Tropical cover crop mulch systems for low-external-input reduced-tillage vegetable production

Stuart A. Weiss

Danielle D. Treadwell, K. Paul Beamer & Rhuanito S. Ferrarezi

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Introduction

- 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.
- More cover crop species need to be tested for their suitability for use with a roller-crimper (Curran and Ryan, 2010), particularly in tropical environments.

Cover Crop Management Using Roller-Crimper Technology

- Cover crops 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 soil nutrient loss through volatilization

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

Rolling/crimping of sunn hemp cover crop on St. Croix, USVI. Design by Stuart Weiss

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
- Surface plant residues provide 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)

Agricultural Relevance

- 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.

- Many warm season CCs can be successfully grown in the U.S. Virgin Islands.
- However, successful CC termination with a roller-crimper and their residual use for weed control is unknown.

Objectives

- To evaluate three cover crops under 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 re-growth.
  - Evaluate cover crop surface sheet mulch for weed suppression following cover crop termination.
- To measure the combined system effects of CC sheet mulch on Jalapeno pepper production after CC termination.

Treatments and Methodology

- **Treatments**
  - Sunn hemp (*Crotalaria juncea* cv. IAC-1)
  - Pigeon pea (*Cajanus cajan* cv. BRS Mandarim)
  - Sun flower (*Helianthus annuus* cv. Black Oil)
  - Weedy Fallow Control – Conventional full-till seed bed preparation
- **Replications: 3**
- **Fields were disk-harrowed in preparation for planting**
- **Cover crops planted by broadcast seeding and then rolled with a culti-packer**
- **No external inputs were applied to the cover crops (no irrigation, fertilizer, or pesticides)**

Cover Crops at Maturity Prior to Termination

Sampling Procedures Prior to Termination

- Biomass sampling of cover crops and volunteer weeds
  - 3 random 0.25m^2 samples collected per plot prior to CC termination
  - 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

Custom Built Roller-Crimper

- Cover crops were terminated at 112 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.

Cover Crop Termination with Roller-Crimper and Crop Residue Surface Sheet Mulch

Sunn Hemp

Pigeon Pea

Jalapeno peppers (Invicto-F1) grown in a green house and transplanted into treatment plots 42 DAP and 7 days after CC termination

Control

Sun Flower

Pigeon Pea

Sunn Hemp

Cover Crop and Weed Monitoring Procedures Post CC Termination

- **Biomass sampling of cover crop re-growth and weeds 3, 6, 9, 12, and 15 weeks after termination.**

- **Six weeks after JP transplanting, all plots were split in half to compare JP yield from weekly weeding vs. reduced-weeding at three week intervals.**

  - **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), no sedges were present**

Agronomy program personnel Jose Hererra,.

Jalapeno Pepper Yields

Peppers where harvested from data rows, graded (marketable or unmarketable), and weighed.

Statistical Analysis

- Data was subjected to General Linear Modeling 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 weed development at termination

Cover crop (CC), broad leaf (BL) weed, and poacea (GW) weed biomass (kg ha^{-1}) within treatments assessed at termination

