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Effects of Hearleaf Cocklebur (*Xanthium strumarium* L.) Extract on Some Crops and Weeds

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Abstract: This study was conducted to determine possible allelopathic and herbicidal effects of ground plant tissues and leaves-flowers and seed extracts of hearleaf cocklebur (*Xanthium strumarium* L.) on some crops and weeds. Experiments were repeated twice in 2003 and 2004 using organs and seeds of hearleaf cocklebur were collected in the Spring of 2002. Seedling studies were carried out in the laboratory with extract of hearleaf cocklebur in 9 cm diameter petri dishes and in greenhouse in pots 12x16 dimension pots. In the laboratory, hearleaf cocklebur had no allelopathic effect on the seeds of *Daucus carota* L., *Descurania sophia* (L.) Webb. Ex Prant., *Abutilon theophrastii* Medik. and *Lepidium sativum* L.. However, it inhibited the germination considerably in *Triticum vulgare* L., *Hordeum vulgare* L., *Lolium perenne* L. and *Avena sterilis* L. Effect of hearleaf cocklebur on the plants growth in the pots in post-emergence ranged from 0.00% to 86.66%. The herbicidal effects of hearleaf cocklebur was high in *Amaranthus retroflexus* L., *Papaver somniferum* L. and *D. sophia*. The inhibitory effect of ground hearleaf cocklebur on *A. retroflexus*, *A. sterilis* and *Conium maculatum* L. was greater than on the other plant species used in this study.

Key words: Hearleaf cocklebur, plant extracts, allelopathy, germination

INTRODUCTION

There is complex interactions in plants kingdom. Plants have weapons most of which are not known to us. For example, plants protect themselves against insects, fungi and other plants by some over ten thousand exudates[1].

Some plants may inhibit emergence and growth of other plants by exudating toxic substances. These substances are called allelopathic chemicals and the process is called allelopathy[2]. Allelopathic substances may be exudated from the residues after harvest as well as from the roots, shoots and flowers of the living plants[3]. When these substances are taken up by either same plant species of attacking plants or target species, they are affected in some degree[4].

Today, one of the most important issues regarding with human health is the damage to environment caused by the pesticides. Millions of tons of these chemicals are used over millions of hectares for either agricultural or non-agricultural purposes.

New means of pest control that will decrease side effects of synthetic chemicals have been sought. One of these is to control the pests by using plant originated chemicals rather than synthetic chemicals. Besides studies on decreasing weed damage by using plant originated, or simply natural chemicals, studies regarding to effects of some plants on others have been widely conducted.

Hearleaf cocklebur is a weed, which is predominant in Turkey and some countries in the world, affects the crops negatively. It causes damage on the crops (cotton, onion, sunflower and some vegetables) mostly during the summer[5-7]. Data are needed to know whether hearleaf cocklebur has any negative allelopathic effect on the crops besides its competition. Cutler and Cole[8] reported that potassium carboxyactractyloside and hypoglyaemic isolated from the residues of this weed, strongly inhibited the hypocotyl of wheat and caused a serious decaying and dwarfing in the corn seedlings. However, some crops may have negative effect on hearleaf cocklebur.

Similar to the above mentioned the effect of hearleaf cocklebur, rizom extracts of *Sorghum halepense* (L.) Pers. inhibited the emergence of *Amaranthus retroflexus* L. and delayed the root and shoot growth in corn. *Nerium oleander* L. and *Melia azederach* L. stimulated growth in corn, causing a fertilizer effect[9].

This study was conducted to examine possible effects of hearleaf cocklebur organs ground, its the leaf-flower and seed extracts on some crop's and weed's germinations in petri dishes and growth in pots.

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MATERIALS AND METHODS

Preparation of plant extracts: Hearleaf cocklebur was used in allelopathic experiments where samples were prepared from plant's leaves and flowers and its half ripen seeds that were collected separately between July and September, 2002. The plant samples were dried in laboratory conditions then they were ground into powder. A 100 g of each sample was put into flask and 600 mL of methanol was added into flask then the mixture was shaken for 24 h with an orbital shaker at 120 rpm. The mixture was then filtered through a four-layer cheesecloth to separate fine material from coarse one. The mixture was placed in glass balloons of known weight and methanol in the mixture was evaporated at 32°C in rotary evaporator. The plant material in the balloon was weighted and then mixed with 10% acetone. Distilled water, proportional to plant weight in amount, was added into the balloon to obtain 10% plant extract. Leaf-flower extracts was used in germination studies in petri dishes and both leaf-flower extracts and seeds extracts were used in pot experiments.

