Original Article

GERMINATION AND EARLY GROWTH OF SOYBEAN, DRY BEAN AND TURNIP GROWN UNDER *Digitaria horizontalis* STRAW

GERMINAÇÃO E DESENVOLVIMENTO INICIAL DE SOJA, FEIJÃO E NABIÇA CULTIVADOS SOB PALHADA DE Digitaria horizontalis

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ABSTRACT: The study aimed to evaluate the possible inhibitory effects of different concentrations of crabgrass (*Digitaria horizontalis* Willd.) dry mass incorporated to the soil over the germination and early growth of soybean (*Glycine max* (L.) Merril.), dry bean (*Phaseolus vulgaris* L.), and turnip (*Raphanus raphanistrum* L.). The experimental design adopted was completely random, with four replications where, each one was consisted of a 2.5 L capacity pot. Dry mass of crabgrass at equivalent amounts of 0, 2.5, 5.0 and 10 t ha^{-1} were incorporated into the soil. Crops seedling emergence was checked daily, and germination, speed germination index, mean germination time, relative frequency and synchronization index of germination were computed at the final of 10 days .The height and dry mass of plants were evaluated at 35 days after sowing. The incorporation to the soil of *D. horizontalis* dry mass caused significant reduction of the height and dry weight of soybean, dry bean and turnip, but were not observed consistent influence over the germination of these species.

KEYWORDS: *Glycine max* (L., Merril.). *Phaseolus vulgaris* L. *Raphanus raphanistrum*. Crabgrass. Weed. Inhibitory effects.

INTRODUCTION

Allelopathy can be defined as the inhibitory or beneficial, direct or indirect, effect of one plant over another, occurring through the production of chemical compounds released to the environment. This phenomenon occurs in natural communities of plants (GRESSEL; HOLM, 1964) and may also interfere with the agricultural crops growth (MULLER, 1966; BELL; KOEPPE, 1972). However, it is not easy to distinguish whether the adverse effect of one plant on another is due to competition or allelopathy (FUERST; PUTNAN, 1983).

The allelopathic effect occurs when phytotoxic substances are released by leaching and root exudation, or by dry matter decomposition affecting the seed germination and growth of other species (NUÑEZ et al., 2006).

These phytotoxic chemicals are responsible for a wide variety of effects on plants. These effects include the delay or complete inhibition of seed germination, standstill of growth, root system injury, chlorosis, wilting and plant death. However, probably the most significant consequence of allelopathy is the alteration of plant development.

According to Weir et al. (2004) the allelopathic substances released by a plant can affect growth, harm the normal development and even inhibit the germination of other plant species. Changes in the patterns of germination can be well studied although in some cases not show significant differences, since it involves only the final results, ignoring inactive periods of germination (CHIAPUSO et al., 1997).

Allelopathic effects of different weed species on different crops were evidenced by the survey. Bhowmik e Doll (1982, 1984) observed that aqueous extract of *Amaranthus retroflexus* dry matter reduced fibrous root length of maize and soybean hypocotyl. Stevens e Tang (1987) demonstrated that *Bidens pilosa* reduced the seedling growth of lettuce, beans, maize and sorghum. Souza et al. (2003) studying the allelopathic effects of various weeds on growth of *Eucalyptus grandis* detected development inhibition caused by plants of *Digitaria horizontalis,* as well as other weed species tested.

It was found that the weed of pastures *Eragrostis plana*, had an influence on the germination and establishment of ryegrass (*Lolium multiflorum* L.), birdsfoot trefoil (*Lotus corniculatus* L.) and white clover (*Trifolium repens* L.), showing that their aggressiveness as invading plant, at least in part, was due to allelopathic substances (COELHO, 1986).

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This study aimed to evaluate the possible inhibitory effects of different concentrations of crabgrass (*Digitaria horizontalis*) dry mass incorporated in the soil, on the germination and early growth of soybean, dry bean, and turnip.

MATERIAL AND METHODS

The experiment was conducted in a greenhouse located at Nucleus of Advanced Research in Weed Science (Núcleo de Pesquisas Avançadas em Matologia - NUPAM) Lageado Experimental Farm, belonging to the Universidade Estadual Paulista "Júlio de Mesquita Filho" UNESP, Botucatu, SP, Brazil, during the months of July and August of 2009. The greenhouse was maintained heated with average temperature of 26ºC.

