Salvia officinalis L. coverage on plants development

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ABSTRACT: Medicinal plants with essential oils in their composition havetypicallybeen shown to be promising in plant control. Sage (*Salvia officinalis* L.) is cited for its allelopathic effects. This study evaluated the allelopathic potential of dried sage leaves in vegetation, soil and the development of *Lycopersicon esculentum* Mill. (tomato), *Panicum maximum* Jacq. (guinea grass) and *Salvia hispanica* L. (chia) plants. Three seedlings were transplanted seven days after germination in 1 kg plastic containers with soil, in a greenhouse. The grinded dry mass of sage was placed at rates of 3.75; 7.5 15 t ha^{-1}, and a control (no mass). After 30 days, the chlorophyll index of tomato and guinea grass plants were inhibited with 7.5 and 15 t ha^{-1} sage cover crops. Tomato shoot length was inhibited in all tested rates, and guinea grass plants showed some reduction in growth when using the highest rate of sage mass (15 t ha^{-1}). The dry mass of tomato and guinea grass plants was reduced when using the15 t ha^{-1}, and 7.5 and 15 t ha^{-1} of sage cover crops, respectively. It can be concluded that there was some effect of sage coverage on the soil in tomato and guinea grass, but no effect was observed on chia plants.

Key words: allelopathic potential, plant growth, sage.

RESUMO: **Cobertura de *Salvia officinalis* L. no desenvolvimento de plantas.** As plantas medicinais que apresentam óleos essenciais em sua composição normalmente têm se mostrado promissoras no controle de plantas. A sálvia (*Salvia officinalis* L.) é citada por seus efeitos alelopáticos. Assim, esse estudo avaliou o potencial alelopático das folhas secas de sálvia na cobertura vegetal, no solo, sobre o desenvolvimento das plantas de *Lycopersicon esculentum* Mill. (tomate), *Panicum maximum* Jacq. (capim mombaça) e *Salvia hispanica* L. (chia). Três plântulas foram transplantadas, sete dias após germinação, em vasos plásticos de 1 kg, com terra, em casa de vegetação. Sobre elas foi disposta a massa seca triturada de sálvia nas proporções 3,75; 7,5 e 15 t ha^{-1}, além da testemunha (sem massa). Após 30 dias, o teor de clorofila das plantas de tomate e capim mombaça foi inibido com 7,5 e 15 t ha^{-1} de sálvia em cobertura. O comprimento da parte aérea do tomate foi inibido em todas as proporções testadas e as plantas de capim mombaça apresentaram redução do crescimento quando se utilizou 15 t ha^{-1} de sálvia como cobertura. A massa seca das plantas de tomate e capim mombaça reduziu com o uso de 15 t ha^{-1} e, 7,5 e 15 t ha^{-1} de sálvia como cobertura, respectivamente. Finalmente, pode-se concluir que houve efeito da sálvia em cobertura sobre o solo em tomate e capim mombaça, mas não houve efeito da mesma sobre as plantas de chia.

Palavras-chaves: potencial alelopático, crescimento, sálvia.

INTRODUCTION

Allelopathy is the plant ability to produce chemical compounds that have been released in the environment and they can present beneficial or adverse effects to the development on another plant, or even microorganisms (Rice, 1984; Cheng & Cheng, 2015).

Modern agricultural practice is known by applying an excess of fertilizers, herbicides, fungicides, and nematocides, etc., jeopardize the physical-chemical properties of the soil and pollute the soil and water to the detriment of the global ecosystem. Sustainable agriculture means making efficient use of internal resources, relying on a minimum of necessary purchases inputs. So,

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allelochemicals (compounds present in plants) can be selected for agricultural purpose, to increase the crop productivity or to reduce the plant growth. Allelopathy interaction has influence on plant growth and the decomposing crop residues can be toxic to weed growth, but also may lower the productivity of subsequent crop (Chou, 1999).

