

ROLLER TYPE AND OPERATING SPEED EFFECTS ON RYE KILL RATES, SOIL MOISTURE AND IRRIGATED SWEET CORN YIELD IN AN ALABAMA NO-TILL SYSTEM

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A field experiment was conducted in Cullman, Alabama to evaluate the effects of three different rollers/crimpers on terminating a rye (*Secale cereale* L) cover crop, soil moisture, and sweet corn yield in a no-till system. Three roller types were tested: a straight bar roller, a smooth roller with crimper, and a two-stage roller at speeds of 2 and 4 MPH. Termination rates provided by the three rollers/crimpers were compared to a smooth drum roller (no crimping bar) plus glyphosate (RoundupTM WeatherMax)** applied at 1 lb/acre. Initial data indicates that three weeks after rolling 100% termination was attained by the smooth roller and glyphosate. A termination of 68% was attained following the smooth roller with crimper at 4 MPH; however, no significant differences were found between the straight bar roller at both speeds, the smooth roller with crimper and the two-stage roller at 4 MPH (67%). Roller type did not affect soil moisture after the first and second week from rolling. No significant difference in sweet corn yield was found between straight bar roller at 4 MPH, two-stage roller at 2 MPH, and smooth roller plus glyphosate. The lowest yield was found with smooth drum roller plus glyphosate. The highest yield (15,348 lbs/ac or 6.85 tonnes/ac) was recorded following the smooth roller with crimper at 4 MPH.

INTRODUCTION

Cover crops are an integral element in no-till conservation systems because they provide important benefits to soils and plants. Covers must produce maximum biomass to maximize these benefits (Brady and Weil, 1999). A commonly used cover crop in the southern United States is rye, which can produce 3000 to 10000 lbs/ac (Bowen et al., 2000). Primary benefits include soil protection from impact of rainfall energy leading to reduced soil erosion and surface 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). Additional benefits are associated with improving soil physical/chemical properties due to increasing soil organic carbon level, resulting in better crop growth.

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 U.S. conservation systems, cover crops should be terminated 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 from early milk to soft dough (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. A study conducted by Ashford and Reeves (2003) showed that anthesis growth stage produced 80% termination three weeks after mechanical rolling/crimping of rye.

Optimum residue conditions for planting a cash crop are usually attained 3 weeks after termination, at which time the residue is dry, crisp, brittle, and easy to penetrate with equipment. To speed up the cover crop termination process, herbicide application has been implemented along with rolling in conservation systems in the southeastern U.S. both for field and vegetable crops. However, herbicide use is not allowed in organic vegetable production; thus, cover crop management must be done mechanically by cutting/incorporating or rolling/crimping technology. Different roller designs have been developed to roll and crimp cover crops; however, none have been evaluated in vegetable production systems. The objectives of this study were to determine the effectiveness of different roller designs and two different speeds on mechanical termination of a rye cover crop and the effects on soil volumetric moisture content and sweet corn yield.

METHODS AND MATERIALS

The experiment was conducted at the North Alabama Horticultural Research Center in Cullman, Alabama on a Hartsells fine sandy loam soil (Fine –loamy, siliceous, subactive, thermic Typic Paleudults). Rye as a winter cover crop was planted on October 16, 2005. All treatments were applied in mid-April 2006, when rye was in anthesis growth stage. Termination of rye at the anthesis growth stage was chosen because sweet corn must be planted early in the spring to produce an optimum yield. Treatment arrangement is shown in Fig. 1. A randomized block design (RBD) was utilized with four replications. Each plot was 50 ft long and 18 ft wide. Roller operating speed was set to 2 and 4 MPH.

