Current Science International
ISSN 2077-4435

Volume : 04 | Issue : 04| Oct.-Dec.|2015
Pages**:** 485-490

The Allelopathic Effect of *Eruca sativa* Mill. Seed Powder on Growth and Yield of *Phaseolus vulgaris* and Associated Weeds

El-Masry R.R., Nadia K. Messiha, Kowthar G. El-Rokiek, S. A. Ahmed and Sanaa A. Mohamed

Botany Department, National Research Centre, Dokki, Giza, Egypt, P.O. Box, 12622

ABSTRACT

Two pot experiments were conducted in the greenhouse of the National Research Centre, Dokki, Giza, Egypt, in the two successive seasons of 2013 and 2014 to study the allelopathic potential of *Eruca sativa* seed powder (Essp) on *Phaseolus vulgaris* growth as well as green and dry yield and associated broad- leaved weeds, *Portulaca oleracea* and *Corchorus olitorius.* Treatments were applied by the incorporation of *E. sativa* seed powder (Essp) to the soil at (0, 15, 30, 45 and 60g/kg soil). At 45 days after sowing (DAS), all Essp concentrations used minimized to great extent the dry weight of both weeds. At 75 DAS, both the higher treatments (45 and 60g/kg soil) gave complete inhibition in both two weeds. On the other side, *P. vulgaris* growth as well as yield and yield components were significantly increased with all Essp concentrations used as compared to their corresponding controls. Essp at 45g/kg soil gave the highest increase. The presence of glucosinolates and phenolic compounds in the seed powder of *E. sativa* (Essp) could play an important role in its natural selective bioherbicide properties in controlling the two annual broad- leaved weeds associated *P. vulgaris* plants.

Key words: Allelopathy, *Eruca sativa*, *Phaseolus vulgaris, Portulaca oleracea*, *Corchorus* olitorius, Glucosinolates content, Phenolic content

Introduction

Brassicaceae family is known to produce allelochemicals that could suppress weed growth and hence received great attention with respect to its allelopathic potentiality. (Fenwick *et al.*, 1983; Velasco *et al*., 2008; Uremis, *et al.* 2009 and Martinez-Ballesta *et al*., 2013). Generally, Brassicaceae species have been reported to have higher glucosinolate in its tissues. When Brassicaceae plants tissues and cells are disrupted they are hydrolyzed by the enzyme myrosinase, resulting in several degradation phytotoxic 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 and Martinez-Ballesta *et al*., 2013) and have pesticidal activities (Borek *et al*., 1994 and Velasco *et al*., 2008). One of the famous plants which belong to Brassicaceae family is *Eruca sativa.*

Recently, Messiha *et al*., 2013 and Ahmed *et al*., 2014 reported that *Eruca sativa* seed powder (Essp) could be used as a bioherbicide similar to the synthetic herbicide Basamid since the mode of action of both is the production of isothiocyanate which effectively control annual as well as perennial weeds.

Materials and Methods

Two pot experiments were carried out during two successive seasons of 2013 and 2014 in the greenhouse of the National Research Centre, Dokki, Giza, Egypt. Common bean (*Phaseolus vulgaris*) seeds as well as seeds of watercress (*Eruca sativa*), purslane (*Portulaca oleracea*) and Jew's mallow (*Corchorus olitorius*) were obtained from Agricultural Research Centre, Giza, Egypt. Clean seeds of *E.sativa* were grinded to fine powder, after that the powder was immediately incorporated in the soil surface before sowing at the rate of 0,15,30,45 and 60g/kg soil. The seeds of *P.vulgaris*, *P. oleracea* and *C. olitorius* were sown 2cm deep in plastic pots filled with 2kg of soil. The experiment consisted of 12 treatments including control; each treatment consisted of 8 replicates.

Characters studied

Weeds

Four replicates were collected from each treatment 40 and 75 days after sowing (DAS), dry weight of both *P. oleracea* and *C. olitorius* (g/pot) were recorded.

Corresponding Author: S. A. Ahmed, Botany Department, National Research Centre, Dokki, Giza, Egypt, P.O. Box, 12622
E-mail: dr_salah54@yahoo.com

***Phaseolus vulgaris* plants**

Plant growth

In both seasons 40 and 75 DAS, samples of *Phaseolus vulgaris* plants were collected from each treatment to determine plant height (cm), number of leaves/plant and dry weight of plant (g).

