Pak. J. Agri. Sci., Vol. 57(6), 1441-1456; 2020
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
DOI: 10.21162/PAKJAS/20.9695
http://www.pakjas.com.pk

PHYTOTOXICITY OF WILD PLANTS EXTRACTS TO REDROOT PIGWEED (*Amaranthus retroflexus* L.) AND NETTLE-LEAVED GOOSEFOOT (*Chenopodium murale* L.)

Loai Jamal Al-Batsh and Jamal Ragheb Qasem*

Plant Protection Department, Faculty of Agriculture, University of Jordan, Amman 11942, Jordan.
***Corresponding author's e-mail: jrqasem@ju.edu.jo**

Aqueous fresh shoot extracts of 200 plant species from 47 plant families were evaluated for their herbicidal activities on *Amaranthus retroflexus* L. and *Chenopodium murale* L. Foliar applications of 192 extracts reduced shoot dry weight and height of *A. retroflexus* and all extracts reduced both growth parameters of *C. murale* under glasshouse conditions. Extract of *Ruta graveolens* L. was the most phytotoxic; showed burning, stunting, yellowing and death of some seedlings of both weeds. The same extract, failed to control both weed species compared with full rate (0.4kg a.i/ha) of paraquat under field conditions. However, a mixture of this weed extract with low rate (0.05kg a.i./ha) of paraquat effectively controlled both weeds and similar to the herbicide used alone at a full rate. It was concluded that a mixture of *R. graveolens* extract with a reduced rate of paraquat was effective against both weed species and could be used instead of full strength application of the herbicide in the field as a more eco-friendly and less coasty method of herbicide application.
Keywords: *Amaranthus retroflexus, Chenopodium murale*, Extracts, Phytotoxicity, Wild plants.

INTRODUCTION

Weeds present a major threat to agriculture and are a remarkable economical issue because they cause yield losses due to their negative interference with crop plants. Weeds compete with crop plants for nutrients, water, and light (Qasem and Biftu, 2010) and their management is one of the most challenging tasks in crop production. However, extensive application of synthetic herbicides causes severe environmental damage besides the development of herbicide resistance and human health concern (Qasem, 2013a).

The search for natural chemicals as substitutes to the widely applied synthetic pesticides is underway across the globe. An alternative to herbicides are allelochemicals which may replace or lower the applied rates of herbicides and reduce environmental hazards (Bhatti *et al.*, 2000; Birkett *et al.*, 2001; Cheema *et al.*, 2005; Bhadoria, 2011). Allelochemicals are secondary metabolites produced as byproducts in the primary metabolic pathways of plants (Kruse *et al.*, 2000). Plant species having allelopathic properties can be exploited in different ways in weed management (Qasem, 2010a), and utilization of their aqueous extracts is one possible tool. Promising results have been already reported (Cheema *et al.*, 2013) and different workers proved the effectiveness of plant extracts, dead or living tissues as soil mulch in controlling different weed species (Qasem and Foy, 2001; Qasem, 2013b and 2017). A wide array of allelochemicals possessing herbicidal activity was isolated, identified and some were synthesized and produced as natural herbicides (Duke, 1990; Qasem, 2010a).

Nettle-leaved goosefoot (*Chenopodium murale*) and redroot pigweed (*Amaranthus retroflexus*) are the most dominant weed species in vegetable crops in Jordan. *Amaranthus retroflexus* reduced tomato yield by 68% (Qasem, 1992) while both weeds were listed among the worst species in the world that cause great yield loss (Holm *et al.*, 1977). Qasem (2009) showed that extracts and residues of lavender (*Lavandula angustifolia* Mill.) and rosemary (*Rosmarinus officinalis* L.) exhibited high toxicity on germination and growth of both weeds under glasshouse conditions, while foliar application of peppermint (*Mentha piperita* L.) leaf extract reduced *A. retroflexus* plant height up to 68.3% compared with untreated plants (Pashoutan and Yarnia, 2014).

Previous workers (Duke and Laydon, 1993; Cheema *et al.*, 2005) have reported possible use of plant extracts mixtures or their combinations with reduced rates of herbicides in weed management. Water extract of allelopathic crops alone or with low rates of herbicide is an inexpensive, environmentally safe and an effective weed control option (Cheema and Khaliq, 2005; Kim and Shin, 2008). However, combinations of different plant aqueous extracts might have synergistic or additive effects on target species.

The objectives of the present work were to search for possible phytotoxic effects of different plant species (mostly wild and weeds) found in Jordan flora on growth of *A.*

retroflexus and *C. murale* grown under glasshouse and field conditions. Secondly to investigate the effect of phytotoxic extract and low rate of herbicide/s mixture on both weeds, aiming at reducing herbicide application rates, and its environmental hazards.

MATERIALS AND METHODS

Collection of plants: Two hundred plant species (including common weeds, medicinal herbs and shrubs) from 47 plant families, mostly naturally growing in Jordan were collected (Table 1). Tested species were collected from different locations in Jordan. At the time of collection, these species were varied in the growth stages, ranging from vegetative to fruiting. Shoots of healthy plants were harvested from the above soil level, placed in plastic bags and brought to the laboratory for aqueous extracts preparation. *Amaranthus retroflexus* and *C. mural* were used as indicator species for recording phytotoxic activities of extracts.

Table 1. Scientific and family names, life cycle and the growth stage at which plant species were collected.

Scientific name	Family name	Life cycle	Growth stage
Acanthus syriacus Boiss.	Acanthaceae	Perennial	Vegetative
Achillea aleppica DC.	Compositae	Perennial	Vegetative
Adonis aestivalis L.	Ranunculaceae	Annual	Flowering
Adonis annua L.	Ranunculaceae	Annual	Vegetative
Aegilops geniculata Roth.	Gramineae	Annual	Fruiting
Aizoon canariense L.	Aizoaceae	Perennial	Vegetative
Alcea acaulis (Cav.) Alef.	Malvaceae	Annual	Vegetative
Alhagi maurorum Medikus	Leguminosae	Perennial	Flowering
Alkanna strigosa Bioss. Et Hohen.	Boraginaceae	Perennial	Flowering
Allium erdelii Zucc.	Liliaceae	Perennial	Flowering
Alyssum damascenum Boiss. & Gaill.	Cruciferae	Annual/Perennial	Flowering
Amaranthus gracilis L.	Amaranthaceae	Annual	Vegetative
Amaranthus retroflexus L.	Amaranthaceae	Annual	Fruiting
Amaranthus viridis L.	Amaranthaceae	Annual	Flowering
Ammi majus L.	Umbelliferae	Annual	Vegetative
Anabasis syriaca L.	Chenopodiaceae	Perennial	Flowering
Anagallis arvensis L.	Primulaceae	Annual	Flowering
Anchusa italica Retz.	Boraginaceae	Perennial	Vegetative
Anchusa officinalis L.	Boraginaceae	Perennial	Flowering
Anemone coronaria L.	Ranunculaceae	Annual	Flowering
Anthemis palestina Reut.	Compositae	Perennial	Vegetative
Aristolochia maurorum L.	Aristolochiaceae	Annual	Vegetative
Arnebia decumbens (Vent.) Cosson & Kralik	Boraginaceae	Annual	Flowering
Arum dioscoridis Sm.	Araceae	Perennial	Vegetative
Astoma seselifolium DC.	Umbelliferae	Annual	Vegetative
Astragalus hamosus L.	Leguminosae	Annual	Vegetative
Astragalus hispidulus DC.	Leguminosae	Annual	Vegetative
Atriplex halimus L.	Chenopodiaceae	Perennial	Vegetative
Avena sterilis L.	Gramineae	Annual	Fruiting
Beta vulgaris L.	Chenopodiaceae	Annual	Vegetative
Bongardia chrysoganum C.A. Mey.	Amaranthaceae	Perennial	Vegetative
Bromus sterilis L.	Gramineae	Annual	Vegetative
Bromus tectorum L.	Gramineae	Annual	Vegetative
Calendula arvensis L.	Compositae	Annual	Flowering
Calendula palaestina Boiss.	Compositae	Annual	Flowering
Calotropis procera (Aiton) Aiton fil.	Asclepidaceae	Perennial	Flowering
Capparis spinosa L.	Capparaceae	Perennial	Vegetative
Capsella bursa-pastoris (L.) Medikus	Cruciferae	Annual	Vegetative
Cardaria draba L.	Cruciferae	Perennial	Vegetative
Carthamus nitidus Boiss.	Compositae	Annual	Flowering

