Apical Dominance and Planting Density Effects on Weed Suppression by Sunn Hemp (*Crotalaria juncea* L.)

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Abstract. A field study was conducted in 2008 and 2009 in Citra, FL, to evaluate the effects of seeding rate and removal of apical dominance of sunn hemp (*Crotalaria juncea* L.) on weed suppression and seed production by sunn hemp. Three seeding rates of sunn hemp were used: a representative seed production rate of 11 kg·ha⁻¹, an intermediate seeding rate of 28 kg·ha⁻¹, and a cover crop seeding rate of 45 kg·ha⁻¹. Cutting the main stem at 3, 4, or 5 weeks after planting to break apical dominance was compared with an uncut treatment. Cutting had no significant effect on shoot biomass, photosynthetically active radiation (PAR) penetrating the canopy, and nondestructive leaf area index (LAI). As a result, cutting also had no effect on weed density and biomass in 2008 and very little effect in 2009. Increase in seeding rate resulted in linear decrease in PAR and increase in LAI in both years. Seeding rate had a greater effect on suppression of weed biomass than on suppression of weed density. There was a linear decline in sunn hemp branching with increased seeding rate in 2009 and, averaged across years, flower number decreased linearly with increased seeding rate. Cutting to break apical dominance induced branching but had no effect on flower number. No seed pod production occurred and we postulate that the lack of seed production may be the result of the absence of effective pollinators in fall when short-day varieties of sunn hemp flower in Florida.

Weed management is a major cost and constraint in both organic and conventional cropping systems (Walz, 1999). Although critical during the growing season, weed management during fallow periods is also important to avoid weed infestations in following cash crops. In Florida, vegetable crops are grown during the fall, winter, and spring, but during the hot, rainy summer months, the land is often left fallow (Wang et al., 2003). The type of fallow is specific to each grower depending on costs, management, and resources of each individual. The integration of a cover crop fallow into a cropping system as an alternative to a weedy fallow can incur additional production costs but can also provide beneficial agroecosystem

services. In addition to suppressing weed populations and limiting or preventing additions to the weed seed bank, a cover crop can provide soil stability, improve nutrient cycling, reduce leaching and runoff of nutrients and pesticides, and provide nutrients such as nitrogen, thus serving as a green manure.

Cover crop species are most effective in smothering and suppressing weed populations when they emerge and establish rapidly and produce a large amount of shoot biomass (Teasdale, 1998). Cover crops reduce weed pressure through physical interference with weed seed germination and seedling growth through alteration of light quantity, light quality, temperature, soil moisture content, and nutrient availability (Teasdale and Mohler, 1993). Some cover crops adversely affect weed seed germination and growth through chemical interference (allelopathy). Various types and amounts of allelochemicals are produced and can be released from the plant through leaching, volatilization, root exudation, death, and decay of plant parts, aided by various biotic and abiotic factors (Rice, 1984). Scientists agree that allelopathy

is an aspect of plant interference; however, there is a lack of consensus on the importance of allelopathy in weed suppression and information on the modes of action (Marcias et al., 2007; Putnam and Tang, 1986).

Sunn hemp has rapid stand establishment and shoot biomass accumulation and thus is a suitable cover crop for weed suppression. A leguminous cover crop, sunn hemp obtains nitrogen through biological fixation, and the cultivar Tropic Sun has been shown to suppress root-knot nematodes (Rotar and Joy, 1983). As a tool for weed suppression, sunn hemp is low maintenance and requires no attention after planting until the time of harvest (White and Haun, 1965). Sangakkara et al. (2006) investigated crops, including sunn hemp, which could be used in place of weedy fallows in tropical farming systems. Sunn hemp was found to have the largest above-ground biomass and, therefore, the greatest weed suppression in comparison with other crops (*Tithonia diversifolia*, *Phaseolus* beans, and a natural fallow), suppressing up to 82% of the weeds. They also showed that a cash crop of mungbean (*Vigna radiata* L.) planted after the sunn hemp fallow had the lowest weed populations, indicating that a grower might see a continued benefit of reduced weed populations in cash crops that follow a sunn hemp cover crop.

