*Journal of Experimental Agriculture International*

*43(2): 21-32, 2021; Article no.JEAI.66322*
*ISSN: 2457-0591*
*(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)*

# Management of *Eleusine indica* and *Digitaria insularis* with Herbicides in Association with Cover Plants

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author GCR managed the analyses of the study. Authors PHVS and BFS performed the statistical analysis and the first revison. Author ACSH managed the literature searches. Author PAM designed the study, wrote the protocol, and wrote the first draft of the manuscript. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/JEAI/2021/v43i230641
Editor(s):
(1) Professor. Lanzhuang Chen, Minami Kyushu University, Japan.
Reviewers:
(1) Aditi Sharma, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, India.
(2) Debarati Datta, ICAR-Central Research Institute for Jute and Allied Fibers, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/66322

***Original Research Article***

***Received 10 January 2021***
***Accepted 15 March 2021***
***Published 08 April 2021***

## ABSTRACT

**Aims:** This study aimed to evaluate the control of *Eleusine indica* Gaertn. and *Digitaria insularis* (L.) Fedde through the combination of soil cover with green manure straw and herbicides applied in pre-emergence.
**Study Design:** Each weed species was evaluated in different experiments. The experiments were set up in a greenhouse in a completely randomized design and arranged in a factorial scheme (5×4)+2, with four replications.
**Place and Duration of Study:** Center of Agricultural Sciences, São Paulo, Brazil, from May 2019 to May 2020.
**Methodology:** Seeds of *Digitaria insularis* and *Eulesine indica* were sown at a depth of 1 cm from the soil surface. Then, the pots were watered, and the straw of *Cajanus cajan*, *Sorghum bicolor*,

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*Crotalaria juncea, Crotalaria spectabilis*, and *Crotalaria breviflora* was deposited on the surface. The pre-emergence herbicides trifluralin (900 g ai $ha^{-1}$), pendimethalin (1200 g ai $ha^{-1}$), clomazone (1000 g ai $ha^{-1}$), and s-metolachlor (1920 g ai $ha^{-1}$) were applied one day after the weed seeds were sown. The percentage of weed control was evaluated at 10, 20, and 30 days after emergence (DAE). The plant shoot was cut at 30 DAE and the weight of dry biomass was determined. The control without herbicide and with soil cover crop and no herbicide and no soil cover were also evaluated.

**Results:** *Sorghum bicolor*, *Cajanus cajan*, and *Crotalaria breviflora* were the most effective in controlling *Eleusine indica* when no herbicide was applied. Only *Sorghum bicolor* showed a satisfactory control of *Digitaria insularis* without the use of chemical management (above 80%). The association of pre-emergence herbicides with soil cover showed high control of weeds.

**Conclusion:** The results showed that the association between chemical and cultural methods is an effective alternative to control *Eulesine indica* and *Digitaria insularis.*

*Keywords: Grasses; green manure; chemical control.*

## 1. INTRODUCTION

*Digitaria insularis* (L.) Fedde (*Poaceae*) is a perennial herbaceous, erect weed species that forms tufts of short rhizomes, and reproduces by small seeds covered by hairs, thus being carried by the wind over long distances [1]. Resistant populations to glyphosate were found in several agricultural areas in Brazil between 2012 to 2015 [2]. The species is included in the list of pests of greatest economic importance and phytosanitary risk for several crops [3]. *Digitaria insularis* infestation is one of the great responsible for soybean yield losses in Brazil. The infestation of resistant biotypes of *Digitaria insularis* to glyphosate and cross-resistance to glyphosate and haloxyfop-P-methyl has increased in agricultural areas in the Brazilian Cerrado biome [1]. This can result in increases of the production costs because of the need to adopt other management strategies to control this weed [1].

*Eleusine indica* Gaertn (*Poaceae*) represents one of the most important grass weeds in crops from tropical and temperate regions of the world [4]. This species is described as a dominant weed, especially in farming systems and annual row-crops, where it grows vigorously and produces abundant seedlings. *Eleusine indica* became a difficult weed to control with biotypes resistant to glyphosate and acetyl-CoA carboxylase (ACCase) inhibitor herbicides [4,5,6,7,8] which require studies to evaluate strategies for its management and avoid its spread [8].

