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Cover crops and their effects on the biomass yield of *Serjania marginata* plants

Culturas de cobertura e seus efeitos na produção de biomassa de plantas de *Serjania marginata*

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ABSTRACT

*The use of cover crops can reduce or even eliminate the use of nitrogenous fertilizers, contributing to a more sustainable agriculture and ensuring the conservation of natural resources. Thus, the aim of this research was to evaluate the use of cover crops to improve the biomass yield of **Serjania marginata** plants. The experiment was carried out at the Federal University of Grande Dourados, in Dourados-MS, from December 2009 to February 2011. A split plot design was used in a randomized block design with four replications, being evaluated in plots three species of tropical legumes (**Stizolobium aterrimum, Crotalaria spectabilis** and **Canavalia ensiformes**, and one control plot (without cover crops), and in subplots the addition or not of nitrogen (N) (at 150 days after transplant (DAT)). Plants of **S. marginata** in each subplot were harvested at 240 and 350 DAT. **S. aterrimum** and **C. ensiformes** showed higher accumulation of fresh (average of 37.61t ha^{-1}) and dry (average of 6.39t ha^{-1}) biomass of shoot in flowering, compared with the **C. spectabilis** (21.92 and 4.63t ha^{-1}, respectively). The contribution of cover crops as a likely source of N only was observed for **S. aterrimum** and **C. ensiforme,** which promoted an increase in chlorophyll index, leaf area, fresh and dry weight of leaves and stem of **S. marginata** plants, in absence of N. In leaves of **S. marginata**, only **C. ensiformes** contributed significantly to an increase in N levels, while an increase in K levels was observed with all cover crop treatments, when compared to control. Pre-cultivation with **S. aterrimum** and **C. ensiformes** provided an increase in P levels in leaves of **S. marginata**. Therefore, **S. aterrimum** and **C. ensiformes** were the most promising cover crops for growing of **S. marginata**, improving the biomass yield and probably the N economy.*

Key words: *Sapindaceae, timbó, **Stizolobium aterrimum, Crotalaria spectabilis, Canavalia ensiformes**.*

RESUMO

*O uso de culturas de cobertura pode reduzir ou até mesmo eliminar o uso de fertilizantes nitrogenados, contribuindo para uma agricultura mais sustentável e garantindo a conservação dos recursos naturais. Assim, o objetivo deste trabalho foi avaliar o uso de culturas de cobertura para incrementar a produção de biomassa de plantas de **Serjania marginata**. O experimento foi realizado na Universidade Federal da Grande Dourados, em Dourados-MS, de dezembro de 2009 a fevereiro de 2011. Um delineamento de blocos casualizados foi usado, em parcelas subdivididas, com quatro repetições, sendo avaliadas, nas parcelas, três espécies de leguminosas tropicais (mucuna (**Stizolobium aterrimum**), crotalária (**Crotalaria spectabilis**) e feijão-de-porco (**Canavalia ensiformes**)) e uma parcela controle (sem culturas de cobertura), e, nas subparcelas, foi avaliada a adição ou não de nitrogênio (N) (aos 150 dias após o transplante (DAT)). As plantas de **S. marginata,** em cada subparcela, foram colhidas aos 240 e 350DAT. Mucuna e feijão-de-porco apresentaram a maior acumulação de biomassa fresca (média de 37,61t ha^{-1}) e seca (média de 6,39t ha^{-1}) da parte aérea no florescimento, comparado com a crotalária (21,92 e 4,63t ha^{-1}, respectivamente). A contribuição das culturas de cobertura como prováveis fontes de N somente foi observada para mucuna e feijão-de-porco, as quais promoveram um aumento no índice de clorofila, área foliar, e massa fresca e seca de folhas e caule de plantas de **S. marginata** na ausência de N. Em folhas de **S. marginata**, somente a mucuna contribuiu significativamente para um aumento nos níveis de N, enquanto um aumento nos níveis de K foi observado com todos os tratamentos com culturas de cobertura, comparados com o controle. O pré-cultivo com mucuna e feijão-de-porco promoveu um aumento nos níveis de P em folhas de **S. marginata**. Portanto, mucuna e feijão-de-porco foram as*

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*culturas de cobertura mais promissoras para o cultivo de **S. marginata**, melhorando a produção de biomassa e provavelmente a economia de N.*

