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Original Article

Allelopathic Potential of Velvet Bean and Chia against Rigid Ryegrass

Ilias TRAVLOS*, Ioannis ROUSSIS, Christos RODITIS, Clementina SEMINI, Lina ROUVALI, Panagiota STASINOPOULOU, Nikolina CHEIMONA, Chrysoula VLASSOPOULOU, Dimitrios BILALIS

*Agricultural University of Athens, School of Agriculture, Engineering and Environmental Sciences, Department of Crop Science, Laboratory of Agronomy, 75 Iera Odos str., 118 55 Athens, Greece; htravlos@yahoo.gr (*corresponding author); iroussis01@gmail.com; chris21rod21@gmail.com; nikolinaxm@gmail.com; bilalisdimitrios@gmail.com*

Abstract

Environmental concerns and several adverse effects of reliance on and improper use of pesticides make necessary the use of alternative methods. Allelopathy has a rather unexploited potential in integrated weed management and ought to be further studied. The allelopathic effects of velvet bean (*Mucuna pruriens* (L.) DC. var. *utilis*) on seedling emergence and first growth of the important weed rigid ryegrass (*Lolium rigidum* L.) were evaluated in a pot experiment conducted at Agricultural University of Athens. Leaf residues of velvet bean were used to determine their inhibitory potential on seedling emergence and growth parameters including height, leaf number, tillering and fresh and dry weight of rigid ryegrass. Moreover, the allelopathic potential of inflorescence residues of chia (*Salvia hispanica* L.) on rigid ryegrass was also evaluated. Our results revealed a significant weed suppressive ability of the studied plants. The plant residues incorporated into the soil significantly reduced the seedling emergence and growth parameters of rigid ryegrass as compared to the control. In particular, velvet bean's residues also reduced height, leaf number and biomass of rigid ryegrass up to 26, 51 and 62%, respectively. The indicated allelopathic activity of velvet bean and chia could be further exploited in future studies, by using either allelochemicals as models for future herbicides or the plants as useful cover crops or mulches in terms of integrated weed management.

Keywords: allelopathy, integrated weed management, *Lolium rigidum*, *Mucuna pruriens*, plant growth, *Salvia hispanica*, seedling emergence

Introduction

Velvet bean (*Mucuna pruriens* (L.) DC. var. *utilis*) is a member of Fabaceae family, widely growing in tropical and subtropical regions as forage and cover crop (Anaya, 1999; Marchiosi *et al*., 2016) It has been reported to be cultivated in sustainable and organic cropping systems and to increase the productivity of gramineous crops such as rice and corn in mixed culture (Sasamoto *et al*., 2013). In addition, with its great nitrogen fixation potential, it is also considered to have a high weed suppressive ability (Lawson *et al*., 2006). Velvet bean is a very useful species, since all plant parts have valuable medicinal properties including anti-diabetic, aphrodisiac, anti-neoplastic, anti-epileptic, and anti-microbial activities (Lampariello *et al*., 2012).

Environmental concerns and several adverse effects of reliance and improper use of pesticides make necessary the use of alternative methods as well. Allelopathy can be considered as the plants' ability to produce chemical compounds, considered to be secondary metabolites and referred to as allelochemicals, which are released in the environment and may have a positive or negative influence on the growth, survival, development and reproduction ofother plants or even microorganisms (Cheng and Cheng, 2015; Cruz-Silva *et al*., 2016). Allelopathy has a rather unexploited potential in integrated weed management and ought to be further studied.

Velvet bean is characterized as one the strongest allelopathic plants (Ortiz-Ceballos *et al*., 2012). Its allelopathic activity is related to levodopa or L-DOPA (L-3,4-dihydroxyphenylalanine), an amino acid exuded from leaves and roots (Adler and Chase, 2007). Several studies have shown that L-DOPA selectively suppresses seed germination (Adler and Chase, 2007).

However, very few studies reported to date have assessed the allelopathic potential of velvet bean especially against weeds of high agronomic importance. Rigid ryegrass (*Lolium rigidum* L.) is a serious weed problem, partially due to its developed resistance to several herbicides (Powles *et*

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al., 1998). The aim of the present study was to evaluate the allelopathic activity of *M. pruriens* on the germination and first growth of the important weed rigid ryegrass. In addition, the allelopathic potential of chia (*Salvia hispanica* L.) on rigid ryegrass was also assessed, since there are indications that other species of the genus *Salvia* (e.g. *Salvia officinalis* L.) have several allelopathic effects but without any specific information on chia.

