Journal of Materials and Environmental Science
ISSN : 2028-2508
e-ISSN : 2737-890X
CODEN : JMESCN
Copyright © 2024,

J. Mater. Environ. Sci., 2024, Volume 15, Issue 3, Page 464-475

http://www.jmaterenvironsci.com

The Allelopathic Influence of the Seed Powder of *Brassica napus* (Canola) in Controlling *Orobanche crenata* (broomrape) Infesting *Pisum sativum* (Pea) Plants

Ahmed S.A., El-Dabaa M.A.T., Messiha N.K., El-Masry R.R., Dawood M.G.*

Botany Department, Agriculture and Biological Institute, National Research Centre, 33 El-Buhouth St P.O. 12622, Dokki, Giza, Egypt

**Corresponding author, Email address: monagergis@yahoo.com*

Received *25 Feb 2024,*
Revised *28 Mar 2024,*
Accepted *29 Mar 2024*

Keywords:
- ✓ *Allelopathy*
- ✓ *Brassica napus*
- ✓ *Glucosinolates*
- ✓ *Phenolic contents*
- ✓ *Pisum sativum*
- ✓ *Orobanche crenata*

Citation*: Ahmed S. A., El-Dabaa M. A. T, Messiha N. K., El-Masry R. R., Dawood M. G. (2024). The Allelopathic Influence of the Seed Powder of Brassica Napus (Canola) in Controlling Orobanche crenata (broomrape) Infesting Pisum sativum (Pea) Plants, J. Mater. Environ. Sci.,15(3), 464-475*

Abstract: Purpose: In order to compare the herbicidal effect of Basamid (Dazomet) to the allelopathic potentiality of *Brassica napus* seed powder on the growth, yield and yield components of *Pisum sativum* infected with *Orobanche crenata*. So, two pot experiments were conducted in the greenhouse of the National Research Centre, Dokki, Giza, Egypt, during two successive winter seasons in 2020/2021 and 2021/2022. The soil was treated with various doses of *B. napus* seed powder (at 0, 5, 10, 15, 20, 25, 30, 40 and 45g/kg soil) and Basamid herbicide (at 0.2g/pot). Results show that dry weight of *O. crenata* tubercles per pot (g) that were infecting *P. sativum* plants at 90 days after sowing (DAS) and at harvest significantly decreased with the application of all *B. napus* rates as well as Basamid treatments. The higher concentrations of *B. napus* 45, 40 and 30g/kg soil were found to be the most effective treatments for controlling *O. crenata* from infecting *P. sativum*. All *B. napus* rates utilized (except number of branches/plant at 90 DAS with the lowest rate of 5 g/kg soil) and Basamid herbicide significantly boosted *P. sativum* growth as well as yield and yield components when compared to the corresponding infected control. The biggest increases in growth, yield and yield component metrics were demonstrated by *B. napus* at 30, 40, 45 and 25g/kg soil, respectively, above the corresponding healthy control. Due to the presence of allelochemicals, primarily glucosinolates and phenolic contents, *B. napus* has an allelopathic action that can act as a natural bioherbicide to reduce the parasitic weed *O. crenata* and boost yield. It could be concluded that *incorporating B. napus* seed powder used for controlling *O. crenata* from infecting *P. sativum* as well as resulted in higher growth parameters, yield and yield components for *P. sativum*.

1. Introduction

The Orobanchaceae family includes the obligatory root parasite *Orobanche crenata* (broomrape). It is a significant root parasite that affects several crops in Egypt, including pea, faba bean, lentil and chickpea (Messiha *et al*. 2004 & 2018; El-Dabaa *et al*. 2019; El-Masry *et al*. 2019a; Ahmed *et al*. 2020). The parasitic weed is a significant pest of grains and forage legumes and is primarily restricted to the Mediterranean basin, Southern Europe and the Middle East (Rubiales *et al*. 2009b; Kandil *et al*. 2015). Depending on the level of infestation and the planting date, considerable yield losses of leguminous plants have been documented as a result of broomrape infestation (Rubiales *et al*. 2009a; Kandil *et al.* 2015). According to Rubiales *et al*. (2009a); Kandil *et al*. (2015), the severity of the infection, the sowing date and the fluctuation in dominating environmental conditions all affect the leguminous yield losses caused by *O. crenata* infestation. Orobanche has been shown to be particularly difficult to eradicate in agricultural crops when compared to non-parasitic weeds because of its underground position, strong relationship with host plant roots and complicated mechanisms of seed dissemination, germination and longevity (Linke and Saxena 1991). Therefore, a variety of parasitic weed control measures, such as cultural practices, biological control and chemical control, have been established (Rubiales *et al*. 2009a). Along with cultural practices, other recent strategies have been developed to suppress *O. crenata* parasitic weed, including those by Rubiales *et al*. (2009a); Messiha *et al*. (2018); El-Dabaa *et al*. (2019); Ahmed *et al*. (2020); Saudy *et al*. (2022); Telib (2023).