Palavras-chave: *Sapindaceae, timbó,* ***Stizolobium aterrimum, Crotalaria spectabilis, Canavalia ensiformes****.*

INTRODUCTION

Concerns with the increased degradation of most Brazilian soils and with the prevention of deterioration of new areas have led to the use of practices which aim to increase soil organic matter. There is also an increasing demand of organic products by consumers, who are increasingly concerned about food quality and safety (DOLTRA et al., 2011). The development of farming systems designed to reduce fertilizer use, provide environmental benefits and reduce production costs partly depends on the optimization of the supply and cycling of naturally derived nitrogen (N). Accordingly, the use of cover crops is considered an important management practice with potential to reduce the dependence on mineral fertilizers and to maintain or increase soil organic matter content (ELFSTRANDE et al., 2007; FERREIRA et al., 2011). The use of cover crops can reduce or even eliminate the use of N fertilizers, contributing to a more sustainable agriculture, and to the conservation of natural resources. Such crops add organic matter and, in turn, improve physical, chemical, and biological soil properties, reclaim alkaline and acid soils, neutralize soil pH, increase microbial biomass-C and soil respiration, break the cycles of insects and pathogens and reduce weed infestation (FAGERIA & BALIGAR, 2005; TEJADA et al., 2008; PARTELLI et al., 2010). However, the availability of adequate quantity of high quality cover crops is a constraint to their use (KUMAR et al., 2011).

The leguminous family is the most commonly used cover crop because it ensures self-sufficiency in N, recycles macro and micronutrients, has usually a deep and extensive root system, is able to extract nutrients from deeper soil layers, and provides large amounts of organic matter in soil (ESPINDOLA et al., 2005; ALAGOZ & YILMAZ, 2009; PARTELLI et al., 2011). The effects promoted by cover crops on soil chemical properties are quite variable, depending on factors such as the species used, the management of biomass, planting and cutting time of cover crop, residence time of the residues in soil, local conditions, and the interaction among these factors (ALCÂNTARA et al., 2000).

There are several leguminous for cover crops in the Cerrado region. The most promising crops include ***Mucuna aterrima***, ***Cajanus cajan, Crotalaria juncea, C. paulina, C. spectabilis, Canavalia brasiliensis, C. ensiformis***, and ***Stylosanthes guianensis*** (BURLE et al., 1988) because they are hardy, have efficient vegetative development, and are adapted to conditions of low fertility and high temperatures.

Serjania marginata Casar., Sapindaceae, is a scandent vine known as timbó, occurring in abundance in the Brazilian Cerrado; it is used as ornamental in hedges and in degraded areas, showing insecticide potential (GUARIM NETO & SANTANA, 2000). This specie has medicinal potential and its leaves are popularly indicated to stomach pain (BOURDY et al., 2004). Because the use of medicinal plants is growing in Brazil and all over the world, it becomes essential to develop sustainable and more efficient farming practices, seeking to optimize the biomass yield and active principles of medicinal interest. Few studies have reported the effect of cover crops on medicinal plant yield. Thus, the aim of this research was to evaluate the use of cover crops to improve the biomass yield of ***S. marginata*** plants.

MATERIALS AND METHODS

The experiment was carried out at the Federal University of Grande Dourados, in area located at 22°11'44"S of latitude, 54°56'07"W of longitude and 452m of altitude, from December 2009 to February to 2011. The climate of Dourados, according to Köppen, is mesothermal humid, Cwa type, with temperature and annual rainfall averages ranging from 20º to 24ºC and 1250-1500mm, respectively. The soil, originally under Cerrado vegetation, is classified as a dystrophic red oxisol of clayey texture. Before the experiment, soil samples were collected (0-20cm soil depth) for the determination of the chemical characteristics, which showed the following results: pH ($CaCl_2$): 4.8; 24g kg^{-1} of organic matter; 15mg dm^{-3} of P; 4.5$mmol_c$ dm^{-3} of K; 3.1$mmol_c$ dm^{-3} of Al; 25.0$mmol_c$ dm^{-3} of Ca and 17.0$mmol_c$ dm^{-3} of Mg, and 45% of saturation.

One split plot design was used and installed in a randomized block design with four replications, being evaluated in plots three species of tropical legumes (***Stizolobium aterrimum, Crotalaria spectabilis*** and ***Canavalia ensiformes***) and one control plot (without cover crop)), and in subplots the addition or not of N. The subplots had a total area of 6.0m^2 (4.0m long and 1.50m in width).