Yield and yield components

Samples of *P.vulgaris* plants were taken from each treatment to determine: - A- Green yield, i.e. number of pods/plant and weight of pods/plant (g) B- Dry yield , i.e. number of pods/plant, weight of seeds/pod (g), weight of 100 seeds(g) and weight of seeds / plant(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 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 *E.sativa* seed 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 LSD at 5% probability.

Results

Weed growth characters

The results in Table (1) show that different concentrations (15-60g/kg soil) of *Eruca sativa* seed powder (Essp) incorporated to the soil significantly suppress the dry weight of both *Portulaca oleracea* and *Corchorus olitorius* as compared to the corresponding untreated weed. At 40 days after sowing (DAS), the growth reductions of both weeds depend on Essp concentration used. Maximum reductions in the dry weight of each weed (*P. oleracea* or *C. olitorius*) were recorded with the highest Essp concentration (60g/kg soil) that reached to 94.3 and 99%, respectively, as compared to corresponding untreated control. Moreover, at 75 DAS, the dry weight reduction of *P. oleracea* and *C. olitorius* increased by Essp concentration used till reached to complete inhibition with both higher concentrations (45-60g/kg soil).

Table 1: Effect of different concentrations of seed powder of *Eruca sativa* on dry weight of *Portulaca oleracea* as well as *Corchorus olitorius* (g/pot).

Treatments		Weed dry weight (g/pot)	
Plants	Concentrations of *Eruca sativa* (g/kg soil)	40 days	75 days
Portulaca oleracea	…….	10.80	27.00
Phaseolus vulgaris + Portulaca oleracea	…….	8.73	22.85
Phaseolus vulgaris +Portulaca oleracea	15g	2.80	7.90
	30g	2.50	6.20
	45g	0.57	0.00
	60g	0.50	0.00
Corchorus olitorius	…….	15.45	24.15
Phaseolus vulgaris +Corchorus olitorius	…….	9.63	20.33
Phaseolus vulgaris +Corchorus olitorius	15g	1.30	1.65
	30g	0.63	0.80
	45g	0.10	0.00
	60g	0.10	0.00
LSD at 5%		0.63	0.54

***Phaseolus vulgaris* growth**

The results in Table (2) show that all *Phaseolus vulgaris* growth characters as plant height (cm), number of leaves/plant as well as dry weight of plant (g) at 40 and 75 DAS were significantly increased by different Essp concentrations. Not only, all treatments of Essp concentrations (15 to 60g/kg soil) alleviated the harmful effect of the two weeds (*P. oleracea* and *C. olitorius*) associated to *P. vulgaris* plant, but also induced significant increase in all *P. vulgaris* characters at the two ages of growth (40 and 75 DAS) when compared to the corresponding untreated controls. Maximum increase in all *P. vulgaris* growth characters at 40 and 75 DAS was recorded with 45g/kg soil Essp concentration as compared to corresponding controls. The increase in the dry

weight of *P. vulgaris* associated with *P. oleracea* or *C. olitorius* at 75 DAS reached to 10.3 and 19.2%, respectively over the dry weight of *P.vulgaris* free from weeds.

Table 2: Effect of different concentrations of seed powder of *Eruca sativa* on different growth characters of *Phaseolus vulgaris*.

Treatments		Growth characters					
		40 days			75 days		
Plants	Concentrations of *Eruca sativa* (g/kg soil)	Plant height (cm)	No. of leaves/plant	Dry weight of plant (g)	Plant height (cm)	No. of leaves/plant	Dry weight of plant (g)
Phaseolus vulgaris only	…….	30.0	8.0	1.70	41.0	10.30	4.58
Phaseolus vulgaris +Portulaca oleracea	…….	26.3	3.0	1.06	32.4	6.33	1.32
Phaseolus vulgaris +Portulaca oleracea	15g	29.8	4.5	1.25	35.0	7.30	2.15
	30g	35.2	5.3	1.60	41.6	9.80	3.57
	45g	36.2	6.9	1.73	45.0	10.00	5.05
	60g	33.8	5.0	1.45	40.8	9.20	3.26
Phaseolus vulgaris + Corchorus olitorius	…….	27.5	3.5	1.22	33.0	7.00	1.83
Phaseolus vulgaris + Corchorus olitorius	15g	32.0	5.2	1.53	40.5	8.50	2.88
	30g	36.0	6.2	2.20	42.2	9.88	4.10
	45g	37.0	7.5	2.30	51.0	13.60	5.46
	60g	34.0	5.5	2.05	41.0	9.70	3.38
LSD at5%		1.2	0.7	0.17	1.4	0.83	0.21

***Phaseolus vulgaris* yield**

A- Green yield

The results of the green yield of *P. vulgaris* associated with *P. oleracea* or *C. olitorius* recorded in Table (3) show that different Essp at (15-60g/kg soil) induced significant increase in the number of green pods/plant as well as weight of pods/plant of *P. vulgaris* as compared to their corresponding untreated controls. Maximum increase in number and weight of green pods/plant of *P. vulgaris* was recorded with 45g/kg soil Essp treatment as compared to their corresponding controls. This treatment (45g/kg soil) alleviated the reduction caused by the effect of *P. oleracea* or *C. olitorius* on the weight of green pods/plant to 53 and 64%, respectively.

