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Seeds germination and early development of beggartick on extracted soil solution from an area with cover crops

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Plants produce and store many products of secondary metabolism that are released into the environment and can influence direct or indirectly on nearby organisms. Thus, this study investigated the allelopathic potential of extracted soil solution from an area with cover crops according to germination and early development of beggartick. Soil solution was extracted in an area where black oats, turnip and hairy vetch were grown. The concentrated solution was tested in sand substrate while the dilutions were tested in 100; 200; 300 and 400 ml L^{-1} germitest paper substrate, plus the control treatment on beggartick. Germination was tested for 10 days and the early development for 20 days. Twenty seeds or seedlings were distributed in gerbox, with three replications and the experimental design was completely randomized (CRD). Soil solution showed considerable changes on beggartick germination only in the last collections, mainly with extracted solution in an area cropped with turnip and hairy vetch. The results, in this case, were more significant when germitest was used than with sand substrate. Therefore, it is recommended these cover crops in crop rotation, aiming to reduce beggartick infestation in a long term.

Key words: Allelopathy, Weeds, crop rotation, secondary metabolites.

INTRODUCTION

Secondary metabolites had been considered, wrong, without function, except in storing extra carbon that was fixed during photosynthesis process, but it is known that they play a fundamental role in the process of plants development and their interaction with the environment (Kutchan, 2001). Plants produce and store many products of secondary metabolism, which are released into environment. They may suffer direct or indirectly influence of a number of factors such as quality and light intensity, day length, mineral deficiency, age of plant organs, genetic, pathogens and predators, among others. These factors can influence both allelochemical production in donor species and their susceptibility to the same receptor species (Pedrol et al., 2006).

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On soil, these substances can interact strongly with colloids and also suffer microbial transformations, responsible for their disappearance or deactivation. Microorganisms have the ability to convert, synthesize, eliminate or use secondary metabolites as carbon and energy sources. The allelochemicals can be immobilized on solid phase, can establish equilibrium with soil solution and can undergo degradation or even leaching, mainly on sandy soils (Moreira and Siqueira, 2006; Colozzi Filho; Andrade, 2006).

A lot of work done has been allelopathic effects on weeds in recent years (Isik et al., 2009; Souza et al., 2010; Mauli et al., 2011; Rosa et al., 2011), however, many things still need to be studied and what new information will be added to science via this research. Knowledge of occurrence and activity of microorganisms and natural compounds in soil processes underlies the design of crop rotation and residue management, in order that they get more efficient and conservationist (Pedrol et al., 2006). Allelopathic effects and action mechanisms of many substances are also important to understand plants interactions in both natural and agricultural systems (Ferreira and Aquila, 2000).

In this context, this study aimed to evaluate the allelopathic potential of extracted soil solution in an area with black oats (*Avena strigosa* Schreb.), turnip (*Vicia villosa* Roth) and hairy vetch (*Raphanus sativus* L.) as cover crops on seed germination and early development of beggartick (*Bidens pilos*a), weed affecting commercial crops.

MATERIALS AND METHODS

The trials with soil solution were carried out at Seeds and Plants Evaluation Laboratory, at Western Paraná State University, *Campus* of Cascavel-PR, Brazil. The solutions were collected with soil solution extractors and it was used a 20 cm pipe with a ceramic tip of 1 Bar to be applied on soils of intermediate and high hardness, model EX-20-TR, brand Tracom®, according to Filizola (2006). The extractors were set in the cropped area with black oats, turnip and hairy vetch, 20 cm depth, in Catanduvas-PR countryside.

The study was carried out under field conditions in farm, whose geographical location is 25° 18' 16" S latitude, 53° 11' 34.1" W longitude and 465 m altitude. The climate is subtropical, mesothermal and super-humid, with 1,800 mm average annual rainfall, hot summers, with rainfall concentrations without defined dry season and little frequent frosts. The annual average temperature is around 20°C and average relative humidity is 75% (IAPAR, 1998). The local soil is classified as dystrophic Oxisol Udic (USA, 1998) or red distroferric latosol with a soft relief and clayey soil, according to EMBRAPA (2006). Soil solution samples were obtained in 15, 30; 45 and 60 days after the management of the three evaluated cover crops.

The soil solutions were collected and tested on germination and early plant development of beggartick weed. Concentrated solutions were directly tested on seed germination, in gerbox, with approximately 1 cm of sand. It was moistened with distilled water and subsequently added 3 ml of pure soil solution plus the control treatment with only distilled water. Dilutions were also obtained with water as solvent from the pure solution to 100, 200, 300 and 400 ml L^{-1} and the control treatment, which were applied in germitest substrate about 20 beggartick seeds.