The well-known vegetable known as the pea (*Pisum sativum* L.) is a member of the Leguminosae family. It satisfies the nutritional needs of individuals all over the world and is a key component of vegetarian diets. It also has considerable levels of vitamins, minerals and fiber as well as the majority of the nutrients that are necessary for human health (Han and Baik 2008). It also has a reasonably high antioxidant activity. To boost *P. sativum* yield, numerous ecologically friendly, non-chemical weed control techniques have been used (El-Rokiek and Saad El-Din 2017; El-Rokiek *et al*. 2018; El-Wakeel *et al*. 2019; Ahmed *et al*. 2020). One of the legume species that *O. crenata* infests and severely reduces plant production is pea. Recently, allelopathic potential of plants are getting much interest to face all these problems in controlling weeds (El-Masry *et al*. 2015 &2019b; El Ouariachi *et al*. 2010; Jabran *et al*. 2015; Ahmed *et al*. 2016 & 2022; El-Rokiek *et al*. 2018; El-Dabaa *et al*. 2019; García-Robles *et al*. 2022; Saudy *et al*. 2022; El-Wakeel *et al*. 2023; Messiha *et al*. 2023).

In order to reduce the negative effects of synthetic chemicals (like herbicides, insecticides, nematicides and fungicides), as well as to improve the quality and increase the production of various crops, recent approaches in agricultural production try to use natural and safe substances to compete with weeds, insects, nematodes, etc. Allelopathy, which can be utilized as a safe method to eradicate some weeds, is the phenomena where natural substances are released from the various sections of the plant, such as roots, shoots, leaves or flowers, which impact neighboring plants and can be used as a safe approach for controlling some weeds (Rice 1995). The use of compounds having allelopathic qualities has been permitted for many higher plant species; these allelochemicals impact nearby plants when they are exuded, leached or formed during the decomposition of plant leftovers (Einhellig, 2004). The allelochemicals have a positive or negative impact on these nearby receptor plants (Zhou *et al*. 2011). In different allelopathic plants, allelochemicals such as flavonoids, terpenoids, alkaloids, glucosinolates, phenolic compounds and amino acids were found (Velasco *et al*. 2008; Ahmed *et al*. 2018 & 2022; Messiha *et al*. 2018 & 2023; El-Dabaa *et al*. 2019; El-Masry *et al*. 2019 a & b; El-Rokiek *et al*. 2018; El-Wakeel *et al*. 2019 & 2023). According to Cheng and Cheng (2016), allelopathy is an interference process in which living or dead plant components emit chemicals that either impede or stimulate the growth of the linked plants. By releasing substances into the soil that may prevent plant growth, nitrogen uptake, or germination, allelopathic plants harm adjacent plants (Singh *et al*. 2003).

Brassicaceae family is reported to have allelochemicals that enhanced its inhibitory effect on weed growth and as a result, received significant attention to be used as a safe controlling method. Velasco *et al*. (2008); Martinez-Ballesta *et al*. (2013); Messiha *et al*. (2013); El-Masry *et al*. (2015); El-Rokiek *et al*. (2017), Messiha *et al*. (2018); El-Masry *et al*, (2019a); Ahmed *et al*. (2020 &2022); Telib (2023) mentioned the allelopathic potential of the Brassicaceae family on the growth of other plants. Glucosinolates, which they mostly manufacture, are not physiologically active in a typical environment. Myrosinase hydrolyzes plant tissues and cells when they are damaged, producing a variety of degradation products include isothiocyanates, nitriles, thiocyanates, epithionitriles and oxazoliolines (Bones and Rossiter 2006). The primary breakdown products are isothiocyanates, which have pesticidal properties (Velasco *et al*. 2008) and are phytotoxic (Martinez-Ballesta *et al*. 2013). Glucosinolate levels in Brassicaceae seed plants have been found to be higher than those in the leaves, stems and roots (Velasco *et al*. 2008). Glucosinolates are hydrolyzed into a variety of products when the tissues of Brassicaceae plants are disrupted, including phytotoxic isothiocyanates (Bones and Rossiter 2006; Velasco *et al*. 2008; Martinez-Ballesta *et al*. 2013). *Brassica napus* is a well-known member of the Brassicaceae family of plants.

