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SOWING DEPTH IN EMERGENCE OF *Senna occidentalis* SEEDLING

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ABSTRACT
Senna occidentalis, popularly known as coffee senna in Brazil and regions of South America, is a very problematic weed species both in pasture areas and in annual and perennial crops. Management strategies for this species range from the use of harrows to the practice of cultural management with straw and the use of herbicides. The knowledge of the capacity of this species to emerge from great depths becomes important for the adoption of preventive management strategies. The research aimed to verify at what depth this species emerges in Amazonian soil. It was found that even at 10.0 cm deep, the seedlings managed to emerge and form with the same height as those kept close to the soil surface. For the species, the best depths were between 2.0 and 6.0 cm, indicating that these conditions favor its development.

KEYWORDS: Weed, Coffee senna, germination

PROFUNDIDADE DE SEMEADURA E TEXTURA DO SOLO EM EMERGÊNCIA DE PLÂNTULAS DE *SENNA OCCIDENTALIS*

RESUMO
Senna occidentalis, popularmente conhecido como 'fedegoso' no Brasil e nas regiões da América do Sul, é uma espécie de planta daninha muito problemática em áreas de pastagem, bem como em culturas anuais e perenes. As estratégias de manejo desta espécie variam desde o uso de roçada à prática de manejo cultural com palha e uso de herbicidas. O conhecimento da capacidade dessa espécie de emergir de grandes profundidades é importante para a adoção de estratégias de manejo preventivo. A pesquisa teve como objetivo verificar a profundidade desta espécie em solo de uma região Amazônica, no estado de Mato Grosso. Verificou-se que, mesmo a 10,0 cm de profundidade, as plântulas podem emergir e se desenvolver atingindo a mesma estatuta das mantidas próximas à superfície do solo. Para a espécie, as melhores profundidades foram entre 2,0 e 6,0 cm, indicando que essas condições favorecem o seu desenvolvimento.

PALAVRAS-CHAVE: Planta daninha, fedegoso, germinação

INTRODUCTION

Coffee senna is the popular name of *Senna occidentalis* (L.) Link (synonymy *Cassia occidentalis*) (LORENZI, 2008). This is a perennial herbaceous species with Pantropical distribution, native to the tropics, which belongs to the family Fabaceae (Leguminosae) and subfamily Caesalpinioideae (CABI, 2021; LOMBARDO et al., 2009). It is described as a problematic weed of different crops in tropical and subtropical regions such as cotton, soybean, citrus, sugarcane, corn, coffee, sorghum and pasture areas (LORENZI, 2014; PIER, 2016; PROTA, 2016).

However, in cattle breeding areas, this species has been described as an extremely toxic plant, causing death in animals that ingest it (TAKEUTI et al., 2011). The main toxic plant parts are the leaves, the stem and the pods, but the seeds are the structures that present the greatest toxicity (RIETT-CORREA et al., 2007; RAFFI et al., 2003; CARVALHO et al., 2014).

Intoxication can affect cattle, horses, birds and swine, being characterized by intense degenerative myopathy (BARTH et al., 1994). This clinical picture is caused either by the ingestion of hay or feed contaminated with the seeds of the species (TAKEUTI et al., 2011). But outbreaks can also occur, especially in the period between late autumn and early winter, caused by the spontaneous consumption of these plants together with forages, which can affect up to 60% of the herd (BARROS et al., 1999).

In grazing areas, seeds and vegetative propagules, which make up the weed seed bank in the soil, constitute the main source of regeneration of these species in these environments. These plants spontaneously emerge in agroecosystems and propagate predominantly by sexual propagules. The seeds remain in the soil, waiting for adequate conditions to start the germination process, until the complex dormancy mechanisms cease (YAMASHITA et al., 2005).

