IMPACT OF DIFFERENT COVER CROP RESIDUES AND SHANK TYPES ON NO-TILL TOMATO YIELD

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SUMMARY

A three year experiment with no-till tomatoes was conducted in Cullman, AL to determine the impact of plastic mulch (control), rye and crimson clover cover crops, and different subsoiler shanks on no–till tomato yield. In 2006 and 2008, plastic cover provided higher yield compared with rye and crimson clover in all shank treatments. In 2007, higher yield was produced following rye compared with plastic mulch and crimson clover. Across years, tomato yield after crimson clover was lower compared with rye and plastic. Percent of marketable fruit yield to total yield exceeded 80% in all treatments including the plastic control.

INTRODUCTION

Cover crops have become a vital part of no-till systems for row crops in the southern US; however, no-till systems using cover crops for vegetable production has not been widely adopted. Only 12% of the Alabama vegetable production area is under no-till production (CTIC, 2004). A limitating factor is the lack of equipment (rollers/crimpers) needed to manage tall cover crops such as cereal winter rye (*Secale cereale, L.)* and winter crimson clover (*Trifolium incarnatum* L.) in flat or ridge vegetable production systems. In addition, the tradition of plowing/disking soil in vegetable production is strong in this region. However, there is interest in Alabama to utilize cover crops in no-till vegetable systems to reduce cost and protect soil resources while increasing or maintaining yields. Cover crop use can improve soil physical properties, increase soil organic carbon, conserve soil water, reduce surface runoff, and recycle nutrients (Hubbell and Sartain, 1980; Reeves, 1994; Mansoer et al., 1997).
Cereal rye is the main cover crop widely used in Alabama and produces between 3 to 11 tons/ac of biomass which provides benefits such as alleopathic weed suppression and a mulch effect due to enhanced residue cover (Barnes and Putnam, 1983). Another widely used cover crop is the legume crimson clover which can be utilized in a mixture or alone to fix atmospheric nitrogen. To realize benefits of cover crops, they must be managed appropriately to avoid cash crop planting problems. To generate maximum biomass, these covers must be terminated at the appropriate growth stage. A common method to terminate cover crops is the use of herbicides since spraying is relatively fast and effective. However, since rye is very tall and lodges in multiple directions, planting efficiency of a cash crop can be reduced due to frequent delays required to clean accumulated cover residues from planting units.
Flattening and crimping cover crops by mechanical rollers in the direction parallel to planting of a cash crop is widely used in South America (especially in Brazil) to successfully terminate cover crops without herbicides (Derpsch et al., 1991). Because of potential environmental and monetary benefits (no use of herbicides), this technology is now receiving increased interest in North America. Ashford and Reeves (2003) indicated that when rolling was conducted at the

In M.S. Reiter (ed.) A multidisciplinary approach to conservation. Proc. 31st Southern Conservation Agric. Systems Conf., Melfa, VA. 20-23 July 2009. Extension Publ. 2910-1417. Dep. Crop and Soil Environ. Sci., Eastern Shore Agric. Res. Ext. Cntr., Virginia Polytechnic Inst. and State Univ., Painter, VA. Available at: http://pubs.ext.vt.edu/2910/2910-1417/2910-1407.html.

appropriate plant growth stage (i.e. soft dough), the roller was equally effective (as chemical herbicides) at terminating cover crops (94%). They concluded that rye mortality above 90% was sufficient to begin cash crop planting due to accelerated cover crop senescence.
Conventional tomato production typically includes deep tillage and bedded plastic mulch to minimize weed populations. Conventional tillage increases soil erosion and nutrient loss, reduces organic carbon, and increases soil strength (Blough et al., 1990; Mahboubi et al., 1993). Plastic mulch is expensive and could cause environmental problems if not removed from the field after harvest. According to Teasdale and Abdul-Baki (1995), tomatoes grown under plastic mulch increased soil temperature which caused tomatoes to produce fruit early in the season. In contrast, tomatoes grown under hairy vetch mulch systems showed that fruit production was more uniform throughout the season (Abdul-Baki et al., 1996). Therefore, no-till tomato production with cover crops might be a good alternative to protect the soil and the environment while decreasing tomato production costs.
The objective of this study was to evaluate the effects of two different cover crops (rye and crimson clover) and two shank types on tomato (*Lycopersicon esculentum* L.) yield.

