Managing Cover Crops in Conservation Agriculture

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- Conservation Tillage definition: >30% of residue cover on soil surface

Important factors in conservation tillage:

1. Minimizing soil disruption, and
2. Maximizing soil coverage using cover crops

Cover Crops

- Cover crops are a vital part of conservation agriculture and they need to produce maximum biomass to provide most benefits.

Cereal Rye: 3,000 to 7,000 lbs./acre

Crimson Clover: 3,500 to 5,500 lbs./acre,
N production: 150 lbs. N/acre

Hairy Vetch: 4,000 to 7,000 lbs./acre,
N production: 90-200 lbs. N/acre

Sunn Hemp: 5,000 lbs./acre,
N production: 120 lbs. N/acre

These crops must be managed appropriately to prevent planting problems for producers.

Benefits from cover crops:

- ✓ Reduced soil erosion
- ✓ Reduced soil compaction
- ✓ Increased soil organic carbon and nitrogen source
- ✓ Reduced weed pressure (mulch and allelopathy)

➢ Improving soil quality and plant growth

- ✓ Reduced runoff
- ✓ Reduced evaporation
- ✓ Increased water infiltration
- ✓ Increased available moisture

➢ Providing better water utilization by plants

Increase farm profitability and soil sustainability

Benefits from Cover Crops cont.,

Carbon (C) content in a plant: 42%*

* Brady and Weil (1999)

- For Average dry biomass of cereal rye = 5800 lbs./acre, the total carbon is 2400 lbs/acre (42%)*
- Microorganisms use 1600 lbs./acre as energy source (2/3 of total C)
- Sequestered carbon: 800 lbs./acre (1/3 of total C) per year is added to the soil

From 6,000 acres in Alabama's No-till vegetable production, near 2,200 tons of Carbon from rye are sequestered each year to typically low organic carbon content in Alabama's soils.

It is important to notice that each year carbon is added to the soil and increase organic matter content.

Planting problems in High Residue Systems

Hair Pinning

When improperly managed cover crops can interfere with planting. Causing skips and lower rate of plant emergence.

Planting problems in High Residue Systems

Hair Pinning
Residue accumulation on Planter

Tall residue can interfere with planters and require frequent cleaning thus casing delays in planting.

Cover Crop Management Methods

- Incorporation
- Mowing
- Burning
- Chemical application

Benefits are lost

- No soil protection from rainfall energy and CO_2 emission
- Re-growth and competition for resources with cash crop
- Toxic gases, CO_2 emission, soil hydrophobic surface due to heat
- Tall cover crops will interfere with planters, and environmental impact

- Rolling/crimping technology → Full Benefits

Principle of rolling crimping

Crimping action injures cover crop by crashing plant's tissue thus restricting nutrients flow and causing plant death

