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Agricultural waste management of winter cover crops on weeds and soybean, under controlled conditions, in a greenhouse

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Mauli, Márcia Maria; Lúcia Helena Pereira Nóbrega; Antonio Pedro da Silva Souza Filho; Danielle Medina Rosa; Adriana Maria Meneghetti; Gislaine Piccolo de Lima (2018) Agricultural waste management of winter cover crops on weeds and soybean, under controlled conditions, in a greenhouse. Rev. Fac. Agron. Vol 117 (2): 185-195.

In order to meet the great need to increase agricultural yield associated with the research of healthy products, which do not cause problems for the environment, this study aims to investigate the influence of mass quantity on black oats, radish and hairy deer in the emergence and development of *B. pilosa*, *S. rhombifolia* and *G. max*. It was carried out in the greenhouse with 10, 20, 30, 40 or 50 g of the studied weights. The weed and soybean seeds were sown and evaluated for 10 days to record their emergence. For the initial development of plants, five seedlings were transplanted, which evaluation occurred after 30 days. In general, increasing the amount of weight also increased the percentage inhibition of the weeds studied, but did not negatively influence the soybean. ESI (Emergence Speed Index) and ES (emergence speed) were negatively affected by the increase in weight, with the exception of soy ES. Weed mass was negatively influenced by cover crops, but did not cause problems for soybeans. Thus, the greatest amount of mass in relation to the winter cover crops studied was lower, being the infestation of these weeds without significant problems for the soybean. Finally, species may be recommended for further field studies as cover crops in large areas in the no-tillage system.

Keywords: *Bidens pilosa*; crop rotation; green manure; *Glycine max; Sida rhombifolia*.

Mauli, Márcia Maria; Lúcia Helena Pereira Nóbrega; Antonio Pedro da Silva Souza Filho; Danielle Medina Rosa; Adriana Maria Meneghetti; Gislaine Piccolo de Lima (2018) Manejo de resíduo vegetal de plantas de cobertura de inverno sobre plantas invasoras e soja, sob condições controladas, em casa de vegetação. Rev. Fac. Agron. Vol 117 (2): 185-195.

Visando suprir a crescente necessidade de incremento na produção agrícola, associada à busca por produtos saudáveis e que não agridam ao ambiente, este trabalho teve por objetivo verificar a influência da quantidade de massa de aveia preta, nabo forrageiro e ervilhaca peluda sobre emergência, índice de velocidade de emergência (IVE), velocidade de emergência (VE), massa fresca e seca de parte aérea e raiz de picão preto, guanxuma e soja. O experimento foi desenvolvido em casa de vegetação, em vasos contendo aproximadamente 1 kg de solo, sobre os quais foram depositadas 10, 20, 30, 40 ou 50 g (equivalentes a 17; 33; 50; 66 e 83 kg ha^{-1}) das massas estudadas. Para avaliação da emergência, as sementes das espécies invasoras e soja foram semeadas e avaliadas durante 10 dias, com contagem diária. Para desenvolvimento inicial de planta, foram transplantadas cinco plântulas para cada vaso, com avaliação após 30 dias. De modo geral, o aumento na quantidade de massa aumentou a porcentagem de inibição de guanxuma e picão preto, mas não influenciou negativamente a soja. O IVE e VE das espécies foram afetados negativamente com o aumento da quantidade das massas, exceto para VE de soja. As massas das invasoras foi influenciada negativamente pelas plantas de cobertura, sem entretanto, prejudicar a soja. Assim, quanto maior a quantidade de massa das espécies de cobertura de inverno utilizadas, menor será a infestação dessas invasoras, sem prejuízos significativos à soja. Por fim, as espécies podem ser recomendadas para maiores estudos em campo como culturas de cobertura em grandes áreas no sistema de plantio direto.

Palavras-chave: *Bidens pilosa*; rotação de culturas; adubação verde; *Glycine Max*; *Sida rhombifolia*.

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INTRODUCTION

The use of plants with allelopathic properties is a proven promising alternative in agriculture since they can control weeds invasion in commercial crops. It is known that cover crops management reduces significantly the intensity of weeds infestation and also changes the local weed population (Tokura & Nóbrega, 2006; Trezzi et al., 2006; Souza Filho, 2006; Mauli et al., 2013). The introduction of cover crops in crop rotation preserves the quality of the environment, without prescinding from the high productivity of commercial crops and their economic return. The species which produce a great amount of straw and root favor the direct seeding system and nutrient recycling, besides increasing the soil protection against climate agents and promoting improvements in its physical, chemical and biological features (EMBRAPA, 2013).

When in field, cover crops have already shown some influence on the studied weeds, although there is no great interference in soybeans, under tropical conditions (Mauli et al, 2011; Uchino et al., 2012; Theisen et. al, 2000; Severino & Christoffoleti, 2001). Thus, they can be an option to the integrated management of species in no-tillage system. The use of herbicides can be reduced or even eliminated with the correct cover crops concerning their physical, chemical and biological soil properties (Mauli et al, 2011; Silva, 2012). But, despite being a promising alternative to control weeds, there has been little researched about this subject (Souza Filho, 2006; Monquero et al., 2009).

Concurrently with the requirement to increase agricultural sustainability, there is some need to reduce the use of chemical control in the integrated control of weeds, either because of high costs due to the gains on the main crop performance as well as the concern about possible impacts of compounds used in herbicides composition on natural resources and organisms that are directly or indirectly exposed to such chemical management (Doyle, 1997, Weih et al., 2008, Rains et al., 2011).

It is essential using soil cover crops to crop rotation for an efficient use of non-tillage system in soybean cropping areas. It has also mitigated problems in producing grain species as interrupting the life cycle of most common weeds, for example. This can be accomplished with the use of competitive species, contrasting habits and by appropriate management techniques. Furthermore, it increases the number of natural enemies, thus, leading to some balance (Santos & Reis, 2003; EMBRAPA, 2011).