Design of experiments

Laboratory studies: Crops and weeds shown in Table 1 were used in the experiments. The experiments were designed in Completely Randomized Blocks with four replication. The laboratory studies were repeated twice between January, 2003 and October, 2003.

The petri experiments were carried out in 9 cm diameter petri dishes in which sterile whatman no:10 filter paper was placed. The petri dishes were washed then were sterilized, dipping into solution of ethyl alcohol. The plant seeds were subjected to surface sterilization, keeping in 10% of Na-hypocloride solution for 1 min and then washing in tap water. After counting, seeds were processed in 10% of plant extract to achieve an adequate surface wetness of the seeds. The seeds then let dry out for one day to achieve the seeds to dry and placed in petri dishes. Based on seed size of the seeds, 10 to 50 seeds were placed per petri dishes. Hence, the same treatment was applied to all the seeds from different crops. Sterilized water was used as control. After the petri dishes were watered with approximately 5 mL of sterilized water just enough to wet filter paper; chickpea, barley, wheat, wild carrot, onion, opium poppy, garden cress, fixweed, wild oat, poison hemlock, curly dock and white clover were allowed to germinate in germination cabin at 15°C and tomato, pepper, pumpkin, corn, common bean, English rye grass, velvetleaf, and redroot pigweed were at 24°C. Germination count in petri dishes were done once in every three day. Seeds forming 2-3 mm radicle and hypocotyl were considered germinated and taken out from the dishes. The counting was continued for 21 days.

The results from the treatments were evaluated, calculating the germination rate for seeds of each crop. Percent germination rate was calculated, dividing the number of seeds germinated to total number of seeds used.

Pot experiments with extracts of *Xanthium strumarium* L.: Seeds of crops and weeds given in Table 1 were used in pot experiments. A Completely Randomized Blocks Design with four replications was adapted to the experiment. A control and leaf-flower extracts and seed

Table 1: The crops and weeds subjected to extract and ground parts of hearleaf cocklebur

Latin name	Family	Common name	Type
Abutilon theophrastii Medik. *	Malvaceae	Velvetleaf	Weed
Allium cepa L.* **	Liliaceae	Onion	Crop
Amaranthus retroflexus L.	Amaranthaceae	Redroot pigweed	Weed
Avena sterilis L.	Poaceae	Wild oat	Weed
Capsicum annuum L.	Solanaceae	Pepper	Crop
Cicer arietinum L.	Fabaceae	Chickpea	Crop
Conium maculatum L.	Apiaceae	Poison hemlock	Weed
Cucurbite pepo L.	Cucurbitaceae	Pumpkin	Crop
Daucus carota L.	Apiaceae	Wild carrot	Crop
Descurania sophia (L.)Webb Ex Prant.	Brassicaceae	Fixweed	Weed
Hordeum vulgare L.	Poaceae	Barley	Crop
Lepidium sativum L.	Brassicaceae	Garden cress	Crop
Lolium perenne L.	Poaceae	English rye grass	Weed
Lycopersicum esculentum Mill.	Solanaceae	Tomato	Crop
Papaver somniferum L.*	Papaveraceae	Opium poppy	Crop
Phaseolus vulgaris L.	Fabaceae	Common bean	Crop
Rumex crispus L.**	Polygonaceae	Curly dock	Weed
Sorghum halepense (L.) Pers. ***	Poaceae	Jonsongrass	Weed
Trifolium repens L. * **	Fabaceae	White clover	Weed
Triticum vulgare L.	Poaceae	Wheat	Crop
Zea mays L.	Poaceae	Corn	Crop

*Ground plant parts was not applied to these plants, ** No post-emergence extract was used, *** Only post-emergence extract was applied to this plant extracts of hearleaf cocklebur were treatments. The experiment were carried out in 12x16 cm dimensions pots. The pots were filled with a soil-sand mixture (1 volume sand+2 volume soil). Twenty seeds were planted in December, 2003 and January, 2004 in each pot. The seeds were sown at varying depths depending on their size. Following emergence, approximately 3-6 leaves stage of plants, 10% of leaf-flower and seed extracts of hearleaf cocklebur was pulverized to the plants until the leaves become thoroughly wet. The experiments were repeated two times. The phytotoxic effect of treatments on plants were determined as percent[10]. Distilled water was used in controls.

