Screening of Five Broad Leaf Plants for use as Tropical Cover Crops and their Response to Termination with a Roller-Crimper

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Introduction

Cover crops (CC) can provide numerous ecosystem services to agricultural crop production systems that include soil conservation, soil quality/fertility improvement, increased biodiversity, and pest management benefits. Hot-humid environments of the tropics and the Southern U.S.A. pose difficult challenges for the sustainable management of soil and weeds. Cover crops that are mechanically terminated with a roller-crimper produce surface sheet mulch that can protect and improve soil health, suppress invasive weed development, reduce soil temperature, reduce soil moisture loss and increase water availability to the farming system. The proper selection and management of CCs is critical to the success of the farm system and little is known about CCs terminated with a roller-crimper under hot-humid conditions. This experiment evaluated 5 warm season CCs, determined their potential nutrient contribution (PNC), and measured the effect of roller-crimper termination on CC regrowth and weed development.

Objective

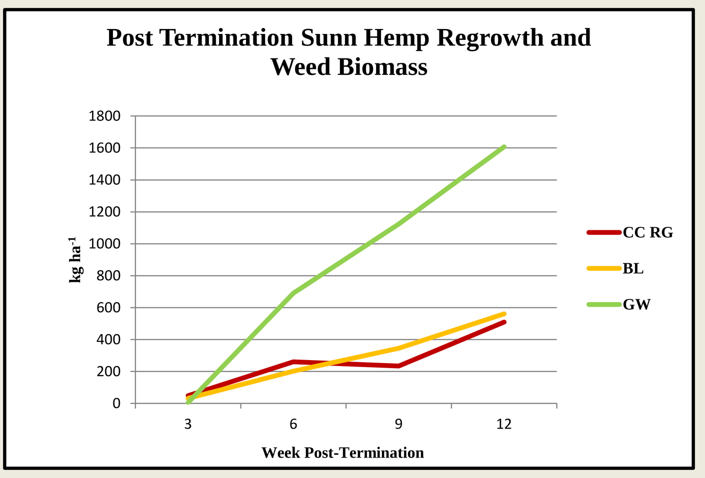
To evaluate 5 cover crops in a tropical climate pre and post termination with a roller-crimper on:

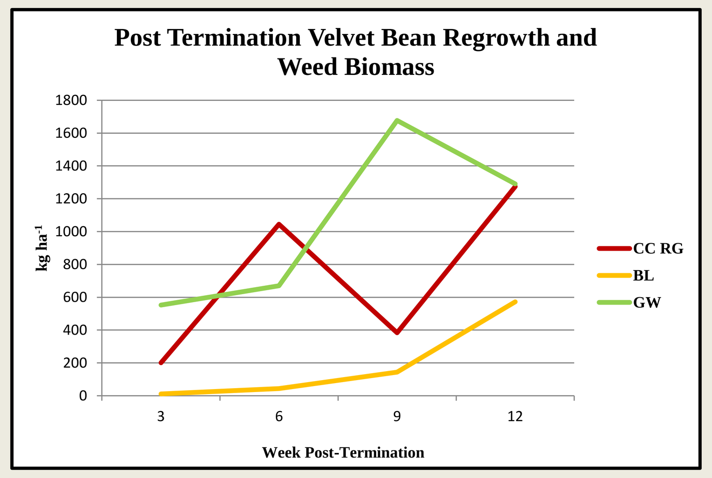
- Pre-termination cover crop biomass
- Pre-termination cover crop plant tissue nutrient content
- Cover crop potential nutrient contribution (PNC)
- Post-termination CC regrowth
- Post-termination weed biomass
- Post-termination weed suppression