Some species used as cover crop, in rotation of crops with commercial crops in no-tillage, have indications of negatively influencing the weeds. Among them, black oats, vetches and forage turnip stands out. These species have allelopathic potential that can act on germination and / or development of other plants, affecting the affected organism in several ways, such as reducing photosysthesis, protein synthesis, membrane permeability and inhibition of enzymatic activity, among several others (Mauli et al., 2013; Santos & Reis, 2003; EMBRAPA, 2011; Weih et al., 2008, Rains et al., 2011; Monteiro & Vieira, 2002)

The black oats (*Avena sativa*) belongs to the Poaceae family (Grassy) and it has also great tillering capacity, shoots mass as well as improves physical and chemical conditions of soil. It plays an important role to the grain yield system. So, it is a good alternative for winter farming and crop rotation systems (Calegari et al., 1992). According to EMBRAPA (2005), black oat produces a good amount of crop waste. It helps on soil particles aggregation and still stands out in fungi control and good carbon/nitrogen ratio.

The hairy vetch (*Vicia villosa* Roth) is a fabacea (Fabaceae family), which has been adapted to the weather and grows well during autumn/winter/spring. It shows a prostrated growth habit and grows very well in soils with low fertility and acidity problems. It produces large amount of mass and is usually used as a winter fodder or as green manure (Formentini et al, 2008; Soltys et al.,2012).

Oilseed radish (*Raphanus sativus* L.) belongs to the Brassicaceae family, which has a high ability to recycle nutrients, mainly nitrogen and phosphorus. It is a very vigorous plant, which in 60 days can cover approximately 70% of a soil, in tropical regions. Consequently, due to its fast growth, it also competes with weeds. It has a very deep tap root system, reaching over two meters, which decompacts and oxygenates a soil (EMBRAPA, 2005). There are lots of leaves with low carbon/nitrogen, which decompose fast, so that only stalks remain on the ground, due to their high C:N ratio (Ferreira et al., 2000; Matera et al.,2012; Borges et al., 2012).

Isik et al. (2009) have already confirmed that species of cover crops as peas, ryegrass, rye and vetch can be used to reduce weeds emergence, especially *Capsicum annuum* L., in Turkey, and improve the effectiveness of management systems, soil fertility and subsequent crop yield.

In this context, this study was carried out to evaluate the influence of the amount of cover crops dry mass as black oats, oilseed radish and hairy vetch on emergence and initial growth of two main weeds that affect soybean plantations (*Bidens pilosa* and *Sida rhombifolia*) and soybeans.

MATERIAL AND METHODS

This research was carried out in a greenhouse, at the Exact Sciences and Technology Center (CCET), from the Western Paraná State University, in *campus* of Cascavel - PR, Brasil.

The dry mass of shoots of the cover crops studied was collected during the flowering period, in Catanduvas-PR. The material was taken to the Laboratory of Seeds and Plants Evaluation (LASP). Then, it was dried in an oven with forced air circulation at 50°C for 72 hours or until constant weight. Then, the material was ground in Willey mill type, 0.2 mm sieve, resulting in smaller particles than are found in the field, in order to accelerate the decomposition process, since it is a short, greenhouse experiment. Under field conditions, these residues are larger and the decomposition time will therefore also be higher, but when it comes to the possible release of allelochemicals, the effect will be reproduced. This material was placed in paper bags and stored in laboratory conditions at 15 °C.

The soil was collected in an agricultural area at 0-20 cm depth. It was sieved and dried in air (air-dried soil - ADS). Then, it was put in pot of almost 1 kg capacity. Five seeds were sown in each pot to evaluate germination. The seeds of the invasive plants used were collected in the field and tested for germinative power previously.This procedure was carried out with weeds as *Bidens pilosa, Sida rhombifolia* and soybeans (cultivar Coodetec 208). The dry mass of each studied cover crop (black oats, oilseed radish and hairy vetch) was placed on them according to the following rates: 10, 20, 30, 40 and 50 g, equivalent to 7.5, 15, 22, 5, 30 and 37.5 t ha^{-1}, as well as the control (no mass). Some of these values analyzed are greater than those found in the field, in normal yields. These values were stipulated by the averages found in the literature and determined other values above and below them with the objective of testing their possible effects, both in invasive plants and soybean.

Seedling emergence was daily evaluated during 10 days, based on the removal of the emerged seedlings. The emergence speed index (ESI) (Maguire, 1962) and emergence speed (ES) (Edmond & Drapalla, 1958) were also calculated.

The seedling growth bioassay was carried out under the same germination conditions. However, five pre-germinated seedlings of *Bidens pilosa*, *Sida rhombifolia* and soybeans have been used with seven to eight days of age. After 30 days, each fresh and dry mass of roots and shoots was evaluated. The material was dried at 65 °C to constant weight.

Data were submitted to analysis of variance to check significance and regression analysis. Firstly, normality and homogeneity of variances were recorded in order to evaluate data variability; while some changes were done for parameters that had not shown normal distribution of errors, according Banzatto and Kronka (1989). The Minitab ® 14 software was used to check data normality and homogeneity of variances, but the analysis of variance was recorded by Sisvar ® software (Ferreira et al., 2000).

RESULTS AND DISCUSSION

The equations and coefficients of determination (R^2) are shown in Table 1 according to the regression studies on the effects of the analyzed winter cover crops (black oats, oilseed radish and hairy vetch) on inhibition percentage of weeds and soybeans.

Bidens pilosa and *Sida rhombifolia* showed a quadratic behavior, except for *Bidens pilosa* under oilseed radish, which has shown feasible adjustment of data to the studied model. On the other hand, there was no significant regression for soybeans.

