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Assessment of allelopathic plants for their herbicidal potential against field bindweed (*Convolvulus arvensis*)

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Abstract

This study was conducted to examine the allelopathic potential of *Crocus sativus, Ricinus communis, Nicotiana tabacum, Datura inoxia, Nerium oleander* and *Sorghum vulgar* on germination and growth of field bindweed (*Convolvulus arvensis*). In the laboratory experiment, aqueous extracts of plants in various concentrations (2.5, 5.0, 7.5, 10.0 g L^{-1}) were used to determine their effects on germination and growth of field bindweed seedling. In other experiments, the effects of 10 g L^{-1} aqueous extract and 0, 1, 2 and 4 t ha^{-1} powders of all the tested species were used in two different pot experiments to determined their allelophatic potentials on plant height, dry weight, number of survivor plant, leaf area, chlorophylls (a, b and total) and carotenoid contents of field bindweed. Results showed that aqueous extracts of *R. cummunis, N. tabacum, D. inoxia* and *S. vulgar* significantly ($p<0.05$) inhibited germination and seedlings growth of field bindweed and the effects were concentration specific; as the concentration of extracts increased the allelopathic effects were more pronounced. Application of 10 g L^{-1} aqueous extracts of all tested species significantly ($p<0.05$) reduced all of measured traits, but their effects depended on the species type. Besides, all of the powder treatments influenced the measured parameters including dry weight, height, leaf area as well as chlorophyll and carotenoid contents. The results demonstrated that both aqueous extracts and powders of tested species could be used as post emergence bioherbicides against field bindweed.

Keywords: Allelopathy, *Convolvulus arvensis*, Natural herbicides, Weed Control.

Introduction

Weeds are extensively present in agricultural systems which reduce yield of many crops (Oerke et al., 1995). They are usually controlled by using of mechanical methods and synthetic herbicides as well. Meanwhile, mechanical methods are labor intensive and time consuming and using of herbicides not only creates perceived hazardous impacts on agricultural products but also enhances environmental pollution (Batish et al., 2007). Additionally, the risk of weed resistance development and high cost-benefit ratio are other disadvantages of synthetic herbicides and pesticides usage (Kordali, 2009).Therefore in recent years, new approaches such as plant allelopathic effects have been considered to suppress weeds in agricultural systems (Dayan et al., 2009).
The allelopathic potential of various plants and their effectiveness for weeds control have been studied under both laboratory and field conditions. Fujii (2001) assessed 53 cover plant species for their allelopatic activity and found that hairy vetch, velvet bean, oat, rye, wheat and barley were promising and reported that the inhibitory effects of the plants were similar to that of traditional weed control methods. Om et al. (2002) used extracts of several weed and crop plants on germination and seedling growth of *Phalaris minor* which showed a negative effect on these parameters, however their inhibitory effects depended on type of species and doses of extracts. Iqbal (2003) concluded that aqueous and organic solvent extracts of aerial parts of buckwheat had allelopathic potential and reduced germination of lettuce seeds. Similar results were also reported by Jefferson and Pennacchio (2003). Lin et al. (2003) working with dwarf lilyturf showed that aqueous extracts of this species inhibited the germination and seedling growth of *Monocharia vagnakis, Cyperus difformis* and *Bidens biternata*, considering its stimulatory and inhibitory effects on barnyardgrass in low (1 and 2% w/v) and high (4 and 8%, w/v) concentrations, respectively. Khanh et al. (2005) showed that *Alocasia cucullata, Nerium oleander, Passiflora incarnate* and *Sophora japonica* powders at 1.5 t ha^{-1} caused more than 90% reduction in paddy weed density and dry weight. Sodaeizadeh et al. (2010) applied residues of *Oeganum harmala* to *Avena fatua, Convolvulus arvensis* and reported that leaves were the most toxic among the plant parts and caused significant reduction in seedling growth, leaf area and chlorophyll content of tested plants. They concluded that residues of this species could be used as a natural herbicide for weed control. Sampietro et al., (2007) indicated that soil treated with sugarcane straw residue decreased root elongation and growth of arrowleaf sida by inducing root oxidative stress and proline accumulation. *Convolvulus arvensis* (field bindweed), a perennial broadleaf, is one of the most problematic weeds in agricultural fields worldwide (Holm et al., 1977). Beneficial or detrimental effect of a donor plant on recipient by chemical pathways (i.e. allelopathy) is an efficient approach which can be alternatively used to combat this weed in cropping systems.

