IMPROVED ROLLER TECHNOLOGY FOR COVER CROP MANAGEMENT

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Abstract:

Cover crops have been shown to provide beneficial results for crop production and environmental protection; however, they can interfere with proper cash crop establishment and growth. Cover crops must be properly killed prior to planting to conserve moisture for cash crops. Cover crops rollers provide an easy alternative for this purpose. However, when machines developed in South America have been used in the U.S., producers have reported excessive amounts of vibration resulting from traveling at normal U.S. field speeds. A series of experiments were performed to modify the blade system used to crimp the residue without sacrificing the ability to kill the cover crop. Results showed that reduced vibration and equivalent percentages of cover crops were killed with the modified blade systems were used.

Introduction

Between 1990 and 2002, the number of U.S. cropland acres planted without tillage increased from 73.2 million acres to 103.1 million acres (CTIC, 2003). The use of cover crops has contributed to the overall success of conservation systems for many producers. Many studies have recognized the positive benefits of winter cover crops as a component of conservation tillage systems. These include increased water infiltration, reduced runoff, reduced soil erosion, and reduced negative effects of soil compaction (Reeves, 1994; Raper *et al.*, 2000a; Raper *et al.*, 2000b).

Prior to planting the cash crop, the cover crop must be terminated. This should prevent the cover crop from using valuable spring moisture that could be used by the main cash crop after it has been planted. Several methods have been used for this purpose with the most common being the use of chemicals. This option is relatively quick and inexpensive and has quickly become the method of choice. However, planting after a chemical kill can sometimes be difficult if the cover crop was allowed to become too large and it has lodged in multiple directions. Another method that has often been used to terminate the cover crop is to mow it. This option may also have problems because cover crops can sometimes re-sprout and can compete with the cash crop for available moisture and nutrients. Also, the unattached crop residue can make planting difficult as row cleaners can become clogged with the loose residue and require frequent cleaning. Flattening and crimping cover crops has become a preferred method of terminating cover crops in South America. Implements for this purpose are usually round drums with attached blunt blades. There are multiple benefits of rolling a cover crop (Ashford and Reeves, 2003). First, when the operation is conducted at the optimal stage of plant growth, the roller is equally effective as chemicals at terminating the cover crop. Second, the energy required for rolling is significantly reduced from that of mowing, perhaps even as much as tenfold. Thirdly, a flattened mat of cover crop is created. Producers using planters operating parallel or slightly off parallel to this direction have been very successful in obtaining proper plant establishment.

Some North American producers have reported problems with mechanical rollers; however, when they have attempted to use rollers copied from South America. The main complaint has been the excessive vibration that the rollers translate to the tractor. The most effective method of alleviating the vibration has been to reduce travel speed. However, most producers find this to be an unacceptable solution due to the much higher speeds that they were able to previously chemically spray their cover crops. The objective of this paper is, therefore; to determine if alternative blade designs would reduce vibration while maintaining adequate termination of cover crops.

Materials and Methods

Vibration Experiment

An experimental roller was designed and manufactured by an Auburn University Mechanical Engineering design class as part of their capstone design project that had the capability of using three different blade systems (Figure 1). This implement had a diameter of 0.41 m, a width of 0.91 m, and weighed 341 kg. It was mounted on a category 1 toolbar. This toolbar was mounted on a soil bin car. Using this car, nothing was allowed to touch the cover crop or soil except for the roller which was operated at a speed of approximately 1.3 m/s. Vibration data was obtained with a Quest Technologies VI-100 Vibration Meter. The vibration sensor was mounted on the frame of the experimental roller perpendicular to the measuring surface to give a vertical acceleration. Seven observations were read from the digital display and were manually recorded for each plot. Acceleration data (m/s^2) was reported in root-mean-square (RMS) values, which is 0.707 of the peak-to-peak acceleration.