During the analysis of weed species as *Bidens pilosa* and *Sida rhombifolia* (Figure 1), the use of cover crops as black oats, hairy vetch and oilseed radish has increased their inhibition percentage, as the dry mass amount was increased. However, there was no influence on soybean.

Mauli et al. (2011) have studied the same species above and in order to corroborate these results, but under field conditions, the authors concluded that the greater the amount of crop waste on soil, the lower was weeds incidence.

Severino & Christoffoleti (2001) have also studied green manures as *Arachis pintoi*, *Crotalaria juncea* and *Cajanus cajan* on weeds and observed that the biomass of green manure has significantly reduced *Bidens pilosa*, *Brachiaria grass* and *Guinea grass* populations.

Rosa et al. (2012) have studied Fabaceae effect (*Mucuna deeringiana* (Bort.) Merr, *Canus cajan* L., *Stylosanthes capitata* and *macrocephala*) in field conditions and concluded that all these species presented decreased answers of weeds incidence when they were compared to the control plant. In the same trial, when extracts of plants were tested, the authors observed that *Mucuna deeringiana* species affected negatively *Sida* spp seeds germination. The authors have also used the same plants, in intercropping maize experiment, to observe a higher number of weeds in fallowing crops plots and, as a result, the weeds percentage decrease answers were 52, 43 and 29% for cover crops, respectively.

Weih, et al. (2008) have also highlighted the possibility of using allelopathic activity as an alternative to the use of chemical control for suppressing weeds in agroecosystem. Thus, the knowledge of such effects allows its use in crop rotation or intercropping with crops during the weed integrated management (Erasmo et al., 2004). Cover crops management can suppress weeds faster than when in soils with natural fallow (Chiloye et al., 2008).

Table 1. Equations and coefficients of determination in relation to the inhibition percent of weeds and soybean under winter cover crops (black oat, oilseed radish and hairy vetch).

Indicators	Cover Crops	Equations	Coefficients of determination (R^2)
Sida rhombifolia	Black oats	$y = -0.0102x^2 + 1.9007x + 32.759$	0.90
	Oilseed radish	$y = -0.0766x^2 + 6.2438x – 23.037$	0.97
	Hairy vetch	$y = -0.092x^2 + 7.092x – 28.76$	0.95
Bidens pilosa	Black oats	$y = -0.0051x^2 + 1.3796x + 45.635$	0.7
	Oilseed radish	$y = 0.0012x^3 – 0.1431x^2 + 5.6034x + 28.467$	1
	Hairy vetch	$y = -0.046x^2 + 3.546x + 35.62$	0.95
Soybeans	Black oats	ns	
	Oilseed radish	ns	
	Hairy vetch	ns	

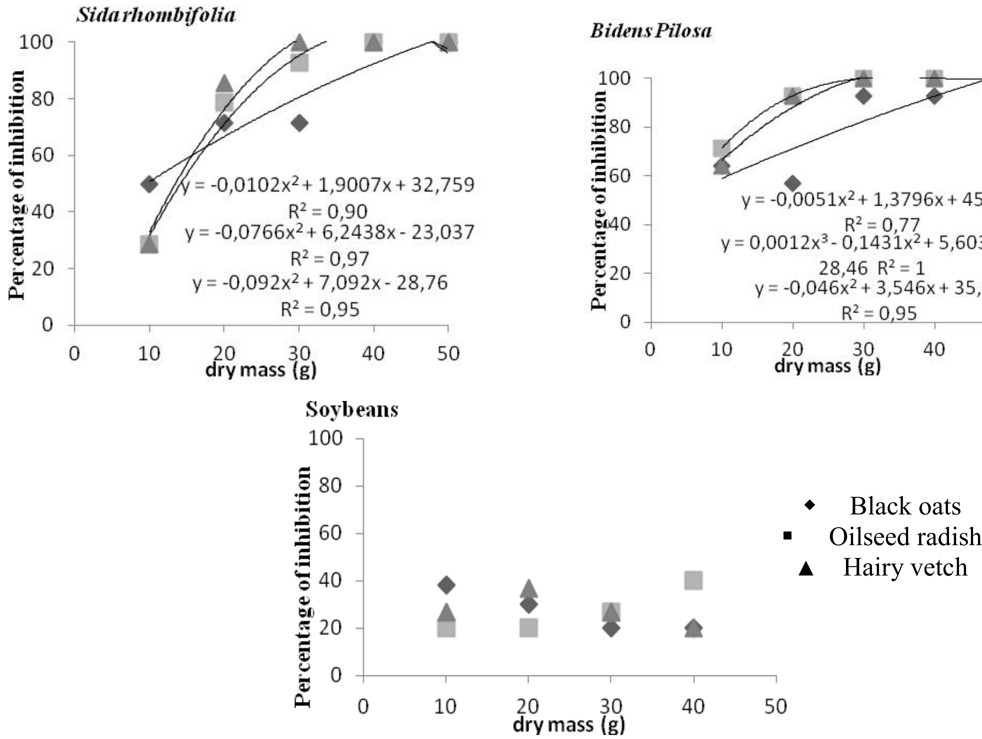

Figure 1. Inhibition percentage of Bidens pilosa, Sida rhombifolia and soybean under black oats, oilseed radish and hairy vetch.

Sida rhombifolia ESI has shown a quadratic behavior as well as *Bidens pilosa* under oilseed radish and hairy vetch, but for black oats, there was a linear decrease (Table 2). For soybeans, there was no significant answer for black oats and hairy vetch, but for oilseed radish, there was a linear decrease.

In Figure 2, it can be observed that weed plants ESI decreased significantly as there was an increase in the amount of dry cover plants. For soybeans ESI, there was no significant difference in black oats and hairy vetch, but there was some linear decrease for oilseed radish.

Piccolo de Lima et al. (2012), different from these results, have obtained results concerning single black oats and black oats intercropping, oilseed radish and vetch associated with periods of desiccation, and found out that the use of the same cultures increased soybean seedling ESI when compared with areas without cover crops (fallow).