Germination evaluation was daily obtained during 10 days in growth chamber for 12 h of light and 25°C, while germinated seeds were removed. The seeds with 2.00 mm root extension were considered as germinated. The germination speed index (GSI) was calculated according to Maguire (1962) and germination speed (GS) was obtained according to Edmond and Drapalla (1958).Ten pre-germinated seedlings, with three days, were used to obtain the early development of plants. They were taken to growth chamber for 24 h light photoperiod at 25°C. After 20 days, the plants were separated into roots and shoots and the fresh mass (g per plant) was determined on a 0.001 g precision scale. They were dried at 65°C until constant mass so, dry mass was determined. The experiment was a completely randomized design (CRD) with three replications per treatment. The results of seed germination were presented as percentage of inhibition in relation to the control. Qualitative data were submitted to analysis of variance and to regression analysis at 5% probability to identify the significant model of the highest degree of regression with some adjustments to the studied data. Quantitative data were submitted to averages comparison by Tukey test at 5% probability.

Data variability evaluation was initially performed to verify data normality and homogeneity of variances and if necessary their transformation; these analyses were performed according to Pimentel Gomes (2000) and Banzattto and Kronka (2000) with Minitab® 14 and SISVAR software (Ferreira, 2008). Data in percentage were transformed by arcsen$\sqrt{(x / 100)}$ and those who were not normally distributed underwent transformation $\sqrt{x}$. A trend line and a regression equation were added for significant data according to the model. On the other hand, the average plotted values were presented for non-significant data.

RESULTS AND DISCUSSION

The SGI of beggartick seeds under soil solution, in an area cropped with turnip, collected 15 days after cover crop management, showed significant difference, with a decrease on germinated seeds number per day as soil solution concentration increased. Germination inhibition percentage and SG showed no changes when submitted to black oats, turnip and hairy vetch (Figure 1). The allelopathic effect sometimes does not occur on germination percentage, but on other parameters of this process such as germination speed (Ferreira and Borghetti, 2004), and this answer was observed in this trial.

The soil solution collected 30 days after cover crops management did not influence on germination percentage with black oats, turnip and hairy vetch. There was a decrease on GSI of beggartick seeds when concentration of soil solution (extracted from areas cropped with the three studied species) was increased (Figure 2). The germination speed of beggartick seeds was influenced by soil solution with hairy vetch. Thus, the number of days for seeds germination was increased as soil solution concentration increased.

Allelopathy is a mechanism by which certain plants interfere on the others development. It can become crop management by the plants use that control some undesired species, consequently, more efficient production systems are obtained (Goldfarb et al., 2009).

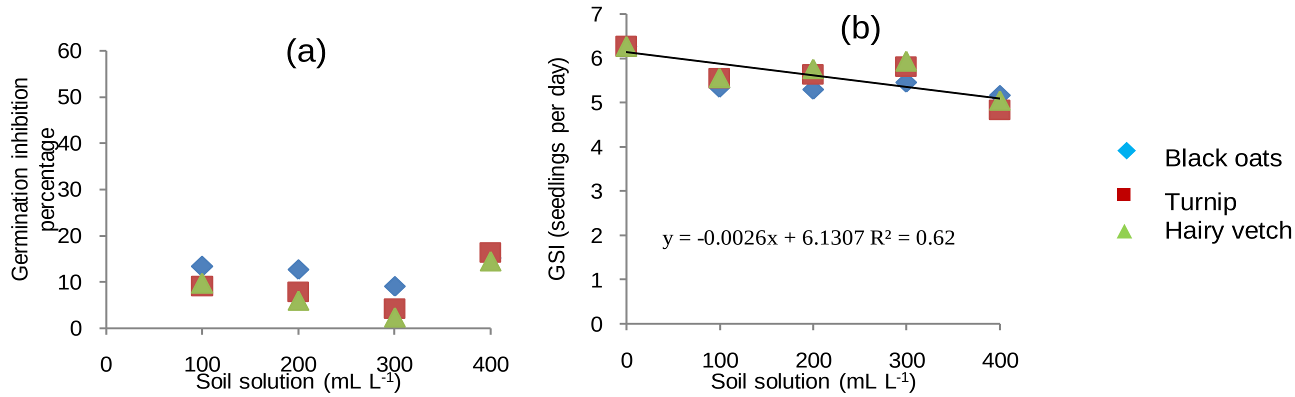

Figure 1. (a) Germination inhibition percentage and (b) germination speed index (GSI), of beggartick seeds moistened with soil solution in 0, 100, 200, 300 and 400 mL L^{-1} ratios, collected 15 days after management of black oats, turnip and hairy vetch as cover crops.

