Evaluation of Three Cover Crops and Their Termination with a Roller-Crimper to Produce Residual Surface Sheet Mulch On Cover Crop Re-Growth and Weed Development Under Tropical Environmental Conditions

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- Project # OS11-062
- University of the Virgin Islands, Agricultural Experiment Station
- Duration: 2011-2013
- Cooperating
  - Sejah Farm; Dale and Yvette Brown

Introduction

- Leguminous species can fix nitrogen in the soil, which is especially important in the tropics, as degradation of nutrients occur rapidly under environmental conditions (Smithson and Giller, 2002).

- Nutrients tied up in CC biomass are released back into the soil beginning at termination (Ditsch and Alley 1991)

- Minimum- till, mechanical-kill systems for cover crops have proven to be cost efficient, all while improving soil organic matter and providing weed suppression (Curran et al., 2010).

- Roller crimpers combine these methods into a low-input system that conserves energy and time, and can improve subsequent crop yield by increasing labile nitrogen (NRCS, 2002).

Cover Crop Management Using Roller-Crimper Technology

- Cover crops (CC) that are mechanically killed with a roller-crimper benefit the agricultural system by;
  - Reduction of soil temperature
  - Block solar radiation
  - Reduce soil moisture loss
  - Increase water availability to succeeding crops
  - Decreases nutrient loss through volatilization

Cereal rye cover crop rolling/crimping in late March 2011 at Brock Farm in Monticello, Florida. Custom roller/crimper design and fabrication by Kirk Brock

Courtesy of Rodale Institute

Cover Crop Residue Surface Sheet Mulch

- Increases soil conservation through reduced tillage
- Decomposition of CC sheet residue allows for the slow release and conversion of organic matter to plant available nutrients
- Sheet residue more efficiently converts carbon into soil organic matter

- Sheet residue acts as a barrier against weeds
- It provides a beneficial microorganism rhizosphere

(Southern SARE, 2012, Sullivan, 2011; Curran and Ryan, 2010, Hoorman et al., 2009; Wang and Klassen, 2005; Sullivan, 2003; NRCS, 2002)

Background

- Inorganic commercial fertilizers, bulk soil amendments and chemical inputs are not economically feasible for smallholder farmers and are often not available at all (Smithson and Giller, 2002; Palm et al., 2001)

- Tropical conditions result in heavy, year-round weed pressure causing decreased farm productivity.

- CC can be successfully grown in the U.S. Virgin Islands during the fall rainy season with no irrigation requirement.

- “More cover crop species need to be tested for their suitability for using a roller-crimper” (Curran and Ryan, 2010)

Objectives

- To evaluate three cover crops in tropical conditions produced with zero external inputs

- To evaluate the effectiveness of a roller-crimper to terminate the cover crops to produce surface sheet mulch
  - Evaluate termination method efficiency through cover crop residue re-growth
  - Evaluate cover crop surface sheet mulch for weed suppression following cover crop roll down

Treatments and Methodology

- **Three cover crops Tested**
  - lab lab (*Dolichos lab lab* cv. Rongai)
  - sunn hemp (*Crotalaria juncea* cv. IAC-1)
  - sorghum-sudan grass (*Sorghum bicolor x S. sudanense* cv. Mega Green),
- **Replications: 3**
- **Fields were disk-harrowed in preparation for planting**
- **Cover crops planted by broadcast seeding and then rolled with a culti-packer on November 1, 2012**
- **No external inputs were applied to the cover crops (no irrigation, fertilizer, or pesticides)**

Experimental Design

- Sejah Farm, St. Croix US Virgin Islands
- Randomized complete block design
- 3 on-farm vegetable fields divided and randomly assigned a cover crop treatment

Photo Courtesy of the St. Croix Source

Yvette and Dale Brown of Sejah Farm

Vegetable crop rotation in fore ground with cover crop treatments of replication #1 in the background

Sampling Procedures Prior to Roll Down

- Biomass sampling of cover crops and volunteer weeds
  - 3 random $0.25m^2$ samples collected per plot prior to CC kill
  - CCs and weeds were separated
  - Weeds were sorted by class (grass and broad leaf)
  - Samples were dried in a forced air oven to determine dry matter

