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Study on Inhibitory Effects of *Ailanthus altissima* on the Growth of Weeds and Agricultural Plants

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ABSTRACT: *Ailanthus altissima* is an invasive tree. The extracts of different limbs of this tree were evaluated under laboratory and greenhouse conditions in order to determine its herbicidal effects. This study was carried out to investigate whether or not there exist Allelopathic compounds in different tissues of *Ailantus altissima* located at the north of Fars Province. The limbs of the tree were sampled in spring and autumn. In the first test, the effect of toxicity level on seed germination and *Lepidium sativum* weed radicle growth was studied. Germination was not affected by *A. altissima* extract but radicle length significantly reduced. In the second test, the effect of activity and selectivity of *A. altissima* extracts on different agricultural plants and weeds were studied. The extracts were sprayed at ratios 0, 10, 20, 30 and 40 gram/liter on young growing plants in the greenhouse. Bark extract was found to be very toxic. *Amaranthus retroflexeus* **and *Carthamus tinctorius* were significantly sensitive to all ratios of the sprayed extracts. *Echinochola crus-galli* and *Abutilon theophrasti* were not sensitive to any ratio of the extract. Therefore, this invasive tree can be used as a biological herbicide to control weeds.**

Keywords: Allelopathic, biological herbicides, *Amaranthus retroflexus*, invasive tree.

INTRODUCTION

Ailanthus Altissima, also known as Chinese Sumac and Tree of Heaven, is a deciduous tree from theSimaroubaceae family. Though native to China and South Korea, it is found in all continents, in tropical and temperate climates. This tree is a fast-growing species with roots quickly scattering. Under appropriate conditions, it grows rapidly in a bush-like manner. It is resistant to drought, food poverty and hard soil. Ailanthus tree seeds were brought from China to France and England in 1740s and 1750s. At first, it was used as an ornamental tree in streets, as a material for making pulp (Illick and Brouse, 1926) and as a food resource for silkworm larva (Anderson E, 1961). Nowadays, this tree has been classified as an unwanted and invasive weed tree in most of regions of the world. Its population in its native region, China, is under control by biological agents and pathogenic fungus (Ding *et al*, 2006). In some other region, however, it has become an invasive plant due to lack of ecological pressure. This plant has medicinal properties and is also used in wood industry (Hu, 1979). Also, it is able to kill insects and nematodes and has anti-nutritional properties and is therefore used as a pesticide in China (Grainge & Ahmed, 1988; Yang & Tangs 1988). Allelopathic compounds, which are the secondary products resulting from metabolic routes of the plant, are produced in different limbs of the plant and enters the environment through roots, being able to affect the adjacent plants. This can directly or indirectly create an ecological communication between different plant species (Chon & Nelson, 2010). The plants which are able to produce allelopathic compounds can affect the adjacent plants and reduce their growth, whereby extending their own growth and dominating the area. In other words, allelopathy is a tool by which invasive plants, particularly non-native ones, can dominate their area. Environmental tensions such as water tension, saltiness, heavy metals and high and low temperature can increase secretion of allelochemicals (Tesio & Ferero, 2010). Hence, allopathic potential of a plant varies under different environmental conditions. Among the most important herbaceous plants with allelopathic potential is rice (*Oryza sativa*). This herbaceous plant possesses very effective allelopathic substances. Researchers believe that such substances come from roots and, in the time of germination, the barks around the seed. Rice straw has allelopathic substances too. Phenolic, aromatic and benzene have been identified as inhibitory substances of rice (Rimando and Duke, 2003).