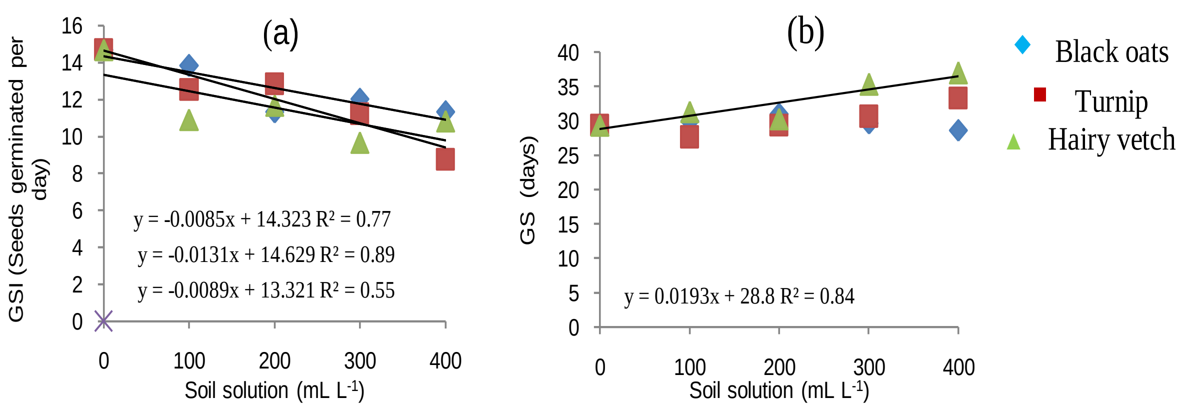

Figure 2. (a) Germination speed index (GSI) and (b) germination speed (GS) of beggartick seeds moistened with soil solution in 0, 100, 200, 300 and 400 ml L^{-1} ratios, collected 30 days after management of black oats, turnip and hairy vetch as cover crops.

There was no significant difference in the following parameters: germination inhibition percentage, germination speed index and germination speed when soil solution extracted from cropped area with the three studied cover crops was applied. This occured in the third collection 45 days after the management.

Martins et al. (2006) have already studied the soil solution in an area cropped with *Brachiaria brizantha* cv. Marandu for five years. The authors found out that there was no influence of soil solution on germination speed index and normal seedlings percentage of *Sida rhombifolia*. This trial is in accordance with these results with beggartick weed. One of the possible causes of non-fact is that plant substances, when in soil, interact strongly with colloids and may also suffer microbial transformations responsible for disabling or even degradation (Moreira and Siqueira, 2006).

The speed germination index of seeds submitted to the last collection of soil solution (Figure 3), 60 days after the management of cover crops, showed significant difference under extracted soil solution from a black oat cropped area. There was some decrease up to 200 ml L^{-1} concentrations and there was an increase in the number of germinated seeds per day when this value increased. Martins et al. (2006) studied the soil solution from an area with *B. brizantha* cv. Marandu (Poaceae), cropped along five years and found out that, when compared to distilled water, the soil solution decreased the germination speed index of *Panicum maximum* cv. Tanzania, as it happened in this experiment with black oats (Poaceae) (Figure 3).

The germination speed also showed statistically significant differences in soil solution extracted in an area cropped with black oats. Thus, it reduced the number of days the seeds took to germinate, as concentration increased. It was observed that the shoot dry mass of beggartick plants that were moistened with soil solution, extracted from an area cropped with turnip and collected 15 days after management of cover crops, showed

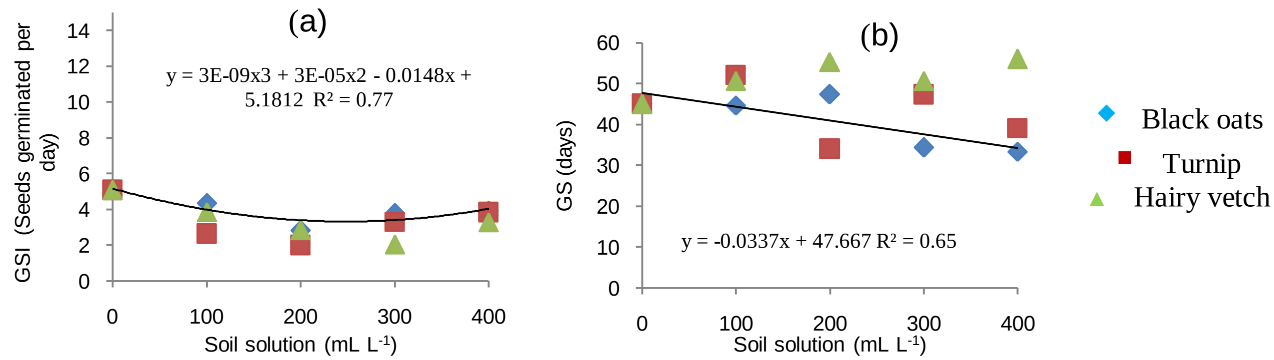

Figure 3. (a) Germination speed index (GSI) and (b) germination speed (GS) of beggartick seeds moistened with soil solution in 0, 100, 200, 300 and 400 ml L^{-1} ratios, collected 60 days after management of black oats, turnip and hairy vetch as cover crops.

