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Allelopathic effects of Yarrow (*Achilla millefalium*) on the weeds of corn (*Zea mays* L.)

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ABSTRACT

The allelochemicals or secondary plant metabolites when released to the environment, influence the germination and seedling growth of neighbor weeds. The aim of this study was to investigate the effect of the extract of Yarrow (Achilla millefalium) on the number and mass of weed seedlings and their seed germination under laboratory conditions. The effects of different concentrations (1.25 to 20%) of Yarrow extracts were evaluated on the germination and seedlings growth of Zea maize, Johnsongrass (Sorghum halepense), Common lambsquarter (Chenopodium album) and Redroot pigweed (Amaranthus retroflexus) for 5 days. Results showed that with the increasing concentration of Yarrow extracts, their effects on reducing seed germination and seedling growth of the above mentioned plants were more severe. Comparison of extract effects with polyethylene glycol, revealed that reduction of seed germination and seedling growth in Johnsongrass and Common lambsquarter were attributed to the osmotic pressure of the extract, whereas inhibition of seed germination of Redroot pigweed and corn was due to allelochemicals.

Key words: Allelopathy, *Achilla millefalium*, extract, weeds, corn.

INTRODUCTION

Environmental effects of chemical herbicides and the limitations of their implementation have led to the increasing importance of non-chemical alternatives in the management of weeds [3]. Allelopathy is the biochemical reactions between two or more plants or cultivars in which the release of natural chemical materials (Allelopathins) by a herb affects the physiological processes of neighboring plants or organisms [3]. Using this phenomenon, one might be able to control the weeds in farms without implimenting chemical herbicides. For example, the inhibitor effect of walnut leaves on neighboring herbs is an instance of allelopathic effects [15]. Jung et al. (2004) reported that various types of rice have different inhibitor effects on the emersion of Barnyardgrass seedlings [14]. In addition, in their green house experiments, Abdul- Rehman and Habib (1989) demonstrated that alfalfa and its decomposed remains have allelopathic effects on Gramine (*Imperata cylindrica*) [1].

Observations conducted in Pakistan indicate that commixing the remains of forage sorghum with soil and cultivating wheat in it is 40-50 percent effective in controlling weeds and leads to a better performance of the seed up to 15 percent [4]. With its allelochemicals, Rye (*Secale cereale*) has been used as a covering plant and mulch in cultivations such as corn, cotton and soya in the U.S [13, 2].

Medicinal and aromatic plants have ingredients that pose inhibitor effects on germination and growth of other plants [12]. Inhibitory capability of allelopathins of shaddock medicinal plant on the growth of some plants indicates that the extract of this plant has inhibitory effects on the growth of weeds [8]. Effect of tea leaf extract on the growth of linen showed that this plant is affected by the tea leaf extract [11].

Yarrow (*Achilla millefalium*) is a several-years-old plant from Asteraceae family which is used as medical plant due to its multiple essenses and alkaloid and glycoside ingredients [3]. Known allelopathing in plants which have toxic properties mostly inclued alkaloid, glycoside and phenolic ingredients [9, 18].

The objectives of this research was (i) to study the allelopathic effects of Yarrow medicinal plants on the germination of the seeds and the growth of seedlings of weeds including Reedroot pigweed (*Amaranthos retroflexus*), Common lambsquarter (*Chenopodium album*) and Johnsongrass (*Sorghum halepense*) as well as cultivation plant corn (*Zea maize*) in laboratory circumstances (ii) to segregate the allelopathic effects of the extracts, from Osmotic pressure (Polyethylene glycol solution).

MATERIALS AND METHODS

This research was conducted in the laboratory of Iranian Phytopathology Research Institute. After drying in shaddow and 25ºC temperature, aerial parts of Yarrow was grinded and powdered. Fifty grams of this powder was added to 500 ml water containing 20' alchohol and then put on shaker with rotational speed of 130 tpm in room temperature (22$\pm$2ºC) for 24 hours. The extract was passed through filter paper and 500 ml water containing 20º alchohol and then put on shaker with rotational speed = 130 tpm in room temperature for 24 hours. The resulted solution was passed through filter paper. The extracts obtained from this two processes were then mixed and kept in temperature -5ºC for the next steps of the experiment. In order to eliminate alchohol, the extract was dried in room temperature under vacuum using rotary evaporator. Resulting remains from drying the extract was dissolved in 50 ml water containing 20º alchohol and various densities of the medicinal plant extract were provided from it. Densities of 1.25, 2.5, 3.75, 5, 10, 15 and 20 microliters of this alchoholic extract were added to Petri dishes containing filter paper [19] (**Table 1**).