Allelopathic substances present inrice have inhibitory effect on *Echinochola crusgalli*. They reduced germination by 88%, reduced radicle length by 100% and reduced plumule length by 83%. Also, according to greenhouse studies, allelopathic properties reduced the height by 45% and reduced dry weight of the plant by 64% (Jafari *et al.*, 2011)

A research on ecological effect of Ailanthus tree on native and non-native plants in Virginia Forest Park revealed that the most important inhibitory effect of this tree comes from allelopathic compounds present in the soils in which the plant has grown. Compared to non-native plants, native herbaceous plants were more affected by allelochemicals of Ailanthus tree (Small et al., 2010). The studies made in Shiraz University on the limbs of Ailanthus tree located at Eram Garden revealed that the extract of plumule of this tree considerably reduces radicle growth (Moradshahi *et al.*, 2002). Heisay & Heisay (2003) studied the effect of different levels (0, 23, 47, 93 and 177 kg/hectare) of Ailanthus tree bark extract on 17 weed plant species. Low levels of bark extract caused death and over 50% damage in 9 out of 17 species under study and meaningfully reduced dry weight of biomass of stem in 17 species. This research was made to investigate whether or not such inhibitory compounds exist in different tissues of Ailanthus tree located at Bajgah, Fars Province.

MATERIALS AND METHODOLOGY

The trees under study are located at Bajgah, Shiraz, Fars Province. Bajgah region is situated at the north of Fars Province, 12 km distant from Shiraz, with longitude of 52-46, latitude of 29-50 and altitude of 1810 m. Its rainfall is 393 mm and its average humidity is 35.1%. The used limbs of Ailanthus tree were: 1) leaf and 2) bark (in the height of 10-20 cm from lower part of the tree); 3) young stems, 4) root, 5) fruit. The limbs were broken into smaller parts and were dried in the special container for three days in temperature of 50°C. To achieve the best time period of soaking the tissues in water, 10 grams of the dried limbs were soaked in 1000 ml of distilled water in separate containers for 3, 6, 9, 12 and 15 days in room temperature (laboratory). 25*lepidium*seeds and 10 ml of the prepared extract were added to each pot in the intended day (four repetitions). Also, a treatment was used as control (only distilled water). The amount of germinated seeds and final growth of *lepidium* radicles were measured after three days. After achieving the right time period of soaking the limbs, concentrations of 0 (control), 10, 20, 30 and 40 mg of the extract in 1000 ml of distilled water were tested on *Echinochola crus-galli*, *Amaranthus retroflexus*, *Abutilon theophrasti* and *Carthamus tinctorius* in the greenhouse. 240 vases with diameter of 10 cm were prepared and 20 seeds of agricultural plants and weeds were separately planted in each pot. After germination and before applying treatments, the number of plants decreased to 10 in each pot. When the plants reached the four-leaf stage, the extract was sprayed to each pot in a way to fully cover the plants. The sprayed plants were studied once every two days for a period of two weeks and the percent of phytotoxicity was calculated by eye (Heisey, 1996). Data statistical analysis was carried out by SAS software.

RESULTS AND DISCUSSION

A. Laboratorial bioassay

According to data variance analysis, the type of tissue had no significant effect on the number of *lepidium* germinated seeds. The findings revealed that bark has more inhibitory effect on *lepidium* growth than other tissues had. In general, the lowest growth of *lepidium* was seen to be in the presence of bark extract, fruit extract, root extract and leaf extract, respectively (Table 1).

Table 1: Variance analysis of tissue effect, time period of soaking and the effect of these two on germination and length of Lepidium radical.

Source of changes	Degree of Freedom	Means of Squares (MS)	
		Number of germinated seeds	Length of radicle (mm)
Tissue type	4	1.26 ^{ns}	11.29**
Period of soaking	5	26.93**	545.54**
Tissue kind * period of soaking	20	8.55**	2.06^{ns}
Eror	72	1.36	2.63
Total	95		

Ns, * and ** are meaninglessens and meaningfullness in the level 5% and 1%.

Heisey (1996) found out that *lepidium* is more sensitive to *Ailanthus* bark extract than to extracts of its other limbs. In view of laboratorial results, since there was no significant difference between soaking time periods (3 to 15 days), an average time period (9 days), was determined for extract preparation in greenhouse (Table 2). This soaking time period has been also recommended by Heisey (1996).