Seed germination and subsequent seedling emergence are processes influenced by several factors, including temperature, soil physical and chemical characteristics, moisture and sowing depth. Although the depth of seed location in the soil profile is a direct condition for the emergence of several weed species (YAMASHITA & GUIMARÃES, 2015). Another factor that can directly influence the formation of the weed community is the soil texture, which can also significantly interfere in this occupation, especially where the soils are compacted or with excessive amounts of clay, in addition to other characteristics such as aeration, degree of pathogen infestation and water retention capacity (MONQUERO et al., 2012).

When plants are subjected to intense competition, their physiological developmental characteristics undergo adaptations, resulting in changes for survival under inadequate conditions, including when their reproductive propagules are found at great depths (MELO et al., 2006).

The objective of this work is to evaluate the emergence of coffe senna at different sowing depths.

MATERIAL AND METHODS

This study was carried out in the premises of CEPTAM (Center for Research and Technology of the Southern Amazon) and LaSeM (UNEMAT Seed Technology and Matology Laboratory), Campus of the University of the State of Mato Grosso, in the municipality of Alta Floresta-MT, Brazil.

Cassia occidentalis seeds were manually collected in natural infestations that occurred in pasture areas in the municipality of Alta Floresta-MT. Only pods that were visibly ripe in color were collected. The pods were air-dried for 48 hours in a ventilated and dry place. Later, these were opened, removing the seeds. Soon after, a visual selection was performed, discarding seeds with damage and impurities. After this procedure, the seeds were placed in paper bags and stored in a refrigerated environment at 12 °C, until use.

The experiment was carried out inside a greenhouse with coverage on the sides and top, with temperature controlled by fans and a water curtain. The experimental design was completely randomized with four replications, with six depths (0, 2, 4, 6, 8 and 10 cm) of seedbed sowing being studied with five replications.

The experimental units were represented by perforated plastic containers (20 x 15 cm) with a capacity of 1 liter of volume, filled with substrate composed of forest soil + organic compost in a 3:1 ratio. Therefore, a total of 20 cm^3 of substrate was used to fill the containers.

Before sowing, the seeds were subjected to mechanical scarification, rubbing an abrasive sandpaper on the seeds, aiming to break the impermeable integument, allowing the hydration of the embryo (MENECKELLI et al., 2016).

In each experimental unit, 20 seeds were placed at their respective depths. The containers were kept with sufficient humidity to avoid water deficit, requiring manual irrigation twice a day.

The number of seedlings that emerged (height greater than 1.0 cm) was counted daily, and their height was determined on two occasions, 5 and 10 days. After this period, the seedlings were carefully removed from the container and washed under running water to determine the length of the root and aerial part. And, later these were dried in an oven at 65 ºC for 72 hours, to obtain dry mass (weighing in a semi-analytical scale).

At the end of this period, the total emergence percentage for each experimental unit was calculated, as well as the emergence velocity index (IVE). The IVE was determined using the formula proposed by Maguire (1962):

$$IVE = E1/N1 + E2/N2 + ... + En/Nn$$

where: IVE = emergence speed index; E1, E2, En = number of emerged seedlings computed in the first, second and last counts; and N1, N2, Nn = number of sowing days in the first, second and last counts.

Data were subjected to analysis of variance and means compared by Tukey test at 5% probability for qualitative parameters and regression analysis for quantitative parameters, using the statistical program SISVAR (FERREIRA, 2014).

RESULTS AND DISCUSSION

The percentage of emergence, the speed of this process and the height of the seedlings at 5 days after sowing differed according to the sowing depth. But seedling height at 10 days, root length and seedling dry mass remained without significant difference by the F test, as shown in Table 1.

In the first days of evaluation it was found that there was reduced emergence in treatments whose sowing was carried out at greater depths and also the seeds kept on the substrate surface. The results obtained are similar to those reported by Yamashita et al. (2005), Norsworthy & Oliveira

(2005) and also to other species such as *Cardiospermum halicacabum* (BRIGHENTI et al., 2003), *Conyza bonariensis* and *C. canadensis* (VIDAL et al., 2007), *Commelina benghalensis* (DIAS et al., 2008), *Bidens pilosa* (SOUZA et al., 2009) and *Rottboellia exaltata* (MONQUERO et al., 2012).

