Allelopathic Effects of Sorghum Halepense (L.) Pers. and Avena Sterilis L. Water Extracts on Early Seedling Growth of Portulacca Oleracea L. and Medicago Sativa L.

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Abstract

Allelopathy uses, as target plants, the cultivated species that are sometimes considered useful for comparative analysis, but do not naturally co-exist with the donor species (Reigosa et al., 2013) . Therefore, the weed common purslane (portulaca oleracea) (Portulacaceae) was selected as a target in addition to alfalfa (Medicago sativa) (Fabaceae) to compare with it. Two worldwide distribution weeds: sterile oat (Avena sterilis), and Aleppo grass (Sorghum halepense) (Poaceae) were chosen as donor plants, Water extracts of donor plants were prepared, 2%,4%,8% concentrations were used and distilled water was used for control. Seed germination and early seedling growth of target plants were studied in petri dishes. Lengths of seedlings were measured, after that, following indicators were calculated: Relative seed germination (RSG), relative elongation ratio of Shoot (RERs) and root (RERr), Inhibition percentage of germination, shoot and root length (I), and root/shoot ratio. Means and standard deviation were calculated and means were statically analyzed with one – way ANOVA, LSD test was chosen to compare differences between treatment means at a probability levels (0.01, 0.05). The result showed that extracts had greater effects on seedling growth rather than on germination and all measurements were affected, extracts had inhibition effects on root length of the two tested species, shoot length of alfalfa, but a stimulation effect on shoot length of common purslane. All root / shoot ratios were significant in all treatments of common purslane, and alfalfa treated with Aleppo grass only, while the seed germination differences were generally non – significant, Aleppo grass extracts were more effective than that of sterile oat, and the effect generally increased by increasing concentration.

Keywords — *Allelopathy, extracts, Sterile oat, Aleppo Grass, common purslane, alfalfa, RSG, RER, root / shoot ratio, LSD.*

I. INTRODUCTION

Sterile oat and Aleppo grass belong to Poaceae (the grasses) which is considered the most successful plant family. Thus, grasses have had excellent opportunities to become aggressive invaders, and their biology has enabled them to capitalize on these opportunities (Linder, *et al.*, 2017). Allelopathy was one of these features. It has been reported in several published works to show evidence of allelopathic activity (Sánchez-Moreiras *et al.*, 2004).

Allelopathy is defined as direct or indirect, beneficial or deleterious biochemical interaction between plant and weeds, and / or plants and microorganisms through the production of chemical compounds that escape into the environment and subsequently influence the growth and development of neighbouring plants. (Rice, 1984; Sangeetha & Baskar ,2015).

Allelochemicals are present in all types of tissues, although leaves seem to be the most consistent producers of these allelochemicals (Sisodia & Siddiqui, 2010), Allelochemicals are released into the rhizosphere by a variety of mechanisms, including decomposition of residues, volatilization and root exudation. The most clearly identified compounds in poaceae can be divided into four groups: phenolic acids, hydroxamic acids, alkaloids, and quinones (Sánchez-Moreiras *et al.*, 2004; Albuquerque *et al.* , 2010; Golubinova & Ilieva,2014).

The structure and mode of action of allelochemicals are different and may offer a potential for herbicide future development. The occurrence of natural allelopathic activity in crops has important positive and negative implications for cropping system. From an ecological perspective, allelopathy may play an important role in the process of biological invasion. (Sangeetha &Baskar ,2015). Most of the extracts of various parts of weeds under test contains water soluble compounds to varying degrees. These compounds may be released by rain or irrigation and dissolved in water under field conditions (Mubeen *et al.*, 2011).

Holm *et al.* (1977) put common purslane and Aleppo grass in the list of "10 world's worst weeds", while Alfalfa was considered as the 'Queen of Forages' all over the world (Putnam *et al.*, 2001).

