ROLLER/CRIMPER DESIGNS FOR COVER CROPS MANAGEMENT ON DIFFERENT FARM SCALES USING CONSERVATION PRACTICES



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Location of the USDA-Agricultural Research Service, National Soil Dynamics Laboratory



Alabama soils: Ultisols, sandy soils - coastal plains; Alfisols, the fine-textured soils – Piedmont These soils are highly weathered, low organic matter (less than 1%)

Presentation Outline

- Conservation tillage information
- > Cover crops benefits
- > Roller/crimper technology background
- > Results from testing different rollers/crimpers
- > Other equipment development
- Summary

Conservation tillage: more than 30% of residue cover

Important factors in conservation tillage:

- 1. <u>Minimizing soil disruption</u> (non-inversion tillage), and
- 2. <u>Maximizing soil coverage</u> using cover crops



Conservation Agriculture (CA)

CA is defined as <u>minimal soil disturbance</u> (no-till) and <u>permanent soil cover</u> (mulch) <u>combined with rotations</u>, as a more <u>sustainable cultivation system</u> for the future (FAO).

COUNTRY	CA area (ha)	%	
U.S.A.	35,613,000	23.0	
Brazil	31,811,000	20.6	
Argentina	27,000,000	17.5	84.3%
Canada	18,313,000	11.8	
Australia	17,695,000	11.4	
Rest of the World: 24,378,000 ha (15.7%). Total CA	154,810,000	100	FAO, 2014

Cover crops are a vital part of conservation agriculture and they need to produce optimum biomass to provide most benefits. Cover crops used in Alabama

Secale cereale L

Cereal Rye: 4000 to 9000 kg ha⁻¹



Hairy Vetch: 4500 to 7800 kg ha⁻¹, Nitrogen production: 100-220 kg ha⁻¹



Crimson Clover: 3900 to 6200 kg ha⁻¹, Nitrogen production: 170 kg ha⁻¹



Sunn Hemp: 5600 kg ha⁻¹, Nitrogen production: 130 kg ha⁻¹

Benefits from cover crops

- Improved soil quality and plant growth through:
- ✓ Reduced soil erosion
- ✓ Reduced soil compaction
- \checkmark Increased soil organic C and N
- ✓ Reduced weed pressure (mulch)

- Better water utilization by plants due to:
 - ✓ Reduced runoff
 - ✓ Reduced evaporation
 - ✓ Increased water infiltration
 - ✓ Increased available moisture

 Maintain soil sustainability and farm profitability

Benefits from cover crops are lost through:

- Incorporation (no soil protection and CO₂ emission)
- Mowing (regrowth and competition for resources)
- Burning (toxic gases emission, hydrophobic surface)

Planting problems in High Residue Systems

Hair Pinning



Residue accumulation on planter





General poor stands or yield loss



Rolling/crimping technology

Rollers/crimpers have been used to <u>flatten and mechanically</u> <u>terminate cover crops in the same direction as cash crop</u> <u>planting</u>.

<u>Rolling is important for tall cover crops</u>, even if terminated with herbicides (but not rolled down) the residue will interfere with

<u>planters</u>.







Crimping action injures cover crop by crushing plant's tissue <u>against</u> <u>a firm soil surface</u>.

Termination and cover crop growth stage

Cover crops must be terminated at the appropriate growth stage.



In the Southern U.S. cover crops are <u>terminated three weeks before</u> <u>planting a cash crop</u> to eliminate competition for nutrients and water between cover and cash crop (Ashford and Reeves, 2003).

Cover crop termination rate at planting cash crop must exceed 90%.

Ashford, D. L., and D. W. Reeves. 2003. Use of a mechanical roller crimper as an alternative termination method for cover crop. *American J. of Alternative Agric.* 18(1): 37-45.

Examples of different roller designs



Original design: straight bar roller, which at higher speeds generated excessive vibration.



Curved bars roller



Two-section curved bars roller



Smooth roller with crimping arm; Kornecki, U.S. Patent # 7,604,067 B1

Single-section Roller Experiment

Three roller designs were tested at 1.6 km/h, 3.2 km/h and 8.0 km/h operating speeds to evaluate speed and roller type effects on rye termination one, two and three weeks after rolling, and tractor vibrations



Developed at the National Soil Dynamics Lab.