Cassia senna L.	Leguminosae	Perennial	Vegetative
Centaurea iberica Trev. Ex Spreng	Compositae	Biennial	Vegetative
Centaurea pallescens Del.	Compositae	Annual	Flowering
Cerastium dicotomum L.	Caryophyllaceae	Annual	Vegetative
Chenopodium album L.	Chenopodiaceae	Annual	Vegetative
Chenopodium murale L.	Chenopodiaceae	Annual	Vegetative
Chenopodium vulvaria L.	Chenopodiaceae	Annual	Flowering
Chrozophora tinctoria (L.) A. Juss.	Euphorbiaceae	Annual	Vegetative
Chrysanthemum coronarium L.	Compositae	Annual	Flowering
Chrysanthemum segetum L.	Compositae	Annual	Flowering
Cichorium pumilum Jacq.	Compositae	Annual	Vegetative
Convolvulus arvensis L.	Convolvulaceae	Annual	Vegetative
Conyza bonariensis (L.) Cronquist	Compositae	Annual	Vegetative
Coriandrum sativum L.	Umbelliferae	Annual	Vegetative
Coronilla scorpioides (L.) Koch	Leguminosae	Annual	Vegetative
Crambe orientalis L.	Cruciferae	Annual/Perennial	Flowering
Crepis aspera L.	Compositae	Annual	Vegetative
Crepis syriaca (Bornm.) Babcock & Nav.	Compositae	Annual	Flowering
Crocus hermoneus Kotschy ex Maw	Iridaceae	Perennial	Flowering
Cucumis prophetarum L.	Cucurbitaceae	Perennial	Vegetative
Cynodon dactylon (L.) Pers.	Gramineae	Perennial	Vegetative
Cyperus rotundus L.	Cyperaceae	Perennial	Vegetative
Datura innoxia Miller	Solanaceae	Annual	Vegetative
Dianthus strictus Bank ex Prantl.	Caryophyllaceae	Perennial	Flowering
Digitaria sanguinalis (L.) Scop.	Gramineae	Annual	Vegetative
Diplotaxis erucoides (L.) DC.	Cruciferae	Annual	Vegetative
Ecballium elaterium (L.) A. Rich	Cucurbitaceae	Perennial	Vegetative
Echinochloa colonum (L.) Link	Gramineae	Annual	flowering
Emex spinosa (L.) Campd.	Polygonaceae	Annual	Flowering
Eragrostis cilianesis (Willd.) Delile	Gramineae	Annual	Vegetative
Erodium acaule (L.) Bech. &Thell.	Geraniaceae	Annual/Perennial	Vegetative
Erodium gruinum (L.) L'Her	Geraniaceae	Perennial/Annual	Flowering
Eruca sativa Mill.	Cruciferae	Annual	vegetative
Erucaria hispanica (L.) Druce	Cruciferae	Annual	Vegetative
Eryngium creticum Lam.	Umbelliferae	Annual/Perennial	Flowering
Eucalyptus camaldulensis Dehnh	Myrtaceae	Perennial	Vegetative
Euphorbia geniculata Ortega	Euphorbiaceae	Annual	Vegetative
Euphorbia helioscopia L.	Euphorbiaceae	Annual	Vegetative
Falcaria vulgaris Bernh.	Umbelliferae	Annual	Flowering
Ferula communis L.	Umbelliferae	Annual	Vegetative
Filago pyramidata L.	Compositae	Annual	Vegetative
Foeniculum vulgare Miller	Umbelliferae	Annual	Vegetative
Fumaria densiflora DC.	Fumariaceae	Annual	Vegetative
Fumaria parviflora Lam.	Fumariaceae	Annual	Vegetative
Galium tricornutum Dandy	Rubiaceae	Annual/Perennial	Vegetative
Geranium tuberosum L.	Geraniaceae	perennial	Vegetative
Geropogon hybridus (L.) Schultz Bip.	Compositae	Annual	Flowering
Gladiolus italicus Miller	Iradaceae	Perennial	Flowering
Glaucium corniculatum (L.) J. H. Rudolph	Papaveraceae	Annual	Vegetative
Glycyrrhiza glabra L.	Leguminosae	Perennial	Vegetative
Gundelia tournefortii L.	Compositae	Annual	Flowering
Gypsophila pilosa Barkoudah	Caryophyllaceae	Annual/Perennial	Flowering
Helianthemum aegyptiacum (L.) Mill.	Cistaceae	Annual/Perennial	Flowering

Heliotropium europaeum L.	Boraginaceae	Annual	Flowering
Hippocrepis unisiliquosa L.	Leguminosae	Annual	Vegetative
Hirschfeldia incana (L.) Lagreze-Fossat	Cruciferae	Perennial	Flowering
Hordeum bulbosum L.	Gramineae	Annual	Vegetative
Hordeum spontaneum K. Koch	Gramineae	Annual	Vegetative
Hyoscyamus niger L.	Solanaceae	Annual/Biennial	Vegetative
Hyoscyamus reticulates L.	Solanaceae	Annual/Biennial	Vegetative
Hypecoum procumbens L.	Apocynaceae	Annual	Flowering
Hypericum triquetrifolium Turra	Hypericaceae	Perennial	Vegetative
Inula viscose (L.) Ait.	Compositae	Perennial	Vegetative
Isatis lusitanica L.	Cruciferae	Annual	Vegetative
Juncus acutus L.	Juncaceae	Perennial	Flowering
Juncus bufonius L.	Juncaceae	Perennial	Flowering
Koelpinia lineris Pallas	Compositae	Annual	Vegetative
Lactuca serriola L.	Compositae	Annual/Biennial	Flowering
Lamium amplexicaule L.	Labiatae	Annual	Vegetative
Lathyrus cicera L.	Leguminosae	Annual	Vegetative
Lathyrus pseudocicera Pamp.	Leguminosae	Annual	Flowering
Launaea nudicaulis (L.) Hooker fil.	Compositae	Perennial	Vegetative
Leontice leontopetalum L.	Berberidaceae	Perennial	Vegetative
Lepidium sativum L.	Cruciferae	Annual	Vegetative
Linum bienne Miller	Linaceae	Perennial	Flowering
Lolium perenne L.	Gramineae	Perennial	Vegetative
Malva nicaeensis ALL.	Malvaceae	Annual	Flowering
Malva parviflora L.	Malvaceae	Annual	Flowering
Malva sylvestris L.	Malvaceae	Annual	Vegetative
Mandragora autumnalis Bertol.	Solanaceae	Perennial	Flowering
Matricaria aurea (Loefl.) Schultz Bip	Compositae	Annual	Vegetative
Matthiola parviflora (Schousb.) R. Br.	Cruciferae	Annual	Vegetative
Medicago orbicularis (L.) Bart.	Leguminosae	Perennial	Vegetative
Medicago sativa L.	Leguminosae	Perennial	Vegetative
Melilotus indicus (L.) All.	Leguminosae	Annual/Biennial	Flowering
Mentha spicata L.	Labiatae	Perennial	Vegetative
Mercurialis annua L.	Euphorbiaceae	Annual	Vegetative
Moluccella laevis L.	Labiatae	Perennial	Vegetative
Nerium oleander L.	Apocynaceae	Perennial	Flowering
Neslia apiculata Fischer, C. A. Meyer & Ave'-Lall.	Cruciferae	Annual	Vegetative
Notobasis syriaca (L.) Cass.	Compositae	Annual	Flowering
Ocimum basilicum L.	Labiatae	Annual	Vegetative
Onobrychis crista-galli (L.) Lam.	Leguminosae	Annual	Vegetative
Origanum syriacum L.	Labiatae	Perennial	Vegetative
Oxalis corniculata L.	Oxalidaceae	Perennial	Flowering
Pallenis spinosa (L.) Cass.	Compositae	Annual	Vegetative
Papaver rhoeas L.	Papaveraceae	Annual	Flowering
Parietaria diffusa Mert. et Koch	Urticaceae	Perennial	Vegetative
Peganum harmala L.	Zygophyllaceae	Perennial	Vegetative
Phagnalon saxatile (L.) Cass.	Compositae	Perennial	Vegetative
Phalaris aquatica L.	Gramineae	Annual	Flowering
Pisum syriacum (Berg.) Lehm.	Leguminosae	Annual	Flowering
Plantago coronopus L.	Plantaginaceae	Annual	Flowering
Plantago lanceolata L.	Plantaginaceae	Perennial	Vegetative
Poa annua L.	Gramineae	Perennial	Flowering
Poa bulbosa L.	Gramineae	Perennial	Flowering

Polygonum arenastrum Bor.	Polygonaceae	Annual	Vegetative
Polypogon monspeliensis (L.) Desf.	Gramineae	Annual	Vegetative
Prosopis farcta (Banks et Sol.) Macbride	Leguminosae	Perennial	Vegetative
Reseda lutea L.	Resedaceae	Annual/Biennial	Vegetative
Ridolfia segetum (Guss.) Moris	Umbelliferae	Annual	Flowering
Rosmarinus officinalis L.	Labiatae	Perennial	Vegetative
Rubia tinctorum L.	Rubiaceae	Perennial	Vegetative
Rubus sanguineus Friv.	Rosaceae	Perennial	Flowering
Rumex crispus L.	Polygonaceae	Biennial/Perennial	Flowering
Rumex vesicarius L.	Polygonaceae	Biennial/Perennial	Vegetative
Ruta graveolens L.	Rutaceae	Perennial	Vegetative
Salsola vermiculata L.	Chenopodiaceae	Perennial	Vegetative
Salvia aegyptiaca L.	Labiatae	Annual	Flowering
Salvia officinalis L.	Labiatae	Perennial	Vegetative
Salvia syriaca L.	Labiatae	Annual	Vegetative
Scandix pecten-veneris L.	Umbelliferae	Annual	Vegetative
Scorpiurus muricatus L.	Papilionaceae	Annual	Vegetative
Senecio vernalis Waldst & Kit.	Compositae	Annual	Vegetative
Setaria verticillata L.	Gramineae	Annual	Vegetative
Silene aegyptiaca (L.) L. fil.	Caryophyllaceae	Perennial	Vegetative
Silene crassipes Fenzl.	Caryophyllaceae	Perennial	Flowering
Silybum marianum (L.) Gaertn.	Compositae	Biennial	Flowering
Sinapis alba L.	Cruciferae	Annual	Fruiting
Sinapis arvensis L.	Cruciferae	Annual	Vegetative
Sisymbrium irio L.	Cruciferae	Annual	Vegetative
Sisymbrium officinale (L.) Scop.	Cruciferae	Annual	Flowering
Solanum elaeagnifolium Cav.	Solanaceae	Perennial	Flowering
Solanum nigrum L.	Solanaceae	Perennial	Vegetative
Sonchus oleraceus (L.) L.	Compositae	Annual	Flowering
Sorghum halepense (L.) Pers.	Gramineae	Perennial	Flowering
Spergula fallax (Lowe) Krause	Caryophyllaceae	Annual	Vegetative
Spergularia diandra (Guss.) Heldr. &Sart.	Caryophyllaceae	Perennial	Vegetative
Stellaria media (L.) Vill.	Gramineae	Perennial	Vegetative
Stipa parviflora Desf.	Gramineae	Perennial	Vegetative
Tetragonolobus palaestina Boiss. et Blanche	Leguminosae	Annual	Flowering
Teucrium polium L.	Labiatae	Perennial	Vegetative
Texiera glastifolia (DC.) Jaub. et Spach	Cruciferae	Annual	Vegetative
Tordylium aegyptiacum (L.) Lam.	Umbelliferae	Annual	Vegetative
Torularia torulosa (Desf.) O. E. Schulz	Cruciferae	Annual	Flowering
Tragopogon collinus DC.	Compositae	Biennial/Perennial	Flowering
Tribulus terrestris L.	Zygophyllaceae	Annual	Vegetative
Trifolium arvense L.	Leguminosae	Perennial	Flowering
Trifolium clusii Godr. et Gren.	Leguminosae	Perennial	Flowering
Trifolium pratenese L.	Leguminosae	Annual	Vegetative
Trigonella foenum-graecum L.	Leguminosae	Annual	Vegetative
Typha latifolia L.	Typhaceae	Perennial	Vegetative
Urtica urens L.	Urticaceae	Annual	Vegetative
Vaccaria pyramidata Medikus	Caryophyllaceae	Annual	Vegetative
Verbascum thapsus L.	Scrophulariaceae	Biennial	Vegetative
Vicia ervilia (L.) Willd.	Leguminosae	Annual	Vegetative
Vicia sativa L.	Leguminosae	Annual	Flowering
Vicia syriaca L.	Leguminosae	Annual	Vegetative
Xanthium echinatum Murr.	Compositae	Perennial	Vegetative