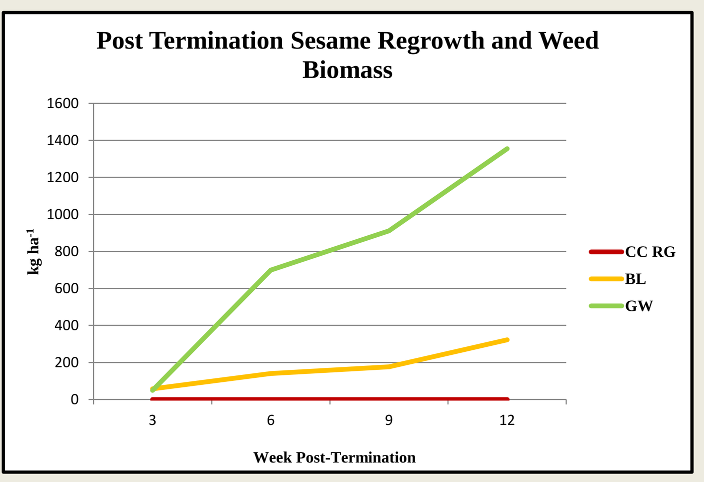
Materials and Methods

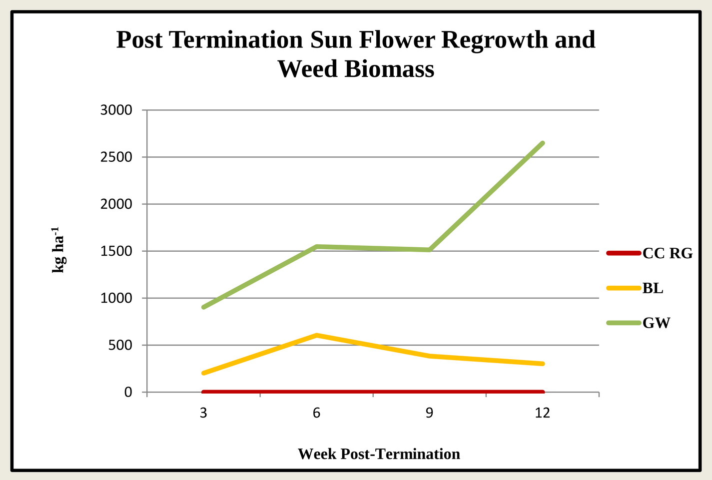
The experimental design was a complete randomized block with three replications conducted from August, 2013 through February, 2014. CCs evaluated were: velvet bean (*Mucuna pruriens* L. cv. Vine 90; VB), sunn hemp (*Crotalaria juncea* L. cv. IAC-1; SH), pigeon pea (*Cajanus cajan* L. cv. BRS Mandarim; PP), sesame (*Sesamum indica* L. cv. ns; SE), and sunflower (*Helianthus annus* L. cv. Black Oil; SF).

CCs were planted by broadcast sowing prior to the start of the heavy rainy season and terminated when 90% flowering was observed for SH, SE, SF, and VB via roller crimping 70 days after planting (DAP). PP took longer to mature and was terminated at 120 DAP. CCs were evaluated pre-termination on biomass, understory weed development and PNC nitrogen, phosphorus, and potassium estimated from CC biomass yield and CC tissue nutrient content and expressed as kg/ha^{-1}. Post termination CC plots were evaluated for CC regrowth and weed development 3, 6, 9 and 12 weeks after termination (WAT). Weed categories were designated as broadleaf weeds (BW) or grass weeds (GW) and were separated from any CC regrowth present. All plant samples were collected by sampling a 0.25-m^2 area clipped at ground level with three samples collected per plot. Dimensions of treatment plots measured 5 x 10 m. PP results are reported separately from the other CC results and were not a part of the statistical analysis for SH, SF, SE, or VB data.









