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Research Article

ALLELOPATHIC EFFECTS OF MEDICINAL PLANTS ON GERMINATION AND SEEDLING GROWTH OF SOME WEEDS

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ABSTRACT

In order to investigation of allelopathic effects of medicinal plants on germination and seedling growth of different weeds, an experiment was done in Biotechnology Laboratory, Islamic Azad University- Mashhad Branch, and Iran. The experiment was conducted according to the completely randomized design (CRD) as factorial having two factors with four replications in 2011. Three different species of weeds including Peganum Harmala, Alyssum, Amaranthus Retroflexus and concentrations of shoot dry matter at five levels consisting of (0, 37, 75, 112 and 150 powder gram) of Mint, Rosemarinus, Lavandula and Achilla were applied. Results of data analysis showed that the effect of different levels of shoot dry matter concentration on germination percentage, plumule length, radicle length, seed vigor and seedling fresh weight was significant ($p<0.01$) and with increasing concentration, GP, PL, RL, SV and SFW were decreased considerably. Also, results revealed that Alyssum and Peganum were more sensitive to the inhibitory effects of dry matter concentration of medicinal plants in all the measured traits except for seed vigor index of Peganum.

Keywords: Allelopathy; morphologic characteristics; dry matter.

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1. INTRODUCTION

In developing countries which weed plants are not controlled completely, a considerable part of the production is lost due to the weed competition or allelopathy effect (Marianne et al., 2000). The ability of plants to inhibit and or stimulate growth of the other plants in the environment by exuding chemicals has been being called allelopathy. In other words, a harmful or beneficial effect of one plant on another via the production of chemical compounds that it releases into the environment directly or indirectly is nominated allelopathy (Siddiqui et al., 2009). Those allelochemicals which indirectly influence on plants growth inhibit microorganisms' activity such as nitrogen-fixing, nitrifying bacteria and ectomycorrhizae (Hunter and Menges, 2002). Allelopathy is one of the many factors which help a plant to establish in an ecosystem (Moktar Hossain et al., 2012). Use of synthetic herbicides around the world has been being led to the weed species which are resistant to the herbicides. Also environmental concerns about the safety of herbicides has brought about a demand for systems of weed management which are not so dependent on herbicides and in this regard allelopathy has been being recognized as a new approach which is environmentally friendly weed management system (Pukclai and Kato-Noguchi, 2011). Allelopathy has a considerable role in aroecosystems so that the growth and development of the crops, weeds and trees are influenced by the allelopathy (Kavitha et al., 2012). Researchers have recommended that allelopathic effects are positive and negative based on based on dose and organism (Arouiee et al., 2010). These authors claimed that allelochemicals which are released into the environment affect other plants by reducing the membrane of cells and their permeability, mineral uptake disruption and damage to the genetic material. In Asia and Africa because of human demands for wild native plants as herbal remedies, medicinal plants have been being became a component of agricultural ecosystems (Badmus and Afolayan, 2012). Many different plant species have been being investigated for the potential of allelopathy specifically aromatic plants which are able to produce a large amount of allelochemicals (Campiglia et al., 2007). It was announced that different secondary metabolites which have known as allelochemicals such as monoterpenes, sesquiterpenes and alpha-pinenes from the essential oils of specific plants prevent seed germination and brought about morphological and physiological changes in the seedling growth of different plants (Badmus and Afolayan, 2012). Since allelochemicals of different plants including medicinal plants have inhibitory effects on weeds growth, using these compounds as natural herbicides has been being suggested (Babu and Kandasamy, 1997). It was reported that investigation of allelopathic effects of medicinal plants on weeds could be helpful as guidance for sustainable agriculture (Arouiee, 2010).

So the purpose of the present study was to evaluate the allelopathic potential of different concentration of shoot aqueous extract of medicinal plants on weeds morphological characteristics.

2. MATERIAL AND METHODS

In order to study of allelopathic effects of shoot aqueous extract of medical plants (Mint, Rosemarinus, Lavandula and Achilla) on germination and seedling growth of different weeds, an experiment was done in Biotechnology Laboratory, Islamic Azad University- Mashhad Branch. The experiment was conducted according to completely randomized design (CRD) as factorial having two factors with four replications in 2011. Experiment treatments consisted of stem and leaf dry matter of Mint, Rosemarinus, Lavandula and Achilla at five levels of (0, 37, 75, 112 and 150 gram) powder in pot and seeds of three different species of weeds including Peganum Harmala, Alyssum and Amaranthus Retroflexus were applied. In every pot, 20 seeds were sown. The emerged seeds were counted daily and at the end of the period (2 months), eight seedlings were left. During the last 4 weeks of the growing season, yield indicators of the eight seedlings were calculated at flowering stage.