Polyethylene glycol tests were conducted to determine the standard of osmotic pressure in exploring the effects of Yarrow extract on the germination and growth of weeds and differentiating it from allelopathic effect [19]. For this purpose, osmotic potential of the extracts with various densities was determined by osmometer and then, PEG solutions with similar potential were provided. Evaluation of indicators including percentage of germination, length of radicles and plumules were examined five days later [6].

Table 1. Osmotic potential of various densities of Yarrow

Density of extract (%)	0	1.25	2.5	3.75	5	10	15	20
Osmotic potential (mega passcal)	0	4.12	8.25	12.37	16.50	33.00	49.50	66.00

To evaluate the effects of Yarrow extract and polyethylene glycol, tests were conducted separately under similar conditions. After evaporating the organic resolvent, sterile aquapura was added to each Petri dish to create various densities of the extract in terms of milligram/ liter [6]. In laboratory, 50 aseptic seeds of weeds and corn were placed in each Petri dish. Viability of the tested seeds for corn, Redroot pigweed, Common lambsquarter and Johnsongrass were determined 90, 98, 40 and 60 percent, respectively. In order to break the sleep of the seeds in Common lambsquarter case Clorox solution (5.25 percent hypochlorite sodium) was applied in temperature 25'C for 10 minutes and in Johnsongrass case it was done by scratching the seeds.

Petri dishes containing filter paper and water with 20ºC alchohol were used as instance. Petri dishes containing seeds were placed in germinator in thermal and lighting cycles of 25ºC and 14 hours of lighting and 20ºC with 10 hours of darkness. Each of the two experiments on the extracts and polyethylene glycol were conducted as balanced and random models with four repetitions for each treatment in laboratory conditions including 16 hours of lighting with 25ºC and 8 hours of darkness with 22ºC.

Statistical analysis

Transformation of data using the formula $\sqrt{x+o.5}$ [10]. Analysis of variance and mean comparison with Duncan,s multiple range test were performed by SAS software.

RESULTS

Results indicated that Yarrow extract had the capacity of inhibitory effects on the germination and growth of wild Redroot pigweed, Common lambsquarter, Johnsongrass and corn seedlings. This effect, however, is different on the germination and length growth of the radicles and plumules of the species studied. In this regard, the effects of Yarrow extracts with various densities were compared with those of polyethylene. Since polyethylene glycol does not have phototoxic effect and the inhibition of germination and growth of corn seedlings and weeds takes place due to osmotic pressure, it can differentiate between allelopathic effect of the extract and osmotic pressure [19].

It was also observed that the allelopathic effect of Yarrow extract on the germination and growth of Johnsongrass and Common lambsquarter seedlings was low due to osmotic pressure, while its effect on the germination of Redroot pigweed and corn was considered as allelopathic effect.

Effect of Yarrow extract

Effect of Yarrow extract on the percentage of germination and length of radicles and plumules of Redroot pigweed, Common lambsquarter and Johnsongrass as weeds and corn as a cultivation plant is demonstrated in **Table 2**. The results exhibited that densities of 2.5 percent and higher of Yarrow extract significantly reduced the percentage of germination of Redroot pigweed and Common lambsquarter. Its extract with densities of 10 and 15 percent and higher decreased percentage of germination of Johnsongrass and corn significantly. Yarrow extract significantly decreased the radicles length of Redroot pigweed, Common lambsquarter and Johnsongrass in all densities (**Table 2**).

However, its effect on the radicles length of corn in densities of 3.75 and higher was significant, while compared to that of the instance. Length of plumules of Redroot pigweed, Common lambsquarter and corn in densities of 2.5 percent and higher significantly decreased, while its effect on the plumules length of Johnsongrass in densities of 3.75 percent and higher was significant, while compared to that of the instance.

