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The allelopathic efficiency of *Eruca sativa* seed powder in controlling *Orobanche crenata* infected *Vicia faba* cultivars

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Abstract

Background: *Orobanche crenata* (Broomrape) is an obligate root parasitic weed belonging to Orobanchaceae. It causes a great damage to legume crops. Many attempts have been done in order to control this parasitic weed. So, the aim of this work is to study the allelopathic potentiality of *Eruca sativa* seed powder (Essp) in comparison to the herbicidal effect of Basamid (Dazomet) treatments in controlling *Orobanche crenata* (*O. crenata*) and their effect on growth and yield of two *Vicia faba* cultivars.

Materials/methods: Two pot experiments were conducted in the greenhouse of the National Research Centre, Dokki, Giza, Egypt, in the two successive winter seasons of 2015/2016 and 2016/2017. Treatments were applied by incorporating Essp to the soil at (15, 30, and 45 g/kg soil) and Basamid treatments at 0.2 and 0.4 g/pot.

Results: All Essp concentrations used as well as Basamid treatments minimized to great extent, the number of *O. crenata* tubercles/pot, and the fresh and the dry weight of *O. crenata* tubercles/pot (g) infecting both *V. faba* cultivars at 90 days after sowing (DAS) and at harvest. The best results for controlling *O. crenata* infesting both *V. faba* cultivars were recorded with both 45 g/kg soil Essp concentration and 0.4 g/pot Basamid treatments. On the other side, both *V. faba* cultivars growth as well as yield and yield attributes were significantly increased with all Essp concentrations used and Basamid treatments when compared to their corresponding infected control. Essp at 45 g/kg soil and 0.4 g/pot Basamid treatments gave the highest increases which exceed than their corresponding healthy control.

Conclusion: The presence of the allelochemicals mainly glucosinolates and phenolic compounds in Essp could play an important role, as a natural selective bioherbicide, in controlling the parasitic *O. crenata* weed infecting *V. faba* cultivars and increasing the yield.

Keywords: Allelopathy, *Eruca sativa*, Glucosinolates, Phenolic content, *Vicia faba*, *Orobanche crenata*

Background

Faba bean (*Vicia faba* L.) is a major food and feed legume because of its high nutritional value of the seeds. It is considered one of the most important legumes in Egypt. It is also one of the strategic crops due to its income to the farmers, and it is important for soil fertility, human nutrition as a good source of vegetable protein, and industry purposes. Increasing faba bean production and improving yield quality are the major targets to meet the demand of the increasing population, since faba bean constitutes a major part of the people's diet (Zeidan, 2002).

Orobanche crenata has been known to threaten legume crops (e.g., faba bean, lentil, pea, and common vetch), since antiquity. The parasitic weed is mainly restricted to the Mediterranean basin, Southern Europe, and Middle East and is an important pest in grain and forage legumes (Rubiales et al., 2009b; Kandil et al., 2015). Due to broomrape infestation, severe yield losses of leguminous plant have been reported depending on the severity of infestation and the planting date (Sauerborn, 1991; Rubiales et al., 2009a; Kandil et al., 2015). Comparing with non-parasitic weeds, the control of

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Orobanche has been proved to be exceptionally difficult in agricultural crops due to its underground location, close association with host plant roots, complex mechanisms of seed dispersal, germination, and longevity (Foy et al., 1989; Linke and Saxena, 1991). So, numbers of strategies for parasitic weed control have been developed including cultural practices and biological and chemical control (Rubiales et al., 2009a; Fernandez-Aparicio et al., 2011).

Using natural or synthetic allelopathic materials has been started as a way to control broomrape (Sauerborn, 1991). Allelopathy is the phenomenon where natural compounds are released from the root, shoot, leaves, or flower of the plant to influence other plants (Rice, 1995), and it may be used to control some weeds. Plants from the Brassicaceae family are characterized by chemical compounds called glucosinolates. The decomposing tissues of these plants release glucosinolates which are then converted to isothiocyanate compounds that are toxic to other plants (Haramoto and Gallandt, 2005; Bangarwa et al., 2011). Particularly, the plants of *Brassica* genus are known to suppress weeds (Narwal, 1999; Uludag et al., 2006; Uremis et al., 2009).

The aim of the present investigation is to assess the potentiality of *Eruca sativa* seed powder as one of Brassicaceae family in comparison to the herbicidal effect of Basamid treatment on controlling *Orobanche crenata* infected two *Vicia faba* cultivars as well as their effect on the growth and yield of the plant.