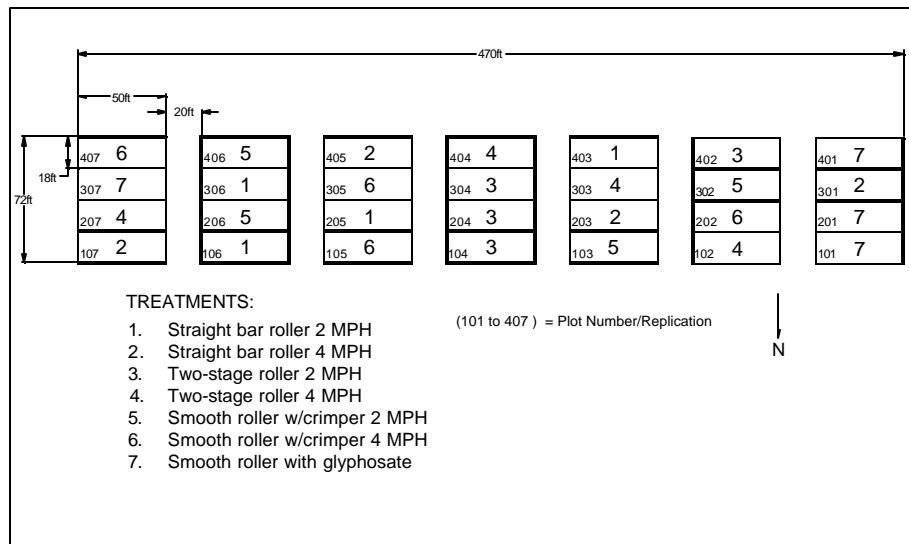


Figure 1. A randomized block design (RBD) experimental layout with four replications.

Three different roller designs having a width of 6 ft were compared: 1. Straight-bar roller, a design based on the original technology from Brazil (Fig. 2); 2. Smooth roller with crimping bar developed at the National Soil Dynamics Lab (NSDL) (Fig. 3); and 3. Two-stage roller also developed at the NSDL, Auburn, AL (Fig. 4). Two operating speeds were chosen: 2 and 4 MPH. Comparison was made with a smooth drum roller with no-crimper attached plus glyphosate applied at 1 lb/acre as a control.



Figure 2. Original straight-bar roller.



Figure 3. Smooth roller with crimping bar.



Figure 4. Two-stage roller comprised of a smooth drum and spring loaded crimping bar drum.

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 treatment and at one and two weeks after treatment using a portable TDR300 meter (Spectrum Technologies, Inc.; Plainfield, IL)** with 4.8 inch stainless steel rods. On April 23, 2006, the day before rolling/crimping of rye, plant biomass and heights were collected. Treatment means were separated by the Fisher's protected least significant difference test at the 0.10 probability level using ANOVA Analyst's linear model in SAS 9.1 (SAS Institute Inc., Cary, NC).

RESULTS

RYE TERMINATION

An average height for rye was 67 in and average dry biomass was 7,656 lbs/acre. Figure 5 shows rye termination at one, two, and three weeks after treatment. At one week after rolling significantly higher termination rate (98%) was obtained for the smooth roller without crimper and glyphosate application compared to other treatments. The second highest termination rate of 33% was found with two-stage roller at both operating speeds; however, there were no significant differences between these treatments and straight bar roller at both speeds and smooth roller/crimper at 4 MPH. Significantly lower termination rates (27%) were recorded for the smooth roller/crimper at 2 MPH.