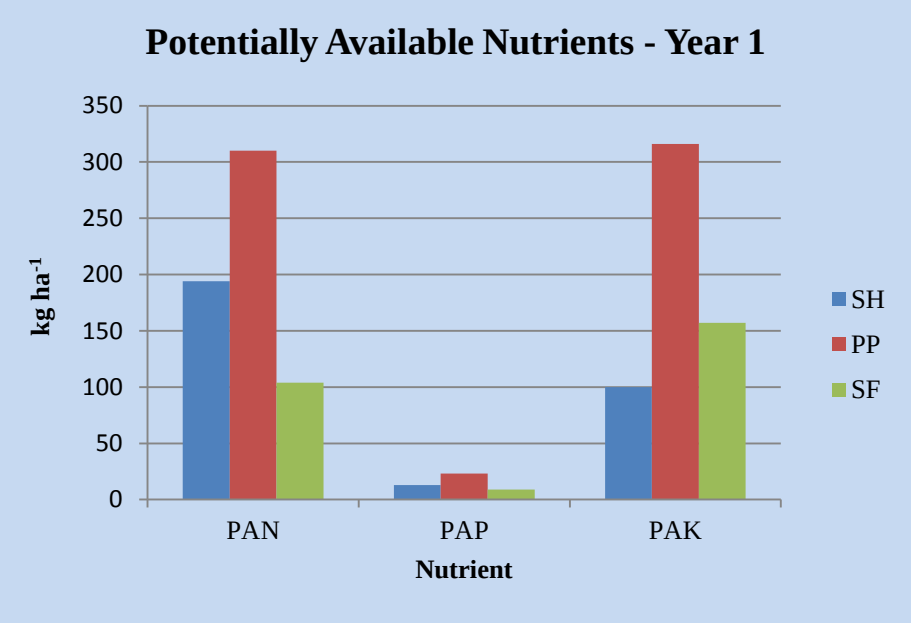
Treatment	Plant	Year 1	Year 2
Control	C	NA	NA
Control	BL	1,904d	1,271d
Control	GW	1,867d	1,736d
Pigeon Pea	PP	13,842a	2,598bc
Pigeon Pea	BL	1,631def	1,894cd
Pigeon Pea	GW	1,791de	435e
Sun Flower	SF	4,760c	2,682b
Sun Flower	BL	<1f	124e
Sun Flower	GW	30ef	165e
Sunn Hemp	SH	7,976b	7,551a
Sunn Hemp	BL	<1f	<1e
Sunn Hemp	GW	<1f	<1e
SE		635	271

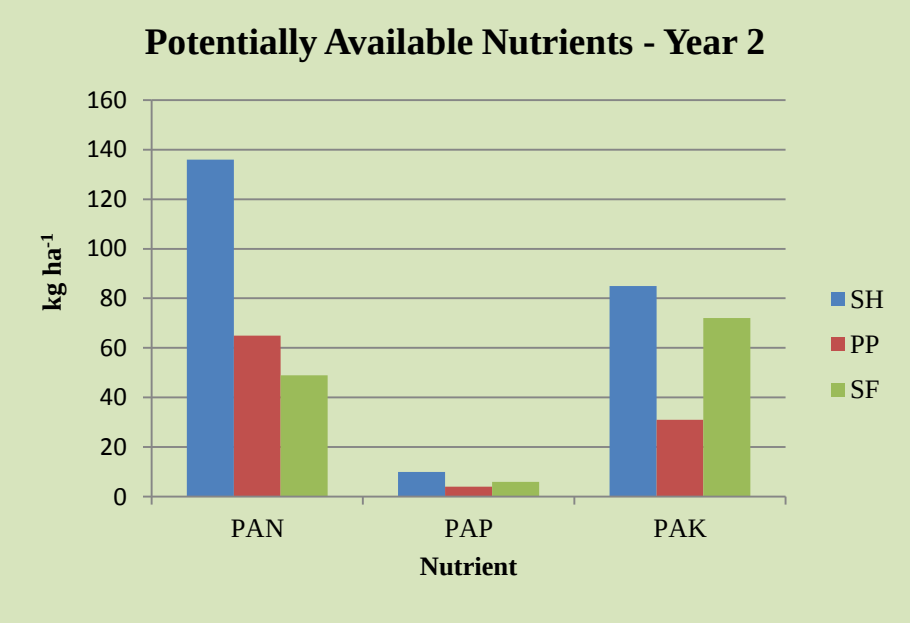
Values within the same column group followed by different letters differ ($p<0.05$) according to a least significant range seperation.




Potentially Available Nutrients

(Plant Biomass x Plant Tissue Nutrient Concentration)





Total weed biomass (kg ha^{-1}) by treatment at three and six weeks

Control

Sun Flower

Pigeon Pea

Sunn Hemp

Three Week Harvest

Treatment	Year 1	Year 2
Control	31b	109b
Pigeon Pea	87b	404a
Sun Flower	214a	604a
Sunn Hemp	51b	30b
SE	35	88

Six Week Harvest

Treatment	Year 1	Year 2
Control	250c	1,427a
Pigeon Pea	616a	1,632a
Sun Flower	541ab	1,295a
Sunn Hemp	357bc	206b
SE	85	171

Values within the same column group followed by different letters differ ($p<0.05$) according to a least significant range separation.