Materials and methods

Experimental procedures

Two pot experiments were carried out during two successive winter seasons of 2015/2016 and 2016/2017 in the greenhouse of National Research Centre, Dokki, Giza, Egypt. Two *Vicia faba* L. (faba bean) cultivars (CV. Sakha 1 (a susceptible CV. to *Orobanche crenata* infection) and Giza 843 (a tolerant CV. to *O. crenata* infestation) as well as *Eruca sativa* L. seeds (watercress) were obtained from the Agriculture Research Centre, Giza, while parasitic weed seeds of *O. crenata* (broomrape) were obtained from the weed control section, Ministry of Agric., Giza, Egypt. Clean seeds of *E. sativa* were ground to fine powder and immediately incorporated to the soil surface before sowing *V. faba* seeds at the rate of 15, 30, and 45 g/kg soil. The experiment consisted of seven treatments for each *V. faba* cultivar, including two controls (healthy and infected). Each treatment represented by nine pots (30-cm diameter) filled with 5-kg Nile clay soil. All treatments, except healthy control, were infected with *O. crenata* seeds (0.2 g/pot) at 5 cm depth from the soil surface. The experiment also includes two herbicidal treatments with Basamid (Dazomet) for comparison with the allelopathic effect of *E. sativa* treatments. Basamid granules (tetrahydro – 3,5-dimethyl-2H-1,3,5-thiadiazine-2-thione) were mixed to the soil infected with *O. crenata* at the concentration 0.2 and 0.4 g/pot 10 days before planting the host seeds. *V. faba* seeds were sown (8 seeds/pot) at 3 cm from the soil surface. Two weeks later, the *V. faba* plants were thinned to 4 plants/pot. All pots were distributed in a complete randomized design. The normal cultural practices of growing *V. faba* plants especially fertilization and irrigation were done.

Characters studied

Weeds

Three replicates were collected from each treatment at 90 days after sowing (DAS) and at harvest. The number and fresh as well as the dry weight of *O. crenata* tubercles/pot were recorded at the two growth ages.

Vicia faba plants

Plant growth

In both seasons, samples of *V. faba* plants at 60 and 90 DAS were collected from each treatment to determine plant height (cm), number of leaves/plant, number of branches/plant, fresh and dry weight of shoot/plant (g), and fresh and dry weight of root/plant (g).

Yield and yield attributes

At harvest, samples of *V. faba* plant cultivars were taken from each treatment to determine the number of pods/pot, pod length (cm), weight of pods/pot (g), number of seeds/pod, weight of seeds/10 pods (g), and weight of 100 seeds (g).

Chemical analysis

Total glucosinolates (μmol/g DW)

Total glucosinolates were extracted from dry samples of seed powder of *E. sativa*. Glucosinolates were measured by determining the liberated glucose which is released during hydrolysis by myrosinase enzyme (Rauchberger et al., 1979). The resulting glucose was determined colorimetrically according to the method defined by Nasirullah and Krishnamurthy (1996).

Total phenol content (mg/g DW)

Total phenol content of *E. sativa* seeds was determined colorimetrically using Folin and Ciocalteu phenol reagent according to the method defined by Snell and Snell (1953).

Statistical analysis

All data were statistically analyzed according to Snedecor and Cochran (1980), and the treatment means were compared by using LSD at 5% level of probability.

Results

Weed growth characters

The results in Table 1 showed the potential effect of controlling *O. crenata* in the two *Vicia faba* cultivars (Sakha 1 and Giza 843) by incorporating different concentrations (15 to 45 g/kg soil) of *Eruca sativa* (Essp) as well as Basamid treatments (0.2 and 0.4 g/pot) to the soil. The data recorded in Table 1 revealed that different Essp concentrations (15 to 45 g/kg soil) as well as Basamid treatments (0.2 and 0.4 g/pot) significantly suppressed *O. crenata* infestation and decreased the number, fresh, and dry weight of *O. crenata* tubercles/pot at the two ages of growth (90 and at harvest) in both *V. faba* cultivars as compared to their corresponding infected controls. The efficiency in controlling *O. crenata* increased by increasing the applied concentration used. The maximum reduction in number and fresh and dry weight of *O. crenata* was recorded with the highest Essp concentration (45 g/kg soil with Giza, 843 *V. faba cultivar*) and the higher Basamid treatment (0.4 g/pot with Sakha, 1 *V. faba cultivar*) at the two ages of growth with both *V. faba* cultivars as compared to their corresponding control. The maximum rate of reduction of *O. crenata* tubercles dry weight at harvest was recorded with 45 g/kg soil Essp concentration as well as by 0.4 g/pot Basamid treatment which reached to 93.50 and 98.23%, respectively, with Sakha 1 *V. faba* cultivar, while with Giza 843 *V. faba* cultivar, the reduction in the same character with the same treatments reached to 99.13 and 98.52%, respectively, as compared to their corresponding control.

