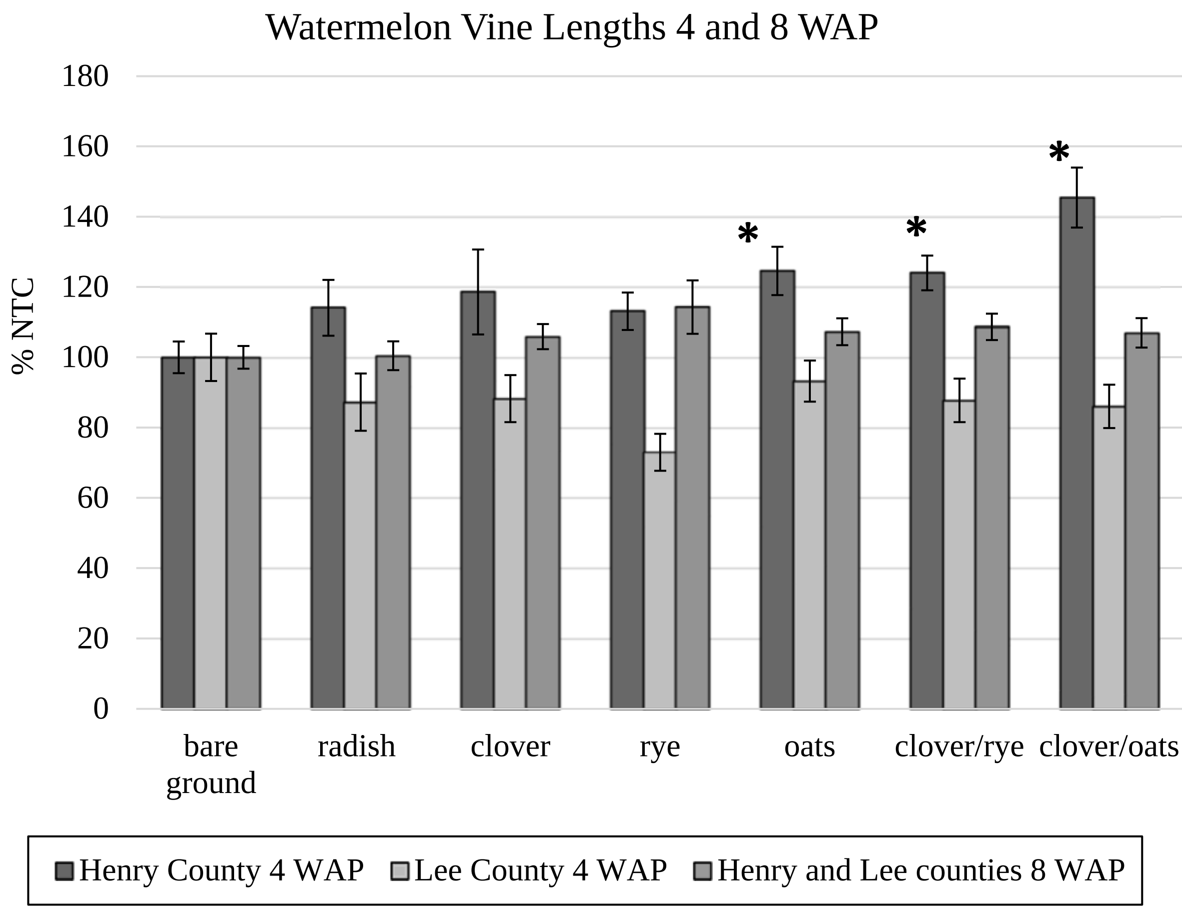

Figure 1. Watermelon vine length 4 and 8 weeks after planting. Asterisk indicates means differ significantly from bare ground at P =0.05. A location by cover crop interaction for vine length was observed 4 WAP (P = 0.003). No significant differences observed across locations, row middle treatment, or cover crops 8 WAP.