The sowing of the cover crops was carried out in three rows 0.40m apart from each other, in the density of 25 seeds m^{-1} for ***S. aterrimum***, 37.5 seeds m^{-1} for ***C. spectabilis***, and 20 seeds m^{-1} for ***C. ensiformes***, without inoculation of nitrogen-fixing bacteria. At flowering, they were cut and the material was left on the surface to dry and be incorporated into the surface soil horizons by soil macrofauna. Immediately after cutting, samples of the plant material cut (1.0m^2) of each cover crop were collected in each plot for the determination of fresh biomass. The sub-samples were then transferred to an incubator at 65°C, where they remained until constant weight to measure the dry weight. Two weeks after cutting the cover crops, plants of ***S. marginata*** were transplanted for the different treatments.

The spread of ***S. marginata*** was performed by indirect sowing and the seedlings were produced initially in polystyrene trays with 128 cells, with Plantmax® substrate, and transplanted to the field 60 days after sowing. Sixteen plants per subplot were used, with spacing of 0.5m between plants and rows. To assess the ability of N supply by the cover crops to ***S. marginata*** plants, at 150 days after transplanting (DAT) was added 80kg ha^{-1} of urea in covering on plots of each treatment. Irrigations were made using the sprinkler system every two days until harvest. Spontaneous vegetation was controlled by weeding with hoe between plots and manually within plots.

From 90DAT, every 30 days, the plant height (with ruler in cm) and chlorophyll content (chlorophyll meter SPAD-502) were evaluated in all plants on the subplot. At 240DAT, 50% of the plants in each subplot were harvested, and the remaining 50% of the plants were harvested at 350DAT. The fresh and dry weight of leaves and stem as well as the foliar area were then evaluated. Levels of N, P and K were determined based on the dry weight of the leaves (MALAVOLTA et al., 1997).

The analyses of variance were computed on statistically significant differences determined based on the appropriate F-tests. The results are the means ± SD of the four independent replicates. The mean differences were compared utilizing Tukey test with $P<0.05$.

RESULTS AND DISCUSSION

Among the three cover crops studied, ***S. aterrimum*** and ***C. ensiformes*** showed higher accumulation of fresh (average of 37.61t ha^{-1}) and dry (average of 6.39t ha^{-1}) biomass of shoot in flowering, compared with ***C. spectabilis*** (21.92 and 4.63t ha^{-1}, respectively). The high biomass yield of these cover crops in a short period of time reveals that these species can be considered as potential for cultivation in the Cerrado, ensuring a large residual effect for subsequent culture. ***C. ensiformes*** showed the highest fresh (39.68t ha^{-1}) and dry (6.85t ha^{-1}) biomass accumulation, overcoming in 81% and 48% the fresh and dry biomass of ***C. spectabilis***, respectively. These results suggest that the higher biomass yield of these cover crops can positively influence the retention of nutrients, reduce losses by leaching, and improve soil structure.

In ***S. marginata*** plants, there was no significant effect of interaction among the evaluation periods, cover crops and N presence for any of the variables analyzed. In the second harvest (350DAT), plants had higher fresh weight of leaves (933.86g plant^{-1}), fresh weight (652.05g plant^{-1}), and dry weight (210.62g plant^{-1}) of stem and leaf area (14616.79cm^2 plant^{-1}), compared with the first harvest (240DAT) (703.88g plant^{-1}, 325.50g plant^{-1}, 114.09g plant^{-1}, and 29669.96cm^2 plant^{-1}, respectively). Accordingly, the N added through leguminous biomass was mineralized gradually ensuring a regular supply of N throughout the growth period. Considering the isolated effect of cover crops, ***S. aterrimum*** and ***C. ensiformes*** promoted an increase of 15% in height (average of 245.5cm) and 45% in stem dry weight (average of 187.3g plant^{-1}) of ***S. marginata*** plants, compared with the control (214.2cm in height and 129.03g plant^{-1} of stem dry weight). Similarly, ***C. ensiformes*** significantly increased the leaf area of ***S. marginata*** plants by an average of 55.0% (26738.58cm^2 plant^{-1}) over the control without cover crops (17182.5cm^2 plant^{-1}), while the fresh weight of leaves in all cover crops treatments was higher (average of 893.73g plant^{-1}), compared to the control (594.23g plant^{-1}). The favorable effect of these treatments on growth parameters was likely due to the increase in organic matter, which improves physical (bulk density and soil aggregation) and chemical conditions (total soil N) (MANDAL et al., 2003). Addition of organic matter also provides better conditions for mineralization which results in increased availability of nutrients in soil (KUMAR et al., 2011) and consequently better soil conditions for plant growth and development. Decomposition of organic matter releases nutrients slowly and made available for a longer period.