It is confirmed, as reported by Ferreira & Áquila (2000) that mostly the allelopathic effect is not significant on the final germination percentage, but it is on the germination rate or other parameter of the germination process, in order to highlight the importance of monitoring daily germination.

Sida rhombifolia ES showed a quadratic behavior as well as *Bidens pilosa* under oilseed radish and hairy vetch (Table 3). On the other hand, *Bidens pilosa* under black oats and soybeans under oilseed radish and hairy vetch have shown a linear behavior. Thus, all of them have shown a good data adjustment to the model, but soybean under black oats has shown no significant answer.

In Figure 3, it can be seen that weeds ES decreased as the amount of dry cover crops increased, while for soybeans, it was just the opposite.

Unlike the results of this experiment, Piccolo de Lima et al. (2012) observed that soybean ES under single black oats and the intercropping of black oats, oilseed radish and hairy vetch associated with desiccation periods, was lower under cover crops when compared to fallow areas, however, different from them, showed similar behavior to the ESI.

The advantage of delay in weeds emergence is time increase to control them correctly, which would make the management more efficient in field conditions (Moraes et al., 2011).

On Table 4, the equations and coefficients of determination (R^2) from the regression studies are obtained based on the effects of winter cover crops management as black oats, oilseed radish and hairy vetch on fresh weight of weeds and soybeans shoots. *Sida rhombifolia* showed a linear decrease of shoots fresh weight according to the increased amount of black oats mass. *Sida rhombifolia* had fresh weight of shoots decreased linearly where there was an increase of vetch mass amount. There was a decrease of fresh weight in *Bidens pilosa* shoots up from 30g under hairy vetch (Figure 4).

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Table 2. Equations and coefficients of determination in relation to the emergence speed index of weeds and soybean plants under winter cover black oats, oilseed radish and hairy vetch.

Indicator	Cover crops	Equations	Coefficients of determination (R^2)
	Black oats	$y = 0.0004x^2 – 0.0376x + 0.8613$	0.94
Sida rhombifolia	Oilseed radish	$y = 0.0006x^2 – 0.051x + 0.9498$	0.97
	Hairy vetch	$y = 0.0006x^2 – 0.0468x + 0.9361$	0.99
	Black oats	$y = -0.015x + 0.6371$	0.82
Bidens pilosa	Oilseed radish	$y = 0.0006x^2 – 0.046x + 0.7356$	0.93
	Hairy vetch	$y = 0.0007x^2 – 0.0466x + 0.753$	0.95
	Black oats	ns	
Soybeans	Oilseed radish	$y = -0.0059x + 1.1314$	0.55
	Hairy vetch	ns	

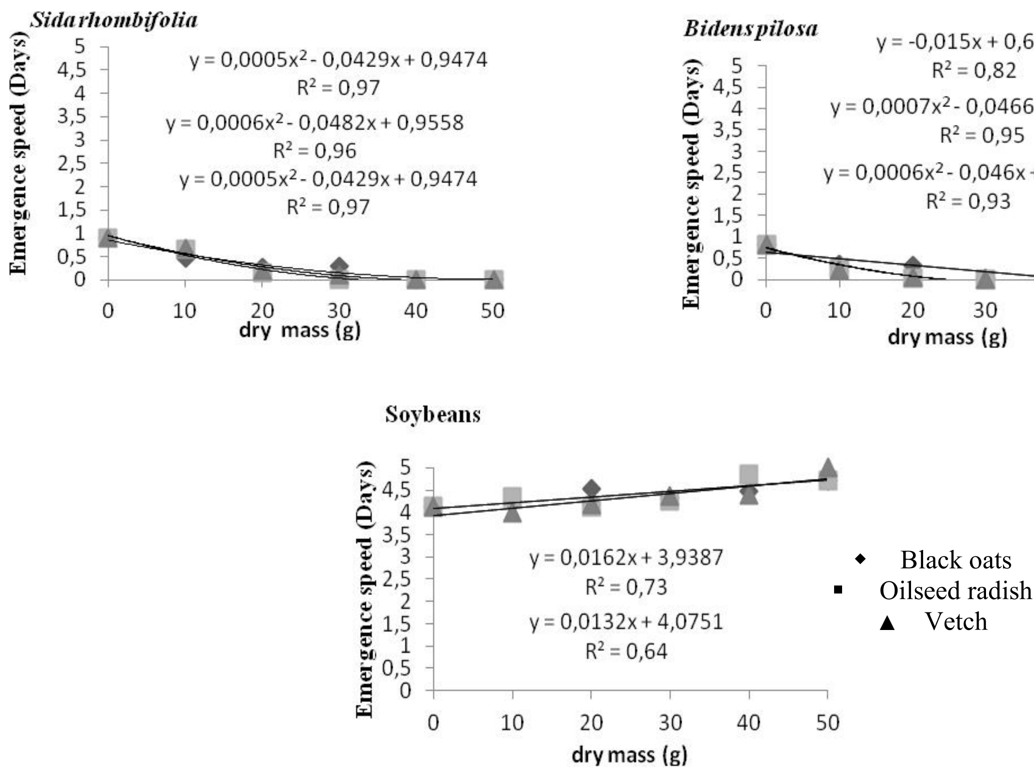

Figure 2. Emergence Speed Index of Bidens pilosa, Sida rhombifolia and soybean under black oats, oilseed radish and hairy vetch.

Table 3. Equations and coefficients of determination in relation to weeds emergence speed and soybean under winter crops as black oat, oilseed radish and hairy vetch.