Table 1. Variance analysis table with mean square of emergence speed index (ESI), % emergence (% E), plant height at 5 (A5) and 10 days (A10), root length (CR) and dry mass (DM) of *Senna occidentallis* plants, whose seeds were sown at different depths.

	ESI	% E	A5	A10	CR	MS
Sowing depth	321.782*	1108.54*	6.617*	4.750ns	5.724ns	0.00163ns
Residue	7.635	97.569	0.354	1.882	2.972	0.00085
F value	42.144	11.362	18.682	2.524	1.926	1.918
Depth						
0	14.75 b	50.00 c	8.00 a	13.13 a	21.3575 a	0.1330 a
2	16.28 b	78.75 ab	7.38 a	15.25 a	22.3025 a	0.1533 a
4	27.75 a	88.75 a	8.38 a	16.00 a	18.9325 a	0.1015 a
6	19.55 b	92.50 a	7.50 a	15.63 a	20.1525 a	0.1120 a
8	5.05 c	63.75 bc	6.00 b	16.00 a	20.6650 a	0.1198 a
10	4.08 c	62.50 bc	5.00 b	14.75 a	19.7450 a	0.1010 a
DMS	6.212	22.204	1.338	3.084	3.875	0.0656
C.V. (%)	18.96	13.59	8.45	9.07	8.40	24.30

* and ns: significant and non-significant at 5% by F test, respectively
Means followed by the same letter in the column do not differ from each other by the Tukey test at 5% probability.

Figure 1 shows information about the IVE (emergence velocity index) of the species when sown at different depths. It is observed that S. occidentalis had its peak of emergence speed when the seeds were kept at a depth of 4 cm. The greater emergence of plants at lower depths may be due to the lesser physical impediment imposed by the soil under these conditions, in addition to a greater alternation of temperature, which may favor certain species (MUNIZ-FILHO et al., 2004; LABONIA et al., 2009). The delay in the germination process, indicated by the IVE, demonstrates the effect of positioning the seeds of this species along the soil profile which, in ecological terms, can be considered an adaptive mechanism of the species to these conditions, resulting in a staggered germination when the condition environment is inappropriate for the emergence of seedlings and their subsequent survival (SILVA et al., 2009).

There was a difference in the percentage of emergence of S. occidentalis seedlings (Figure 2), and at 6.0 cm, the emergence was greater than 90% and, from that depth, there was a sharp drop. But still at 10 cm, this was greater than 60%, indicating great capacity of this species to develop and emerge even when its propagules are at greater depths. Also when the seeds were placed on the surface, they reached emergence a little above 50%, indicating that this condition also affects the development of a greater percentage of these propagules.

It is known that there is an effect of light, which regulates the germination process of weeds through phytochrome and this, as the depth of placement of seeds in the soil increases, undergoes wavelength filtration (YAMASHITA et al., 2011). This impediment in the penetration of light, especially the red wavelengths, must have reduced the light intensity that reached the seeds, decreasing the percentage of germination of the species seeds beyond a depth of 4 cm. These results are similar to those reported by Nosworthy & Oliveira (2005) in a biotype of this species infesting the southeastern United States.