Sterile oat is closely related to cereal crops. So, it is expected that the potential distribution of this species will correspond to the potential distribution of cereal crops. However, sterile oat requires a specific set of climatic conditions which are not present at certain latitudes. Therefore, the distribution of this species did not correspond to the distribution of cereal crops (Kadioğlu & Farooq, 2017). The researches concentrated on the allelopathic effect of the other species of Avena (i.e. *A. fatua*) more than Sterile oat.

Common purslane is a weed of cultivation reported to be found in 45 crops in 81 countries (Galinato *et al*.,1999), the extract of its seeds has an allelopathic activity (Shehata, 2014). Aleppo grass is a companion weed to Alfalfa in all fields which were studied by Antar & Kasim (2012). Its extracts' effect on alfalfa was studied by Golubinova & Ilieva (2014) among many leguminous targeted species. Alfalfa itself has Auto-toxicity effect (Rice, 1984)

The aim of this study was to evaluate the allelopathic effects of water extract of vegetative biomass of Sterile oat, and Aleppo grass, on seed germination and early seedling growth of common purslane , and Alfalfa by some kind Simulation of nature.

II. MATERIALS AND METHODS

The experiment was performed under laboratory conditions. Seed germination and early seedling growth were studied because the critical stage in the establishment of a plant is the seed germination (Ahmad *et al.*, 2014).

1) *Plant and seed material:*

Two species of grass (Sterile oat and Aleppo grass) were used as donor plants, total vegetative mass of each one was collected, the samples were washed to remove any pollution, then they were cut into 1-3 cm pieces, after that they dried at room temperature for about a month. The samples were ground to get fine flour. Seeds of Alfalfa, common purslane were used in a germination test without any treatment.

2) *Extract preparation:*

Aqueous extract was prepared by soaking 8 grams of the grinded material in 100 ML of distilled water at room temperature, the mixture was stirred by a Magnetic mixer for 24 h. The mixture was filtered by two layers of Gauze, then by Whatman filter paper. The mother solution (8% w/v) was diluted by distilled water to get the final concentrations (2%, 4%, and 8%). The solutions were used immediately to avoid any pollution or changing in there features. Agar was prepared, and autoclaved, and used as a culture media afterwards.

3) *Bioassay for growth:*

This experiment was performed in completely randomized design (CRD) with 4 replications of each treatment, 15 seeds of tested plant were set in each 15 cm diameter petri dish, 2.5 ml of water extract from each concentration was added to each petri dish, distilled water was used for control. All petri dishes were placed in growth chamber (24°C), the number of germinated seeds was calculated after 8 days, and shoot and root length of the seedling were measured using a millimeter ruler.

4) *Data analysis:*

Seedling growth was evaluated by the use of the following indicators: relative seed germination (RSG), relative elongation of root (RERr) + shoot (RERs) by the formulas of Rho & Kil (1986) , Asgharipour and Armin (2010):

$$RSG = \frac{(\text{number of seeds germinated in extract})}{\text{number of seeds germinated in control}} * 100$$

$$RERs = \frac{\text{mean shoot elongation in extract}}{\text{mean shoot elongation in control}} * 100$$

$$RERr = \frac{\text{mean root elongation in extract}}{\text{mean root elongation in control}} * 100$$

Percentage of inhibition (Chung *et al.*, 2001):

$$I = \left[\frac{\text{control} - \text{sample extracts}}{\text{control}}\right] * 100$$

where: I=0 there are no effect, I< 0 stimulation effect, I > 0 inhibition effect. (Iman *et al.*,2006)**.**

Root/shoot ratio: is an indicator of relative growth of the root and shoot in a plant (Ahmad *et al.*, 2014).

Data were analysed statically by using one way analysis of variance ANOVA to get LSD (Least significant differences) at (0.01, 0.05) probability levels. IBM Spss Statistic ver. 19 was used for LSD test , Excel 2010 was used for equations.

