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Research article

GREEN SUGARCANE CROP RESIDUE AFFECTS VELVET BEAN SEED GERMINATION

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ABSTRACT

A study was carried out at the experimental farm of Universidade Federal de Goiás, campus Jataí, Brazil. The aim was to evaluate the germination of velvet bean (*Stizolobium aterrimum*) seeds covered by sugarcane (*Saccharum* sp.) leaf trash. The trash cane left by the mechanized harvesting process, aids to control certain weed germination, but doesn't control not all the weeds. Well managed, velvet bean is a useful legume cover crop in fields of green sugarcane. However, velvet bean might become a troublesome weed due to its staggered seed germination, and resistance to leaf trash. Velvet bean seeds and the trash cane were collected from a sugarcane field where the variety SP81-3250 was planted. Scarified and intact velvet bean seeds were sown on soil surface, 2, 5, 10 and 20 cm below. For screening, seeds were sown in pots in the sunlight, also planted in the field covered with sugarcane leaf trash. The cane trash caused irregular seed germination in each depth in the field, only reaching 100% at 30 days after seeds had been sown; moreover, it affected the dry matter of plants that were dispersed on soil surface, and covered by trash cane. The intact seeds germination in pots failed reach 100%, however, scarified seeds reached 100% germination.

Keywords: velvet bean; sugarcane; burned cane; intercropping; testa and weed control.

INTRODUCTION

As a perennial crop, sugarcane in Brazil can be harvested four to ten times from a single plant. Most of the sugarcane fields in Brazil are green cane harvest instead burned cane harvest. Mechanical harvesting speeds up the harvesting process, and sugarcane tops and leaves are deposited on the ground. The plant litter left from the mechanized harvesting process, aims to control weeds and holds soil moisture, yet it impedes the sun light from reaching the soil surface and heating the soil; thus, slowing the soil seed bank germinate. Also, the leaf trash reduces evaporation from soil because the thick blanket acts as a mulch to preserve soil water. However, the blanket doesn't impede all the weeds from germinating. Therefore, intercropping with a legume cover crop has been used to managed weeds during ratooning of sugarcane field.

The genus *Mucuna* has approximately 150 species of annual and perennial legumes, widely spread in tropical and subtropical regions of the world. Many countries have adopted to intercrop in the rotation of sugarcane crop (Bodner et al., 2007; Conlong, et al., 2010), because the notification of herbicide resistant weeds is rising each day (Heap, 2016). India is the country where *Stizolobium aterimum* or velvet bean originated, and it is well adapted to tropical climate. In Brazil, velvet beans are commonly used as a legume cover crop in sugarcane crops (Deminicis, et al., 2014) because of its physiological characteristic for suppressing weeds rapidly. Velvet beans plays an important role to fix nitrogen, nutrients recycling, soil surface protection (Anugroho et al., 2010). Velvet bean is also used for bioremediation (Souza et al. 2011), nematode control (Moura et al. 2010), and phytoextraction (Nascimento & Xing, 2006). Intercropping sugarcane with velvet beans is an economical method to increase sugarcane yield, improving soil biological activity; moreover, the characteristic of suppressing weeds (Mhlanga, et al., 2016), is an environmentally acceptable alternative than a chemical weed control.

Velvet bean's seed coat or testa protects the seed against pathogens, environmental hazards and mechanical damages when sugarcane is harvested (Debeaujon et al., 2000). The testa has a biophysical characteristic that might influence the properties of seed germination, facilitating staggered seed germination. This biophysical characteristic is related to oil and water seed content, desiccation tolerance and dormancy (Footitt et al., 2016). Also, it influences the seed germination whether the water breaks the seed dormancy or enhances the length of dormancy. Germination should be tested in laboratory or in field (Baskin et al. 2006). The germination and dormancy also influenced by temperature, precipitation and soil properties (Jiménez-Alfaro et al., 2016). When a plant mother is affected by the climate, the progenitors are affected as well, and might elongate the dormancy (Rosbakh & Poschlod, 2015). Therefore, velvet bean might become an annual weed if it isn't well managed.

Many researchers have observed the benefits of velvet bean as a biological weed control, and a sustainable agriculture practice. Therefore, a study of velvet bean seed behavior in sugarcane litter is needed, so velvet bean might be correctly managed. Therefore, this study aims to evaluate the behavior of velvet bean seeds under sugarcane litter.