VB at termination (top) and 6 weeks post termination (bottom)

SF at termination (top) and 6 weeks post termination (bottom)

SE at termination (top) and 6 weeks post termination (bottom)

SH at termination (top) and 6 weeks post termination (bottom)

PP at termination (top) and 6 weeks post termination (bottom)

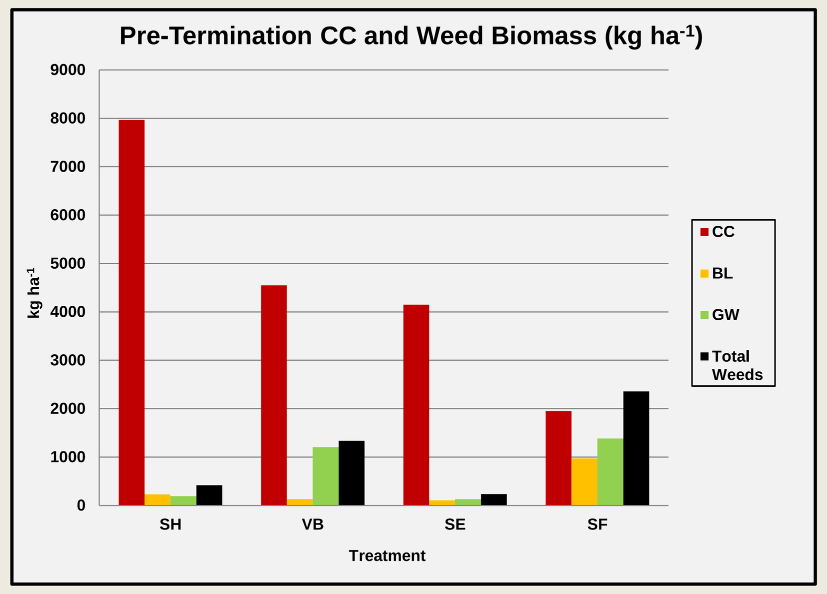


Figure 1.

Table 1: Plant Tissue Nutrient Content at Termination

	N%	P%	K%
SH	2.9b	0.17ab	1.5b
VB	3.2a	0.19a	2.3a
SE	1.2d	0.15c	2.4a
SF	1.3d	0.16bc	2.4a
PP	2.3c	0.16bc	2.1a

Means in the same column with different letters are significantly different (LSMeans, $p \leq 0.05$).

Table 2: Potential Nutrient Contribution of Vegetative Biomass at Termination (kg ha^{-1})

	N	P	K
SH	231b	118b	14b
VB	148c	103b	9c
SE	51d	101b	6c
SF	28d	53b	3c
PP	310a	316a	23a

Means in the same column with different letters are significantly different (LSMeans, $p \leq 0.05$).

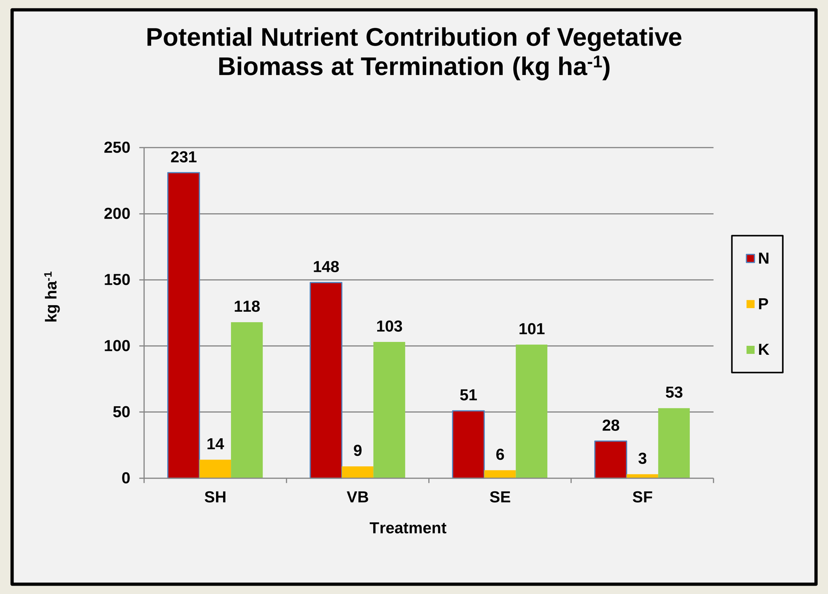


Figure 2.