Materials and Methods

Biological material

Plant material was collected at the reproductive stage of velvet bean and chia crop established in the experimental field of Agricultural University of Athens in May 2016. For the purpose of allelopathic experiment, velvet bean leaves and chia inflorescences were used. The selected material was air-dried and kept in airtight plastic bags and at room temperature until further use.

Experimental procedures

A greenhouse experiment was conducted from February to April 2017 at Agricultural University of Athens in order to determine the inhibitory potential of each of these tissues on rigid ryegrass germination and above-ground growth. The experiment was set up according to a completely randomized design (CRD), with five treatments and three replications for each treatment. The treatments were: untreated (control), 10 and 20 g of velvet bean leaf residues, 10 and 20 g of chia inflorescence residues. The plant residues were incorporated into the soil at the beginning of February and after 20 days, rigid ryegrass seeds of high germinability were uniformly dispersed (40 seeds per pot) in 9.5 L pots (24 cm diameter) containing only soil and watered as required. The soil was a clay loam (34.1% clay, 28.8% silt and 37.1% sand), pH (1:1 H_2O) 7.29, 1.47% organic matter (Wakley and Black, 1934), 13.4% nitrogen content, sufficient levels of nitrate, moderate in available phosphorus and rich in available potassium and sodium (104.3, 9.95, 590 and 110 ppm, respectively).

The rate of seedling emergence was determined twice at 11 and 19 days after sowing (DAS). Measurements were taken on growth parameters including plant height (11, 19, 27, 34, 40, 52, 59 DAS), number of tillers and number of leaves per plant (27, 34, 40, 52, 59 DAS) and fresh and dry weight of above-ground biomass (40, 52, 59 DAS) using three randomly selected plants from each pot. The dry weight was determined after drying for 48 h at 62 °C.

Statistical analysis

For the statistical analysis, JMP 8 software (SAS Institute Inc., Cary, USA) was used. The experimental data were analysed according to the completely randomized design to examine the allelopathic potential of velvet bean and chia against rigid ryegrass. Values were compared by the analysis of variance (ANOVA) and differences between means were separated using the *LSD* test. All comparisons were made at the 5% level of significance ($P < 0.05$).

Results and Discussion

The combined analysis of variance revealed that the rate of rigid ryegrass seed germination was significantly affected by the different plant residues. In particular, it was observed that the lowest values (35.88 and 49.26% at 11 and 19 DAS, respectively) were achieved in pots treated with 20 g chia inflorescence residues. Previous studies confirm the high allelopathic potential of the inflorescences of several plant species (Travlos and Paspatis, 2008). On the contrary, other researchers demonstrated that there was no significant allelopathic activity leaf, stem and root extracts of velvet bean on the germination percentage of lettuce seed (Fujii *et al*., 1991; Appiah *et al*., 2015) (Fig. 1).

Concerning the plant height, the effect of different plant residues was found to be statistically significant ($p<0.001$) during the experiment with the lowest height observed in the case of incorporation of 20 g chia inflorescence residues in all conducted measurements. It has to be noted that the highest quantity of velvet bean leaf residues presented exceptional effects on height, resulting in the significantly lowest values

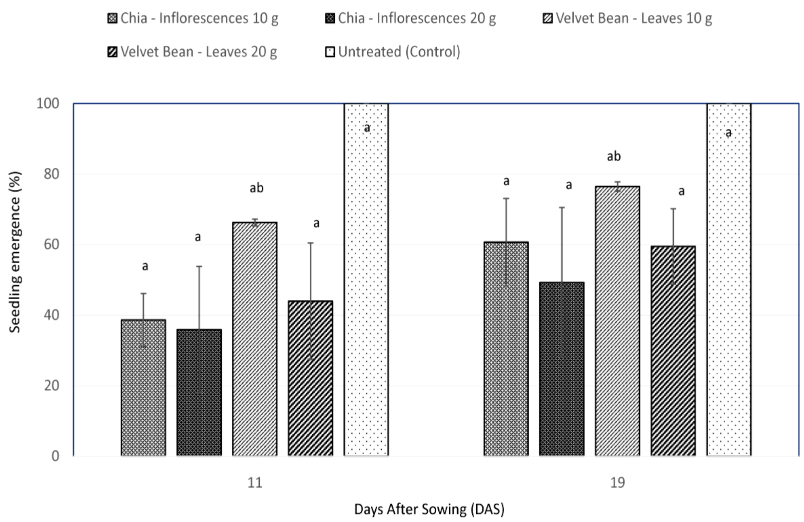

Fig. 1. Effects of plant residues on seedling number of rigid ryegrass. Vertical lines represent standard mean errors. Different low case letters indicate statistically significant differences at $p<0.05$; ns – not significant