Pot Experiments with ground parts of *Xanthium strumarium* L.: The experiment and experimental design was carried out with the seeds of the same crops and weeds. Ground leaf-flower powder of hearleaf cocklebur was applied to each pot 50 g ground leaf-flower per pot. Twenty seeds were sown in each pot in November and December of 2003, for the first and second experiment, respectively. The percent emergence of seeds from treatments were compared with those from control. Delay in emergence, retardation or stimulation in growth were observed for two months.

Statistical analysis of the results: The results were first subjected to ANOVA test to determine overall effect of treatments on plant growth. Based on the Anova results, the means of treatments were grouped with Least Significant Difference (LSD) procedure at the 0.05 probability level. The software SAS was used to conduct all the statistical analysis.

RESULTS AND DISCUSSION

Effect of hearleaf cocklebur extract on emergence of seeds used in this study were shown in Table 2. Hearleaf cocklebur extract did not significantly affected the germination of *Daucus carota* L., *Descurania sophia* (L.) Webb. Ex Prant, *Abutilon theophrastii* Medik. and *Lepidium sativum* L. The hearleaf cocklebur extract promoted the germination in *D. carota* and *D. sophia.* Allelopathy is not only, one plant's affecting negatively but it may also one plant's positively affecting another[2,11,12]. This aspect of allelopathy may be exploited in plant protection.

The previous studies[13] showed that hearleaf cocklebur extract was effective on crops such as barley, wheat and grass and members of Poaceae family such as *Avena sterilis* L. which is an important weed in the wheat fields in Turkey. Its effect on corn from the same family, Poaceae, which was not so prominent. Therefore, hearleaf cocklebur even with a low density occurring in wheat and barley fields during growing period may not cause series problems. However, its residues from the previous year in soils may cause allelopthic effect on these crops. Cutler and Cole[8] reported that potassium carboxyactractyloside and hypoglyaemic matters were isolated from residues of *X. strumarium* the chemicals strongly inhibited the wheat hypocotyl and caused decaying and dwarfing in corn seedlings. Another hearleaf cocklebur species *X. occidentale* inhibited the germination of seeds of *Medicago sativa*[14]. Present results showed that extract of *X. strumarium* decreased the emergence of the seeds of chickpea, common bean, pepper, pumpkin, onion, opium poppy, velvetleaf, redroot pigweed, poison hemlock, white clover, curly dock in some degree.

Post-emergence applications results shown that effect of extracts on plants varied from 0.00 to 86.66% (Table 3). Both leaf-flower and seed extracts greatly affected mortality rate in *A. retroflexus* (86.66 and 83.33%, leaf-flower and seed extracts, respectively), in *Papaver somniferum* L. (83.33 and 80.00%) and in *D. sophia* (73.33, 70.00%). Seed germination of *A. retroflexus* and *P. somniferum* decreased in petri dishes, too. Germination in *D. sophia* under extract application was greater than control, however, the plant mortality ratio applied post-emergence was also grater in the same species.

Effects obtained in pot experiments carried out with ground parts of hearleaf cocklebur were not so high and parallel as it was *in vitro* conditions (Table 4). Emergence rates in corn and *D. sophia* were higher compared to control and in *D. carota* and *Capsicum annuum* L. were the same as in the control. The emergence rate in other crops and weed species were low, taking values between 3.33 and 36.33%. Emergence in the members of Fabaceae such as common bean, chickpea and white clover was affected similarly as it was in petri studies. Chon *et al.*[14] reported that were extracted from *Lactuca sativa*, *X. occidentale* and *Cirsium japonicum* of coumain, *trans*-cinnamic acid, o-coumaric acid, p-coumaric acid strongly inhibited the growth and germination of *Medicago sativa*, a member of Fabaceae. They further stated that several members of Compositae family could show a herbisidal effect on many other plants. *A. retroflexus,* reported as an allelopathic plant[15], was one of the highly affected plants. Moreover, white colored necrosis were observed on the leaves of barley and wheat, which are from Poaceae family. Cutler and Cole[8] reported that color changes similar to those observed in our study were observed in corn leaves following hearleaf cocklebur application. In the present study, compared to control,

Table 2: Emergence (%) of some crops and weed species as affected by hearleaf cocklebur