Parameters measured were germination percentage (GP), plumule length (PL), radicle length (RL), seed vigor (SV), seedling length (SL) and seedling fresh weight (SFW). Each replication consisted of a petri dish in which 25 seeds were put and the needed amount of extraction was added depending on treatment. Then during 10 days, the germinated seeds were counted.

(1) $GP=100*(Ni/S)$ GP = germination % Ni = germinated seeds S = seeds total number

(2) $GR = Ni/Ti$ GR = germination rate Ni = germinated seeds Ti = day numbers

(3) $SV = (RL+PL)*G$ (%) SV = seed vigor RL = radicle length PL = plumule length

Statistical analysis was conducted using the MSTAT-C statistical package. Microsoft Excel was used to make graphs of the collected data. Duncan's multiple rang test (DMRT) at the 0.05 probability level was applied to compare treatment means.

3. RESULTS AND DISCUSSION

1- Germination Percentage (GP): Analyze of variance showed that in Alyssum the effect of different dry matter concentration on germination percentage was significant ($p<0.01$) (table

1). While in Peganum and Amaranthus the effect of medicinal plant and different dry matter concentration on germination percentage was significant ($p<0.01$) (table 1). Mean comparisons revealed that in Alyssum, Lavandula (49.87 %) and Achilla (41.73 %) dry matter caused the highest and lowest GP, respectively (fig 1). Also in Peganum, Lavandula (64.13 %) and Achilla (39.20 %) dry matter and in Amaranthus, Lavandula (67.73 %) and Achilla (47.20 %) had the maximum and minimum GP (fig 1). Furthermore, mean comparisons showed that with increasing concentration of dry matter concentration, germination percentage of the weeds was decreased. These results are in agreement with those of Sunar et al., 2009 who found that Verbascum aqueous extract reduced dramatically corn germination percentage and Alagesaboopathi (2011) who showed that Andrographis paniculata declined seed germination of Sesamum. Effects of allelochemicals on seeds germination is exerted via normal cellular metabolism disrupting than through damage or organelles (Hassan et al, 2012). Moktar Hossain et al (2012) found that the difference in the plants germination percentage was due to the differences in the selective permeability of the seed coat to inhibitory substances.

2- Plumule Length (PL): Analyze of variance showed that the effect of medicinal plant and different dry matter concentrations on plumule length of the weeds was significant ($p<0.01$) (table 1). Mean comparisons revealed that in Alyssum, Peganum, and Amaranthus, Lavandula dry matter brought about the maximum PL (6.26, 6.40 and 12.40 cm), respectively (fig 2) and the lowest length of plumule in all the weeds was related to the Achilla dry matter (4.46, 4.55, 10.77 cm) (fig 2). Increase in powder concentration had the inhibitory effect on PL. The highest and lowest length of plumule in Alyssum was recorded for control (7.83 cm) and 150 gr powder (2.60 cm). In Peganum, control (8.50 cm) and 150 gr powder (2.97 cm) concentration had the highest and lowest PL, respectively. Also, in Amaranthus, the maximum PL was recorded for control (18.50 cm) and the minimum PL was recorded for 150 gr powder (6.70 cm) concentration. The inhibitory effect of some allelochemicals on growth and development of different species at certain concentration could simulate the growth of other species (Kavitha et al., 2012). Benyas et al., (2010) claimed that plumule length of Lentil was not affected by different concentrations of Xanthium. Nesrine et al., (2011) found that plumule length of Bromus tectorum was decreased by increasing of Euphorbia aqueous extract concentration. While, Melilotus indica plumule length was not completely reduced by the Euphorbia. Reduction in PL by the allelochemicals is due to the inhibition of cell division and elongation or decrease in stimulatory effects of abscisic acid (ABA) and gibberellin

(Benyas et al., 2010). Essential oil action on the growth of plumules is not clear but some researches have shown that volatile monoterpens are strong inhibitors of cell mitosis (Romangi et al., 2000). Hormonal imbalance could be one of the most important reasons of plumule length reduction. Since some of the allelopathy mechanism are like plant hormones and allelochemicals injure cell membranes of the receiver plants which consequently affect hormonal balance and ions assimilation (Peng et al., 2004).