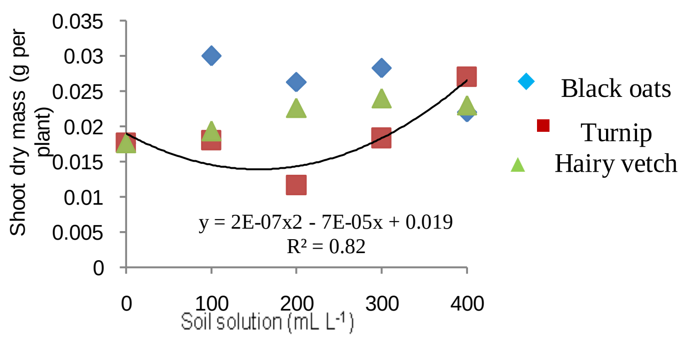

Figure 4. Shoot dry mass (g per plant) of beggartick, moistened with 0, 100, 200, 300 and 400 ml L^{-1} soil solution, collected 15 days after management of black oats, turnip and hairy vetch as cover crops.

decreases in 100 and 200 ml L^{-1} concentrations and increased in the other concentrations (Figure 4). Parameters such as shoot and root fresh mass and root dry mass did not show significant statistical changes.

The allelochemical substances can have no effect at low concentrations, positive effects as the concentration increases, which can reach from adverse to lethal effects to the plants. Therefore, the intrinsic power and some bioavailability of these substances in soil should be considered (Moreira and Siqueira, 2006). Thus, based on these characteristics, it can be defended the obtained results in this trial.

The shoot dry mass of beggartick plants under soil solution collected from an area cropped with hairy vetch, 30 days after their management, showed a linear decrease as the solution concentration increased (Figure 5). There was no significant effect on the following parameters: shoot and root fresh mass and root dry mass.

Parameters as shoot and root fresh mass and root dry mass of beggartick plants showed no significant effect when grew on soil solution collected 45 days after management of the three studied cover crops (Figure 6). Only the shoot dry mass under soil solution extracted from an area cropped with hairy vetch showed a linear decrease as solution concentration increased. The shoot fresh mass of beggartick plants under soil solution extracted from an area cropped with turnip, 60 days after the cover crop management, increased as soil solution concentration increased (Figure 7). The root fresh mass of beggartick plants also had a significant increase up to 200 ml L^{-1} solution, from an area cropped with turnip plants with subsequent decrease. While the shoot dry mass of beggartick plants showed a decrease on its mass up to 200 ml L^{-1} with the subsequent increase. Just the opposite of the following answers, whose root dry mass under soil solution of turnip and hairy vetch had an initial decrease (100 ml L^{-1}) with a subsequent increase for turnip, but a linear increase as soil solution concentration increased for hairy vetch.

However, the nutritional effect provided by the soil solution should be considered as there are some ions like: Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, Fe^{+2}, Cl^{-}, NO_3^{-}, SO_4^{-2}, and $Si(OH)_4$. It is known that the root plants absorb ions by mass flow or diffusion, whether it is in soil solution (Meurer, 2010). This would explain the highest values found for the initial development of beggartick plants and in some cases in the presence of soil solution. The values of germination percentage, germination speed index and germination speed of beggartick seeds under soil solution extracted 15 days after cover crop management for tests using sand as substrate are shown on Table 1. Soil solution collected at 15 days and extracted from an area cropped with the three studied plants was applied with a pure solution on beggartick seeds on sand substrate and did not influence on the analyzed parameters. The allelochemicals interact in the environment, as well as herbicides, and are submitted to degradation processes such as microbial degradation, photolysis, oxidation and removal or transfer processes,

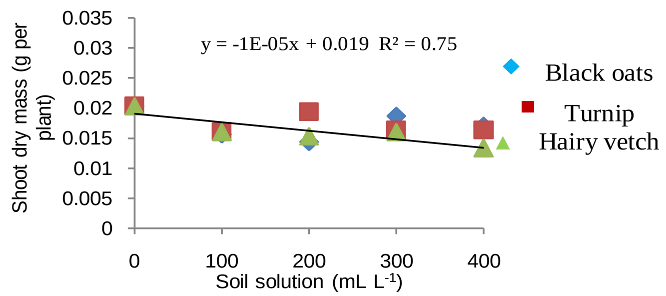

Figure 5. Shoot dry mass (g per plant) of beggartick, moistened with 0, 100, 200, 300 and 400 ml L^{-1} soil solution, collected 30 days after management of black oats, turnip and hairy vetch as cover crops.