III. RESULTS and DISCUSSION

Common Purslane: The shoot length ranged between 3.71 cm in control and 5.22 cm in Aleppo grass extract (8%). There were statistically significant differences in the shoot length comparing with the control in all treatments except for sterile oat extract (2%) where the difference was non-significant (table 1, figure 1), RERs ranged between (111.8%, 140.75%) with a stimulation percentage ranged between (-11.8% , - 40.75%) in the extracts of sterile oat (2%), Aleppo grass (8%) respectively, (Table 2, figure 3).

Table 1: The effects of extracts on the germination of seeds, root and shoot length of common purslane - * , ** The mean difference is significant at the (0.05, 0.01) level respectively.

Do.	Tr.	SLM	LSD	RLM	LSD	GM	LSD	R/S	LSD

	Co	3.71 ± 0.68		2.687 ± 0.83		14.75 ± 0.5		0.73 ± 0.1	
sterile oat	2%	4.15 ± 1.8	-0.44	2.257 ± 1.06	0.43**	13 ± 1.16	1.75*	0.55 ± 0.024	0.18*
	4%	4.61 ± 1.48	-0.90**	2.135 ± 0.73	0.55**	14 ± 1.16	0.75	0.46 ± 0.023	0.27**
	8%	4.31 ± 1.97	-0.60-*	1.712 ± 0.89	0.98**	13.5 ± 1	1.25	0.40 ± 0.043	0.33**
Aleppo grass	2%	4.68 ± 1.64	-0.97**	1.880 ± 0.92	0.81**	13.75 ± 0.5	1.0	0.40 ± 0.03	0.33**
	4%	4.952 ± 1.56	-1.24**	1.695 ± 0.77	0.99**	13.75 ±1.26	1.0	0.35 ± 0.09	0.38**
	8%	5.22 ±1.14	-1.51**	1.323 ± 0.68	1.36**	14.50 ± 0.58	0.25	0.25 ± 0.039	0.48**

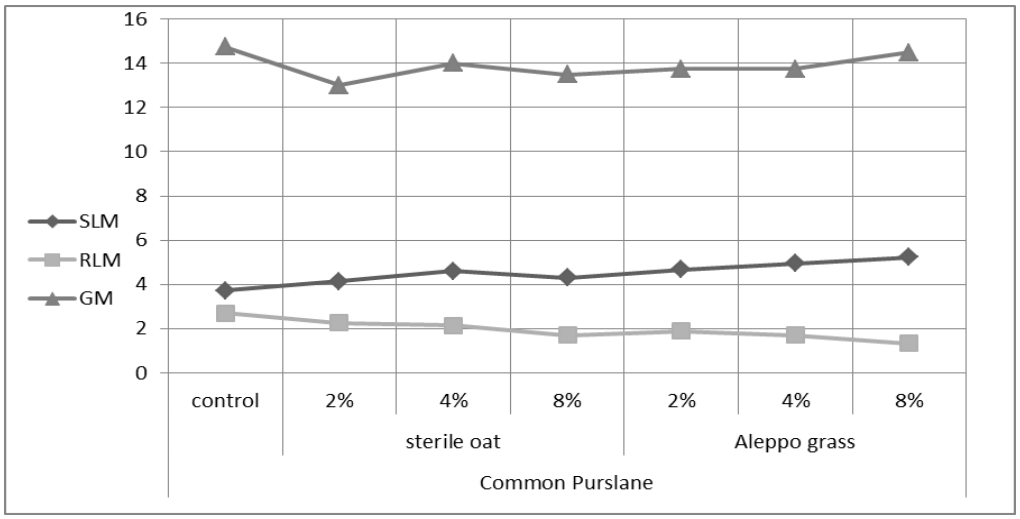

Figure 1: effects of extracts on means of germination and seedling length of common purslane.