The soil was classified according to the new Brazilian System of Soil Classification (EMBRAPA, 1999), termed as Oxisol typical loam (46.5% clay, 14.5% silt and 39% sand), whose chemical analysis is presented in Table 1. The soil was dried in the shade, sieved at 5 mm mesh and fertilized according to the needs advocated by chemical analysis, carrying out correction with lime (PRNT equal to 91%). The method of base saturation (V%) was employed for calculating lime requirement, in order to raise to 70% (RAIJ et al., 1997). The limestone was homogenized to the soil and incubated for 30 days.

Table 1. Chemical characteristics of soil used as substrate in the experiment.

pH	M.O.	P_{resina}	Al^{3+}	H+Al	K	Ca	Mg	SB	CTC	V%	S
$CaCl_2$	g/dm^3	mg/dm^3	-------------			$mmol_c/dm^3$		-------------			mg/dm^3
4,8	20	37	---	40	3,1	19	5	27	67	40	---

The experimental units consisted of plastic pots with 2.5 L capacity, in a completely randomized design with four replications. The treatments consisted of four concentrations of crabgrass dry matter, being 0, 2.5, 5.0 and 10 t ha^{-1} incorporated into the soil, which were planted 10 seeds of soybean, dry bean, and 15 seeds of turnip. Daily irrigations were performed in all treatments.

The mass of crabgrass was collected in an experimental area located in the University, noting that the species was in pure groups in the place, keeping other species of weeds apart. The plants were, except roots, dried in an oven of forced air, 45 ° C for 72 hours, then grind in a grinder (0.3 mm mesh) and stored in a dry chamber for subsequent incorporation into the soil.

The experiment was conducted for 35 days from the sowing of species. It was proceeded daily counts of emergence and it was calculated the percentage of germination, germination speed index (GSI) (Maguire, 1962), the mean germination time (MGT), the frequency of germination and synchronization index of germination (U) (LABOURIAU; AGUDO, 1987) at ten days after sowing. After these evaluations were undertaken thinning by, leaving two plants per pot. At the end of the experiment were evaluated the height and dry mass (oven with forced air circulation at 60°C for 72 hours) of plants.

The results were subjected to analysis of variance by F test at 5% probability and when significant, the variables had their average adjusted by regression.

RESULTS AND DISCUSSION

Analyzing the results of germination percentage of soybean (Table 2) and dry beans (Table 3) it was noted that there was no difference between treatments, indicating the absence of inhibitory effect of *D. horizontalis* on the germination of both species. However, the germination of turnip (Table 4) was higher according to the concentration increases of the weed dry mass. Probably this fact was due to some factors such as greater retention of soil moisture, or the increased availability of nutrients and microorganism activity. Although there was no significant difference between the plots sown to soybeans, the emergence tended, as with the turnip, to increase with increase in straw concentration.

The lack of inhibitory effect on the germination of the species tested can be explained by the findings of Olibone et al. (2006). According to the researchers, the chemicals released from plant residues left on the soil surface, as observed in no tillage, have responded differently in terms of what happens by the method of incorporation. The allelochemicals are distributed in the soil profile at total depth according to the dry matter is incorporated and, consequently, its degradation is more quickly. However, dry matter remain in the surface layer when in no tillage systems, as well the toxic substances. Thus, the intensity of the allelopathic effect depends on the concentration of allelochemicals and their effect is easier observed in no tillage conditions.

Table 2. Germination percentage, germination speed index (GSI), mean germination time (MGT) and synchronization index of germination (U) of soybean seedlings at different crabgrass dry mass concentrations.

Straw Concentrations (t ha^{-1})	Germination (%)	GSI	MGT	U[1]
0.0	70	1.32 b	5.50	1.00
2.5	75	1.53 a	4.93	0.49
5.0	78	1.54 a	5.12	0.75
10.0	78	1.49 a	5.32	0.81
$f_{treatments}$	2.40^{ns}	5.01*	2.57^{ns}	0.72^{ns}
CV(%)	6.1	6.4	5.9	6.4
l.s.d	7.03	0.14	0.47	0.06

ns - not significant at 5% probability level, * significant at 5% probability; Means followed by same letter in column do not differ by t test at 5% probability;[1] Data transformed into √ x/100 + 0.5.