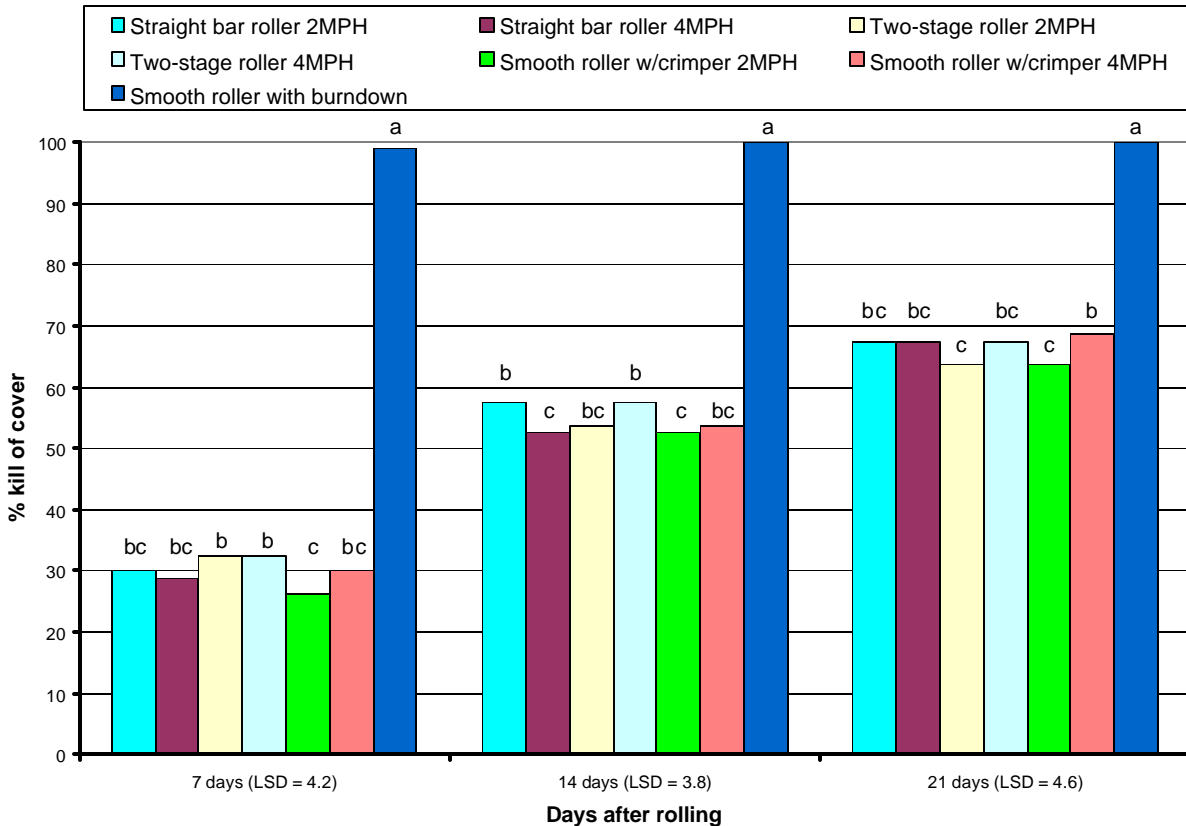


Figure 5. Termination rates of rye for different rolling treatments at one, two, and three weeks after rolling.

Two weeks after rolling treatment, smooth roller drum plus glyphosate produced 100% termination. Significantly lower termination rates (from 53% to 57%, LSD= 3.8) were produced by all other rollers; however, no differences were found between straight bar roller, at 2 MPH, two-stage roller at both speeds and the smooth roller w/crimper at 4 MPH. The lowest termination rate was found with the straight bar roller at 4 MPH, and the smooth roller w/crimper at 2 MPH. Three weeks after treatment, termination rates following rolling/crimping without herbicide application were between 63% and 68% for all rollers and speeds. This level of termination was not sufficient to plant sweet corn at the third week after rolling. Ashford and Reeves (2003) indicated that a termination rate for rye above 90% was acceptable for planting a cash crop into the rolled/crimped rye residue cover. The lower termination rate of rye in this study might be associated with termination too early in the anthesis growth stage which may have allowed rye to recover. Also, uneven soil surface (i.e. depressions from previous raised beds) and possibly lower soil strength resulting from higher volumetric soil moisture content that averaged about 15% at rolling treatment could reduce crimping effectiveness. Nelson et al., (1995) stated that later growth stage such as a soft dough stage for rye might be ideal for mechanical termination. To avoid late planting of sweet corn, an alternative treatment may be needed to fully terminate rye, in addition to mechanical termination using rollers.

SOIL MOISTURE

Soil moisture was measured on the day of roller treatment and, one and two weeks after. 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 14.0 to 16.0%. These differences might be associated with variations in water holding capacity as influenced by differing soil physical properties within the plot area. Significantly higher soil moisture was recorded for plots treated with the smooth roller/crimper at 2 MPH compared to the straight bar roller at 4 MPH and the smooth roller plus glyphosate. One week after rolling, similar trends in soil moisture content were recorded for all treatments except for the smooth drum roller with glyphosate where volumetric moisture content increased more rapidly (over 5%) compared to other treatments and to the day of treatments application. This can be explained by faster termination of cover crop due to glyphosate treatment, thus conserving more moisture in the soil. Rainfall events totaling 3 in. of depth (May 04-07, 2006), occurring between the first and second week after treatment application, raised volumetric moisture content above 30%, approaching field capacity, and no significant differences in soil moisture were found between all treatments. This rainfall required a waiting period for soil to dry and for the moisture to return to optimum conditions prior to planting sweet corn.