MATERIALS AND METHODS

The experiment was conducted during the 2006-2008 growing seasons at the Northern Alabama Horticultural Research Station in Cullman, Alabama. The study was initiated in the fall of 2005 by planting two cover crops: winter Rye (Secale cereale, L.) and winter crimson clover *(Trifolium incarnatum* L.). Each fall cover crops were drilled with a no-till drill in rows 7 inches apart in plots 16 ft wide and 20 ft long. Rye was seeded at a rate of 90 lb/ac, whereas clover was seeded at 25 lb/ac. Nitrogen was applied at a rate of 60 lb/ac on rye plots in early spring each year. The experiment was established on a Hartsells fine sandy loam soil (Fine-loamy, siliceous, sub-active, thermic Typic Hapludults). The experimental design was a randomized complete block with four treatment replications. Treatments included two cover crops (winter rye and crimson clover). For each cover crop treatment three subsoil shank treatments were used: no shank, slim shank and wide shank. These treatments were compared to control plots (no cover crops) using plastic mulch, a typical tomato production system in Alabama. Each plot was 20 ft long and 8 ft wide and had a single row of tomatoes in the middle of the plot with 15 inch spacing between plants. To determine winter cover crop biomass, plants were clipped at the ground from two randomly selected 2.7 ft^2 sections per each plot immediately before termination. Plant samples were dried at 149 F for 72 hours and weighed. The winter cover crops were terminated each spring with a mechanical roller crimper prior to a supplemental chemical application of glyphosate at a rate of 1.0 a.i. lb/ac at the end of April approximately 3 weeks before transplanting tomatoes. The roller/crimper used in this experiment was 8 ft wide and consisted of a round drum with equally spaced blunt straight steel bars around the drum's circumference and across the drum's length (Fig. 1). The function of the bars was to crimp or crush the cover crop stems without cutting them. The rolling process produced a uniform residue cover on the soil surface.

Figure 1. Rolling cover crops using a 8 ft straight bar roller/crimper with ¼ inch thick crimping bars

Tomato cultivar 'Florida 47' seedlings were transplanted on May 15 in 2006, May 02 in 2007, and on May 01 in 2008. Seedlings were planted into both residue covers using a modified RJ No-till transplanter (RJ Equipment*, Blenhiem, Ontario; Fig. 2).

Figure 2. Planting tomato seedlings into rolled rye residue cover using a modified RJ No-till transplanter from RJ Equipment Company, Blenhiem, Ontario

To alleviate the soil compacted layer, the transplanter was modified by adding a sub-frame between the toolbar (with a mounted plastic tank for water/startup fertilizer) and the parallel linkage of the transplanter. The sub-frame was able to accommodate both commercially available shanks (subsoilers) and custom made shanks. Subsoiler shanks were able to penetrate the heavy residue and disrupt a naturally occurring consolidated compacted soil layer to a depth of 12-16 inches which is common at the experimental site in Cullman (Fig. 3). Additionally, in 2007, two driving wheels were utilized (one wheel on each side of the tomato row) instead of the original single wheel at the center of the row to improve stability and help minimize re-compaction of the soil opening created by the shank.

Figure 3. Side view of the RJ transplanter showing the sub-frame with the subsoiler shank and two powered wheels

A day after transplanting tomatoes, 13 temperature sensors were placed below the soil surface on selected plots at the plot center to collect soil temperatures (using 13 HOBO Water Temp pro Model H20-001 data loggers) for different covers during the growing season. Tomatoes were hand harvested four times at mature-green to pink color stages from 14 plants in each plot. Fruit number and fruit weight for total (cull included) extra large, large, medium and small sizes from each plot were recorded. Data was analyzed by analysis of variance and treatment means were separated using the Fisher's protected Least Significant Differences (LSD) test at the 10 % probability level. Where interactions between treatments and years occurred, data was presented separately and when interactions were not present, data was combined.