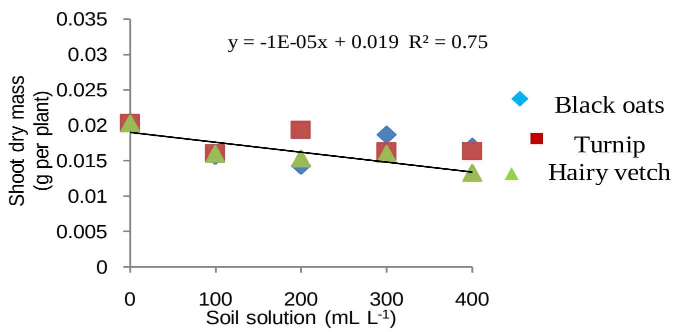

Figure 6. Shoot dry mass (g per plant) of beggartick, moistened with 0, 100, 200, 300 and 400 ml L^{-1} soil solution, collected 45 days after management of black oats, turnip and hairy vetch as cover crops.

as volatilization and adsorption (Vidal; Bauman, 1997). This fact can justify some possible causes of non-effects that were observed in soil solution collection during this experiment.

Analyzing germination parameters on beggartick seeds, submitted to soil solution and collected 30 and 45 days after cover crops management (second and third collection), there was no significant change (Tables 2 and 3).

Soil solution, in the last sample, 60 days after cover crops management, caused no change in germination percentage of beggartick seeds (Table 4). However, it was observed that seeds in soil solution extracted from an area with hairy vetch modified in other germination processes: as germination speed index and germination speed. Speed germination has been changed under soil solution extracted from the area with black oats. These answers are in accordance with Borghetti and Ferreira (2004), who stated that the allelopathic effect can occur on other parameters of this process, such as germination speed. This may be due to hairy vetch has shown faster decomposition when compared to the others. It has also provided allelopathic substances more quickly in soil solution.

According to Crusciol et al. (2008), 53 days after black oats management, there was still a remain of 33.6% of initial dry matter in soil, in order to highlight the low residue of grass decomposition. Perhaps, the collection period for this experiment was short to evaluate the availability of these substances, since the most important changes were recorded in the indicating parameters 60 days after cover crops management, which was also observed in Figure 8. Values of shoot and root for fresh and dry mass of beggartick plants are shown on Table 5. They were submitted to soil solution extracted from the area cropped with black oats, turnip and hairy vetch at 15 days (first collection). There was a significant difference only for beggartick shoot fresh mass submitted to soil solution extracted from the area with turnip. When beggartick plants received soil solution, their mass was higher when compared to the control, so, the other parameters did not show any significant change.

Martins et al. (2006) found out that the soil solution collected in grazing area with *B. brizantha* cv. Marandu (Poaceae), cropped for more than five years, increased shoot and root length of *Sida rhombifolia* weed. This result was different from the one obtained in this experiment. Soil solution collected 30 days after cover crops management, applied on a substrate where beggartick plants were cropped, caused no significant change (Table 6).

The shoot fresh mass of beggartick plants submitted to soil solution extracted at 45 days in an area cropped with black oats was significant (Table 7). The plants mass increased due to soil solution presence when compared to the control. There was no significant result for soil solution treatments extracted from turnip and hairy vetch crops neither on the other studied parameters. It was found that root fresh mass increased significantly under extracted soil solution in a cropped area with hairy vetch when compared to the control (Table 8). On the other hand, the other studied parameters showed no significant changes 60 days after the cover crops management.

One of the main analyzed variables in allelopathic tests is germination; however, this is less sensitive to allelochemicals than seedling development (Souza Filho et al., 2010). Therefore, this did not happened in these tests, in which extracted soil solutions in area with turnip and hairy vetch changed seeds germination patterns of beggartick and did not affect its initial development. When sand was used as substrate, under concentrated soil solution, the effects were lower than when germitest paper was used.