For interaction between cover crops and N presence, there was a significant interaction for all the variables analyzed of ***S. marginata*** plants, with varying effects among cover crops. For the controls, in all parameters evaluated, the supply of N did not affect the biomass yield of the plants. For plant height, the contribution of cover crops as a likely source of N only was observed for ***S. aterrimum*** (Table 1), while for chlorophyll index and dry weight of leaves and stem, ***S. aterrimum*** and ***C. ensiformes*** (Table 1) promoted an increase in these parameters. In addition to N supply,

Table 1 - Plant height, relative chlorophyll index, leaf area and dry weight of leaves and stem of ***S. marginata*** plants pre-grown with cover crops and in presence or absence of nitrogen.

	Nitrogen	Plant height (cm)	Chlorophyll (SPAD value)	Leaf area (cm^2 $plant^{-1}$)	Leaf dry weight (g $plant^{-1}$)	Stem dry weight (g $plant^{-1}$)
Control	With	219 a	47 a	15634.2 a	231.5 a	127.5 a
	Without	209.3 a	48.8 a	18730.8 a	287.1 a	130.6 a
S. aterrimum	With	241 a	51.9 a	19778.2 a	276.4 a	149.8 a
	Without	223.3 a	48.7 a	24871 a	318.9 a	211.2 a
C. spectabilis	With	245.3 a	51.3 a	29640.7 a	372.3 a	201 a
	Without	190.7 b	44.3 b	15015 b	160.3 b	90.7 b
C. ensiformes	With	284.7 a	49.9 a	27721.5 a	386.7 a	210.7 a
	Without	233 b	51.1 a	25755.7 a	343.8 a	177.5 a

Means followed by same letter within each cover crop did not differ statistically by Tukey test ($P<0.05$).

cover crops can also provide other beneficial effects on plants due to the release of various growth-promoting substances and improve availability of other nutrients including micronutrients (DE RIDDER & KEULEN, 1990). The area where the cover crop treatment included ***S. aterrimum*** and ***C. ensiformes***, the N supply by these species was sufficient for the increase in leaf area of ***S. marginata*** plants (Table 1), once the plants had the same leaf area with or without N supply. Improvement in this growth parameter was likely due to the higher availability of N in soil following cultivation with these cover crops.

The contribution of cover crops as N source for fresh weight of leaves and stem (Figure 1A and 1B, respectively) of ***S. marginata*** was only observed for ***S. aterrimum*** and ***C. ensiformes***. The higher production of organic matter from these cover crops may have favored the development of root in ***S. marginata*** plants, allowing a better exploitation of soil and increased nutrient absorption. This show that addition of ***S. aterrimum*** and ***C. ensiformes*** as cover crops mobilizes soil nutrients and makes them available to plants, and that N fertilizer requirement of this medicinal plant could be substituted by the cultivation these cover crops. The beneficial effects of cover crops have been also reported in other crops such as rice-wheat system (YADAV, 2004), maize (JERANYAMA et al., 2000), and tobacco (BILALIS et al., 2009). Furthermore, fresh biomass yields of menthol mint increased by 23.4% and essential oil yield by 25.2% by cover crops when compared to control (SINGH et al., 2010).