Table 3. Germination percentage, germination speed index (GSI), mean germination time (MGT) and synchronization index of germination (U) of dry bean seedlings at different concentrations of dry mass of crabgrass.

Straw Concentrations (t ha^{-1})	Germination (%)	GSI	MGT	U[1]
0.0	75	1.47	5.13	0.28
2.5	80	1.53	5.29	0.63
5.0	75	1.36	5.18	0.67
10.0	72	1.31	5.25	0.64
$f_{treatments}$	0.70^{ns}	0.77^{ns}	0.47^{ns}	0.79^{ns}
C.V.(%)	9.9	16.1	4.0	7.3
l.s.d	11.55	0.35	0.32	0.06

ns - not significant at 5% probability level;[1] Data transformed into √ x/100 + 0.5.

Table 4. Germination percentage, germination speed index (GSI), mean germination time (MGT) and synchronization index of germination (U) of wild radish seedlings at different concentrations of dry mass of crabgrass.

Straw Concentrations (t ha^{-1})	Germination (%)	GSI	MGT	U[1]
0.0	50 c	1.58	4.38	0.95
2.5	55 b	1.86	4.62	1.09
5.0	62 a	1.73	5.18	1.40
10.0	62 a	2.04	4.51	0.49
$f_{treatments}$	15.68**	0.97^{ns}	1.75^{ns}	2.81^{ns}
C.V.(%)	5.0	22.0	11.4	5.9
l.s.d	4.40	0.61	0.82	0.59

ns - not significant at 5% probability, ** significant at 1% probability; Means followed by same letter in column do not differ by t test at 5% probability; [1] Data transformed into √ x/100 + 0.5.

According to Correia et al. (2005), when the effect of extracts on seedling development is assessed in petri dishes, it is observed that the root system is more affected than the shoot, as the absorption and concentration of phytotoxins are favored in this tissue due to increased contact between the radicle and the filter paper. However, these researchers report that sometimes is not observed inhibition of seed germination. In such cases, the site of action of phytochemical may not be related to inhibition of cell division of the embryonic axis, resulting in no effect on the germination of seeds. Thus, the bioactivity of aqueous extracts would be contingent on the ability of absorption, translocation and action mechanism of potential inhibitory compounds.

By the other way, studies of allelochemicals added to soil, suggest that some others factors such as clay, oxides, organic matter, pH, nutrients and microorganisms, determine the concentrations of these active compounds in the soil (DALTON et al., 1983, WANG et al. , 1978). According to Souza et al. (2003) a variety of chemical elements are formed and dissolved in the soil during the microorganism decomposition and enzymatic degradation of plant parts, where many of them play important role in biological activity.

The germination and the germination rate of soybean seeds were not affected by extracts of sorghum in the Correia et al. (2005) studies. Nunes et al. (2003) found a decrease in germination percentage and germination rate of soybean seedlings grown under different levels of sorghum straw. Other species such as lettuce (Medeiros; Lucchesi, 1993) and tomato (CASTRO et al., 1983) had the germination also reduced by allopathic effect of some plants, including weeds.

D. horizontalis straw provided no significant effect on the GSI in the dry beans and turnip trials (Tables 3 and 4). However, was observed influence on the GSI of soybean (Table 2). Unlike the inhibitory effect expected, the presence of straw tended to increase the GSI, or in other words, higher average number of seedlings emerged per day. The probable responsible factors were discussed above. Nevertheless, other weed species may have allelopathic effects on soybean seeds germination, affecting the IVG. Maciel et al. (2003), found significant reduction in the GSI of soybean affected by *Brachiaria* allelopathy.

Germination and emergence of seeds, in general, is not perfectly synchronized. Some factors like water, temperature, or other treatments used may increase or decrease this synchrony, tending to change the polymodal frequency of germination. However, in this study, the results for the synchronization index (U) showed no influence on the germination timing of any species studied (Tables 2, 3 and 4) with the use of different straw concentrations treatments. So there was no difference in synchrony in the presence or absence of *D. horizontalis* dry mass incorporated into the soil, resulting in polymodal frequency of germination (Figures 1, 2 and 3).