RESULTS AND DISCUSSION

Cover crops height and biomass

Rye and crimson clover plant heights are shown in Table 1. There were interactions between years and covers (P=0.0001), thus the heights for each year were analyzed separately. Average rye and crimson clover heights during three growing seasons were 65.5 inches and 21 inches, respectively. Rye heights were different each year whereas clover heights were similar. For rye, the lowest height was 58.7 inches in 2007 and the highest (71.6 inches) in 2008. The differences in rye height were reflected in biomass produced each year. In 2007, rye produced the lowest biomass (5528 lb/ac) and in 2008 the biomass was the highest (8630 lbs/ac). In 2007, there was no significant difference (P=0.6450) in rye and clover biomass (4949 lbs/ac). Lower rye biomass in 2007 might be related to soil moisture deficit after fall rye planting in 2006. Similar to rye, in 2008 crimson clover also produced the highest biomass (6297 lbs/ac).

Soil temperature for different covers

Over three years, maximum temperature for rye was significantly lower compared to clover and plastic (P=0.021; Table 2). Maximum temperature under rye was 93.3^{o} F compared to clover (97.9^{o} F) and plastic (100.5^{o} F). In 2006, no difference in minimum temperature was found between covers, whereas in 2007 minimum temperature under plastic was at least 2 degrees higher (68.2^{o} F) compared to rye and clover. In 2008, minimum temperature for rye was higher compared to plastic and clover. Since maximum temperature under clover during three years was higher than rye, it appears that higher temperature and lower clover biomass production lead to incomplete soil cover, resulting in more weed pressure that affected tomato yield.

Total tomato yield

There was a significant interaction between treatments and years (P = 0.0027) for total tomato yield, thus statistical analysis was done separately for each year. In 2006, averaged across treatments, total tomato yield was significantly lower compared to 2007 and 2008. In 2006, total tomato yield under plastic mulch was higher compared to no shank and wide shank treatments in rye and clover residue covers, even though there was no significant difference between plastic control and slim shank treatments after rye and clover covers (Fig. 4).

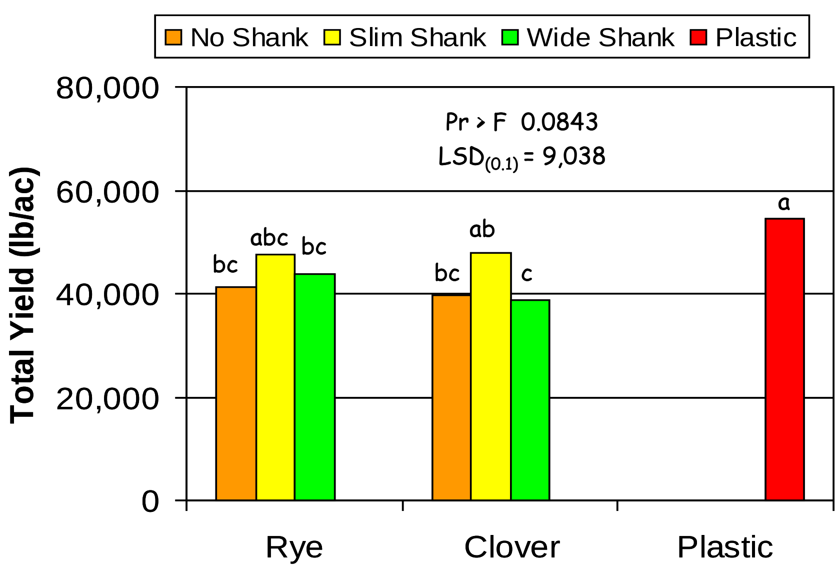

Figure 4. Total tomato yield in 2006 growing season

In 2007, the highest tomato yield was obtained for rye cover with no shank and with wide shank treatments. The lowest yield was calculated for plastic and crimson clover cover with no shank on the transplanter (Fig. 5).