3- Radicle Length (RL): Data presented in table 1 showed that the effect of medicinal plant on radicle length was significant ($p<0.01$) except for Amaranthus but the effect of dry matter concentration was significant on the three weeds ($p<0.01$) (table 1). Mean comparisons indicated that in Alyssum, Peganum, and Amaranthus, Lavandula dry matter brought about the maximum RL (6.36, 5.58 and 8.60 cm), respectively (fig 3) and the lowest length of Radicle in all the weeds was related to the Achilla dry matter (5.05, 4.33, 7.36 cm) (fig 3). The highest and lowest length of Radicle in Alyssum was observed in control (8.50 cm) and 75 gr powder (3.18 cm). In Peganum, control (7.66 cm) and 150 gr powder (3.11 cm) concentration had the highest and lowest RL, respectively. Also, in Amaranthus, the maximum RL was observed for control (13.67 cm) and the minimum RL was recorded for 150 gr powder (4.33 cm) concentration. Tokasi et al., (2011) reported that radicle length of Amaranthus retroflexus, Chenopodium album and Solanum nigrum was decreased by the aqueous extract of alfalfa. It was claimed that aqueous extract of allelopathic plants had more inhibitory effect on radicle length than plumule length. Since radicle length is the first part which absorb the allelochemicals from the environment (Salam and Kato-Noguchi, 2010). Also, the permeability of allelechemicals into the radicle is more than plumule (Nishida et al., 2005). Reduction of radicle length by the allelochemicals is due to the decrease in cell division, decrease in the root growth auxin-induced rate and interfering in respiration and oxidative phosphorylation (Connick et al., 1989).

4- Seed Vigor Index (SVI): Analyze of variance revealed that the effect of dry matter concentration on seed vigor index was significant in Alyssum, Peganum and Amaranthus ($p<0.01$) and the effect of medicinal plant was significant in Amaranthus ($p<0.05$) (table 1). Mean comparisons revealed that in Alyssum, Peganum, and Amaranthus, Lavandula dry matter brought about the maximum SVI (175.1, 453.5 and 238.5), respectively (fig 4) and the lowest Seed Vigor Index in all the weeds was related to the Achilla dry matter (142.7, 358, 151.7 cm) (fig 4). The highest and lowest of SV in Alyssum was observed in control (342.2) and 150 gr powder (54.99). In Peganum, control (853.8) and 150 gr powder (152.2) concentration had the highest and lowest SV, respectively. Also, in Amaranthus, the maximum SV was observed for control (355.2) and the minimum SV was recorded for 150 gr powder (83.89) concentration. The present findings got support from the earlier studies of Khan et al., (2011) who found seed vigor index of Kidneybean, Mungbean, Chickpea and Soybean was decreased with increasing aqueous extract concentration of Silybum marianum. Yasin et al., (2012) reported that seed vigor index of wheat was decreased up to 87.23 % due to the phytotoxicity effect of Calotropis procera extract. Also, Tanveer et al., (2010) claimed that aqueous extract of Euphorbia helioscopia reduced the seed vigor index of Wheat, Chickpea and Lentil.

5- Seedling Length (SL): Data presented in table 1 showed that the effect of medicinal plant on seedling length was significant ($p<0.01$) except for Amaranthus but the effect of dry matter concentration was significant on the three weeds ($p<0.01$) (table 1). Mean comparisons revealed that in Alyssum, Peganum, and Amaranthus, Lavandula dry matter caused the maximum SL (12.63, 11.7 and 20.93 cm), respectively (fig 5) and the lowest seedling length in all the weeds was related to the Achilla dry matter (9.55, 9.17 and 18 cm) (fig 5). With increasing powder concentration, SL was decreased. The highest and lowest amount of SL in Alyssum was observed in control (16.33) and 150 gr powder (5.79). In Peganum, control (16.17) and 150 gr powder (6.09) concentration had the

highest and lowest SL, respectively. Also, in Amaranthus, the maximum SL was observed for control (31.83) and the minimum SL was recorded for 150 gr powder (11.04) concentration. Nouri et al., (2012) found that different tissues extracts of sorghum plants has an effect stimulated on longitudinal growth of wheat seedling. Allelochemicals via cell division stimulating and its elongation could improve seed germination and seedling growth (Bhowmic and Inderjit, 2003). Piraste Anoshe et al., (2011) claimed that Rosemary aqueous extract significantly reduced wheat and oat seedling length. An important part of allelochemicals effect appears at early growth stages of seedling which impair cell division and seedling metabolism (Panwar et al, 2004). One of the stated reasons for reducing in seedling growth when exposed to allelopathic compounds is alteration in mitochondrial respiration leading to decrease in ATP providing for all the process that require energy (Gniazdowska and Bogatek, 2005).