According to Ferreira & Aquila (2000), all plants produce secondary metabolites, which can differ in quantity and quality of species-to-species, even the metabolite amount, local of occurrence or crop cycle. Many allelopathic compounds produced by plants are regulated by environmental factors, such as water potential in the environment, temperature, light quality and quantity, soil composition, nutrients, microorganisms, besides others. The compound amount is significantly higher when the plant grows under stressful conditions when compared to normal environment (Chou, 1999).

Allelochemicals can effect functions like nutrient uptake, growth, photosynthesis, cell division, respiration, membrane permeability, protein synthesis and enzyme activity. The same compound can have different physiological functions or too, several compounds can effect just one process in the organism (Malheiros & Peres, 2001).

Studies on allelopathy in crops and weeds have been developed in the past few decades and the use of allelopathic crops in crop rotation, cover crops, green manure, intercropping, etc., has become a reality. However, allelopathy must be recognized as a dynamic process that involves more than just donor and target plants. Variations in the type of soil, water and nutrient availability, previous or companion crops, climate conditions, etc. are determinants of the occurrence of effective allelopathic activity (Albuquerque et al., 2011).

There are many processes by which the metabolites are released into the environment, as: volatilization, leaching, decomposition of plant residues in soil, and root exudation (Reigosa et al., 1999). Thus, the cover crop can release allelochemicals compounds that inhibit the seeds germination or the seedling development from certain species. In addition, works as insulating layer between the atmosphere and the soil, it changes the temperature and humidity conditions and decreases their amplitudes (Almeida, 1991), and protects the soil against erosion, improves soil fertility, increases the population of micro and mesofauna (Theisen & Vidal, 1999).

Agricultural practices such as reseeding, over seeding, cover crops and crop rotation must take into account the allelopathic activity of the crops involved, at the risk of obtaining low yields (Sangeetha & Baskar, 2015).

Many chemical compounds present in medicinal plants can lead to appearance of allelopathic effect. Saito (2004) reported that medicinal plants that are rich in essential oil, usually have shown potential to inhibit the development of weed.

Plants of Lamiaceae Family are cultivated worldwide, mainly for use as culinary and medicinal herbs, and are widely studied as natural antioxidant sources since they are rich in polyphenols (Kontogianni et al., 2013).

In Brazil, the genus *Salvia* contain 68 species, distributed in the South, Southeast, Midwest and Northeast regions (Santos, 2014). *Salvia officinalis* L. (sage) is an important cultivated species. Sage has been used for the treatment of digestive and circulation disturbances, bronchitis, cough, asthma, angina, mouth and throat inflammations, depression, excessive sweating, skin diseases, and many other diseases (Hamidpour et al., 2014).

It was also cited its allelopathic effects on seeds and seedlings of lettuce (*Lactuca sativa* L.) (Viecelli & Cruz-Silva, 2009; Bouajaj et al., 2013), maize (*Zea mays* L.), tomato (*Lycopersicum* esculentum Mill.) and sunflower (*Helianthus annus* L.) (Simoneto & Cruz-Silva, 2010).

Thus, the present study evaluated the allelopathic potential from sage leaves as cover crop under soil, on chlorophyll index, shoot length and dry mass of cherry tomato (*Lycopersicum esculentum* Mill. var. Cerasiforme Alef.), guinea grass (*Panicum maximum* var. Mombaça) and chia (*Salvia hispanica* L.) seedlings.

MATERIAL AND METHODS

Plant material

Dried leaves of sage, purchased from a commercial supplier, were grinded in Willey grinder to produce a powder that was maintained in the dark until its use.

Bioassay

The study was performed in the Laboratory for Seeds and Plants Evaluation and greenhouse, with controlled temperature of 25 ± 3 ºC, at the Western Paraná State University (UNIOESTE), on 24º 59' 20 West longitude and 53º 26' 59 South latitude and altitude of 756 meters, located in Cascavel, Paraná, Brazil.