Table 3: Effect of different concentrations of seed powder of *Eruca sativa* on yield and yield components of *Phaseolus vulgaris*.

Treatments		Yield and yield components					
		Green yield		Dry yield			
Plants	Concentrations of *Eruca sativa* (g/kg soil)	No.of green pods/plant	Weight of green pods/plant (g)	No.of dry pods/plant	Weight of seeds/pod (g)	Weight of 1oo seeds (g)	Weight of seeds /plant (g)
Phaseolus vulgaris only	…….	4.33	14.74	4.12	1.48	29.6	9.68
Phaseolus vulgaris +Portulaca oleracea	…….	2.84	3.43	2.66	0.70	20.0	2.88
Phaseolus vulgaris +Portulaca oleracea	15g	3.50	5.63	3.25	0.86	21.5	4.20
	30g	6.00	8.80	4.90	1.14	27.2	6.95
	45g	7.00	11.25	6.65	1.55	32.6	11.33
	60g	5.00	7.36	4.50	0.91	23.6	6.43
Phaseolus vulgaris + Chorchorus olitorius	…….	3.30	3.83	3.06	0.74	21.4	3.93
Phaseolus vulgaris + Chorchorus olitorius	15g	3.83	7.23	3.20	0.99	23.5	5.50
	30g	6.50	9.00	5.85	1.37	28.9	9.40
	45g	8.33	13.25	8.03	1.87	33.1	12.83
	60g	5.77	8.38	4.50	1.00	24.3	8.88
LSD at 5%		0.66	0.40	0.23	0.10	1.38	0.52

B- Dry yield

Dry yield and yield components of *P. vulgaris* associated with *P. oleracea* or *C. olitorius* revealed that all Essp concentrations (15-60g/kg soil) induced significant increase in the different yield characters (number of

dry pods/plant, weight of seeds/pod, weight of 100 seeds as well as weight of seeds/plant) as compared to corresponding untreated controls (Table 3). The best treatment was recorded with 45g/kg soil Essp concentration that achieved the highest increase in most *P. vulgaris* plant yield characters. The increase in weight of seeds/plant of *P. vulgaris* associated with *P. oleracea* or *C. olitorius* reached to about 17 and 33 %, respectively over that of corresponding control free from weeds.

Table 4: Total glucosinolates (µmol/g DW) and Total phenolic contents (mg/g DW) in *Eruca sativa**

Material	Total glucosinolates (µmol/g DW)	Total phenolic contents (mg/g DW)
Eruca sativa seeds	313.03	35.62

**Messiha et al. (2013)*

Discussion

The allelopathic compounds (allelochemicals) released from plants into the environment, as a result of secondary metabolites, include a variety of compounds, often attract or repel, nourish or poison other organisms. Allelochemicals like phenolic compounds, flavonoids, terpenoids, alkaloids, amino acids and glucosinolates were found in allelopathic plants (Fahey *et al*., 2001; Einhellig 2002; Velasco *et al*., 2008 and Ahmed *et a*l., 2012).

Recently, weed management systems seek biological solutions to minimize the harmful effects resulted from the use of herbicides in agricultural systems. Therefore, allelochemicals could be considered as an important tool for sustainable weed control management (Singha *et al*. 2001; Tesio and Ferrero, 2011; El-Metwally *et al.*, 2014 and El-Wakeel, 2015).

The results of the present investigation reveal to great extent significant reduction in the two broad – leaved weeds, *P. oleracea* and *C. olitorius* growth after the incorporation of Essp to the soil at 40 DAS. Complete reduction of both weeds recorded by the higher concentrations (45 and 60g/kg soil) of Essp at 75 DAS (Table1). The previous results showed that Brassicaceae family has allelopathic potential on the growth of other plants (Petersen *et al*., 2001; Norsworthy 2003; Turk and Tawaha 2003; Messiha *et al*., 2013; Ahmed *et al.,* 2014 and Baeshen, 2014). Messiha *et al*., 2013 and Ahmed *et al*., 2014 attributed the effect of *E. sativa* seed powder on the reduction of weed growth to the effect of allelochemicals, glucosinolates and phenols (Table 4).