6- Seedling Fresh Weight (SFW): Analyze of variance indicated that the effect of medicinal plant on seedling fresh weight of Alyssum ($p<0.01$) and Peganum ($p<0.05$) was significant except for Amaranthus but the effect of dry matter concentration was significant on the three weeds ($p<0.01$) (table 1). Mean comparisons revealed that in Alyssum, Peganum, and Amaranthus, Lavandula dry matter caused the maximum SFW (0.032, 0.02 and 0.103 gr), respectively (fig 6) and the lowest seedling fresh weight in all the weeds was belong to the Achilla dry matter (0.019, 0.018 and 0.09 gr) (fig 6). With increasing powder concentration, SFW was reduced. The highest and lowest value of SFW in Alyssum was observed in control (0.039 gr) and 150 gr powder (0.014 gr). In Peganum, control treatment (0.039 gr) and 150 gr powder (0.011 gr) concentration had the highest and lowest SFW. Also, in Amaranthus, the maximum SFW was observed for control (0.29 gr) and the minimum SFW was recorded for 150 gr powder (0.018 gr) concentration. Our results were in line with the findings of Ayyaz Khan et al., (2008) who stated that The Eucalyptus extract had decreased the seedling fresh weight of wheat varieties. Nouri et al., (2012) claimed that leaf and stem aqueous extract of Sorghum halepense had a significant effect on wheat seedling length and reduced seedling fresh weight of wheat. Also, Alagesaboopathi (2010) reported that aqueous extract of Centella asiatica decreased fresh and dry weight of Pearl millet and Chickpea which was due to the stunting of vegetative growth, thin seedlings and phytotoxicity activity of allelochemicals. It was indicated that fresh weight of Sisymbrium officinale was decreased by root exudates of rice (Mahmoodzadeh et al., 2011).

4. CONCLUSION

The present study showed that different weeds had various sensitivities to the allelochemicals and weed species differences in sensitivity to the medicinal plants have been being reported by many researchers. Also, the inhibitory effects of medicinal plants was different that could be due to the type, quantity and the characteristics of allelopathic substances produced by these plants. The obtain results proved that higher concentrations of medicinal plants have more inhibitory effects on germination and seedling growth of weeds and can be used in cultivation of organic crops and natural herbicides production.

Table 1. Analysis of variance of effect of medical plants on germination and morphological traits of weeds

Weed	S.O.V	df	GP	PL	RL	SVI	SL	SFW
				MS				
Alyssum	Medical plants	3	202.106ns	10.915**	4.804**	3753.266ns	29.198**	0.001**
	Concentration	4	12576.517**	47.408**	50.363**	193813.884**	195.860**	0.001**
	Interaction	12	35.161ns	0.791ns	0.964ns	1497.275ns	2.325ns	0.002ns
	Error	40	157.483	0.594	0.756	8212.248	2.356	0.002
Peganum	Medical plants	3	1920.244**	9.425**	5.030**	45571.234ns	18.341**	0.001*
	Concentration	4	10722.667**	54.967**	34.122**	1381486.166**	174.024**	0.002**
	Interaction	12	237.467**	1.358**	1.424**	18465.203ns	4.451**	0.001**
	Error	40	78.133	0.198	0.346	76104.576	0.847	0.001
Amaranthus	Medical plants	3	1293.511**	7.082ns	4.567ns	30314.378*	23.571 ns	0.001ns
	Concentration	4	6320.500**	266.152**	168.933**	203844.953**	827.285**	0.158**
	Interaction	12	165.122**	2.613ns	5.039ns	3000.784ns	14.394ns	0.001ns
	Error	40	41.800	7.933	9.025	8155.074	35.004	0.004

