Effects of rolling/crimping of cover crops on their termination, soil strength and moisture

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Introduction

Cover crops are a crucial part of conservation agriculture, but they have to be managed appropriately to optimize their benefits (Brady and Weil, 1999). Previous research identified benefits, such as increased water infiltration, reduced runoff, reduced soil erosion, and reduced soil compaction (Kern and Johnson, 1993; Reeves, 1994; Raper et al., 2000a; Raper et al., 2000b). Flattening and crimping of cover crops by mechanical rollers/crimpers originated in Brazil to successfully terminate cover crops without herbicides (Derpsch et al., 1991) and this technology is now receiving an interest within the farming community in the southern United States. Mechanical termination of cover crops using a roller/crimper requires waiting at least three weeks before planting a cash crop into rolled residue (Ashford and Reeves, 2003; Kornecki, et al., 2006). Ashford and Reeves (2003) indicated that when rolling was conducted at the appropriate plant growth stage (i.e., soft dough), the roller was equally effective (vs. chemical herbicides) at terminating the cover crop (94%) and that rye termination rates above 90% were sufficient to begin planting of cash crop due to accelerated rye senescence. To speed up termination, producers utilize herbicides as a supplement to rolling. However, in organic vegetable production, common herbicides cannot be used and multiple rolling/crimping events may be necessary. There is a concern, however, that multiple rolling might cause soil compaction which could be detrimental to water infiltration and plant/root development. A field study conducted in Cullman, Alabama evaluated the effects of multiple rolling/crimping events on cover crops termination, soil strength and soil moisture.

To determine the effect of multiple rolling operations on soil strength, termination rate and soil water content, two rollers, straight-bar roller and two-stage roller, were used in a replicated field experiment in the spring of 2007. Cover crop termination rates were evaluated one, two, and three weeks after rolling.

The objectives of this study were: 1. Determine the effectiveness of two different roller designs in terminating a single cover crop (rye) and mixture (rye, clover, hairy vetch) in multiple rolling operations, 2. Determine the effect of multiple rolling on gravimetric soil water content and soil strength (Cone Index, CI).

Materials and Methods

In spring of 2007 a replicated field experiment (factorial treatment arrangement) was conducted in Cullman, Alabama to evaluate multiple mechanical terminations of two cover crops (factor I): single (rye) and a mixture (rye, hairy vetch and crimson clover) using two different rollers (factor II). Rye and mixture was drilled in the fall of 2006 (the end of October) using a Tye grain no-till drill*. The experiment was conducted April 24, 2007 when rye was in the early milk growth stage (Nelson et al., 1995) which is a desirable growth stage for rye termination. The experiment was a randomized complete block design (RCBD) with four blocks (replications). Treatments were randomized within each block. Each experimental unit was 6-m long and 1.8-m wide. Randomly assigned cover crops were rolled once, two, and three times (factor III) and scheduled every other day from previous rolling application. Before rolling, soil samples were obtained to determine gravimetric soil water content and soil strength was measured using a mobile soil cone-index meter. Two 1.8-m wide rollers utilized in the experiment were: a straight-bar roller (Figure 1a) and two-stage roller (Figure 1b).

Figure 1. (a) Straight-bar roller (b) Two-stage roller/crimper

Rye and mixture injury, based on visual desiccation, was estimated on a scale of 0 (no injury symptoms) to 100 (complete death) (Frans et al., 1986), and was evaluated at one, two, and three weeks after rolling. The speed 6.4 km/h was chosen to match speeds commonly used in field chemical applications. Treatment means were separated by the Fisher's protected LSD test at α=0.1 probability level (SAS, 2001).