Image 1: Comparative of SH and SE biomass

Image 2: SH stand Pre-termination

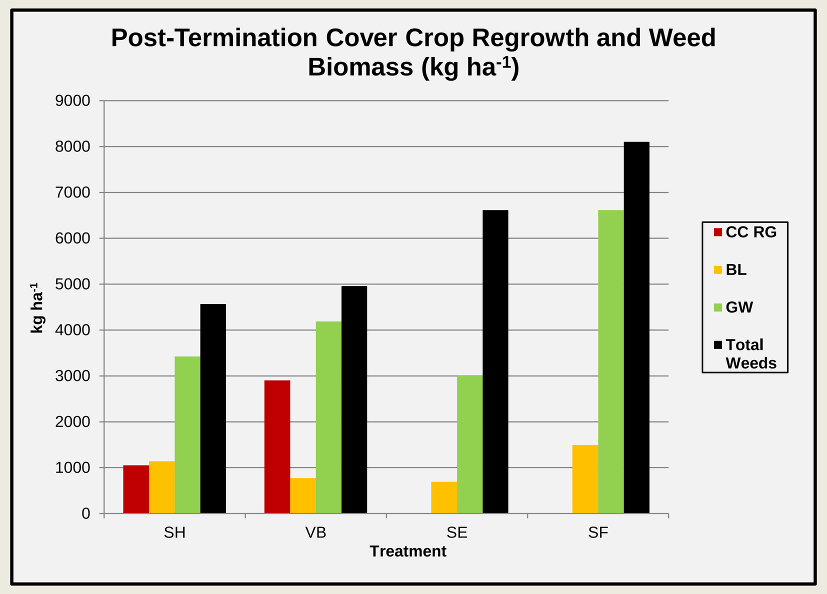


Figure 3.

Table 3: Cover Crop Regrowth, Broadleaf and Grass Weed biomass kg ha^{-1} Post-Termination with a Roller-Crimper

	Weeks after Termination			
	3 wks	6 wks	9 wks	12 wks
Sunn Hemp Regrowth	49c	261cde	234e	509de
Grass Weeds	5c	690bc	1124bc	1607b
Broadleaf Weeds	32c	202cde	345de	561cde
Velvet Bean Regrowth	201c	1045ab	384de	1274bcd
Grass Weeds	552b	670bc	1677a	1290bcd
Broadleaf Weeds	11c	44de	144e	572cde
Sesame Regrowth	0c	0e	0e	0e
Grass Weeds	49c	699bc	911c	1355bc
Broadleaf Weeds	57c	140cde	176e	322e
Sunflower Regrowth	0c	0e	0e	0e
Grass Weeds	904a	1547a	1513ab	2649a
Broadleaf Weeds	202c	605bcd	384de	301e

Means in the same column with different letters are significantly different (LSMeans, $p \leq 0.05$).

Table 4: Pigeon Pea Regrowth, Broadleaf and Grass Weed Development Following Termination with a Roller-Crimper in kg ha^{-1} Post-Termination

	Weeks after Termination			
	3	6	9	12
Pigeon Pea Regrowth	197a	393a	18a	0a
Grass Weeds	4a	86a	873b	3919b
Broadleaf Weeds	84a	530a	746b	3464b

Means in the same column with different letters are significantly different (LSMeans, $p \leq 0.05$).

Results and Discussion

Cover Crop and Weed Biomass at Termination

SH yielded the greatest biomass at 7,967 kg ha^{-1} which was different compared to VB, SE and SF at 4,549, 4,149 and 1,952 kg ha^{-1}, respectively ($p \leq 0.05$). There was no difference between VB and SE biomass yield; however, SF had the lowest yield which produced less biomass than SE ($p = 0.09$).