Indicators	Cover crops	Equations	Coefficients of determination (R^2)
	Black oats	$y = 0.0003x^2 – 0.033x + 0.8529$	0.93
Sida rhombifolia	Oilseed radish	$y = 0.0006x^2 – 0.0482x + 0.9558$	0.96
	Hairy vetch	$y = 0.0005x^2 – 0.0429x + 0.9474$	0.97
	Black oats	$y = -0.015x + 0.6371$	0.82
Bindens pilosa	Oilseed radish	$y = 0.0007x^2 – 0.0466x + 0.7538$	0.95
	Hairy vetch	$y = 0.0006x^2 – 0.046x + 0.7356$	0.93
	Black oats	ns	
Soybeans	Oilseed radish	$y = 0.0132x + 4.0751$	0.64
	Hairy vetch	$y = 0.0162x + 3.9387$	0.73

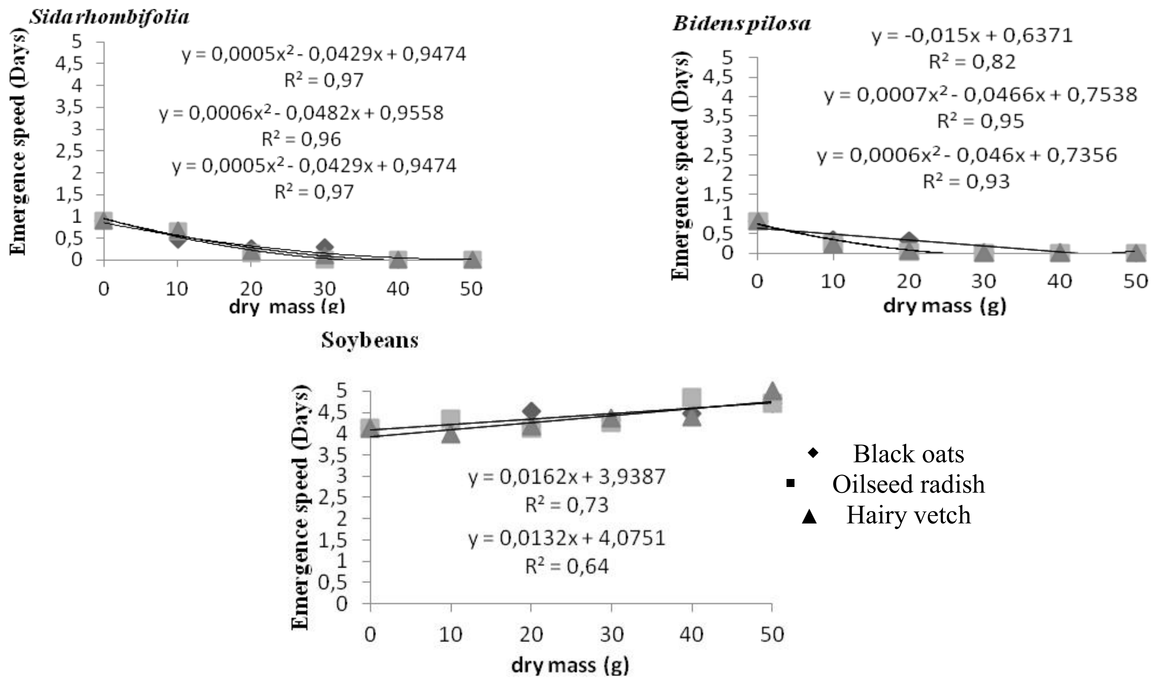

Figure 3. Bidens pilosa, Sida rhombifolia and soybean emergence speed under black oats, oilseed radish and hairy vetch.

Table 4. Equations and coefficients of determination on shoots fresh weight of weeds and soybean under winter cover crops as black oats, oilseed radish and hairy vetch.

Indicators	Cover crops	Equations	Coefficients of determination (R^2)
Sida rhombifolia	Black oats	ns	
	Oilseed radish	ns	
	Hairy vetch	$y = -0.0738x + 6.1971$	0.49
Bidens pilosa	Black oats	$y = 0.1069x + 9.2962$	0.79
	Oilseed radish	ns	
	Hairy vetch	$y = -0.0087x^2 + 0.4896x + 7.7304$	0.96
Soybeans	Black oats	$y = 0.0003x^3 – 0.0276x^2 + 0.8542x + 17.771$	0.96
	Oilseed radish	$y = 0.1693x + 19.173$	0.63
	Hairy vetch	$y = -0.0086x^2 + 0.6429x + 17.552$	0.99

Norsworthy (2003) worked with oilseed radish in soil and observed that the fresh weight of *Sida* spp weed was reduced when there was an increasing percentage of waste incorporated into soil, as it was carried out in this trial. However, there was a decrease on corn, cotton and wheat weights.

Severino & Christoffoleti (2001) have observed that green manures as *Arachis pintoi*, *Crotalaria juncea* and *Cajanus cajan* also reduced the biomass yield of the following weeds: *Bidens pilosa, Brachiaria grass* and *Colonião grass*.

Sida rhombifolia and soybean under oilseed radish and *Bidens pilosa* under hairy vetch showed a linear behavior (Table 5). On the other hand, there was a quadratic behavior when soybean was associated with black oats and vetch with good data adjustment to the model, the other crops did not show significant regression (Figure 5).

The fresh weight *of Sida rhombifolia* root was negatively influenced by the increase of oilseed radish dry mass with a linear behavior. *Bidens pilosa* showed a linear behavior, causing an increase on its root fresh weight. For soybeans, there was a decrease up from 30g dry mass of hairy vetch and oilseed radish and for black oats, there was a linear increase of root fresh weight.

Thus, in order to corroborate these results, Ducca & Zonetti (2008) have also observed that soybean root was more responsive to the extracts of cover crops presence than the shoot part.