Collins et al. (2007) suggested that branching in an erect cover crop, including sunn hemp, could increase leaf area of the cover crop and thereby increase the competitive nature of the cover crop with weed species. Additionally, Collins et al. (2007) suggested that cover crop suppression of weeds can be enhanced by choosing cover crop cultivars with growth habits that reduce light penetration to the soil surface and reduce weed seed germination. Branching in sunn hemp depends on the planting density and apical dominance of the plant. Planting density can influence the height and formation of primary and secondary branches (Rotar and Joy, 1983) and low planting densities can increase the number of branches (Abdul-Baki et al., 2001).

The flowers of sunn hemp appear in racemes on the terminal 15 to 20 cm of secondary branches, and an increase in branches could also mean an increase in flowering (Abdul-Baki et al., 2001). Nanda (1962) noted the importance of apical dominance on flower bud formation and that terminal flower budbreak always preceded the breaking of lateral flower buds.

Abdul-Baki et al. (2001) reported that cutting the main stem at 90 cm to break apical dominance reduced plant height at maturity, but increased stem diameter, the number of branches, and flowers per plant. The results in that study indicated that the most responsive morphological changes from cutting the main stem were the increases in plant biomass and numbers of primary and secondary branches compared with uncut plants. Most farmers will not have equipment that can remove main stems of 90-cm-tall sunn hemp. However, mowers can be used for this purpose earlier in the season.

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The objectives of this study were to determine the effect of planting densities and early removal of apical dominance of sunn hemp on weed suppression, branch formation, and seed production. The hypothesis was that seeding rate and cutting to remove apical dominance would impact plant morphology, weed suppression, and seed production of sunn hemp.

Materials and Methods

The experiment was conducted on certified organic land (Quality Certification Services, Gainesville, FL) at the University of Florida's Plant Science Research and Education Unit in Citra, FL, from May to December in 2008 and was repeated in 2009. Irrigation and fertilizers were not used in either year. Plots were 1.4 m × 7.6 m with 1.8-m alleys between plots and 6.1-m alleys between blocks. The experimental design was a randomized complete block with four replications and a factorial arrangement of treatments that included three seeding rates, three cutting dates, and an uncut control. An untreated (no cover crop) weedy control was added in 2009. The lowest seeding rate of 11 kg·ha⁻¹ was selected to represent commercial seed production practices and the highest seeding rate of 45 kg·ha⁻¹ represented a typical cover crop seeding rate for sunn hemp. An intermediate seeding rate of 28 kg·ha⁻¹ was included as a result of interest

in developing sunn hemp seed production as an alternative enterprise for organic growers during the summer off-season. We hypothesized that the intermediate seeding rate would give the benefit of seed production while still providing adequate weed suppression. Sunn hemp seeds (Kauffman Seed, Haven, KS) were inoculated with cowpea-type *Rhizobium* (Nitragin, Inc., Brookfield, WI) before seeding. Seeds were drilled in three rows spaced 45 cm apart with a Monosem air planter (NG Plus, Edwardsville, KS) on 15 May 2008 and 18 May 2009. To remove apical dominance, the top (2 to 3 cm) of the main stem was removed by manually cutting with scissors at 3, 4, or 5 weeks after planting (WAP) or plants were left uncut.

Sunn hemp shoot biomass was assessed by harvesting shoots at the soil level within a randomly placed 0.25-m² quadrat. Biomass was dried to constant weight in a forced-air oven at 60 °C for ≈4 d. *PAR* penetrating the cover crop canopy and nondestructive LAI were measured using an AccuPar Ceptometer (Decagon Devices, Pullman, WA). Readings were taken at 3, 6, 9, and 12 WAP at midday with no cloud cover. At 3 WAP, *PAR* and LAI were measured before the application of the cutting treatment. An unobstructed reading was taken from above the sunn hemp canopy if possible, and if not, an unobstructed reading was taken at 1 m above ground. Below-canopy readings were taken by inserting the probe perpendicular through the rows.