Tomato, guinea grass and chia seeds were planted in germination trays, with soil and Tropstrato HT® substract during seven days, at greenhouse. After, three seedlings with 5 cm length of each species were transferred to plastic containers with 1 kg capacity that were filled with soil. Ten replications were conducted for each treatment, so dried mass of sage leaves, at 3.75; 7.5 and 15 t ha^{-1} rates, were put on soil. The control was cultivated without mass. The containers were then wet, when necessary.

After 30 days, tomato, guinea grass and chia plants were evaluated to chlorophyll index, shoot length (cm) and dry mass (g). The chlorophyll index was expressed as Falker Chlorophyll Index (FCI) units, using clorofiLog by Falker® 1030. The first and second leaves of each plant were measured three times by chlorophyll meter reading. To determine the dry mass, the samples were dried in a forced ventilation oven at 65 °C for 72 hours. After that, samples were weighed to obtain the dry mass.

Experimental design and statistical analysis

Experiment has a completely randomized design (CRD) with four ratios of dry mass of sage leaves as coverage and ten replications per treatment. All data were submitted to normality (Shapiro-Wilk) and homoscedasticity (Bartlett) tests to Analysis of variance (ANOVA) and means were compared by the Tukey test at 5% probability using the software R (R Development Core Team, 2014).

RESULTS AND DISCUSSION

After 30 days, it was observed that the dry mass of sage leaves used as coverage on soil, adversely influenced the tomato and guinea grass chlorophyll indices, when it was used at 7.5 and 15 t ha^{-1} in comparison with the control treatment (without mass) (Table 1). Chia seedlings did not show influence in its chlorophyll index leaves by the treatments.

Shoot length of tomato plants was inhibited in all rates of sage coverage on soil. It showed a growth reduction at 26, 32 and 56% to 3.75; 7.5 and 15 t ha^{-1} of sage dry mass, respectively, as a dependent dose. While, the guinea grass plants had their growth reduced when it was used the highest mass rate (15 t ha^{-1}), resulting in 29% length inhibition in comparison with the control treatment. Growth of chia plants was not influenced by the presence of sage coverage.

The dry mass of tomato plants was reduced in 71% when 15 t ha^{-1} of sage mass per container were used, with statistical difference in comparison with the control treatment. There was also a reduction in guinea grass mass when 7.5 and 15 t ha^{-1} of sage coverage were used, decreasing at 43 and 52%, respectively. Thus, there was no effect for chia plants.

The studied results on species and variables can be associated with compounds present in sage. The dry mass of sage leaves used as coverage reduced the chlorophyll indices of tomato and guinea grass. According to Chou (1999), photosynthesis is affected by allelochemicals, since they cause

TABLE 1. Chlorophyll index, shoot length (SL) and dry mass of tomato, guinea grass and chia plants growth on sage coverage on soil.

	Tomato		
Treatments	Chlorophyll (FCI)	SL (cm)	Dry mass (g)
0 t ha^{-1}	12.72a	20.07a	0.56a
3.75 t ha^{-1}	10.12ab	14.81b	0.36ab
7.5 t ha^{-1}	8.27bc	13.64bc	0.36ab
15.0 t ha^{-1}	5.95c	8.71c	0.16b
CV	35.65	35.19	68.16
	Guinea grass		
Treatments	Chlorophyll	SL (cm)	Dry mass (g)
0 t ha^{-1}	36.45a	45.18a	0.21a
3.75 t ha^{-1}	33.28ab	43.38a	0.18ab
7.5 t ha^{-1}	31.27b	38.84ab	0.12bc
15.0 t ha^{-1}	28.55b	32.12b	0.10c
CV	14.74	20.99	47.00
	Chia		
Treatments	Chlorophyll	SL (cm)	Dry mass (g)
0 t ha^{-1}	33.65a	15.50a	0.18a
3.75 t ha^{-1}	31.32a	13.78a	0.14a
7.5 t ha^{-1}	32.78a	16.28a	0.18a
15.0 t ha^{-1}	33.06a	14.21a	0.13a
CV	8.55	19.43	51.29

FCI: Falker chlorophyll index. Distinct letters in the column indicate significant differences according to Tukey test at 5% probability level. CV: coefficient of variation.

changes in the chlorophyll content of the target plants. The reduction of chlorophyll may be attributed to biosynthesis inhibition by allelopathic compounds (Borella et al., 2012).