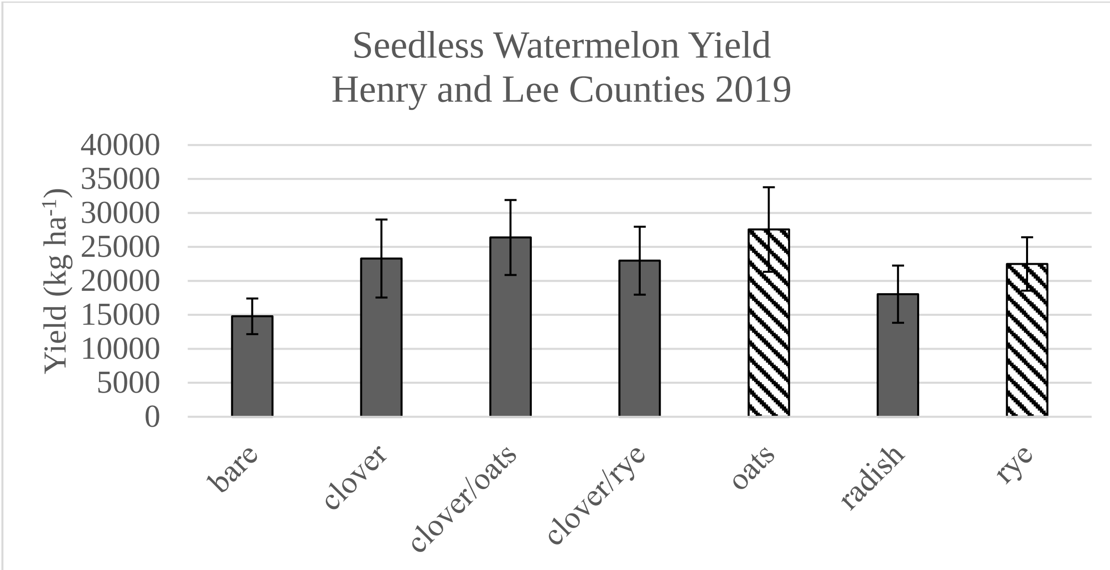

Figure 2. Watermelon yield at harvest. Pattern bars indicate means differ significantly from bare ground at *P* =0.05. No cover crop x location or row middle treatment interactions; therefore, data were combined to show cover crop effect.

Field Studies in 2018/2019

Field studies were conducted in Fall 2018 and Spring/Summer 2019 in Henry and Lee counties in Alabama. Challenges faced in the previous year of research were addressed through modification of cover crop seeding method, reduction of row middle size, evaluation of living versus terminated mulch systems, and addition of preemergence herbicides for further weed suppression. The study had a randomized complete block design with 4 replications. Plot was 3.6 by 6 m long bed, with beds formed on 1.8m row spacing (typical grower spacing). Beds were formed and plastic mulch was laid in Fall 2018. White clover, cereal rye, and a mixture of cereal rye plus crimson clover were broadcast seeded at rates of 16, 224, and 224 + 28 kg ha^{-1} (high seeding rates). Both seedless melons of the ‘Crunchy Red’ variety and bell peppers of the ‘Aristotle’ variety were included in individual plots. Every other row was planted to reduce cover crop interference and allow herbicide applications on an individual plot basis. Plots were either rolled before termination, terminated with glyphosate at 1.5 kg ha^{-1}, glyphosate at 1.5 kg ha^{-1} + paraquat at 560 g ha^{-1}, or glyphosate at 1.5 kg ha^{-1} + flumioxazin at 143 g ha^{-1} (Table 3). Plots that received glyphosate only were either rolled before or after applications to determine if residues from chemically terminated plots degrade faster than those rolled green. Vegetables were planted on 46 cm plant spacing and watermelons were planted at a 3:1 seedless melon to pollinator ratio. Herbicide treatments consisted of preemergence application of flumioxazin at 143 g ai ha^{-1} + trifluralin at 841 g ha^{-1} and/or postemergence applications of halosulfuron at 39 g ha^{-1} + clethodim at 136 g ha^{-1} 5 WAP. Some plots only received a pre or a post application. Treatments are listed in table 3. Plant heights or vine lengths were recorded at 4 and 8 WAP followed by yield at maturity.

Data from Henry County past 4 WAP is unavailable due to crop failure. Data were subjected to an analysis of variance and means separations were generated from Fisher's protected LSD.

Cover crop biomass for cereal rye and cereal rye plus crimson clover mixtures were 4,642 and 5,253 kg ha^{-1} for Henry County and 6,841 and 5,497 kg ha^{-1} for Lee County (Table 4). A location by treatment interaction was observed for weed densities 4 WAP (P = 0.05). **Weed densities for all cover crops tested were significantly lower than the nontreated control 4 WAP in Henry and Lee counties with reductions of 65 to 96% in Henry County and 76 to 90% in Lee County** (Table 5). Weed densities in Lee County were also significantly reduced for plots with cover crops compared to the nontreated control 8 WAP. However, cover crops did not differ from one another regardless of herbicide regime or termination method. In general, addition of a preemergence herbicide did not increase weed suppression.