Many researchers have demonstrated that various plant extracts and powders have allelopathic potential and could be suitable for field bindweed control. Extracts of sorghum aerial parts reduced dry weight and density of field bindweed and extract of eucalyptus leaf inhibited germination of field bindweed (Cheema et al. 2001; Khan et al. 2008). Seed germination of field bindweed decreased progressively with increasing the extract concentration of Persian and berseem clovers aerial parts (Maighany et al., 2005) . Application of mulch of rye in field conditions resulted in reduction density and biomass of field bindweed (Hasannezhad and Alizadeh, 2006). Recognition of new plants containing strong allelopathic potential, which may result in greater weed control, is very important to reduce application of synthetic herbicides in the agricultural systems. Therefore, we have evaluated allelopathic potential of six plants species considering the hypothesis that they have phytotoxin and allelochemicals and may play an important role in weed suppression. Consequently, the objectives of the current research were (1) bio-assessment of phytotoxic potential of *Crocus sativus*, *Ricinus communis*, *Nicotiana tabacum*, *Datura inoxia*, *Nerium oleander* and *Sorghum vulgare* on field bindweed under laboratory conditions, and (2) determination of phytotoxic effects of the plant extracts and powders on growth of field bindweed under greenhouse conditions.

Results

Laboratory experiment

Effects of plant extracts and their concentrations on seed germination and root and shoot growth of field bindweed are shown in Table 1. The germination percentage and rate, seedling length and weight decreased with increasing concentration of extracts and the highest inhibitory effect was shown in 10 g L^{-1} treatment. The effect of extracts depended on plant species. *Crocus sativus* and *N. oleander* had no significant ($p<0.05$) effect on germination and seedling growth of the weed but, *R. communis*, *N. tabacum*, *D. inoxia* had a significant inhibitory effect on the parameters, so that germination of field bindweed was reduced 53 to 61%, compared with the control (without plant extract). At 10 g L^{-1} concentration, the species completely inhibited the germination of field bindweed (Table 2). Weed germination and seedling growth exposed to extract of *C. sativus* and *N. oleander* even at the highest concentration had no inhibitory effect but *S. vulgar* had inhibitory effect only at 10 g L^{-1} (Table 2).

Pot experiment

Effect of plants extracts

In pot experiment, only highest concentration (10 g L^{-1}) of extracts was used. The extract reduced field bindweed dry weight and height and decreased the number of survival weeds (Table 3). Extracts of all species reduced weed biomass between 50 and 60% and there were no differences between species. The results in pot experiment indicated that the influence of the plants on weed growth differed in bioassay and greenhouse conditions. Weed growth inhibitory was lowest for *C. sativus* and *N. oleander* in bioassay but the effectiveness of the species extract was not different from other plant extracts in pot trials (Tables 3). Plant extracts also affected physiologic traits of field bindweed and its chlorophyll and carotenoid contents decreased when extracts applied in spray from (Table 3).

Effect of plant powders

Dried powders of species significantly affected weed biomass. Furthermore, the weight and height of field bindweed were significantly reduced as compared with the control when plant residues added to soil (Table 4). Leaf area and survival weed number of field bindweed were decreased in pots having plant residues. Application of plant powders also reduced chlorophyll and carotenoid contents of field bindweed. The inhibitory effect of amended plant residues on field bindweed was proportional to the type of used species and applied doses. Increasing the amount of residue in soil enhanced the inhibitory effect (Table 5). Among the selected species, *C. sativus*, *N. tabacum*, *D. inoxia* showed higher inhibitory effect and could suppress growth of field bindweed greater than the others.

