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Evaluating the allelopathic potentiality of seed powder of two Brassicaceae plants in controlling *Orobanche ramosa* parasitizing *Lycopersicon esculentum* Mill. plants

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Abstract

Background: *Orobanche ramosa* (Broomrape) is an obligate root parasite belonging to Orobanchaceae. It causes a great damage to tomato plants. Several attempts have been done in order to control this parasitic weed. So, the aim of this work is to study the allelopathic efficiency of *Eruca sativa* (Essp) and *Sinapis alba* (Sasp) seed powder in comparison to the herbicidal effect of Basamid (Dazomet) treatment in controlling *Orobanche ramosa* (*O. ramosa*) infesting *Lycopersicon esculentum* (tomato) as well as their effect on *Lycopersicon esculentum* plant growth and yield.

Materials/methods: Two pot experiments were performed in the greenhouse of the National Research Centre, Dokki, Giza, Egypt, during two successive winter seasons of 2016/2017 and 2017/2018. Treatments were applied by incorporating *E. sativa* (Essp) and *S. alba* (Sasp) seed powder to the soil at (5, 10, 15, 30, and 45 g/kg soil) concentration and Basamid treatment at 0.2 g/pot.

Results: The results indicated that no *O. ramosa* infestation on *Lycopersicon esculentum* appeared with all Essp and Sasp concentrations except with the lowest concentration (5 g/kg soil) that reduced *O. ramosa* tubercles dry weight at 100 days from transplanting (DFT) to about 48.4 and 42.0%, respectively, as compared to the infected control. *Lycopersicon esculentum* growth as well as its yield and yield components were significantly increased with Basamid treatment at 0.2 g/pot and all Essp and Sasp concentrations (5–45 g/kg soil) except some parameters with the lowest concentration (5 g/kg soil) of both materials used when compared with their corresponding infected control. The highest yield, which exceeds the yield of the healthy control, was obtained by using both Essp and Sasp at concentrations 45 followed by 30 g/kg.

Conclusion: The allelopathic efficiency of Essp and Sasp is due to the presence of allelochemicals, mainly glucosinolates and phenolic compounds which could play an important role, as a natural selective bioherbicide.

Keywords: Allelopathy, *Eruca sativa*, *Sinapis alba*, Glucosinolates, Phenolic content, *Lycopersicon esculentum*, *Orobanche ramose*

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Background

Orobanche ramosa (Broomrape) is an obligate root parasite belonging to Orobanchaceae. In Egypt, three *Orobanche* species (*O. crenata*, *O. ramosa,* and *O. aegyptiaca*) are common which cause great damage to several crops such as faba bean, tomato, peas, lentil, chick pea, and also several crops (Al-Menoufi 1994; Messiha et al. 2004, 2018; Hershenhorn et al. 2009). The extent of crop losses due to broomrape infestation depends on some factors such as the extent of infestation, crop sensitivity, and the different prevailing environmental factors (El-Desoki et al. 2003). Generally, *Orobanche* thrives in the hot climate of the Middle East and also in the Mediterranean area as well as Asia but also in more temperate areas such as Eastern Europe, where it is one of the most serious problems in vegetable crops (Pieterse 1979; Vouzounis and Americanos 1998). All species produce a very large number of tiny seeds which remain viable for many years, germinating only in the presence of a suitable host. A single plant of *Orobanche* can produce over 100,000 seeds which can survive in the field for up to 20 years (Gold et al. 1978). Hence, the control of *Orobanche* species is very difficult. Control has been attempted through the use of trap crops (Krishnamurthy et al. 1977), germination stimulants (Saghir 1986), soil solarization (Abu-Irmaileh 1991), rotations, selection of resistant varieties (Petzoldt and Sneyd 1986), and chemical methods including fumigation with methyl bromide, metham-sodium, and Dazomet, which directly kill the seeds in the soil (Vouzounis and Americanos 1998).