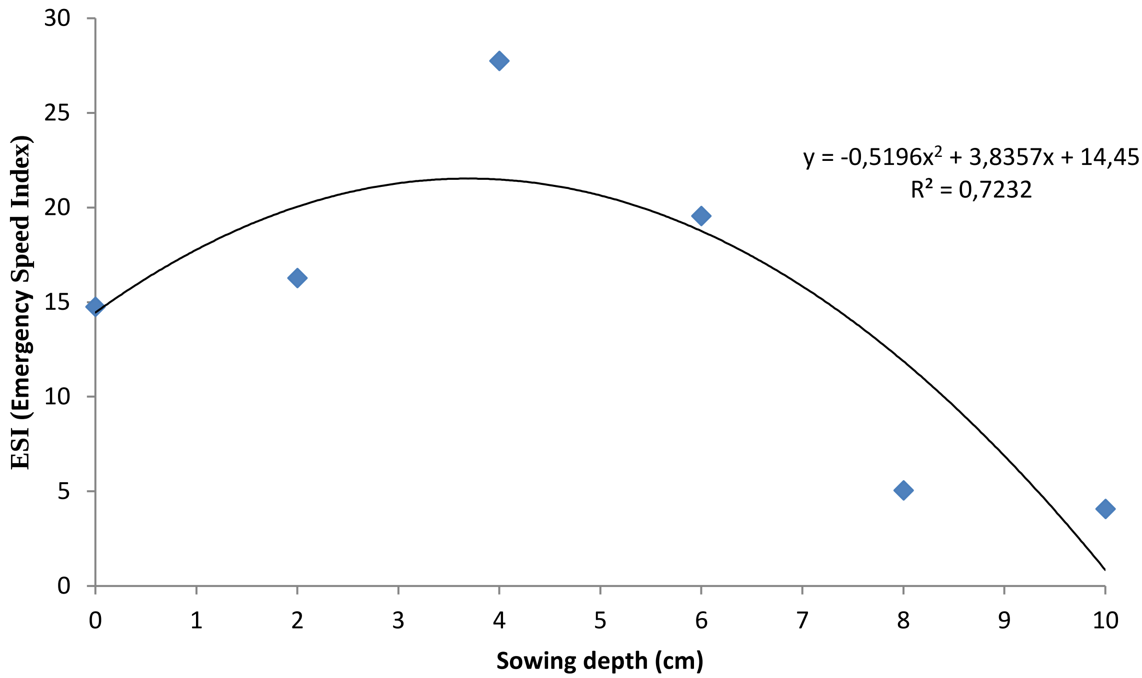

Figure 1. Emergence speed index (ESI) of *Senna occidentallis* seedlings that were sown at different depths.

The differential germinability of seeds placed on the soil surface and the others kept at greater depths has been reported in several studies with similar results, and whose researchers have indicated that this fact is also due to the greater contact of seeds with soil moisture when they are positioned at a depth greater than zero and less than 6 cm (SOUZA FILHO et al., 1998; GHORBANI et al., 1999; SILVA et al., 2013). On the soil surface, there is a rapid loss of moisture, even with daily replacement of water through irrigation. This condition of water loss causes the seeds to stop absorbing this element in the amount necessary to activate the mechanisms that command the germination process of the seeds (SOUZA et al., 2011).

Germination occurred after the second day of sowing, similar to information reported by Norsworthy & Oliveira (2005), who studied the same species whose biotype developed both in clayey and sandy soil, in the southeastern United States. According to studies carried out in soil not protected by straw, the stimuli necessary to overcome the dormancy of seeds of several weeds can be intense (CANOSSA et al., 2007).

Weed seeds, such as *S. occidentalis*, can also detect the presence of potential competitors (thick vegetation cover, shading of neighboring plants), by the absence of light at the appropriate wavelength, thus reducing the probability of competition and increasing the survival rate (NOSWORTHY & OLIVEIRA, 2005; YAMASHITA et al., 2011).

As for the height of *S. occidentalis* plants, in the evaluation carried out five days after the implementation of the experiment (Figure 3), it is possible to observe greater height of these plants when the seeds were sown at a depth of four centimeters and, from that depth onwards, there is decrease as depth increases. This fact is due to the greater delay in the emergence of seedlings that are at greater depths. The greatest emergence verified by *S. occidentallis* seedlings on the soil surface occurs due to the fact that the seeds are always kept moist, preventing dryness and allowing the supply of sufficient water to activate the germination mechanisms (CANOSSA et al., 2007; ALBERGUINI & YAMASHITA, 2010). Furthermore, the seeds were more exposed to light and temperature fluctuations, which contributed to increase emergence. This has also been observed in research with other weeds (GHERSA et al., 1992; LUZ et al., 2014). Norsworthy & Oliveira (2005) report that this species is sensitive to stress caused by environmental conditions, which results in germination delay and all other stages of development, including its development and shoot formation, significantly affecting plant height, especially at the beginning of its development.