**, *, ns: Significant at 1 and 5 % probability levels and non-significant, respectively.

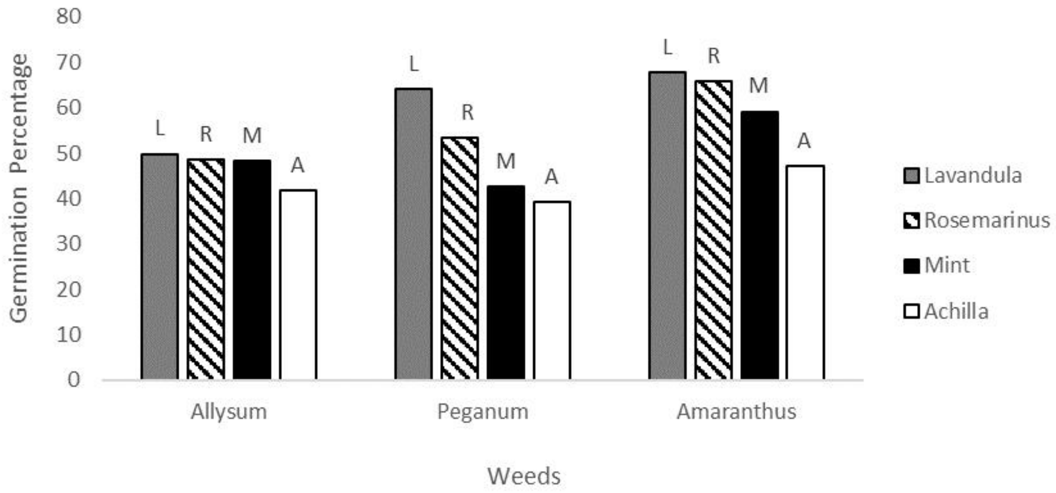

Fig.1. Allelopathy effect of medicinal plants on weeds germination percentage

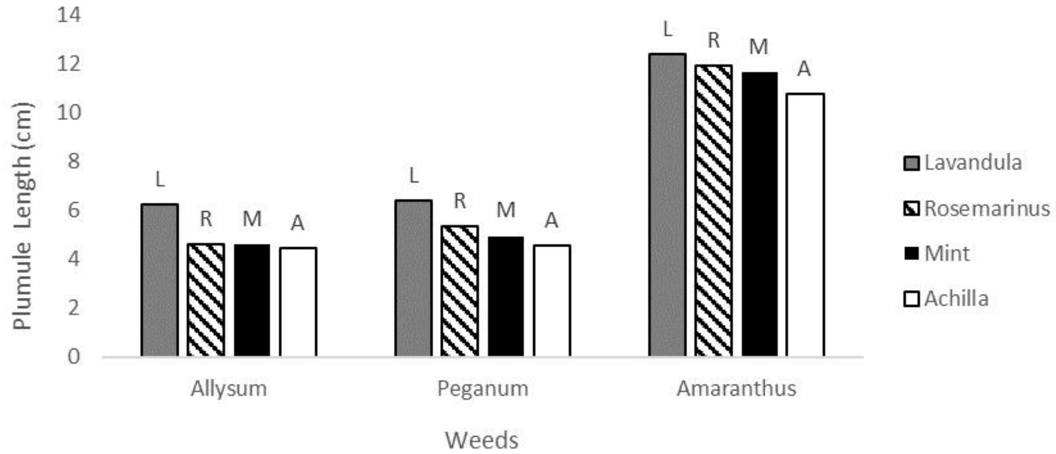

Fig.2. Allelopathy effect of medicinal plants on weeds plumule length

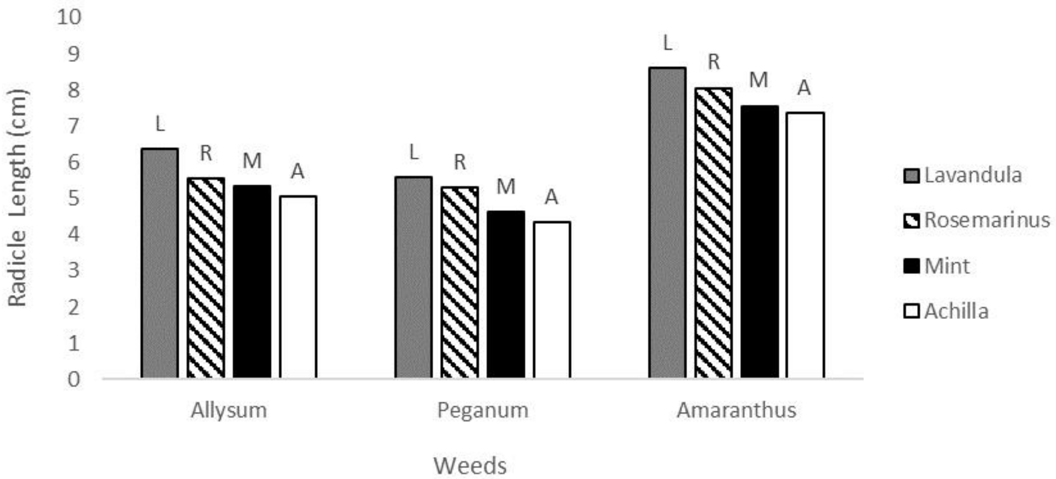