Discussion

Germination and seedling growth bioassays

The extracts of the species in this study exhibited allelopathic potential on seed germination and seedling growth of field bindweed in the bioassays indicating that extracts contained some inhibitory compounds could prevent germination and reduced seedling growth of plant which depended on the concentration of extracts. In line with our results, Lin et al. (2003) showed that all aqueous extracts of dried powders of dwarf lilyturf ranging from 1 to 8% (w/v) inhibited germination percentage and seedling growth of monchoria, smallflower umberella and bur-marigold which showed a increasing trend from 1 to 8% of agueous extracts. Similarly, the aqueous extracts of *Atriplex bunburyana*, *Enchylaena tomentosa*, *Atriplex codonocarpa* and *Maireana georgei* were reported to prevent seed germination and seedling growth of lettuce seeds and their effect generally depended on the concentration of extracts. In consistent with our results, inhibitory effect and extract concentrations dependency of billy goat and *Targetes minuta* on seed germination and seedling growth of radish and rice were reported, respectively (Xuan et al., 2004). In contrast to our results, Kowthar et al. (2011) reported that leaf extract of croton had no effect on germination, but inhibited seedling growth of *Portulaca oleracea* and *Echinochloa colonum*. Rice (1984) suggested that inhibition of cell division and elongation, prevention of gibberellins and/or indoleacetic acid-induced growth, reduction of mitotic activity, as well as inhibition of protein formation and respiration and decrease in cell membranes permeability, among others could be the main reasons of inhibition of germination and seedling growth of field bindweed influenced by allelochemicals. The plant extracts also increased duration of field bindweed germination indicating that allelochemicals may reduce weed competition by delaying their germination. Jefferson and Pennacchio (2003) concluded that delaying germination and reducing of seedling growth of weeds by allelochemicals in soil are detrimental to their survival since plants that usually germinate at slower rates are smaller. Consequently, this may seriously reduce the plant competing chances with the neighboring plants for water, nutrients and light resources (Fowler, 1986; Weiner et al., 1997). Complete inhibition of germination of field bindweed by *R. communis*, *N. tabacum*, *D. inoxia* and differential response of *Crocus sativus* and *Nerium oleander* might be due to different nature of their allelochemicals released by these species. In addition, inhibitory effect of these extracts depended on the type of plant species. In line with our results, a number of studies have shown that there were a large differences between plant species in their ability to suppress weeds and these differences were explained in part by means of variable capacity to secrete chemical substances and the nature of secreted chemicals affecting weed growth (Jefferson and Pennacchio, 2003; Fujii et al., 2003; Khanh et al., 2005; Machado, 2007). Furthermore, interaction between species and concentration (Table 2) suggested that the degree of inhibition was both species- concentration- specific. The results are in line with the result reported previously (Jefferson and Pennacchio, 2003; Khanh et al., 2005). The results of pot experiment using 10 g L^{-1} spraying of the different species extracts showed that the extracts reduced plant dry weight, height, leaf area, SPAD reading chlorophylls (a, b and total) and carotenoid of field bindweed, however, the reduction was species-specific. In line with our results, Yarina et al. (2009) reported that 5 to 20% leaf extract of sorghum reduced plant height, leaf area, shoot and root dry weighs of *Amaranthus retroflexus*. Besides, Dadkhah (2012) reported that application of *Ephedra major* aquatic extracts (15 to 45%) decreased leaf area, plant height and shoot and root weights and chlorophyll content of *Cirsium arvence* and the reduction was concentration-specific. He suggested that inhibitory effects could be related to allelochemicals such as phenolic , alkaloids and volatile compounds in the foliage extracts. In similar study, Anjum and Bajwa (2007) used different concentrations of sunflower extracts on *Chenopodium album* and reported that growth and harvest index of weed was significantly reduced. Anjum and Bajwa (2008) also screened different cultivars of sunflower

Table 1. Main effect of different extract concentrations and aqueousextractsof plants on germination percentage and rate, seedling length and dry wieght of *Convolvulus arvensis*.