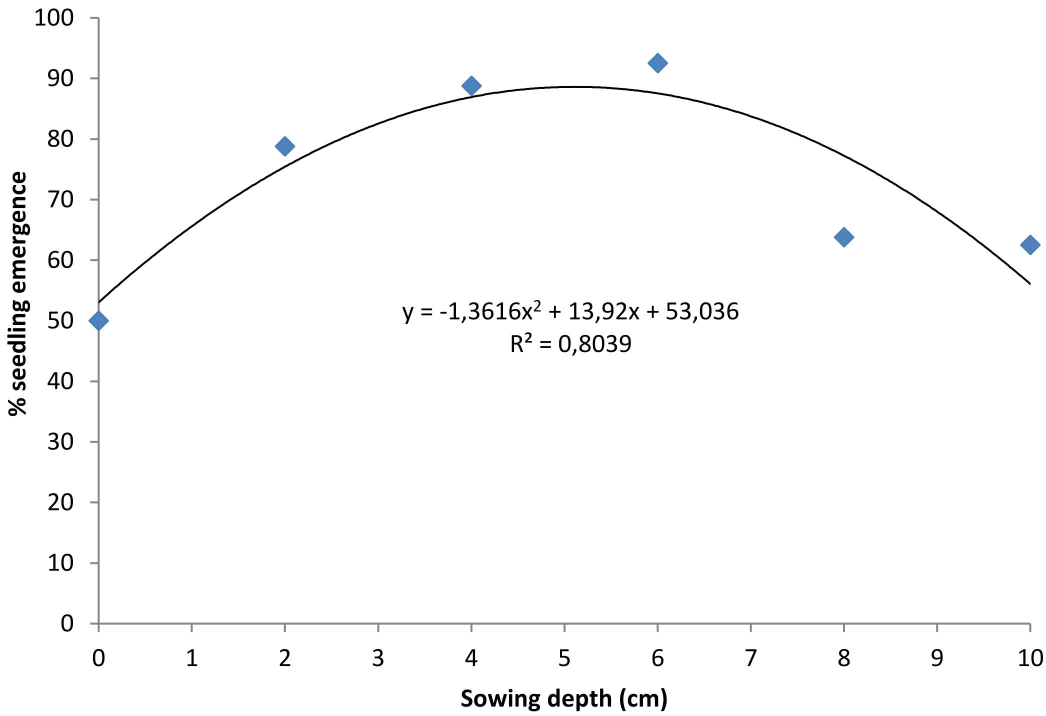

Figure 2. Emergence percentage (%) of *Senna occidentallis* seedlings that were sown at different depths.

In Figure 4, it is possible to verify the emergence of S. occidentallis seedlings, 10 days after sowing, the date of the last evaluation. The curve presents greater initial germination up to 4.0 cm. However, as time goes by, the seedlings that suffered a delay in emergence because they were sown up to 10 cm in depth, recovered development and, on the date of the last evaluation, it appears that their height was similar to those that were seeded at 2.0 cm. The fact that draws attention is that the seedlings that were formed from the seeds placed on the soil surface presented lower height than the others.