MATERIALS AND METHODS

The experiment was conducted in 2009 trial 1 and 2010 trial 2, both carried out at Universidade Federal de Goiás, campus Jataí-Brazil (17° 52' 51" S 51° 42' 50" W, elevation 708 m). The soil in both trials were Latossolo Vermelho distroférrico (Brazilian Soil Classification) or Oxisols (USDA Soil Classification), having clay 64.52%, silt 18.84%, sand 16.64% and chemical properties is given in (Table 2). Velvet bean seeds and sugarcane litter were collected from the same field where the SP81-3250 was planted in 2006 and had a yield of 90 Mg ha^{-1} in 2009. Temperature and precipitation at the site for both trials is given in Table 1.

Trial 1 was organized as randomized complete factorial experiment with two seed treatments (intact and scarified), and four sowing depths (2, 5, 10 and 20 cm) (Lentner and Bishop, 1993). There were four replicates for each seed treatments by sowing depth combination. Plastic planting pots (7 dm^3), filled with the same soil from the field trial 2. The pots were placed in full sunlight to simulate the environmental conditions after cane-field renewal. The testa (seed coat) on opposite side of the embryo, was removed to simulate mechanical damaged (Maeda e Lago, 1986). A measuring ruler was used to simulate planting depth for each velvet bean seed's planting. Each pot had 50 seeds sown without sugarcane litter. Seedling emergence was estimated by counting the seedlings emerged every 10 days after the sowing for 60 days.

Trial 2 was randomized complete block design with four replications (Lentner and Bishop, 1993). Each experimental unit had a dimension of 1.7 x 1.7 feet, 12 intact seeds sown equidistantly at the same depth on trial 1 and 13 Mg ha^{-1} of plant litter. The screening followed the procedures of sowing depths on trial 1, and covered with plant litter. Also, a simulation of dispersal by mechanical harvester were made by scattering seeds on soil surface, after covered them with plant litter. Seedling emergence was estimated by counting the seedlings emerged at 10th, 20th and 30th day after sowing. Stems and leaves from the plants emerged at the 30th day were used to determine dry matter (Benincasa, 2003).

ANOVA was performed on velvet bean dry matter, using ESTAT for windows 8 (UNESP, Jaboticabal, BR). Mean comparisons between data were made by using Tukey with statistical significance 5%. The germination percentage in each trial was assessed by SigmaPlot 11.0 (Systat Software).

RESULTS AND DISCUSSION

Results obtained in the germination test showed that velvet bean's intact seeds didn't reach 100% of germination. Dormancy level influenced germination similar to observances by (Bewley et al.,2012). They also found that for each 1% decrease in seed moisture, dormancy longevity is doubled.

Intact velvet bean seeds did not all germinate 100% at any depth (Fig. 1). Scarified seeds sown at 2.0 and 20 cm of depth reached 100% germination, probably because the temperature broke dormancy at 2.0 cm, while in 20 cm the water temperature decreased dormancy. Otherwise, intact and scarified seeds had the same percentage of germination at 5.0 and 10 cm of depth, and didn't reach 100% as well. Oliveira (2013) studied four methods (water temperature, mechanic scarification, sulfuric acid and sun light) to break dormancy in velvet beans seeds, and concluded that mechanic scarification, sulfuric acid and water temperature had higher percentage of germination than sun light treatment. (Kobori et al., 2013) showed the same results, proving that mechanical scarification enhance the germination and decreasing the dormancy level in velvet bean seeds. (Bewley & Black, 1994) states that water content regulates the seed dormancy, for the testa become more impermeable as the water content increase. In addition, late embryogenesis abundant (LEA) genes in orthodox seeds has protective functions that might aid the seed against abiotic stress (Tunnacliffe & Wise, 2007; Chantelain et al., 2012; Amara et al., 2012).