Results and Discussion

a. Cover crop termination rates

Termination rates for rye and mixture (rye crimson clover and hairy vetch) are shown in Table 1. One week after rolling, significantly higher termination rates were reported for cover crops (rye only and mixture) rolled three times compared with rolled once and no-rolled cover crops. Second week after rolling, lower termination rates were reported for rye, crimson clover, hairy vetch mixture compared to rye only. The main reason for lower rates was a new and active growth of hairy vetch that altered termination rates. Three weeks after rolling no significant differences in termination rates (90% and above) were reported between roller types and numbers of rolling events. Although, compared to rolled residue no rolled covers produced significantly lower termination rates (51% to 63%). It should be noted that two weeks after rolling rye three times by each roller type, rye termination rates were high enough (90% and above) to successfully establish a cash crop into rye residue (Ashford and Reeves, 2003).

Table 1. Rye and mixture termination rates (%) for roller types and number of rolling operations. **Same letters indicate no significant differences within each column.

Rolling Treatment	Cover Crop	Roller type	First week	Second week	Third week
Not Rolled	Rye	No roller	0.0 d	38.8 f	63.3 b
	Mixture	No roller	0.0 d	21.3 g	51.3 c
Rolled 1 time	Rye	Straight	66.3 c	80.0 bc	91.0 a
		Two-stage	68.3 bc	82.5 abc	91.3 a
	Mixture	Straight	67.5 bc	46.3 ef	92.0 a
		Two-Stage	68.8 bc	46.3 ef	94.5 a
Rolled 2 times	Rye	Straight	78.8 a	87.5 ab	90.0 a
		Two-stage	73.8 abc	86.3 ab	92.5 a
	Mixture	Straight	67.5 bc	52.5 e	95.0 a
		Two-Stage	75.0 ab	63.8 d	93.3 a
Rolled 3 times	Rye	Straight	81.3 a	91.3 a	93.3 a
		Two-stage	81.3 a	90.0 ab	93.8 a
	Mixture	Straight	77.5 a	63.8 d	92.5 a
		Two-Stage	77.5 a	72.5 cd	92.0 a
LSD at α = 0.1 Significance level			8.15	10.28	9.26

b. Gravimetric soil moisture content before rolling treatment
No significant differences in gravimetric water content reported between all treatments at each depth i.e. 0-15 cm and 15-30 cm. Average gravimetric water content in the top layer (0 to 15 cm) was 12%.

c. Soil Cone Index (CI) before rolling treatment application
No significant differences in soil cone index at the top layer (0 to 15 cm) was found between all rolling treatments (rolled + non-rolled), roller types and number of rolling operation (Figure 2). These results provided a good base to determine rolling treatment effects on soil compaction and soil gravimetric water content.

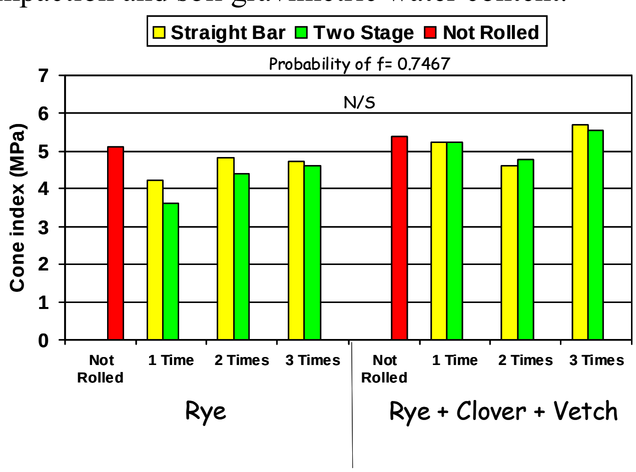

Figure 2. Soil Cone Index (CI) before rolling/crimping of both cover crops. No statistical differences between treatments found at α=0.1 significance level.

d. Gravimetric water content after rolling treatment application
There was a significant difference in soil gravimetric water content after rolling operation for different treatments. Compared with rolled cover crops, the lower gravimetric soil water content was associated with both non-rolled covers: rye and the mixture of rye crimson clover, hairy vetch (Figure 3). Significantly lower water content was most likely associated with the actively growing covers (rye and mixture) resulting in higher water usage. In addition, both non-rolled cover crops exhibited significantly lower termination

rates compared with rolled/crimped residue indicating actively growing covers which used more available water from soil than rolled/crimped residue.