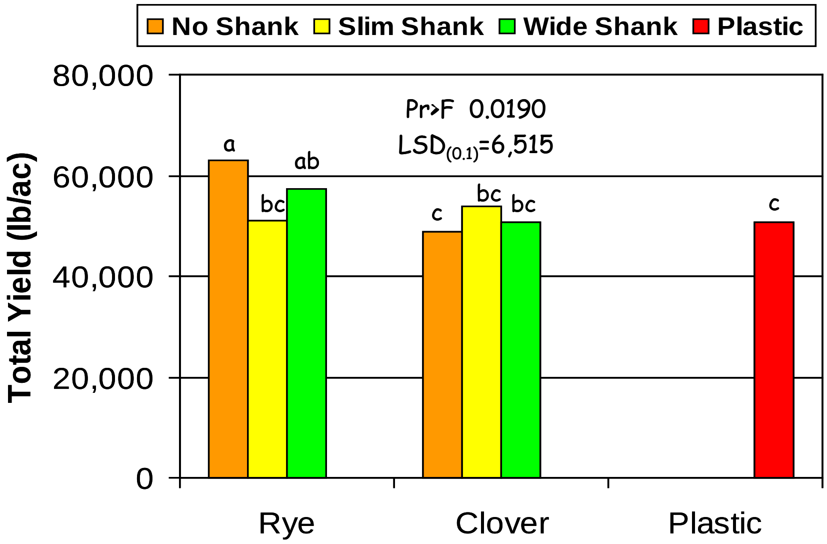

Figure 5. Total tomato yield in 2007 growing season

In 2008, significantly higher total tomato yield was reported for plastic mulch cover compared to rye cover crop and crimson clover residues. Tomatoes planted into rye residue produced significantly higher total yield compared to crimson clover cover. Shank treatments did not have any significant effects on yield in 2008 (Fig. 6).

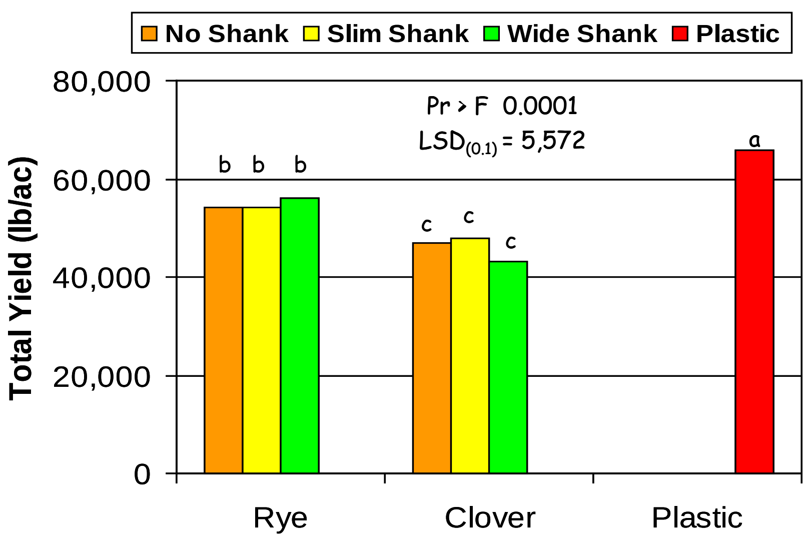

Figure 6. Total tomato yield in 2008 growing season

Marketable tomato yield

In 2006, there were no significant differences between both cover crop residue (with three shank treatments) and plastic mulch control (Pr>F 0.1637). Average marketable yield during 2006 growing season was 36,205 lbs/ac.