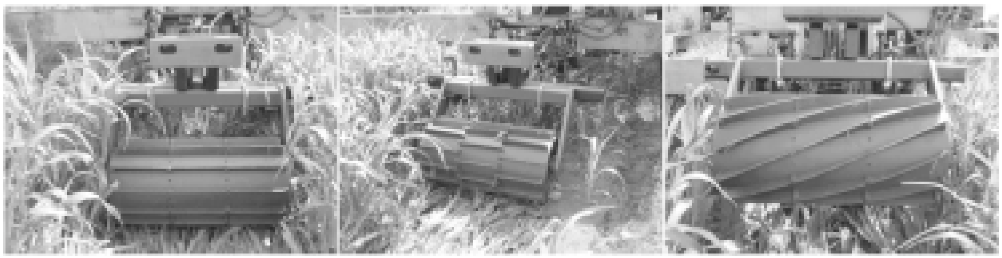

Figure 1. Small roller used for Experiments. On the left is the long-straight blade system, in the center is the short-staggered straight blade system, and to the right is the curved blade system.

Evaluation of Different Blade Systems

Another experiment was conducted in the field and in a concrete-floored shed at the E.V. Smith Research Station near Shorter, AL. This experiment consisted of determining vibration information for each of the three blade systems used on the experimental roller used in the previous experiment. These blade systems were: long-straight blades, short-staggered straight blades, and curved blades. Four replications of each blade treatment were conducted on three surfaces: rye cover crop in field, grassed area, and concrete shed floor. The small roller was attached to the JD 4400 tractor and was operated at a constant speed of 1.3 m/s.

A rye cover crop was grown during winter months of 2002 and spring months of 2003. The experiment was conducted in late April 2003 when the rye cover crop was in a late soft dough stage. Measurements of rye cover crop mass were taken on a 0.25-m^2 plot area immediately after the completion of the experiment as well as weekly measurements of cover crop kill. Measurements of vibration using the Quest Technologies Vibration Meter were also obtained for each blade system on each surface.

Results and Discussion

Vibration Experiment

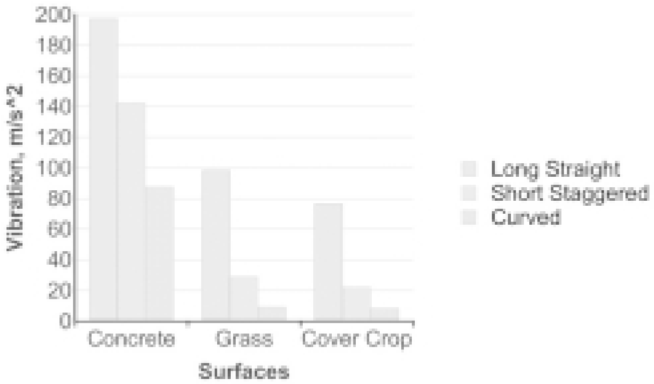

Figure 2. Vibration data obtained with the experimental roller. $LSD_{0.1}$ between surfaces within treatments = 6.9 m/s^2; $LSD_{0.1}$ between treatments within surfaces = 5.8 m/s^2.

Statistically significant vibration results were found for each of the blade systems on each of the surfaces tested (Figure 2). As expected, the highest levels of vibration were measured on the concrete floor by all three blade treatments. On the concrete surface, the long-straight blade system recorded the highest value of almost 200 m/s^2. The grassed area recorded the next highest vibration values which were statistically greater than those recorded for the rye cover crop area.

The long-straight blade system consistently recorded the maximum values for each surface tested. Although the short-staggered straight blade system recorded statistically higher vibration values as compared to the curved blade system, both of these two treatments were more similar as opposed to the long-straight blade system.

Evaluation of Different Blade Systems in Field

During the winter months of 2002 and spring months of 2003, the rye cover crop produced 3404 kg/ha. By the time the rolling experiment was conducted in late April of 2003, the cover crop had already started to die. Partly due to timing and partly due to the success of the blade systems, there were no measurable differences with all three designs achieving a 100% kill within one week after the rolling operation.

Conclusions

Small experimental rollers were used which provided adequate pressures for rolling and crimping cover crops and to provide for adequate kill. The minimum pressure of 614 kPa provided similar kill values of the cover crop as those resulting from the much larger pressure of 1048 kPa. Two alternate blade systems for the roller which were designed to reduce vibration were found to reduce vibration significantly with the curved systems having reduced vibration as compared to the short-staggered straight blade system. All blade systems performed equally well in killing the cover crops in field and soil bin experiments.

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