A location by treatment interaction did not exist for watermelon vine lengths 4 WAP. Therefore, data were combined. No significant differences were observed for watermelon vine lengths 4 WAP for any treatment compared to the nontreated control (Figure 3). A location by treatment interaction was observed for bell pepper heights 4 WAP (P = 0.04). Regardless of termination method, bell peppers planted in cereal rye + crimson clover plots that received preemergence and postemergence applications and the chemical control had significantly reduced heights of 27 to 42% as compared to the nontreated control in Henry County (Figure 4). Bell peppers grown in the chemical control plots in Lee County also had significantly lower heights than the nontreated control by 33%**. The results for the chemical control are likely due to drift of flumioxazin onto plastic during termination of winter weeds prior to planting, which grower should be aware of in their production**. Data collection from Henry County was not taken following after 4 WAP due to plot destruction therefore the remainder of the discussion pertains to Lee County only.

Bell pepper heights in Lee County 8 WAP for all cereal rye and cereal rye plus crimson clover mixtures (PRE + POST, rolled) were significantly higher as compared to the nontreated control with increases of 19 to 47% (Figure 5). **Bell pepper yields followed similar trends and the treatments listed above yielded more than the nontreated control by at least 4-fold** (Figure 6). Watermelon vinelengths recovered from injury observed in the chemical control plots by 8 WAP and were 48% longer than the NTC (Figure 5). Additionally, vinelengths of watermelons grown with cereal rye and cereal rye cover crop residues were 19 to 47% longer than the NTC with the exception of the cereal rye and crimson clover mixture that did not receive a preemergence herbicide application. **Compared to the nontreated control, watermelons grown with terminated mulch had increased yields at least 3-fold. Living mulch of white clover did not increase yields as compared to the nontreated control and a large amount of disease was observed on watermelon plants in those plots**. Watermelons grown in plots with cereal rye residues that received a pre and post herbicide application and cereal rye + crimson clover mixtures with all herbicide regimes produced yields that were not significantly different from the chemical control. Similar to bell peppers, watermelons in the chemical control were injured early in the season from flumioxazin drift onto plastic while terminating winter weeds before planting. However, the growing season for watermelons is much longer in comparison to bell peppers and plants were able to recover. The data suggest **terminated cover crop residues in combination with herbicide applications can produce similar yields as the chemical control, however, there is no concern with PRE herbicide drift on plastic causing crop seedling injury**. Furthermore, **watermelons grown with cereal rye + crimson clover residues that only received a post herbicide application in row middles produced yields similar to the chemical control, indicating a preemergence herbicide application could be removed from programs in the presence of cover crop mixtures**. Additional research may be warranted to further explore the practicality of using cover crop residues for weed suppression in vegetable production. Cover crop residues in combination with herbicide regimes could provide an additional platform for weed suppression in vegetable row middles.

Table 3. Cover crops, termination methods, and herbicide timing

Cover Crop	Termination Method	Herbicides (row middles)[AB]
White clover	Glyphosate (1.5 kg ai ha^{-1}) + paraquat (560 g ai ha-1)	PRE
Cereal rye	rolled	PRE + POST
Cereal rye	rolled	POST
Cereal rye + crimson clover	Glyphosate (3.1 kg ai ha^{-1}), rolled	PRE + POST
Cereal rye + crimson clover	rolled	PRE + POST
Cereal rye + crimson clover	rolled	POST
Chemical control	Glyphosate (1.5 kg ai ha^{-1}) + flumioxazin (143 g ai ha^{-1})	PRE + POST
NTC	N/A	N/A

[A] PRE application: flumioxazin (143 g ai ha^{-1}) + trifluralin (841 g ai ha^{-1})
[B] POST application: halosulfuron (39 g ai ha^{-1}) + clethodim (136 g ai ha^{-1}) at 5 WAP

Table 4. Cover crop seeding rates and biomass at termination in Henry and Lee counties in 2019.