The biotypes of resistant weeds have become a more serious problem than the weed itself, as they are pests of increased hazard due to the difficulty of elimination. The effectiveness of an herbicide to control a weed plant is related to its physical and chemical characteristics, dose, development stage and biology of the weed, soil moisture, among others [9]. However, environmental and economic aspects are essential in planning weed management [10].

Thus, resistance prevention requires the adoption of an integrated weed management approach, as no single control strategy can effectively and sustainably eliminate resistant weeds [11]. Thereby, the association of two or more control methods increases the chances of success in the management of these species.

Cultural control consists of the use of practices that increase the development and the competition potential of crops. No-tillage cropping systems are effective soil management alternatives for weeds suppression using the phytomass produced by cover plants. The cover plant species used in production systems need to establish quickly and produce adequate amounts of phytomass to cover the soil [12].

A higher emergency capacity of *Digitaria insularis* resistant to glyphosate was observed in areas without cover crops [13]. Thus, the amount of phytomass produced by cover crops can interfere with the process of germination of *Digitaria insularis*, which exhibit negative photoblastism. Moreover, the wheat straw, for example, promoted a reduction of 50% in the emergence of this species [14]. *Digitaria insularis* has a slow initial growth, which may reduce its competition with other weed species, but it may become the dominant species if the herbicide dose is not sufficient for its control [15].

Takano et al. [16] studied the biology of *Eleusine indica* and conclude that, with a regime of 8 hours of light at 35°C and 16 hours in the absence of light at 20°C daily, *Eleusine indica* needed 12 days to emerge in 80%. Tillering starts at 9 days after emergence (DAE), and the seed production at 38 DAE, being able to produce more than 120 thousand seeds per plant at 108 DAE and finishing the cycle at 120 DAE. Therefore, control measures must be performed early to prevent the plant from producing seeds and spreading to other places. *Eleusine indica* is favored by zero-tillage techniques, being well suppressed by residues of some cover crops, such as rye [17].

The use of herbicides is still the first option of producers due to their efficiency although cultural weed control has been growing [18]. However, continued use of low herbicide doses, application in advanced development stages, and the absence of rotation crops have been related to failures in controlling *Eleusine indica* and *Digitaria insularis* [4,15]. On the other hand, studies have shown that crop rotation with cover crops assists in the chemical control of weeds [19,20].

The integration of weed management technologies based on a better understanding of the species biology and ecology can provide more sustainable management of resistance and integrated management strategies [21].

Considering that *Eleusine indica* and *Digitaria insularis* are a global problem and that the difficulty to control it has increased mainly due to the resistance of herbicides, the objective of this study was to evaluate the control of *Eleusine indica* and *Digitaria insularis* through the combination of green manures covering the soil and pre-emergence herbicides.

## 2. MATERIALS AND METHODS

The experiment was carried out in a greenhouse in 2019 and 2020. Experimental units were made up of polyethylene pots with a 5-L capacity filled with Dystrophic Red Latosol.

The experiment was randomized in a factorial design (5×4)+2, with four replications. The factors consisted of the straw of green manures (*Cajanus cajan, Sorghum bicolor, Crotalaria juncea, Crotalaria spectabilis*, and *Crotalaria breviflora*) and herbicides applied in pre-emergence (trifluralin, pendimethalin, clomazone, and s-metolachlor). Additionally, controls without herbicide and with straw and without straw and herbicide were evaluated. The experiments were carried out separately for each weed species.

Seeds of *Digitaria insularis* and *Eleusine indica* were provided by Agro Cosmos Ltda. (Engenheiro Coelho, SP, Brazil). After sowing (20 seeds per pot sown at a depth of 1 cm), the pots were irrigated, and the straw from the different green manure species was placed on the surface. The amount of plant material was determined according to the production capacity of each cover species: *Cajanus cajan* (10 t ha$^{-1}$), *Sorghum bicolor* (20 t ha$^{-1}$), *Crotalaria juncea* (15 t ha$^{-1}$), *C. spectabilis* (15 t ha$^{-1}$), and *C. breviflora* (10 t ha$^{-1}$) [22].