during the period from 27 DAS until the end of experiment (59 DAS). In addition, time was another factor that influenced plant height, with progressively higher differences. The results obtained from combined analysis of variance indicated that the number of tillers was also negatively affected by plant residues. Significant differences were obtained at 34 DAS, where the lowest value was found under the high quantity of chia inflorescence tissues. After 52 DAS, there was a significant difference between plant residue treatments and control, but without any significant differences observed between the several plant residues. Despite that, the lowest values (1.7 and 2.1 at 52 and 59 DAS, respectively) were recorded in pots treated with the low quantity (10 g) of velvet bean leaf residues. Moreover, tiller number was actually affected by time and an interaction between plant residues and time was also observed. Leaf number was also significantly influenced by plant residues. With the exception of the first measurement (27 DAS), plant residue treatments were significantly different from the control. The rigid ryegrass plants treated with the high quantity (20 g) of chia inflorescence or velvet bean leaf residues presented the lowest number of leaves at 34 DAS. From 52 DAS until the end of experiment, the plant residue treatments had a significant difference with the control. Particularly, the lowest value was recorded in the case of 20 g of soil-incorporated velvet bean tissues. As in the previous growth parameter, leaf number was also influenced by time and an interaction between plant residue and time was found (Figs. 2 and 3) (Table 1).

The above-ground fresh weight of *L. rigidum* was also inhibited by plant residues. During the experiment, the lowest weed growth was recorded in 20 g of chia inflorescence treatment. The effect of plant residues on dry weight of above-ground biomass of rigid ryegrass was also significant. Caamal-Maldonado *et al.* (2001) conducted an experiment to evaluate allelopathy activity of velvet bean and observed that although tomato seed germination was negatively affected by aqueous velvet bean extracts, biomass of tomato transplants was not influenced by soil-incorporated velvet bean leaf residues (Fig. 4).

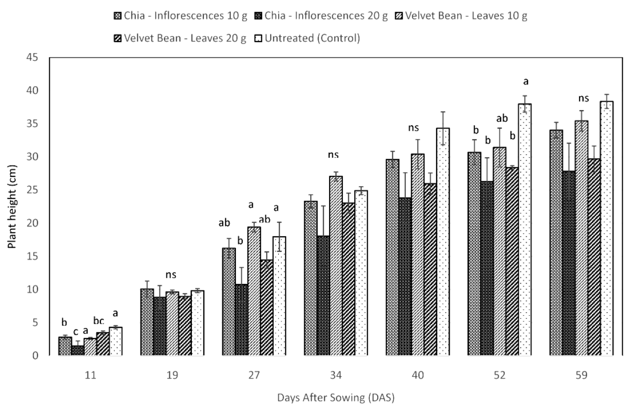

Fig. 2. Effect of plant residues on height of rigid ryegrass. Vertical lines represent standard mean errors. Different low case letters indicate statistically significant differences at p<0.05; ns – not significant