The 2.0 and 20 cm depth seeds emerged in 10 days, differently from seeds on soil surface, 5.0 and 10 cm depth, which were staggered (Fig. 2). (Campos et al., 2011) also showed staggered germination for velvet bean seeds at different sowing depths; moreover, the emergence of seeds was not affected by cane trash. Velvet bean adapts well in green sugarcane system. Studying the effect of velvet bean seed's size on germination, (Nakagawa Cavariani et al., 2008) concluded that small seeds have a higher percentage of seed germination than big seeds. According to (Marcos, 2005) velvet bean is characterized as having a hard testa, which doesn't allow the seed to imbibe. Also, this hard testa influences the germination time, so the seeds can sprout in a range of times, becoming a weed and interfering with sugarcane yield. Dormancy, germination and longevity are controlled by seed coats that are resistant to environment factors (Debeaujon, 2000). Dormancy is important to understand because it is correlated with germination traits, water content, chemical properties of endosperm or embryo, seed shape, seed production and seedling size (Westoby et al., 2002; Forbis et al., 2002; Hamilton et al., 2013). Studying the reduction of *Mucuna andreana* seedling vigor by drilling hole in the seed, (Janzen, 1976) identified the loss of seed weight or seed reserves reflects on shoots and longevity during seed germination. In addition, the level of dormancy may correspond with the habitat of the mother plant, genetic adaptation and the environment factors affecting the mother plant (Gutterman, 2000; Rosbakh & Poschlod, 2015). In addition, the aging of seeds or seed deterioration are factors linked to germination due to seeds having high concentration of lipid and low concentration of water (Heydecker et al., 1973; Walter, 1988; Balešević-Tubić et al. 2010).

The dry matter of leaves and stems, 30 days after sowing was statistically higher in 2.0, 5.0 and 10 cm when compared to surface sown and 20 cm (Fig. 3). The energy used by the seedlings to emerge from 20 cm resulted in lower aboveground dry matter production. Leaves had higher dry matter than stems (Fig. 4). Soil is tilled during the renewal of sugarcane field, so velvet bean seeds might stay below ground. Then, the plants will emerge healthy and steady. Thus, the control will be easier because the plant will have high biomass, and the herbicide application will be more effective. However, pre-emergent herbicides are required to control the seeds haven`t emerged. (Silva et al., 2012) assessed the efficiency of pre-emergent herbicides in velvet beans (*Mucuna cinerea*, *Mucuna aterrima* and *Mucuna deeringiana*), showing that sulfentrazone and amicarbazone had the highest effectivity.

CONCLUSION

In conclusion, intact velvet bean seeds are less harmful than damaged seeds and are less likely to propagate and become weed, yet the trash cane doesn`t control well the outgrowth. Finally, tilling the soil followed by a post-emergent herbicide is the best management to control velvet beans in green sugarcane system.

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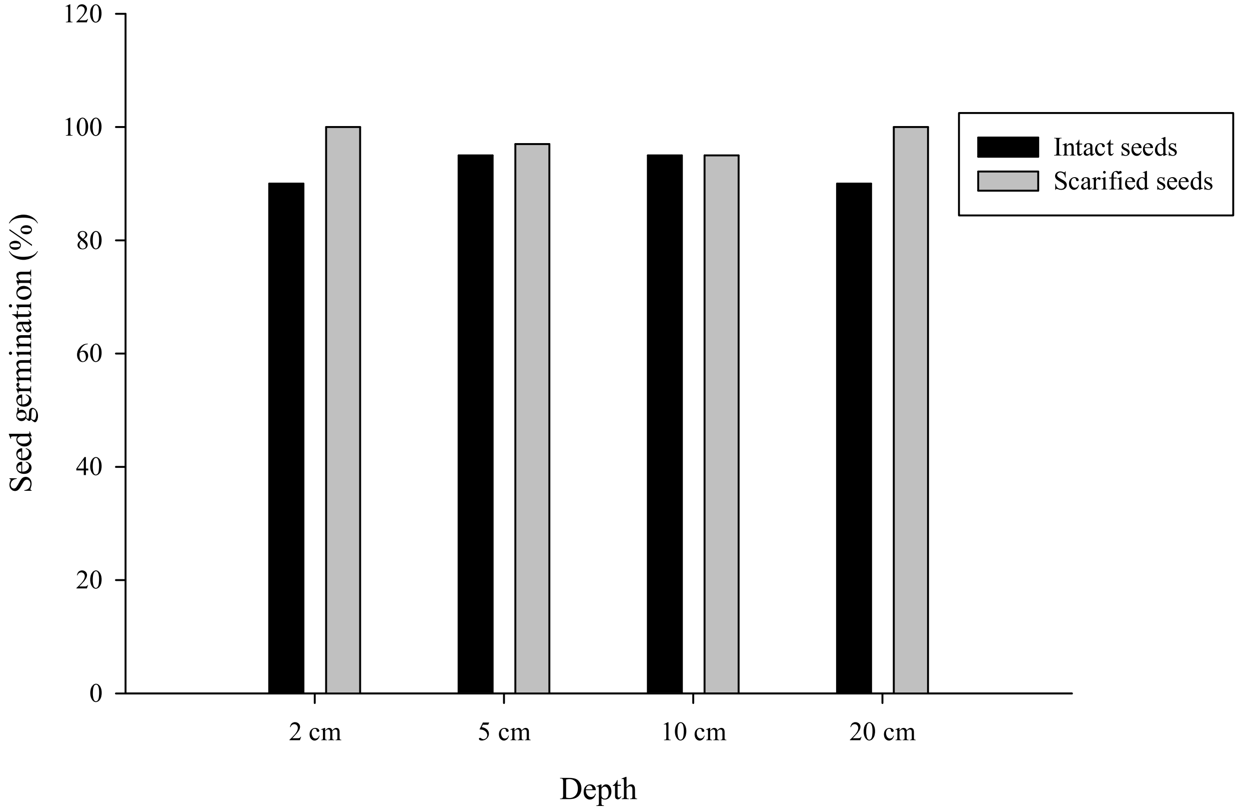