O. crenata infestation with Sakha 1 and Giza 843 *V. faba* cultivars at harvest could be minimized to 89.8 and 99.4%, respectively, by applying 45 g/kg soil Essp concentration as compared to their corresponding control as shown in a number of *O. crenata* tubercles/pot (Table 1). It is worthy to mention that at 60 DAS, no *O. crenata* tubercle infestation was found in both *V. faba* cultivars.

Vicia faba cultivars' growth

The results in Tables 2 and 3 illustrated that most growth characters of the two *V. faba* cultivars (Sakha 1 and Giza 843) such as plant height (cm), number of leaves/plant, number of branches/plant, fresh, and dry weight of shoot/plant (g) as well as fresh and dry weight of root/plant (g) at 60 and 90 DAS were significantly increased with all *E. sativa* seed powder concentrations used (15 to 45 g/kg soil) as well as Basamid treatments (0.2 and 0.4 g/pot) as compared

Table 1 Effect of different concentrations of *Eruca sativa* L. seed powder and Basamid herbicide on *Orobanche crenata* developed in two *Vicia faba* L. cultivars at 90 days after sowing and at harvest (combined analysis of two seasons)

Treatments	At 90 days after sowing			At harvest		
	No. of *O. crenata* tubercles/pot	Fresh wt. of *O. crenata* tubercles/pot (g)	Dry wt. of *O. crenata* tubercles/pot (g)	No. of *O. crenata* tubercles/pot	Fresh wt. of *O. crenata* tubercles/pot (g)	Dry wt. of *O. crenata* tubercles/pot (g)
Sakha 1						
Healthy control	00.00	00.00	00.00	00.00	00.00	00.00
Infected control (I)	59.00	52.25	7.10	64.50	61.45	10.15
(I) + *Eruca sativa* 15 g/kg soil	39.02	34.62	5.62	20.28	32.61	8.29
(I) + *Eruca sativa* 30 g/kg soil	20.13	31.80	5.11	10.45	25.00	6.50
(I) + *Eruca sativa* 45 g/kg soil	7.15	16.94	4.21	6.52	3.59	0.66
(I) + Basamid 0.2 g/pot	9.00	20.65	6.12	7.26	19.39	5.10
(I) + Basamid 0.4 g/pot	4.00	14.75	3.83	0.57	0.86	0.18
Giza 843						
Healthy control	00.00	00.00	00.00	00.00	00.00	00.00
Infected control (I)	50.00	36.25	5.85	54.25	46.38	8.09
(I) + *Eruca sativa* 15 g/kg soil	32.45	25.13	4.16	12.79	19.92	3.71
(I) + *Eruca sativa* 30 g/kg soil	5.82	8.94	1.62	2.10	2.50	1.00
(I) + *Eruca sativa* 45 g/kg soil	1.26	1.35	0.74	0.31	0.20	0.07
(I) + Basamid 0.2 g/pot	8.00	8.75	1.15	4.55	7.76	0.99
(I) + Basamid 0.4 g/pot	1.50	2.25	0.45	0.41	0.25	0.12
LSD at 5%	1.84	2.61	1.09	1.78	1.93	0.77

I infected control

Table 2 Effect of different concentrations of *Eruca sativa* L. seed powder and Basamid herbicide on growth parameters of two *Vicia faba* L. cultivars at 60 days after sowing (combined analysis of two seasons)