Table 2. Effect of Yarrow on germination and growth of weeds and corn seedlings

Treatment (desity of extract)	**Common lambsquarter**			**Redroot pigweed**			**Johnsongrass**			**Corn**		
	Radicles (mm)	Plumule (mm)	Germination (%)	Radicals (mm)	Plumule (mm)	Germination (%)	Radicals (mm)	Plumule (mm)	Germination (%)	Radicals (mm)	Plumule (mm)	Germination (%)
0%	5.7^{a*}	3.9^{a}	26.7^{a}	17.05^{a}	8.4^{a}	46.5^{a}	16.05^{a}	21.7^{a}	45.5^{a}	25.3^{a}	8.7^{a}	45.5^{a}
1.25%	4.4^{b}	3.05^{a}	20.5^{a}	11.8^{b}	6.9^{a}	44.7^{ab}	7.4^{b}	20.3^{ab}	45^{a}	20.2^{ab}	7.05^{ab}	45.5^{a}
2.5%	1.6^{dc}	1.2^{b}	10.2^{bc}	5.05^{c}	2.6^{b}	37.2^{bc}	6.9^{bc}	19.2^{ab}	47^{a}	19.5^{ab}	5.3^{bc}	41.5^{a}
3.75%	1.9^{c}	1.2^{b}	13^{b}	4.3^{cd}	1.6^{c}	31.7^{c}	6.3^{cd}	18.8^{b}	43.7^{a}	16.5^{bc}	3.8^{dc}	45^{a}
5%	1.3^{dc}	1^{b}	8.7^{bc}	3.3^{d}	1.4^{c}	23.5^{d}	6.3^{cd}	18.7^{b}	42.7^{ab}	12.5^{dc}	2.9^{de}	43^{a}
10%	1^{de}	1.05^{b}	6.5^{c}	1.15^{e}	1^{c}	9^{e}	5.6^{d}	14.8^{c}	37.7^{b}	11.5^{dc}	2.7^{de}	39.5^{a}
15%	0.5^{e}	0.5^{b}	0.75^{d}	0.25^{f}	0.25^{d}	0.25^{f}	2.3^{e}	10^{d}	31^{c}	10.7^{d}	2.5_{de}	29^{b}
20%	0.5^{e}	0.5^{b}	0.5^{d}	0.25^{f}	0.25^{d}	0.25^{f}	1.4^{f}	8.6^{d}	29.2^{c}	10.7^{d}	1.8^{e}	30.5^{b}

Table 3. Effect of polyethylene glycol on germination and growth of weeds and corn seedlings

Traetment (desity of extract)	**Common lambsquarter**			**Redroot pigweed**			**Johnsongrass**			**Corn**		
	Radicals (mm)	Plumule (mm)	Germination (%)	Radicals (mm)	Plumule (mm)	Germination (%)	Radicals (mm)	Plumule (mm)	Germination (%)	Radicals (mm)	Plumule (mm)	Germination (%)
0%	14.65^{a}	8.65^{a}	36.2^{a}	23^{a}	14.65^{a}	45.5^{a}	18.4^{a}	35.32^{a}	33.7^{a}	38.2^{a}	17.95^{a}	45.5^{a}
1.25%	14.05^{a}	8.2^{a}	34^{ab}	20.97^{b}	14.2_{ab}	44.2^{a}	18^{ab}	34.65^{a}	32.7^{a}	33.8^{b}	17.85^{a}	44.5^{a}
2.5%	12.7^{b}	8.35^{a}	32.7^{b}	19.05^{c}	13.8^{ab}	42.7^{ab}	18.65^{a}	33.65^{a}	31.2^{a}	32.15^{b}	15.67^{b}	43.5^{ab}
3.75%	12.55^{b}	8^{a}	32.2^{bc}	19.45^{c}	13.65^{b}	40.7^{b}	17.92^{ab}	33.85^{a}	28.5^{b}	30.75^{bc}	15.45^{b}	42.5^{abc}
5%	11.6^{b}	7.15^{b}	29.7^{c}	13.9^{d}	9.3^{c}	40.7^{b}	16.7^{bc}	33.8^{a}	27.7^{b}	28.5^{cd}	15.45^{b}	42.5^{abc}
10%	9.25^{c}	6.7^{b}	27^{d}	12.6^{e}	8.45^{d}	33.5^{c}	19.9^{c}	30.65^{b}	20.2^{c}	28^{cd}	13.65^{c}	42^{abc}
15%	7.2^{d}	4.45^{c}	22^{e}	12.25^{ef}	7.55^{e}	25.2^{d}	12.45^{d}	24.5^{c}	16^{d}	26.05^{d}	13^{c}	41^{bc}
20%	6.8^{d}	3.75^{d}	13.7^{f}	11.5^{f}	5.6^{f}	17.7^{e}	10.1^{e}	21.9^{d}	13.5^{e}	17.3^{e}	4.4^{d}	40^{c}

