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Effectiveness of different herbicide applicators mounted on a roller/crimper for accelerated termination of rye cover crop

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Abstract. *Under ideal weather conditions, a cash crop can be planted 3 weeks after rolling mature rye without using herbicides. However, cloudy and wet weather can delay the rolling and/or desiccation of rye thereby delaying cash crop planting which can negatively impact yield. One effective way to reduce the time between rolling and planting is to apply herbicide while rolling using a sprayer. However, a continuous spray may not be required if a roller is used. Two different methods of applying glyphosate (Roundup^{TM}) to rolled rye were compared. First, a felt strip saturated with herbicide was attached to the roller's crimping bar and provided Roundup application with every crimp. The second method was a boom (five nozzles controlled by solenoid valves) mounted on the roller providing spray either continuously, every 2nd crimp or every 4th crimp. Results showed that 7 days after rolling, the highest rye termination rates were recorded for continuous spray (100%) and for spray every 4th crimp (98%). The Roundup saturated felt strip and 2nd crimp spray produced 96% termination rates. For roller/crimper alone and no-roller, termination rates were 92% and 70%, respectively. Since spraying Roundup every 4th crimp provided a 98% termination rate one week after rolling, it may be feasible to use this method to allow a cash crop to be planted in a timely fashion. One and two weeks after rolling, volumetric soil moisture content for all rolled rye/chemical treatments were significantly higher compared to standing rye.*

Keywords. Chemical termination, cover crop, glyphosate, mechanical termination, roller/crimper.

Introduction

Cover crops are an essential component in conservation systems because they provide important benefits to soils and plants. To maximize benefits of cover crops they must produce maximum biomass (Brady and Weil, 1999). A widely used cover crop in the southern United States is rye (*Secale cereale* L), which produces between 3400 to 11200 kg/ha (Bowen et al., 2000). Primary benefits include soil protection from impact of rainfall energy, reduced runoff, decreased soil compaction and increased infiltration (Kern and Johnson, 1993; McGregor and Mutchler, 1992; Reeves, 1994; Raper et al., 2000a; Raper et al., 2000b). Cover crops also provide a physical barrier on the soil surface which inhibits weed emergence and growth. In addition to providing a physical barrier, rye has alleopathic properties that provide weed control similar to applying a pre-emergence herbicide (Barnes and Putman, 1986; Hoffman et al., 1996). Long term soil quality effects are associated with improving soil physical/chemical properties due to increasing soil organic carbon, resulting in better crop growth and sustainable agriculture.

Rolling/crimping technology has been used to manage mature cover crops by flattening and crimping cover crops such as rye in no-till conservation systems. Crimping cover crop tissue causes plant injury and accelerates its termination rate. In southern United States no-till conservation systems, terminating cover crops should be accomplished three weeks prior to planting the cash crop which is similar to standard burndown recommendations. Typically, three weeks after rolling, the termination rate for rye is above 95% when rolling is performed at an optimal growth stage (Ashford and Reeves, 2003; Kornecki et al., 2006). Most agricultural extension services recommend terminating the cover crop at least two weeks prior to planting the cash crop to prevent the cover crop from competing for valuable spring soil moisture that could be used by the main cash crop after planting. According to Hargrove and Frye (1987) a minimum time from rolling/crimping should be at least 14 days before planting of cash crop to enable soil water recharge prior to planting.

Under ideal weather conditions in the Southeast, rye cover termination for cotton is usually accomplished at the end of March, followed by planting of the cash crop 3 to 4 weeks after rolling. However, if late winter months and early spring months are unusually cold and wet or too dry, producers must wait longer for rye to obtain an optimum rye growth (in terms of appropriate growth stage and biomass), while planting the cash crop late which might compromise yield. Delays in termination of cover crop may decrease the time between rolling and planting the cash crop and might also create problems with managing cover crop residue during planting. Optimum residue conditions for planting a cash crop is usually attained 3 weeks after termination, at which time the residue is dry, crisp, brittle, and easy to penetrate with equipment. However, if there is an insufficient time between cover crop termination and planting of a cash crop, the cover crop might not completely loose its elasticity, strength and moisture, making planting difficult due to the possibility of frequent wrapping and accumulation of rye residue on planting units, as well as increasing the possibility of hair-pinning.