Table 2: relative measurements of shoot , root and seed germination, and inhibition percentage of common purslane.

donor	Treatment	RERs	I. S	RER r	I. R	RSG	I. G
	Control					98	
Sterile oat	2%	111.8	-11.8	84	16.00	88.1	11.9
	4%	124.25	-24.25	79	20.53	94.9	5.08
	8%	116.16	-16.16	64	36.29	91.5	8.47
Aleppo grass	2%	126.19	-26.19	70	30.02	93.2	6.78
	4%	133.56	-33.56	63	36.91	93.2	6.78
	8%	140.75	-40.75	49	50.74	98.3	1.69

The root length of common purslane ranged between (1.32 to 2.69) cm in Aleppo grass extract (8%) and control respectively, the differences in root length were significant in all treatments (table 1, figure 1), RERr ranged from 84% to 49% with an inhibition percentage (16%, 50.74%) in the extracts of sterile oat (2%), Aleppo grass (8%) respectively (table 2, figure 3) while the differences in seed germination were significant only in sterile oat extract (2%).

Root/shoot ratio was extremely affected, it ranged between (0.73 – 0.25) in the treatments of control and Aleppo grass (8%) respectively, and all differences were significant, the ratio decreased by increasing the concentration, extracts of Aleppo grass was more effective (table 1, figure 4).

Alfalfa: The shoot length of alfalfa ranged between (5.78, 5.87 to 7.89) cm in Aleppo grass (8%, 4%) and control respectively. There were statistically significant differences in the shoot length comparing with control in all Aleppo grass concentrations only (table 3, figure 2), RERs ranged between (99.49%, 73.28%) with an inhibition percentage that ranged between (0.51% , 26.72%) in the extracts of sterile oat (2%), Aleppo grass (8%) respectively, (Table 4, figure 3).

Table 3: The effects of extracts on the germination of seeds, root and shoot length of alfalfa * , ** The mean difference is significant at (0.05, 0.01) level respectively.

donor	Tr.	SLM	LSD	RLM	LSD	GM	LSD	R/S	LSD

	c.	7.89 ± 1.21		3.66 ± 1.05		15.00 ± 0		0.46 ± 0.04	
Sterile oat	2%	7.85 ± 2.06	0.04	3.43 ± 1.12	0.23	14.50 ± 1	0.5	0.44 ± 0.04	0.03
	4%	7.38 ± 2.18	0.515	3.06 ± 1.08	0.60**	14.25 ± 0.96	0.75	0.41 ± 0.03	0.05
	8%	7.44 ± 2.24	0.45	3.06 ± 1.11	0.60**	14.25 ± 0.5	0.75	0.41 ± 0.05	0.05
Aleppo grass	2%	5.99 ± 1.93	1.90**	1.64 ± 0.74	2.02**	14.00 ± 1.16	1.00	0.27 ± 0.06	0.19**
	4%	5.87 ± 2.37	2.03**	1.33 ± 0.76	2.33**	13.50 ± 0.58	1.5*	0.23 ± 0.02	0.24**
	8%	5.78 ± 2.39	2.11**	1.3 ± 0.69	2.36**	13.25 ± 1.26	1.8*	0.22 ± 0.02	0.24**