In soils, allelochemicals may have limited activity in space and time. The space limitations occur because, even though all allelochemicals could be present in plant residues and released at once, microbial degradation and adsorption were interrupted, the natural chemicals performance would be spatially limited concerning the seeds closed to the donor plant or residues under decomposition. The time limitation happens because allelochemicals are not released at once from residues

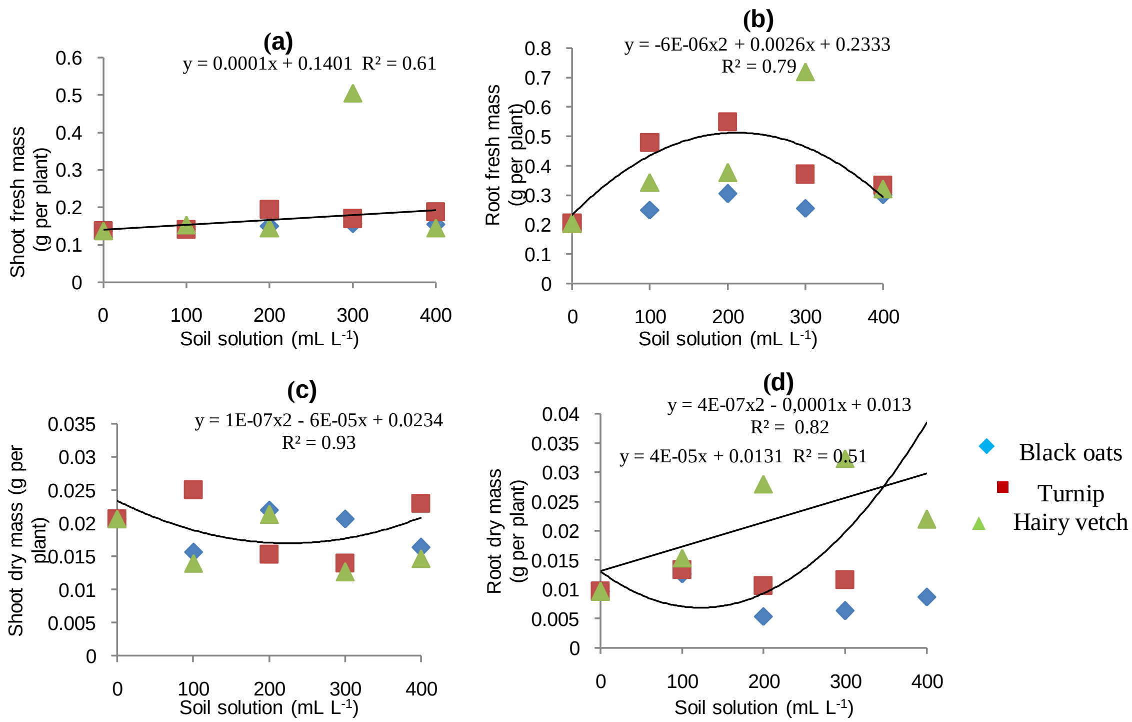

Figure 7. (a) Shoot fresh mass (b) root fresh mass (c) shoot dry mass and (d) root dry mass (g per plant) of beggartick, moistened with 0, 100, 200, 300 and 400 ml L^{-1} soil solution, collected 60 days after management of black oats, turnip and hairy vetch as cover crops.

Table 1. Germination percentage, germination speed index and germination speed of beggartick seeds in moistened sand substrate with soil solution collected 15 days after management of black oats, turnip and hairy vetch as cover crops.

	Black oats	Turnip	Hairy vetch
	% germination		
Control	90.66	90.66	90.66
Soil solution	80.66	90.33	90.20
Average	85.66	90.49	90.43
CV	19.30	7.72	7.70
F value	0.59^{ns}	0.06^{ns}	0.05^{ns}
	Germination speed index (seeds per day)		
Control	3.73	3.84	3.86
Soil solution	2.82	3.73	3.71
Average	3.28	3.78	10.68
CV	18.10	10.84	10.68
F value	0.89^{ns}	0.11^{ns}	0.13^{ns}
	Germination speed (days)		
Control	31.33	31.30	31.33
Soil solution	26.00	27.66	27.00
Average	28.66	29.50	22.53
CV	17.79	17.99	11.19
F value	0.45^{ns}	0.72^{ns}	0.65^{ns}

Averages followed by lettes, in collun, differ among themselves by Tukey test at 5% probability. ns = none significant; * = significant, CV = coefficient variation.

Table 2. Germination percentage, germination speed index and germination speed of beggartick seeds in moistened sand substrate with soil solution collected 30 days after management of black oats, turnip and hairy vetch as cover crops.

% germination			
	Black oats	**Turnip**	**Hairy vetch**
Control	100.00	100.00	100.00
Soil solution	90.00	90.67	90.66
Averages	95.00	95.33	95.34
CV	14.22	7.48	7.20
F value	2.46^{ns}	2.30^{ns}	0.42^{ns}
Germination speed index (seeds per day)			
Control	7.41	7.41	7.47
Soil solution	5.36	7.22	7.41
Average	6.38	7.31	7.44
CV	21.25	14.11	19.14
F value	0.85^{ns}	0.05^{ns}	0.002^{ns}
Germination speed (days)			
Control	26.66	26.66	28.66
Soil solution	23.33	25.66	26.66
Average	24.99	26.16	27.66
CV	15.78	14.04	11.71
F value	6.12^{ns}	0.11^{ns}	0.57^{ns}

Averages followed by lettes, in collun, differ among thenselves by Tukey test at 5% probability. ns = none significant; * = significant, CV = coefficient variation.