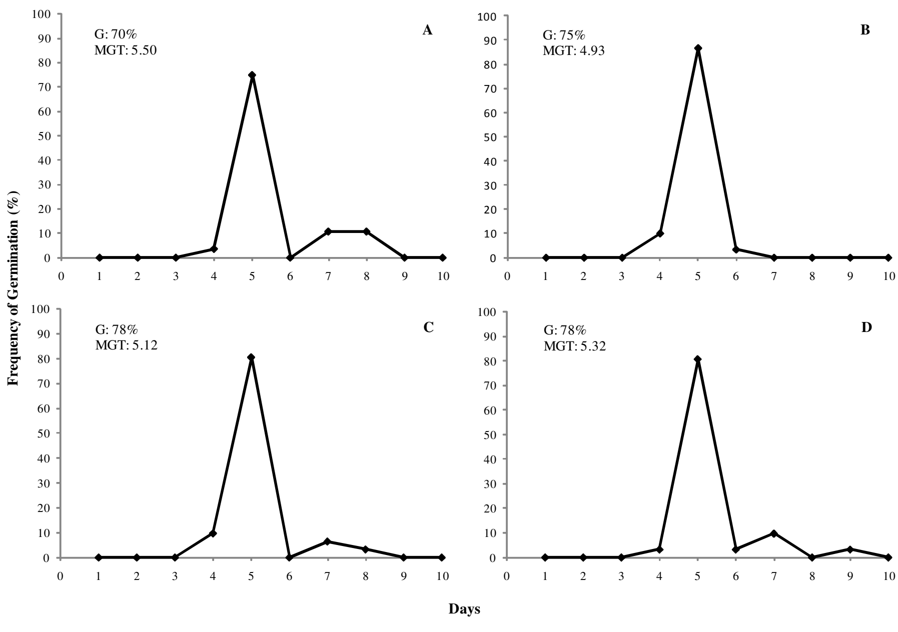

Figure 1. The relative frequency of soybean seeds germination, sown in soil amended with different concentrations of dry mass of crabgrass. A) 0 t ha^{-1}, B) 2.5 t ha^{-1}, C) 5.0 t ha^{-1}, D) 10 t ha^{-1}.

It was found that although there was no significant difference between the GMT of each treatment, the increase in the concentration of straw led to an increase on this time observed by a small displacement of the germination frequency curve of dry beans and turnip to the right (Figures 2 and 3), indicating a little delay in germination. Observing the values of dry beans synchrony of germination, one realizes that this tended to be higher in the absence of the mass of crabgrass.