On the other side, Essp treatments not only achieved to great extent good results in controlling the two broad – leaved weeds, *P. oleracea* (C_4 plant) and *C. olitorius* (C_3 plant) but also increased *P. vulgaris* growth (Table 2) and consequently improved its green and dry yield (Table 3). Several workers found that the inhibition of weed growth increased the competitive ability of the plant and consequently improved growth and yield (Abdelhamid and El-Metwally, 2008; Ahmed *et al*., 2012 and 2014 and El-Rokiek *et al*., 2012 and 2013).

It is worthy to mention that Essp at 45 g/kg soil was the best treatment in controlling the two broad – leaved weeds (*P. oleracea* and *C. olitorius*) and consequently increasing the growth and yield of *P. vulgaris* as compared to corresponding controls, this may be due to the selectivity of allelochemicals in their action and plants in their responses (Einhellig, 1995). Allelochemicals which inhibit the growth of some species at certain concentrations may stimulate the growth of same or different species at different concentrations (Narwal, 1994; Ahmed *et al.*, 2012 and 2014; Messiha *et al*., 2013 and Baeshen, 2014).

The results of the present work as well as our previous work indicate clearly the possibility of using allelopathic activity of *Eruca sativa* seed powder as a selective bioherbicide for controlling annual and perennial weeds in summer as well as winter seasons.

References

Abdelhamid, M.T. and I. M. El-Metwally, 2008. Growth, nodulation and yield of soybean and associated weeds as affected by weed management. Planta Daninha 26(4): 855-863.

Ahmed, S.A., K. G. El-Rokiek, R. R. El-Masry and N. K. Messiha, 2014.The Efficiency of Allelochemicals in The Seed Powder of *Eruca sativa* in Controlling Weeds *in Pisum sativum*. Middle East Journal of Agriculture Research, 3(4): 757-762.

Ahmed, S. A., N. K. Messiha, R. R. El-Masry and K. G. El-Rokiek, 2012. Allelopathic potentiality of the leaf powder of *Morus alba* and *Vitis vinifera* on the growth and propagative capacity of purple Nutsedge (*Cyperus rotundus* L.) and maize (*Zea mays* L.). J. of Appl. Sci. Res., 8(8): 4744-4751.

Baeshen, A. A., 2014. Morphological and elements constituent effects of allelopathic Activity of some medicinal plants extracts on *Zea mays*. Int. J. Curr. Res. Aca. Rev. 2 (4): 135-145.

Bennett, R.N., F. A. Mellon, N.P. Botting, J. Eagles, E.A.S. Rosa and G. Williamson, 2002. Identification of the major glucosinolates (4- mercaptobutyl glucosinolate) in leaves of *Eruca sativa* L. (rocket salad). Phytochemistry, 61:25-30.

Bones, A.M. and J.T. Rossiter, 2006. The enzymic and chemically induced decomposition of glucosinolates. Phytochemistry, 67:1053-1067.

Borek, V., M. J. Morra, P. D. Brown and J. P. McCaffrey, 1994. Allelochemicals produced during Siigri decomposition in soil. Agric. Food Chem., 42: 1030-1034.

Einhellig, F. A., 1995.Mechanism of Action of Allelochemical in Allelopathy. In Allelopathy Organisms, Processes and Application. Am.Chem.Soc., Washington, USA, pp.: 96- 116.

Einhellig, F.A., 2002. The physiology of allelochemical action: clues and views. Pp.1-23 In: Allelopathy, from Molecules to Ecosystems, Reigos M.J.; Pedrol N.Eds. Science Publishers, Enfield, New Hampshire.

El-Metwally, I.M., M. N. Shehata, E. R. El-Desoki, S. A. Ahmed and M. A. El-Wakeel, 2014. Response of Wheat and Associated Weeds to Allelopathic Water Extracts Tank Mixed with Reduced Wheat Herbicides Dose. Middle East Journal of Applied Sciences, 4(4): 873-883.

El-Rokiek, K. G., M. T. Abdelhamid and S. A. Saad El-Din,2013.Physiological response of purslane weed (*Portulaca oleracea*) and two common beans (*Phaseolus vulgaris*) recombinant inbred lines to Phosphorus fertilizer and bentazon herbicide. Journal of Applied Sciences Research, 9(4):2743-2749.