One way to speed-up the termination process of cover crops is applying herbicide in addition to rolling/crimping. This practice has been implemented by producers in the southeastern United States. However, mechanical crimping and a broadcast application of herbicide might exceed the amount of herbicide needed to effectively terminate a cereal cover crop. An alternative method is to apply herbicide in short spray intervals to the area of injured rye tissue. Thus a question arises as to how much herbicide is needed and what is the most efficient method to apply herbicide in conjunction with rolling/crimping.

The objectives of this study were to determine the effectiveness of different methods of herbicide application attached to the roller/crimper to apply Roundup™ directly to crimped tissue of rye and rolling/herbicide treatment effects on volumetric soil moisture content.

Methods and Materials

These experiments were conducted at the E.V. Smith Research Station near Shorter, Alabama on a Compass loamy sand soil (thermic Plinthic Paleudults). Rye as a winter cover crop was planted in fall 2005. All treatments were applied in mid-April 2006, when rye was in the soft dough growth stage, which it is a desirable growth stage for mechanical rye termination according to Nelson et al., (1995). Treatment arrangement is shown in Fig. 1. A randomized complete block design (RCDB) was utilized with four replications. Each plot was 15 m (50 ft) long and 1.8 m (6 ft) wide. Roller operating speed was set to 4.8 km/h (3.0 MPH).

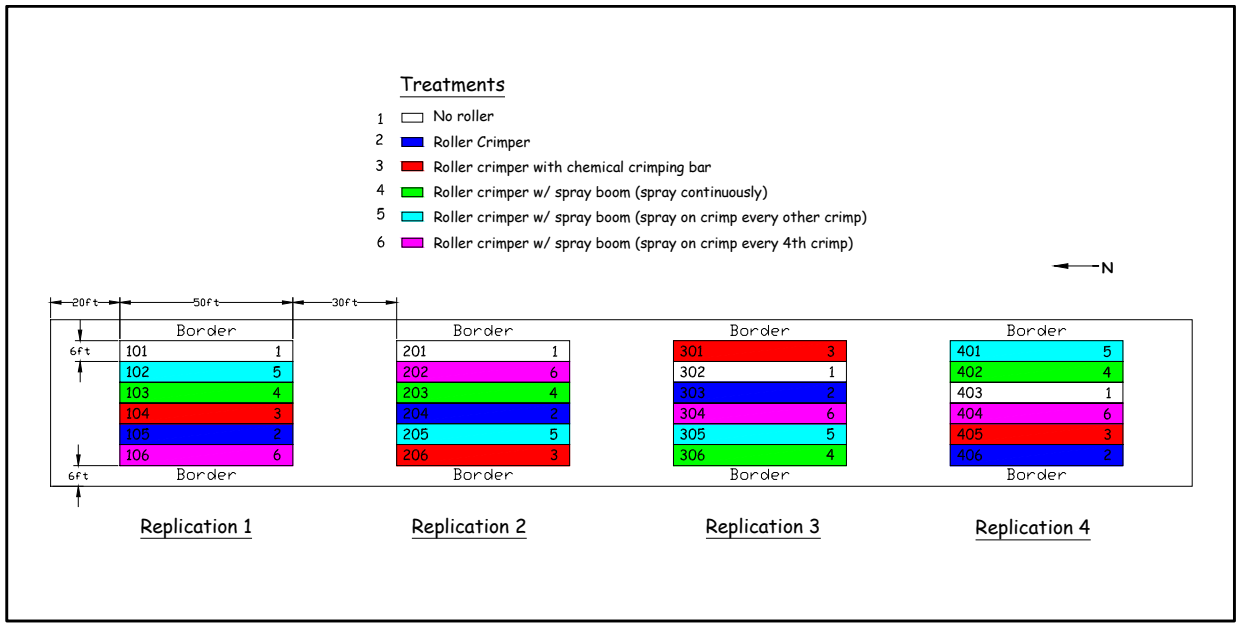

Figure 1. A randomized complete block design (RCBD) experiment layout with four replications.