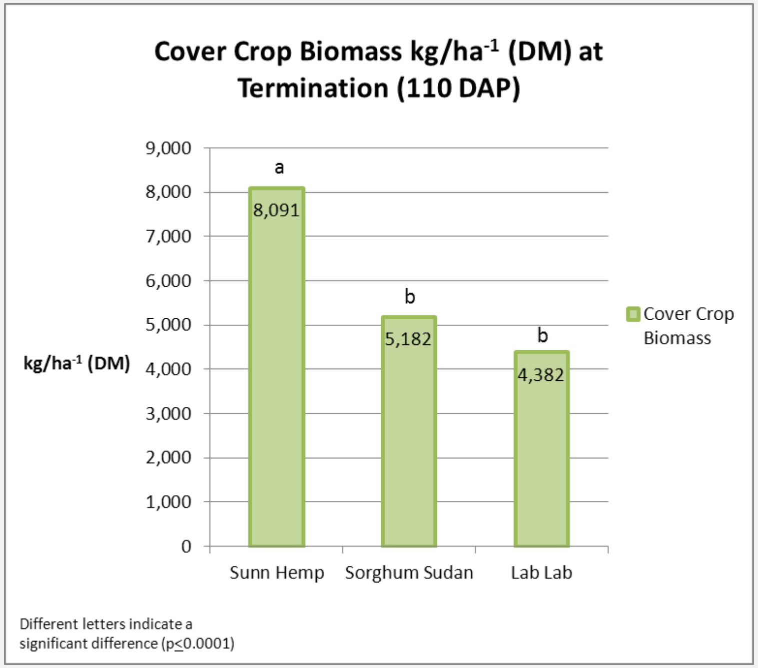
Sampling Procedures Post CC Roll Down

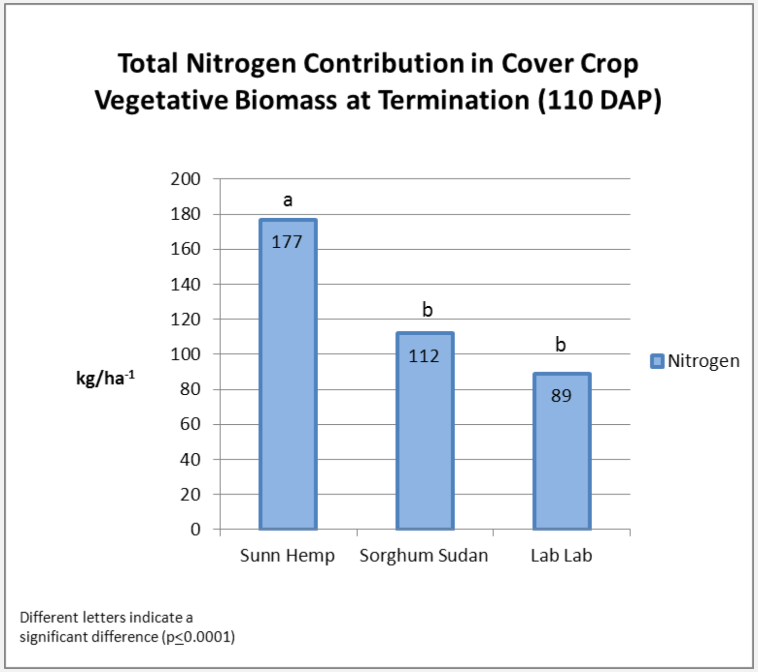
- Biomass sampling of cover crop re-growth and volunteer weeds 28 and 42 days after roll down
  - 3 random $0.25m^2$ samples collected per plot per harvest
  - CCs and weeds were separated
  - Weeds were sorted by class (grass and broad leaf)
  - Samples were dried in a forced air oven to determine dry matter
  - Plant height was recorded for CC re-growth

Statistical Analysis

- Data was subjected to General Linear Modeling (GLM) tests with a least significant difference range separation using SAS.
  - Version 9.3; SAS Institute, Cary N.C.
  - Significance reported at $P \leq 0.05$

Cover Crop Performance and Nitrogen Contribution from Vegetative Biomass at Termination





No difference was observed in CC plant tissue phosphorus or potassium levels

Cover Crop Weed Suppression

Poacea, broad leaf, and total weed biomass (kg/ha^{-1}) within cover crop treatments assessed at cover crop termination at 110 days after planting.