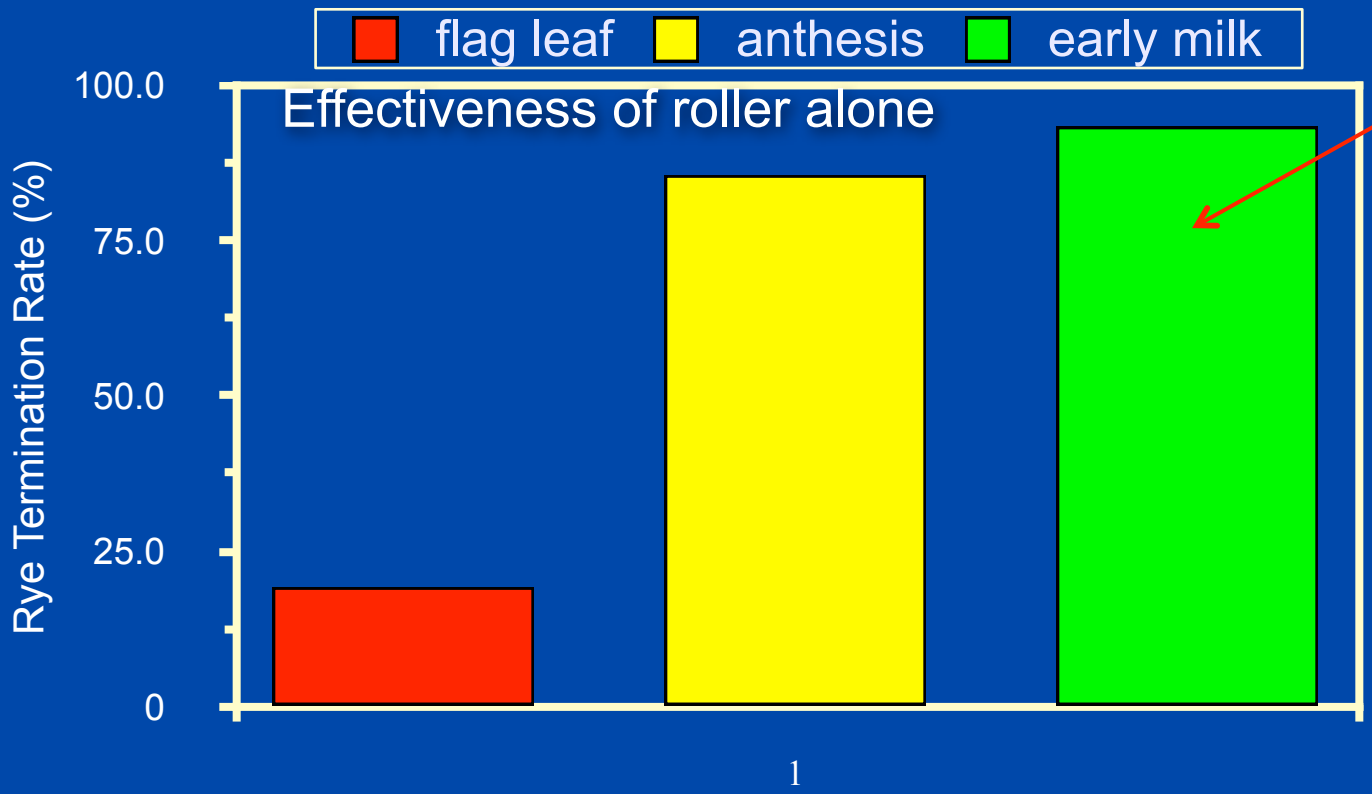
To improve crimping effectiveness of the original design, water was added into roller's drum to increase weight of the roller/crimper

Different varieties has been developed but all designs have crimping bars equally spaced around perimeter.

Planting problems in High Residue Systems

Hair Pinning
Residue accumulation on Planter
General Poor Stands

Relationship between rye growth stage and rolling/ crimping effectiveness 3 weeks after rolling



Ashford and Reeves, 2003

When do we terminate cover crops?

Recommended termination of rye is 3-4 weeks before planting a cash crop

Period of 3 weeks allows to effectively terminate rye mechanically using rollers above 95% and eliminate rye competition with cash crop for nutrients and water. After that period cash crop can be planted.

(Ashford and Reeves, 2003; Kornecki et al., 2006)

Cover crops are very important part in conservation systems and they have produce maximum biomass

CSR-Three-section straight bar roller

Why are original rollers-crimpers not widely adopted in the USA ?

Excessive vibration at higher speeds generated by the original roller design prevent to widely adopt this technology

With increasing speeds vibration levels also increase that are transfer to the tractor frame and consequently operator is subjected to these vibrations.

New Rolling/crimping technology

Smooth roller with crimping arm; Kornecki at al. 2009 U.S. Patent # 7,604,067 B1

Cold and wet weather in spring can delay the rolling of cover crop also delaying cash crop planting which can negatively impact yield. How to effectively speed-up cover termination ?

ON-OFF micro-switch

Fast acting solenoid valve

Single-section Roller Experiment

Three roller designs tested at 1.6 km/h, 3.2 km/h, and 8.0 km/h speeds to evaluate speed and roller type effects on rye termination and tractor vibrations