In 2007, the highest marketable yield was calculated for rye with no shank treatment (51,226 lbs/ac) in comparison with rye (slim and wide shanks), crimson clover (all shank treatments) and plastic mulch control (Fig. 7)

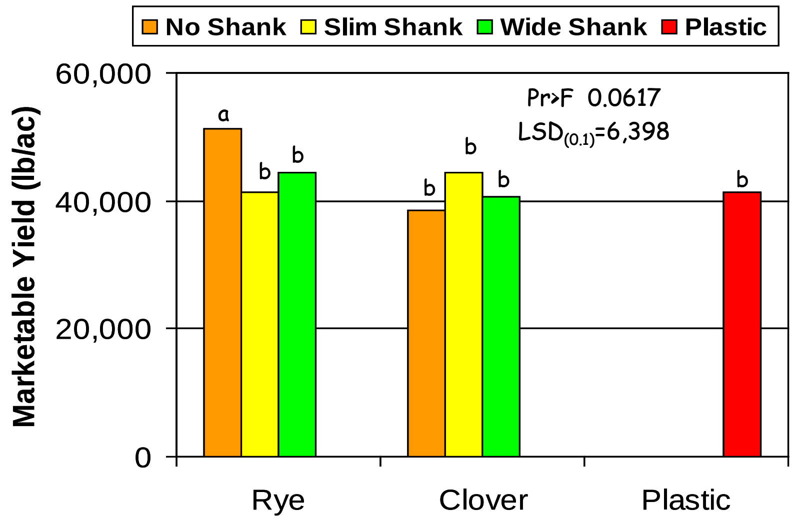

Figure 7. Marketable tomato yield in 2007 growing season.

In 2008, significantly higher marketable tomato yield was found for plastic mulch control (54,821 lbs/ac) compared to rye and crimson clover covers with all shank treatments. Comparing two residue covers and the shank treatments, rye residue cover with slim and wide shanks produced significantly higher yield than crimson clover with all three shank treatments (Fig. 8).

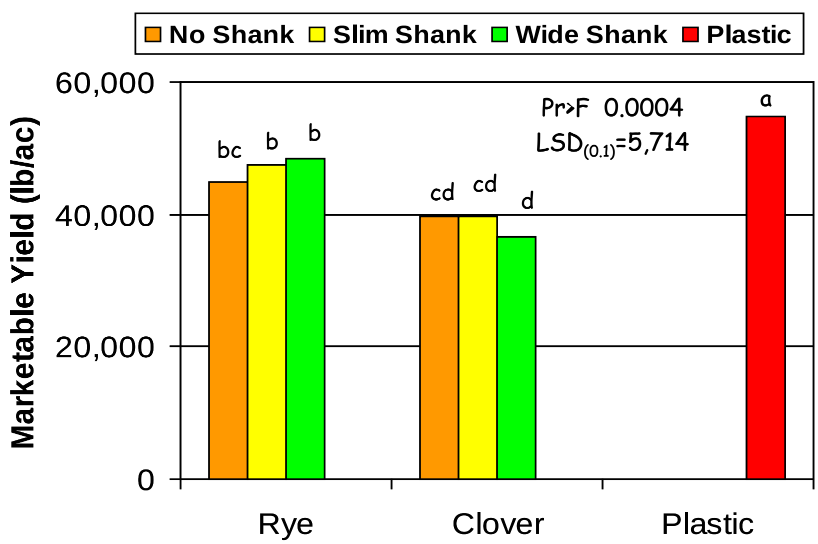

Figure 8. Marketable tomato yield in 2008 growing season.

Percentage of marketable tomato vs total yield
Comparing three growing seasons, significantly higher percentage (84.6%) of marketable tomato to total yield was recorded in 2008, compared to 2006 (80.7%) and 2007 (80.3%).

Overall, during 2006 - 2008 no differences were detected between all treatments (cover crops, shanks and plastic mulch control) indicating that plastic mulch did not improve percentage of marketable fruit.

Number fruit per plant

No significant difference in number of fruit per plant averaged over all treatments was found during the three growing seasons. Average number of fruit per plant was 24.8, 23.2 and 24.8, in 2006, 2007, and 2008, respectively.

