Reduced tillage termination of cover crop systems in the tropics

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Introduction:

Cover crop (CC) use is increasing around the world and their use is considered a valued component of sustainable agricultural production systems. Cover crops provide a range of agricultural and ecosystem benefits which range from soil protection and improvement to pest reduction.

Low-external-input farmers rely heavily on farm-derived resources such as cover crops for soil and pest management. Tropical agroecosystems require unique CC management strategies that meet environmental and cultural conditions. The use of reduced tillage practices have been promoted to increase soil conservation and reduce on-farm expenses.

Conventional CC management strategies were developed for temperate climates where plant senescence is timed with seasonal transition for effective CC termination. Mechanical cutting followed by full incorporation of CCs in the tropics has been the accepted practice for CC termination, but can result in soil decline. While an effective termination tool, this method relies on conventional soil tillage that can result in decreased soil conservation, and increased soil nutrient and organic matter loss. The alternative termination method of rolling/crimping CCs to produce surface sheet mulch has gained attention as a progressive practice that reduces tillage and provides additional agroecosystem benefits. Due to the persistent high temperatures in the tropics that promote re-growth of many indeterminate CCs, assessment of different mechanical CC termination methods is needed to avoid having CCs become weedy pests. A CC termination study was conducted on St. Croix in the U.S. Virgin Islands to test four mechanical termination methods and their effects on CC regrowth, as well as on broadleaf and grass weed suppression.

Objectives:

To evaluate sunn hemp [(*Crotalaria juncea* cv. IAC-1) SH] and lablab [(*Lalab purpureus* cv. Rongai) LL] as CCs and their ability to suppress weeds.

To evaluate four different types of mechanical CC termination and their effect on CC regrowth and weed development.

To monitor the physical and chemical decomposition of SH and LL residue.

Materials and Methods:

At the University of the Virgin Islands in St. Croix, sunn hemp and lablab were planted on October 3, 2012, evaluated as CCs, and then terminated 120 days after planting. No additional external inputs were applied to the fields.

Termination treatments included:

- 1) Full incorporation with a disc harrow (3 passes),
- 2) Minimum incorporation with a disc-harrow (1 pass)
- 3) Mowing with a rotary brush mower (1 pass),
- 4) Roll down with a roller-crimper (1 pass).

Cover crop and weed biomass were determined prior to termination and subsequent CC regrowth and weed biomass was determined at 6, 9, and 12 weeks post-termination. Weed species were separated by weed class and designated either a grass or broadleaf, no sedges were encountered in this trial. Litter bags containing either SH or LL crop residue were placed in treatments 1 (buried) and 4 (surface) on 1 day after termination (DAT) and were collected at 28, 42, and 63 days after termination and analyzed for plant chemical properties.

Cover crop (CC), broad leaf (BL) weed, and poacea (GW) weed biomass (kg/ha^{-1}) of Sunn Hemp and Lablab at termination

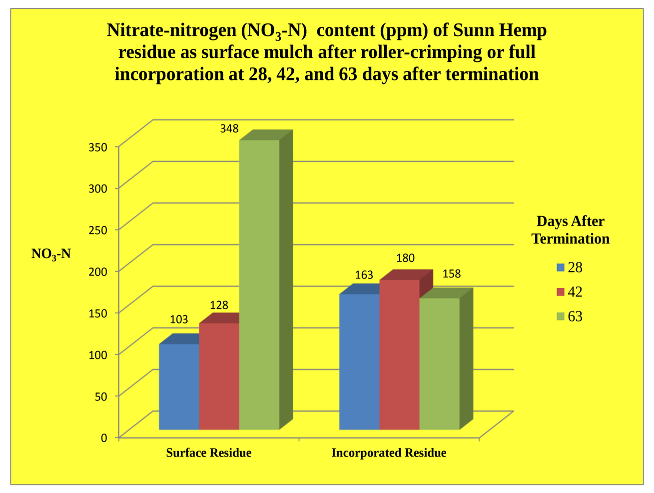
	CC	BL	GW	Total Weeds
Sunn Hemp	6,800 ± 684^{a}	196 ± 130^{a}	413 ± 619^{a}	609 ± 614^{a}
Lablab	3,127 ± 684^{b}	238 ± 130^{a}	1,480 ± 619^{a}	1,718 ± 614^{b}

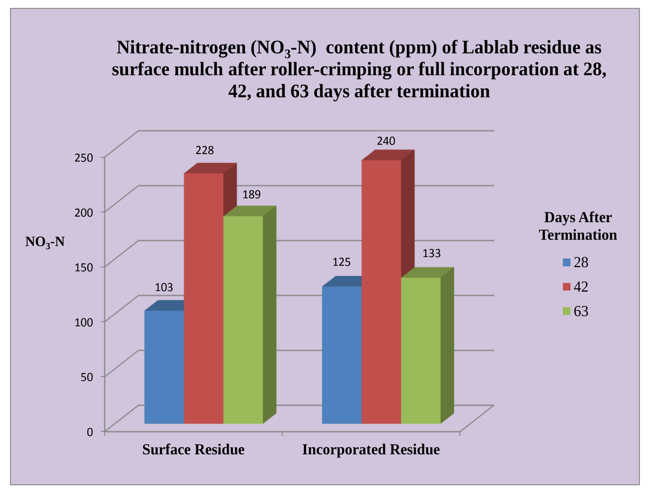
Values within the same column group followed by different letters differ (p<0.05) according to a least significant range seperation.