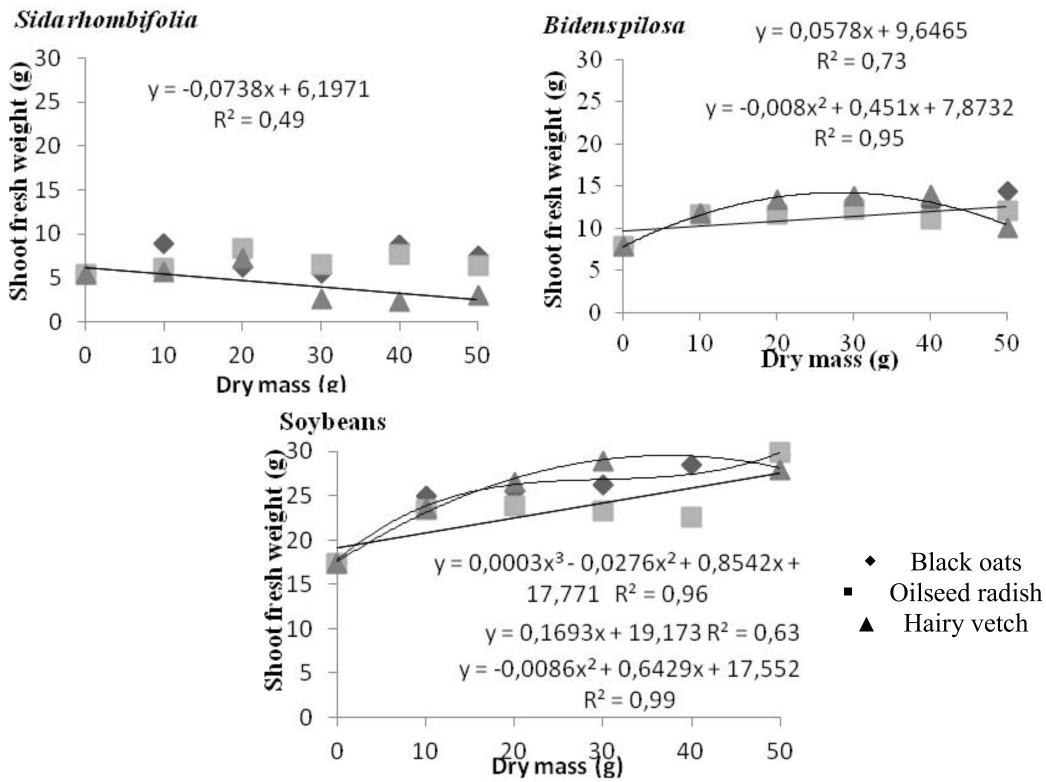

Figure 4. Shoots fresh weight of a) Bidens pilosa, b) Sida rhombifolia and c) soybean under black oats, oilseed radish and hairy vetch.

Table 5. Equations and coefficients of determination on root fresh weight of weeds and soybean crops under winter cover crops as black oats, oilseed radish and hairy vetch

Indicators	cover crops	Equations	coefficients of determination (R^2)
Sida rhombifolia	Black oats	ns	
	Oilseed radish	y = -0.0797x + 9.4773	0.75
	Hairy vetch	ns	
Bidens pilosa	Black oats	ns	
	Oilseed radish	ns	
	Hairy vetch	y = 0.1235x + 10.128	0.73
Soybeans	Black oats	$y = -0.0041x^2 + 0.3463x + 7.3429$	0.86
	Oilseed radish	y = 0.164x + 6.8938	0.87
	Hairy vetch	$y = -0.0075x^2 + 0.3903x + 6.7002$	0.98

Ferreira & Borghetti (2004) have also claimed that germination is less responsive to allelochemicals than to the seedling growth. In this context, allelopathic substances may induce the emergence of abnormal seedlings, since rootlet necrosis is one of the most common symptoms.

On Table 6, there are equations and coefficients of determination (R^2) in regression studies concerning the effects of winter cover crops as black oats, oilseed radish and hairy vetch on shoots dry weight of weeds and soybeans.

On Figure 6, it can be observed the shoot dry weight of *Bidens pilosa, Sida rhombifolia* and soybean under black oats, oilseed radish and hairy vetch.

The mass of black oats, oilseed radish and hairy vetch did not influence the shoot dry weight of *Sida rhombifolia*. *Bidens pilosa* has shown a linear behavior under black oats mass, with some increase in root weight and a quadratic behavior under oilseed radish, with a decrease up from 30g. For soybeans, only black oats showed some influence, causing a decrease up from 30g dry mass.