SH and SE had the lowest weed biomass at termination for both BW and GW; total weed biomass for SH and SE was 419 and 235 kg ha^{-1}, respectively, which was lower than total weed development in VB and SF with 1,336 and 2,358 kg ha^{-1}, respectively ($p \leq 0.05$). SF BW totalled 973 kg ha^{-1} which was greater than the level of BW in SE at 104 kg ha^{-1} ($p = 0.068$). Similar results were observed for GW biomass with SE and SH having similar low weed levels of 130 and 192 kg ha^{-1}, respectively, compared to VB and SF with much higher values at 1,205 and 1,385 kg ha^{-1}, respectively ($p \leq 0.03$).

PP produced 13,842 kg ha^{-1} of biomass and had 1,631 and 1,791 kg ha^{-1} of BL and GW biomass, respectively, for a total of 3,422 kg ha^{-1}.

Plant Tissue Nutrient Content

Nitrogen: N concentration in plant tissue was highest in VB at 3.2%, followed by SH at 2.9% ($p = 0.0026$), and then SF and SE which did not differ at 1.3% and 1.2% N, respectively. PP had 2.3% N.

Phosphorus: P plant tissue level was highest in VB at 0.19% which was not different from SH at 0.17% but greater than SF (0.16%) and SE (0.15%; $p \leq 0.05$).
PP had 0.16% P.

Potassium: K levels did not differ between SE, SF or VB at 2.4, 2.4, and 2.3%, respectively, but all three were higher than SH at 1.5% K. PP had 2.1% K.

Potential Nutrient Availability (Table 2)

Estimated total nitrogen contribution in SH was the highest at 231 kg ha^{-1} which was higher than VB (148 kg ha^{-1}), SE (51 kg/ha^{-1}), and SF (28 kg/ha^{-1}). Estimated total phosphorus contribution was also highest in SH at 14 kg ha^{-1}); there was no difference between VB, SE and SF potentially available P (9, 6, and 3 kg ha^{-1}, respectively). There was no difference for potentially available K across SH, VB, SE and SF treatments (118, 103, 101, and 53 kg/ha^{-1}, respectively).

Cover Crop Regrowth and Weed Development after Termination

Grass Weed Development after Termination (Table 3)

3 WAT: SH and SE had similar GW biomass at 5 and 49 kg/ha^{-1} respectively, which was lower than that for VB and SF at 552 and 904 kg/ha^{-1}, respectively ($p \leq 0.05$). VB had less GW than SF ($p = 0.02$) which could be attributed to poor VB termination from the roller-crimper resulting in greater regrowth competition with weed species.
6 WAT: SH, VB and SE had 690, 670 and 699 kg ha^{-1} (respectively) of GW biomass which were lower than SF (1,547 kg ha^{-1} $p \leq 0.004$).
9 WAT: SE GW biomass was 911 and is similar to SH levels of 1,124 kg ha^{-1} (respectively). VB and SF were not different at 1,677 and 1,513 kg ha^{-1} (respectively), but both had greater BW than SE ($p = 0.0087$).
12 WAT: VB, SE and SH had less GW biomass at 1,290, 1,355, and 1,607 kg ha^{-1}
(respectively) compared to SF with 2,649 kg ha^{-1} ($p \leq 0.01$).

Conclusion

SH produced the greatest biomass levels with relatively high plant tissue N content that resulted in SH having the highest estimated N and P contribution potential for returning nutrients back to the farming system. The SH cover crop contained 231 kg ha^{-1} at termination. Both SE and SH were effective at suppressing both BW and GW during cover crop establishment. SH, SE, and SF were effectively terminated with a roller crimper while VB was not, as evidenced by substantial levels of VB regrowth following roll down with the roller-crimper. Following roll down, SE and SH cover crop surface residue has the greatest potential for suppressing weed development for 6 weeks.

Due to the long establishment period to reach physiological maturity (120 days) before PP could be terminated, PP results were reported separate. However, PP did produce extremely high amounts of biomass that contained high N, P, and K that resulted in high PNA levels to the farming system (310 kg ha^{-1} of N, 23 kg/ha^{-1} P, and 316 kg/ha^{-1} of K).

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