Weeds were counted by species within one randomly placed quadrat (91 cm × 46 cm) in the center of each plot at 8 and 12 WAP. Weeds were harvested at the soil surface and separated into monocotyledon and dicotyledon species. Weed biomass was then dried at 49 °C for at least 1 week and dry weights were recorded.

At 4 months after planting (MAP), the number of primary branches longer than 1 m was counted. Three plants were randomly selected from the center row of each plot and branches were counted. At 5 MAP, the same plant selection process occurred and the number of open flowers per plant was recorded.

Data were analyzed using SAS STAT (Version 9.2; SAS Institute Inc., Cary, NC) of the SAS System for Windows. The significance level was 0.05. Analysis of variance was performed using the GLM procedure and separation of cutting date means was performed using a protected Fisher's least significant difference test. Orthogonal polynomials were applied to the analyses of shoot biomass, *PAR*, and LAI data to determine whether the response to seeding rate or sampling date was linear or quadratic. The MIXED procedure was used for repeated-measures analysis of the weed density data and separation of cutting date means was accomplished using the PDIF option of the LSMEANS statement.

Fig. 1. Shoot dry biomass production by sunn hemp in 2008 (A) and 2009 (B) at Citra, FL. Sunn hemp was planted on 15 May 2008 and 18 May 2009. Using orthogonal polynomial regression, the response in A was both linear and quadratic ($P < 0.0001$) and in B the response was linear at all seeding rates ($P < 0.001$).

Table 1. Photosynthetically active radiation and leaf area index of sunn hemp canopies in response to cutting to remove apical dominance and seeding rate over 2 years in Citra, FL.^z

Treatment	<i>PAR</i> ^y (%)		LAI ^y	
	2008	2009	2008	2009
Cutting date (CD) ^x				
Uncut	32.5	44.3	3.6	2.3
CD 1	31.0	44.1	4.1	2.6
CD 2	31.4	40.7	4.0	2.7
CD 3	30.0	44.3	4.2	2.7
Seeding rate				
11 kg·ha ⁻¹	34.8	46.9	3.6	2.2
28 kg·ha ⁻¹	29.8	42.0	4.1	2.7
45 kg·ha ⁻¹	29.1	39.2	4.1	2.8
Sample date				
3 WAP	87.7	93.1	0.3	0.1
6 WAP	20.8	47.7	3.6	1.7
9 WAP	11.8	18.0	5.0	4.2
12 WAP	4.5	11.0	7.0	4.2
Significance ^w				
Cutting date (CD)	NS	NS	NS	NS
Seeding rate (SR)	*	**	*	**
Linear	*	**	*	**
Quadratic	NS	NS	NS	NS
Sample date (SD)	***	***	***	***
Linear	***	***	***	***
Quadratic	***	***	**	***

^zSunn hemp was planted on 15 May 2008 and 18 May 2009.

^y*PAR* = photosynthetically active radiation penetrating the canopy; LAI = leaf area index.

^xCD1, CD2, and CD3 represent cutting at 3, 4, and 5 weeks after planting (WAP), respectively.

^wNS, *, **, *** Nonsignificant or significant at $\alpha = 5\%$, 1%, or 0.1%, respectively. All interactions between and among the main effects were not significant.

Results and Discussion

Sunn hemp canopy. The effect of cutting date on shoot biomass was not significant in either 2008 or 2009 (data not shown). In 2008, seeding rate also had no significant effect on shoot biomass, so data were averaged over cutting date and seeding rate to assess the effect of sample date. Sunn hemp shoot biomass was 1593 kg·ha⁻¹ at 6 WAP and increased to 6774 kg·ha⁻¹ by 10 WAP (Fig. 1A). An interaction obtained between seeding rate and sample date in 2009 ($P < 0.0001$) resulted from the more rapid biomass accumulation with the 45-kg·ha⁻¹ seeding rate than with the two lower seeding rates (Fig. 1B).