Figure 1. Percentage (%) germination of seeds from intact and scarified treatments at different planting depths in Trial 1.

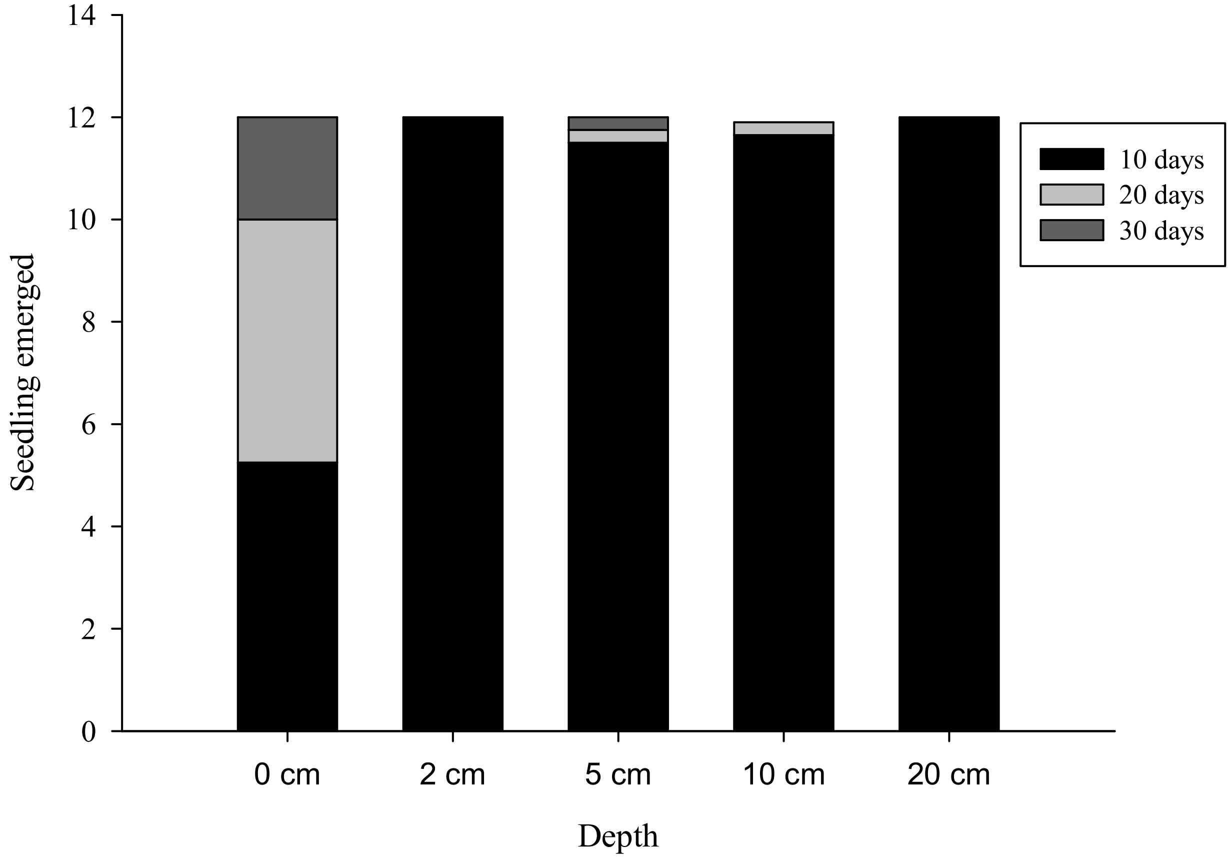

Figure 2. The mean seedlings emerged in