Lycopersicon esculentum Mill. (Tomato) is one of the most important vegetable crops grown in Egypt and occupies the first place among vegetable crops with regard to cultivated area as well as its production and value. Cogan and Toth (2003) reported that the decrease in the yield of tomato caused by *Orobanche ramosa* parasitization was estimated to be in the range from 43 to 53%. Therefore, a great attention is paid to raise its production through planting the high yielding cultivars as well as improving its agricultural practices specially weed control treatments (El-Dabaa 2008). Tomato is one of the main hosts of *O. ramosa* (Musselman 1980; Parker 1986).

Allelopathy is a natural process in which plants interact with other plant species through releasing allelochemicals into the environment, hence affecting the growth of each other (Rice 1984). Many higher plant species contain chemicals with an allelopathic activity in different parts (Duke et al. 2000). Under certain conditions, these allelochemicals are released into the environment, either as exudation or through decomposition of plant residues that affect the neighboring plants (Einhellig 2004). This effect may be positive or negative (Zhou et al. 2011). Allelopathy is an interference mechanism, in which live or dead plant materials release chemical substances, which inhibit or stimulate the associated plant growth (Macias et al. 2003; Cheng and Cheng 2016). Allelopathic plants interfere with nearby plants by dispersing chemicals into the soil that may inhibit plant growth, nutrient uptake, or germination (Singh et al. 2003). Allelochemicals like phenolic compounds, flavonoids, terpenoids, alkaloids, amino acids, and glucosinolates were found in different allelopathic plants (Fahey et al. 2001; Einhellig 2002; Velasco et al. 2008; Ahmed et al. 2012).

Brassicaceae family has allelopathic potential on the growth of other plants (Fenwick et al. 1983; Velasco et al. 2008; Zaji and Majd 2011; Martinez-Ballesta et al. 2013). They mainly produce glucosinolates that are not biologically active under normal conditions. When the plant tissues and cells are disrupted, they are hydrolyzed by the enzyme myrosinase, resulting in several degradation products, including isothiocyanates, nitriles, thiocyanates, epithionitriles, and oxazoliolines (Bones and Rossiter 2006). The main breakdown products are isothiocyanates which are phytotoxic (Fenwick et al. 1983; Fahey et al. 2001; Bennett et al. 2002; Kim and Ishii 2006; Zaji and Majd 2011; Martinez-Ballesta et al. 2013) and have pesticidal activities (Borek et al. 1994; Velasco et al. 2008). Brassicaceae seed plants have been reported to be higher in glucosinolate levels than the leaves, stems, and roots (Fahey et al. 2001; Velasco et al. 2008).

Therefore, the aim of the present work is to assess the allelopathic ability of the seed powder of two Brassicaceae plants, i.e., *Eruca sativa* and *Sinapis alba*, in controlling another member from the *Orobanchaceae* family (*Orobanche ramosa*) parasitizing *Lycopersicon esculentum* plants.

Materials and methods

Two pot experiments were carried out during two successive winter seasons of 2016/2017 and 2017/2018 in the greenhouse of National Research Centre, Dokki, Giza, Egypt. *Lycopersicon esculentum* (Tomato) seedlings (cultivar Super marmand) and seeds of both watercress (*Eruca sativa*) and white mustard (*Sinapis alba*) were obtained from Agricultural Research Centre, Giza, while parasitic weed seeds of *Orobanche ramosa* (broomrape) were obtained from the Weed Control Department, Ministry of Agric., Giza, Egypt. Clean seeds of both *E. sativa* and *S. alba* were grinded to fine powder and immediately incorporated to the soil surface before transplanting *L. esculentum* seedlings at concentration of 5, 10, 15, 30, and 45 g/kg soil. The experiment consisted of 13 treatments, i.e., two controls (healthy and infected), 10 treatments by different concentrations (5, 10, 15, 30, and 45 g/kg) of both (Essp) and (Sasp), and a treatment with Basamid. Each treatment is represented by nine pots (30 cm diameter) filled with 5 kg Nile clay soil. All treatments, except the healthy control were infected with *O. ramosa* seeds (0.2 g/pot) at 5 cm depth from the soil surface. The experiment also included herbicidal treatment with Basamid (Dazomet) for comparison with the allelopathic effect of both *E. sativa* and *S. alba* treatments. Basamid granules (Tetra hydro -3,5- dimethyl-2H-1,3,5-thiadiazine2-thione) were mixed in the soil infected with *O. ramosa* at the concentration 0.2 g/pot 10 days before planting the host seedlings. Three *L. esculentum* seedlings were sown/pot. All pots were distributed in a complete randomized design. Three replicates were collected from each treatment at 45, 80, and 100 days from transplanting. The normal cultural practices of growing *L. esculentum* plants were followed especially fertilization and irrigation.