B. Greenhouse Bioassay

Based on the analysis of variance table bark extract Root extract of Ailanthus altissima had a significant effect on dry Biomass of *Amaranthusretroflexus*, *Abutilon theophrasti*, *Carthamus tinctorius* and decreased it, but had not significant effect on *Echinochola crus-galli* (Table 3). According to the results, bark extract with concentration of 40 ml significantly reduced (64.44%) the dry weight of *Carthamus tinctorius*. Root extract with concentration of 20 ml reduced the dry weight of *Carthamus tinctorius* by 67.77%. Fruit extract with concentrations of 30 and 20 ml reduced the dry weight of *Carthamus tinctorius* by 85.55% and 84.44% respectively (Table 4).

Table 2: The effect of tissue type on the amount of germination and length of lepidium radicle (25 seeds in each pot).

Tissue type	Number of germinated seeds	Lengh of radicle (mm)
Control	25[a]	19.8a
Leaf	24.25[a]	8.21 [b]
Stem	24.17[a]	8.2 [b]
Root	24[a]	7.51 [c]
Bark	23.83[a]	7.04 [d]
Fruit	24.37[a]	7.56 [c]

* Means with different letters in each row are significantly different (5%, LSD)

Table 3: Variance analysis of the effect of concentration on dry weight of biomass of plants.

Source of changes Degree of Freedom	Degree of Freedom	Means of Squares (MS)			
		Carthamus Tinctoriu	***Amaranthus retroflexus***	***Abutilon Theophrasti***	***EchinocholoaCrus galli***
Organ	3	0.99**	0.02**	0.07 ns	0.03 ns
Concentration	4	0.04**	0.05**	0.10 ns	0.02 ns
Organ × concentration	12	0.01 ns	0.05**	0.07 ns	0.008 ns
Error	30	0.01	0.001	0.01	0.008

Ns, * and ** are meaninglessens and meaningfullness in the level 5% and 1%.

Table 4: The effect of tissue type and concentration on biomass dry weight (grams per surface unit) and loss percentage*Carthamus tinctorius* plant.

Organ type	Concentration	Biomass weight (g/pot)	Damage
Bark	0	0.9 [a]	0
	10	0.78 [b]	25
	20	0.8 [b]	25
	30	0.69 [c]	50
	40	0.58 [d]	50
Root	0	0.9 [a]	0
	10	0.67 [b]	25
	20	0.61 [b]	25
	30	0.68 [b]	25
	40	0.68 [b]	25
Fruit	0	0.9 [a]	0
	10	0.8 [b]	25
	20	0.82 [b]	25
	30	0.77 [c]	25

Means with different letters in each row are significantly different (5%, LSD). Each pot (78.5cm^2) contains 10 plants.

Heisey & Heisey (2003) reported that the use of Ailanthus bark extract with concentrations of 366 and 177 kg/hectare caused damages such as brownness and dryness of leaves five or six days after being sprayed on upper limbs of soya, corn, horseradish and sorghum. With respect to effect of tissue type and concentration on dry weight of biomass of *Amaranthus retroflexus*, there was a significant difference between the control and Ailanthus tree limbs extract with different concentrations. Bark and root extracts with concentrations of 40 ml reduced the dry weight of *Amaranthus retroflexus* by 21.87% and 18.75% respectively, and fruit extract with concentration of 30 ml reduced the dry weight of *Amaranthus retroflexus* by 50%.

The highest and lowest damages to *Amaranthus retroflexus* were seen to be in the presence of root extract with concentrations of 30 and 40 ml and bark extract with concentration of 40 ml (100%) respectively (Table 5).Heisey & Heisey (2003) found out that spraying *Ailanthus* bark extract with concentration of 23 kg/hectare caused the highest reduction of the dry weight and biomass of *Convolvulus arvensis*, *Chenopodium* and *Amaranthus retroflexus*. With respect to the effect of the tissue type and concentrationon dry weight of weeds, this research revealed that two weeds of *abutilon theophrasti* and *Echinocholo crusgalli* resisted against extracts of different limbs with any concentration and damage was 0% in all the treatments (Tables 6 and 7).

Table 5: The effect of tissue type and concentration on biomass dry weight (grams per surface unit) and loss percentage *Amaranthus retroflexus* plant.