As for shoot biomass, cutting to remove apical dominance had no significant effect on *PAR* and LAI (Table 1) in either year; however, seeding rate and sample date both resulted in significant changes in both *PAR* and LAI. In 2008 and 2009, consistent with an increase in canopy closure, *PAR* declined

with an increase in seeding rate and with later sample dates. The LAI, which is an indicator of leaf area, had a reverse trend and increased as seeding rate increased and peaked with later sample dates.

Cover crops reduce weed pressure through physical interference with weed seed germination and seedling growth through alteration of light quantity, light quality, temperature, soil moisture content, and nutrient availability (Teasdale and Mohler, 1993). The increase in sunn hemp biomass with time, the reduction in *PAR* penetrating the sunn hemp canopies, and concomitant increase in LAI under all seeding rates by 12 WAP suggest that light interception is a contributing factor in the suppression of weed populations by the cover crop.

Weed species. Weed species present throughout the experiment varied by year, most likely as a result of the use of different fields within the research station (Table 2). In 2008, the primary weed species under the sunn hemp canopies were hairy indigo

(*Indigofera hirsuta* Harvey), bahiagrass (*Paspalum notatum* Fluegge), and purple nutsedge (*Cyperus rotundus* L.) at 48%, 27%, and 10% of the weeds, respectively. In 2009, the primary weed species under the sunn hemp canopies were Florida pusley (*Richardia scabra* L.), bahiagrass, and bermudagrass (*Cynodon dactylon* L. Pers.) at 66%, 12%, and 11%, respectively.

Weed density. In 2008, cutting date and seeding rate had no significant effect on weed density (Table 3). Dicotyledon and total weed densities were higher at 8 WAP than at the later sample date of 12 WAP. In 2009, at 8 WAP, the only significant effect of cutting date and seeding rate on weed density was observed for total weed density with sunn hemp plants sown at the 11-kg·ha⁻¹ seeding rate. Plants cut at 3 WAP resulted in the lowest total weed density when compared with the other cut and uncut treatments (Table 4). By 12 WAP, dicotyledon and total weed densities were higher when sunn hemp cutting occurred at 5 WAP than when the cutting was done at the two earlier dates, but this was not apparent with monocotyledon weed density.

Weed biomass. In 2008, as for weed density, cutting date had no significant effect on weed biomass (data not shown). However, whereas seeding rate had no effect on weed density, linear declines in monocotyledon, dicotyledon, and total weed biomass occurred as seeding rate increased (Fig. 2A). As a result of a significant seeding rate by sample date interaction for dicotyledon and total weed biomass, results for 2009 are presented by sample date (Fig. 2B). Seeding rate had no significant effect on weed biomass at 8 WAP (data not shown); however, by 12 WAP, there were linear decreases in dicotyledon and total weed biomass as seeding rate increased (Fig. 2B). A significant cutting date effect was obtained only for monocotyledon biomass at 12 WAP ($P = 0.04$; data not shown). Delaying cutting until 5 WAP and not cutting at all gave the lowest monocotyledon weed biomass of 12 g·m⁻² and 13.9 g·m⁻², respectively, compared with 33.9 g·m⁻² and 25.1 g·m⁻² when stems were cut at 3 and 4 WAP, respectively (least significant difference = 16.6 g·m⁻²).

Branching and flowering. Branching results are presented by year as a result of significant year by cutting date and year by seeding rate interactions ($P < 0.001$). In 2008, the effect of seeding rate on branching of sunn hemp plants was significant only when cutting occurred at 5 WAP with less branching observed as seeding rate increased (Table 5). Cutting at all three dates resulted in more branching than the uncut treatment. In 2009, all cutting dates had increased branching compared with no cutting, and delaying cutting date resulted in a greater number of branches per plant (Table 6). Conversely, a linear decrease in branching was observed as seeding rate increased. Flowering results were averaged over the 2 years as a result of the absence of interactions with the other variables. Cutting had no significant effect on the number of flowers per plant

Table 2. Weed species composition within sunn hemp cover crop trials in 2008 and 2009 (Citra, FL).^z