Cover Crop	Seeding rate (kg ha^{-1})	Biomass at Termination (kg ha^{-1})	
		Henry Co.	Lee Co.
White clover	16	N/A	N/A
Cereal rye	224	4642	6841
Cereal rye + Crimson clover	224 + 28	5253	5497

Table 5. Weed densities 4 and 8 weeks after planting

Cover Crop	Weed Density 4 WAP [C] (plants per 10 m^2)		Weed Density 8 WAP (plants per 10 m^2)
	Henry Co.	Lee Co.	Lee Co.
White clover	1.68 c	6.05 bc	1.68 b
Cereal rye (PRE + POST, rolled)	1.61 c	4.10 bc	3.29 b
Cereal rye (POST, rolled)	3.49 bc	5.78 bc	6.05 b
Cereal rye + crimson Clover (PRE + POST, glyphosate)	14.06 b	2.35 c	19.10 b
Cereal rye + crimson clover (PRE + POST, rolled)	1.54 c	3.22 bc	2.35 b
Cereal rye + crimson clover (POST, rolled)	2.35 c	6.79 b	3.90 b
Chemical control (PRE + POST)	9.88 bc	4.17 bc	10.96 b
NTC	41.17 a	26.03 a	101.45 a

[A] Weed densities were combined for *Amaranthus* spp., *Cyperus* spp., Oenothera sp. and *Digitaria* spp.

[B] Means followed by the same letter in a column are not significantly different at $P = 0.05$

[C] Location x cover crop interaction observed 4 WAP ($P = 0.0029$)

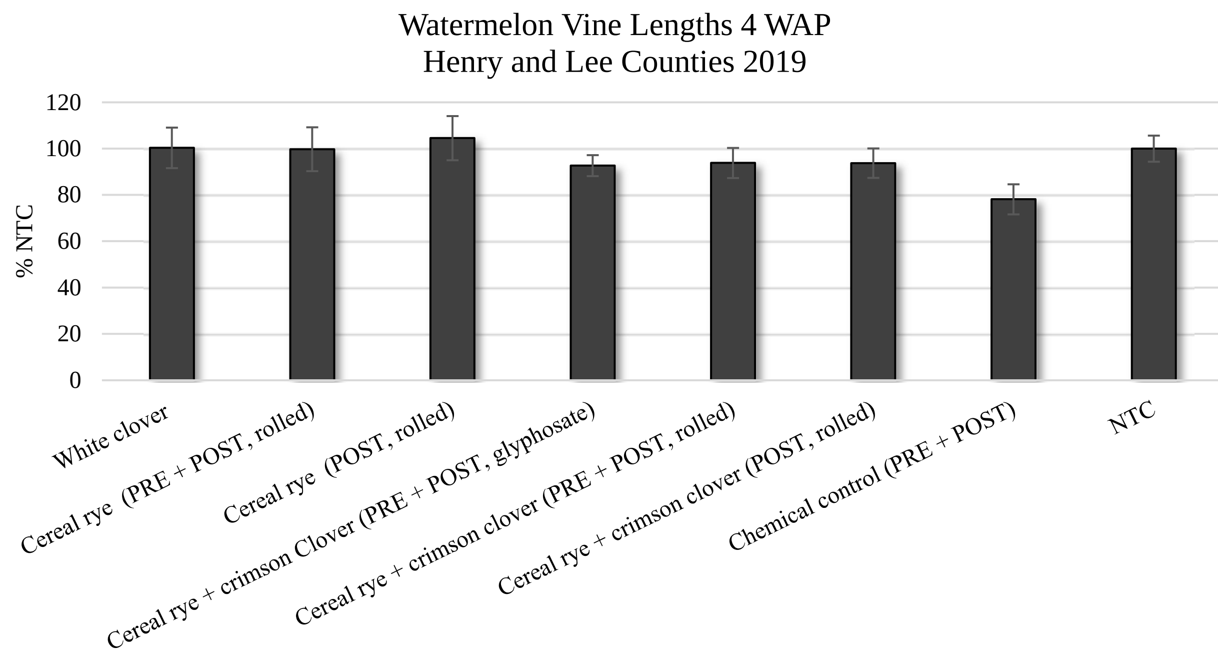

Figure 3. Watermelon vine lengths 4 weeks after planting in Henry and Lee Counties. No location by treatment interaction was observed, therefore data were combined. No significant differences observed.