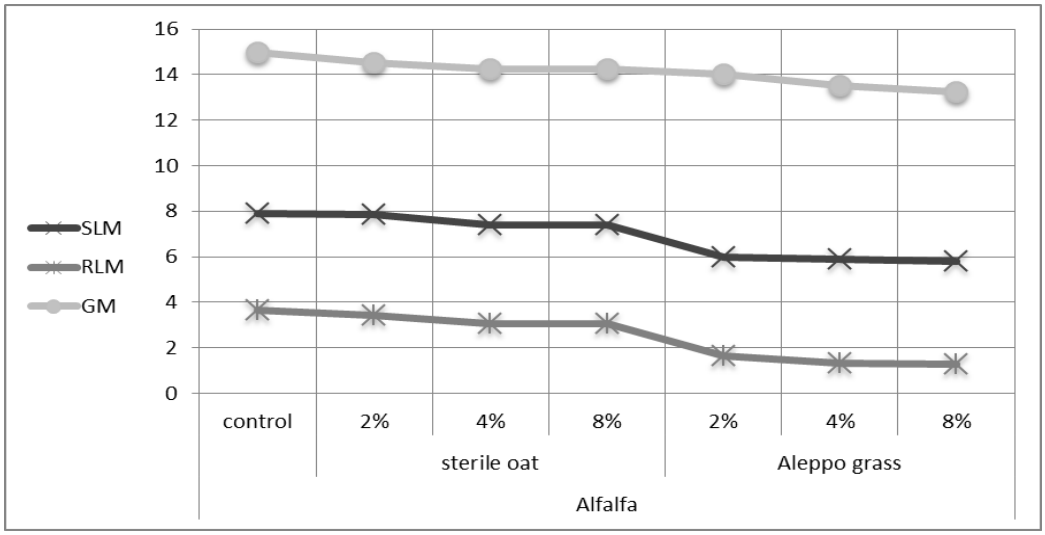

Figure 2 : effects of extracts on means of germination and seedling length of alfalfa.

Table 4: relative measurements of shoot , root and seed germination, and inhibition percentage of alfalfa.

donor	Treatment	RERs	I. S	RER r	I. R	RSG	I. G
	Control					100	
Sterile oat	2%	99.49	0.51	94	6.29	96.7	3.33
	4%	93.47	6.53	84	16.36	95	5
	8%	94.30	5.70	84	16.41	95	5
Aleppo grass	2%	75.87	24.13	45	55.10	93.3	6.67
	4%	74.34	25.66	36	63.76	90	10
	8%	73.28	26.72	36	64.45	88.3	11.67

The root length of alfalfa ranged between (1.3 to 3.66) cm in Aleppo grass extract (8%) and control respectively, the differences in root length were significant in all treatments except for sterile oat extract (2%) (table 3, figure 2), RERr ranged from 94% to 36% with an inhibition percentage (6.29%, 64.45%) in the extracts of sterile oat (2%), Aleppo grass (8%) respectively, (table 4, figure 3). There were statistically significant differences in alfalfa seed germination in the extracts of Aleppo grass (4%,8%) only.

Root/shoot ratio was between (0.22 – 0.46) in the treatments of Aleppo grass (8%) and control respectively. Root / shoot ratio was affected only in Aleppo grass extracts where the differences were significant, the ratio decreased by increasing the concentration, there were no significant effects in the rest of treatments (table3, figure 4).

The results confirm the findings of many researchers showing that allelochemicals have an inhibitory and/or lethal effects on seed germination, growth and development of seedling. the germination percentage was not much affected .

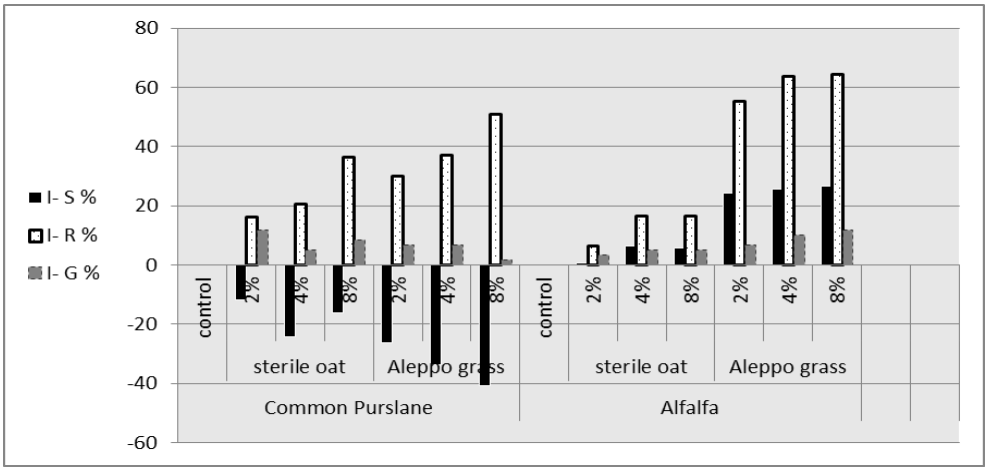

Figure 3: Inhibition percentage of shoot, root and seed germination of two tested species.