Organ type	Concentration	Biomass weight (g/pot)	Damage
Bark	0	0.32^{d}	0
	10	0.13^{b}	50
	20	0.13^{b}	50
	30	0.15^{b}	75
	40	0.07^{a}	75
Root	0	0.32^{d}	0
	10	0.20^{c}	50
	20	0.15^{b}	50
	30	0.10^{b}	75
	40	0.06^{a}	75
Fruit	0	0.32^{d}	0
	10	0.20^{c}	50
	20	0.22^{c}	50
	30	0.22^{b}	50
	40	0.16^{c}	50

Means with different letters in each row are significantly different (5%, LSD). Each pot (78.5cm^2) contains 10 plants.

Table 6: The effect of tissue type and concentration on biomass dry weight (grams per surface unit) and loss percentage *Abutilon theophrasti* plant.

Organ type	Concentration	Biomass weight (g/pot)	Damage
Bark	0	0.59^{a}	0
	10	0.58^{a}	0
	20	0.58^{a}	0
	30	0.55^{a}	0
	40	0.55^{a}	0
Root	0	0.59^{a}	0
	10	0.58^{a}	0
	20	0.59^{a}	0
	30	0.58^{a}	0
	40	0.58^{a}	0
Fruit	0	0.59^{a}	0
	10	0.59^{a}	0
	20	0.55^{a}	0
	30	0.58^{a}	0
	40	0.55^{a}	0

Means with different letters in each row are significantly different (5%, LSD). Each pot (78.5cm^2) contains 10 plants.

Table 7: The effect of tissue type and concentration on biomass dry weight (grams per surface unit) and loss percentage *Echinocholo acrusgalli* plant.

Organ type	Concentration	Biomass weight (g/pot)	Damage
Bark	0	0.47[a]	0
	10	0.45[a]	0
	20	0.45[a]	0
	30	0.44[a]	0
	40	0.44[a]	0
Root	0	0.47[a]	0
	10	0.46[a]	0
	20	0.47[a]	0
	30	0.45[a]	0
	40	0.46[a]	0
Fruit	0	0.47[a]	0
	10	0.44[a]	0
	20	0.48[a]	0
	30	0.44[a]	0
	40	0.46[a]	0

Means with different letters in each row are significantly different (5%, LSD). Each pot (78.5cm2) contains 10 plants.

Interestingly, studies on two herbicides of glyphosate and paraquat and *Ailanthus* extract revealed that *Ailanthus* extract in the amount of 0.5-1 kg/hectare has an inhibitory effect comparable to the said two herbicides (Mister, 1990). According to the reports, the extract of this plant is rapidly decomposed in soil and has a very short half-life (Heisey, 1996).

CONCLUSION

The use of toxic substances (allelochemicals) present in plants is one of the ways fororganic management of weeds and other pests and diseases. *Ailanthus Altissima* can have an inhibitory effect on sensitive plants owing toallelochemicals such as Ailanthone and Methylene Chloride present in its limbs, which is a sustainable and eco-friendly management method (Hang et al., 2013). The findings revealed that *Ailanthus* extract has allelopathic effects and is able to affect certain weeds after growth. According to this research, it seems that different plant species show different sensitivities to extract of different limbs of Ailanthus tree with various densities. This indicates the selectivity of herbicidal potential of Ailanthus extract, which is very important in function. *Ailanthus altissima* is an invasive, non-native plant in Iran and very few studies have been made so far on the use of its phytotoxicity. Greenhouse and laboratorial studies revealed that *Ailanthus* extract is toxic to other plants. Although allelopathic compounds are present in the entire limbs of this plant, its bark and root had the highest inhibitory effect on agricultural plant of *Carthamus tinctoriu*. Among the weeds of *Amaranthus retroflexus*, *Echinocholo crusgalli* and *Abutilon theophrasti*, it had the highest inhibitory effect on *Amaranthus retroflexus*. *Echinocholo crus-galli* and *Abutilon theophrasti* highly resisted against the inhibitory compounds.

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