Characters studied

Weeds

In each season, three replicates were collected from each treatment at 80 and 100 days from transplanting (DFT) to determine number, length, and fresh and dry weight of *O. ramosa* tubercles/pot.

Lycopersicon esculentum plants

In both seasons, samples of *Lycopersicon esculentum* plants at 45, 80, and 100 DFT were collected from each treatment: plant height (cm), root length (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). Also, the number and weight of fruit set/plant (g) were recorded at 80 and 100 (DFT).

Chemical analysis

Total glucosinolates (μ mol/g DW)

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

Total phenolic contents (mg/g DW)

Total phenolic contents of both *E. sativa* and *S. alba* seeds were 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 least significant difference (LSD) at 5% significant level.

Results

Weed growth parameters

The results in Table 1 showed the potentiality of controlling *Orobanche ramosa* parasitizing *L. esculentum* by incorporating different seed powder concentrations (5–45 g/kg soil) of *Eruca sativa* (Essp) and *Sinapis alba* (Sasp) as well as Basamid treatment (0.2 g/pot), to the soil. The lowest Essp concentration (5 g/kg soil) significantly reduced *O. ramosa* infestation and decreased number, length, and fresh and dry weight of *O. ramosa* tubercles/pot at the two ages of growth (80 and 100 DFT) as compared to their corresponding infected control. Also, the same Sasp concentration (5 g/kg soil) induced significant reduction in the same *O. ramosa* parameters only at the second age of growth (100 DFT), since no *O. ramosa* infestation tubercles appeared on *L. esculentum* at the first age of growth (80 DFT). The rate of reduction of *O. ramosa* tubercles' dry weight was recorded with the lowest concentration (5 g/kg soil) of Essp and Sasp) reached to 48.36 and 41.96%, respectively, as compared to the infected control. It is worthy to mention that no *O. ramosa* infestation occurred on *L. esculentum* plants by applying different treatments of both Essp and Sasp from (10–45 g/kg soil) concentrations as well as Basamid treatment at 0.2 g/pot.

Lycopersicon esculentum growth

The results in Tables 2, 3, and 4 show that most growth parameters of *L. esculentum* at 45, 80, and 100 (DFT) were significantly increased with all seed powder concentrations used (5–45 g/kg soil) of both *E. sativa* and *S. alba* and Basamid treatment at 0.2 g/pot compared to their corresponding infected controls. The highest significant increases in the different *L. esculentum* growth parameters were recorded with both 30 and 45 g/kg soil concentrations of Essp and Sasp as well as Basamid treatment (0.2 g/pot), especially at the later growth age (100 DFT). Treatment with 30 and 45 g/kg soil concentrations not only alleviated the harmful effect of *O. ramosa* parasite but also induced increases in most growth parameters of the plant. At 100 DFT, Essp treatments at 30 and 45 g/kg soil concentrations induced increases in the total dry weight of plant (shoot + root) reached to 21.10 and 35.62 %, respectively, over the corresponding healthy control, while the same treatment of Sasp achieved increases in the same plant parameter, reached to 10.05 and 31.86 %, over the corresponding healthy control.