The herbicides trifluralin (900 g ai ha$^{-1}$), pendimethalin (1200 g ai ha$^{-1}$), clomazone (1000 g ai ha$^{-1}$), and s-metolachlor (1920 g ai ha$^{-1}$) were applied using a $CO_2$-pressurized knapsack sprayer at a pressure of 30 lb in$^{-2}$ equipped with a boom containing four XR 11003 fan tips spaced at 0.5 m from each other. A total of 200 L ha$^{-1}$ of spray solution was used. Pre-emergence application of the herbicides was performed one day after the weed seeds were sown. The meteorological data at the time of herbicide application were as follows: wind speed of 1.0 m s$^{-1}$, humidity of 60%, and temperature of 30°C.

The pots were maintained in a greenhouse under irrigation to ensure seed germination. The percentage of weed control was evaluated at 10, 20, and 30 days after emergence (DAE). A percentage scale of scores was used to determine the phytotoxicity, in which zero corresponded to no injury to the plant and 100 indicated plant death [23]. The plant shoot was cut at 35 DAE and dried in a forced-air circulation oven (60 ± 2°C) until constant weight to determine the dry biomass. The reduction in the percentage of dry biomass relative to that of the control plants was also evaluated.

### 2.1 Statistical Analysis

The data were submitted to an analysis of variance using the F-test, and the means were compared by the Scott-Knott test at a 5% significance using the statistical program ASSISTAT [24]

## 3. RESULTS AND DISCUSSION

The results of soil chemical analyses are shown in Table 1. Soil organic matter is intrinsically linked to herbicide efficacy in weed control, as it directly influences herbicide behavioral factors, such as the bioavailability of product absorption, which regulates management success. The bioavailability of the herbicides in the soil depends on the particular characteristics of each molecule. Besides soil pH affects how long some herbicides persist for and how available they are for plant uptake and soil binding. Herbicide with low water solubility and high organic carbon sorption coefficient (KOC) values such trifluralin and pendimenthalin reflect their affinity for adsorption onto soil particles [25].

The results obtained in the control of *Digitaria insularis* at 10, 20, and 30 DAE are shown in Table 2. All evaluations showed an interaction between the use of cover crops and herbicides.

The control of *Digitaria insularis* was unsatisfactory at 10 DAE when the straw of *Cajanus cajan* was used alone or associated with trifluralin and pendimethalin. These same herbicides also showed less control when associated with *C. breviflora.* The herbicides clomazone and s-metolachlor obtained control above 80%, regardless of the type of straw used. Moreover, trifluralin and pendimethalin have in common low solubility in water and a high coefficient of adsorption, which may hinder their mobility on the plant cover, especially at the beginning, when the accumulated irrigation may not be enough to carry these herbicides to the soil.

The herbicides in association with the cover crop provided control averages close to or equal to 100% at 20 and 30 DAE, showing a significant difference from the control without herbicide.

Regarding the control of *Digitaria insularis* by cover crops alone, the species *C. cajan* showed an initial control of 61.25%, but this control was reduced to 26.2% at 30 DAE. *C. juncea* presented the least effect on the suppression of *Digitaria insularis*, with virtually no control (3.75%). *C. spectabilis* and *C. breviflora* presented low initial control, which increased with the evaluations, culminating in the suppression of *Digitaria insularis* in more than 70%. *S. bicolor* had high control over *Digitaria insularis*, with suppression of 52.5% in the initial evaluation and 81.2% at 30 DAE. These results agree with those obtained by Mateus et al. [26], who found that 15 t $ha^{-1}$ of *S. bicolor* straw promoted 95% control in the incidence of grasses present in the area.