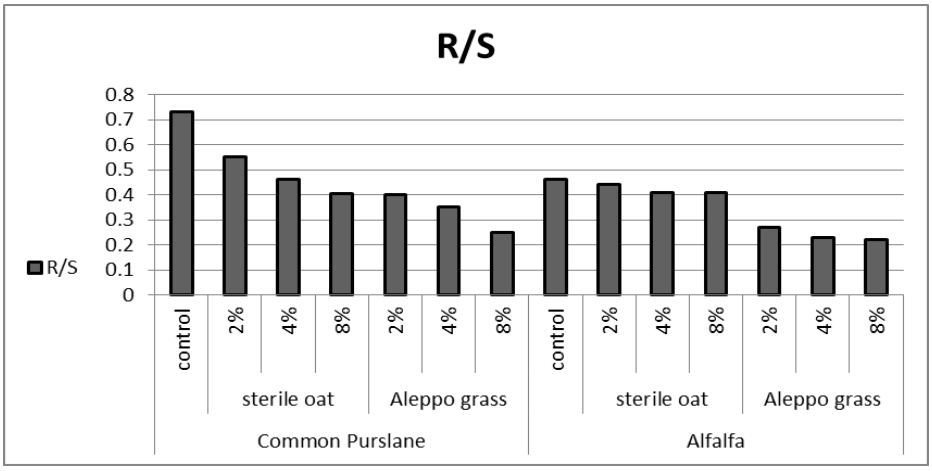

Figure 4: Root/ Shoot ratio of two tested species

The results showed extracts had greater effect on seedling growth, rather than on germination. This result is consistent with the result of many researchers such as Baličević and Ravlić (2015) in their studies on carrot's seed germination and seedling growth.

Stimulation of common purslane shoot in this study agrees with the result of Haddad and Tabbache, (2018) who noticed a stimulation effect of *Ephorbia paralias* L. extracts on common purslane seedling growth. Moreover, they explained this result according. to An *et al.* (1997), who reported that extracts may behave like Gibberellins especially at low concentrations. Decreasing root length of the tested species, agrees with most of researches as Rice (1984) reported, and the result of Golubinova & Ilieva (2014) who studied the effect of Aleppo grass on alfalfa. However, the measurements were different, maybe because they used different concentrations. Aleppo grass extracts in the present study was the most effective, the effect increased with the increase of extract concentrations, indicating that the effect of plant extracts depends on their concentrations. These results confirm that allelopathy is a concentration dependent phenomena (Shehata, 2014). The root Sensitivity to allelopathic effect could be attributed to its direct contact with the extract during bioassay. The mechanism of growth inhibition by allelopathic substances might be a result of reducing cell division and elongation. (Iman *et al.* ,2006)

IV. CONCLUSION

The allelochemicals present in the aqueous extracts of sterile oat, Aleppo grass strongly affected seedling growth parameters especially root/shoot ratio of common purslane and alfalfa. Root length was inhibited in all treatments, while shoot length was stimulated in common purslane and inhibited in alfalfa .The extracts of Aleppo grass were more effective than that of sterile oat, the effect increased by increasing the concentration. This grass was inserted in the "Global Invasive Species Database" (GISD) while sterile oat was not. So, In nature, Aleppo grass is more aggressive than sterile oat, and the result of this present study confirmed that the allelopathic effect must has a great role in the natural and ecological systems. As a result, Aleppo grass, in fields should be controlled at any stage of their life to avoid the phytotoxic allelopathic effects on crops, on the other hand Aleppo grass can be used as a natural herbicide. Allelopathy researches should concentrate on wild species, and their results should be applied.

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