Common name	Scientific name	Species composition (%)	
		2008	2009
Hairy indigo	<i>Indigofera hirsuta</i> L.	48	—
Florida pusley	<i>Richardia scabra</i> L.	8	66
Bahiagrass	<i>Paspalum notatum</i> Fluegge	27	12
Bermudagrass	<i>Cynodon dactylon</i> (L.) Pers.	—	11
Purple nutsedge	<i>Cyperus rotundus</i> L.	10	1
Carpetweed	<i>Mollugo verticillata</i> L.	—	5
Asiatic dayflower	<i>Commelina communis</i> L.	3	—
Simpson's croton	<i>Croton glandulosus</i> L. var. <i>simpsonii</i> A.M. Ferguson	2	—
Tropical fimbry	<i>Fimbristylis cymosa</i> R. Br.	—	2
Prickly sida	<i>Sida spinosa</i> L.	—	1
Goosegrass	<i>Eleusine indica</i> (L.) Gaertn.	1	—
Other	—	1	2
Total	—	100	100

^zSunn hemp was planted on 15 May 2008 and 18 May 2009. Weeds were counted by species within a 91 cm × 46-cm quadrat randomly placed in the center row at 8 and 12 weeks after planting (2008) and at 4, 8, and 12 weeks after planting (2009). Weed species composition was averaged over collection dates and treatments.

Table 3. Effect of cutting date and seeding rate of sunn hemp on the density of monocotyledon and dicotyledon weed species in 2008 (Citra, FL).^z

Treatment	Monocotyledons	Dicotyledons	Total
Cutting date (CD) ^y	Plants/m ²		
Uncut	17.0	21.4	38.4
CD1	12.3	20.3	32.7
CD2	18.3	21.5	39.8
CD3	13.4	24.4	37.8
Seeding rate (SR)			
11 kg·ha ⁻¹	18.5	21.3	39.9
28 kg·ha ⁻¹	15.4	22.3	37.7
45 kg·ha ⁻¹	12.0	22.0	34.0
Sample date (SD)			
8 WAP	17.5	27.2 a	44.8 a
12 WAP	13.4	16.5 b	29.6 b
Significance ^x			
Cutting	NS	NS	NS
Seeding rate	NS	NS	NS
Sample date	NS	*	*
CD × SR	NS	NS	NS
CD × SR × SD	NS	NS	NS

^zSunn hemp was planted on 15 May 2008.

^yCD1, CD2, and CD3 represent cutting to break apical dominance by removing the top (2 to 3 cm) of the main stem at 3, 4, and 5 weeks after planting (WAP), respectively.

^xNS, *, **, *** Nonsignificant or significant at $\alpha = 5\%$, 1%, or 0.1%, respectively.

Table 4. Effect of cutting date and seeding rate of sunn hemp on the density of monocotyledon and dicotyledon weed species in 2009 (Citra, FL).^z

Treatment	Monocotyledons		Dicotyledons		Total			
	8 WAP	12 WAP	8 WAP	12 WAP	8 WAP			
					11 kg·ha ⁻¹	28 kg·ha ⁻¹	45 kg·ha ⁻¹	12 WAP
Cutting date (CD) ^y								
Uncut	32.9	30.9	120.0	70.1 ab	154.1 a	156.5	148.1	100.9 ab
CD1	51.2	44.4	80.4	51.2 bc	70.5 b	180.4	144.0	95.5 b
CD2	46.4	44.8	79.8	46.6 c	158.2 a	120.7	99.7	91.4 b
CD3	48.4	45.4	99.5	74.7 a	166.0 a	159.5	118.2	120.0 a
Seeding rate (SR)								
11 kg·ha ⁻¹	41.2	33.4	96.0	50.3	—	—	—	83.8
28 kg·ha ⁻¹	59.1	58.2	95.1	65.5	—	—	—	123.8
45 kg·ha ⁻¹	33.7	32.4	93.8	66.0	—	—	—	98.4
Significance ^x								
Cutting	NS	NS	NS	*	**	NS	NS	*
Seeding rate	NS	^w Q**	NS	NS	—	—	—	^w Q***
CD × SR	NS	NS	NS	NS		*		NS