Xanthium spinosum L.	Compositae	Perennial	Vegetative

***Preparation of aqueous shoot extracts*:** Three hundred gram fresh shoots of each collected plant species were washed with tap water, then with distilled water, allowed to dry at room temperature for 2 h and then were separately chopped into small pieces. Macerated materials were added to a liter of distilled, mixed and homogenized in an electrical blender for five minutes at room temperature (Rice, 1984; Qasem and Foy, 2001; Qasem, 2010a, 2013b). The mixture was allowed to stand for half an hour before the supernatant was filtered through a Whatman no. 1 filter paper. The filtered extract, considered as a full strength, was filled into dark brown plastic bottles and placed in a refrigerator at 4 ºC for 4 weeks before being used. Prior to extract use, the pH of each extract was determined using Eutich Instrument Ion 510 (Serial No 1283428) pH meter, and the electrical conductivity (EC) was also measured using Trans Instruments BC 3020 NATO/OTAN.

The following experiments were carried out under glasshouse and field conditions at the University of Jordan, Amman. Jordan.

Experiment 1: Effect of foliar application of different plant extracts on seedling growth of A. retroflexus and C. murale under glasshouse conditions: One gram seeds of *A. retroflexus* and *C. murale* were sown separately in four PVC pots (11 cm in diameter and 10 cm in height) filled with 250 g peatmoss/soil mixture (1:1 V/V). All emerged weed seedlings (average 15-20 seedlings per pot) were allowed to grow under glasshouse conditions for the period from March to April, 2017 at 26/17ºC average day/night temperature. Three weeks after emergence, seedlings at 3-4 leaf stage of both weeds were sprayed with the full strength aqueous extracts of different plant species using a hand-held sprayers (www.dimartino.It; made in Italy; 2006/C2; FIESTA 500 VAPORIZZATORE, PEHD), 80 ml of each extract was used per treatment (4 pots) to completely cover seedling foliage parts. Seedlings of both weeds sprayed with the same volume of distilled water were included and considered as controls. Pots were irrigated thereafter when needed until harvest.

Vegetative growth of treated weed seedlings was monitored throughout the experimental period, and any changes in their normal growth or toxicity symptoms resulted changes in green color appearance or burning/necrosis on foliage parts resulted from extracts treatments on both weeds were recorded and compared with their respective controls. The experiment was continued for five weeks after treatment at which plants of *A. retroflexus* and *C. murale* in all treatments were harvested from the above soil level, their heights, and shoots fresh and dry weights (oven-dried at 75 ºC for 48 h) were determined.

Experiment 2: Effect of application of Ruta graveolens extract alone or in combination with paraquat on seedlings growth of Amaranthus retroflexus and Chenopodium murale under field conditions: Since *R. graveolens* extract was the most phytotoxic to growth of both weed species among all tested extracts in glasshouse experiments, therefore it was chosen for further testing under field conditions.

Plots each of 0.5 x 0.5 m were made with a hand-hoe and each was sown by fifteen gram seeds of either weed species per plot to establish a dense (≈ 350 seedlings/m^2) stand for each weed species, separately. After emergence only seedlings of *A. retroflexus* and *C. murale*, were left in the plots while other weed species were hand removed.

Different rates (0.4, 0.3, 0.2, 0.1 and 0.05 kg a.i/ha) of the herbicide Herbikill (a.i Paraquat 20%) were preliminary tested on *A. retroflexus* and *C. murale* naturally growing in the field to determine the minimum effective dose of the herbicide required for the control of these weeds. The lowest phytotoxic rate of application detected was then considered and combined with *R. graveolens* extract/paraquat mixture at 10/1 (V/V).

Treatments included the use of only *R. graveolens* extract, paraquat herbicide full (0.4 kg a.i/ ha) rate of application, and a mixture of one volume of paraquat minimum effective rate (10 g a.i/ha) and 10 volumes of *R. graveolens* extract. Plots from both weed species were also included but only sprayed with similar volume of tap water and considered as controls. Plants of both weed species were treated at 3-4 leaf stage and kept observed daily for any change/s in normal growth, green color appearance or burning/necrosis (toxicity symptoms). Symptoms of extracts treatments were noted for two weeks after application. Visual estimation of the efficacy of extract in controlling both weeds was conducted using a scale from 0 to 10 at which zero means weeds were not affected while 10 score denotes that weed plants were completely controlled. Plants of both weed species in all plots were harvested from the above soil surface 14 days after treatments, their fresh weights were recorded, then oven-dried at 75 ºC for 48 h and their dry weights determined.

Treatments in glasshouse and field experiments were laid out in a Randomized Complete Block Design with four replicates for each plant species tested.

***Statistical analysis*:** All data were statistically analyzed by ANOVA and treatments means were compared using the least significant difference (LSD) at p = 0.05 using SAS software SAS (r) version 9.1 (SAS Institute Inc. 2004).

RESULTS

***pH and EC of plants extracts*:** All extracts had pH values less than 7. The pH of extracts varied considerably and ranged from 4.02 for *Adonis aestivalis* to 6.53 for

Tetragonolobus palaestina. The highest number of extracts had pH values between 5.51 to 6.0 (Fig.1a). However, 37 plant extracts were extremely acidic (pH < 5), and extracts of 59 species had pH values above 6 (Table 2).

Table 2. Effect of foliage applied aqueous extracts of different plant species having different pH and EC values on mean shoot dry weights, and plant height of *A. retroflexus* and *C. murale* grown in pots under glasshouse conditions.

Plant species	Extract pH	Extract electrical conductivity (EC) (millisiemnes/cm)	*A. retroflexus*		*C. murale*	
			Plant height (cm)	Shoot dry weight (g/pot)	Plant height (cm)	Shoot dry weight (g/pot)
Control (dH_2O)	6.75	0.04	15.5^{b*}	3.9^{a-c}	21.5^{a}	11.9^{a}
Acanthus syriaca	4.52	7.23	11.1^{c-q}	2.0^{p-s}	11.9^{d-n}	4.6^{c-x}
Achillea aleppica	5.43	3.07	9.5^{c-u}	2.3^{h-c}	12.4^{d-n}	4.1^{e-x}
Adonis aestivalis	4.02	9.56	10.6^{c-l}	3.9^{a-c}	14.6^{b-d}	4.3^{e-x}
Adonis annua	5.63	5.15	5.9^{o-z}	1.9^{s}	13.3^{c-l}	4.9^{b-r}
Aegilops geniculata	5.45	8.23	6.8^{h-z}	3.7^{a-d}	11.0^{h-n}	4.8^{b-s}
Aizoon canariense	6.23	8.73	7.1^{f-z}	2.0^{r-s}	14.0^{b-g}	3.8^{n-x}
Alcea acaulis	4.49	12.29	9.8^{c-s}	2.4^{d-s}	11.8^{e-n}	4.8^{b-s}
Alhagi maurorum	6.19	12.56	9.9^{c-u}	2.4^{d-s}	12.5^{d-n}	4.2^{e-x}
Alkanna strigosa	5.51	9.83	8.0^{d-z}	2.4^{d-s}	11.8^{e-n}	4.1^{e-x}
Allium erdelii.	4.95	5.70	10.5^{c-m}	2.0^{p-s}	11.6^{f-n}	3.4^{q-x}
Alyssum damascenum	4.93	7.15	9.6^{c-t}	2.4^{d-s}	11.5^{f-n}	4.8^{b-s}
Amaranthus gracilis	4.21	5.63	7.9^{d-z}	2.2^{j-s}	11.6^{f-n}	4.2^{e-x}
Amaranthus retroflexus	6.12	12.10	6.8^{h-z}	2.1^{p-s}	12.1^{d-n}	4.7^{b-v}
Amaranthus viridis	5.77	7.20	4.5^{x-z}	2.3^{h-s}	11.3^{g-n}	4.7^{b-v}
Ammi majus	6.41	9.13	9.0^{c-w}	2.3^{h-s}	13.5^{b-j}	4.9^{b-r}
Anabasis syriaca	6.24	9.98	11.1^{b-h}	2.1^{p-s}	11.9^{d-n}	4.6^{c-x}
Anagallis arvensis	5.52	9.33	8.1^{c-z}	2.2^{j-s}	14.5^{b-e}	4.2^{e-x}
Anchusa italic	6.01	4.07	7.6^{f-z}	2.4^{d-s}	13.0^{c-m}	4.9^{b-r}
Anchusa officinalis	5.81	7.63	7.9^{d-z}	2.5^{d-s}	12.0^{d-n}	5.3^{b-n}
Anemone coronaria	5.34	4.32	7.5^{f-z}	2.2^{j-s}	13.0^{c-m}	4.5^{c-x}
Anthemis palestina	5.87	7.76	9.6^{c-t}	2.4^{d-s}	12.3^{d-n}	4.5^{c-x}
Aristolochia maurorum	6.36	11.34	9.3^{c-u}	2.0^{p-s}	9.8^{n}	4.2^{e-x}
Arnebia decumbens	5.23	3.49	7.4^{f-z}	2.0^{p-s}	11.6^{f-n}	4.6^{c-x}
Arum dioscoridis	6.43	10.76	7.5^{f-z}	2.4^{d-s}	10.6^{k-n}	3.9^{i-x}
Astoma seselifolium	6.17	4.4	9.9^{c-r}	3.4^{a-l}	11.8^{e-n}	4.6^{c-x}
Astragalus hamosus	5.82	5.72	9.9^{c-r}	2.2^{j-s}	12.9^{d-m}	4.8^{b-s}
Astragalus hispidulus	5.98	12.32	8.3^{c-z}	2.6^{d-s}	11.3^{g-n}	4.4^{e-x}
Atriplex halimus	6.01	10.18	7.5^{f-z}	3.4^{a-l}	13.3^{c-l}	3.7^{o-x}
Avena sterilis	4.92	4.16	9.0^{c-w}	2.5^{d-s}	10.3^{m-n}	4.4^{e-x}
Beta vulgaris	5.38	3.76	6.6^{i-z}	2.0^{p-s}	12.5^{d-n}	3.9^{i-x}
Bongardia chrysoganum	6.12	5.54	6.6^{i-z}	3.6^{a-f}	11.8^{e-n}	4.5^{c-x}
Bromus sterilis	5.61	7.21	9.8^{c-s}	3.4^{a-l}	11.0^{h-n}	4.2^{e-x}
Bromus tectorum	5.55	10.60	7.8^{e-z}	2.0^{p-s}	12.8^{d-m}	4.1^{e-x}
Calendula arvensis	6.18	10.77	4.8^{v-z}	2.3^{h-s}	12.8^{d-m}	3.9^{i-x}
Calendula palaestina	4.82	7.23	8.4^{c-y}	2.3^{h-s}	10.8^{j-n}	3.5^{p-x}
Calotropis procera	6.01	4.57	9.1^{c-v}	2.6^{d-s}	11.4^{f-n}	4.7^{b-v}
Capparis spinosa	6.11	4.43	7.8^{e-z}	2.2^{j-s}	12.5^{d-n}	5.1^{b-o}
Capsella bursa-pastoris	5.84	4.53	6.6^{i-z}	2.5^{d-s}	13.5^{b-j}	4.9^{b-r}
Cardaria draba	4.95	9.21	8.8^{c-x}	2.4^{d-s}	12.6^{d-n}	4.3^{e-x}
Carthamus nitidus	5.82	3.77	6.1^{m-z}	1.8^{S}	10.6^{k-n}	4.5^{c-x}
Cassia senna	5.67	8.36	10.9^{c-j}	2.1^{p-s}	9.8^{n}	4.8^{b-s}
Centaurea iberica	6.27	7.27	10.4^{c-n}	2.9^{p-s}	13.1^{c-l}	3.3^{s-x}
Centaurea pallescens	4.89	3.08	7.8^{e-z}	1.9^{r-s}	11.9^{d-n}	4.7^{b-v}
Cerastium dicotomum	5.68	7.30	6.4^{k-z}	2.7^{c-s}	11.0^{h-n}	4.8^{b-s}
Chenopodium album	4.88	4.67	7.6^{f-z}	2.2^{j-s}	11.6^{f-n}	4.8^{b-s}