Concentration	Germination (%)	Germination rate	Seedling length (cm)	Seedling dry weight (g)
Control	87.33a[1]	36.00a	6.16a	3.83a
2.5	81.71b	32.77b	5.95b	3.36b
5	70.19c	22.40c	5.18c	3.27b
7.5	49.71d	16.49d	3.13d	1.93c
10	37.71e	13.56e	2.10e	1.24d
Species				
Crocus sativus	85.33a	35.71a	6.97a	2.83b
Ricinuscommunis	40.83c	9.86d	2.81c	1.69c
Nicotianatabacum	37.17cd	11.38d	2.32d	1.48c
Daturainoxia	33.67d	9.29d	2.50cd	1.81c
Nerium oleander	82.33a	27.58b	4.39b	3.61a
Sorghum vulgar	63.67b	21.08c	4.50b	2.66b

1 Means followed by the same letter are not significantly different according to LSD test at 0.05 level.

Table 2. Interaction effect between different extract concentrations and aqueous extracts of plants on germination percentage and rate, seedling length and dry weight of *Convolvulus arvensis*.

Species	Concentration (g L^{-1})	Germination percentage (%)	Rate of germination	Seedling length (cm)	Seedling dry weight (g)
Control	Control	87.33bcde[1]	36.00abc	6.16cde	3.83abc
Crocus sativus	2.5	89.33ab	40.53a	7.75a	3.13abc
	5.0	90.00a	35.90abc	7.47ab	3.00abc
	7.5	82.00a-d	31.73b-f	6.73bc	2.50bc
	10.0	80.00a-d	34.67a-d	5.91c-g	2.70abc
Ricinuscommunis	2.5	81.33a-d	23.90ghi	5.97c-f	3.43abc
	5.0	66.00ef	12.63kl	5.27f-i	3.33abc
	7.5	16.00h	2.90mn	0.00m	0.00d
	10.0	0.00i	0.00n	0.00m	0.00d
Nicotianatabacum	2.5	78.00a-e	25.93f-i	5.65d-h	2.80abc
	5.0	54.67fg	15.87jk	3.65l	3.13abc
	7.5	15.33h	3.60mn	0.00m	0.00d
	10.0	0.67i	0.10n	0.00m	0.00d
Daturainoxia	2.5	82.00a-d	27.57d-h	5.63d-h	3.93a
	5.0	50.67g	9.40klm	4.35jkl	3.30abc
	7.5	2.00i	0.20n	0.00m	0.00d
	10.0	0.00i	0.00n	0.00m	0.00d
Nerium oleander	2.5	84.00abc	36.53ab	4.99hij	3.37abc
	5.0	79.33a-d	26.00fghi	4.35jkl	3.67abc
	7.5	84.00abc	27.30e-i	4.15kl	3.73ab
	10.0	82.00a-d	20.50hij	4.06kl	3.67abc
Sorghum vulgar	2.5	78.67a-d	37.10ab	6.31cd	4.00abc
	5.0	73.33cde	21.10hij	6.11cde	3.00abc
	7.5	78.67a-d	20.30ij	5.56d-i	3.63abc
	10.0	24.00h	5.80lmn	0.00m	0.00d