Cover crop plant tissue nutrient content (percent) and estimated nutrient contribution (kg/ha^{-1}) for nitrogen (N), phosphorus (P), and potassium (K) based upon total vegetative biomass (kg/ha^{-1})

	Vegetative Biomass	Plant N %	N Contribution	Plant P %	P Contribution	Plant K %	K Contribution
Sunn Hemp	6,800 ± 684^{a}	1.7 ± 0.1^{a}	117 ± 15^{a}	0.09 ± 0.006^{a}	6 ± 0.5^{a}	1.3 ± 0.07^{a}	85 ± 15^{a}
Lablab	3,127 ± 684^{b}	2.3 ± 0.1^{b}	70 ± 15^{b}	0.08 ± 0.006^{a}	2.3 ± 0.5^{b}	2.2 ± 0.07^{b}	71 ± 15^{a}

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





Nutrient content of Sunn Hemp and Lablab vegetative residue at 1, 28, 42, and 63 days after termination

Dayss After Termination	Sunn Hemp N%	Sunn Hemp P%	Sunn Hemp K%	Lablab N%	Lablab P%	Lablab K%
1	1.7 ± 0.2b	0.09 ± 0.03a	1.3 ± 0.05a	See Table 4	0.08 ± 0.01a	2.2 ± 0.1a
38	2.1 ± 0.2a	0.21 ± 0.03b	0.7 ± 0.05b		0.15 ± 0.01ab	1.3 ± 0.1b
42	1.7 ± 0.2b	0.19 ± 0.03b	0.5 ± 0.05c		0.14 ± 0.01b	0.8 ± 0.1c
63	1.7 ± 0.2b	0.2 ± 0.03b	0.6 ± 0.05c		0.18 ± 0.01c	0.8 ± 0.1c

Differences in values observed by week, not by treatment. Values within the same column group followed by different letters differ (p<0.05) according to a least significant range seperation.

Nitrogen (percent) content of Lablab vegetative residue left on the surface or soil incorporated

Days After Termination	Lablab Rolled	Lablab Full Till
1	2.1 ± 0.2^{ac}	2.1 ± 0.2^{ac}
28	2.5 ± 0.2^{abc}	1.9 ± 0.2^{ad}
42	2.8 ± 0.2^{bc}	2.1 ± 0.2^{ad}
63	3.0 ± 0.2^{bc}	2.5 ± 0.2^{bc}

$^{a, b}$ values within the same column group differ and $^{c, d}$ values within the same row group differ (p<0.05) according to a least significant range seperation.

Cover crop regrowth and weed biomass (kg/ha^{-1}) at 6, 9, and 12 weeks after termination

Treatments (TM) Sunn Hemp	6 Week Harvest CCRG	CCVol	BL	GW	TM	9 Week Harvest CCRG	CCVol	BL	GW	TM	12 Week Harvest CCRG	CCVol	BL	GW
1) Full Disc (FD; 3 passes)	0 ± 47^{a}	264 ± 47^{a}	11 ± 47^{b}	0 ± 47^{a}	FD	0 ± 127^{b}	1,111 ± 127^{a}	9 ± 127^{a}	0 ± 127^{b}	FD	0 ± 260^{b}	2,613 ± 260^{a}	631 ± 260^{a}	44 ± 260^{a}
2) Disc (D;1 pass)	0 ± 47^{a}	138 ± 47^{b}	87 ± 47^{ab}	29 ± 47^{a}	D	0 ± 127^{b}	740 ± 127^{b}	482 ± 127^{ab}	0 ± 127^{b}	D	0 ± 260^{b}	2,418 ± 260^{a}	1,084 ± 260^{ab}	1,389 ± 260^{b}
3) Mow (M; 1 pass)	0 ± 47^{a}	102 ± 47^{b}	151 ± 47^{ab}	142 ± 47^{a}	M	84 ± 127^{ab}	362 ± 127^{c}	411 ± 127^{ab}	537 ± 127^{a}	M	0 ± 260^{b}	478 ± 260^{b}	1,613 ± 260^{b}	2,231 ± 260^{b}
4) Roller-Crimp (RC; 1 pass)	0 ± 47^{a}	58 ± 47^{b}	198 ± 47^{a}	38 ± 47^{a}	RC	211 ± 127^{a}	0 ± 127^{b}	696 ± 127^{b}	196 ± 127^{b}	RC	367 ± 260^{a}	67 ± 260^{b}	1,202 ± 260^{ab}	1,967 ± 260^{b}