Plant species	Extract pH	Extract electrical conductivity (EC) (millisiemnes/cm)	*A. retroflexus*		*C. murale*	
			Plant height (cm)	Shoot dry weight (g/pot)	Plant height (cm)	Shoot dry weight (g/pot)
Chenopodium murale	5.74	11.51	7.3^{f-z}	2.2^{j-s}	11.3^{g-n}	4.6^{c-x}
Chenopodium vulvaria	6.24	9.60	8.8^{c-x}	2.0^{p-s}	11.3^{g-n}	4.8^{b-s}
Chrozophora tinctoria	5.67	7.78	8.8^{c-x}	2.0^{p-s}	12.1^{d-n}	3.2^{v-x}
Chrysanthemum coronarium	5.71	6.52	9.8^{c-s}	2.1^{p-s}	12.1^{d-n}	4.2^{e-x}
Chrysanthemum segetum	6.08	4.61	7.4^{f-z}	2.2^{j-s}	13.0^{c-m}	4.9^{b-r}
Cichorium pumilum	5.81	7.65	3.6^{z}	2.1^{p-s}	12.5^{d-n}	4.4^{e-x}
Convolvulus arvensis	4.92	8.56	11.3^{b-g}	2.0^{p-s}	12.8^{d-m}	4.6^{c-x}
Conyza bonariensis	5.14	12.54	10.8^{c-k}	2.5^{d-s}	13.3^{c-l}	5.0^{b-r}
Coriandrum sativum	5.71	11.94	6.5^{j-z}	2.1^{p-s}	11.0^{h-n}	3.8^{n-x}
Coronilla scorpioides	6.15	8.21	9.0^{c-w}	2.5^{d-s}	13.3^{c-l}	3.7^{o-x}
Crambe orientalis	5.48	10.71	5.4^{s-z}	2.0^{q-s}	11.5^{f-n}	4.7^{b-v}
Crepis aspera	6.18	4.35	9.5^{c-u}	2.2^{j-s}	11.8^{e-n}	4.2^{e-x}
Crepis syriaca	6.12	10.94	8.1^{c-z}	2.2^{j-s}	12.8^{d-m}	5.1^{b-o}
Crocus hermoneus	5.75	7.13	9.5^{c-u}	2.2^{j-s}	12.1^{d-n}	4.1^{e-x}
Cucumis prophetarum	4.84	3.43	10.1^{c-p}	2.3^{h-s}	10.5^{l-n}	5.6^{b-g}
Cynodon dactylon	4.73	6.37	9.0^{c-w}	3.5^{a-h}	13.0^{c-m}	4.6^{c-x}
Cyperus rotundus	5.75	12.84	6.4^{k-z}	1.9^{r-s}	12.7^{d-m}	5.5^{p-h}
Datura innoxia	5.85	6.32	5.3^{t-z}	2.3^{h-s}	11.5^{f-n}	3.1^{w-x}
Dianthus strictus	5.01	6.42	8.6^{c-x}	2.3^{h-s}	13.5^{b-j}	4.4^{e-x}
Digitaria sanguinalis	6.25	6.93	7.8^{e-z}	2.3^{h-s}	11.6^{f-n}	4.8^{b-s}
Diplotaxis erucoides	5.85	12.80	6.4^{k-z}	1.9^{r-s}	13.6^{b-i}	4.4^{e-x}
Ecballium elaterium	5.35	7.57	7.5^{f-z}	2.4^{d-s}	11.6^{f-n}	3.9^{j-x}
Echinochloa colonum	5.51	6.36	6.8^{h-z}	3.4^{a-l}	13.5^{b-j}	4.8^{b-s}
Emex spinosa	6.12	7.27	11.0^{c-i}	2.9^{p-s}	11.4^{f-n}	4.7^{b-v}
Eragrostis cilianesis	5.95	7.87	8.3^{c-z}	2.1^{p-s}	12.6^{d-n}	4.7^{b-v}
Erodium acaule	6.48	12.32	8.3^{c-z}	2.0^{q-s}	13.6^{b-i}	4.8^{b-s}
Erodium gruinum	6.26	11.51	11.0^{c-i}	2.5^{d-s}	12.0^{d-n}	5.6^{b-g}
Eruca sativa	5.75	12.14	6.6^{i-z}	3.0^{b-s}	12.8^{d-m}	3.8^{n-x}
Erucaria hispanica	6.23	11.12	12.5^{b-c}	3.4^{a-l}	13.5^{b-j}	4.2^{e-x}
Eryngium creticum	5.81	7.11	8.4^{c-y}	2.0^{p-s}	13.0^{c-m}	4.7^{b-v}
Eucalyptus camaldulensis	5.57	3.49	4.6^{w-z}	2.4^{d-s}	10.6^{k-n}	4.8^{b-s}
Euphorbia geniculata	5.62	8.74	6.5^{j-z}	1.9^{r-s}	14.1^{b-f}	5.6^{b-g}
Euphorbia helioscopia	5.86	12.55	25.0^{a}	2.0^{p-s}	11.9^{d-n}	4.4^{e-x}
Falcaria vulgaris	5.46	8.56	8.8^{c-x}	2.7^{c-s}	11.6^{f-n}	6.0^{b-d}
Ferula communis	6.33	3.50	6.1^{m-z}	2.2^{j-s}	11.0^{h-n}	4.1^{e-x}
Filago pyramidata	5.43	10.67	7.8^{e-z}	2.1^{p-s}	10.5^{l-n}	4.3^{e-x}
Foeniculum vulgare	6.15	8.20	8.4^{c-y}	2.4^{d-s}	12.3^{d-n}	5.4^{b-l}
Fumaria densiflora	4.51	3.64	8.1^{c-z}	2.7^{c-s}	12.3^{d-n}	5.5^{b-h}
Fumaria parviflora	4.56	7.07	11.5^{b-f}	2.6^{d-s}	11.0^{h-n}	4.9^{b-r}
Galium tricornutum	4.35	7.46	8.0^{d-z}	2.0^{q-s}	11.9^{d-n}	4.6^{c-x}
Geranium tuberosum	5.63	5.07	7.0^{g-z}	2.1^{p-s}	11.8^{e-n}	4.9^{b-r}
Geropogon hybridus	5.53	8.33	8.0^{d-z}	1.8^{S}	13.5^{b-j}	5.4^{b-l}
Gladiolus italicus	6.23	7.63	6.6^{i-z}	2.9^{p-s}	12.1^{d-n}	4.3^{e-x}
Glaucium corniculatum	5.57	6.71	8.8^{c-x}	2.1^{p-s}	11.8^{e-n}	4.6^{c-x}
Glycyrrhiza glabra	5.32	3.32	10.3^{c-o}	2.4^{d-s}	13.9^{b-g}	4.7^{b-v}
Gundelia tournefortii	6.12	3.45	5.6^{q-z}	2.4^{d-s}	12.4^{d-n}	4.7^{b-v}
Gypsophila pilosa	6.15	3.83	6.5^{j-z}	2.6^{d-s}	12.1^{d-n}	6.1^{bc}
Helianthemum aegyptiacum	4.48	6.85	8.5^{c-o}	3.5^{a-h}	13.1^{c-l}	4.7^{b-v}
Heliotropium europaeum	6.45	3.21	10.0^{c-q}	2.0^{p-s}	11.4^{f-n}	4.3^{e-x}
Hippocrepis unisiliquosa	4.95	7.09	8.9^{c-x}	2.3^{h-s}	10.5^{l-n}	5.2^{b-o}
Hirschfeldia incana	5.58	9.14	8.5^{c-y}	2.2^{j-s}	12.5^{d-n}	4.9^{b-r}