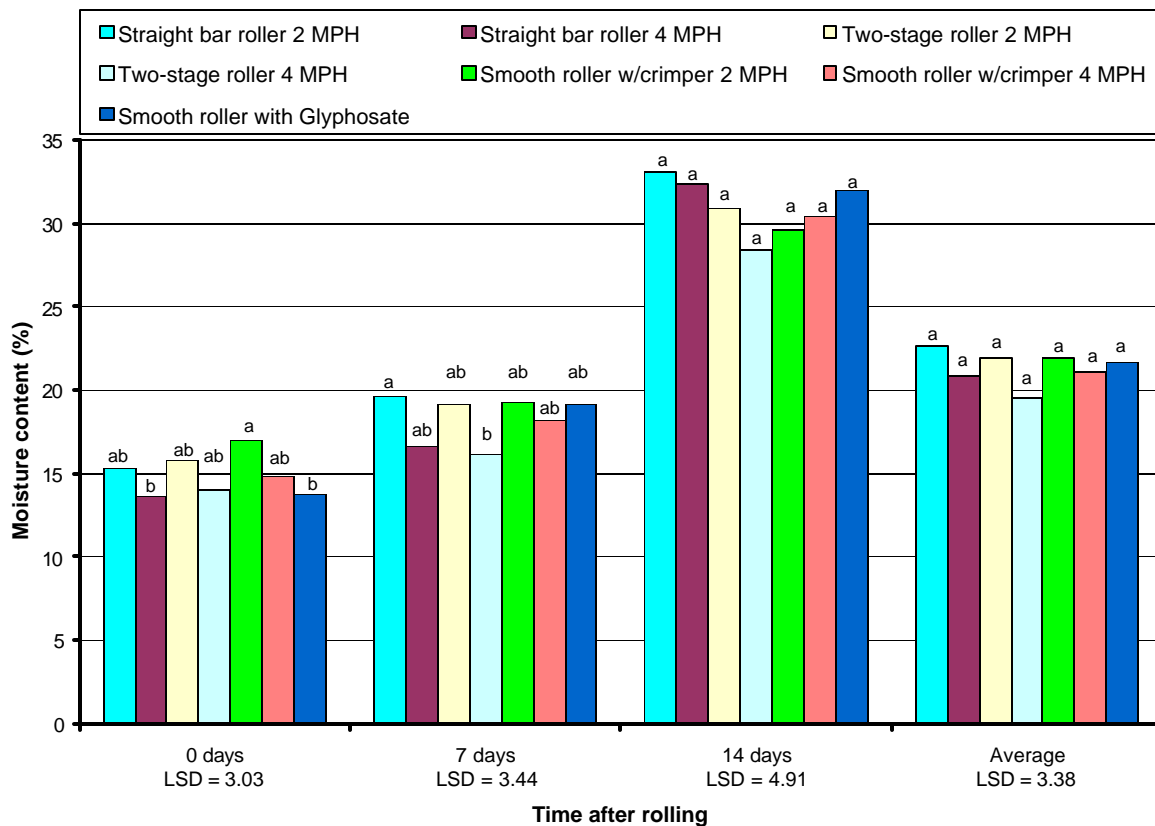


Figure 6. Soil volumetric moisture content at rolling, and one and two weeks after rolling.

SWEET CORN YIELD

No significant differences in sweet corn yield were found between operating speed and roller types. However, operating speed had an effect in increasing yield especially for the two-stage roller where sweet corn yield was 1,800 lbs/ac higher at 4 MPH (Fig. 7). Smaller differences in yield were recorded for the straight bar roller and the smooth roller with crimper. Unexpectedly higher sweet corn yields were found for all rollers and speeds compared to the control treatment of a smooth roller drum with glyphosate application. Significantly lower yield was recorded for

the smooth roller drum plus glyphosate application compared to the straight bar roller at 2 MPH, two-stage roller at 4 MPH and smooth roller/crimper at both speeds. Sweet corn yield recorded for the smooth drum roller and glyphosate was 4,000 lbs/ac lower when compared with the highest yield of 15,348 lbs/ac (6.85 tonnes/ac) following the smooth roller/crimper at 4 MPH. It is not clear why flattening and glyphosate treatment resulted in lower yield whereas mechanical rolling did not. One might speculate that perhaps glyphosate inhibited emergence of corn. There is no data suggesting Roundup's negative effects on emergence; however, it has been observed that in vegetable production under plastic, application of a herbicide to treat weeds before plastic installation inhibited vegetable growth, especially in dry years. Lower sweet corn yield from weed competition must be ruled out because all treatments received the same post emergence herbicide application to control weeds. Another explanation for the significantly lower yield reported for the smooth roller drum and glyphosate could be due to possible differences in soil properties within the field leading to different amounts of plant available water during the drought period which occurred in the 2006 growing season.