Two methods of Roundup** application were compared to a non-treated check. In the first method, a #95 Medium density gray felt material (Western Felt & Fiber**, Alhambra, CA) which was 1.4 cm (5/8 in) thick, 4.4 cm (1 ¾ in) wide, and 180 cm (6 ft) long was mounted directly on the roller's crimping bar. A custom made 180 cm (6 ft) long aluminum housing was used to contain the felt material. Felt material was placed below a soaker hose that applied herbicide to the felt. The soaker hose was silicone sealed inside the housing and supplied chemical directly to the felt material (Fig. 2). The aluminum housing/felt assembly was attached directly to the back side of the crimping bar. The felt material was positioned 0.5 cm (0.25 in) below the crimping edge of the crimping bar.

When the crimping bar was in contact with the rolled cover crop, the felt material saturated with Roundup was compressed against the cover crop Roundup was released from felt strip on the injured rye tissue and applied herbicide with every crimp. To supply an equal amount of herbicide and control the flow and pressure of the water solution, a plastic 53 L tank with a pressure compensated vane pump powered by a 12-Volt electric motor from FlowJet** (model # 4300-504) and flow regulator were used. Operating system pressure was set to 207 kPa, (30 PSI).

Figure 2. Roundup discharge assembly from felt strip mounted to the crimping bar: A. sealed soak-type garden hose; B. crimping bar; C. Felt strip material.

The second application method was a steel boom with five nozzles mounted to the roller to provide spray continuously, every 2nd crimp and every 4th crimp using five fast acting solenoid valves from Capstan Ag System** (Fig 3).