Straight bar roller

Curved bar roller

Smooth roller with crimper

Roller's width = 1.8 m

Cumulative termination rates



Kornecki, T.S., Price, A.J., Raper, R.L. 2006. Performance of different roller designs in terminating cover crops. Applied Engineering in Agriculture. 22(5):633-641

Tractor frame vibration



Kornecki, T.S., Price, A.J., Raper, R.L. 2006. Performance of different roller designs in terminating cover crops. Applied Engineering in Agriculture. 22(5):633-641

How to effectively speed-up cover crop termination ? <u>Cold and wet weather in spring can delay the rolling of cover</u> <u>crop also could delay cash crop planting</u>





ON-OFF micro-switch



Fast acting solenoid valve

Amounts of glyphosate (Roundup) used

Treatment	Roundup solution applied (gal/ac)	% Roundup amount of continuous spray	Rye termination after one week (%)
Continuous spray	14.9	100	100
Spray every other crimp	4.3	29	98
Spray every 4 th crimp	1.9	13	96

T. S. Kornecki, A. J. Price, R. L. Raper, J. S. Bergtold, 2009. Effectiveness of different herbicide applicators mounted on a roller/crimper for accelerated rye cover crop termination. Applied Engineering in Agriculture. Vol. 25(6): 819-826

Roller/crimper for elevated beds



Two-row, three furrows Kornecki, U.S. Patent #7,662,517 B1



One row, two furrows



One row, two furrows



Transplanting sweet potato into cereal rye residue cover

Two-stage roller/crimper





Rear view Side View Kornecki, 2011,U.S. Patent # 7, 987, 917 B1



Two-stage roller for Randle Farms in Auburn, Alabama as a part of a CIG grant for multiyear on-farm experiment

2008 Results: Rye termination rates



Rye and Crimson Clover termination by two-stage roller

Rolling Treatments: Two-stage roller/crimper only Continuous spray + roller Spray every other crimp + roller Spray every third crimp + roller

- Roundup Powermax—325mL/7.5gallons (22 ounces/acre) (\$28.00-30.00/gallon)
- VINEGAR—20% No Dilution (15 gallons/acre) (\$16.10-21.49/gallon)
- WEED ZAP—Mix 64oz/per 10 gallons H2O (96 ounces/acre) (\$75.60-79.99/gallon)



Controlled herbicide discharge fo two-stage roller/crimper





2010 termination Rates for Rye



2010 termination rates for Crimson Clover



Video of rolling/crimping cover crops



Experiment evaluating rollers/crimpers for walk-behind tractors used on small farms

Rolling Treatments:

- Compare termination effectiveness in terminating cereal rye by three different roller types
- Effect of rolling passes by each roller (from 1 to 3) on cereal rye termination



Two-stage roller/crimper: Kornecki, 2011 U.S. Patent #7,987,917 B1 (USDA-NSDL)



Chevron type, curved bar roller from Earth Tools Inc. in Kentucky, USA



Powered roller/crimper, Kornecki 2012, U.S. Patent #8,176,991 B1 (USDA-NSDL)

Rye termination rates for different roller types



Rye terminated: April 23, 2013

For each week, different letters indicate significant differences between roller types and number of passes.



Video of rye termination by rollers/crimpers for walk-behind tractors



Other equipment development for no-till systems



Modified RJ one-row transplanter: Sub-frame with shank was added to alleviate soil compaction

Transplanting tomatoes into a heavy rye residue cover in Cullman, Alabama



Video of RJ transplanter with coulter and row cleaners



Video of Custom Residue Manager



Cover Crop Residue Manager, Kornecki et. al., 2014, U.S. Patent # 8770,119 B1

Summary

- New roller/crimper designs effectively terminate dense and tall cover crops without vibrations. Applicable for different tractor sizes/farm scales.
- Roller for elevated beds can effectively terminate cover crops grown on elevated bed culture.
- Compared to roller alone, termination process can be faster with continuous or reduced supplemental applications of Glyphosate herbicide.
- Powered and the two-stage roller/crimper for walk behind tractors gives small farms effective solution to terminate cover crops using limited power source.
- Sub-soiling and transplanting is an effective way to combine operations. Use of cover crop residue managers is effective alternative to a rotary row cleaners.



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