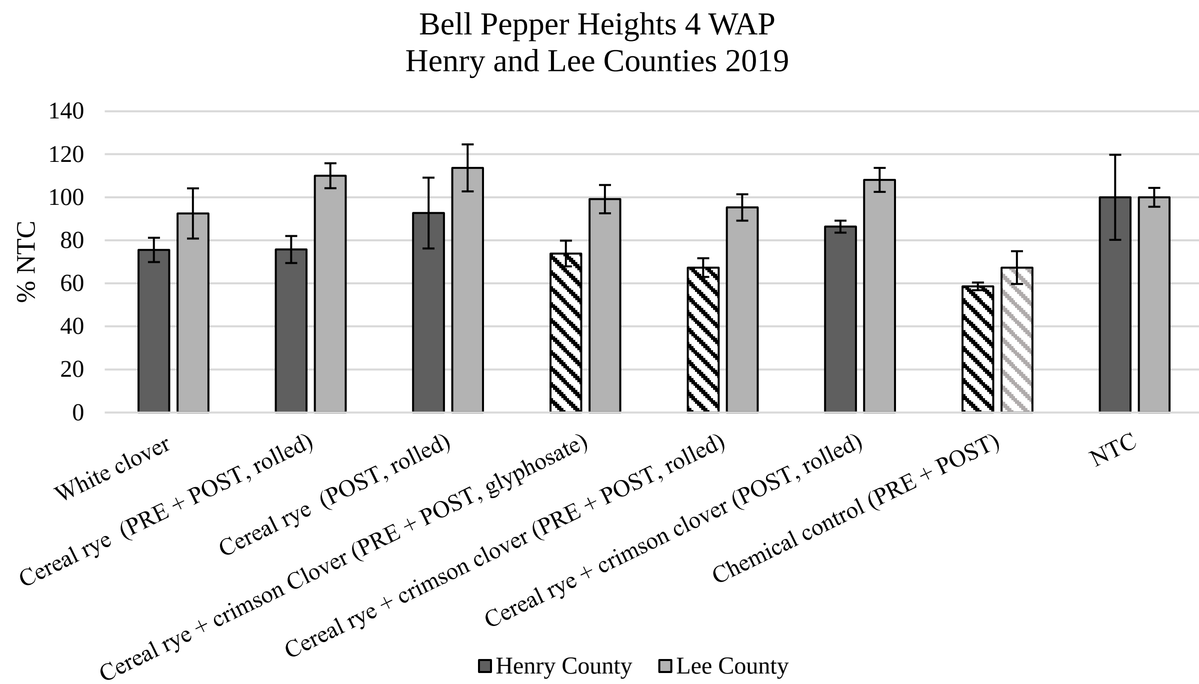

Figure 4. Bell pepper heights 4 weeks after planting in Henry and Lee counties. A location by treatment effect was observed at $P = 0.04$. Patterned bars indicate significant differences.