Petter et al. [27] observed that *Mucuna pruriens, Cajanus cajan*, and *Urochloa brizantha* stood out in the suppression of *Digitaria insularis*, and 4 t $ha^{-1}$ of dry phytomass of these species were sufficient to promote an expressive reduction in the total number of emerged plants, germination speed index, dry phytomass of shoots, leaf area, dry phytomass, and root volume. For these species, the development of *Digitaria insularis* was no longer detected from 8 t $ha^{-1}$ of phytomass. The authors concluded that *Digitaria insularis* was highly sensitive to the presence of residues on the soil surface, making cover crops cultivation an important tool for the integrated management of this species. Green manure has been used in different agricultural systems to assist in the elimination of weeds, through allelopathic effects, restricting growth space and competition for water, light, oxygen and nutrients and suppressing reinfestations [28].

Table 3 shows the final values of dry biomass accumulation with the interaction between cover crops and herbicides. The results corroborated with the control evaluations and the association of herbicide and cover crop reduced the dry biomass by nearly 100%, regardless of the green manure species.

Treatments with straw and without herbicide showed that *S. bicolor* had no differences compared to the treatments of pre-emergence herbicides, with a 90.7% reduction in *Digitaria insularis* dry biomass. The other treatments obtained inferior control. According to Gomes et al. [29], cover management with *S. bicolor* is a good option to control cover plants of the grass *Cenchrus echinatus* and *D. horizontalis*, corroborating with this study for *Digitaria insularis*.

*Sorghum bicolor* is an allelopathic crop that influences the growth of weeds and other crops. It has certain cyanogenic glucosides, which suppress plant growth. Decomposed shoots of sorghum residues release phenolic compounds, which render inhibitory influence on plants [30].

The results of *Eleusine indica* control at 10, 20, and 30 DAE are shown in Table 4. All evaluations showed significant interaction among the straw of cover crops and all herbicides, indicating that the treatments with pre-emergence herbicides differed in control according to the green manure used as a cover crop.

Excellent control of *Eleusine indica* (above 90%) was observed at 10 DAE with *S. bicolor, C. juncea*, and *C. breviflora* without herbicide application. Herbicides associated with straw were efficient in the control, regardless of the cover crop.

The evaluation performed at 20 DAE showed that the cover crop with *C. cajan* and *C spectabilis* without herbicides were ineffective to control *Eleusine indica*. However, the straw of *C. juncea*, *S. bicolor*, and *C. breviflora* was efficient even without the association with herbicides. The herbicide trifluralin in association with *C. spectabilis* resulted in a lower percentage of control (87.50%). All other associations were effective to control *Eleusine indica*.

Increased control with *C. cajan* without herbicide was observed in the evaluation at 30 DAE. On the other hand, reduced control of the *Eleusine indica* was observed when *C. juncea* (52.5%) and *C. spectabilis* (20.0%) straw was used without herbicide association.

Green manure promotes efficient suppression of weeds, but green manure species can exhibit distinct behaviors, depending on the environmental conditions. Germination, growth, and development of the weeds present in the soil seed bank can be inhibited or stimulated by the allelopathic influence of mulch. This allelopathic activity depends on the quality and quantity of plant material deposited on the soil surface, soil type, microbial population, climate conditions, and composition of the weed species community [22]. Gomes et al. [29] also observed that the use of green fertilizers to suppress weeds depends on the green fertilizer, the species to be controlled, and the phytomass management.

The straw of *C. cajan*, *S. bicolor*, and *C. breviflora* efficiently controlled *Eleusine indica*, regardless of the applied herbicides, with 82.5, 86.2, and 83.2% control, respectively. Thus, the use of the pre-emergence herbicides clomazone, trifluralin, pendimethalin, and s-metolachlor in association with cover crops was effective to control *Eleusine indica*.