Lycopersicon esculentum yield

The results of yield and its components of *L. esculentum* such as the number of fruit set/plant and weight of fruit set/plant (g) at 80 and 100 DFT recorded in Table 5 revealed that all Essp and Sasp concentrations used (5 to

Table 1 Effect of different concentrations of both *Eruca sativa* L. and *Sinapis alba* L. seed powder and herbicide Basamid on *Orobanche ramosa L.* infesting *Lycopersicon esculentum* Mill. plants at 80 and 100 days from transplanting. (average of the two seasons)

Treatments	At 80 days from transplanting				At 100 days from transplanting			
	No. of *O. ramosa* tubercles/pot	Length of *O. ramosa* tubercles (cm)	Fresh wt. of *O. ramosa* tubercles/ pot (g)	Dry wt. of *O. ramosa* tubercles/pot (g)	No. of *O. ramosa* tubercles/pot	Length of *O. ramosa* tubercles (cm)	Fresh wt. of *O. ramosa* tubercles/pot (g)	Dry wt. of *O. ramosa* tubercles/pot (g)
Healthy control	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
Infected control (I)*	6.0	16.5	21.54	9.69	9.0	18.0	15.60	11.25
(I) + Basamid 0.2 g/pot	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
(I) + *Eruca sativa* 5 g/kg soil	4.5	13.5	10.52	4.75	4.6	9.7	8.26	5.81
(I) + *Eruca sativa* 10 g/kg soil	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
(I) + *Eruca sativa* 15 g/kg soil	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
(I) + *Eruca sativa* 30 g/kg soil	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
(I) + *Eruca sativa* 45 g/kg soil	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
(I) + *Sinapis alba* 5 g/kg soil	0.0	0.0	0.0	0.00	5.1	10.9	8.93	6.53
(I) + *Sinapis alba* 10 g/kg soil	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
(I) + *Sinapis alba* 15 g/kg soil	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
(I) + *Sinapis alba* 30 g/kg soil	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
(I) + *Sinapis alba* 45 g/kg soil	0.0	0.0	0.00	0.00	0.0	0.0	0.00	0.00
LSD at 5%	0.93	0.76	0.58	0.61	0.53	0.99	0.83	0.90

***I = infected control**

Table 2 Effect of different concentrations of both *Eruca sativa* L. and *Sinapis alba* L. seed powder and herbicide Basamid on growth parameters of *Lycopersicon esculentum* Mill. at 45 days from transplanting. (average of the two seasons)

Treatments	Growth parameters							
	Plant height (cm)	Root length (cm)	No. of leaves/plant	No. of branches/plant	Fresh weight of plant		Dry weight of plant	
					Shoot (g)	Root (g)	Shoot (g)	Root (g)
Healthy control	47.4	18.7	16.15	1.65	36.43	6.95	6.37	3.11
Infected control (I)*	32.1	15.2	9.13	1.00	14.80	3.41	2.75	1.48
(I) + Basamid 0.2 g/pot	48.2	18.6	13.40	1.32	30.60	6.43	5.62	2.77
(I) + *Eruca sativa* 5 g/kg soil	35.1	16.8	11.60	1.24	24.90	4.86	4.63	2.11
(I) + *Eruca sativa* 10 g/kg soil	39.2	17.9	13.00	1.31	28.80	5.33	5.35	2.31
(I) + *Eruca sativa* 15 g/kg soil	39.8	19.8	17.30	1.56	39.25	5.82	6.86	2.58
(I) + *Eruca sativa* 30 g/kg soil	50.7	20.8	19.28	2.00	48.20	7.81	8.64	3.49
(I) + *Eruca sativa* 45 g/kg soil	55.1	24.7	21.25	2.40	56.63	9.47	9.27	4.17
(I) + *Sinapis alba* 5 g/kg soil	33.4	16.5	10.80	1.21	21.40	4.65	3.98	2.02
(I) + *Sinapis alba* 10 g/kg soil	38.7	17.4	12.40	1.27	27.20	5.21	5.05	2.26
(I) + *Sinapis alba* 15 g/kg soil	41.9	18.6	14.99	1.35	34.10	5.52	6.13	2.38
(I) + *Sinapis alba* 30 g/kg soil	50.2	20.3	18.84	1.86	44.96	7.43	8.45	3.21
(I) + *Sinapis alba* 45 g/kg soil	52.3	22.5	19.85	2.20	51.71	8.98	8.76	3.95
LSD at 5%	2.9	2.0	1.60	0.25	2.28	0.97	0.34	0.23