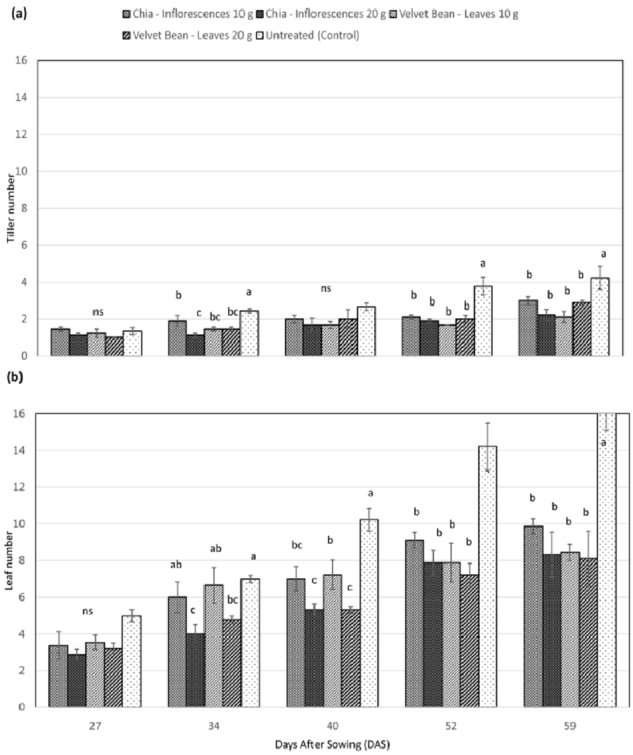

Fig. 3. Effects of plant residues on a) tiller number and b) leaf number of rigid ryegrass. Vertical lines represent standard mean errors. Different low case letters indicate statistically significant differences at p<0.05; ns – not significant

Table 1. Analysis of variance (ANOVA) for plant residue treatment and time effects on seedling emergence and first growth of rigid ryegrass

	Seedling Emergence		Height		Tiller Number	
Source	df	F	df	F	df	F
Treatment	4	7.87^{***}	4	15.28^{***}	4	20.96^{***}
Time	1	2.72^{ns}	6	179.70^{***}	4	29.79^{***}
Treatment × Time	4	0.24^{ns}	24	0.99^{ns}	16	1.86^{*}
Source	Leaf Number		Fresh weight of above-ground biomass		Dry Weight of above-ground biomass	
	df	F	df	F	df	F
Treatment	4	34.01^{***}	4	53.07^{***}	4	62.63^{***}
Time	4	58.80^{***}	2	38.18^{***}	2	87.92^{***}
Treatment × Time	16	2.99^{**}	8	0.52^{ns}	8	7.23^{***}

$^{*}P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$; ns – not significant

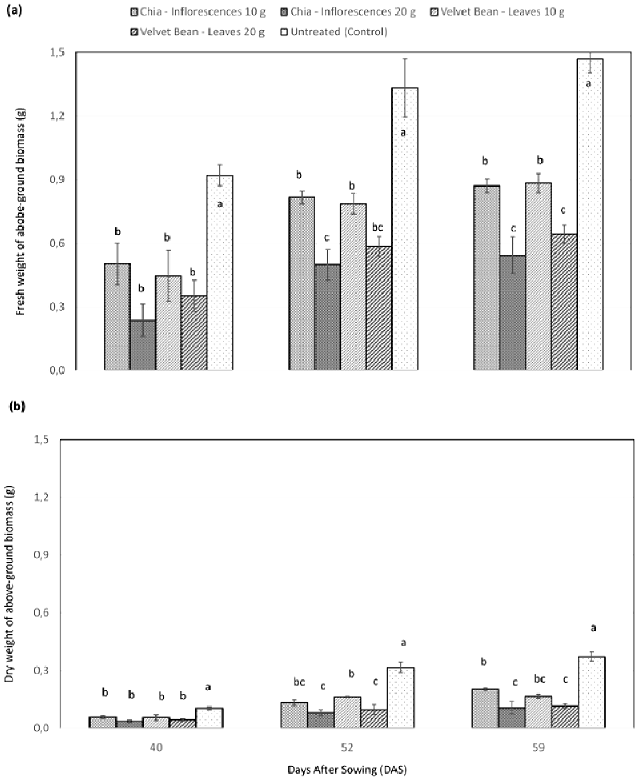

Fig. 4. Effects of plant residues on a) above-ground fresh weight and b) above-ground dry weight of rigid ryegrass. Vertical lines represent standard mean errors. Different low case letters indicate statistically significant differences at $p<0.05$; ns – not significant

Conclusions

The result of present study indicated that velvet bean leaf and chia inflorescence tissues had a significant allelopathic activity on seedling emergence and growth parameters of rigid ryegrass. The lowest rate of seedling emergence was achieved in pots treated with 20 g chia inflorescence residues. Velvet bean's residues also had a noticeable effect on emergence, growth and biomass of *L. rigidum*. The lowest value of tiller number was achieved in 10 g of velvet bean leaf tissues, while the lowest leaf number was observed in 20 g velvet bean leaf residues treatment. The indicated allelopathic activity of velvet bean and chia could be further exploited in future studies, by using either allelochemicals as models for future herbicides or the plants as useful cover crops or mulches in terms of an integrated weed management system.

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