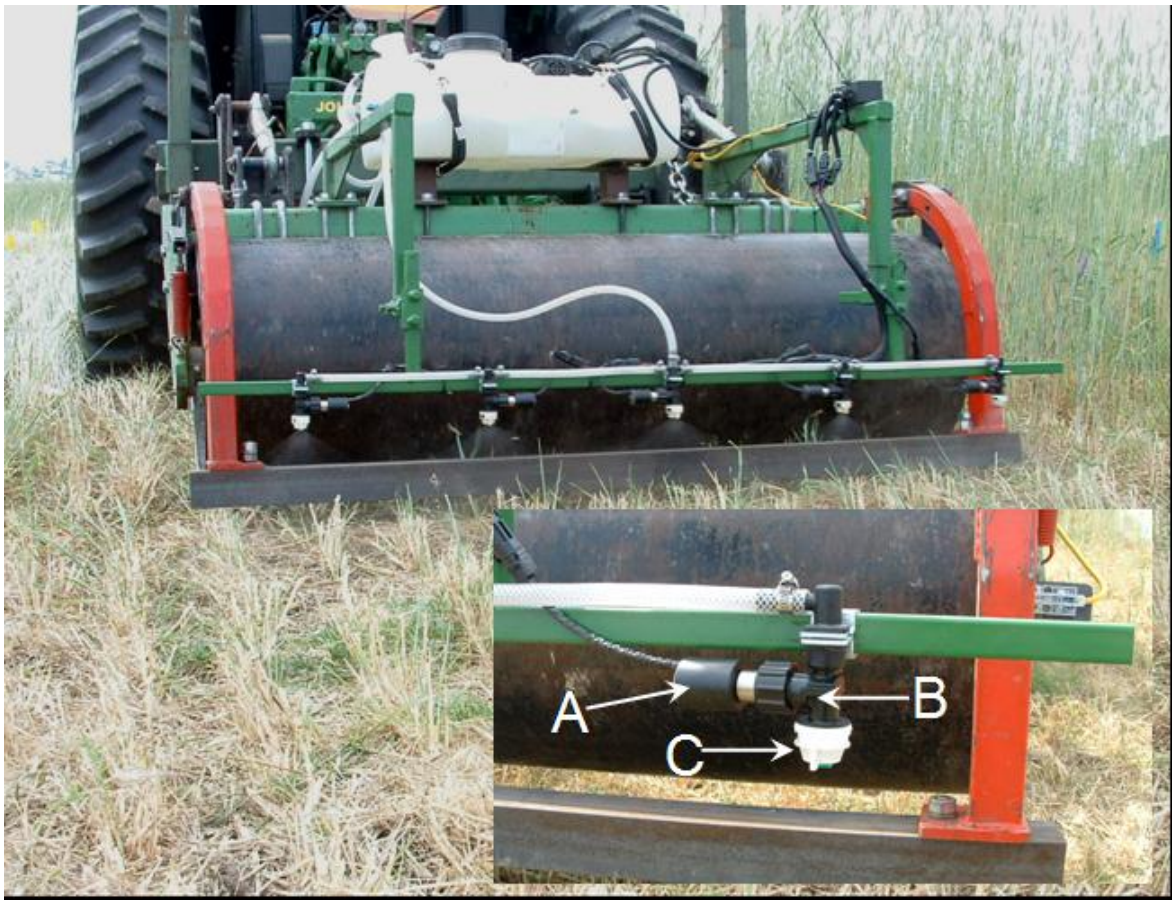

Figure 3. Back view of the smooth roller with crimping bar and the attached high speed solenoid valve: A. Solenoid valve, B. Nozzle body, C. Nozzle.

The same plastic tank, pump and flow regulator as described in the first method were used in the second method to supply Roundup to the nozzles. Five nozzles spaced 37 cm (14.5 in) apart were mounted to the steel boom providing a 1.8 m (6 ft) spraying width (Fig 3). Each nozzle assembly comprised of a fast acting solenoid valve and a narrow band nozzle (Fig 3 -A, B, C). Components of the control system were an electric micro-switch mounted to the roller's structural bar (Fig 4-A) and custom bolts used to trigger the switch (Fig. 4-B). The electrical switch was comprised of an adjustable engagement arm both in length and angle of engagement.

Four engagement bolts (for every second crimp) and two bolts (for every fourth crimp) as shown in Fig 4-B were fastened to the cam mechanism at equal intervals 10 cm (4 in) from the center of the roller's rotation. In operation, with roller rotation the engagement bolts were also rotated. When the bolt was in contact with the micro-switch arm, the arm was rotated and energized/de-energized the solenoid valves through the ON-OFF micro-switch (Fig. 4). When the solenoids were energized and activated the fast acting valves, Roundup was discharged through the nozzles for a very short period of time.

Rye mortality, based on visual observation, was estimated on a scale of 0% (no injury symptoms) to 100% (complete death of all plants) (Frans et al., 1986) and was evaluated at one, two, and three weeks after rolling treatments. Volumetric soil moisture content was measured at the time of rolling, one, two and three weeks after rolling using a portable TDR300 with 12 cm stainless steel rods from Spectrum Technologies**.

On April 15, 2006, the day before rolling/crimping of rye, plant biomass and heights were collected. Average dry biomass of rye was 7471 kg/ha, with an average plant height of 169 cm.