Besides, Dayan et al. (2000) explained that the phenotypic response to a phytotoxin might be the result of secondary effects, rather than the primary mechanism of action of the compound. For example, assessing the inhibition parameters of allelochemical sorgoleone by measuring root growth may be inadequate. Since there is no direct correlation between the parameters measured and the known mechanism of action of this allelochemical, which is inhibition of photosystem II.

The 2-Benzoxazolinone (BOA) is an allelochemical compound and it has been found in some dicotyledonous including the Lamiaceae Family (Hussain & Reigosa, 2011), this Family includes *Salvia* species. The chlorophyll content is its average quantity present in a specific leaf area. Soybean (*Glycine max* L. Merrill) plants exposed to the BOA had lower chlorophyll content, and this reduced photosynthetic rate (Parizotto et al., 2011).

Khaliq et al. (2013) tested aqueous extracts from six allelopathic plants and verified that chlorophyll total content of six weeds decreased in comparison with the control treatment. They observed that the reduction was different, depending on who was the donor or the target species. Similarly, it was observed in this study that there was variation on response in accordance with the target species used.

Kontogianni et al. (2013) related that *S. officinalis* plants presented a high content of phenolic compounds. Yang et al. (2004) studied the phenolic compounds effects in rice seedlings, and they found out some inhibitory effects, but in different degrees, in chlorophyll content, a and b chlorophyllase activities. These enzymes are associated with the chlorophyll degradation, since they help on decreasing the photosynthetic efficiency.

Simoneto & Cruz-Silva (2010) tested sage aqueous extract and verified that shoot length of sunflower was inhibited in all tested concentrations (7.5 to 30%) and it was observed a decrease of tomato growth in the highest concentration (30%). Similarly, this was recorded in this work to shoot length because sage has shown some allelopathic potential.

In another study with sage extracts, prepared by decoccion, maceration and grind, it was shown an inhibition of lettuce growth at 30% concentration, according to the season of leaf collection (Viecelli & Cruz-Silva, 2009). Also, Bouajaj et al. (2013) related its essential oil exerted an inhibitory effect on the germination of lettuce and reduced its root growth.

In this study, the dry mass of tomato and guinea grass plants showed less reduction when used sage coverage on soil in comparison with chlorophyll index and shoot length. According Pirzad et al. (2010), the sage aqueous extract had less influence on shoot than root growth in seedlings of purslane (*Portulaca oleracea* L.). The stem development was inhibited using 10% extracts, whereas root growth was inhibited at all concentrations (5-20%) in comparison with the control. The same pattern of inhibition was recorded for dry mass of purslane seedling, which was reduced when exposed to 10, 15 and 20% concentrations when compared to 0 and 5% concentrations.

Bajalan et al. (2013) also observed inhibition of stem and root growth and dry mass of barley (*Hordeum vulgare* L.) and purslane when exposed to sage aqueous extracts. The effect was more pronounced when extract concentration was increased (6 to 50%). The authors proposed to use the features from *S. officinalis* to produce natural herbicides and pesticides.

Salvia macrosiphon Boiss extracts, the same genus of the species studied in this trial, inhibited the germination, shoot and root growth, fresh and dry mass of maize according to the increase of extract concentrations (Rowshan & Karimi, 2013). Release of terpene compounds into soil probably represents an attempt by the plant to create a surrounding environment that is unfavorable to the development of other species. Consequently, this would ensure the plant more advantageous conditions in the struggle for survival (Angelini et al., 2003).