Fig.3. Allelopathy effect of medicinal plants on weeds radicle length

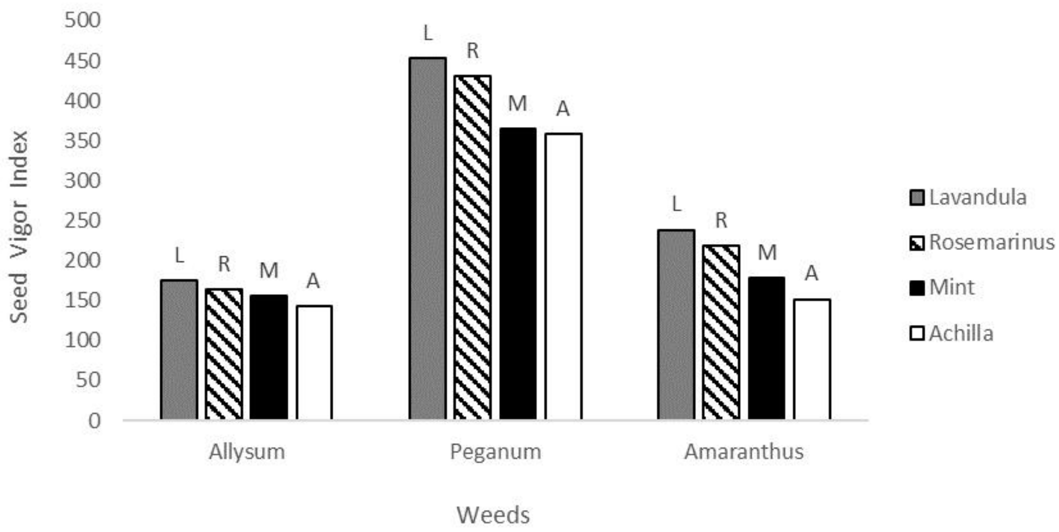

Fig.4. Allelopathy effect of medicinal plants on weeds seed vigor index

Fig.5. Allelopathy effect of medicinal plants on weeds seedling length

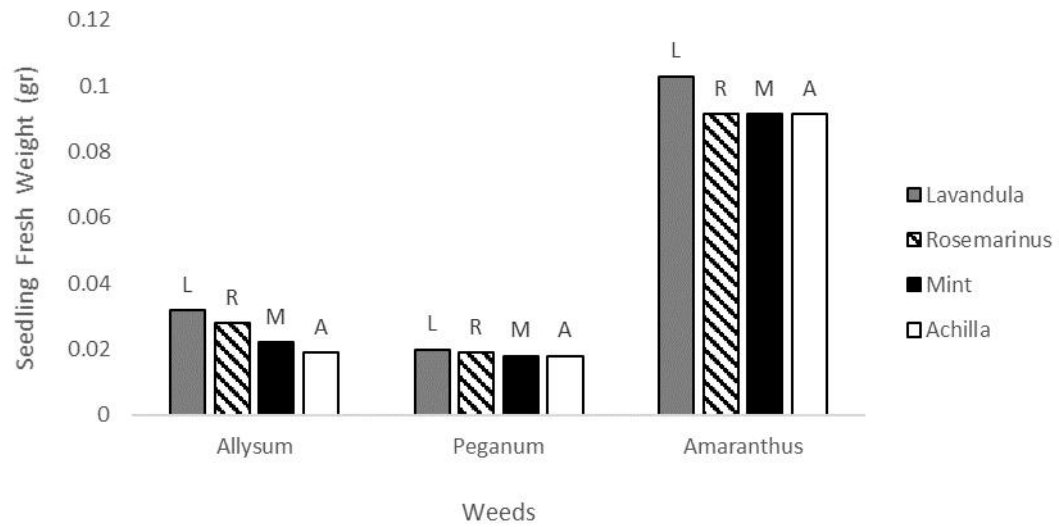

Fig.6. Allelopathy effect of medicinal plants on weeds seedling fresh weight

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