each screening day and sowing depth, covered by trash cane on Trial 2.

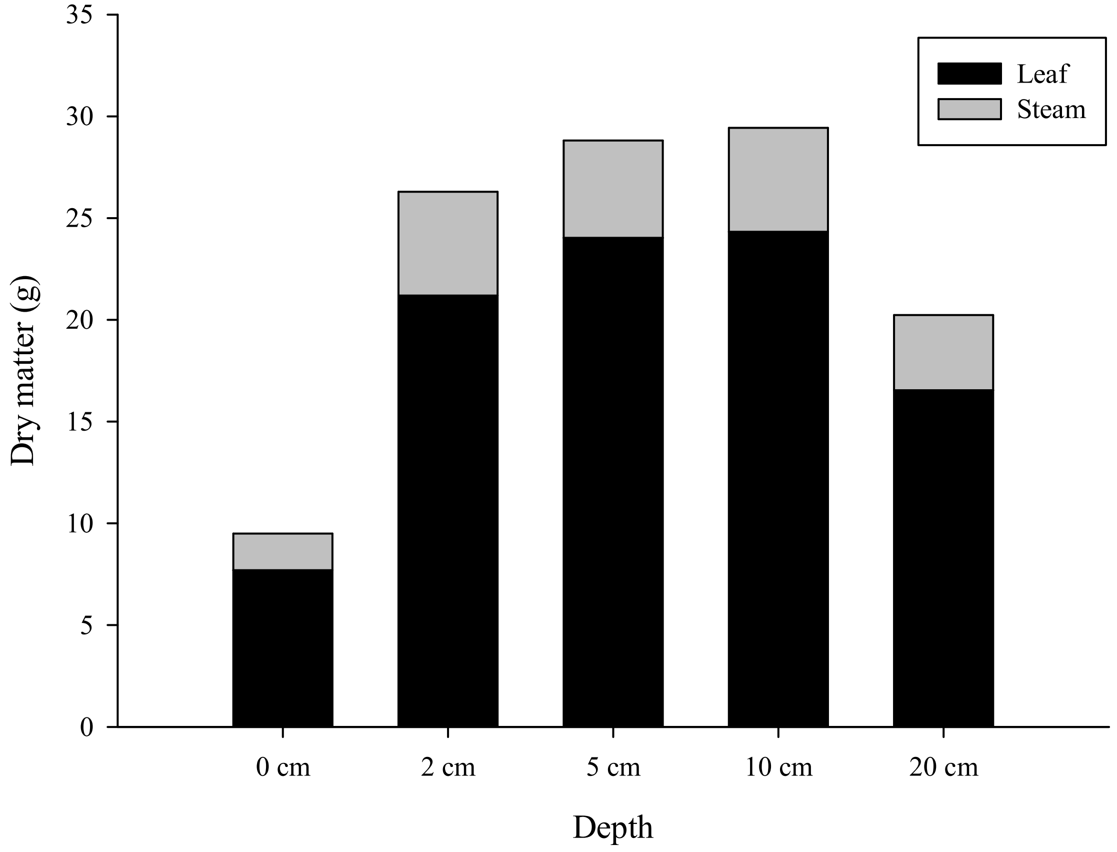

Figure 3. Dry matter in grams (g) of stem and leaf from twelve velvet bean plants on Trial 2.