The compounds of secondary metabolism confer a multitude of adaptive and evolutionary advantages to the producing plants. As a strategy for survival and for the generation of diversity at the organisms, the ability to synthesize specific classes of secondary metabolites is often restricted to selected taxonomic groups. It often imparts a species-specific chemical "signature" which has shown a high intraspecific variability (Ncube & Van Staden, 2015). According to Pichersky & Gang (2000), their biosynthesis is often restricted to a particular tissue and occurs at a specific stage of development.

Different results were obtained in tests carried out by Chalkos et al. (2010). These authors tested two species of Lamiaceae Family, *Mentha spicata* and *Salvia fruticosa*, using soil mixtures with both species, during 60 days. They observed, in general, that the shoot length and mass of tomato plants grown in compost had greater mass than those grown in the control soil. This growth tended to increase with increasing compost rate (2, 4 e 8%), but not proportionally. Also, the growth parameters of tomato plants growing in soil mixtures with 8% *M. spicata* increased even at the very early stages, 20 days after emergency. Thus, there was a reduction in the number of weeds that emerged in soil incorporated with *M. spicata* when compared to the others.

This fact may be due to the dry mass amount and the studied species, the experiment design and/or specificity of target species. Ferreira & Aquila (2000) reported that resistance or tolerance to the secondary metabolites that act out as allelochemicals is specific. There are more sensitive species than others. Lettuce and tomato are sensible species that can be used as an indicator of allelopathic activity (Kruse et al., 2000; Pires & Oliveira, 2001). The observations in this study confirm this feature, as the tomato plants were more sensitive to sage coverage in comparison with guinea grass plants. The chia plants proved to be tolerant to sage coverage, without reduction in the evaluated parameters. Also, this specie and sage are the same genus, and Veberič (2010) related that each plant family, genus, and species produces a characteristic mix of these chemicals, and they can sometimes be used as taxonomic characters in classifying plants. Thus, plants must often be careful to store their toxins in plant-defensive mechanism that include sequestering the allelochemicals in different organs, specialized vacuoles or in exportable substances such as wax are mechanism to avoid autotoxicity (Murphy, 1999).

Most plants release biogenic organic compounds into the surrounding environment and through coevolutionary history. So, the plants of the native range can ''ignore,'' tolerate, or overcome these compounds in an evolutionary arms race. The response is according the different quantities of metabolite and with different ecological consequences depending on the target specie. The species may evolve tolerance to the previously novel compounds with increasing exposure (Barney et al., 2009).

In this context, Matysiak et al. (2014) studied the effect of dry mass of medicinal plants on the emergence and fresh mass of four species and found out that sage affected differently, according to target species. Sage mass caused a significant decrease on germination and fresh mass of *Brassica napus* var. *oleifera* (L.) cultivar maximus, without influencing these parameters for the other species, including *B. napus* var. *oleifera* (L.) cultivar californium, which is the same plant species that were negatively influenced. This demonstrates that each specie has answered distinctly to the donor plant.

Thus, assays with more than one species allow better scaling of the allelopathic potential of the donor species than using a single specie. Besides, it can enable broader and closer to reality inferences. It can be considered that, among target species, there was one more sensitive, another moderately and other with low sensitivity (Souza-Filho et al., 2010).

In general, sage coverage on soil reduced the development of tomato and guinea grass plants, consequently it indicated that there is some allelopathic potential. The chia plants showed no sensitivity by sage coverage

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REFERENCE

ALBUQUERQUE, M. B. et al. Allelopathy, an alternative tool to improve cropping systems. A review. **Agronomy for Sustainable Development**, v.1, n.2, p. 379-395, 2011.

ALMEIDA, F. S. Controle de plantas daninhas em plantio direto**.** Londrina: IAPAR, 1991. 34p. (**Circular 67**).

ANGELINI, L.G.; et al. Essential oils from Mediterranean Lamiaceae as weed germination inhibitors. **Journal of Agricultural and Food Chemistry**, v.51, n.21, p.6158-6164, 2003.