Table 3. Germination percentage, germination speed index and germination speed of beggartick seeds in moistened sand substrate with soil solution collected 45 days after management of black oats, turnip and hairy vetch as cover crops.

% germination			
	Black oats	**Turnip**	**Hairy vetch**
Control	100.00	100.00	100.00
Soil solution	90.00	91.66	91.33
Average	95.00	95.83	95.66
CV	7.72	5.44	6.60
F value	4.00^{ns}	1.00^{ns}	0.07^{ns}
Germination speed index (seeds per day)			
Control	5.39	6.77	5.39
Soil solution	4.52	5.38	5.11
Average	4.95	6.08	5.25
CV	14.58	14.39	9.19
F value	2.13^{ns}	3.74^{ns}	0.50^{ns}
Germination speed (Days)			
Control	34.66	34.66	34.66
Soil solution	26.33	31.00	33.33
Average	30.50	32.83	34.00
CV	17.06	10.77	18.10
F value	1.08^{ns}	0.45^{ns}	0.02^{ns}

Averages followed by lettes, in collun, differ among thenselves by Tukey test at 5% probability. ns = none significant; * = significant, CV = coefficient variation.

Table 4. Germination percentage, germination speed index and germination speed of beggartick seeds in moistened sand substrate with soil solution collected 60 days after management of black oats, turnip and hairy vetch as cover crops.

% germination			
	Black oats	**Turnip**	**Hairy vetch**
Control	100.00	100.00	100.00
Soil solution	90.00	90.66	90.33
Average	95.00	95.33	95.16
CV	25.67	12.46	2.09
F value	1.47^{ns}	3.94^{ns}	64.00^{ns}
Germination speed index (seeds per day			
Control	5.83	5.83	5.83 ^{a}
Soil solution	4.17	4.84	3.83 ^{b}
Average	5.00	5.33	4.83
CV	15.28	12.32	7.40
Valor F	1.61^{ns}	16.70^{ns}	47.25*
Germination speed (Days)			
Control	69.66 ^{a}	69.66	69.66 ^{a}
Soil solution	38.00 ^{b}	41.33	38.66 ^{b}
Average	53.83	55.50	54.16
CV	27.42	20.78	5.02
F value	1.53*	2.05^{ns}	47.26*

Averages followed by lettes, in collun, differ among thenselves by Tukey test at 5% probability. ns = none significant; * = significant, CV = coefficient variation.

Table 5. Shoot and root for fresh and dry mass of beggartick plants (g per plant) in sand, moistened with soil solution collected 15 days after black oats, turnip and hairy vetch as cover crops management.

Shoot fresh mass (g per plant)			
	Black oats	**Turnip**	**Hairy vetch**
Control	0.11	0.11 ^{b}	0.12
Soil solution	0.16	0.18 ^{a}	0.10
Average	0.14	0.15	0.12
CV	29.16	9.98	5.93
F value	1.96^{ns}	18.75*	0.03^{ns}
Root fresh mass (g per plant)			
Control	0.13	0.13	0.12
Soil solution	0.06	0.07	0.09
Average	0.09	0.10	0.09
CV	7.61	8.14	5.71
F value	1.03^{ns}	0.61^{ns}	1.78^{ns}
Shoot dry mass (g per plant)			
Control	0.01	0.02	0.02
Soil solution	0.02	0.03	0.02
Average	0.02	0.03	0.02
CV	1.03	0.79	0.40
F value	0.14^{ns}	1.00^{ns}	1.00^{ns}

Table 5. Contd.

Root dry mass (g per plant)			
Control	0.02	0.03	0.02
Soil solution	0.04	0.05	0.04
Average	0.03	0.04	0.03
CV	2.65	4.08	2.50
F value	0.33^{ns}	0.074^{ns}	1.48^{ns}

Averages followed by lettes, in collun, differ among thenselves by Tukey test at 5% probability. ns = none significant; * = significant, CV = coefficient variation.

Table 6. Shoot and root for fresh and dry mass of beggartick plants (g per plant) in sand, moistened with soil solution collected 30 days after black oats, turnip and hairy vetch as cover crops management.