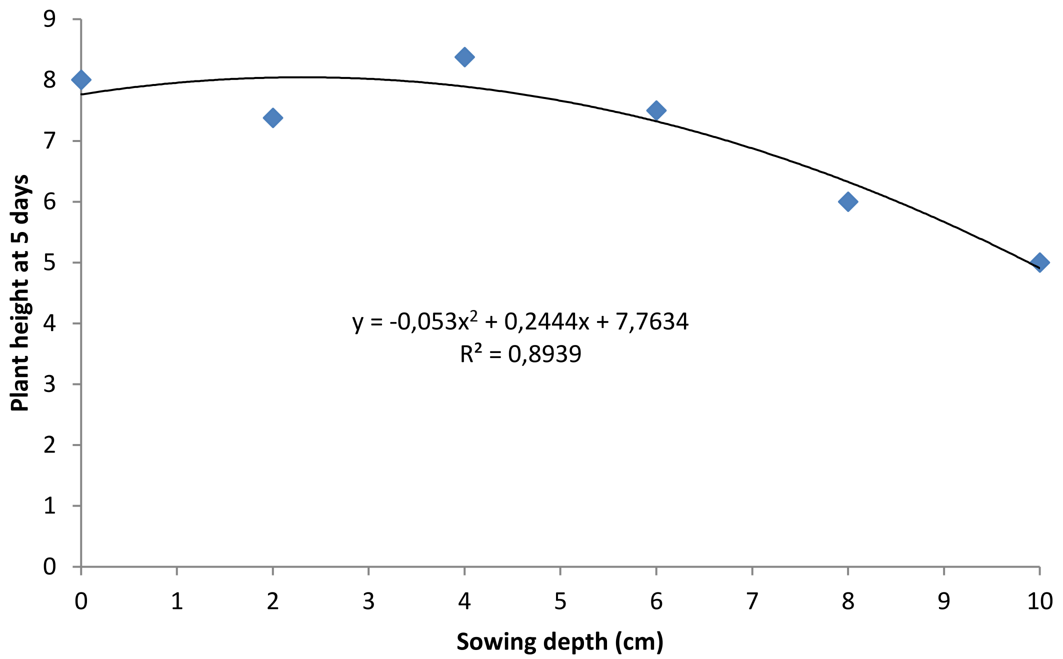

Figure 3. Height of *Senna occidentallis* plants at 5 days sown at different depths.

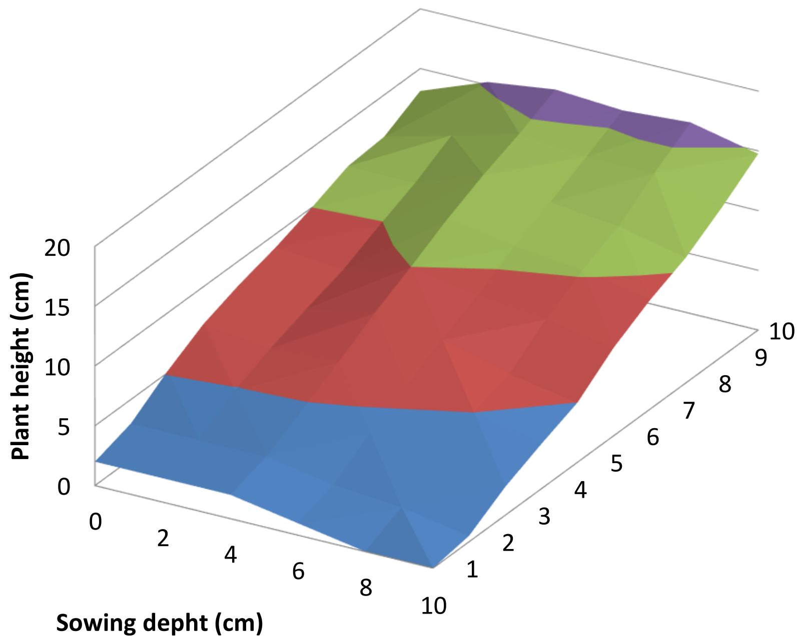

Figure 4. Height of *Senna occidentallis* plants sown at different depths.

Direct contact with sunlight, bad weather, direct attacks from microorganisms, lack of protection and maintenance of temperature, without major variations, caused this situation, preventing plants from developing like the others, whose seeds were positioned below the soil surface. According to Alberguini & Yamashita (2010), in general, seeds placed on the soil surface directly suffer the effects of environmental variations that may reflect in lesser emergence compared to those kept at depth, as they are more harmed by dryness in function. of direct light incidence and temperature fluctuations, which cause damage in its development because there is not enough water supply to activate the germination mechanisms and maintain them for the seedling growth.