^zSunn hemp was planted on 18 May 2009.^yCD1, CD2, and CD3 represent cutting to break apical dominance by removing the top (2 to 3 cm) of the main stem at 3, 4, and 5 weeks after planting (WAP), respectively.^xNS, *, **, *** Nonsignificant or significant at $\alpha = 5\%$, 1%, or 0.1%, respectively.^wQ indicates a significant quadratic response determined using orthogonal polynomial regression. Fig. 2. Effect of sunn hemp seeding rate on weed biomass (A) showing results averaged over cutting date and sample date for 2008 [8 and 12 weeks after planting (WAP)] and (B) in 2009 results averaged over cutting date are presented for 12 WAP only (no significant response at 8 WAP). Sunn hemp was planted on 15 May 2008 and 18 May 2009 at 11, 28, and 45 kg·ha⁻¹. Stems were either uncut or cut to break apical dominance by removing the top (2 to 3 cm) of the main stem at 3, 4, and 5 WAP. L indicates a linear response obtained with orthogonal polynomial regression. NS, **, *** Nonsignificant or significant at $\alpha = 1\%$ or 0.1%, respectively.

(Table 6). However, flower numbers decreased linearly as sunn hemp seeding rates increased.

Because sunn hemp flowers occur on branches in terminal racemes, an increase in branching could also increase flowering and seed production (Abdul-Baki et al., 2001; Pursglove, 1974). Because Abdul-Baki et al. (2001) observed an increase in primary and secondary branches and an increase in flowering when the main stem of sunn hemp was cut at 90 cm, the effects of removing apical dominance on branch and flower formation were considered in our study. Cutting to remove apical dominance in this study led to branches that were oriented vertically, more like secondary main stems. An increased stem number resulting from axillary bud release with meristem removal appears to have compensated for temporary adverse effects caused by cutting.

The lowest seeding rate (11 kg·ha⁻²) used in this study was intended to serve as a representative seeding rate for organic seed production of sunn hemp. Rotar and Joy (1983), for example, recommended a seeding rate of 3 to 5 kg·ha⁻² with a pre-emergence herbicide application for weed management. However, a cultural approach for managing weeds in organic sunn hemp seed crops such as increasing the planting density is permitted by the national organic program, whereas synthetic herbicides are not. Although our lowest seeding rate produced more flowers than the highest seeding rate, because of the lack of seed yield, we cannot confirm that the lowest planting density would also produce the highest seed yield.

Despite placing commercial bumblebee (*Bombus impatiens* Cresson) hives (Koppert Biological Systems, Inc., Howell, MI) in the

Table 5. Effect of seeding rate and cutting date of sunn hemp on number of primary branches in 2008 (Citra, FL).^z

Seeding rate	Cutting date (CD) ^y			
	Uncut	CD1	CD2	CD3
11 kg·ha ⁻¹	0 a	2.3 bc	1.9 b	2.6 c
28 kg·ha ⁻¹	0 a	2.1 b	2.2 bc	2.6 c
45 kg·ha ⁻¹	0 a	1.9 b	2.2 b	1.8 b
Significance				
Linear	—	NS	NS	*
Quadratic	—	NS	NS	NS

^zSunn hemp was planted on 15 May 2008.^yCD1, CD2, and CD3 represent cutting to break apical dominance by removing the top (2 to 3 cm) of the main stem at 3, 4, and 5 weeks after planting (WAP), respectively. Means in rows followed by the same letter are not significantly different at $\alpha = 0.05$.NS, *, **, *** Nonsignificant or significant at $\alpha = 5\%$, 1% or 0.1%, respectively. Branching results are presented by year resulting from significant year by cutting date and year by seeding rate interactions, $P < 0.001$.