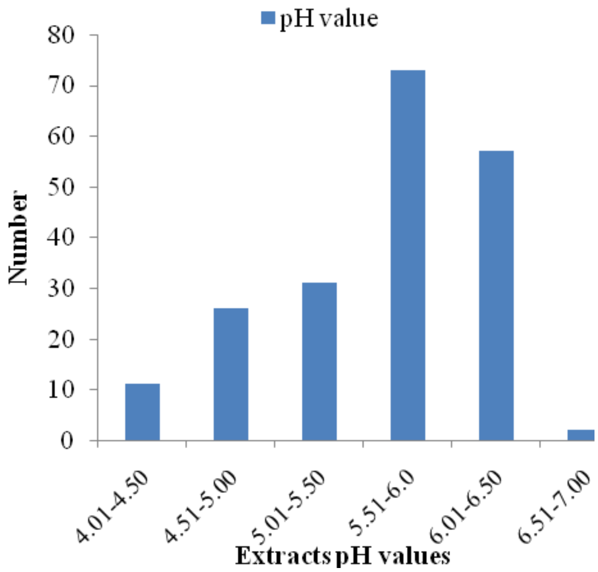
Plant species	Extract pH	Extract electrical conductivity (EC) (millisiemnes/cm)	*A. retroflexus*		*C. murale*	
			Plant height (cm)	Shoot dry weight (g/pot)	Plant height (cm)	Shoot dry weight (g/pot)
Hordeum bulbosum	5.07	12.86	8.9^{c-x}	2.7^{c-s}	11.5^{f-n}	5.1^{b-o}
Hordeum spontaneum	4.48	3.67	4.8^{v-z}	2.0^{p-s}	10.5^{l-n}	5.0^{b-o}
Hyoscyamus niger	5.67	8.41	7.8^{e-z}	2.1^{p-s}	13.3^{c-l}	4.2^{e-x}
Hyoscyamus reticulates	5.72	10.19	8.3^{c-z}	2.2^{j-s}	12.4^{d-n}	4.7^{b-v}
Hypecoum procumbens	5.63	4.71	9.3^{c-u}	2.6^{d-s}	11.9^{d-n}	3.7^{o-x}
Hypericum triquetrifolium	6.38	8.10	10.0^{c-q}	2.9^{p-s}	12.5^{d-n}	5.2^{b-o}
Inula viscosa	4.78	8.56	10.3^{c-o}	2.2^{j-s}	11.5^{f-n}	3.1^{w-x}
Isatis lusitanica	6.45	12.45	10.8^{c-k}	2.3^{h-s}	14.1^{b-f}	4.4^{e-x}
Juncus acutus	6.28	3.43	6.5^{j-z}	2.3^{h-s}	12.3^{d-n}	4.8^{b-s}
Juncus bufonius	4.35	7.19	5.5^{r-z}	2.1^{p-s}	11.8^{e-n}	4.3^{e-x}
Koelpinia lineris	4.35	11.31	9.3^{c-u}	2.3^{h-s}	10.6^{k-n}	4.4^{e-x}
Lactuca serriola	5.56	4.21	10.3^{c-o}	2.5^{d-s}	12.5^{d-n}	5.1^{b-o}
Lamium amplexicaule	5.67	11.22	7.8^{e-z}	2.5^{d-s}	13.0^{c-m}	4.6^{c-x}
Lathyrus cicera	5.68	6.11	8.1^{c-z}	2.2^{j-s}	11.8^{e-n}	4.8^{b-s}
Lathyrus pseudocicera	6.23	12.71	5.9^{o-z}	2.2^{j-s}	12.1^{d-n}	3.9^{i-x}
Launaea nudicaulis	5.89	5.15	10.3^{c-o}	2.3^{h-s}	11.0^{h-n}	5.2^{b-o}
Leontice leontopetalum	5.48	12.25	9.9^{c-r}	2.6^{d-s}	11.4^{f-n}	4.8^{b-s}
Lepidium sativum	5.45	8.30	9.4^{c-u}	2.7^{c-s}	11.0^{h-n}	3.9^{i-x}
Linum bienne	5.85	7.34	8.4^{c-y}	2.2^{j-s}	11.5^{f-n}	4.8^{b-s}
Lolium perenne	5.81	4.72	8.1^{c-z}	1.8^{s}	13.8^{b-h}	4.7^{b-v}
Malva nicaeensis	6.05	6.54	7.0^{g-z}	2.0^{p-s}	11.8^{e-n}	4.7^{b-v}
Malva parviflora	6.41	11.83	11.3^{b-g}	2.4^{d-s}	15.8^{b}	5.0^{b-r}
Malva sylvestris	5.59	10.77	8.6^{c-x}	2.3^{h-s}	14.5^{b-e}	4.8^{b-s}
Mandragora autumnalis	6.52	3.65	7.5^{f-z}	2.2^{j-s}	13.8^{b-h}	5.3^{b-m}
Matricaria aurea	5.74	5.89	9.1^{c-v}	2.2^{j-s}	10.5^{l-n}	4.6^{c-x}
Matthiola parviflora	6.43	6.53	6.2^{l-z}	2.7^{c-s}	11.8^{e-n}	4.5^{c-x}
Medicago orbicularis	5.55	6.79	8.8^{c-x}	2.1^{p-s}	13.0^{c-m}	4.4^{e-x}
Medicago sativa	6.23	10.03	10.6^{c-l}	3.0^{b-s}	12.1^{d-n}	4.2^{e-x}
Melilotus indicus	5.45	9.76	7.4^{f-z}	2.2^{j-s}	11.8^{e-n}	5.4^{b-l}
Mentha spicata	5.71	5.60	9.3^{c-u}	2.1^{p-s}	12.5^{d-n}	4.2^{e-x}
Mercurialis annua	5.84	9.30	4.6^{w-z}	2.7^{c-s}	10.5^{l-n}	4.4^{e-x}
Moluccella laevis	4.72	7.73	8.8^{c-x}	2.2^{j-s}	11.9^{d-n}	5.1^{b-o}
Nerium oleander	4.37	9.21	5.9^{o-z}	2.8^{c-s}	11.3^{g-n}	4.7^{b-v}
Neslia apiculata	6.22	12.43	8.3^{c-z}	1.9^{r-s}	13.8^{b-h}	5.1^{b-o}
Notobasis syriaca	5.26	7.20	8.8^{c-x}	2.2^{j-s}	11.3^{g-n}	4.6^{c-x}
Ocimum basilicum	4.93	11.20	6.5^{j-z}	2.2^{j-s}	12.9^{d-m}	4.7^{b-v}
Onobrychis crista-galli	6.25	5.41	12.3^{b-d}	2.1^{p-s}	12.5^{d-n}	3.4^{q-x}
Origanum syriacum	6.11	4.36	8.9^{c-x}	1.8^{S}	12.4^{d-n}	4.6^{c-x}
Oxalis corniculata	5.27	5.63	6.0^{n-z}	2.5^{d-s}	12.5^{d-n}	5.0^{b-o}
Pallenis spinosa	5.85	8.20	6.9^{g-z}	2.3^{h-s}	11.0^{h-n}	4.8^{b-s}
Papaver rhoeas	5.07	12.54	7.8^{e-z}	2.0^{q-s}	13.0^{c-m}	4.8^{b-s}
Parietaria diffusa	5.32	11.94	7.5^{f-z}	2.6^{d-s}	14.1^{b-f}	4.3^{e-x}
Peganum harmala	4.84	8.21	7.9^{d-z}	2.2^{j-s}	14.0^{b-g}	3.9^{i-x}
Phagnalon saxatile	6.00	10.71	5.8^{p-z}	1.9^{r-s}	11.0^{h-n}	4.7^{b-v}
Phalaris aquatica	5.02	4.35	9.3^{c-u}	2.4^{d-s}	11.3^{g-n}	5.2^{b-o}
Pisum syriacum	5.53	10.94	9.0^{c-w}	2.1^{p-s}	13.1^{c-l}	4.7^{b-v}
Plantago coronopus	5.87	7.13	7.6^{f-z}	2.2^{j-s}	11.3^{g-n}	4.3^{e-x}
Plantago lanceolata	6.31	3.43	9.8^{c-s}	2.1^{p-s}	12.5^{d-n}	4.5^{c-x}
Poa annua	4.86	6.37	8.8^{c-x}	2.3^{h-s}	13.0^{c-m}	5.6^{b-g}
Poa bulbosa	5.57	12.84	6.4^{k-z}	3.6^{a-f}	11.0^{h-n}	4.1^{e-x}
Polygonum arenastrum	5.90	6.32	9.4^{c-u}	3.4^{a-l}	11.3^{g-n}	4.0^{h-x}