Treatments	Growth parameters						
	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	F.W. of shoot/ plant (g)	F.W. of root/ plant (g)	D.W. of shoot/ plant (g)	D.W. of root/ plant (g)
				Sakha 1			
Healthy control	40.50	18.96	1.80	18.63	8.55	2.75	1.26
Infected control (I)	37.90	14.47	1.41	13.54	6.27	1.99	1.15
(I) + *Eruca sativa* 15 g/kg soil	38.83	17.36	1.72	16.32	6.95	2.52	1.22
(I) + *Eruca sativa* 30 g/kg soil	43.52	19.55	2.00	22.42	10.25	3.56	1.41
(I) + *Eruca sativa* 45 g/kg soil	45.98	22.34	2.50	27.65	12.18	3.92	1.56
(I) + Basamid 0.2 g/pot	43.62	19.21	1.86	19.95	8.96	3.24	1.29
(I) + Basamid 0.4 g/pot	44.38	20.82	2.15	24.55	11.54	3.71	1.43
				Giza 843			
Healthy control	45.95	20.73	1.93	21.82	9.75	3.72	1.78
Infected control (I)	41.86	15.74	1.47	15.36	7.16	2.41	1.39
(I) + *Eruca sativa* 15 g/kg soil	44.19	18.22	1.80	17.83	8.09	3.13	1.49
(I) + *Eruca sativa* 30 g/kg soil	46.25	21.00	2.14	23.96	11.84	3.75	1.92
(I) + *Eruca sativa* 45 g/kg soil	48.68	24.75	2.63	33.54	17.50	4.09	2.26
(I) + Basamid 0.2 g/pot	45.47	19.77	1.89	21.10	9.04	3.63	1.66
(I) + Basamid 0.4 g/pot	47.21	21.75	2.37	29.15	13.36	3.85	1.96
LSD at 5%	1.82	1.88	0.22	1.30	1.18	0.33	0.18

I infected control

Table 3 Effect of different concentrations of *Eruca sativa* L. seed powder and Basamid herbicide on growth parameters of two *Vicia faba* L. cultivars at 90 days after sowing (combined analysis of two seasons)

Treatments	Growth parameters						
	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	F.W. of shoot/ plant (g)	F.W. of root/ plant(g)	D.W. of shoot/ plant (g)	D.W. of root/ plant (g)
				Sakha 1			
Healthy control	58.93	20.06	1.77	21.20	3.49	3.26	1.22
Infected control (I)	47.62	17.43	1.59	17.09	2.89	2.66	1.04
(I) + *Eruca sativa* 15 g/kg soil	57.43	18.92	1.66	19.14	3.06	2.96	1.17
(I) + *Eruca sativa* 30 g/kg soil	60.94	22.60	1.87	35.63	3.75	5.36	1.44
(I) + *Eruca sativa* 45 g/kg soil	65.00	24.64	2.64	41.11	5.31	6.64	1.82
(I) + Basamid 0.2 g/pot	59.62	20.37	1.84	23.26	3.57	3.75	1.39
(I) + Basamid 0.4 g/pot	61.26	23.25	2.13	37.36	4.55	6.12	1.63
				Giza 843			
Healthy control	77.10	24.36	2.55	43.44	5.83	6.32	1.63
Infected control (I)	68.29	19.94	1.66	37.91	3.08	4.64	1.17
(I) + *Eruca sativa* 15 g/kg soil	70.53	21.42	1.80	40.49	3.34	5.43	1.36
(I) + *Eruca sativa* 30 g/kg soil	82.51	36.90	2.33	45.26	5.42	6.54	2.27
(I) + *Eruca sativa* 45 g/kg soil	84.06	44.70	2.81	50.61	7.23	7.87	2.96
(I) + Basamid 0.2 g/pot	72.85	22.99	2.16	42.37	4.47	5.53	1.44
(I) + Basamid 0.4 g/pot	80.95	35.02	2.53	49.74	6.25	7.61	2.38
LSD at 5%	2.24	1.93	0.23	2.25	0.40	0.43	0.19

I infected control, *F.W* fresh weight, *D.W.* dry weight to their corresponding infected control. The highest significant increases in different growth parameters of the two *V. faba* cultivars were recorded with both 45 g/kg soil of Essp concentration and 0.4 g/pot Basamid treatment at the two growth ages when compared to the corresponding control in the most growth characters. These treatments not only alleviated the harmful effect of *O. crenata* infestation but also induced significant increases in most growth characters of both *V. faba* cultivars at the two growth ages as compared to their corresponding healthy control. At 90 DAS, Essp at 45 g/kg soil concentration and Basamid treatment at 0.4 g/pot achieved maximum increase in the total dry weight (shoot + root) of (Sakha 1) *V. faba* cultivar which reached to 88.8 and 72.9%, respectively, over the corresponding healthy control. The second *V. faba* cultivar (Giza 843) recorded increases in the total dry weight with the same treatments and reached to 36.22 and 50.81%, respectively, over the corresponding healthy control.