Developed at the USDA-ARS-National Soil Dynamics Laboratory

Long-straight bars

Elliptical bars

Smooth with crimping arm

Roller's width = 1.8 m

Vibration Measurements

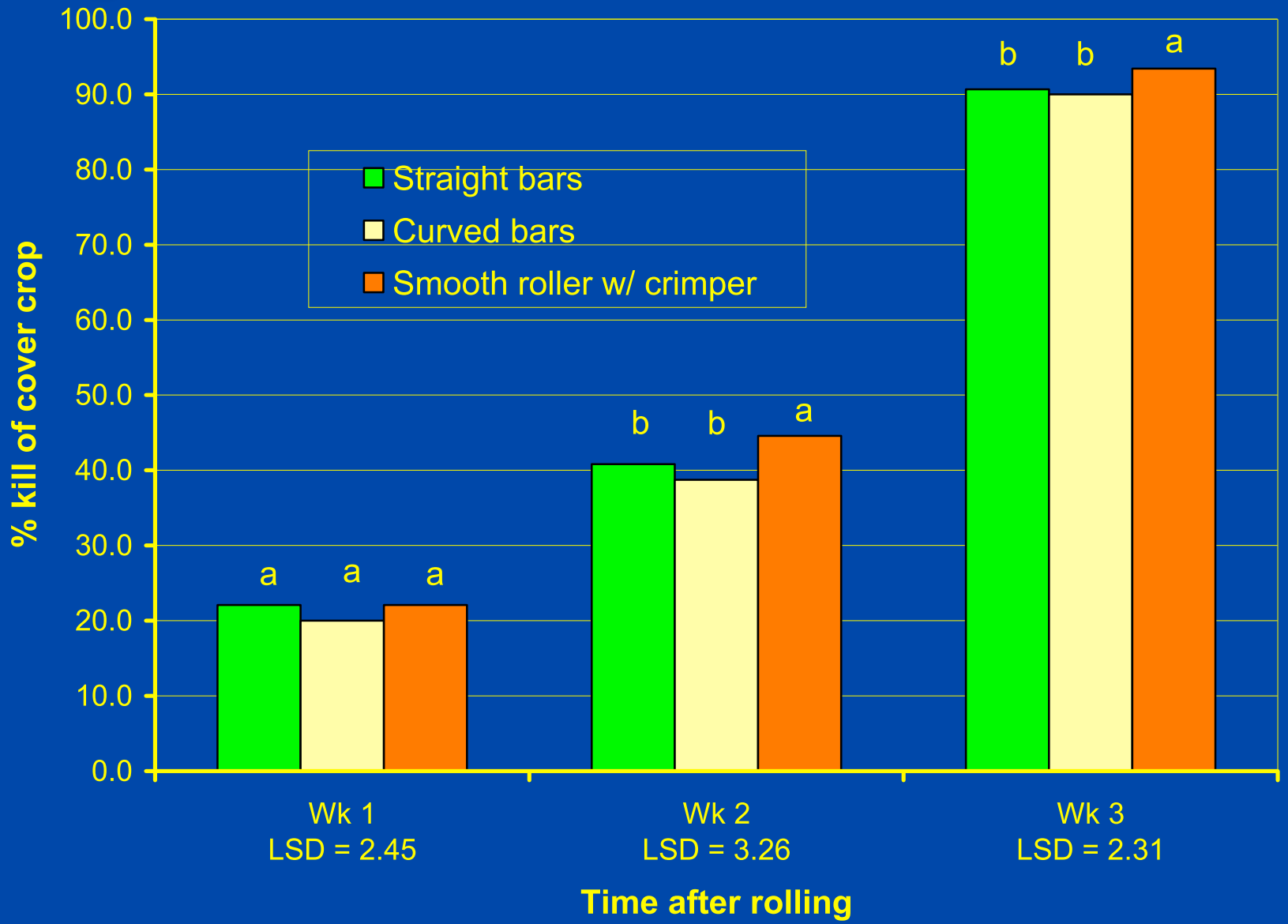
Tractor's frame

Roller's frame

Accelerometer

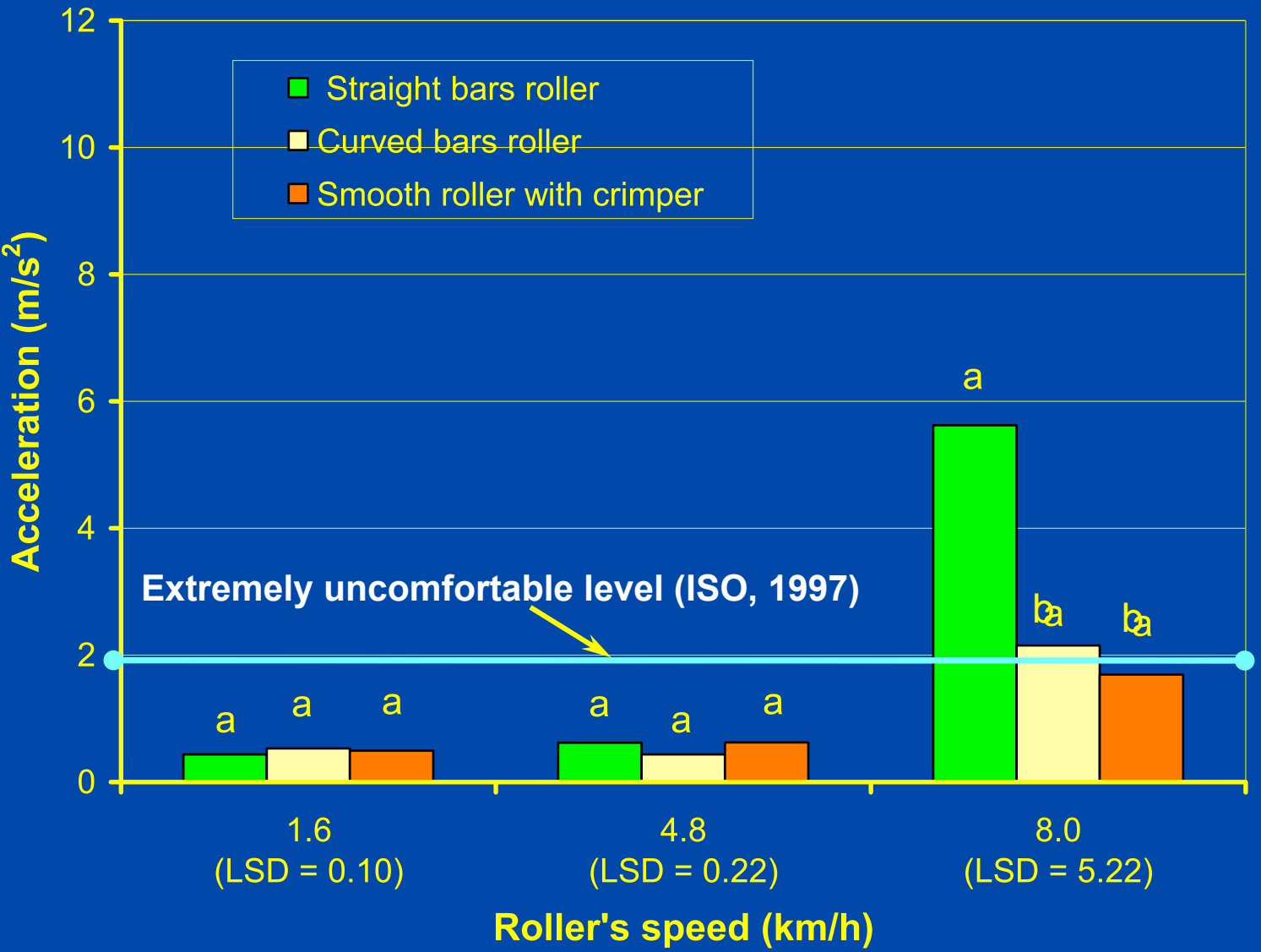
We measured vibrations on the roller frame and on the tractor frame.

Single-section roller: Cumulative termination rate



After 3 weeks above 90% of cover crop was killed and smooth roller produced the highest kill rate.

Tractor frame vibration



With the increase of operating speed vibrations also increased but roller with straight bars generated the highest vibrations on the tractor's frame. Lowest vibrations were produced by the smooth roller.