1 Means followed by the same letter are not significantly different according to LSD test at 0.05 level.

to evaluate their allelophatic effects on several weed species and found the Suncross-42 as the most effective cultivar. They used 50, 60, 70 and 80% extract concentrations on *Rumex dentatus* and *Chenopodium album* and reported that weed growth and leaf area reduced, but the reduction depended on dose and weed species. In contrast to our results, chlorophyll content of the weeds was affected the least among measured traits. In another pot experiment, application of 1, 2 and 3 t ha^{-1} powders of different species on filed bindweed showed that plant dry weight, height, leaf area, chlorophylls (a, b and total) and carotenoids of field bindweed were significantly reduced, however, the reduction was species-specific, rate-specific and species-rate-specific. In general agreement with our results, Kowthar et al. (2011) reported that application of 50 to 300 g m^{-2} powder of croton leaves to control Jasmine trees weeds reduced growth of several weed species, but the effect was rate- specific and depended on weed species. They reported that growth, chlorophyll content and oil quality of Jasmine trees were improved due to the application of the treatments. In consistent with our results, Shao et al. (2013) also reported that application of *Xanthium italicum* residues (20, 50, and 100 g kg^{-1} soil) decreased chlorophyll a, b and carotenoids contents of wheat seedlings and they concluded that the treatment was dose-dependent. In line with our results, Sodaeizadeh et al. (2010) applied residues of *Oeganum harmala* to *Avena fatua* and *Convolvulus arvensis* and reported that leaves were the most toxic among the other plant parts and caused significant reduction on seedling growth, leaf area and chlorophyll content of tested plants. They concluded that residues of this species could be used as a natural herbicide for weed control. Similar to our results, Chung et al. (2001) reported that residual application of selected rice cultivars reduced leaf area, shoot dry weights and tiller number of barnyard grass under the greenhouse and field conditions.

Allelochemicals may affect plants indirectly through the alternation of soil properties, nutritional status and population or activity of microorganisms and nematodes. These compounds may also have direct effects on various processes of plant growth and metabolism (Blum, 2002; Gniazowska and Bagatek, 2005). Biological activities of receiver plants to allelochemicals are known to be concentration, species even cultivar/genotypes within species and stage of plant growth (Khanh et al., 2005; Yarina et al., 2009; Sodaeizadeh et al., 2010). Reduction in seed germination under allelochemical could be due to the reduction or delay in reserve mobilization under allelopathy stress conditions (Gniazowska and Bagatek, 2005), changes in permeability of membranes (Gniazowska and Bagatek, 2005), stimulation or inhibition of respiration, both of which can be harmful to the energy-producing process (Batish et al., 2001), inhibition of mitosis (Mohamadi and Rajaie, 2009) and toxicity of allelochemical such as phenolic acids (Asghari and Tewari, 2007). In addition, decrease in cell turgor (El-Khawas and Shehala, 2009), reduction in enzyme activity such amylase (Hagab et al., 2008) and inhibition of water uptake (Oyun, 2006) could be also the possible reasons of reduction in germination parameters under allelopathy stress. Whereas reduction in growth and survival of plant may be due to inhibition of mitosis in plant (Mohamadi and Rajaie, 2009), reduction in both macro and micronutrients uptake (Akemo et al., 2000), alteration of balance in phytohormones (Chou, 1980), changes in permeability of membranes (Gniazowska and Bagatek, 2005), inhibition of photosynthesis (Batish et al., 2001) and stimulation or inhibition of respiration (Batish et al., 2001) under allelopathy stress could be the effective parameters. Furthermore, inhibition of protein synthesis (Bertin et al., 2007), inhibition or alteration of the function of enzymes in the plant (Rice , 1984; Muscolo et al., 2001) and inhibition of water uptake (Oyun, 2006) may also contribute in reducing the growth and survival of plant under allelopathy stress. However, reduction in growth parameters in our experiment under allelopathy stress could be due to reduction in germination rate and seedlings growth as indicated in tables 1 and 2 as well as decrease in chlorophylls and carotenoid contents, leaf area and plant height as indicated in tables 3, 4 and 5. The results of three experiments clearly demonstrated aqueous extracts of *R. cummunis*, *N. tabacum* and *D. inoxia* inhibited germination and seedling growth and thus could be used as pre-emergence bio-herbicides. Aqueous extracts and powders of all species reduced all measured parameters in pot studies indicating that they could be used as post emergency bio-herbicides. However, their effectiveness was species, concentration and species-concentrations specific.