According to Correia et al. [31], mulching produced by the shoot of *Sorghum bicolor* can reduce weed incidence in several intercropping systems. As straw level increased, both the physical effect of emergence suppression and the possible chemical effects from allelochemicals released by straw may have contributed to a reduction in emergence. *Sorghum bicolor* is known for its high allelopathic potential largely due to the production of a hydrophobic compound known as sorgoleone. The allelopathic activity of *S. bicolor* is dependent on several factors such as different cultivars, environmental conditions, and growth stages of the plant. In addition, the allelochemicals present in sorghum tissues may vary in different parts of the plant. The allelopathic potential of *S. bicolor* can be used to control weeds by means of the application of sorghum residues as mulch or including sorghum cultivars in a crop rotation [32]

According to Narwal et al. [33], the infestation of monocotyledon weeds was reduced between 79 and 91%, and dicotyledon infestation was reduced between 84 to 100% when pearl millet was grown as a forage species. Competition and allelopathic effects performed, during the coexistence of the cover crop with the weeds can be responsible for the suppressive effect.

The results corroborate with those found by Silva et al. [6], who found that the herbicides s-metolachlor, trifluralin, and clomazone showed high effectiveness in controlling *Eleusine indica* (above 85%). These herbicides are characterized by predominantly graminicidal action.

The addition of the residual herbicide in the weed management programs can provide more consistent control of hard-to-control weeds, delay the post planting application timing for glyphosate in glyphosate resistant crops, and reduce selection pressure for resistant biotypes [34].

**Table 1. Results of the chemical analysis of the dystrophic red latosol sample (0–20 cm) used in the experiment**

| Dystrophic red latosol | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **P** | **O.M** | **pH** | **K** | **Ca** | **Mg** | **H+Al** | **B.S** | **CEC** | **V** |
| **mg dm$^{-3}$** | **g dm$^{-3}$** | **$CaCl_2$** | | | | **mmol$_c$ dm$^{-3}$** | | | **%** |
| 19 | 32 | 5.4 | 2.7 | 60 | 10 | 31 | 72.7 | 103.7 | 70 |

**Table 2. Control of *Digitaria insularis* after the application of pre-emergence herbicides in association with cover crops at 10, 20, and 30 days after emergence (DAE)**

| Treatments | Control (%) - 10 DAE *Digitaria insularis* | | | | | |
|---|---|---|---|---|---|---|
| | | Cover crop (1) | | | | |
| | Doses g ai ha$^{-1}$ | *C. cajan* | *S. bicolor* | *C. juncea* | *C. spectabilis* | *C. breviflora* |
| Control test | - | 0.00 cA | 0.00 cA | 0.00 bA | 0.00 bA | 0.00 dA |
| Without herbicide | - | 61.25 bB | 52.50 bA | 0.00 bC | 15.00 bC | 30.00 cB |
| Clomazone | 1000 | 98.75 aA | 95.00 aA | 88.75 aA | 96.25 aA | 96.25 aA |
| Trifluralin | 900 | 55.00 bB | 97.50 aA | 91.25 aA | 98.75 aA | 72.50 bB |
| Pendimethalin | 1200 | 75.00 bA | 82.50 aA | 82.50 aA | 95.00 aA | 85.00 bA |
| S-metolachlor | 1920 | 87.50 aA | 95.00 aA | 95.00 aA | 98.75 aA | 100.00 aA |
| CV (%) | 22.91 | | | | | |
| | *F(Treatments)=144.20** F(Cover Crop)=4.49** F(Treatments X Cover Crop)=7.86*** | | | | | |
| **Treatments** | **Control (%) - *20* DAE *Digitaria insularis*** | | | | | |
| | | **Cover crop (1)** | | | | |
| | **Doses g ai ha$^{-1}$** | ***C. cajan*** | ***S. bicolor*** | ***C. juncea*** | ***C. spectabilis*** | ***C. breviflora*** |
| Control test | - | 0.00 cA | 0.00 cA | 0.00 bA | 0.00 cA | 0.00 cA |
| Without herbicide | - | 61.25 bA | 58.75 bA | 0.00 bB | 41.25 bA | 50.00 bA |
| Clomazone | 1000 | 96.25 aA | 100.00 aA | 98.75 aA | 100.00 aA | 97.50 aA |
| Trifluralin | 900 | 92.50 aA | 98.75 aA | 100.00 aA | 98.75 aA | 88.75 aA |
| Pendimethalin | 1200 | 96.25 aA | 95.00 aA | 100.00 aA | 100.00 aA | 100.00 aA |
| S-metolachlor | 1920 | 87.50 aA | 97.50 aA | 87.50 aA | 100.00 aA | 100.00 aA |
| CV (%) | 21.95 | | | | | |
| | *F(Treatments)=138.35** F(Cover Crop)=1.67NS, except F(C. spectabilis)=10.05** F(Treatments X Cover Crop)=1.92*** | | | | | |
| **Treatments** | **Control (%) - *30* DAE *Digitaria insularis*** | | | | | |
| | | **Cover crop (1)** | | | | |
| | **Doses g ai ha$^{-1}$** | ***C. cajan*** | ***S. bicolor*** | ***C. juncea*** | ***C. spectabilis*** | ***C. breviflora*** |
| Control test | - | 0.00 cA | 0.00 cA | 0.00 bA | 0.00 cA | 0.00 cA |
| Without herbicide | - | 26.25 bB | 81.25 bA | 3.75 bC | 78.25 bA | 72.00 bA |
| Clomazone | 1000 | 98.25 aA | 100.00 aA | 99.50 aA | 100.00 aA | 99.50 aA |
| Trifluralin | 900 | 97.00 aA | 98.50 aA | 99.50 aA | 99.50 aA | 96.25 aA |
| Pendimethalin | 1200 | 98.25 aA | 98.75 aA | 100.00 aA | 100.00 aA | 100.00 aA |
| S-metolachlor | 1920 | 97.00 aA | 99.50 aA | 98.25 aA | 99.00 aA | 99.00 aA |
| CV (%) | 11.52 | | | | | |
| | *F(Treatments )=455.26** F(Cover Crop)=11.85 F(Treatments X Cover Crop)=11.01*** | | | | | |