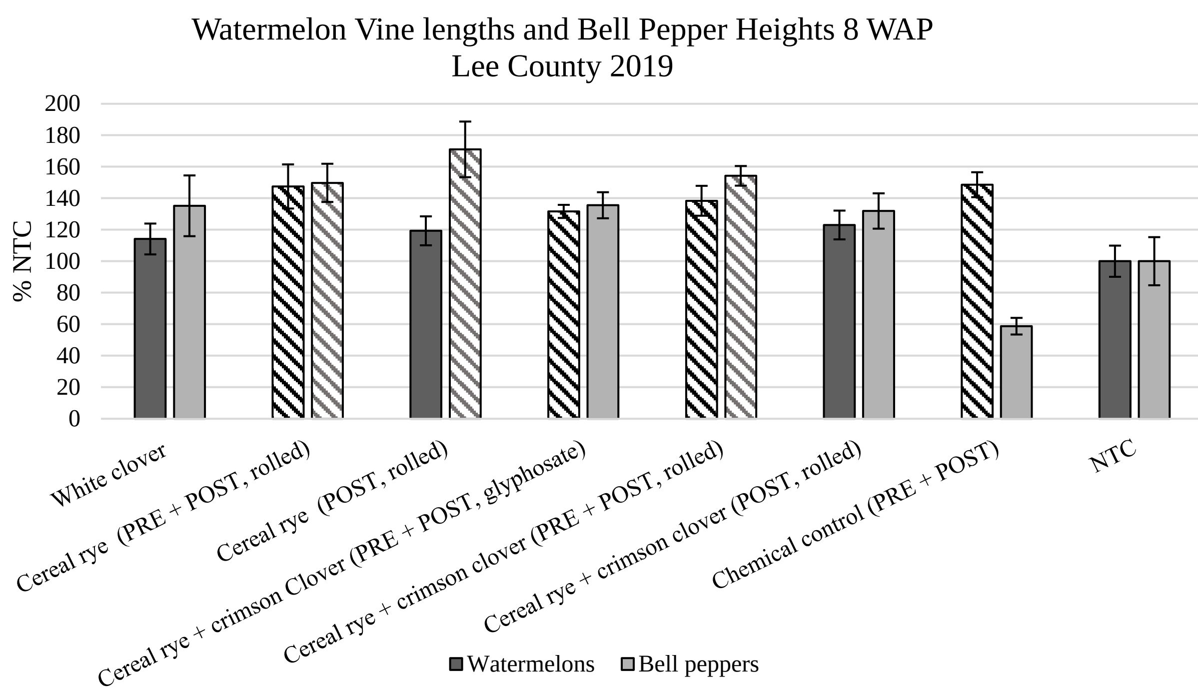

Figure 5. Watermelon vine lengths and bell pepper heights 8 weeks after planting in Lee County.

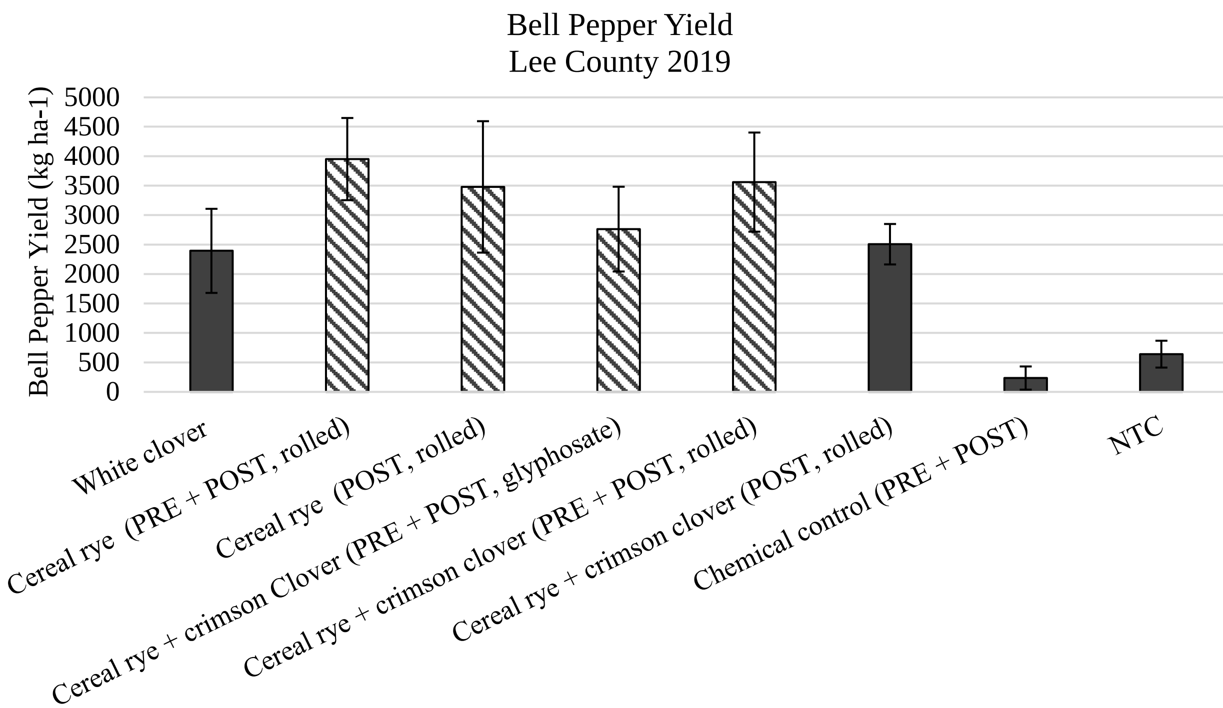

Figure 6. Bell pepper yields in Lee County. Patterned bars are significantly different from the nontreated control (*P*=0.05)