*I = infected control

45 g/kg soil) as well as Basamid treatment (0.2 g/pot) at both ages of growth significantly increased all yield parameters of *L. esculentum*, except the number of fruit set/plant at the lowest concentration (5 g/kg soil) used of both (Essp) and (Sasp) as compared to their corresponding infected control. The best results of *L. esculentum* yield were recorded with 30 and 45 g/kg soil concentrations of both Essp and Sasp as well as by 0.2 g/pot Basamid treatments. The applied treatments with the highest concentration (45 g/kg soil) of both Essp and Sasp not only alleviated the harmful effect of *O. ramosa* parasitizing which reached to 74.6% as shown in the

Table 3 Effect of different concentrations of both *Eruca sativa* L. and *Sinapis alba* L. seed powder and herbicide Basamid on growth parameters of *Lycopersicon esculentum* Mill. at 80 days from transplanting. (average of the two seasons)

Treatments	Growth parameters							
	Plant height (cm)	Root length (cm)	No. of leaves/plant	No. of branches/plant	Fresh weight of plant		Dry weight of plant	
					Shoot (g)	Root (g)	Shoot (g)	Root (g)
Healthy control	73.8	30.8	26.50	2.20	160.27	12.23	24.64	4.34
Infected control (I)*	45.3	19.9	13.75	1.25	62.53	5.91	9.48	2.09
(I) + Basamid 0.2 g/pot	62.3	29.5	23.90	2.17	153.83	11.98	23.63	4.24
(I) + *Eruca sativa* 5 g/kg soil	49.3	21.6	15.92	1.41	78.62	6.32	14.15	2.23
(I) + *Eruca sativa* 10 g/kg soil	52.4	25.8	18.32	1.84	125.18	8.61	18.96	3.04
(I) + *Eruca sativa* 15 g/kg soil	56.3	28.3	21.75	2.06	144.50	10.94	22.24	3.84
(I) + *Eruca sativa* 30 g/kg soil	71.0	32.5	31.03	2.57	188.10	14.38	28.90	5.18
(I) + *Eruca sativa* 45 g/kg soil	77.0	35.5	37.06	3.11	230.81	17.50	35.48	6.16
(I) + *Sinapis alba* 5 g/kg soil	49.1	20.3	14.08	1.32	73.27	6.15	13.89	2.17
(I) + *Sinapis alba* 10 g/kg soil	50.9	23.9	17.60	1.65	119.84	7.93	18.27	2.80
(I) + *Sinapis alba* 15 g/kg soil	54.6	27.6	20.10	1.97	139.07	9.88	21.37	3.61
(I) + *Sinapis alba* 30 g/kg soil	65.7	31.7	27.40	2.40	169.75	13.21	26.12	4.65
(I) + *Sinapis alba* 45 g/kg soil	77.1	34.9	34.02	2.92	227.98	15.46	35.05	5.45
LSD at 5%	2.8	0.8	2.46	0.24	6.65	1.60	2.23	0.37

*I = infected control

Table 4 Effect of different concentrations of both *Eruca sativa* L. and *Sinapis alba* L. seed powder and herbicide Basamid on growth parameters of *Lycopersicon esculentum* Mill. at 100 days from transplanting. (average of the two seasons)