*(1)Cajanus cajan, Sorghum bicolor, Crotalaria juncea, Crotalaria spectabilis, and Crotalaria breviflora. **Significant at the 5% probability level by the F-test. CV (%): coefficient of variation. Means followed by the same lowercase letters in the column and uppercase letters in the row do not differ from each other by the Scott-Knott test at 5% significance. Control = without herbicide and without cover crop; Without herbicide = with cover*

**Table 3. Reduction of shoot dry biomass (%) of *Digitaria insularis* compared after 30 days after emergence (DAE)**

| Treatments | Reduction (%) of shoot dry biomass of *Digitaria insularis* | | | | | |
|---|---|---|---|---|---|---|
| | Cover crop [(1)] | | | | | |
| | ***Doses* g ai ha$^{-1}$** | ***C. cajan*** | ***S. bicolor*** | ***C. juncea*** | ***C. spectabilis*** | ***C. breviflora*** |
| Without herbicide | - | 33.68 bC | 90.68 aA | 6.5 bD | 64.23 bB | 61.28 bB |
| Clomazone | 1000 | 99.33 aA | 100.00 aA | 100.00 aA | 100.00 aA | 100.00 aA |
| Trifluralin | 900 | 95.58 aA | 100.00 aA | 100.00 aA | 100.00 aA | 92.18 aA |
| Pendimethalin | 1200 | 99.43 aA | 99.43 aA | 100.00 aA | 100.00 aA | 100.00 aA |
| S-metolachlor | 1920 | 98.65 aA | 100.00 aA | 98.18 aA | 100.00 aA | 100.00 aA |
| CV (%) | | | | 13.81 | | |
| | *F(Treatments)=60.01** F(Cover crop)=5.75** F(Treatments X Cover crop)=5.41*** | | | | | |

*[(1)]Cajanus cajan, Sorghum bicolor, Crotalaria juncea, Crotalaria spectabilis, and Crotalaria breviflora. **Significant at the 5% probability level by the F-test. CV (%): coefficient of variation. Means followed by the same lowercase letters in the column and uppercase letters in the row do not differ from each other by the Scott-Knott test at 5% significance*