	Poaceae Weeds kg/ha^{-1}	Broad Leaf Weeds kg/ha^{-1}	Total kg/ha^{-1}
Sunn Hemp	< 1[a]	< 1[a]	< 1[a]
Sorghum Sudan	18[a]	31[a]	49[a]
Lab Lab	264[b]	218[b]	482[b]

Values within the same column group followed by different letters differ (P=0.05) according to a least significant difference range separation.

Cover Crop Termination with Custom Built Roller-Crimper

- Cover crops were terminated at 110 DAP with a custom built roller-crimper
  - Built from a recycled 24 inch disc plough using the disc and plough hubs, 24 inch steel pipe, steel tubing, and steel flat bar.


Sunn Hemp


Sorghum Sudan


Lab Lab


Replicate

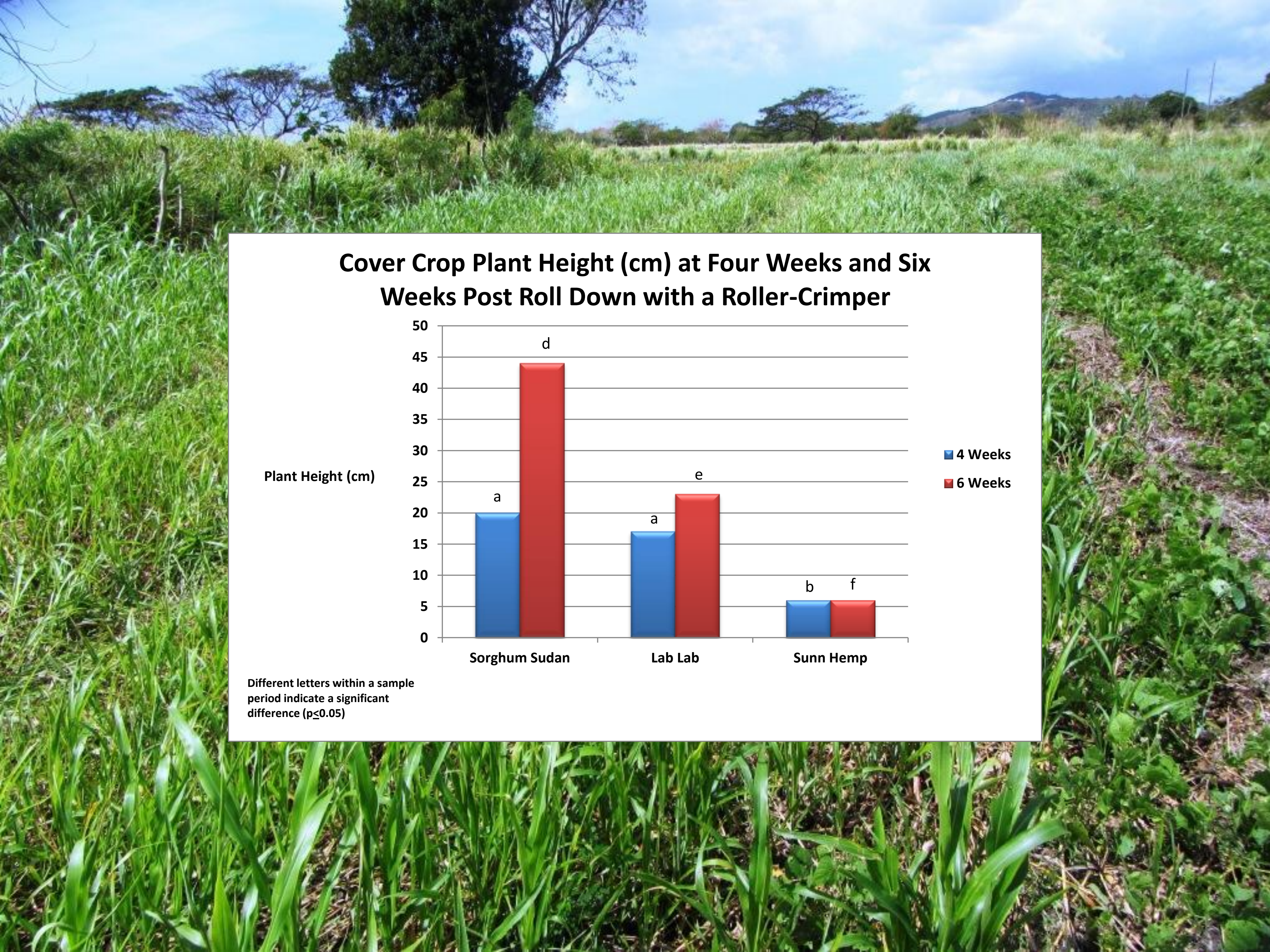
Measuring Results After Roll Down Termination