Effect of polyethylene glycol

Effect of polyethylene glycols on germination percentage and length of radicles and plumules of Redroot pigweed, Common lambsquarter and Johnsongrass as weeds and corn as cultivation plant is demonstrated in **Table 3**. The results revealed that polyethylene glycol in densities of 3.75 percent and higher significantly decreased the germination percentage of Redroot pigweed and Johnsongrass. On the other hard, its effect on the germination of Common lambsquarter in densities of 2.5 percent and higher and in corn, in densities of 15 and 20 percent was significant. Polyethylene glycol significantly decreased the radicle length of Redroot pigweed and corn in all densities. Its effect on the length reduction of Common lambsquarter and Johnsongrass in densities of 2.5 and 5 percent respectively and higher was significant, while compared to the instance (**Table 3**). Comparison of the means showed that densities of 2.5, 3.75, 5 and 10 percent and higher reduced significantly plumule length of corn, Redroot pigweed Common lambsquarter and Johnsongrass

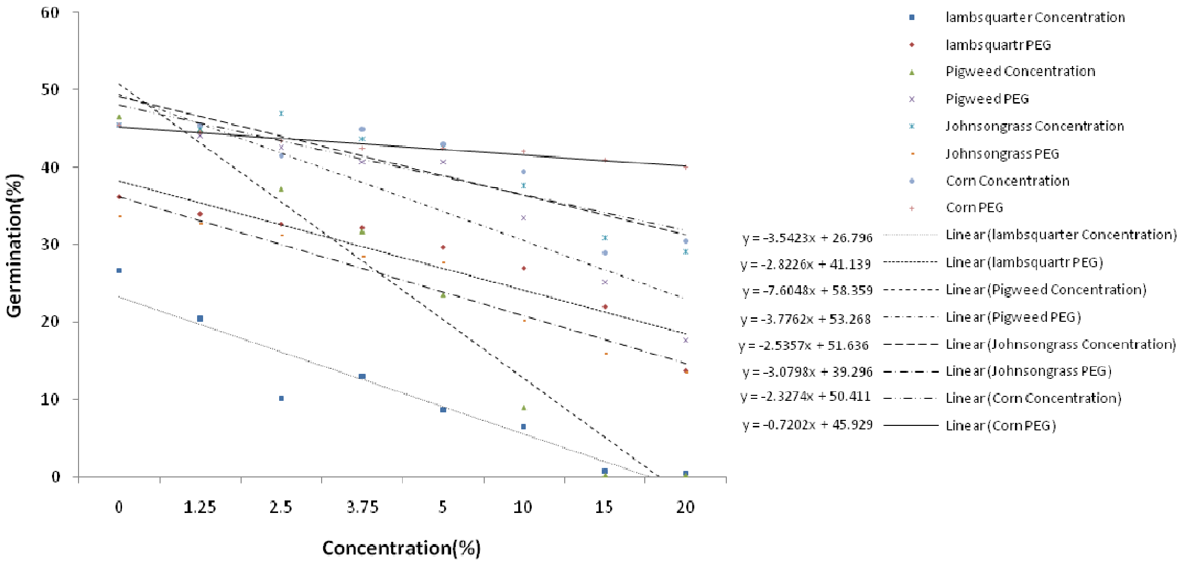

Fig. 1. Effects of Yarrow extract and PEG on germination percentage in common lambsquarter, Redroot pigweed, Johnsongrass and corn.