Vicia faba cultivars' yield

The results of yield and yield attributes of the two *V. faba* cultivars (Sakha 1 and Giza 843) such as number of pods/pot, pod length (cm), weight of pods/pot (g), number of seeds/pod, weight of seeds/10 pods (g), and weight of 100 seeds (g) recorded in Table 4 showed that all Essp concentrations (15 to 45 g/kg soil) used as well as Basamid treatments (0.2 and 0.4 g/pot) significantly increased all yield parameters of the both *V. faba* cultivars as compared to their corresponding infected controls. The best results in the two *V. faba* cultivars yield attributes were recorded with 45 g/kg soil Essp and by 0.4 g/pot Basamid treatment. Both of the previously applied treatments not only alleviated the harmful effect of *O. crenata* infestation but also increased the plant yield over than their corresponding healthy control. The sensitive *V. faba* cultivar (Sakha 1) achieved maximum increase in the weight of seeds/10 pods (g) and weight of 100 seeds (g) using the highest Essp concentration (45 g/kg soil), which reached to 54.5 and 45.1%, respectively, while using 0.4 g/pot Basamid treatment, the increases in the previous yield characters reached to 23.2 and 41.76%, respectively, over their corresponding healthy control. The same trend was obvious with the second *V. faba* cultivar Giza 843, which also recorded maximum increases in the same previous yield characters and showed to 33.59 and 29.19% with 45 g/kg soil Essp concentration, while using 0.4 g/pot Basamid treatment, these increases reached to 25.67 and 18.96%, respectively, over their corresponding healthy control.

Table 4 Effect of different concentrations of *Eruca sativa* L. seed powder and Basamid herbicide on yield and yield attributes of two *Vicia faba* L. cultivars at harvest (combined analysis of two seasons)

Treatments	Yield and yield attributes					
	No. of pods/pot	Pod length (cm)	Wt. of pods/pot (g)	No. of seeds/pod	Wt. of seeds/10 pods (g)	Wt. of 100 seeds (g)
			Sakha 1			
Healthy control	4.11	4.91	4.18	2.49	9.68	43.70
Infected control (I)	2.13	3.57	1.99	1.72	4.62	22.51
(I) + *Eruca sativa* 15 g/kg soil	3.00	4.25	2.81	2.35	7.10	37.00
(I) + *Eruca sativa* 30 g/kg soil	4.91	5.40	6.00	3.05	10.16	58.50
(I) + *Eruca sativa* 45 g/kg soil	6.11	6.50	7.14	3.70	14.96	63.40
(I) + Basamid 0.2 g/pot	4.62	5.15	4.95	2.93	9.96	48.30
(I) + Basamid 0.4 g/pot	5.31	5.71	6.53	3.42	11.93	61.95
			Giza 843			
Healthy control	5.30	8.19	5.38	3.52	14.26	67.50
Infected control (I)	3.35	4.92	3.72	1.99	6.11	35.11
(I) + *Eruca sativa* 15 g/kg soil	4.61	7.90	5.03	3.27	12.70	55.60
(I) + *Eruca sativa* 30 g/kg soil	5.80	8.70	6.09	3.86	16.93	78.10
(I) + *Eruca sativa* 45 g/kg soil	8.10	9.21	9.12	4.50	19.05	87.20
(I) + Basamid 0.2 g/pot	4.95	7.65	5.25	3.43	13.85	62.09
(I) + Basamid 0.4 g/pot	6.52	8.96	6.96	3.99	17.92	80.30
LSD at 5%	0.57	0.36	0.35	0.31	0.73	2.51

I infected control

It is worthy to mention that the natural Essp treatment at 45 g/kg soil concentration achieved increases exceed than that caused by the herbicidal treatment at 0.4 g/pot in both *V. faba* cultivars' yield attributes as compared to their corresponding control (Table 4).

Generally, it is clear from the results recorded in Tables 2, 3, and 4 that the growth parameters as well as the yield and yield attributes of *V. faba* cultivar Giza 843 are better than that of *V. faba* cultivar Sakha 1; these results could be attributed to its partial tolerance to *O. crenata* infestation.

Table 5 clears the amount of total glucosinolates (316.03 μmol/g dry weight) and total phenolic content (35.62 mg/g dry weight) of *Eruca sativa* seeds.