**Table 4. Control of *Eleusine indica* after the application of pre-emergence herbicides in association with cover crops at 10, 20, and 30 days after emergence (DAE)**

| Treatments | Control (%) *of Eleusine indica* at 10 DAE | | | | | |
|---|---|---|---|---|---|---|
| | | | | Cover crop | | |
| | ***Doses*** **g ai ha⁻¹** | ***C. cajan*** | ***S. bicolor*** | ***C. juncea*** | ***C. spectabilis*** | ***C. breviflora*** |
| Control test | - | 0.00 cA | 0.00 bA | 0.00 bA | 0.00 cA | 0.00 bA |
| Without herbicide | - | 43.75 bB | 88.75 aA | 93.75 aA | 31.25 bB | 95.00 aA |
| Clomazone | 1000 | 96.25 aA | 98.75 aA | 100.00 aA | 100.00 aA | 100.00 aA |
| Trifluralin | 900 | 92.50 aA | 98.75 aA | 98.75 aA | 86.25 aA | 96.25 aA |
| Pendimethalin | 1200 | 100.00 aA | 93.75 aA | 100.00 aA | 95.00 aA | 100.00 aA |
| S-metolachlor | 1920 | 97.50 aA | 100.00 aA | 100.00 aA | 98.75 aA | 100.00 aA |
| CV (%) | 14.5 | | | | | |
| | *F(Treatments)=247.63** F(Green Manures)=7.66** F(Treatments X Green Manures)=4.74*** | | | | | |
| **Treatments** | **Control (%) of *Eleusine indica* at 20 DAE** | | | | | |
| | | | | **Cover crop** | | |
| | ***Doses*** **g ai ha⁻¹** | ***C. cajan*** | ***S. bicolor*** | ***C. juncea*** | ***C. spectabilis*** | ***C. breviflora*** |
| Control test | - | 0.00 cA | 0.00 bA | 0.00 bA | 0.00 dA | 0.00 bA |
| Without herbicide | - | 75.00 bB | 92.50 aA | 97.50 aA | 55.00 cC | 100.00 aA |
| Clomazone | 1000 | 98.75 aA | 98.75 aA | 100.00 aA | 100.00 aA | 100.00 aA |
| Trifluralin | 900 | 100.00 aA | 100.00 aA | 100.00 aA | 87.50 bB | 100.00 aA |
| Pendimethalin | 1200 | 100.00 aA | 98.75 aA | 100.00 aA | 98.75 aA | 100.00 aA |
| S-metolachlor | 1920 | 90.00 aA | 100.00 aA | 95.00 aA | 98.75 aA | 97.50 aA |
| CV (%) | 8.94 | | | | | |
| | *F(Treatments)= 613.64**F(Green Manures)= 7.84**F(Treatments X Green Manures)= 4.87*** | | | | | |
| **Treatments** | **Control (%) of *Eleusine indica* at 30 DAE** | | | | | |
| | | | | **Cover crop** | | |
| | ***Doses*** **g ai ha⁻¹** | ***C. cajan*** | ***S. bicolor*** | ***C. juncea*** | ***C. spectabilis*** | ***C. breviflora*** |
| Control test | - | 0.00 cA | 0.00 bA | 0.00 cA | 0.00 cA | 0.00 cA |
| Without herbicide | - | 82.50 bA | 86.25 aA | 52.50 bB | 20.00 bC | 83.25 bA |
| Clomazone | 1000 | 99.00 aA | 98.50 aA | 100.00 aA | 98.50 aA | 99.50 aA |
| Trifluralin | 900 | 92.25 aA | 99.50 aA | 100.00 aA | 89.00 aA | 96.50 aA |
| Pendimethalin | 1200 | 100.00 aA | 97.75 aA | 99.00 aA | 98.25 aA | 99.00 aA |
| S-metolachlor | 1920 | 98.50 aA | 100.00 aA | 100.00 aA | 99.50 aA | 99.50 aA |
| CV (%) | 12.88 | | | | | |
| | *F(treatments)=326.63** F(Green manures)=7.04** F( Treatments X Green Manures )=5.53*** | | | | | |