Materials and methods

Preparation of extracts and powders

Arial parts of *Crocus sativus*, *Ricinus communis*, *Nicotiana tabacum*, *Datura inoxia*, *Nerium oleander* and *Sorghum vulgar* plants at flowering stage were harvested from fields then, air dried and ground to obtain fine powder. Powders were used as mulch in green house experiment. For extracts preparation one hundred ml of distilled water was added to 10 g powder (10 g dry weight) for 24 hr at 20°C and obtained 10% (w/v) extract was filtered through filter paper and used as a source of phytotoxins. Sterile deionized water was used to dilute the extracts and to generate four extract concentrations including 2.5, 5.0, 7.5 and 10 g L^{-1}. The extracts were stored at 4°C until use.

Germination and seedling growth bioassay

Seeds of field bindweed were obtained from Research Field of Isfahan University of Technology. The field bindweed seeds were kept in room temperature for break dormancy of seeds. Then healthy seeds were surface sterilized with 3% sodium hypochlorite and thoroughly rinsed with sterilized distilled water. The comparative assessment of influence of various concentrations of aqueous extracts on seed germination and early growth of field bindweed was carried out in petri dishes of 9 cm diameter. Double-layered sterilized Whatman filter paper No. 1 was placed in sterilized petri dishes. The filter paper was moistened with 5 ml of various extract concentrations with distilled water (control), 2.5, 5.0, 7.5 and 10 g L^{-1} extracts and placed in an illuminated (16 h light: 8 h dark) growth chamber at 25°C. Germination of seeds and early seedling growth was recorded after 7 days of germination.

Greenhouse experiment

Plants extract

Weeds were planted in plastic pots (30 cm deep, 15.5 cm wide) containing approximately 2 kg of 50% soil mixed with 20% commercial peat moss and 30% humus. Ten seeds of field bindweed were sown at one cm depth. After 7 to 10 days, when complete germination was achieved, the seedling number per pot was reduced to five equalized healthy seedlings by careful manual thinning. Three replicates were prepared for each treatment along with control. The pots were arranged in a completely randomized design and were placed in a greenhouse under 25°C with 16 h day and 8 h night and were irrigated with tap water when required. The extracts (10

Table 3. Effect of different aqueous extracts on dry weight, height, SPAD, leaf area (LA), number of plant, chlorophyll a, chlorophyll b, chlorophyll a+b, carotenoid of *Convolvulus arvensis*.

Species	Dry Weight (g)	Height (cm)	SPAD	LA (cm^2)	Number of survival weeds	Chlorophyll a (mg ml^{-1})	Chlorophyll b (mg ml^{-1})	Chlorophyll a+b (mg ml^{-1})	Carotenoid
Control	0.60a[1]	26.83a	51.27a	14.10a	100a	15.02a	6.87a	16.89a	4.53a
Crocus sativus	0.26bc	20.05b	46.91ab	5.77b	66.6b	12.86bc	6.56a	14.35b	3.72b
Ricinuscommunis	0.22c	17.40bcd	37.41c	4.74b	53.4b	12.23c	5.74b	14.24b	3.65b
Nicotianatabacum	0.23c	14.65cd	43.64b	4.33b	46.6b	12.32b	5.80b	14.12b	3.36b
Daturainoxia	0.22c	13.50d	44.79b	4.20b	53.4b	12.45bc	5.66b	14.36b	3.48b
Nerium oleander	0.25bc	18.22bcd	44.51b	5.40b	60.0b	12.47bc	6.85a	15.88a	3.59b
Sorghum vulgar	0.25bc	19.61bc	45.72ab	5.37b	60.0b	13.23b	6.78a	15.89a	3.56b

1 Means followed by the same letter are not significantly different according to LSD test at 0.05 level.

Table 4. Main effect of different powder concentrations and plant powders on dry weight, height, SPAD, leaf area (LA), number of plant, chlorophyll a, chlorophyll b, chlorophyll a+b, carotenoid of *Convolvulus arvensis*.