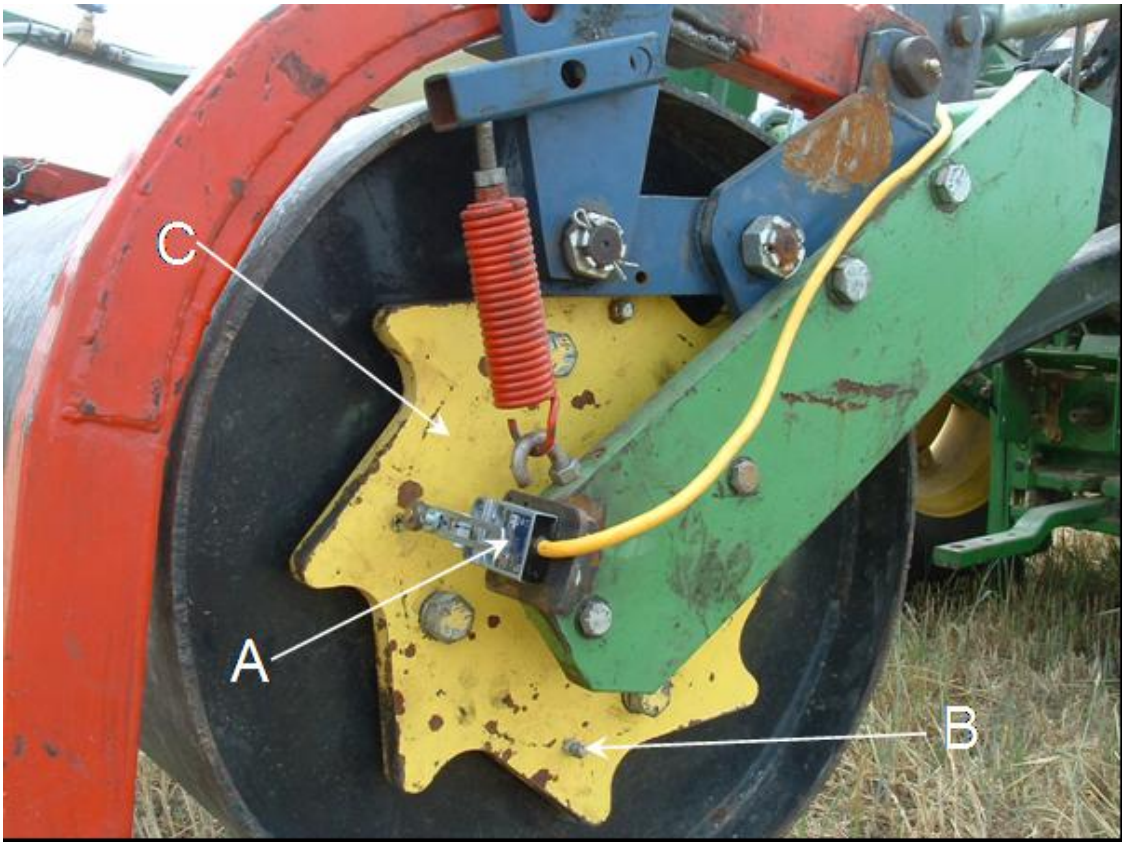

Figure 4. Side view of the smooth roller with crimping bar. A. Micro-switch; B. Engagement bolt with the switch's arm; C. Eight-cam crimping bar control mechanism with clockwise rotation.

Results

Rye Termination

Figure 5 shows rye termination at one, two and three weeks after treatment. At one week after rolling the highest termination rate (100%) was obtained for the roller/crimper and continuous broadcast Roundup application from a spray boom. The second highest termination rate of 98% was found with Roundup application at every 4th crimp; however, there were no significant differences between these treatments (LSD=1.7). Significantly lower termination rates (95%) were recorded for the roller with felt material attached to the crimping bar and roller/crimper with Roundup application with every other crimp. Roller/crimper alone produced 92% rye termination. The lowest termination rate of 70% was obtained with senescing non-treated rye.