*[1]Cajanus cajan, Sorghum bicolor, Crotalaria juncea, Crotalaria spectabilis, and Crotalaria breviflora. **Significant at the 5% probability level by the F-test. CV (%): coefficient of variation. Means followed by the same lowercase letters in the column and uppercase letters in the row do not differ from each other by the Scott-Knott test at 5% significance. Control = without herbicide and without cover crop; Without herbicide = with cover*

**Table 5. Reduction of shoot dry biomass (%) of *Eleusine indica* compared after 30 days after emergence (DAE)**

| **Treatments** | **Reduction (%) of shoot dry biomass of *Eleusine indica*** | | | | | |
|---|---|---|---|---|---|---|
| | | **Cover crop** | | | | |
| | ***Doses* g ai ha$^{-1}$** | ***C. cajan*** | ***S. bicolor*** | ***C. juncea*** | ***C. spectabilis*** | ***C. breviflora*** |
| Without herbicide | - | 76.7 bB | 85.50 bB | 82.62 bB | 9.33 cC | 97.15 aA |
| Clomazone | 1000 | 100.00 aA | 100.00 aA | 100.00 aA | 100.00 aA | 100.00 aA |
| Trifluralin | 900 | 91.23 aB | 100.00 aA | 100.00 aA | 84.33 bB | 89.43 bB |
| Pendimethalin | 1200 | 100.00 aA | 99.83 aA | 100.00 aA | 97.48 aA | 100.00 aA |
| S-metolachlor | 1920 | 100.00 aA | 100.00 aA | 100.00 aA | 100.00 aA | 100.00 aA |
| CV (%) | | | | 8.39 | | |
| | *F(Treatments)=54.28** F(Green manures)=22.58** F(Treatments X Green manures)=15.18*** | | | | | |

*[1]Cajanus cajan, Sorghum bicolor, Crotalaria juncea, Crotalaria spectabilis, and Crotalaria breviflora. **Significant at the 5% probability level by the F-test. CV (%): coefficient of variation. Means followed by the same lowercase letters in the column and uppercase letters in the row do not differ from each other by the Scott-Knott test at 5% significance*

The data of biomass corroborate with the finding of a higher percentage of control in treatments with the association between herbicides and cover crops, except for trifluralin associated with *C. spectabilis* and *C. breviflora,* which presented a reduction in dry biomass of 84.3 and 89.4%, respectively Table 5.

Treatments with *C. cajan*, *S. bicolor*, *C. breviflora*, and *C. juncea* without herbicides stood out in the reduction of dry biomass of *Eleusine indica*, with a reduction of 76.7, 85.5, 97.1, and 82.6%, respectively. These results agree with those obtained by Queiroz et al. [35], who found that *C. breviflora* straw provided a greater reduction in the dry matter of weeds in no-tillage areas.

## 4. CONCLUSION

Herbicides are widely used to manage weeds in glyphosate resistant crops in Brazil; however, herbicides alone cannot provide effective and season-long weed control. Therefore, there is a need to integrate herbicide use with other weed management strategies. The combined use of residual herbicide and cover crop may suppress *Eleusine indica* and *Digitaria insularis* more effectively.

The pre-emergence herbicides clomazone, trifluralin, pendimethalin, and s-metolachlor associated with the straw of *C. cajan, S. bicolor, C. juncea, C. spectabilis*, and *C. breviflora* are an excellent alternative to control *Digitaria insularis* and *Eleusine indica*.

The cover crop *S. bicolor* stood out in the suppression of *Digitaria insularis* regardless of the herbicide association, and *C. breviflora*, *C. cajan*, and *S. bicolor* showed control of *Eleusine indica* higher than 80%.

## ACKNOWLEDGEMENTS

Recognition is extended to the National Council for Scientific and Technological Development (CNPq) for financial support and members of the Agricultural Sciences Research Group (GECA) for their support.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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https://doi.org/10.1590/S0100-83582010000200005.



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