During these growing seasons, the highest number of fruit was produced with plastic mulch (26.4), rye with no shank (24.9), and rye with wide shank (25.1). The lowest fruit number per plant was recorded for crimson clover with no shank (21.1) and with wide shank (21.5). In 2006 and 2007, no significant difference in number fruit per plant was found between cover crops, shanks and control plastic mulch. In contrast, in 2008, the highest number of fruit was found with the plastic mulch (30) and the lowest with the clover cover (21) (Fig. 9). The lower yield and number of fruit per plant following crimson clover (2006 - 2008), may have been due to high weed competition since clover biomass production was low and incompletely covered the soil compared to the higher residue producing rye system (except in 2007).

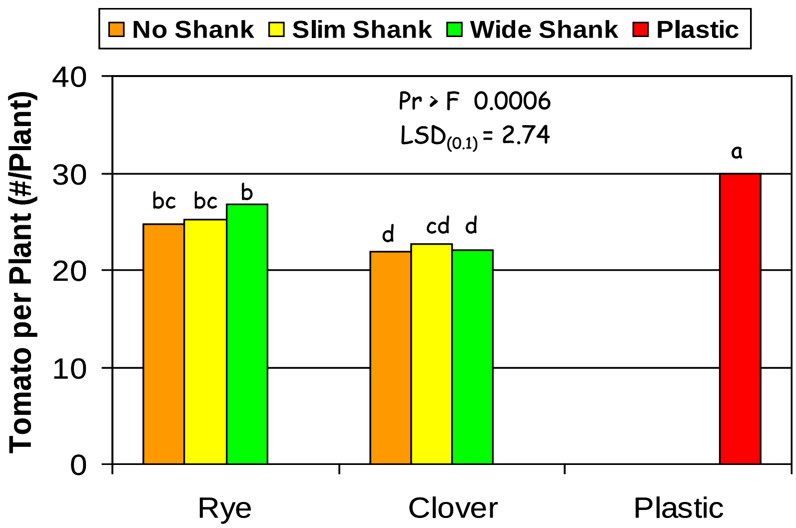

Figure 9. Treatment effect on number tomato fruit per plant in 2008 growing season

CONCLUSION

In two of three growing seasons (2006 and 2008), tomatoes planted into plastic mulch cover produced higher total yield and number of fruit per plant. In 2007, when a severe drought occurred, tomatoes planted into rye residue (without shank) produced significantly higher total and marketable yield in comparison to the plastic mulch control and clover indicating that the rye cover crop was better for conserving soil water for tomato use. Cover crops and shank treatments did not affect percentage of marketable tomato yield compared to total tomato yield. Economical analysis should be performed to determine whether cover crops or plastic provided higher net returns. In addition, soil strength and soil moisture and soil temperature must be included in future studies to better understand why crimson clover generally produced lower yields.

ACKNOWLEDGEMENT

We acknowledge Mr. Arnold Caylor, superintendent at the Horticultural Research Station, Cullman, Alabama for his technical assistance.

Disclaimer

*The use of trade names or company names does not imply endorsement by the USDA-Agricultural Research Service.

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Table 1. Height and dry biomass of rye and Crimson clover cover crops for 2006 through 2008

Year	Height (inch)		Pr > F	Biomass (lbs/ac)		Pr > F
	Rye	Clover		Rye	Clover	
2006	65.1	21.8	<0.0001	7132	4072	0.0461
2007	58.7	20.1	<0.0001	5528	4949	0.6450
2008	71.6	21.1	<0.0001	8630	6297	0.0961

Table 2. Maximum and minimum soil temperature (^{o} F) for different covers during 2006 through 2008 growing seasons.* Values of the means within columns having the same letters are not significantly different at the 10% level.

Year	2006		2007		2008		Average Max temp
Temp (^{o} F)	Max	Min	Max	Min	Max	Min	
Rye	86.8	65.0	109.0	65.2b*	88.0	56.1a	93.3b
Clover	93.2	64.2	116.9	66.2b	93.1	54.6b	97.9a
Plastic	97.0	65.0	115.4	68.2a	92.7	54.7b	100.5a
LSD	N/A	NS	N/A	1.71	N/A	0.75	3.06