Shoot fresh mass (g per plant)			
	Black oats	**Turnip**	**Hairy vetch**
Control	0.11	0.12	0.12
Soil solution	0.14	0.14	0.09
Average	0.13	0.12	0.10
CV	25.58	28.27	35.08
F value	0.57^{ns}	0.62^{ns}	0.43^{ns}
Root fresh mass (g per plant)			
Control	0.14	0.13	0.14
Soil solution	0.07	0.08	0.09
Average	0.10	0.11	0.11
CV	8.43	8.16	5.84
F value	0.63^{ns}	0.48^{ns}	3.16^{ns}
Shoot dry mass (g per plant)			
Control	0.03	0.02	0.02
Soil solution	0.02	0.05	0.02
Average	0.02	0.03	0.02
CV	1.04	1.75	0.39
F value	0.14^{ns}	3.85^{ns}	4.00^{ns}
Root dry mass (g per plant)			
Control	0.04	0.03	0.04
Soil solution	0.02	0.04	0.01
Average	0.03	0.04	0.03
CV	2.65	4.08	2.50
F value	0.33^{ns}	0.77^{ns}	1.48^{ns}

under decomposition, and also because the process degradation and removal may reduce the available concentration in soil solution (Vidal and Bauman, 1997) and this may have occurred in these experiments.

Uchinho et al. (2012) studied the effect of cover crops on weeds in soybeans and concluded that, hairy vetch and rye can suppress effectively these plants without yield decrease of major crops in organic farming systems.

Conclusion

According to the observed changes, the possible allelophatic effects were more evident in the last collection of soil solution 60 days after the cover crops management. This evidence was greater on germination when compared to the early development of the studied plants. There is an indication of longer periods under

Table 7. Shoot and root for fresh and dry mass of beggartick plants (g per plant) in sand, moistened with soil solution collected 45 days after black oats, turnip and hairy vetch as cover crops management.

Shoot fresh mass (g per plant)			
	Black oats	**Turnip**	**Hairy vetch**
Control	0.11 [b]	0.12	0.12
Soil solution	0.17 [a]	0.10	0.09
Average	0.14	0.11	0.10
CV	4.99	2.97	3.25
F value	75.00*	0.20^{ns}	0.38^{ns}
Root fresh mass (g per plant)			
Control	0.14	0.13	0.14
Soil solution	0.07	0.09	0.10
Average	0.10	0.11	0.12
CV	4.81	5.52	4.79
F value	1.66^{ns}	3.98^{ns}	0.66^{ns}
Shoot dry mass (g per planta)			
Control	0.03	0.02	0.02
Soil solution	0.02	0.04	0.03
Average	0.02	0.03	0.02
CV	0.39	0.66	0.79
F value	4.00^{ns}	12.00^{ns}	0.25^{ns}
Root dry mass (g per plant)			
Control	0.04	0.04	0.04
Soil solution	0.02	0.02	0.03
Average	0.03	0.03	0.04
CV	2.65	2.11	1.00
F value	0.32^{ns}	1.58^{ns}	0.57^{ns}

Averages followed by lettes, in collun, differ among thenselves by Tukey test at 5% probability. ns = none significant; * = significant, CV = coefficient variation.

Table 8. Shoot and root for fresh and dry mass of beggartick plants (g per plant) in sand, moistened with soil solution collected 60 days after black oats, turnip and hairy vetch as cover crops management.

Shoot fresh mass (g per plant)			
	Black oats	**Turnip**	**Hairy vetch**
Control	0.12	0.12	0.13
Soil solution	0.18	0.11	0.12
Average	0.15	0.11	0.12
CV	4.48	2.87	4.65
F value	1.81^{ns}	0.01^{ns}	0.02^{ns}
Root fresh mass (g per plant)			
Control	0.15	0.14	0.15 [b]
Soil solution	0.36	0.28	0.52 [a]
Average	0.25	0.22	0.33
CV	10.77	12.48	6.08
F value	9.57^{ns}	0.73^{ns}	17.56*

Table 8. Contd.

	Shoot dry mass (g per plant)		
Control	0.02	0.02	0.02
Soil solution	0.04	0.03	0.03
Average	0.03	0.02	0.02
CV	1.02	1.17	0.39
F value	9.14^{ns}	1.00^{ns}	16.00^{ns}
	Root dry mass (g per plant)		
Control	0.04	0.04	0.04
Soil solution	0.10	0.03	0.08
Average	0.07	0.03	0.06
CV	2.27	3.62	5.49
F value	8.30^{ns}	0.17^{ns}	0.61^{ns}

Averages followed by lettes, in collun, differ among thenselves by Tukey test at 5% probability. ns = none significant; * = significant, CV = coefficient variation.

observation to evaluate green decomposition to release allelochemicals.

Conflict of Interest

The authors have not declared any conflict of interest.

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