Crops and weeds species	Control	Hearleaf cocklebur extract	LSD (0.05)
Abutilon theophrastii Medik.	24.5	15.0	14.842
Allium cepa L.	53.0	2.5	10.434
Amaranthus retroflexus L.	100.0	71.5	22.409
Avena sterilis L.	90.0	25.0	11.176
Capsicum annuum L.	99.5	85.0	4.947
Cicer arietinum L.	75.0	26.0	28.524
Conium maculatum L.	34.0	21.0	11.693
Cucurbite pepo L.	95.0	85.0	3.9781
Daucus carota L.	51.0	64.5	15.400
Descurania sophia (L.) Webb. Ex Prant	54.0	76.7	29.780
Hordeum vulgare L.	98.5	23.0	0.918
Lepidium sativum L.	100.0	99.0	1.837
Lolium perenne L.	96.0	46.0	14.699
Lycopersicum esculentum Mill.	91.0	74.0	16.279
Papaver somniferum L.	85.0	57.5	12.291
Phaseolus vulgaris L.	100.0	73.0	23.386
Rumex crispus L.	45.0	5.0	23.851
Trifolium repens L.	19.5	9.0	8.666
Triticum vulgare L.	98.5	39.0	9.503
Zea mays L.	96.0	65.0	6.093

Table 3: Effect of hearleaf cocklebur extract, applied post-emergence, on some crops and weed species (%)*

	Hearleaf cocklebur		
Latin name	Leaves-flowers extract	Seed extract	LSD (0.05)
Abutilon theophrastii Medik.	16.66	13.33	28.684
Amaranthus retroflexus L.	86.66	83.33	28.684
Avena sterilis L.	6.66	5.00	14.342
Capsicum annuum L.	0.00	0.00	0.000
Cicer arietinum L.	0.00	0.00	0.000
Conium maculatum L.	5.00	5.00	0.000
Cucurbite pepo L.	0.00	0.00	0.000
Daucus carota L.	0.00	0.00	0.000
Descurania sophia (L.) Webb. Ex Prant	73.33	70.00	14.342
Hordeum vulgare L.	13.33	10.00	14.342
Lepidium sativum L.	0.00	0.00	0.000
Lolium perenne L.	0.00	0.00	0.000
Lycopersicum esculentum Mill.	0.00	0.00	0.000
Papaver somniferum L.	83.33	80.00	14.342
Phaseolus vulgaris L.	0.00	0.00	0.000
Sorghum halepense (L.) Pers.	10.00	5.00	12.421
Triticum vulgare L.	10.00	6.66	7.171
Zea mays L.	20.00	20.00	12.421

* Post-emergence in control was considered as 100%

Table 4: Effect of ground parts of hearleaf cocklebur on emergence (%) of some crops and weed species

Latin name	Control	Hearleaf cocklebur extract	LSD (0.05)
Amaranthus retroflexus L.	43.30	6.67	25.856
Avena sterilis L.	66.60	40.00	47.024
Capsicum annuum L.	90.00	90.00	14.342
Cicer arietinum L.	56.67	48.33	18.973
Conium maculatum L.	43.30	11.67	18.973
Cucurbite pepo L.	88.33	81.67	31.258
Daucus carota L.	88.33	88.33	32.862
Descurania sophia (L.) Webb. Ex Prant	25.00	30.00	12.421
Hordeum vulgare L.	88.33	75.00	56.008
Lepidium sativum L.	76.67	68.33	31.258
Lolium perenne L.	90.00	81.67	18.973
Lycopersicum esculentum Mill.	91.67	88.33	39.927
Phaseolus vulgaris L.	86.67	83.33	25.856
Rumex crispus L.	16.60	1.60	12.421
Triticum vulgare L.	91.67	86.67	37.262
Zea mays L.	88.33	96.67	37.946

emergence of negatively affected plants was delayed at varying rates (at least three days) depending on plant species.

In conclusion, members of Poaceae family were most strongly affected by the hearleaf cocklebur extract under *in vitro* conditions. However, ground parts of hearleaf cocklebur did not exhibit the same effect on these plants in pot experiments. We believe that this difference is due to methanol used as a solvent in *in vitro* studies that it released chemical substances in the plant parts. The leaf-flower and seed extracts used in post-emergence highly affected the growth of *A. retroflexes, D. sophia* and *P. somniferum.*

Hearleaf cocklebur occurred to highly affect seed germination under *in vitro* conditions and growth of some plants in pot conditions. The herbicidal effect of hearleaf cocklebur was high for some plants in the study conditions. The pest control by using plant originated chemicals will decrease side effects of synthetic chemicals. Besides studies on decreasing weed damage by using plant originated materials regarding to effects of some plants on others should widely conduct. We suggest that furthermore detailed studies should be conducted to increase detail of knowledge on the effect of hearleaf cocklebur on the members of Poaceae family and on the other plants highly affected.

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