Concentration (tones/ha)	Dry weight (g)	Height (cm)	SPAD	LA (cm^2)	% Survival weeds	Chlorophyll a (mg ml^{-1})	Chlorophyll b (mg ml^{-1})	Chlorophyll a+b (mg ml^{-1})	Carotenoid (mg ml^{-1})
control	2.99a[1]	22.86a	45.31a	13.00a	100a	15.30a	8.70a	18.77a	4.11a
1	2.30b	22.06a	43.43b	5.47b	81.85b	15.41a	8.07a	18.64a	4.26a
2	1.96bc	17.86b	42.25b	4.83b	77.00b	12.75b	6.28b	15.05b	3.44b
4	1.59c	13.87c	40.72c	4.54b	68.68c	9.53c	4.81c	12.25c	2.98c
Species									
Crocus sativus	1.74b	16.08cd	41.48bc	4.52ab	72.22b	12.16bc	5.68b	14.25bc	3.63ab
Ricinuscommunis	2.43a	20.26a	46.49a	5.68a	86.11a	12.02c	5.97b	14.42bc	3.78a
Nicotianatabacum	1.39c	15.59d	40.49c	4.03b	62.30c	11.76c	5.73b	13.87c	3.27c
Daturainoxia	1.74b	17.09c	41.67b	4.49ab	73.32b	13.62a	6.45b	15.24b	3.64ab
Nerium oleander	2.37a	18.98b	42.69b	5.40a	87.50a	12.70abc	6.73ab	15.66b	3.61ab
Sorghum vulgar	2.01b	19.57a	39.97c	5.54a	73.61b	13.12ab	7.75a	18.45a	3.43bc

1 Means followed by the same letter are not significantly different according to LSD test at 0.05 level.

Table 5- Interaction effect between different powder concentrations and plants powders on dry weight, height, SPAD, leaf area (LA), number of plant, chlorophyll a, chlorophyll b, chlorophyll a+b, carotenoid of *Convolvulus arvensis*.