Rollers/crimpers for smaller farms

Roller/crimper for elevated beds; Kornecki, U.S. Patent #7,662,517 B1

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

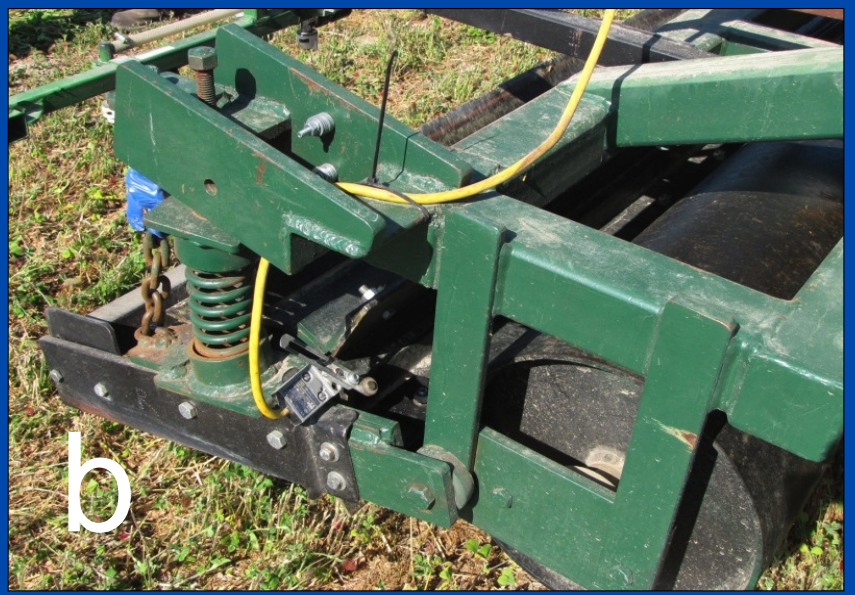
Two Stage roller/crimper, Kornecki, U.S. Patent # 7, 987, 917 B1

Amounts of Roundup used

Treatment	Roundup solution applied (gal/ac)	% Roundup amount of continuous spray	Rye termination after one week (%)
Continuous spray	14.9	100	100
Felt application every crimp	7.9	53	96
Spray every other crimp	4.3	29	96
Spray every 4th crimp	**1.9**	**13**	**98**

Two-stage roller/crimper

a. Rear view

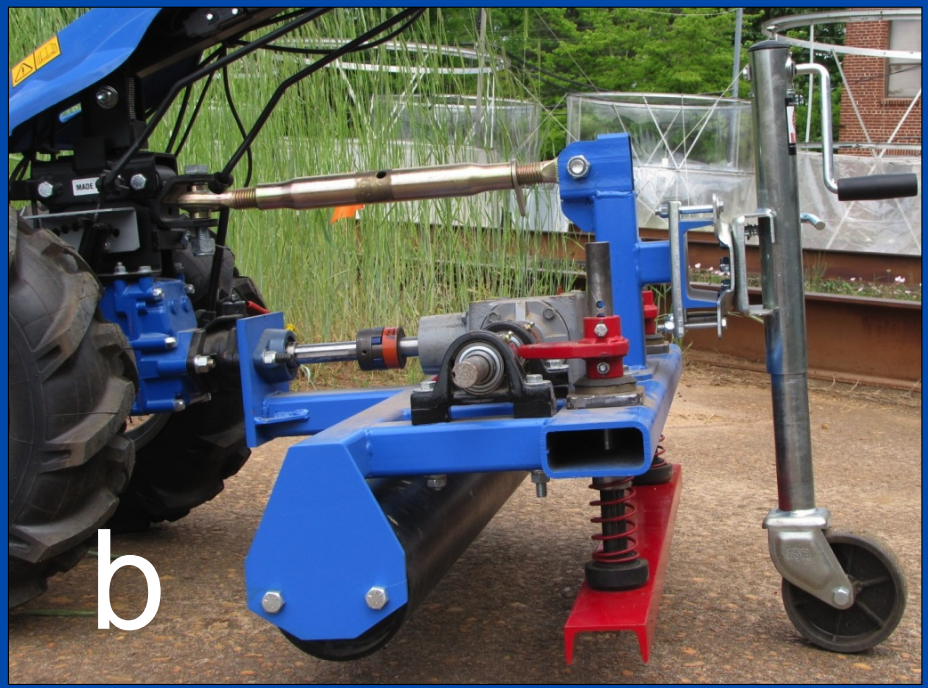


b. Side View

(Kornecki, 2011, U.S. Patent #7,987,917 B1).