On the other hand, pre-cultivation with ***C. spectabilis*** did not provide N sufficient for the ***S. marginata*** plants (Table 1 and Figure 1), since plants responded significantly at 80kg N ha^{-1} in the plots cultivated with this cover crop, showing higher fresh and dry weight compared with the plots without N. The least amount of biomass produced and possibly

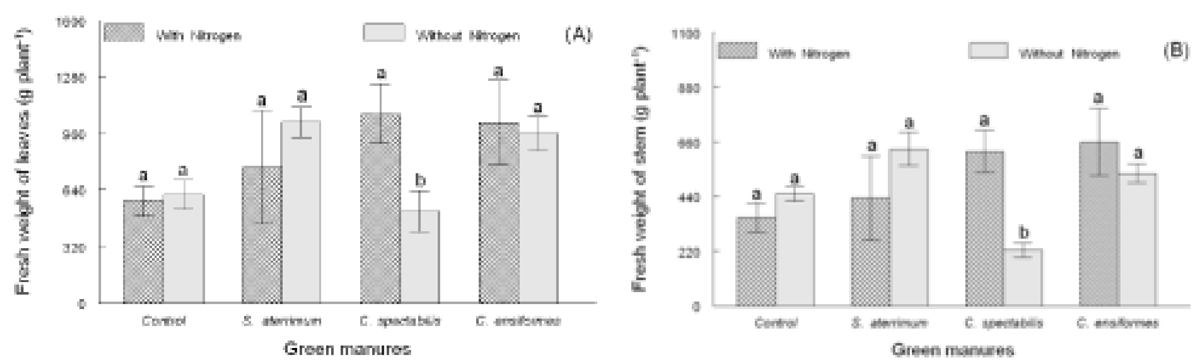

Figure 1 - Fresh weight of leaves (A) and stem (B) of ***S. marginata*** plants pre-grown with cover crops and in presence or absence of N. Means followed by same letters within each cover crop did not differ statistically by Tukey test ($P<0.05$).

the lowest N supply by ***C. spectabilis*** likely caused a reduction in the supply of nutritional elements to the ***S. marginata*** plants, which resulted in the development of smaller plants.

For nutrients content on leaves of ***S. marginata***, there was a significant effect only on the pre-cultivation with cover crops (Table 2) for N and K levels, while for P levels there was a significant effect of all factors in isolation. ***C. ensiformes*** contributed significantly to an increase of 24% in N levels, compared to control, while an increase in K levels was observed with all cover crops (average of 1.99g kg^{-1}), compared to control (1.36g kg^{-1}). Leaves of ***S. marginata*** showed significantly higher P concentrations at 240DAT (0.889g kg^{-1}) and in N presence (0.86g kg^{-1}), compared with 350DAT (0.796g kg^{-1}) and N absence (0.825g kg^{-1}). Moreover, pre-cultivation with ***S. aterrimum*** and ***C. ensiformes*** provided an increase in P levels (Table 2). This may be attributed to the fact that ***S. aterrimum*** and ***C. ensiformes*** mobilize nutrients from deeper layers, making them available for subsequent crop. Cover crops may also have acted as mulch, conserving soil moisture for crop use and inducing an increase in soil biological activity, providing a greater amount of nutrients for crop use. The results of N levels in leaves of ***S. marginata*** do not correlate with the chlorophyll data, indicating that leaf chlorophyll is not a good indicator of N status in ***S. marginata*** plants. Furthermore, these results indicate that the increase in the growth parameters in ***S. marginata*** plants may have been caused not only by increasing the N availability and uptake, but also due to the greater absorption of K and P provided by ***S. aterrimum*** and ***C. ensiformes.*** According LANGE et al. (2009), when the cover crop is grown as preceding crop, it promotes the accumulation of mineral and organic N in soil. These results show the effectiveness of the use of cover crops in a dynamic cropping system to the cultivation of medicinal plants which can be defined as economically viable, environmentally sustainable, and socially acceptable (TANAKA et al., 2002). Other studies are being conducted to evaluate the effects of these cover crops on the active principles of this medicinal plant.

Table 2 - Nutrients levels in leaves of ***S. marginata*** pre-grown with cover crops.

Green manures	-------Nutrients (g kg^{-1})-------		
	Nitrogen	Phosphorus	Potassium
Control	7.41 b	0.680 b	1.36 c
S. aterrimum	8.91 ab	0.98 a	1.82 b
C. spectabilis	7.51 ab	0.71 b	1.82 b
C. ensiformes	9.21 a	0.99 a	2.31 a

Means followed by same letters in column do not differ by Tukey test (P<0.05).

CONCLUSIONS

S. aterrimum and ***C. ensiformes*** were the most promising cover crops for growing ***S. marginata***, improving biomass yield and probably the N economy. N fertilizer requirement of this medicinal plant could also be substituted by cultivation with these cover crops.

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