- Cover crop residue height and re-growth was assessed at 28 and 42 days post roll down to determine the effectiveness of roller-crimper technology on cover crops in the tropics

- Weed biomass was measured at 28 and 42 days post roll down to determine the impact of the resulting surface sheet mulch to inhibit weed development.

28 days post roll down

42 Days Post Roll Down


Cover Crop Plant Height (cm) at Four Weeks and Six Weeks Post Roll Down with a Roller-Crimper
Plant Height (cm)
50
45
40
35
30
25
20
15
10
5
0
a
d
a
e
b
f
Sorghum Sudan
Lab Lab
Sunn Hemp
4 Weeks
6 Weeks
Different letters within a sample period indicate a significant difference (p≤0.05)

Cover crop residue height, re-growth, and weed development was assessed at 28 and 42 days post termination with the roller-crimper

Cover crop response to termination with a roller-crimper and the resulting surface sheet mulch effect on weed development at four and six weeks post roll down.

	Four Weeks Post Roll Down			
	Cover Crop Re-Growth kg/ha^{-1}	**Poaceae Weeds kg/ha^{-1}**	**Broad Leaf Weeds kg/ha^{-1}**	**Total Vegetative Biomass kg/ha^{-1}**
Sunn Hemp	< 1[a]	< 1[a]	< 1[a]	< 1[a]
Sorghum Sudan	1,424[b]	< 1[a]	< 1[a]	1,424[b]
Lab Lab	2,480[c]	1,436[b]	444[a]	4,360[d]

	Six Weeks Post Roll Down			
	Cover Crop Re-Growth kg/ha^{-1}	**Poaceae Weeds kg/ha^{-1}**	**Broad Leaf Weeds kg/ha^{-1}**	**Total Vegetative Biomass kg/ha^{-1}**
Sunn Hemp	< 1[a]	< 1[a]	< 1[a]	< 1[a]
Sorghum Sudan	2067[c]	< 1[a]	< 1[a]	2,067[c]
Lab Lab	962[b]	900[b]	258[a]	2,120[c]

Values within the same harvest group followed by different letters differ (P=0.05) according to a least significant difference range separation.

Summary of Results

- Sunn Hemp produced the greatest amount of vegetative biomass that contributed 177 kg/ha^{-1} nitrogen
- Sunn Hemp provided the greatest level of weed suppression as a cover crop of the three cover crops evaluated while lab lab had the poorest
- The use of a roller-crimper for cover crop termination was effective for sunn hemp, but was not effective for either sorghum sudan or lab lab.
- Sunn hemp cover crop residue formed a dead layer of surface sheet mulch that suppressed weeds for 6 weeks after roll down.
- Sorghum Sudan and lab lab were not killed by roll down with a roller-crimper and continued to grow and sprout new shoots.

Implications

Cover crops can be a valuable management tool in the tropics that require few if any external inputs.

Cover crop re-growth may cause problems when using a roller-crimper in tropical or extended warm season environments.

For vining/twining and Poaceae cover crops, roller-crimper termination may not be viable without herbicide application.

Resulting surface sheet mulch can be used for natural weed suppression and to improve soil quality for subsequent crop rotations.

Continuing Research

Southern SARE Research and Education grant award

"Developing Sustainable Tropical Leguminous Cover Crop and Green Manure Mulch Systems for Low-External-Input Crop Production in the U.S. Virgin Islands, Puerto Rico, and Florida"

Identify and evaluate new warm season CCs

Compare different CC residue surface sheet mulch for weed suppression in vegetable crop rotations

Compare CC surface sheet mulch to conventional weed suppression practices in vegetable crop production

Questions?