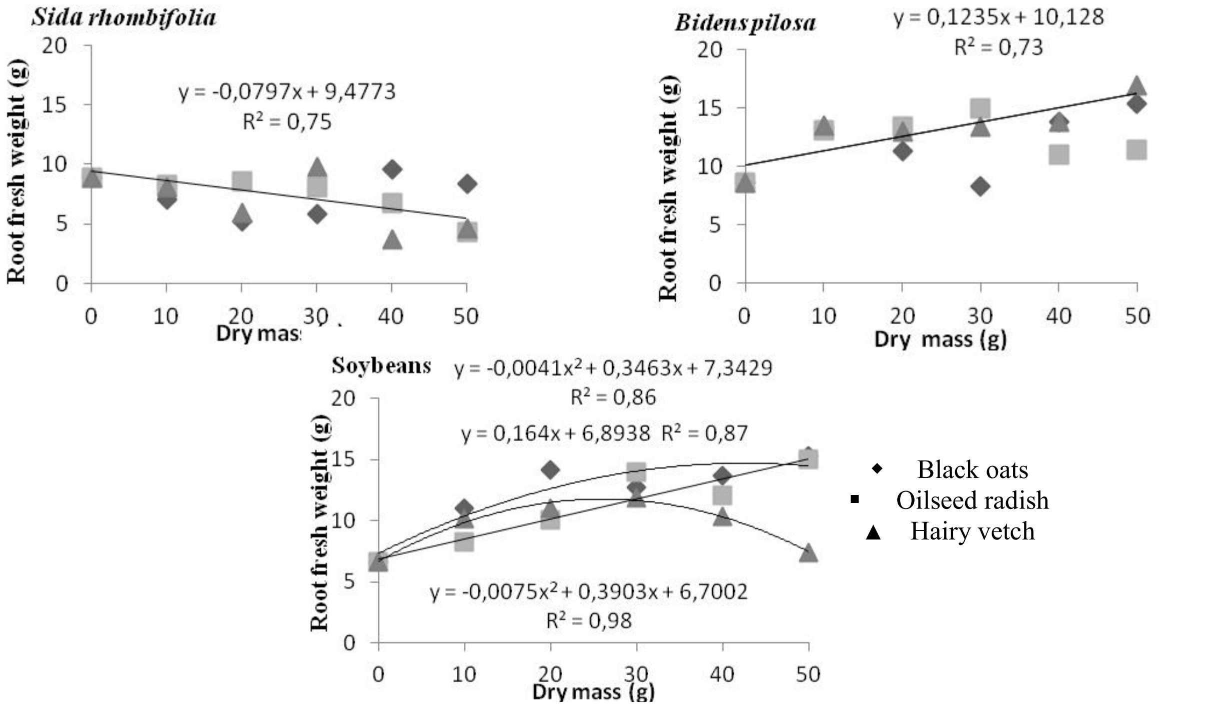

Figure 5. Root fresh weights of Bidens pilosa, Sida rhombifolia and soybean under black oats, oilseed radish and hairy vetch.

Table 6. Equations and coefficients of determination in relation to shoot dry weight of weeds and soybean plants under winter cover crops as black oats, oilseed radish and hairy vetch.

Indicators	Cover Crops	Equations	coefficients of determination (R^2)
Sida rhombifolia	Black oats	ns	
	Oilseed radish	ns	
	Hairy vetch	ns	
Bidens pilosa	Black oats	y = 0.0187x + 4.8357	068
	Oilseed radish	$y = -0.0018x^2 + 0.0977x + 4.4795$	0.95
	Hairy vetch	ns	
Soybeans	Black oats	$y = -0.0023x^2 + 0.1567x + 15.332$	0.92
	Oilseed radish	ns	
	Hairy vetch	ns	

Moraes et al. (2011) studied the cover crops effects when incorporated or not to soil and observed that ryegrass (Grass) was the cover crop in soil surface or incorporated that showed a greater decrease in shoot dry weight of watergrass weeds when compared to the other crops or to the control (no covering). However, when incorporated, there was an increase in watergrass weight as the increased straw levels of oilseed radish crop.

Maciel et al. (2003) have also observed that soybean dry matter was reduced when straw brachiaria grass (Grass) was incorporated to the soil.

On Table 7 and figure 7, it can be observed the equations and coefficients of determination (R^2) that were found in regression studies concerning the management effects of winter cover crops as black. oats, oilseed radish and hairy vetch on root dry weight of weeds and soybeans.

The root dry weight of *Sida rhombifolia* was influenced by black oats and hairy vetch and there was a negative linear behavior on black oats, while there was a quadratic behavior for hairy vetch, which increased up from 30g. The *Bidens pilosa* was not influenced by cover crops, but the soybeans showed a little increase on oilseed radish and hairy vetch crops.

Moraes et al. (2011) observed that cover crops, when kept on soil surface, promoted, in general, less increase of root dry weight variable, except for ryegrass, which showed some decrease of variable, when compared to their soil incorporation. When cover crops were compared among themselves, it was found out that the ryegrass cover crop was kept on soil surface and provided greater reduction in root dry weight of watergrass up from 2 t ha^{-1} straw.