Plant species	Extract pH	Extract electrical conductivity (EC) (millisiemnes/cm)	*A. retroflexus*		*C. murale*	
			Plant height (cm)	Shoot dry weight (g/pot)	Plant height (cm)	Shoot dry weight (g/pot)
Polypogon monspeliensis	5.75	4.67	9.5^{c-u}	2.3^{h-s}	13.4^{c-k}	4.7^{b-v}
Prosopis farcta	6.02	11.51	9.8^{c-s}	1.9^{r-s}	16.3^{b}	5.1^{b-o}
Reseda lutea	4.33	9.60	5.9^{o-z}	2.5^{d-s}	12.1^{d-n}	4.7^{b-v}
Ridolfia segetum	5.72	7.78	7.8^{e-z}	3.0^{b-s}	13.0^{c-m}	3.9^{i-x}
Rosmarinus officinalis	5.71	6.52	6.8^{h-z}	2.0^{p-s}	12.6^{d-n}	4.3^{e-x}
Rubia tinctorum	4.56	4.61	7.8^{e-z}	2.6^{d-s}	12.3^{d-n}	4.4^{e-x}
Rubus sanguineus	5.23	7.65	7.8^{e-z}	2.0^{q-s}	11.8^{f-n}	3.9^{i-x}
Rumex crispus	5.90	4.57	8.5^{c-y}	2.3^{h-s}	13.3^{c-l}	3.8^{n-x}
Rumex vesicarius	5.27	4.43	7.3^{f-z}	2.3^{h-s}	11.6^{f-n}	4.6^{c-x}
Ruta graveolens	5.41	4.53	4.1^{y-z}	2.4^{d-s}	4.3^{o}	1.0^{y}
Salsola verticillata	5.80	9.21	9.1^{c-v}	2.3^{h-s}	10.9^{l-n}	4.5^{c-x}
Salvia aegyptiaca	6.34	3.77	11.0^{c-i}	1.9^{r-s}	14.0^{b-g}	4.7^{b-v}
Salvia officinalis	6.06	8.36	10.0^{c-q}	2.5^{d-s}	12.5^{d-n}	4.6^{c-x}
Salvia syriaca	5.34	7.27	9.1^{c-v}	2.3^{h-s}	12.4^{d-n}	4.8^{b-s}
Scandix pecten-veneris	5.23	3.08	12.1^{b-e}	2.1^{p-s}	12.6^{d-n}	4.7^{b-v}
Scorpiurus muricatus	5.93	7.30	4.1^{y-z}	4.1^{ab}	11.5^{f-n}	4.2^{e-x}
Senecio vernalis	4.16	8.56	11.3^{b-g}	3.6^{a-f}	12.6^{d-n}	4.1^{e-x}
Setaria vermiculata	4.64	6.42	6.6^{i-z}	2.0^{q-s}	12.0^{d-n}	4.8^{b-s}
Silene aegyptiaca	5.16	6.93	7.5^{f-z}	2.2^{j-s}	11.6^{f-n}	4.8^{b-s}
Silene crassipes	5.87	12.80	7.8^{e-z}	2.0^{p-s}	13.8^{b-h}	4.6^{c-x}
Silybum marianum	5.97	7.57	5.9^{o-z}	2.3^{h-s}	12.0^{d-n}	3.7^{o-x}
Sinapis alba	5.32	6.37	6.1^{m-z}	2.5^{d-s}	13.3^{c-l}	4.7^{b-v}
Sinapis arvensis	4.86	7.63	7.8^{e-z}	3.6^{a-f}	12.8^{d-m}	3.8^{n-x}
Sisymbrium irio	5.87	6.23	6.9^{g-z}	2.0^{q-s}	12.0^{d-n}	4.5^{c-x}
Sisymbrium officinale	5.25	3.02	8.0^{d-z}	3.3^{a-p}	10.6^{k-n}	4.6^{c-x}
Solanum elaeagnifolium	5.65	4.33	8.3^{c-z}	2.1^{p-s}	13.1^{c-l}	4.5^{d-x}
Solanum nigrum	6.08	8.35	7.5^{f-z}	2.2^{j-s}	12.3^{d-n}	4.9^{b-r}
Sonchus oleraceus	5.72	8.43	5.6^{q-z}	4.5^{a}	10.3^{m-n}	4.7^{b-v}
Sorghum halepense	6.32	4.32	9.9^{c-r}	3.3^{a-p}	11.3^{g-n}	5.0^{b-o}
Spergula fallax	6.36	10.31	8.6^{c-x}	2.2^{j-s}	12.5^{d-n}	4.7^{b-v}
Spergularia diandra	4.65	4.53	9.4^{c-u}	2.0^{q-s}	13.0^{c-m}	4.7^{b-v}
Stellaria media	4.68	5.91	9.3^{c-u}	2.5^{d-s}	11.5^{f-n}	4.9^{b-r}
Stipa parviflora	5.87	8.73	8.9^{c-x}	2.6^{d-s}	13.3^{c-l}	6.2^{b}
Tetragonolobus palaestina	6.53	11.40	5.1^{u-z}	2.1^{p-s}	12.0^{d-n}	5.0^{b-o}
Teucrium polium	5.85	12.34	8.5^{c-y}	1.9^{r-s}	12.0^{d-n}	4.2^{e-x}
Texiera glastifolia	6.45	7.75	6.5^{j-z}	2.1^{p-s}	11.0^{h-n}	4.2^{e-x}
Tordylium aegyptiacum	5.75	12.80	3.9^{z}	2.0^{q-s}	12.9^{d-m}	4.9^{b-r}
Torularia torulosa	5.65	7.83	10.5^{c-m}	2.3^{h-s}	12.9^{d-m}	4.5^{c-x}
Tragopogon collinus	5.70	7.77	10.1^{c-p}	2.3^{h-s}	11.6^{f-n}	3.2^{v-x}
Tribulus terrestris	6.50	7.23	6.8^{h-z}	2.2^{j-s}	12.4^{d-n}	4.5^{c-x}
Trifolium arvense	5.54	7.73	8.8^{c-x}	3.2^{a-r}	11.3^{g-n}	4.4^{e-x}
Trifolium clusii	6.02	8.80	10.4^{c-n}	2.4^{d-s}	11.9^{d-n}	4.5^{c-x}
Trifolium pratenese	5.38	7.65	7.8^{e-z}	2.3^{h-s}	12.1^{d-n}	4.8^{b-s}
Trigonella foenum-graecum	5.77	9.43	9.5^{c-u}	2.3^{h-s}	12.5^{d-n}	4.8^{b-s}
Typha latifolia	6.24	8.27	9.8^{c-s}	3.1^{b-s}	12.6^{d-n}	5.4^{b-j}
Urtica urens	6.45	5.18	6.4^{k-z}	2.4^{d-s}	12.0^{d-n}	3.8^{n-x}
Vaccaria pyramidata	6.21	3.78	8.3^{c-z}	2.4^{d-s}	10.8^{j-n}	4.8^{b-s}
Verbascum thapsus	6.15	12.67	8.1^{c-z}	2.3^{h-s}	12.0^{d-n}	4.4^{e-x}
Vicia ervilia	4.53	3.61	6.0^{n-z}	2.0^{p-s}	11.0^{h-n}	4.2^{e-x}
Vicia sativa	5.81	4.52	9.0^{c-w}	2.4^{d-s}	12.0^{d-n}	4.9^{b-r}
Vicia syriaca	6.04	3.32	11.0^{c-i}	2.3^{h-s}	13.1^{c-l}	3.2^{v-x}
Xanthium echinatum	5.36	5.04	7.4^{f-z}	2.4^{d-s}	12.0^{d-n}	3.2^{v-x}

Plant species	Extract pH	Extract electrical conductivity (EC) (millisiemnes/cm)	*A. retroflexus*		*C. murale*	
			Plant height (cm)	Shoot dry weight (g/pot)	Plant height (cm)	Shoot dry weight (g/pot)
Xanthium spinosum	4.65	11.69	9.8[c-s]	2.2 [j-s]	12.2[d-n]	4.1 [e-x]
LSD (*p*= 0.05)	**-**	**-**	**4.5**	**1.3**	**2.9**	**1.6**

*Mean values in the same column followed by the same lower-case letter are not significantly different according to Fisher's LSD at P = 0.05.

(a)



(b)

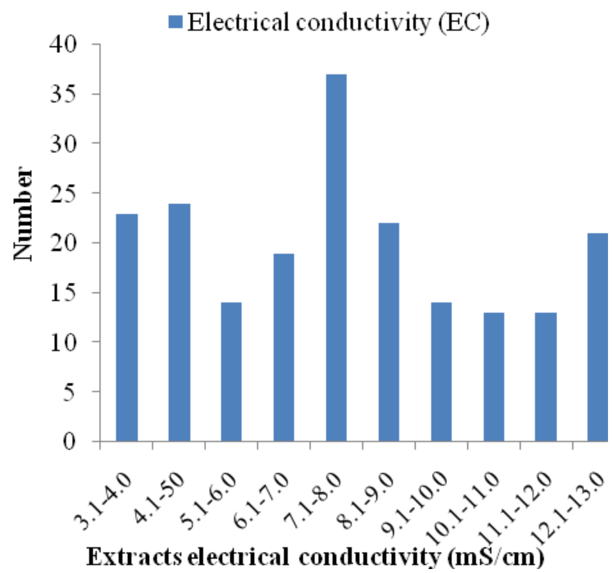


Figure 1. pH (a) and electrical conductivity (b) range of different plant species aqueous fresh shoot extracts.

Electrical conductivity [EC (millisiemnes/cm)] was also varied between examined extracts of different plant species (Table 2). Values ranged from 3.02 for *Sisymbrium officinale* to 12.86 for *Hordeum bulbosum* and many had almost similar values. Thirty-seven plant extracts showed EC values between 7.1 to 8.0 (Fig. 1b). Extracts of *Achillea aleppica, Arnebia decumbens, Beta vulgaris, Carthamus nitidus, Centaurea pallescens, Cucumis prophetarum, Eucalyptus oblique, Fumaria densiflora, Glycyrrhiza glabra, Gundelia tournefortii, Gypsophila pilosa, Heliotropium europaeum, Mandragora autumnalis, Plantago lanceolata, Salvia aegyptiaca, Scandix pecten-veneris, Sisymbrium officinale, Vaccaria pyramidata, Vicia ervilia* and *Vicia syriaca* were of extremely low in EC (< 4). On the other hand, *Alcea acaulis, Alhagi maurorum, Amaranthus retroflexus, Astragalus hispidulus, Conyza bonariensis, Cyperus rotundus, Diplotaxis erucoides, Erodium acaule, Eruca sativa, Euphorbia helioscopia, Hordeum bulbosum, Isatis lusitanica, Lathyrus pseudocicera, Leontice leontopetalum, Neslia apiculata, Papaver rhoeas, Poa bulbosa, Silene crassipes, Teucrium polium, Tordylium aegyptiacum* and *Verbascum thapsus* highest EC values (>12).