Preferential photoblastism and the ability of the soil to filter out certain lengths of light can also lead to variations in the germination and emergence of weeds (LUZ et al., 2014). Similar results have also been reported in other weed species such as *Xanthium strumarium* (TOLEDO et al., 1993), *Rumex obtusifolius* (BENVENUTTI et al., 2001), *Vernonia ferruginea* (ALBERGUINI & YAMASHITA, 2010) and *Murdannia nudiflora* (LUZ et al., 2014).

As for the final emergence of seedlings (Figure 5), it was found that in the beginning, from the second day on, the greatest emergence occurred around 4.0 cm. This condition was maintained until the last assessment, extending from 2.0 to 6.0 cm. Thus, higher percentage values of seedling emergence of *S. occidentallis* generally occur between these depths.

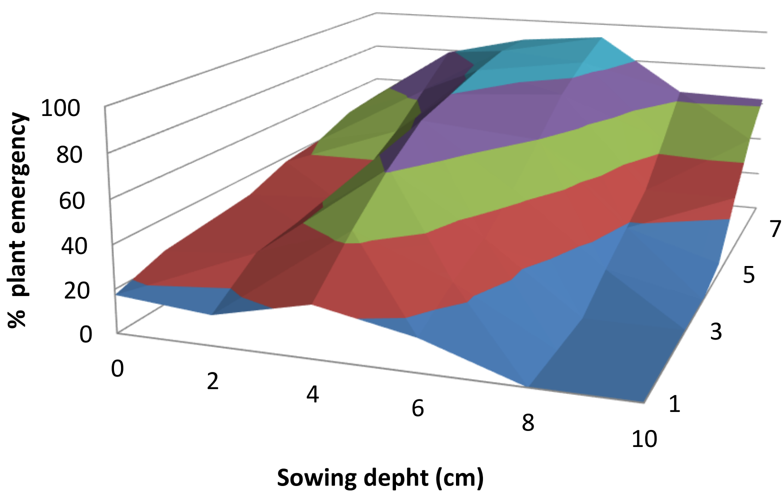

Figure 5. Final emergence of *Senna occidentallis* plantations, whose seeds were originally arranged at different depths.

This fact demonstrates the ability of this species to adapt to common conditions of soil preparation and cultivation that are practiced in most agricultural regions of the world. Soil preparation, involving soil turning up to the first 5.0 cm with the use of grids and levelers, provides a favorable condition for the dispersion and occupation of the area by this weed (CANOSSA et al., 2007).

However, in the same way that turning can lead to the positioning of seeds in this soil profile, favoring their germinability, the subsequent turning, after seed germination and seedling emergence, can incur a significant mortality of these (GUIMARÃES et al., 2002). Thus, it can be considered that the preparation of the soil through the use of agricultural implements such as harrows and levelers can reduce the population of this weed, causing the death of the seedlings and burying the seeds.

However, it is noteworthy that the practice of soil preparation with these implements is not consistent with conservation practices of the no-tillage system. In addition, there is an increase in the cost of production due to the need to turn over the soil and, without discarding the expense of possible chemical management with herbicides for other weed species in the area (BRIGHENTI et al., 2003).

It is also noteworthy that this species presents itself as an important invader for several reasons, including its rusticity, capacity to produce a large amount of seeds per cycle and finally their dormancy (YAMASHITA et al., 2005). This fact makes the viability of the seeds occur gradually, in a staggered way, making their management difficult.

Thus, it is necessary to use weed management methods that are integrated, effectively seeking the best efficiency condition in practice with economic viability. Thus, in soil conservation areas, the strategy is to use registered herbicides for the chemical control of this species, and the application will be favored during the initial stage of seedling development.

In addition, practices such as preventing the entry of new dissemination foci and reducing the population of this species must be carried out annually.

CONCLUSIONS

The results obtained allow us to conclude that the differences in sowing depth influenced the emergence of *Senna occidentallis*. This species emerges with greater intensity between 2.0 and 6.0 cm. Up to 10.0 cm, there is a large amount of seed emergence.

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