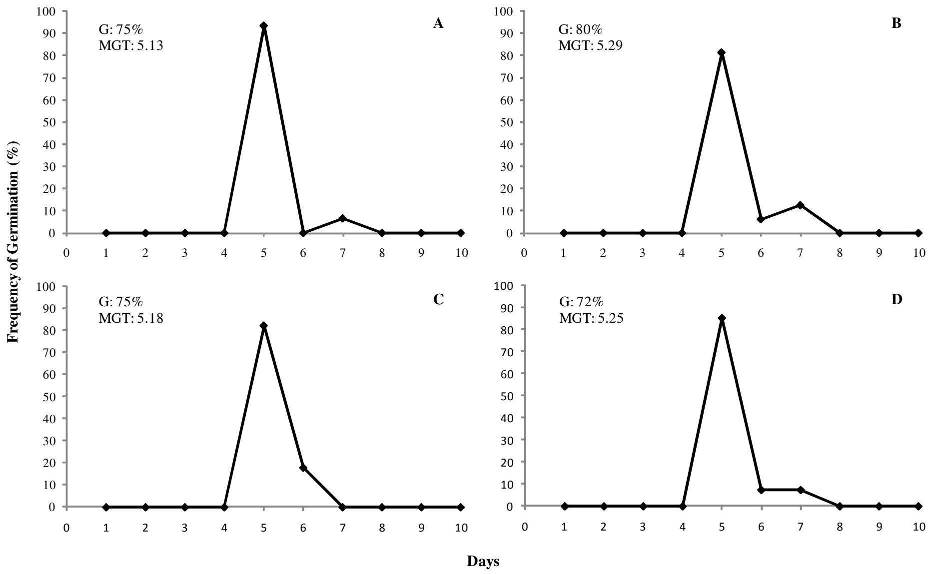

Figure 2. The relative frequency of dry bean seeds germination, sown in soil amended with different concentrations of dry mass of crabgrass. A) 0 t ha^{-1}, B) 2.5 t ha^{-1}, C) 5.0 t ha^{-1}, D) 10 t ha^{-1}.

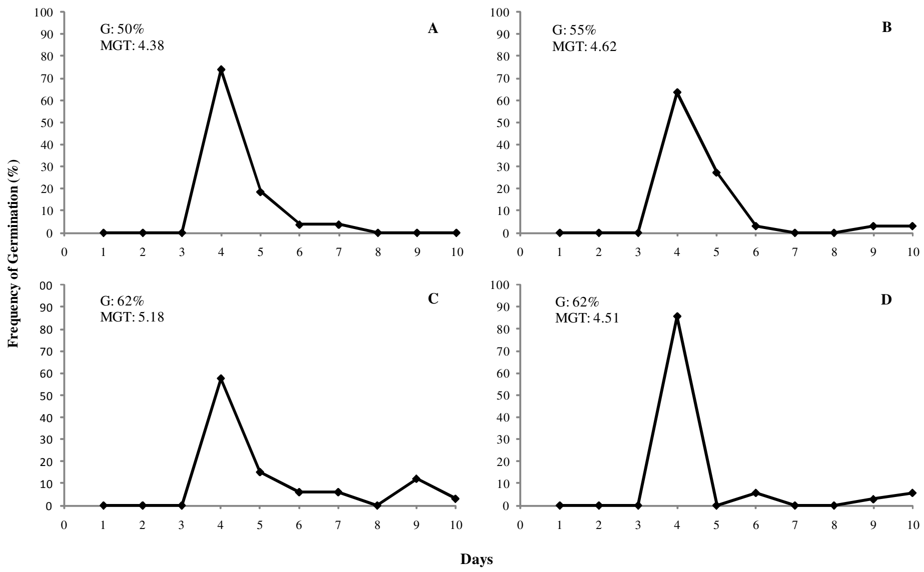

Figure 3. The relative frequency of turnip seeds germination, sown in soil amended with different concentrations of dry mass of crabgrass. A) 0 t ha^{-1}, B) 2.5 t ha^{-1}, C) 5.0 t ha^{-1}, D) 10 t ha^{-1}.

According to Ferreira and Aquila (2000), , germination tests in general are less sensitive than those assessing the seedlings development to determine allelopathic effects, such as mass or length of radicle or shoot. Other researchers such as Jacobi and Ferreira (1991) and Inderjit and Dakshina (1995) also agreed that the dry weights of root or shoot, as well as the length of seedlings or radicles, are the parameters most commonly used to evaluate the allelopathic effect on growth.

It was found a linear different proportions of reduction in seedling height of soybean, dry bean and turnip when the concentrations of *D.horizontalis* dry mass increased (Figure 4).

The results obtained from soybean, dry bean and turnip heights showed a potential inhibitor effect of crabgrass over these species, which provided decreases of 19.91%, 25.32% and 25.42%, respectively, in the height of plants at treatments with 10 t ha^{-1} straw. These results corroborate the data of Maciel et al. (2003), that found significant reduction in the soybean seedlings height grown with *Brachiaria* straw on the soil surface associated with surface irrigation. Souza et al. (2006) also found the same growth reduction of soybean and dry bean plants when promoted the soil incorporation of *Brachiaria decumbens* collected at dry or rainy seasons. The reduction of plant height with the use of 2.5 and 5.0 t ha^{-1} was lower, being respectively 6.83% and 10.98% in soybean, 6.43% and 12.7% in dry bean and 9.23% and 14.4% in turnip plants.