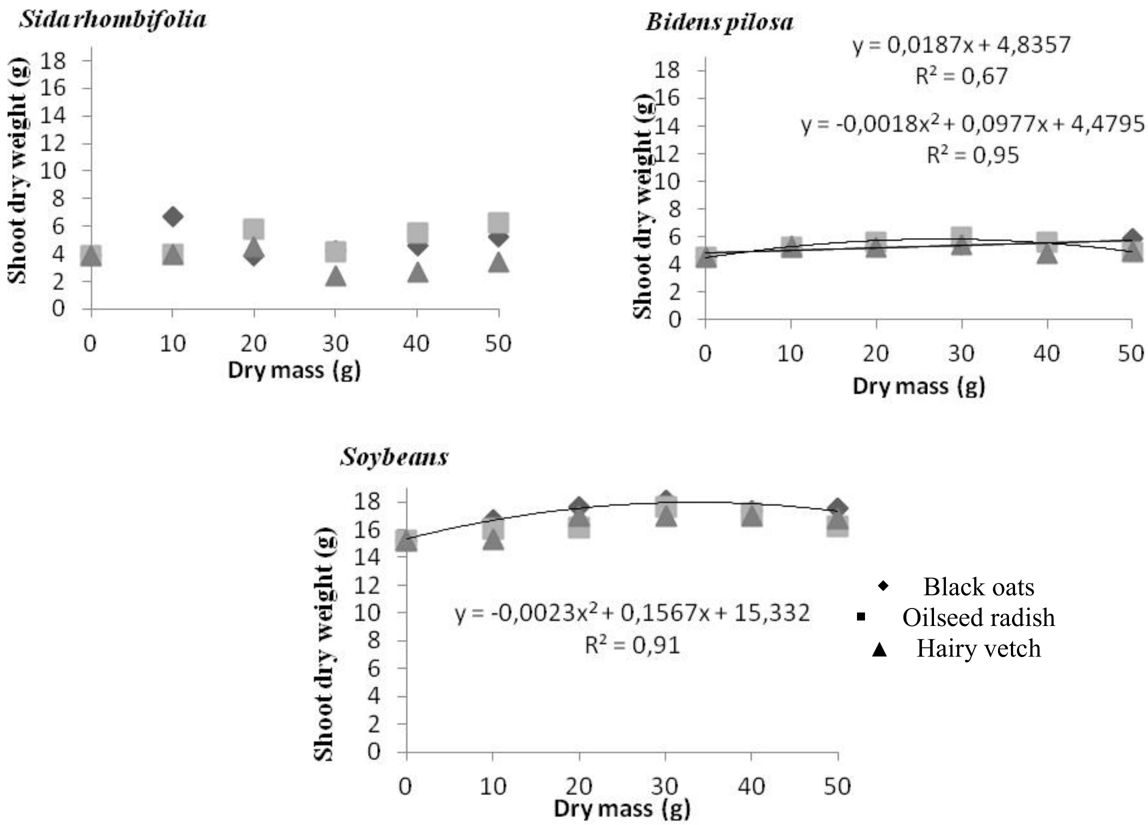

Figure 6. Shoot dry weight of Bidens pilosa, Sida rhombifolia and soybeans under black oats, oilseed radish and hairy vetch.

Table 7. Equations and coefficients of determination in relation to root dry weight of weeds and soybean under winter cover crops as black oats, oilseed radish and hairy vetch.

Indicators	Cover crops	Equations	coefficients of determination (R^2)
Sida rhombifolia	Black oats	$y = 0.0053x^2 – 0.2588x + 6.9689$	0.87
	Oilseed radish	ns	
	Hairy vetch	$y = -0.0711x + 6.6697$	0.68
Bidens pilosa	Black oats	ns	
	Oilseed radish	ns	
	Hairy vetch	ns	
Soybeans	Black oats	ns	
	Oilseed radish	$y = 0.0161x + 4.0505$	0.86
	Hairy vetch	$y = -0.001x^2 + 0.0491x + 4.0289$	0.75

There are other similar results to this trial that were recorded by Norsworthy (2003), in which oilseed radish wastes severely inhibited the roots of *Sida rhombifolia* and *S. obtusifolia* in a certain rate, which increased the waste amount incorporated into soil. Ferreira & Áquila (2000) reported that black oats did not affect the germination of corn, beans or soybeans; however, it affected the growth of these plants.

Ducca & Zonetti (2008) have also observed that the management of black oats extract with 60 days of development influenced positively on soybean seedlings development, while black oats extracts with 30 days affected it negatively.

According to Correia et al. (2006), the different responses of plant wastes on weeds can be justified by their chemical constitution, associated with or without the allelopathic properties, and even by the plant waste geometry, which will let the cover crop more efficient into soil.

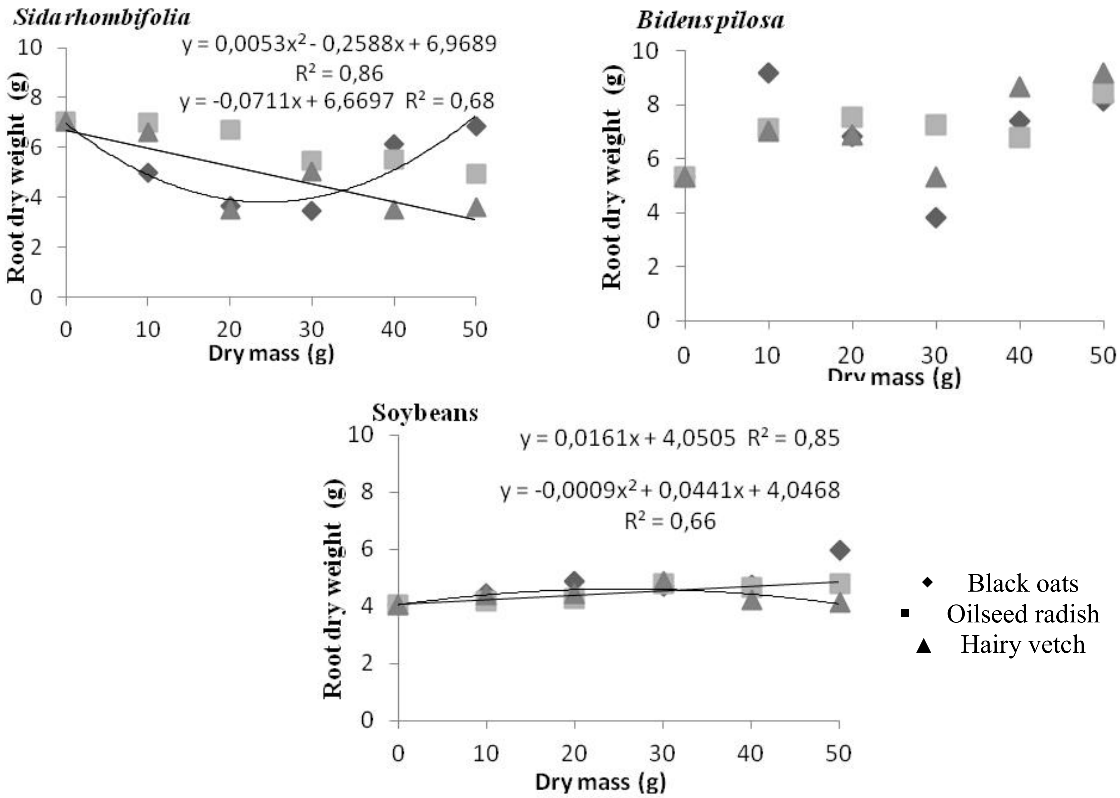

Figure 7. Root dry weights of Bidens pilosa, Sida rhombifolia and soybean under black oats, oilseed radish and hairy vetch.

CONCLUSIONS

In greenhouse, under controlled conditions, the cover crops studied showed some influence on the weeds, without important interferences in soybean. The greater the amount of mass added to the soil, the lower the incidence and the initial development of the invasive plants. Thus, they can be an alternative to the intercalated management of species under no-tillage system, adapting the observed results to the field conditions.

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