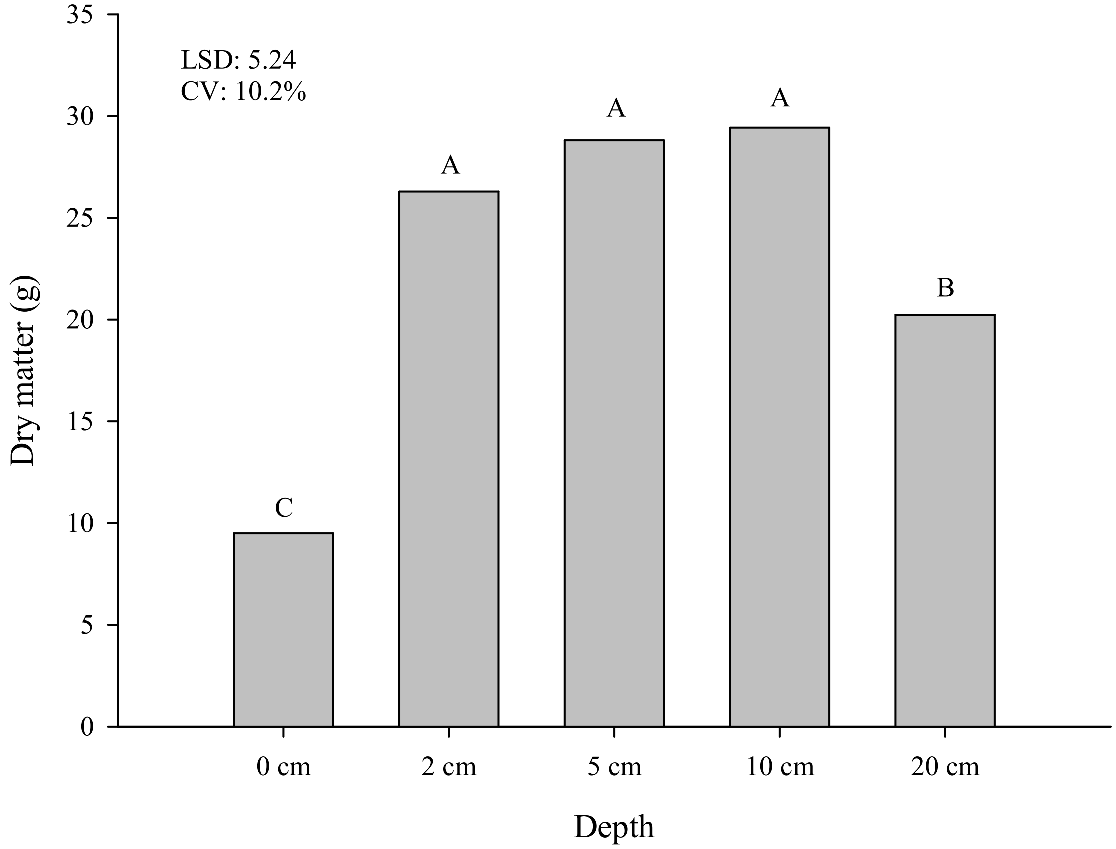

Figure 4. Total dry matter on Trial 2 in grams (g). Means in each bar followed by the same letter are not significantly different (P ≤ 0.05), LSD – Least Significant Difference and CV% - Coefficient of Variation percentage.

Table 1: The mean maximun and minimun temperature (fahrenheit) and precipitation (millimeter) in both trials

Trials	Date Month/Year	T. max. (°F)	T. min. (°F)	Precipitation (mm)
1	August, 2009	73.6	70	22.2
	September, 2009	76.6	73.8	183.6
2	August, 2010	72.7	68.4	168

Maximum temperature (T. max.); Minumum temperature (T. min)

Table 2. Chemical properties from the soil in both trials

pH	K	P	Ca	Mg	Al	H+Al	CTC	SB	V	MO
$CaCl_2$	mg dm $^{-3}$		-------------------------------		cmol$_c$ dm^{-3}		--------------------------			g dm^{-3}
4,6	40	5,3	1,55	0,58	0,13	6,5	8,7	2,23	25,5	26,0