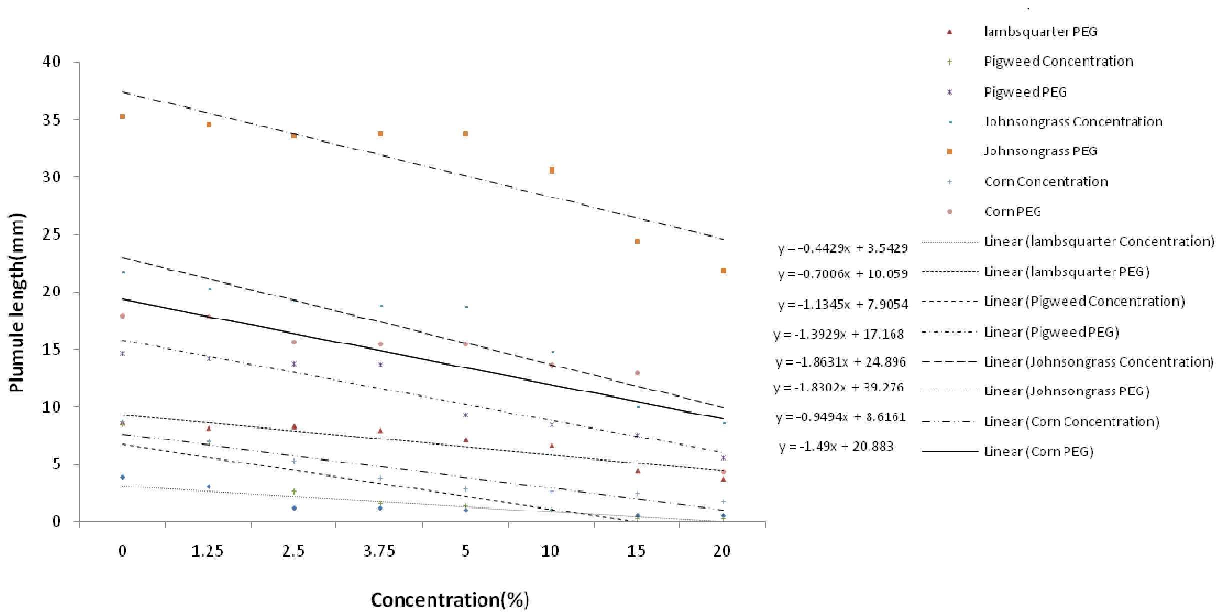

Fig. 2. Effects of Yarrow extract an PEG on the plumule length in Common lambsquarter, Redroot pigweed, Johnsongrass and corn.

Diagram comparisons

Comparing the effect of Yarrow extract with that of PEG diagram on the reduction of germination percentage in corn and Redroot pigweed has a sharper slope than that of polyethylene glycol (**Fig. 1**). This reduction is due to osmotic pressure as well as the allelopathic effects of Yarrow extract. Results suggested that due to parallelism and similarity between the graphs of PEG effects and those of Yarrow on the reduction of germination percentage of Common lambsquarter and Johnsongrass one can attribute this reduction to osmotic pressure. Since equal densities of PEG and Yarrow extract demonstrated different effects, increase in the effects of Yarrow extract was considered as allelopathic effect (**Fig. 1**).

Effects of Yarrow extract on the reduction of length growth of radicles and plumules in Redroot pigweed, Common lambsquarter, Johnsongrass and corn can be attributed to osmotic pressures because their graph is almost parallel with that of PEG (**Fig. 2, 3**).