Experiment 1: Effect of foliar application of extracts on seedlings growth of weeds under glasshouse conditions.

***Effect on A. retroflexus*:** Full strength foliage applied aqueous extracts of most tested species significantly reduced plant height of *A. retroflexus* except those of *A. syriacus, C. thunbergii, E. hispanica, F. parviflora, M. parviflora, O. crista-galli, S. pecten-veneris* and *S. vernalis* (Table 2).

The shortest plants of *A. retroflexus* were those treated with *Cichorium pumilum* and *T. aegyptiacum* extracts with more than 77 and 75% height reduction compared with the control for both extracts, respectively. However, many extracts reduced *A. retroflexus* plants height by more than 50% as compared to untreated control. In contrast, extract of *E. helioscopia* increased weed height over that of untreated control by 61.3%. Similarly, different extracts significantly reduced weed shoot dry weight (Table 2). The minimum weed shoot dry weight was with extracts of *Adonis annua, C. pallescens, C. rotundus, D. erucoides, Euphorbia geniculata, Geropogon hybridus, Lolium perenne, N. apiculata, Origanum syriacum, Phagnalon saxatile, Prosopis farcta, S. aegyptiaca* and *T. polium.* However, the effect of some extracts was not significantly different from that of the control including *A. aestivalis, F. vulgaris, F. densiflora, G. italicus, H. aegyptiacum, H. triquetrifolium, L. sativum, M. parviflora, M. sativa, M. annua, N. oleander, P.*

bulbosa, P. arenastrum, R. segetum, S. vernalis, S. arvensis, S. officinale, S. halepense, S. fallax, T. arvense and *T. latifolia.* On the other hand, *S. muricatus* and *S. oleraceus* extracts increased shoot dry weight of *A. retroflexus* compared with the control. Autotoxicity effect of *A. retroflexus* extract on its own seedlings was pronounced. Seedlings height was reduced by 56.1% and shoot dry weight by 46.2% of the untreated control while the same extract also reduced seedlings height and shoot dry weight of *C. murale* seedlings by 43.7 and 60.5% of the untreated control and for both parameters, respectively.

Among all extracts, *Ruta graveolens* extract was most toxic to *A. retroflexus*, reduced weed height by 38.5% and shoot dry weight by 73.6% compared with the untreated control. Toxicity appeared as burning on leaves; stunting, yellowing and death of some treated seedlings (Fig. 2).

Control

Treated

Figure 2. Effect of foliage applied aqueous extract of *R. graveolens* on the growth of *A. retroflexus* grown in pots under glasshouse conditions.

***Effect on C. murale*:** All extracts significantly reduced heights and dry weights of *C. murale* seedlings compared with the control (Table 2). *Ruta graveolens* extract was the most toxic and toxicity was similar to that observed on *A. retroflexus* seedlings (Fig. 3). In contrast, extract of *P. farcta* was the least inhibitory to weed height, while extract of *S. parviflora* had the least effect on weed shoot dry weight compared with the control.

Weed shoot dry weight and plant height were reduced by an average of more than 60% and 24% of the control, respectively. Both growth parameters were most reduced with *R. graveolens* extract and by 91.6% and 80% compared with the control, respectively. Other extracts caused more than 70% reduction in shoot dry weight included *Allium erdelii, Centaurea iberica, Chrozophora tinctoria, Datura innoxia, Onobrychis crista-galli, Tragopogon collinus* and *V. syriaca*.

Plant height was reduced by more than 50% with *Aristolochia maurorum, C. nitidus, Cassia senna, C. prophetarum, Filago pyramidata, Hippocrepis unisiliquosa, Hordeum spontaneum, Koelpinia lineris, Matricaria aurea, Mercurialis annua*. An autotoxicity effect of *C. murale* extract on its own seedlings was clearly demonstrated. Height and shoot dry weight of the weed seedlings were reduced by 46.5 and 61.4% compared with untreated control and for both growth parameters, respectively. However, the same extract also reduced seedlings height of *A. retroflexus* by 52.9% and their shoot dry Weight by 43.6% compared with the untreated control.

Control

Treated

Figure 3. Effect of foliage applied aqueous extract of *R. graveolens* on the growth of *C. murale* grown in pots under glasshouse conditions.

Table 3. Effect of foliar application of *R. graveolens* aqueous extract alone or in combination with paraquat on *A. retroflexus* and *C. murale* seedling growth under field conditions two weeks after treatment.

Treatments	*A. retroflexus*			*C. murale*		
	Visual*estimationof control score	Shoot fresh weight (g/ plot)	Shoot dry weight (g/ plot)	Visual estimated score of control	Shoot fresh weight (g/ plot)	Shoot dry weight (g/ plot)
Control (tap water)	0	23.7[a**]	12.6[a]	0	17.2[a]	8.1[a]
R. graveolens extract	0	23.5[a]	12.4[a]	0	18.2[a]	9.0[a]
R. graveolens extract + paraquat (0.05kg a.i/ha) at (10:1V/V) ratio	10	7.5[b]	7.0[b]	10	7.9[b]	7.5[a]
Paraquat (0.4kg a.i/ha)	10	6.7[b]	6.3[b]	10	6.3[b]	5.9[b]
LSD (P= 0.05)	**-**	**2.6**	**1.3**	**-**	**1.8**	**1.5**

*Visual estimation scale of 0-10 at which zero score denotes that weeds were not affected while 10 score means weed plants were completely controlled. **Mean values in the same column followed by the same lower-case letter are not significantly different according to Fisher's LSD at P = 0.05.

Experiment 2: Effect of application of R. graveolens extract/paraquat mixture on seedlings growth of weeds under field conditions: Foliar application of full strength extract of *R. graveolens* showed no herbicidal effect on any of the two weeds compared with the untreated controls (Table 3). Shoot dry weights of both weed species were not significantly different from those of the untreated controls (Table 3). However, combined application of *R. graveolens* extract with 10 g a.i./ha paraquat completely killed *A. retroflexus* and *C. murale* and the effect was similar to that of paraquat used alone at full rate of 80 g a.i./ha (Table 3). The mixture of *R. graveolens* extract and paraquat was much more effective than paraquat used alone at 50 g a.i./ha in the preliminary test to determine the lowest effective rate of the herbicide (data not shown).

DISCUSSION

Under glasshouse conditions, foliage application of different plants extracts on *A. retroflexus* and *C. murale* resulted in growth inhibition, promotion or no effect compared with the controls (Table 2). However, many extracts reduced shoot dry weight and seedlings heights of both weed species. Extract of *R. graveolens* was most toxic to *A. retroflexus* and *C. murale* which may be due to presence of high concentrations of phytotoxic chemical compounds. Aliotta *et al.* (2000) reported allelochemicals from rue plants as potential source of natural pesticides. Failure of other extracts to show similar effects may be due to absence of toxic chemicals, low concentrations or degradation (Cheema *et al.*, 2009; Kordali *et al.*, 2009; Jabran *et al.*, 2010) by microorganisms found on plant surface or due to the influence of different environmental conditions (Bhowmik and Doll, 1984). In addition, the concentration of extracts used might not be high enough to cause strong effect, or because of differences in plants growth stages, their ecology or to some other physiological or morphological factors of the treated weeds (Rice, 1984; Qasem, 2011). Yarina *et al.*, (2009) reported that 5 to 20% leaf extract concentration of sorghum reduced plant height, leaf area, shoot and root dry weights of *A. retroflexus* and Dadkhah (2012) found that application of *Ephedra major* crude aqueous extracts (15 to 45% concentration) decreased leaf area, plant height and shoot and root dry weights and chlorophyll content of *Cirsium arvense* and the reduction was concentration dependent. Other workers reported great differences in growth of different plants exposed to extracts of different plant species while low concentrations had stimulatory effects (Mallik and Williams, 2005; Qasem, 2017).

Variations in results obtained may be due to differences in the allelopathic activity of different plant species, condition of spraying or concentrations and type of allelochemicals present in different extracts. Different plants extracts had varied effects on target species (Mallik and Williams, 2005; Qasem, 2017) which may be due to differences in the inhibitory compounds of these extracts, their concentrations or mechanism of inhibitory effects. However, extracts may also act as surfactants modifying leaf waxy layer or lowering leaf surface tension and thus enhance herbicides penetration.

Extracts may act as natural pesticides used as such or in mixtures with synthetic pesticides and thus help reducing environmental hazards (Birkett *et al.*, 2001; Khan *et al.*, 2012).

In the present work, differences between the two weeds in their responses to different plant extracts were obvious. *C. murale* was more negatively affected than *A. retroflexus* and exhibited greater growth reductions in terms of plant height and shoot dry weight in all extracts treatments. High EC indicates more negatively and positively charged anions or cations in plant extract which may act as growth promoters may be due to their richness in nutrients or other organic molecules that enhance plant growth. It is assumed that both extracts pH and EC are somehow interrelated and affect extract osmotic potential. High osmotic pressure of certain extracts may interfere in extract diffusion or absorption through weed seed coat depending on their compatibility or repellence effects. Therefore, different extracts of different pH and EC values may differentially affect seed germination of the same or different plant species. In the present work and since extracts were foliage applied and all or most reduced heights and shoot dry weights of both weed species compared with the untreated controls, therefore the effect of extract pH and EC on both weed species was not clearly demonstrated as with their effects on seed germination. This may be due to foliar application of extracts on both weeds and not directly to their seeds. However, it appears that extracts of lowest EC values slightly increased plants heights and shoot dry weights than extracts of the highest EC values and the same was also found in the effect of extracts pH and on both weeds.

Failure of *R. graveolens* extract in the field to show similar effect to that obtained in glasshouse experiments may be due to that natural phytotoxins of this species are rapidly degradable (Cheema *et al.*, 2009; Kordali *et al.*, 2009; Jabran *et al.*, 2010) by climatic factors or microorganisms on foliage parts of treated plants (Bhowmik and Doll, 1984). Differences in the effect of plant extracts have been already reported between laboratory, glasshouse and field conditions (Qasem, 2010b) in which those showed inhibition under specific condition may have opposite effects under others and *vice versa.* Botanical pesticides are well known as less active than synthetic chemicals and more rapidly degraded although many of the herbicides are rapidly degraded by photo-oxidation or may be lost through volatilization as vapour rapidly dissipated from leaf surface and similar effects may be also applied to plant extracts having volatile substances liable for loss in a similar way. Therefore, higher extract concentrations or rate of application may be necessary applied under field conditions. However, glasshouse-grown plants are softer and more susceptible to stresses including herbicides and plant extracts.