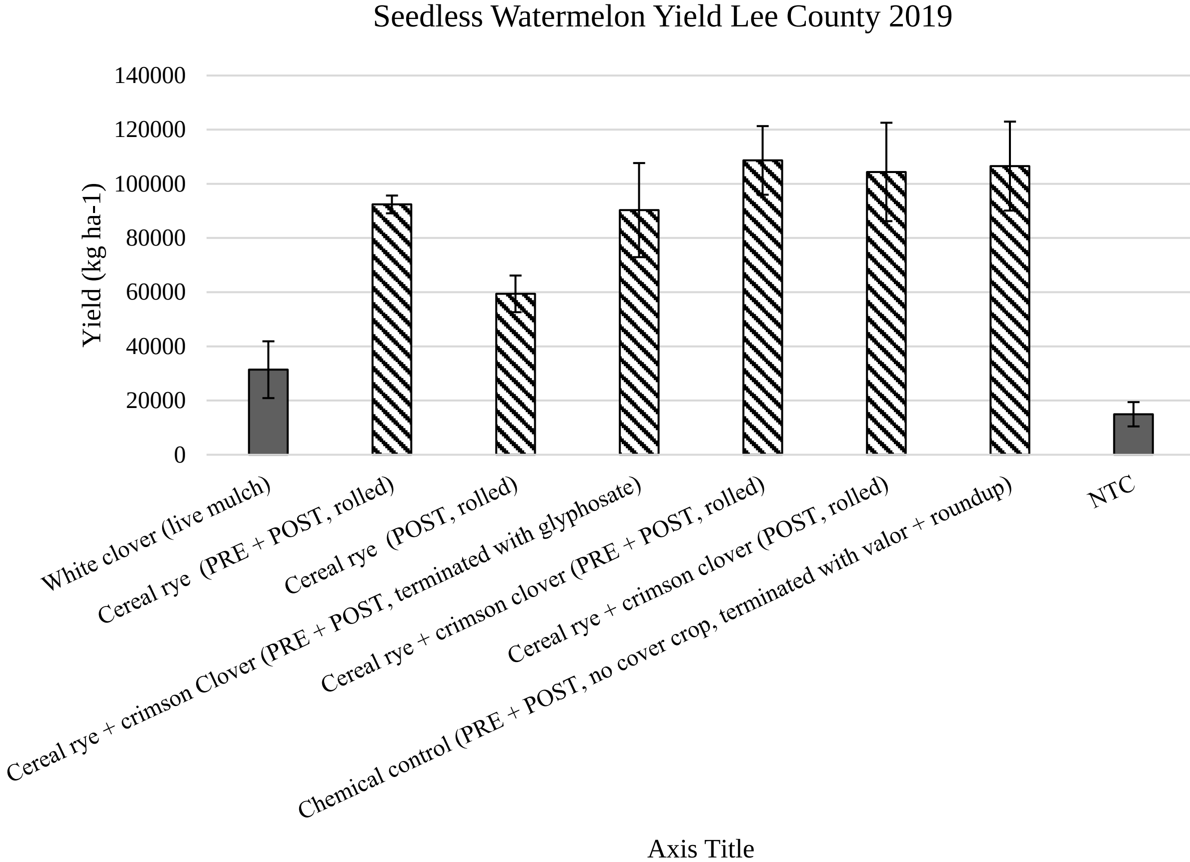

Figure 7. Seedless watermelon yield in Lee County in 2019. Patterned bars are significantly different from the nontreated control (*P*=0.05).

References

Abdul-Baki, A.A., Teasdale, J.R., Korcak, R., Chitwood, D.J. and Huettel, R.N., 1996. Fresh-market tomato production in a low-input alternative system using cover-crop mulch. HortScience, 31(1), pp.65-69.

Brainard, D.C., Bellinder, R.R. and Kumar, V., 2011. Grass–legume mixtures and soil fertility affect cover crop performance and weed seed production. Weed Technology, 25(3), pp.473-479.

Creamer, N.G., Bennett, M.A., Stinner, B.R., Cardina, J. and Regnier, E.E., 1996. Mechanisms of weed suppression in cover crop-based production systems. HortScience, 31(3), pp.410-413.

Creamer, N.G., Bennett, M.A. and Stinner, B.R., 1997. Evaluation of cover crop mixtures for use in vegetable production systems. HortScience, 32(5), pp.866-870.