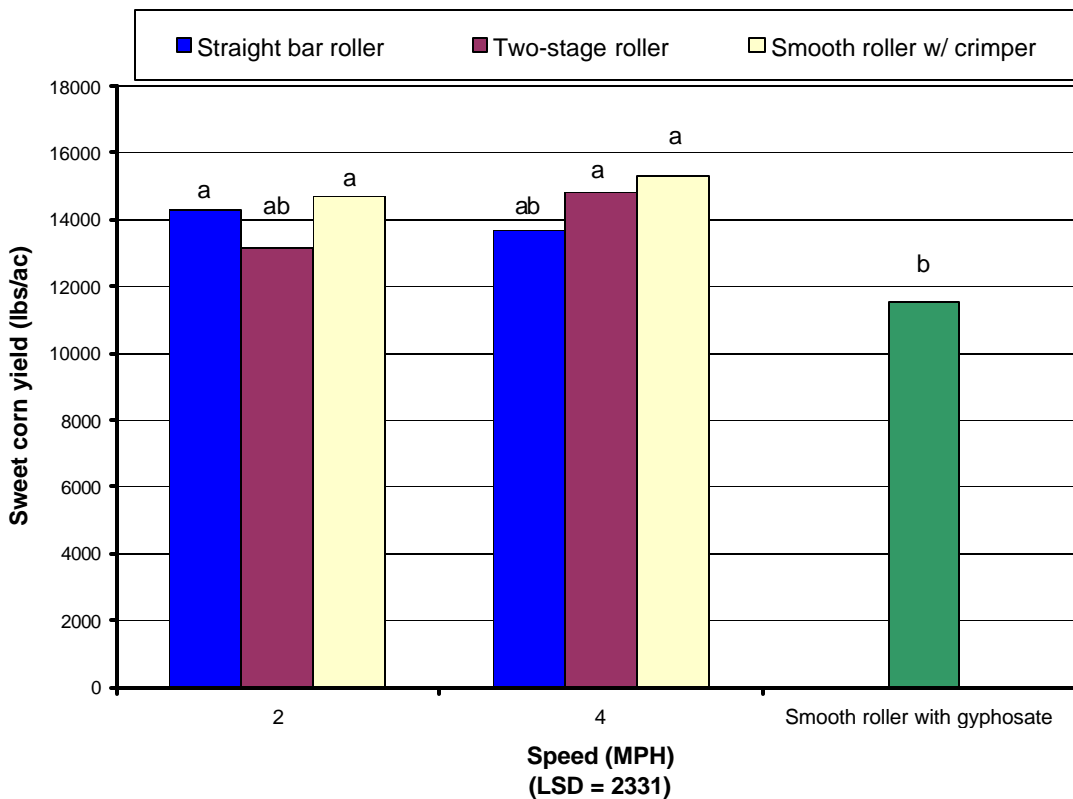


Figure 7. Roller type effect on sweet corn yield.

CONCLUSION

Three different roller designs operated at 2 and 4 MPH were compared to determine roller type and speed effects on rye cover termination, soil volumetric moisture content and sweet corn yield. A smooth drum roller with glyphosate application was used as a control. Based on the results from one growing season (2005-2006) the smooth drum with glyphosate application produced the highest rye termination rates of 98%, 100%, 100% compared to other treatments (30%, 58% and 68%, one, two and three weeks after treatment application, respectively). Lower mechanical termination was most likely caused by anthesis growth stage at time of

rolling/crimping. Roller type and operating speed did not affect soil moisture after the first and second week from rolling. Despite lower termination by rollers, sweet corn yield was not affected. These preliminary results suggest that terminating a rye cover crop using rollers/crimpers may not be suitable in no-till organic sweet corn production. However, the use of rollers/crimpers can still be beneficial in no-till vegetable production where chemicals may be used or where the rolling/crimping operation may be performed at the optimum (early milk/soft dough) stage of cover crop growth.

Disclaimer

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

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