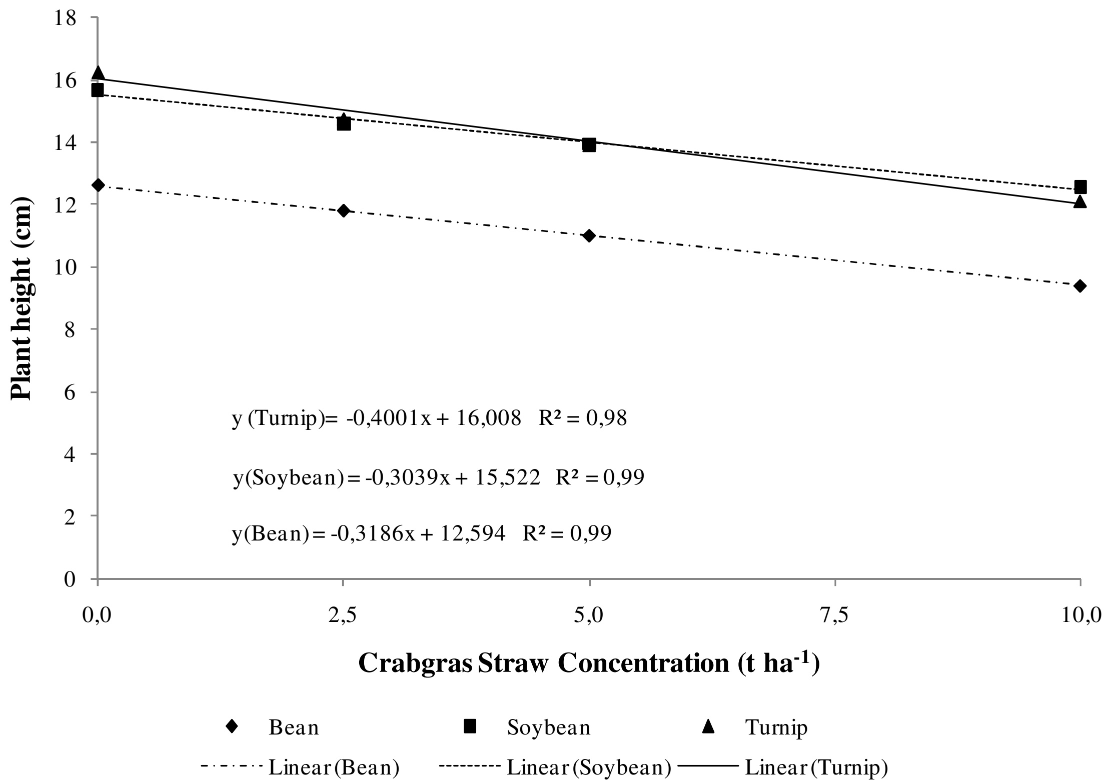

Figure 4. Height of soybean, dry bean and turnip plants grown in different concentrations of crabgrass dry mass.

All the three species showed a significant reduction of dry mass (Figure 5) according to the increasing of *D. horizontalis* dry mass concentration incorporated into the soil, with the greatest reduction in plant dry weight of turnip and less intense in the mass of soybean plants. Souza et al. (2006) found similar results using *Brachiaria decumbens* incorporated into the soybean soil cultivation.

The reduction of dry weight and height of plants were greater with the higher concentration of straw incorporated into soil for all species tested. Thus, the incorporation of 10 t ha^{-1} of *D. horizontalis* straw in the soil decreased the plant weight in 22.14% for soybeans, 20.17% for dry beans and 50.30% for turnip.

The reduction in dry matter accumulated by plants may be related to reduced leaf area and chlorophyll content. The leafs are responsible for the light interception and CO^2 capture and are the primary site of photosynthesis. Reductions in the leaf area and chlorophyll content can discourage growth, leading to a reduction in total dry matter (SOUZA et al., 2003).

Andrade et al. (2009) observed potential allelopathic effects of *Cyperus rotundus* L. on both germination and seedling growth of crop species, more pronounced in the initial growth than on germination stages. This may be related to absorption by roots, because this was the plant structure that suffered the effects of this weed species dried leaves aqueous extract in a more pronounced way.