Culpepper, A.S., Kichler, J., Sosnoskie, L., York, A., Sammons, D. and Nichols, B., 2010, January. Integrating cover crop residue and moldboard plowing into glyphosate-resistant Palmer amaranth management programs. In Proceedings of the 2010 Beltwide Cotton Conference. Cordova, TN: National Cotton Council of America (p. 1650).

Ellis, D.R., Guillard, K. and Adams, R.G., 2000. Purslane as a living mulch in broccoli production. American Journal of Alternative Agriculture, 15(2), pp.50-59.

Finney, D.M. and Kaye, J.P., 2017. Functional diversity in cover crop polycultures increases multifunctionality of an agricultural system. Journal of applied ecology, 54(2), pp.509-517.

Halligan, J.P., 1976. Toxicity of Artemisia californica to four associated herb species. American Midland Naturalist, pp.406-421.

Hartwig, N.L. and Ammon, H.U., 2002. Cover crops and living mulches. Weed science, 50(6), pp.688-699.

Knavel, D.E. and Herron, J.W., 1985. Effect of sudan grass on yield and elemental content of cabbage. HortScience (USA).

Lawson, A., Cogger, C., Bary, A. and Fortuna, A.M., 2015. Influence of seeding atio, planting date, and termination date on rye-hairy vetch cover crop mixture performance under organic management. PloS one, 10(6), p.e0129597.

Leavitt, M.J., Sheaffer, C.C., Wyse, D.L. and Allan, D.L., 2011. Rolled winter rye and hairy vetch cover crops lower weed density but reduce vegetable yields in no-tillage organic production. HortScience, 46(3), pp.387-395.

Miville, D. and Leroux, G.D., 2018. Rolled Winter Rye–Hairy Vetch Cover Crops for Weed Control in No-till Pumpkin. Weed Technology, 32(3), pp.251-259.

Norsworthy, J.K., Ward, S.M., Shaw, D.R., Llewellyn, R.S., Nichols, R.L., Webster, T.M., Bradley, K.W., Frisvold, G., Powles, S.B., Burgos, N.R. and Witt, W.W., 2012. Reducing the risks of herbicide resistance: best management practices and recommendations. Weed Science, 60(SP1), pp.31-62.

Palhano, M.G., Norsworthy, J.K. and Barber, T., 2018. Cover Crops Suppression of Palmer Amaranth (Amaranthus palmeri) in Cotton. Weed Technology, 32(1), pp.60-65.

Purvis, C.E., Jessop, R.S. and Lovett, J.V., 1985. Selective regulation of germination and growth of annual weeds by crop residues. Weed Research, 25(6), pp.415-421.

Putnam, A.R. and DeFrank, J., 1983. Use of phytotoxic plant residues for selective weed control. Crop protection, 2(2), pp.173-181.

Reddy, K.N., 2001. Effects of cereal and legume cover crop residues on weeds, yield, and net return in soybean (Glycine max). Weed Technology, 15(4), pp.660-668.

Severino, F.J. and Christoffoleti, P.J., 2004. Weed supression by smother crops and selective herbicides. Scientia Agricola, 61(1), pp.21-26.

Swanton, C.J., Nkoa, R. and Blackshaw, R.E., 2015. Experimental methods for crop–weed competition studies. Weed Science, 63(SP1), pp.2-11.

Teasdale, J.R., 1993. Reduced-herbicide weed management systems for no-tillage corn (Zea mays) in a hairy vetch (Vicia villosa) cover crop. Weed Technology, 7(4), pp.879-883.

Teasdale, J.R. and Mohler, C.L., 1993. Light transmittance, soil temperature, and soil moisture under residue of hairy vetch and rye. Agronomy Journal, 85(3), pp.673-680.

Teasdale, J.R. and Mohler, C.L., 2000. The quantitative relationship between weed emergence and the physical properties of mulches. Weed Science, 48(3), pp.385-392.

Touchton, J.T., Rickerl, D.H., Walker, R.H. and Snipes, C.E., 1984. Winter legumes as a nitrogen source for no-tillage cotton. Soil and Tillage research, 4(4), pp.391-401.

Verdú, A.M. and Mas, M.T., 2007. Mulching as an alternative technique for weed management in mandarin orchard tree rows. Agronomy for sustainable development, 27(4), pp.367-375.