Species	Concentration (tones ha^{-1})	Dry weight (g)	Height (cm)	SPAD	LA (cm^2)	% Survival weeds	Chlorophyll a (mg ml^{-1})	Chlorophyll b (mg ml^{-1})	Chlorophyll a+b (mg ml^{-1})	Carotenoid (mg ml^{-1})
Control	Control	2.99a[1]	22.86abc	45.31a-d	13.00a	100.00a	15.30ab	8.70ab	18.77ab	4.11abc
Crocus sativus	1	1.95bc	19.29c-f	42.64b-e	4.91bc	79.17abc	16.53a	7.38bcd	19.04ab	4.89a
	2	1.96bc	17.65d-g	41.68b-f	4.53bc	75.00a-d	11.69b-e	5.35bcd	13.60bcd	3.31c-h
	4	1.32d	11.30h	40.11ef	4.12bc	62.50cd	8.27e	4.31d	10.12d	2.69h
Ricinus communis	1	2.77ab	23.96ab	48.11a	6.71b	91.67ab	14.83abc	7.15bcd	17.59abc	4.03a-d
	2	2.47a-d	20.78a-d	45.81ab	5.28bc	87.50abc	10.67cde	5.49bcd	12.99bcd	3.67b-f
	4	2.05abc	16.03efg	45.55abc	5.04bc	79.17abc	10.56cde	5.27bcd	12.69bcd	3.63b-g
Nicotiana tabacum	1	1.56cd	18.89c-g	41.01b-f	4.33bc	70.25bcd	14.36abc	6.85bcd	16.99a-d	3.98b-e
	2	1.36b	17.66d-g	40.47ef	4.02bc	66.35bcd	11.67b-e	6.14bcd	13.37bcd	3.18d-h
	4	1.25b	10.23h	40.00ef	3.75c	50.29d	9.25de	4.21d	11.24cd	2.66h
Datura inoxia	1	1.97b	20.35b-e	42.33b-f	4.86bc	75.00a-d	15.85ab	7.25bcd	17.76abc	4.15abc
	2	1.86b	16.58d-g	41.71b-f	4.47bc	74.84a-d	14.64abc	6.54bcd	15.67a-d	3.63b-g
	4	1.39b	14.33gh	40.98c-f	4.13bc	70.13bcd	10.38cde	5.56bcd	12.28bcd	3.14d-h
Nerium oleander	1	2.66abc	24.52ab	44.80a-e	5.64bc	100.00a	15.55ab	8.32abc	18.31abc	4.34ab
	2	2.44a-d	17.64d-g	43.18b-e	5.41bc	83.33abc	13.29a-d	7.35bcd	17.63abc	3.74b-f
	4	2.02a	14.77fgh	40.09ef	5.14bc	79.17abc	9.26de	4.51d	11.03cd	2.75gh
Sorghum vulgar	1	2.87ab	25.32a	41.68b-f	6.36bc	75.00a-d	15.33ab	11.46a	22.14a	4.14abc
	2	1.68b	16.85d-g	40.66def	5.24bc	75.00a-d	14.56abc	6.79bcd	17.06a-d	3.12e-h
	4	1.49b	16.53d-g	37.57f	5.03bc	70.83bcd	9.47de	5.01cd	16.14a-d	3.02fgh

[1]Means followed by the same letter are not significantly different according to LSD test at 0.05 level.

g L^{-1}) were applied as foliar spray on weed 7 days after germination. Three applications of extracts were carried out at 1-week intervals. Control plants were similarly sprayed with distilled water. After 1 month, the plants were carefully uprooted and were tested for their dry weight, height, the number of survivor weed, carotenoids and chlorophylls contents and leaf area. Leaf area was measured in cm^2 by green leaf area meter (OSK-Model GA-5). The amounts of chlorophyll *a* and *b* and carotenoid content were determined using method of Lichtenthaler and Buschmann (2001).

Plants powder

Another experiment was performed to explore the effect of plant powder on the emergence and growth of the field bindweed under described conditions. Pots were irrigated with tap water and after a week dried powder of *Crocus sativus*, *Ricinus communis*, *Nicotiana tabacum*, *Datura inoxia*, *Nerium oleander* and *Sorghum vulgar* was added as mulch at the dose of 1.0, 2.0 and 4.0 t ha^{-1}. A parallel setup, but without mulch, served as control. Three pots were maintained per treatment as replicates in a completely randomized manner. These pots were watered daily and after 1-month, the number of survivor weed, dry weight, carotenoids and chlorophylls contents and leaf area of field bindweed determined.

Statistical Analysis

A completely randomized design (CRD) with three replications was used in the experiments. For bioassay and powder experiment six types of extracts from different plants and four and three levels of extract concentrations consequently were combined in a complete factorial arrangement. Data of germination and growth parameters were subjected to ANOVA using SAS Statistical Program. Comparison of the means was performed using least significant difference (LSD) test at 0.05 level.

Conclusion

Extracts and residues of tested species might have the potential to use for pre-emergence and post-emergence weed control and could control field bindweed by allelochemical. Furthermore, the bioassay and pot experiment may be used to evaluate the allelopathic potential of a plant which minimizes competitive abiotic and biotic factors. However, the level of weed suppression could be different, because soil physicochemical (organic matter, pH, fertility) and microbiological properties affect the allelopathic expression of a plant. Therefore, the impacts of these plants on field bindweed control in the soil should be examined before they commercially be applied in the field.

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