Sunn Hemp

Sun Flower

Cover crop regrowth (CCRG), broad leaf (BL) weed, and poacea (GW) weed biomass (kg ha^{-1}) by treatment at three and six weeks post termination

Year 1

Three Week Harvest

Treatment	CCRG	BL	GW
Control	NA	31cd	0d
Pigeon Pea	197a	83bc	4d
Sun Flower	0d	108b	106b
Sunn Hemp	0d	32cd	20cd

Six Week Harvest

Treatment	CCRG	BL	GW
Control	NA	239bcd	11e
Pigeon Pea	393ab	530a	86de
Sun Flower	0e	283bc	258bcd
Sunn Hemp	46e	253bcd	104cde

Year 2

Three Week Harvest

Treatment	CCRG	BL	GW
Control	NA	109cb	0c
Pigeon Pea	48c	404a	0c
Sun Flower	0c	217b	388a
Sunn Hemp	7c	30c	0c

Six Week Harvest

Treatment	CCRG	BL	GW
Control	NA	648b	779ab
Pigeon Pea	58d	1150a	482bc
Sun Flower	0d	773ab	521bc
Sunn Hemp	179cd	128cd	78d

Values within the same harvest group followed by different letters differ ($p<0.05$) according to a least significant range separation.

Total Weed Biomass at 9, 12, and 15 weeks after CC Termination (kg ha^{-1})

		Treatment					Weeding Frequency		
Year 1		Control	Pigeon Pea	Sun Flower	Sunn Hemp	SE	1 Week	3 Weeks	SE
	9 Week	219b	1,207a	315b	333b	68	213b	823a	48
	12 Week	63b	410a	92b	184b	63	0.7b	374a	48
	15 Week	366b	2,694a	357b	429ab	813	0b	1,923a	581
Year 2									
	9 Week	306b	774a	212b	485b	101	172b	716a	72
	12 Week*	678ab	959a	452b	629ab	186	*	*	*
	15 Week	32b	94ab	51b	133a	23	39b	116a	16

Values within the same harvest group row followed by different letters differ ($p<0.05$) according to a least significant range separation.

Jalapeno Pepper Yield (kg ha^{-1}) by Treatment, Year, and Weeding Frequency

		Treatment						Weeding Frequency		
Year 1		Control	Pigeon Pea	Sun Flower	Sunn Hemp	SE		1 Week	3 Weeks	SE
	Marketable Yield	20,649b	13,808c	38,279a	24,633b	2,441		27,125a	21,559b	2,028
	Total Yield	21,248b	14,058c	38,991a	25,049b	2,475		27,660a	22,013b	2,055
Year 2										
	Marketable Yield	12,435b	12,018b	18,704a	21,363a	1,696		15,978a	16,281a	1,199
	Total Yield	12,566b	12,134b	18,843a	21,415a	1,707		16,092a	16,387a	1,207

Values within the same harvest group row followed by different letters differ ($p<0.05$) according to a least significant range separation.

- **Pepper yields were greatest in sun flower treatments in year 1 and in sun flower and sunn hemp treatments in year 2.**
- **Weekly weeding resulted in greater yields than reduced frequency weeding in year 1 but not in year 2.**

Summary of Results

- Sunn hemp and sun flower provided excellent weed suppression (near 100%) during the cover crop cycle.
- The use of a roller-crimper for cover crop termination was effective for sun flower and sunn hemp, but was not effective for pigeon pea.
- Sunn hemp surface residue provided similar or greater weed suppression than full tillage for 6 weeks after termination.
- Sun hemp and sun flower conservation tillage systems produced similar or greater yields of jalapeno peppers compared to conventional full till systems.
- Sunn hemp and sun flower reduced the negative effects of drought on pepper yields.

Implications

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

For indeterminate, warm season cover crops, roller-crimper termination may not be viable without additional management.

CCs terminated with a roller-crimper for in situ mulch may suppress weeds and lessen the effects of extreme environmental conditions on subsequent crop yields.

Continuing Research

Identify and evaluate new tropical/warm season CCs that are compatible with roller-crimper technology.

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?

Funding & Collaborators

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- Collaborating :

Danielle Treadwell, Ph.D., Associate Professor, Horticultural Sciences Department, University of Florida, Gainesville, FL.

Elide Valencia, Ph.D., Associate Professor, Agronomy Sciences Department, University of Puerto Rico, Mayaguez, PR.