El-Rokiek, K.G.; W.M. El-Nagdi and R.R. El- Masry, 2012. Controlling of *Portulaca oleracea* and *Meloidogyne incognita* infecting sunflower using leaf extracts of *Psidium guava.* Archives of Phytopathology and Plant Protection, 45(19):2369-2385.

El-Wakeel, M.A.M., 2015. Effect of Allelopathy and Autotoxicity of Some Plants As Well As Herbicides on Wheat and Associated Weeds. Ph.D. Thesis, Fac. of Sci., Benha Univ., Cairo.

Fahey, J.W., A.T. Zalcman and P. Talalay, 2001. The chemical diversity and distribution of glucosinolates and isothiocyanates plants. Phytochemistry, 56: 5-51.

Fenwick, G.R., N.M. Griffiths and R.K. Heaney,1983. Bitterness in Brussels sprouts (*Brassica oleracea* L. var. gemmifera): the role of glucosinolate sands their breakdown products. J.of the Sci. of Food and Agric., 34: 73-80.

Kim, S.J. and G. Ishii, 2006. Glucosinolate profiles in the seeds, leaves and roots of rocket salad (*Eruca sativa* Mill.) and anti- oxidative activities of intact plant powder and purified 4-methoxyglucobrassicin. Soil Sci. and Plant Nutrition, 52: 394-400.

Martinez-Ballesta, M., D. A. Moreno and M. Carvajal, 2013.The Physiological Importance of Glucosinolates on Plant Response to Abiotic Stress in Brassica. Int. J. Mol.Sci. 14: 11607-11625.

Messiha, N.K., S. A. Ahmed, K. G. El-Rokiek, M. G. Dawood and R. R. El- Masry, 2013. The Physiological Influence of Allelochemicals in Two Brassicaceae Plant Seeds on the Growth and Propagative Capacity of *Cyperus rotundus* and *Zea mays* L. World Applied Sciences Journal 26(9): 1142-1149.

Narwal, S.S., 1994. Allelopathy in Crop Production. Production Publ. Scientific Publishers Jodhpur (India) pp.: 288.

Nasirullah and M. N. Krishnamurthy, 1996. A method for estimating glucosinolates in mustard/rape seeds and cake. J. Food Sci. Technol., 33(6):498-500.

Norsworthy, J.K., 2003. Allelopathic potential of wild radish (*Raphanus raphanistrum*).Weed Tech. 17: 307-313.

Petersen, J., R. Betz, F. Walker and K. Hurle, 2001. Weed suppression by release of isothiocyanates from turnip-rape mulch. Agronomy Journal (93): 37-42.

Rauchberger, Y., S. Mokady and U. Cogan, 1979. The effect of aqueous leaching of glucosinolates on the nutritive quality of rapeseed meal. J. Food Agric., 30: 31-39.

Singha, H.P., D.R. Batisha and R. K. Kohlia, 2001. Allelopathy in agroecosystems : an overview. J. Crop. Prod. 4: 1-41.

Snedecor, G.W. and W. G. Cochran, 1980.Statistical Methods.7th Ed.pp:507. The Iowa State Uni. PRESS, Ames, Iowa.

Snell, F.D. and C. T. Snell, 1953. Colorimetric Methods. Pp.: 66 Volume 111. Organi, D.Van Nostrand Company, Inc. Toronto, New York, London.

Tesio,L.A. and A. Ferrero,2011.Allelochemicals identified from Jerusalem artichoke (*Helianthus tuberosus* L.) residues and their potential inhibitory activity in the field and laboratory. Sci. Hortic. Amsterdam, 129: 361-368.

Turk, M. A. and A. M. Tawaha, 2003. Allelopathic effect of black mustard (*Brassica nigra* L.) on germination and growth of wild oat (*Avena fatua* L.). Crop Protect. 22: 673-677.

Uremis,I., M. Arslan, A. Uludag and M. Sangum,2009.Allelopathic potentials of residues of 6 Brassica species on Johnsongrass Sorghum halepense (L.)Pers.]. Africa J. of Biotechnology, 8(15): 3497-3501.

Velasco, P., P. Soengas, M. Vilar and M. E. Cartea, 2008.Comparison of glucosinolate profiles in leaf and seed tissues of different *Brassica napus* crop. J.Amer. Soc.Hort. Sci., 133 (4): 551-558.

Zaji, B. and A. Majd, 2011. Allelopathic potential of canola (*Brassica napus* L.) residues on weed suppression and yield response of maize (*Zea mays* L.). International Conference on Chemical, Ecology and Environmental Sciences IICCEES, Pattaya. December, pp.: 457-460.