BAJALAN, I. et al. Allelopathic effects of aqueous extract from *Salvia officinalis* L. on seed germination of barley and purslane. **International Journal of Agriculture and Crop Sciences**, v.5, n.7, p.802-805, 2013.

BARNEY, J.N. et al. Biogenic volatile organic compounds from an invasive species: impacts on plant-plant interactions. **Plant Ecology**, v.203, n.2, 195-205,2009.

BORELLA, J. et al. Efeito alelopático de extratos de folhas de Solanum americanum sobre o vigor do rabanete. **Revista Trópica - Ciências Agrárias e Biológicas**, v.6, n.1, p.44-51, 2012.

BOUAJAJ, S. et al. Antibacterial, allelopathic and antioxidant activities of essential oil of *Salvia officinalis* L. growing wild in the Atlas Mountains of Morocco. **Natural Product Research,** v.27, n.18, p.1673-1676, 2013.

CHALKOS, D. et al. *Mentha spicata* and *Salvia fruticosa* composts as soil amendments in tomato cultivation. **Plant Soil**, v.332, n.1/2, p.495-509., 2010.

CHENG, F.; CHENG, Z. Research Progress on the use of Plant Allelopathy in Agriculture and the Physiological and Ecological Mechanisms of Allelopathy. **Frontiers in Plant Science**, v.6, p.1-16, 2015.

CHOU, C. Roles of allelopathy in plant biodiversity and sustainable agriculture. **Critical Reviews in Plant Sciences**, v.18, n.5, p.609-636, 1999.

DAYAN, F.E. et al. Investigating the mode of action of natural phytotoxins. **Journal of Chemical Ecology**, v.26, n.9, p.2079-2094, 2000.

FERREIRA, A. G.; ÁQUILA, M. E. A Alelopatia: uma área emergente da ecofisiologia. **Revista Brasileira de**

Fisiologia Vegetal, v.12 edição especial, p.175-204, 2000.

HAMIDPOUR, M. et al. Chemistry, pharmacology, and medicinal property of sage (*Salvia*) to prevent and cure illnesses such as obesity, diabetes, depression, dementia, lupus, autism, heart disease, and cancer. **Journal of Traditional and Complementary Medicine**, v.4, n.2, p.82-88, 2014.

HUSSAIN, M. I.; REIGOSA, M. J. Allelochemical stress inhibits growth, leaf water relations, PSII photochemistry, non-photochemical fluorescence quenching, and heat energy dissipation in three C3 perennial species. **Journal of Experimental Botany**, v. 62, n. 13, p. 4533-4545, 2011.

KHALIQ, A. et al. Differential suppression of rice weeds by allelopathic plant aqueous extracts. **Planta Daninha**, v. 31, n. 1, p. 21-28, 2013

KONTOGIANNI, V. G. et al. Phytochemical profile of Rosmarinus officinalis and Salvia officinalis extracts and correlation to their antioxidant and anti-proliferative activity. **Food Chemistry**, v.136, n.1, p.120–129, 2013.

KRUSE, M.; STRANDBERG, M.; STRANDBERG, B. **Ecological effects of allelopathic plants. A review.** Silkeborg: Denmark, Rep. n.315, 2000. 66p.

MALHEIROS, A.; PERES, M. T. L. P. Alelopatia: Interações químicas entre espécies. Chapecó: Argos: 2001. In: YUNES, R.A.; CALIXTO, J.B. **Plantas medicinais sob a ótica da química medicinal moderna**. 1.ed. Chapecó: Argos: 2001. p. 505-521.

MATYSIAK, K. et al. Allelopathic effect of popular medicinal plants on *Fagopyrum esculentum* (Moench), *Papaver somniferum* (L.) and *Brassica napus* var. Oleifera (L.). **Journal of Medicinal Plant Research,** v.8, p.1051-1059, 2014.

MURPHY, S. Pollen allelopathy. In: INDERJIT. et al. eds. Principles and Practices in Plant Ecology: Allelochemical Interactions. 1.ed. Boca Raton: CRC Press, 1999. p.129-148.