Lablab	6 Week Harvest CCRG	CCVol	BL	GW	TM	9 Week Harvest CCRG	CCVol	BL	GW	TM	12 Week Harvest CCRG	CCVol	BL	GW
1) Full Disc (FD; 3 passes)	11 ± 198^{b}	0	33 ± 198^{a}	40 ± 198^{a}	FD	264 ± 233^{b}	0	322 ± 233^{a}	7 ± 233^{b}	FD	1,109 ± 288^{b}	0	1,147 ± 288^{b}	878 ± 288^{a}
2) Disc (D;1 pass)	1,229 ± 198^{a}	0	229 ± 198^{a}	118 ± 198^{a}	D	1,756 ± 233^{a}	0	429 ± 233^{a}	604 ± 233^{ab}	D	2,178 ± 288^{a}	0	36 ± 288^{a}	867 ± 288^{a}
3) Mow (M; 1 pass)	91 ± 198^{b}	0	267 ± 198^{a}	302 ± 198^{a}	M	484 ± 233^{b}	0	702 ± 233^{a}	1,113 ± 233^{a}	M	736 ± 288^{b}	0	611 ± 288^{ab}	1,384 ± 288^{a}
4) Roller-Crimp (RC; 1 pass)	498 ± 198^{b}	0	149 ± 198^{a}	869 ± 198^{a}	RC	924 ± 233^{ab}	0	687 ± 233^{a}	411 ± 233^{ab}	RC	1,098 ± 288^{b}	0	431 ± 288^{b}	1,869 ± 288^{a}

Cover Crop Regrowth = CCRG
Volunteer Cover Crop = CCVol
Broad Leaf Weeds = BL
Grass Weeds + GW

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

Results and Discussion:

Sunn hemp yielded the highest amount of CC biomass at termination with 6,800 ± 683 kg/ha^{-1} compared to LL at 3,126 ± 683 kg/ha^{-1} (*p=0.002*). Lablab had greater plant tissue nitrogen (N) content than SH at 2.3% ± 0.1 compared to 1.7% ± 0.1, respectively. Due to the greater SH biomass, total estimated N contribution was greater for SH (117 kg/ha^{-1} ± 15) than for LL (70 kg/ha^{-1} ± 15) ($p \le 0.05$). At 6 weeks after termination, SH had no regrowth within treatments. Lablab had the greatest measured regrowth from treatment 2 (1,229 ± 198 kg/ha^{-1}) and similar regrowth in treatments 1, 3, and 4 (11 ± 198, 91 ± 198, and 498 ± 198 kg/ha^{-1}, respectively; $p \le 0.05$).

At 9 and 12 weeks after termination, SH regrowth was effectively controlled in all termination treatments with the only measurable regrowth occurring in plots terminated with the roller-crimper (Table 2). In contrast, LL had greater levels of regrowth among all treatments for all three post-termination harvests and termination treatments 1, 3, and 4 resulted in similar LL regrowth for each respective post-termination harvest date. Results indicate that SH had a favorable response to all reduced tillage termination methods tested compared to LL, thus, SH may be better suited for use as a CC in reduced tillage tropical agroecosystems. Sunn hemp controlled grass weeds in treatments 1, 2, and 4 through week 9 and had similar biomass accumulation of grass weeds at week 9 with 0, 0, and 196 ± 127 kg/ha^{-1}, respectively. At 12 weeks after SH termination, broadleaf and grass weed levels exceeded 1,000 kg/ha^{-1} in all treatments except for treatment 1 which had the lowest levels at 631 ± 260 kg/ha and 44 ± 260 kg/ha, respectively ($p \le 0.05$). Therefore, full incorporation with 3 passes with the disc harrow resulted in the most effective termination and weed suppression method for SH.

Sunn hemp crop residue N content after termination was not influenced by either treatment 1 or 4, but did increase over time from 1 DAT to 28 DAT by 19 percent from 1.7% ± 0.2 to 2.1% ± 0.2 N ($p \le 0.05$), and then returning to 1.7 percent N at 42 and 63 DAT. Total N content in LL crop residue was influenced by treatment and time with greater N levels in LL residue from treatment 4 (2.1 to 3.0 ± 0.2 percent N) compared to treatment 1 (2.1 to 2.5 ± 0.1 percent N) ($p \le 0.05$). Nitrate-N content in SH surface residue resulting from termination with the roller-crimper increased over time to a high of 348 ppm at 63 DAT. In comparison, nitrate-N content of SH residue fully incorporated peaked at 180 ppm at 42 DAT and then decreased to 158 ppm at 63 DAT. Lablab surface residue and fully incorporated residue were highest at 42 DAT at 228 and 240 ppm nitrate-N, respectively. From 42 to 63 DAT both surface and fully incorporated LL residue decreased, however, nitrate-N content in surface residue only dropped to 189 ppm while fully incorporated LL residue dropped to 133 ppm. Nitrate-N content of SH surface residue (termination with a roller-crimper) increased over time and provided a slower, delayed conversion of nitrate-N compared to SH residue that was fully incorporated. Lablab responded in a similar way at 63 DAT where nitrate-N content of surface residue was 30% greater than fully incorporated LL residue. These findings will allow farmers to more accurately align CC residue nitrate-N availability with peak crop demand and thus, to make improved cover and cash crop management decisions to improve production efficiency.