Discussion

The current approaches in agriculture production are to find a suitable biological solution to decrease the harmful effects of the use of herbicides and all other pesticides as well as increasing productivity (Khanh et al., 2005). Allelopathic plants contain many allelopathic compounds (allelochemicals), offer a great possibility to resolve this critical issue, and could be used by different methods to solve this problem (Javaid et al., 2006; Ma et al., 2006; Iqbal et al., 2007). Brassicaceae plant family is considered one of the most important allelopathic plants that contain many allelochemical mainly glucosinolates which are useful and effective to manage different types of weeds in many crops (Biswas et al., 2014; Ahmed et al., 2016; Messiha et al., 2013, 2018).

The results of the present investigation reveal that *E. sativa* seed powder Essp possesses to great extent allelopathic effect in controlling *O. crenata* infesting two *V. faba* cultivars when added to the soil. Incorporating ESSP to the soil at rates from 15 to 45 g/kg soil minimized the number of *O. crenata* tubercles as well as their fresh and dry weight especially with the highest concentration (45 g/kg soil). These results were similar to the effect of synthetic herbicide Basamid treatment at 0.4 g/pot (Table 1), since the mode of action of both is the production of isothiocyanates, which effectively could control the growth of parasitic and non-parasitic weeds (Messiha et al., 1993; Khalaf et al., 1994; Sharara et al., 2011).

It is worthy to mention that the reducing effect of Essp in the weed growth (*O. crenata*) could be attributed to its natural allelochemicals mainly glucosinolates and phenolic compounds (Table 5). Glucosinolates are hydrolyzed by endogenous myrosinase enzyme into many products mainly isothiocyanates (Fenwick et al., 1983) which have different biological function including anticancer, antibacterial, antifungal, antioxidative, allelopathic properties (Traka and Mithen, 2009; Latte et al., 2011) and can also be used as an alternative to synthetic pesticides for pest and disease control (Sarwar and Kirkegaard, 1998) and as bioherbicides for weed control (Messiha et al., 2013, 2018; Ahmed et al., 2014, 2016; El-Masry et al., 2015; El-Rokiek et al., 2017).

The results of the present research reveal that most growth characters and yield attributes of both *V. faba* cultivars significantly increased by different Essp concentrations as well as Basamid treatments Tables 2, 3, and 4. The best treatments were recorded with both 45 g/kg soil Essp and 0.4 g/pot Basamid. In this connection, it is worthy to mention that improving the growth and consequently increasing the yield of the plant is not only due to the inhibition of weed growth by chemical or biological means that lead to increase the competitive ability of the plant (Abdelhamid and El-Metwally 2008; Ahmed et al., 2012, 2014; El-Rokiek et al., 2012, 2013; El-Masry et al., 2015; Jursik et al., 2015; Seshadri et al., 2015) but also due to the selectivity of the allelochemicals in their action and the plants in their responses (Einhellig, 1995). Allelochemicals which inhibit the growth of some species at certain concentration may stimulate the growth of the same or different species at different concentrations (Ahmed et al., 2012, 2014; Messiha et al., 2013, 2018; Bashen, 2014; El-Masry et al., 2015).

The results of the present study as well as our previous work indicate the possibility of using the allelopathic activity of some Brassicaceae plants' seed powder such as *Eruca sativa*, *Raphanus sativus*, *Brassica rapa*, and *Sinapis alba* as a selective bioherbicide for controlling annual, perennial, and parasitic weeds accompanied by different economic crop plants (Messiha et al., 2013, 2018; Ahmed et al., 2014, 2016; El-Masry et al., 2015; El-Rokiek et al., 2017).

Conclusion

Incorporating the seed powder of *Eruca sativa* to the soil is a powerful and safety method in controlling *Orobanche crenata*, parasitizing *Vicia faba*, and also significantly increasing the growth and yield of the plants.

Table 5 Total glucosinolates (μmol/g dry weight) and total phenol content (mg/g dry weight) in the seed powder of *Eruca sativa*

Material	Total glucosinolates (μmol/g dry weight)	Total phenolic content (mg/g dry weight)
Eruca sativa seed extract	316.03	35.62

Abbreviations
CV: Cultivars; DAS: Days after sowing; Essp: *Eruca sativa* seed powder; *O. crenata*: *Orobanche crenata*; *V. faba*: *Vicia faba*

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