Powered walk-behind roller/crimper

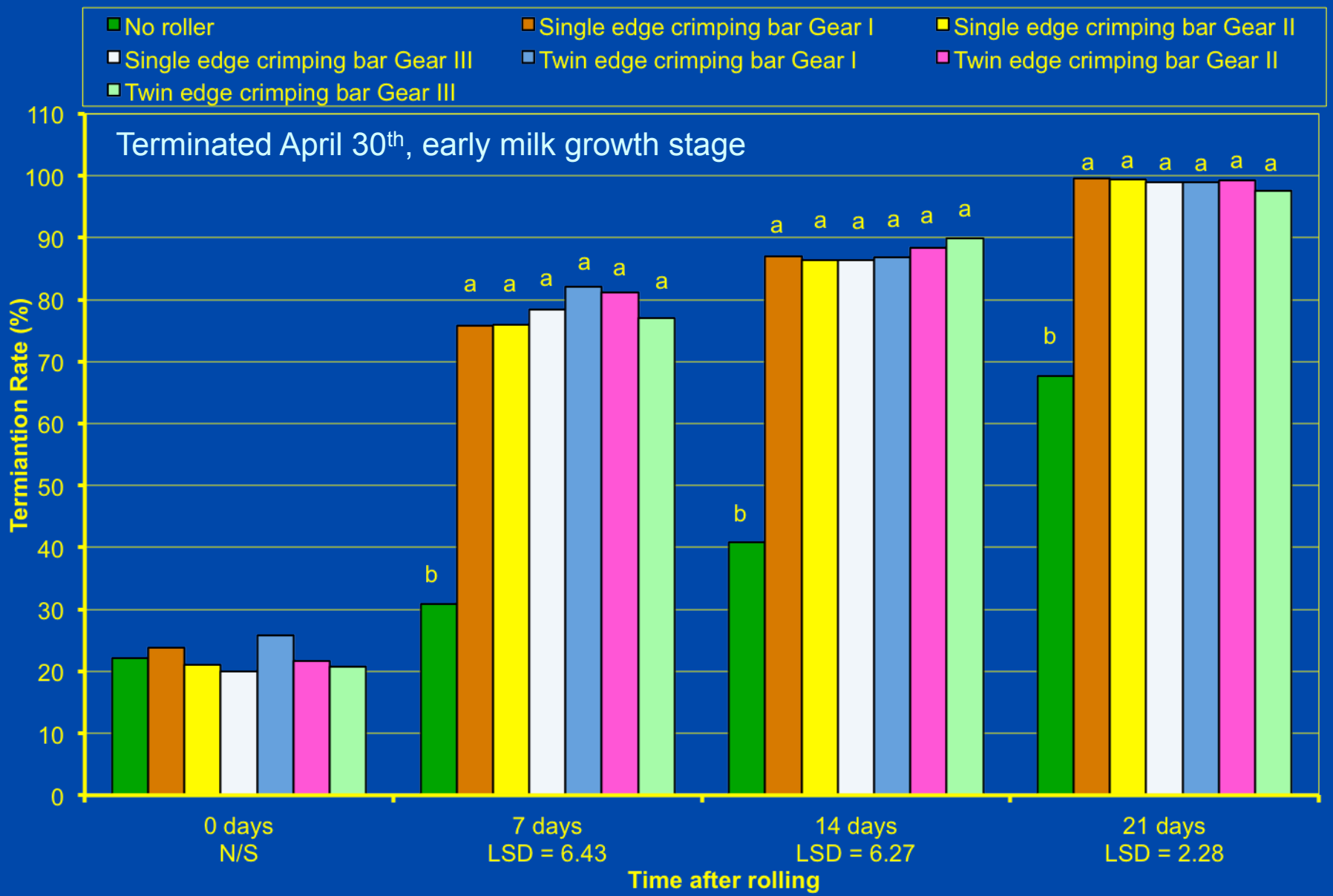
(a) Rear view



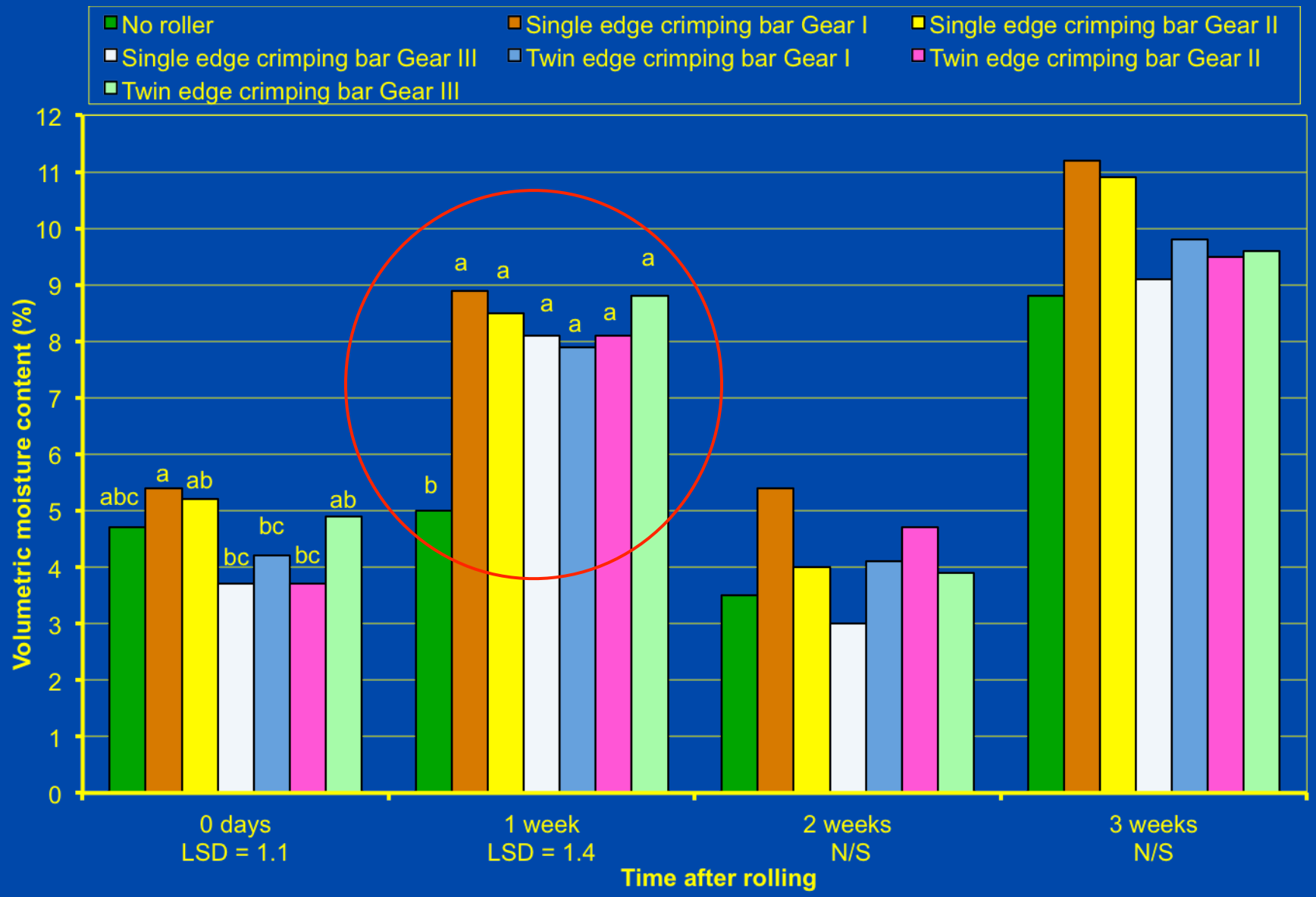
(b) side view close-up.

(Kornecki, 2012, U.S. Patent #8,176,991 B1).

2010 Rye cover crop termination rates



2010 Results. Volumetric Moisture Content



Roller for elevated beds

(Kornecki, 2009, U.S. Patent #7,562,517 B1).

Cullman Horticulture Research Station
Auburn University

Rye

Crimson Clover

Roller for elevated beds

Sweet potato transplanter

Modified RJ one-row transplanter

(a) sub-frame with shank was added to alleviate soil compaction;
(b) transplanting tomatoes into a heavy rye residue cover in Cullman, Alabama

Different rolling patterns for rye

- Not rolled
- Perpendicular
- Parallel
- Diagonal (45°)

Standing rye and 3 different rolling directions were tested against row cleaners

Row cleaner attachments

No row cleaner

DAWN row cleaner

DAWN with no coulter

Yetter row cleaner

We tested no roll cleaner with 2 commercially available row cleaners.

DAWN Row Cleaner

Custom Residue Manager

Mounted residue manager

Residue pusher/shield

Closed residue pusher/shield

Modified pressing “ski”

(Kornecki et al., 2011, U.S. Patent Pending).

Take home Message

- When rolling/crimping of cover crop is done in an appropriate growth stage:

1. Cover crop produces maximum biomass for optimum benefits.

2. Crimping is effective in killing cover crop (3 weeks after rolling) without the need to use herbicides (Roundup).

3. Termination process can be faster with supplemental application of herbicides.

4. Newer roller design can operate at higher speeds without generating high vibration on tractor's frame while maintaining high termination rate (94%)