NCUBE, B.; VAN STADEN, J. Tilting Plant Metabolism for Improved Metabolite Biosynthesis and Enhanced Human Benefit. **Molecules**, v.20, p. 12698-12731, 2015.

PARIZOTTO, A.V. et al. Influência do aleloquímico 2-benzoxazolinona na atividade fotossintética de plantas de soja (*Glycine max* L.Merrill). VII EPCC – Encontro Internacional de Produção Científica Cesumar - Centro Universitário de Maringá, 2011. **Anais...** Maringá: CESUMAR, 2011. p.1-6.

PIRES, N. M.; OLIVEIRA, V. R. Alelopatia. In: OLIVEIRA, R. S.; CONSTANTIN, J. **Plantas daninhas e seu manejo.** 1.ed. Agropecuária, Guaíba, 2001. p. 145-185.

PICHERSKY, E.; GANG, D.R. Genetics and biochemistry of secondary metabolites in plants: an evolutionary perspective. **Trends in Plant Science**, v.5, n.10, p.439-445, 2000.

PIRZAD, A. et al. Allelopathy of sage and white wormwood on purslane germination and seedling growth. **Notulae Scientia Biologicae**, v.2, n.3, p.91-95, 2010.

R DEVELOPMENT CORE TEAM. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. Available at < http://www.R-project.org> Acess on: 20.Aug.2014.

REIGOSA, M. J. et al. Ecophysiological approach in allelopathy. **Critical Reviews in Plant Sciences**, v.18, n.5, p.577-608, 1999.

RICE, E.L. **Allelopathy.** 2.ed., New York: Academic Press, 1984. 422p.

ROWSHAN, V.; KARIMI, S. Essential oil composition and allelopathic effect of *Salvia macrosiphon* Boiss. on *Zea mays* L. **International Journal of Agriculture: Research and Review,** v.3, p.788-794, 2013.

SAITO, L.M. **As plantas praguicidas:** alternativa para o controle de pragas da agricultura. Embrapa: Meio ambiente. Jaguariúna, 2004. 4p.

SANGEETHA, C.; BASKAR, P. Allelopathy in weed management: a critical review. **African Journal of Agricultural Research**, v.10, n.9, p.1004-1015, 2015.

SANTOS, E.P. ***Salvia* in Lista de Espécies da Flora do Brasil.** Jardim Botânico do Rio de Janeiro, 2014. Available at: <http://reflora.jbrj.gov.br/jabot/floradobrasil/FB8296>. Access on: 03.Jun.2015

SIMONETO, E. L.; CRUZ-SILVA, C. T. A. Alelopatia de sálvia sobre a germinação e o desenvolvimento do milho, tomate e girassol. **Cultivando o Saber**, v.3, n.3, p.48-56, 2010.

SOUZA-FILHO, A. P. S. et al. Metodologias empregadas em estudos de avaliação da atividade alelopática em condições de laboratório – Revisão crítica. **Planta Daninha,** v. 28, n.3, p.689- 697, 2010.

THEISEN, G.; VIDAL, R. A. Efeito da cobertura do solo com resíduos de aveia preta nas etapas do ciclo de vida do campim marmelada. **Planta Daninha**, v.17, n.2, p.189 - 96, 1999.

VEBERIČ, R. **Bioactive compounds in fruit plants**. 1.ed. Ljubljana: Biotehniška fakulteta, 2010. 65p.

VIECELLI, C. A.; CRUZ-SILVA, C. A. T. Efeito da variação sazonal no potencial alelopático de Sálvia. **Semina: Ciências agrárias**, v.30, n.1, p.39-46, 2009.

YANG, C. M. et al. Effects of three allelopathic phenolics on chlorophyll accumulation of rice (*Oryza sativa*) seedlings: II. Stimulation of consumption-orientation. **Botanical Bulletin of Academia Sinica**, v.45, n.2, p. 119-125, 2004.