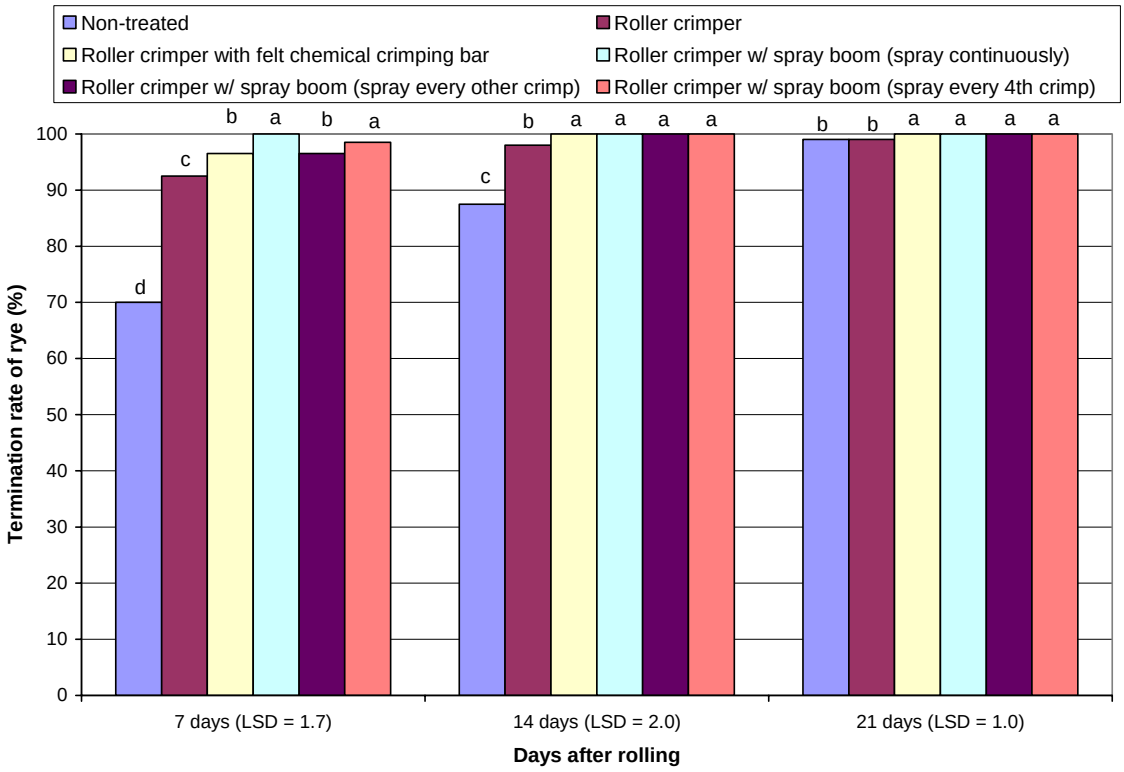

Figure 5. Termination rates of rye for different rolling treatments at one, two, and three weeks after rolling.

Two weeks after rolling treatment, all chemical treatments produced 100% termination. Significantly lower termination rates (LSD= 2) were produced by the roller/crimper alone (97%) and non-treated check (87%). The lowest termination rate was found with no-roller treatment (87%). Three weeks after treatment, termination rates for the roller/crimper and non-treated check increased to 99%. Ashford and Reeves (2003) indicated that termination rates above 90% were acceptable for planting a cash crop into the rolled/crimped rye residue cover. Thus, based on our preliminary results (except for non treated rye), planting a cash crop may be feasible as early as one week after rolling for all rolling plus chemical treatments. Additional economical and environmental benefits of using roller/crimper and intermittent chemical application (every 4th crimp) may be attained compared to a continuous broadcast application.

Soil moisture

Soil moisture was measured on the day of treatment and after the first, second and third week. Rolling treatment effects on soil moisture are shown in Fig. 6. At time of treatment application, volumetric soil moisture content for all rolled rye treatments varied from 6.5 to 8.1%. Significantly higher soil moisture was recorded for roller/crimper and felt chemical applicator (8.1%). However, there were no significant differences between roller/felt applicator, the roller/boom spray at every 4th crimp and roller alone (LSD=1.2). Lower soil moisture was measured with intermittent application (every 2nd crimp), and the roller with continuous application; the lowest was for non treated rye (5.8%). On the day of rolling/crimping, the difference between the highest and the lowest moisture content was 2.4% and the difference between the lowest moisture for rolled rye/chemical treatment and non treated rye was 0.8%.

One week after treatment, all rolled rye and chemical treatments resulted in soil moisture between 8.3 and 10.2%; however, the difference between the significantly higher (LSD=1.8) moisture (rolled + felt applicator) and the lowest (non –treated rye) increased to 5%, suggesting that rolled residue protected soil from loosing moisture by creating a mulch effect, whereas standing rye did not adequately protect the soil surface, most likely due to active rye growth and evaporation from exposed bare soil. The difference between the lowest moisture for rolled rye/chemical treatment and non-treated rye increased to 3.2% from 2.4% at time of treatment application.

Two weeks after rolling, moisture for rolling/crimping and chemical treatments resulted in moisture content between 5.3% and 6.8% (LSD=0.8). For non-treated rye, soil moisture was 1.8%. Although there was soil moisture depletion across all treatments due to lack of rainfall, when compared to the first week, rolling treatments provided greater soil moisture conservation than standing rye. The difference between the lowest moisture for rolled rye/chemical application and standing rye increased to 3.6% (first week after treatment application this difference was 3.2%) indicating that rolled rye continued to provide better soil moisture conservation. Two weeks after rolling, termination rate of non-treated rye increased (87%) while soil moisture further decreased. Likewise, three weeks after rolling, termination rate for non-treated rye further increased (99%) while volumetric soil moisture was significantly lower (3%) than for roller/crimper alone (LSD=1.6). Near full termination rate might indicate that a decrease in soil moisture is more related to soil evaporation due to a lack of surface cover rather than moisture uptake by the cover crop. This is especially important in drought periods when conserved moisture is needed in planting of a cash crop for adequate emergence and plant growth.