Treatments	Growth parameters							
	Plant height (cm)	Root length (cm)	No. of leaves/plant	No. of branches/plant	Fresh weight of plant		Dry weight of plant	
					Shoot (g)	Root (g)	Shoot (g)	Root (g)
Healthy control	83.8	40.5	30.92	2.75	189.15	13.42	31.08	6.74
Infected control (I)*	56.5	28.1	15.25	1.55	71.43	6.17	12.39	3.46
(I) + Basamid 0.2 g/pot	70.2	40.3	29.30	2.71	181.52	13.15	29.91	5.93
(I) + *Eruca sativa* 5 g/kg soil	60.2	29.6	16.95	1.83	89.63	7.50	14.98	4.11
(I) + *Eruca sativa* 10 g/kg soil	62.4	35.5	21.60	2.26	138.21	9.54	22.47	4.65
(I) + *Eruca sativa* 15 g/kg soil	67.3	37.3	26.85	2.65	169.72	11.67	28.09	5.79
(I) + *Eruca sativa* 30 g/kg soil	75.8	41.7	36.34	3.25	230.96	15.53	37.52	8.28
(I) + *Eruca sativa* 45 g/kg soil	88.7	48.3	41.50	3.65	271.36	18.27	41.71	9.58
(I) + *Sinapis alba* 5 g/kg soil	58.8	29.2	15.64	1.79	82.84	6.83	14.81	3.92
(I) + *Sinapis alba* 10 g/kg soil	61.6	34.3	20.40	2.10	134.51	8.93	20.72	4.25
(I) + *Sinapis alba* 15 g/kg soil	64.7	37.0	24.53	2.35	165.84	11.44	26.53	5.35
(I) + *Sinapis alba* 30 g/kg soil	73.1	40.7	33.50	2.85	214.32	14.50	33.95	7.67
(I) + *Sinapis alba* 45 g/kg soil	85.5	44.0	38.00	3.62	267.05	17.19	41.05	8.82
LSD at 5%	3.7	2.3	2.65	0.26	4.86	1.75	2.36	0.72

*I = infected control

weight of fruit set/plant at 100 DFT but also increased this character than the healthy control. At 100 DFT, Essp at 45 g/kg soil concentration induced increases in weight of the fruit set/plant reached to 48.16 and 77.94%, respectively, over the corresponding healthy control and Basamid treatment (0.2 g/pot), while treatment with Sasp with the same concentration recorded increases in the same yield parameter reached to 24.90 and 50.01%, respectively, over the corresponding healthy control and Basamid treatment (0.2 g/pot). It is obvious from the results that Essp treatment at 45 g/kg soil achieved an increase in the weight of fruit set/plant at 100 DFT reached to about the double of that recorded with the same treatment of Sasp in the same yield

Table 5 Effect of different concentrations of both *Eruca sativa* L. and *Sinapis alba* L. seed powder and herbicide Basamid on number and weight of fruit set of *Lycopersicon esculentum* Mill. at 80 and 100 days from transplanting. (average of the two seasons)

Treatments	At 80 days from transplanting		At 100 days from transplanting	
	No. of fruit set/plant	Weight of fruit set/plant(g)	No. of fruit set/plant	Weight of fruit set/plant(g)
Healthy control	5.33	88.98	9.52	165.86
Infected control (I)*	2.25	30.26	3.44	42.13
(I) + Basamid 0.2 g/pot	6.33	100.29	9.11	138.10
(I) + *Eruca sativa* 5 g/kg soil	2.65	38.29	4.65	54.16
(I) + *Eruca sativa* 10 g/kg soil	3.50	69.15	6.41	81.42
(I) + *Eruca sativa* 15 g/kg soil	5.83	95,90	8.25	125.65
(I) + *Eruca sativa* 30 g/kg soil	8.10	130.17	10.94	190.34
(I) + *Eruca sativa* 45 g/kg soil	9.98	172.15	14.73	245.74
(I) + *Sinapis alba* 5 g/kg soil	2.43	35.24	4.12	53.38
(I) + *Sinapis alba* 10 g/kg soil	3.25	56.50	5.63	73.50
(I) + *Sinapis alba* 15 g/kg soil	4.00	78.28	7.24	93.51
(I) + *Sinapis alba* 30 g/kg soil	7.34	116.45	10.83	177.49
(I) + *Sinapis alba* 45 g/kg soil	8.33	160.84	12.51	207.16
LSD at 5%	0.92	3.68	1.24	11.03