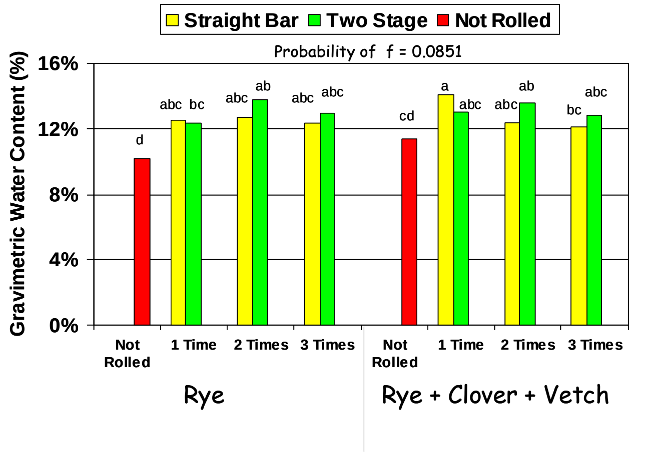

Figure 3. Gravimetric water content after rolling/crimping of both cover crops. Mean separation was performed using LSD (Fisher procedure) at α=0.1 significance level. Same letters indicate no statistical difference between all treatments (LSD=1.77%)

e. Cone Index (CI) after rolling treatment application

Compared to rolled/crimped rye and mixture treatments, significantly higher cone index were noted for both non-rolled residue (Figure 4). No significant differences in CI were found between non-rolled rye and mixture rolled twice by the straight bar roller. Except for the mixture rolled twice by the straight bar roller, all rolled covers exhibited a lower cone index while maintaining higher gravimetric soil water content. Significantly lower cone index for rolled cover crops residue indicates that rolling crimping operation for straight-bar roller designs does not increase CI, thus not elevating soil compaction. In contrast, the higher CI found with non-rolled cover crops is most likely associated with decreased soil water content due to reduced surface cover of standing cover crops and its evapotranspiration.

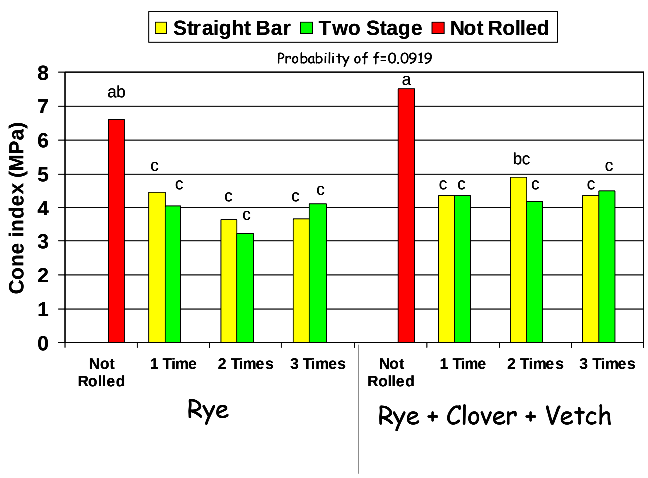

Figure 4. Soil Cone Index (CI) after rolling/crimping of both cover crops. Mean separation was performed using LSD (Fisher procedure) at α=0.1 significance level. Same letters indicate no statistical difference between all treatments (LSD=2.063 MPa)

Summary and Conclusion

1. Both roller types effectively terminated rye (> 90%) three weeks after rolling, which was above the recommended rye termination rates of 90% to plant a cash crop.
2. Rolling two or three times did not cause soil compaction, and rolled residue kept soil strength (Cone Index) significantly lower compared to standing cover crops.
3. Gravimetric soil water content after multiple rolling was significantly higher compared with standing rye and mixture covers. Multiple rolling can be beneficial for faster mechanical termination of single cover crops such as rye but not for mixtures. Mixtures which included hairy vetch, even after three rolling operations exhibited active growth two weeks after rolling.

Disclaimer:

*The use of trade names or company names does not imply endorsement by USDA-ARS.

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