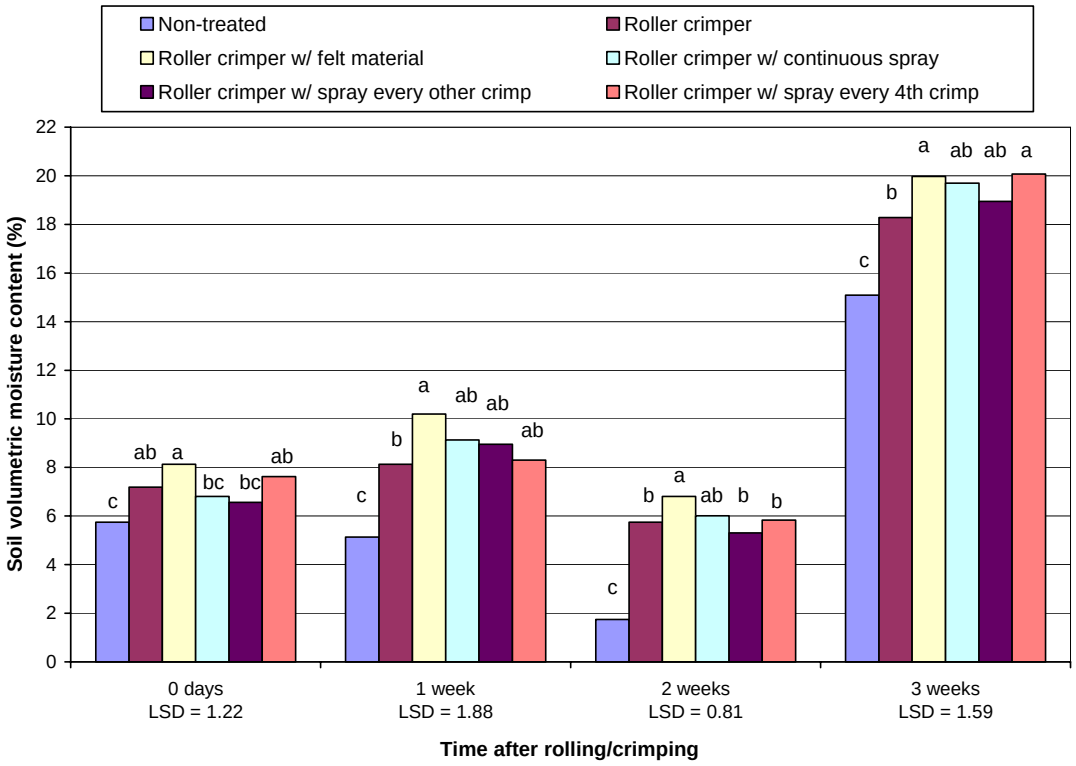

Figure 6. Rolling/chemical treatment effect on soil moisture measured on a rolling day and one, two, and three weeks after rolling/crimping of rye.

Conclusion

Two different methods of Roundup application combined with rolling were compared. Based on the results from one growing season (2005-2006) one week after rolling/crimping plus Roundup application, the highest rye termination rates were obtained for continuous spray (100%) and for spray every 4th crimp (98%). The felt strip saturated with Roundup and every 2nd crimp spray from nozzles both produced a 96% termination rate. For the roller/crimper alone and the non-treated plots, rye termination rates were 92% and 70%, respectively. Results suggest that since spraying Roundup every 4th crimp provided a 98% termination rate one week after rolling rye, it may be feasible to use this method of rolling, allowing a cash crop to be planted one week from rolling and Roundup application. Using less Roundup, would also provide savings to the producer while reducing environmental impacts. Rolling/crimping alone and with Roundup treatment also helped to conserve soil moisture by at least 3% of volumetric moisture content compared to the standing rye.

Disclaimer

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

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