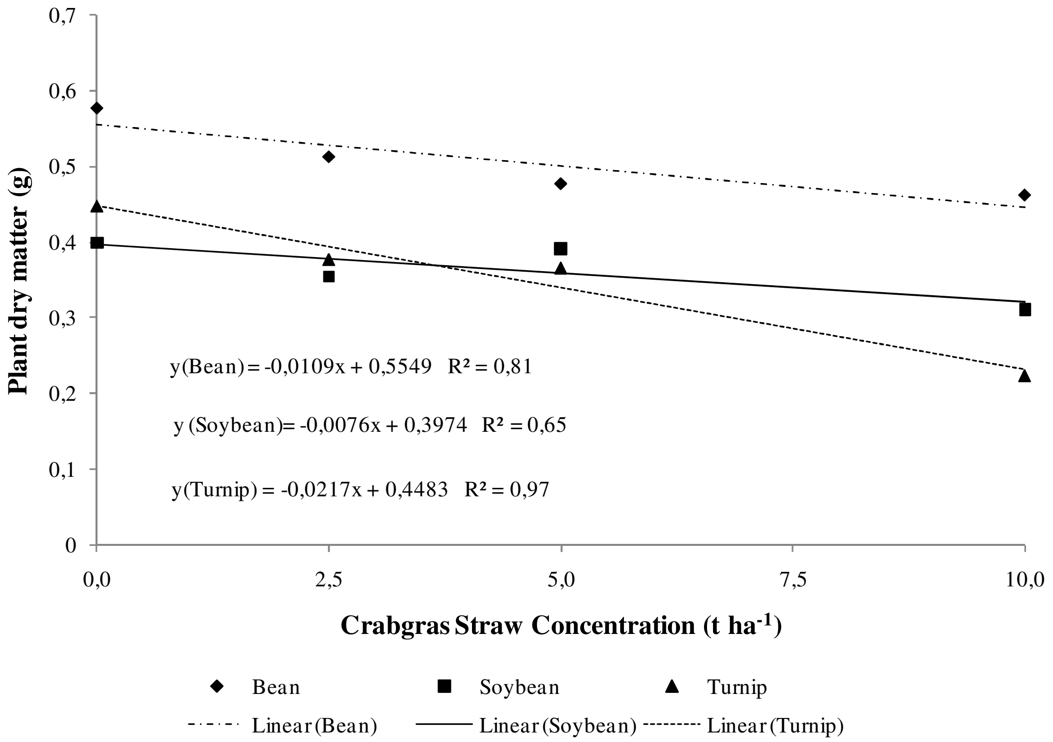

Figure 5. Dry matter of soybean, dry bean and turnip grown in different concentrations of crabgrass dry mass.

CONCLUSION

It was concluded that the incorporation of *Digitaria horizontalis* dry mass into the soil reduced the early growth of soybean, dry bean and turnip, but not consistent influence on the germination of these species was noted.

RESUMO: O trabalho objetivou avaliar os possíveis efeitos inibitórios de diferentes concentrações de massa seca de capim-colchão (*Digitaria horizontalis* Willd.) sobre a germinação e crescimento inicial de soja (*Glycine max* (L.) Merril.), feijão (*Phaseolus vulgaris* L.) e nabiça (*Raphanus raphanistrum* L.). O delineamento experimental adotado foi o inteiramente casualisado, com quatro repetições. Cada parcela foi composta por um vaso de 2,5 L de capacidade. A massa seca de capim-colchão foi incorporada ao solo nas quantidades equivalentes a 0, 2,5, 5,0 e 10 t ha^{-1} . A emergência das plântulas foi avaliada diariamente computando-se ao final de 10 dias a porcentagem de germinação, o índice de velocidade de germinação, o tempo médio de germinação, a freqüência relativa e o índice de sincronização da germinação. A altura e a massa seca das plantas foram avaliadas aos 35 dias após semeadura. A incorporação de *D. horizontalis* ao solo provocou redução significativa da altura e da massa seca de soja, feijão e nabiça, não influenciando de forma consistente a germinação dessas espécies.

PALAVRAS-CHAVE: *Glycine max* (L., Merril.). *Phaseolus vulgaris* L. *Raphanus raphanistrum*. Capim-colchão. Efeitos inibitórios. Planta daninha.

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