In the present study, foliage applied extract of *R. graveolens* had no observed toxic effect on both weeds compared with the controls (Table 3). However, the mixture of reduced rate of the herbicide (only 25% of the recommended rate) and *R. graveolens* extract effectively controlled both weed species similar to the herbicide full rate of application. *Ruta graveolens* extract may have synergistic or additive effects to the herbicide and thus allowed more herbicide penetration and/or enhanced its activity. The mixture may have modified leaf cuticular layer of both weeds and enhanced herbicide or extract activity. The first option may be more probable and extract could have worked as a surfactant of low toxicity. This however, needs further verification. Regardless these possibilities of extract functions, results obtained on both weeds were similar to those when the full rate of herbicide was separately applied. Our results were compatible with those reported by Miri and Armin (2013) who showed half of the recommended rate of atrazine with sorghum extract had similar effect for weed control to the application of full rate of the herbicide. Jabran *et al.* (2008) reported that pendimethalin rate of application can be reduced by more than 50% when used in mixture with sorghum and sunflower water extract for effective weed control in canola. Razzaq *et al.* (2012) similarly found that extract of *Helianthus annuus* and *Oryza sativa* with one-third of the recommended rate of fenoxaprop-p-ethyl resulted best control of grassy weeds and Cheema *et al.* (2003) came to similar conclusion when herbicide rate was reduced by 67% with sorghum and sunflower water extract.

Conclusions: The effect of different plant extracts on *Amaranthus retroflexus* and *Chenopodium murale* ranged from severe growth inhibition to promotion. *Chenopodium murale* was generally more reduced than *A. retroflexus*. *Ruta graveolens* extract was most phytotoxic to both weeds in glasshouse experiments and a mixture of this extract with one fourth of paraquat recommended rate of application was enough to control both weeds in the field and similar to the herbicide full rate of application.

REFERENCES

Aliotta, G., G. Cafiero, V. De Feo, B. Di Blasio, R. Lacovino and A. Oliva. 2000. Allelochemicals from rue (*Rutagraveolens*L.) and olive (*Olea europea*L.) oil mill waste waters, potential natural pesticides. Curr. Top. Phytochem. 3:167-177.

Bhadoria, P.B.S. 2011. Allelopathy: A natural way towards weed management. American J. Exp. Agric. 1:7-20.

Bhatti, M.Q., Z.A. Cheema and T. Mahmood. 2000. Efficacy of sorgaab as natural weed inhibitor in Raya. Pak. J. Biol. Sci. 3:1128-1130.

Bhowmik, P.C. and J.D. Doll. 1984. Allelopathic effects of annual weed residues on growth and nutrient uptake of corn and soybean. Agron. J.76:383-388.

Birkett, M.A., K. Chamberlain, A.M. Hooper and J.A. Pickett. 2001. Does allelopathy offer real promise for practical weed management and for explaining rhizosphere interactions involving higher plants? Plant Soil 232:31-39.

Cheema, S., M. Farooq, A.A. Bajwa and Z.A. Cheema. 2013. Application of allelopathy in crop production. Int. J. Agric. Biol. 15:1367-1378.

Cheema, Z.A., A. Khaliq and M. Mubeen. 2003. Response of wheat and winter weeds to foliar application of different plant water extracts of sorghum (*S. bicolor*). Pak. J. Weed Sci. Res. 9:89-97.

Cheema, Z.A., B. Ali. and A. Khaliq. 2005. Determining suitable combination of sorgaab and pendimethalin for weed control in cotton (*Gossypium hirsutum*). Int. J. Agric. Biol. 7: 889- 891.

Cheema, Z.A., M.N. Mushtaq, M. Farooq, A. Hussain and Islam-Ud-Din. 2009. Purple nutsedge management with allelopathic sorghum. Allelopathy J. 23:305-312.

Dadkhah, A. 2012. Allelopathic effect of *Ephedra major* on growth and photosynthesis of *Cirsium arvense* weed. Int. J. Agric. 2:416-419.

Duke, S.O. 1990. Natural pesticides from plants. In: J. Janick and J.E. Simon (eds.), Advances in New Crops, Timber Press, Portland. 511-517.

Duke, S.O. and J. Laydon. 1993. Natural phytotoxins as herbicides. In: S.O. Duke, J.J. Menn and J.R. Plimmerm (eds.), *Pest Control with Enhanced Environmental Safety*, American Chemical Society, Washington DC. 111-121.

Holm, L.G., D.L. Plucknett, J.V. Pancho and l.P. Herberger. 1977. The World's Worst Weeds. East - West Center Book. University Press of Hawaii, Honolulu.

Jabran, K. 2008. Tank mixing of allelopathic crop water extracts with pendimethalin helps in the management of weeds in canola (*Brassica napus*) field. Int. J. Agric. Biol. 10:293-296.

Jabran, K., M. Farooq, M. Hussain and M. Ali. 2010. Wild oat (*Avena fatua* L.) and canary grass (*Phalaris minor* Ritz.) management through allelopathy. J. Plant Prot. Res. 50: 41-44.

Khan, M.B., M. Ahmad, M. Hussain, K. Jabran, S. Farooq and M. Waqas-Ul-Haq. 2012. Allelopathic plant water extracts tank mixed with reduced doses of atrazine efficiently control *Trianthema portulacastrum* L. in *Zea mays* L. J. Anim. Plant Sci. 22:339-346.

Kim, K.U. and D.H. Shin. 2008. The importance of allelopathy in breeding new cultivars. Progress and prospect of rice allelopathy research. In: (R.S. Zeng, A. U. Mallik, Shi M. Luo (Eds.), Allelopathy in Sustainable Agriculture and Forestry. Springer New York Pub., USA. pp. 189-213.

Kordali, S., A. Cakir, T.A. Akcin, E. Mete, A. Akcin, T. Aydin and H. Kilic. 2009. Antifungal and herbicidal properties of essential oils and n-hexane extracts of *Achillea gypsicola* Hub-Mor. and *Achillea biebersteinii* Afan. (Compositae). Indust. Crops Prod. 29:562-570.

Kruse, M, M. Strandberg and B. Strandberg. 2000. Ecological effects of allelopathic plants a review, (pp: 66). National Environmental Research Institute. NERI, Technical Report No.315, Silkeborg, Available online at: http://www2.dmu.dk/1_viden/2_publikationer/3.../rapporter/fr315.pdf (Accessed: 15 February 2013).

Mallik, M.A.B. and R.D. Williams. 2005. Allelopathic growth stimulation of plants and microorganisms. Allelopathy J. 16:175-198.

Miri. H.R. and M. Armin. 2013. The use of plant water extracts in order to reduce herbicide application in wheat. Euro. J. Exp. Bio. 3:155-164.

Pashoutan, K. and M. Yarnia. 2014. Allelopathic effect of pepper mint on growth and seed production of redroot pigweed (*Amaranthus retroflexus*). J. Bio. Env. Sci. 5:492-500.

Qasem, J.R. 1992. Pigweed (*Amaranthus* spp.) interference in transplanted tomato (*Lycopersicon esculentum*). J. Hort. Sci. 67:421-427.

Qasem, J.R. 2009. Allelopathic effects of selected medicinal plants on *Amaranthus retroflexus* and *Chenopodium murale*. Allelopathy J. 25:380-341.

Qasem, J.R. 2010a. Allelopathy importance, field application and potential role in pest management: A review. JAST B. 4:104-120.

Qasem, J.R. 2010b. Differences in the allelopathy results from field observation to laboratory and glasshouse experiments. Allelopathy J. 26:45-58.

Qasem, J.R. 2011. Herbicides applications: Problems and considerations. In: Andreas Kortekamp (ed.) *Herbicides and Environment*, InTech, 643-664. Available from: http://www.intechopen.com/articles/show/title/herbicides-applications-problems-and-considerations.

Qasem, J.R. 2013b. Potential allelopathic effects of *Matthiola arabica* Boiss. on wheat (*Triticum durum* L.). Dirasat 39:75-87.

Qasem, J.R. 2017. A survey on the phytotoxicity of common weeds, wild grown species and medicinal plants to wheat. Allelopathy J. 42:179-195.

Qasem, J.R. and C.L. Foy. 2001. Weed allelopathy, its ecological impacts and future prospects. J. Crop Prod. 4: 43-119.

Qasem, J.R. and K.N. Biftu. 2010. Growth analysis and responses of cowpea [*Vigna Sinensis* (L.) Savi Ex Hassk]. and redroot pigweed (*Amaranthus retroflexus* L.), grown in pure and mixed stands, to density and water stresses. The Open Horticulture Journal 3: 21-30.

Qasem, J.R. 2013a. Herbicide resistant weeds: The technology and weed management**.** In: *Herbicides - Current Research and Case Studies in Use*. Andrew J. Price and Jessica A. Kelton eds. 2013.pp. 445-471.

Razzaq, A., Z.A. Cheema, K. Jabran, M. Hussain, M. Farooq and M. Zafar. 2012. Reduced herbicide doses used together with allelopathic sorghum and sunflower water extracts for weed control in wheat. J. Plant Prot. Res. 52:281-285.

Rice, E.L. 1984. *Allelopathy*, 2nd ed. Academic Press, New York. pp. 421.

SAS Institute Inc. 2004. *SAS/STAT® 9.1 User's Guide*. Ver. 9.1. SAS Institute Inc., Cary, NC.

[Received 05 Jun. 2019; Accepted 2 Sept. 2020 Published (Online) 25 Oct. 2020]

Yarnia, M., K.M.B. Benam and E.F.M. Tabrizi. 2009. Allelopathic effects of sorghum extracts on *Amaranthus retroflexus* seed germination and growth. J. Food Agr. Environ. 7:770 -774.