sunn hemp field to encourage pollination in both 2008 and 2009, seedpods were not produced in either year. It has been reported that sunn hemp needs large insects such as bees in the *Xylocopa* and the *Megachile* genera for effective pollination (Pursglove, 1974). Honey bees (*Apis mellifera* Linnaeus) are too small and although they visit sunn hemp flowers, they are simply “pollen robbers” because their activities do not pollinate the flowers. The lack of pod set suggests that bumblebees may not be large enough to accomplish the depression of the sunn hemp flower keel that is needed for pollen release (H. Glenn Hall, personal communication). It is likely that the failure to obtain seed in this study was the result of the absence of effective pollinators in fall when short-day varieties of sunn hemp flower in Florida. Seed yield was obtained in a similar study in Puerto Rico where, in addition to honeybees, the Greater Antillean carpenter bee (*Xylocopa mordax* Smith) was observed visiting flowers (Halbrendt, 2010) and is the likely pollinator. In Gainesville, FL,

Table 6. Effect of cutting date and seeding rate of sunn hemp on number of primary branches in 2009 and number of flowers averaged over 2008 and 2009.^z

Treatment	Branches ^y	Flowers
Cutting date ^x		
Uncut	0.3 a	4.6
CD1	1.0 b	3.9
CD2	1.2 bc	5.3
CD3	1.5 c	6.1
Seeding rate		
11 kg·ha ⁻¹	1.6	7.8
28 kg·ha ⁻¹	0.8	4.1
45 kg·ha ⁻¹	0.5	3.1
Significance ^w		
Cutting date	***	NS
Seeding rate	***	**
Linear	***	**
Quadratic	NS	NS

^zSunn hemp was planted on 15 May 2008 and 18 May 2009.

^yOnly primary branches greater than 1 m in length were counted. Means in columns followed by the same letter are not significantly different at $\alpha = 0.05$. Branching results are presented by year as a result of significant year*cutting date and year*seed rate interactions, $P < 0.001$.

^xCD1, CD2, and CD3 represent cutting to break apical dominance by removing the top (2 to 3 cm) of the main stem at 3, 4, and 5 weeks after planting (WAP), respectively.

^wNS, *, **, *** Nonsignificant or significant at $\alpha = 5\%$, 1%, or 0.1%, respectively.

sunn hemp accessions capable of flowering in summer successfully produced seed (Cho, 2010). *Megachile sculpturalis* Smith, a large non-native bee, was observed at the experimental site in Gainesville during flowering (H. Glenn Hall, personal communication).

Although the objective of determining the effects of the treatments on seed production could not be achieved, the results from the study provided useful information. We learned that by using a seeding rate that was double that suggested by Rotar and Joy (1983), the crop stand itself will provide considerable weed suppression. Additionally, our findings can serve as the basis for recommendations for use of sunn hemp as a cover crop for weed suppression. Because the costs involved in additional management and added expenses to a farming system limit the adoption of any cover crop, a reduction in seed cost could encourage the use of sunn hemp (Teasdale, 1996). The weed

suppression achieved by the sunn hemp cover crop in this study demonstrates the efficacy of physical interference from rapid establishment and canopy closure on weed seed germination and growth. Sunn hemp leaf litter might also provide additional physical impedance of weed germination and establishment. Leaf litter may also contribute to suppression of weed germination and growth by means of allelopathy. Adler and Chase (2007) have reported allelopathic suppression of goosegrass and smooth amaranth germination and growth with dried sunn hemp residues.

Sunn hemp can provide several agroecosystem benefits such as weed suppression, soil stabilization, nitrogen accumulation, and root-knot nematode suppression (Balkcom and Reeves, 2005; Mansoer et al., 1997; Sangakkara et al., 2006). Future research needs to take the potential obstacles for adoption of sunn hemp into closer consideration. As a result of the limited domestic seed source, it is important to continue to investigate sunn hemp accessions that could provide a consistent supply of viable seed in the southeastern United States. This would need to include synchronizing flowering with the presence of effective pollinators. Additionally, the potential for sunn hemp to become an invasive species needs to be evaluated carefully before adoption as a seed crop in the southeastern United States, Puerto Rico, and the U.S. Virgin Islands.

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