*I = infected control

Table 6 Total glucosinolates (μmol/g dry weight) and total phenolic contents (mg/g dry weight) in the seed powder of both *Eruca sativa* and *Sinapis alba*

Materials	Total glucosinolates (μmol/g dry weight)	Total phenolic contents (mg/g dry weight)
Eruca sativa seed extract	316.03	35.62
Sinapis alba seed extract	288.59	43.62

parameter (48.16: 24.90). It is worthy to mention that the natural treatments of both Essp and Sasp at 45 g/kg soil concentration induced increases exceeding those caused by the herbicide Basamid treatment in *L. esculentum* yield components.

Changes in total glucosinolates and total phenolic content in *Eruca sativa* and *Sinapis alba* seed powder

The results in Table 6 illustrated that total glucosinolates in Essp is higher than that in Sasp, whereas total phenolic content in Sasp is higher than that in Essp.

Discussion

Our previous work at the botany department of the National Research Centre showed the allelopathic efficiency of seed powder of some Brassicaceae plants as *Eruca sativa*, *Sinapis alba*, *Brassica rapa*, and *Raphanus sativa*) in controlling some annual as well as perennial weeds (Messiha et al. 2013; Ahmed et al. 2014, 2016; El-Masry et al. 2015; El-Rokiek et al. 2017). Moreover, Messiha et al. (2018) showed the high allelopathic efficiency of the seed powder of one of the Brassicaceae plants (*Sinapis alba*) in controlling (*O. crenata*) parasitizing faba bean plants. There is no doubt that the main obstacle in controlling *Orobanche* infestation to several crops is the durable seed bank of the parasite in the soil, which could remain viable for decades (Gold et al. 1978) . This means that as long as the parasite seeds are not controlled, the parasite will persist till a suitable host is present. Therefore, it will be an advantage if we can make use from the allelopathic potentiality of the residues of some plants or from its seed powder as a tool for controlling this parasite. In this connection, it is worthy to mention that our previous work at the National Research Centre showed that using the seed powder of *Sinapis alba* plants could be used as a powerful tool in decreasing the number of infested faba bean plants with *Orobanche crenata*; this means obviously that this practice adversely affects the viability of the seeds of the parasite and hence decreased the number of infected faba bean plants (Messiha et al. 2018). Therefore, it was thought advisable to know the possibility of getting such promising results to control *O. ramosa* which infects tomato plants. Moreover, the results of the present work showed also that the allelochemical potentiality of the seed powder of the two Brassicaceae plants is not only constricted in decreasing the number of infested tomato plants (as shown in the number of tubercles/pot), but also it stimulated significantly the growth and yield of the host plant when compared with both healthy control and those treated with the herbicide Basamid.

In this connection, it is worthy to mention that some previous reports showed that allelochemical 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; Baeshen, 2014; El-Masry et al. 2015).

Conclusion

1. Incorporating the seed powder of *Eruca sativa* or *Sinapis alba* to the soil is a powerful tool in preventing *Orobanche ramosa* infestation to *Lycopersicon esculentum* and also increased significantly its yield.
2. The incorporation of the seed powder of *Eruca sativa* or *Sinapis alba* have privileges when compared with the herbicide Basamid, since treatment with herbicide needs a period of about 10 to 15 days before transplanting.

Abbreviations

CEssp: *Eruca sativa* seed powder; DFT: Days from transplanting; *L. esculentum*: *Lycopersicon esculentum*; *O. ramosa*: *Orobanche ramosa*; Sasp: *Sinapis alba* seed powder

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Authors' contributions

All authors contributed equally in all parts of this study. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and/or analysed during the current study are included in this published article

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Not applicable

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Competing interests

The authors declare that they have no competing interests

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