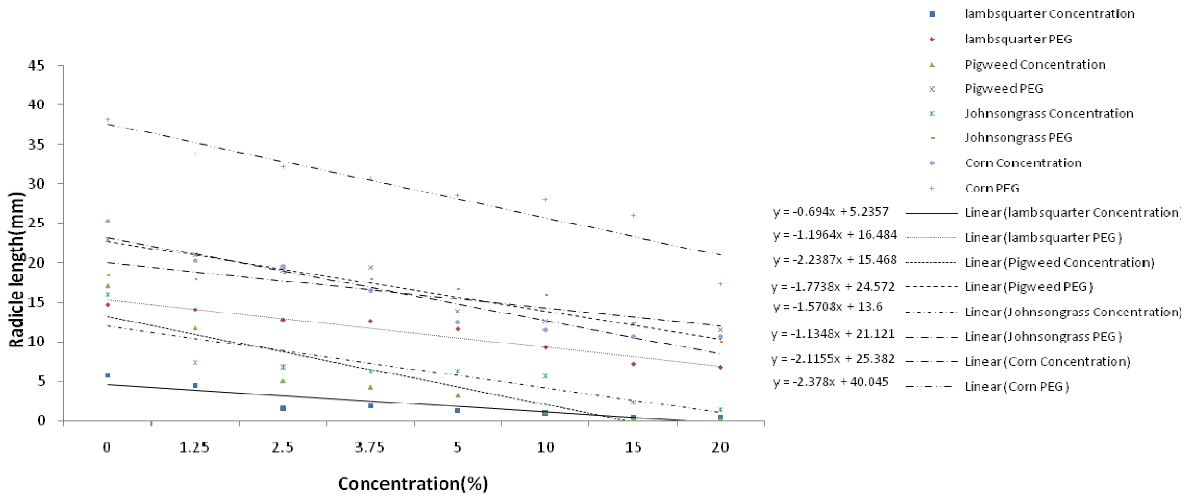

Fig. 3. effects of Yarrow extract and PEG on adicle length in Common lambsquarter, Redroot pigweed, Johnsongrass and corn.

DISCUSSION

Allelochemicals affect physiological processes in neighboring plants or mechanisms. Ingredients in medicinal of aromatic plants contain materials which have inhibitory effects on the germination and growth in other plants [12, 20, 21]. Results of this research and Cheng findings [5] indicated that the extract of aerial parts of medicinal plants had a significant effect on the reduction of germination and growth of the neighboring plants seedlings. These indicators demonstrated that in some plants, inhibitory chemicals exist mainly in the growing parts comparing to their under ground parts.

The results also showed that ingredients in the aerial parts of Yarrow medicinal plant have inhibitory effect on the germination and growth of seedlings of wild Redroot pigweed, Common lambsquarter and Johnsongrass as weeds and corn as a cultivation plant, athough this effect is different on seed germination and length growth of radicles and plumules. Our results as well as those of researches conducted by Romangi and Tworkoski [24, 25] suggested that ingredients in the extract and essence of medicinal plants have strong herbicidal effects and in densities higher than 1 percent can prevent weeds from germinating (**Fig. 1, 2, 3**).

In consistence with Hartman et al. [12] and Rizvi and Rizvi reports [21], our finding showed that Yarrow extract affects the length of radicle more than that of plumule in the plants under investigation. The higher effect on the radicle length is because of its direct contact with the extract. In higher densities, a reduction in the radicle growth comparing to plumule growth was observed which is due to the extract type, plant species and chemical properties of the allelochemicals.

The studies of Fuji [8] on 239 medicinal plants displayed that ingredients in various parts of these plants have strong inhibitory effects. Intensity of this effect on radicle and plumule depends on the density of the extract as well as its ingredients. Moreover, with regard to the existence of osmotic pressure in such extracts, their inhibitory effects can be attributed to the allelopathy phenomenon [19]. Our result along with findings of Dayan et al. [7] showed that effect of Yarrow extract on the growth of seedling of cultivation plants is mostly due to the allelopathic phenomenon.

Studying the allelopathic effects of medicinal plants on controlling weeds is useful for organic agriculture and can be a proper guide for selecting alternation program [14]. Cultivating medicinal plants which are resistant against cold weather in mild and cold regions has the advantage of autumn sowing. The advantage of raining during the growth season, decrease in illnesses and weeds are among advantages of placing medicinal plants such as camomile, oxtongue and maritigal in alternation programs [5].

Since weather conditions and genetic characteristics of plants are considered among the most important factors affecting the formation and diffusion of allelopathic materials, controlling weeds using this method in alternation systems requires supplementary experiments in farm conditions and on other cultivating types of corn [17].

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