A class of secondary plant metabolites known as glucosinolates is particularly prevalent in the seeds and green tissues of the Brassicaceae family. The myrosinase enzymes (thioglucohydrolase) may enzymatically hydrolyze glucosinolates after tissue damage to produce a variety of physiologically active chemicals, such as nitriles, thiocyanate and isothiocyanates (Martinez-Ballesta *et al*. 2013). According to Cartea and Velasco (2008), these compounds exhibit a wide spectrum of biological activities, some of which may have favorable or unfavorable effects on the development and survival of plant-eating herbivores. Brassicaceae plants have allelochemicals that can be used to manage weeds in a variety of crops (Messiha *et al*. 2013; Biswas *et al*. 2014). In this regard, Messiha *et al*. (2013) reported that *Eruca sativa* and *Brassica rapa* seed powder could be used as a natural and selective bioherbicide similar to the chemically synthetic herbicide Basamid, since the mode of action of both is their ability to produce isothiocyanates (Khalaf *et al*. 1994), which effectively control the propagative capacity of the troublesome perennial weed *Cyperus rotundus* associating corn plant and also improved the growth of corn. Additionally, a number of earlier studies shown that Brassicaceae plants can stunt the growth of other plants (Baeshen 2014; El-Masry *et al*. 2015; Ahmed *et al*. 2016; El-Rokiek *et al*. 2017; Messiha *et al*. 2018; El-Masry *et al*. 2019a; Ahmed *et al*. 2020 &2022; Telib 2023).

The objectives of this study were to:

1- The first goal of this study was to determine whether *Brassica napus* seed powder had any allelopathic effects on the *Pisum sativum* plants that *Orobanche crenata* was parasitizing.

2. Examine the potential for employing *B. napus* seed powder as a natural bioherbicide to manage *O. crenata*.

2. Materials and Methods

Two pot experiments were conducted over the course of two subsequent winters in 2020/2021 and 2021/2022 in the National Research Centre's greenhouse in Dokki, Giza, Egypt. The parasitic weed seeds of *Orobanche crenata* (broomrape) were received from the Weed Control Section, Ministry of Agriculture, Giza, Egypt, while the pea (*Pisum sativum*) and canola (*Brassica napus*) seeds (cv. Master B) were obtained from the Agricultural Research Centre, Giza, Egypt. Prior to planting, clean (*B. napus*) seeds were ground into a fine powder and put into the soil's top layer at a rate of 0, 5, 10, 15, 20, 25, 30, 40 and 45g/kg soil. The experiment consisted of 11 treatments; including two controls (healthy and infected). *O. crenata* seeds (0.2g/pot) were sown at a depth of 5 cm in all treatments, with the exception of the healthy control. For comparison with the allelopathic effect of treatments for *B. napus*, the experiment also includes a herbicidal treatment with Basamid (Dazomet). *O. crenata*-infected soil was mixed with Basamid granules (Tetrahydro-3, 5-dimethyl-2H-1, 3, 5-thiadiazine 2-thione) at a concentration of 0.2g/pot at a depth of 5 cm below the soil surface. After two weeks *P. sativum* seeds were planted on November 27 and 26 respectively, in the first and second seasons, respectively (8 seeds/pot) at a depth of 3 cm in pots with a diameter of 30 cm (0.07 m2) and a soil mixture of 2:1 clay: sand. The *P. sativum* plants were thinned to 4 plants per pot two weeks later.



Photo: *Orobanche crenata* (broomrape) pea plant canola seeds

Each treatment represented by nine pots. All pots were distributed in a complete randomized design. The normal cultural practices of growing *P. sativum* plants were followed especially irrigation and fertilizer. Characters under study as follows

2.1. Weed growth

At 90 days after sowing (DAS) and harvest in each season, three replicates were taken from each treatment. The following weed characteristics were noted: number of *O. crenata* tubercles/pot, fresh and dry weight of *O. crenata*/pot (g) at the two growth ages, while *O. crenata* tubercles length (cm) was noted only at harvest.

2.2. Pisum sativum **plants**

2.1.1. Plant growth

At 60 and 90 days after sowing (DAS) in both seasons, samples of *P. sativum* plants were taken from each treatment to measure: the shoot height (cm), root length, number of leaves/plant, number of branches/plant as well as fresh and dry weight of plant (g).

2.1.2. Yield and its constituents

P. sativum plants from each treatment were sampled at harvest to calculate: number of pods/plant, length of pod (cm), fresh weight of pods/ plant (g), number of seeds/pod and dry weight of seeds/ plant (g).

2.3. Chemical analysis

Glucosinolates were measured in defatted canola meal as the liberated glucose during hydrolysis by myrosinase enzyme (Rauchberger *et al*. 1979). The resulting glucose was determined colorimetrically (Nasirullah and Krishnamurthy 1996). Glucosinolates value was obtained by multiplying the factor 2.1 for glucose. Phenolic compounds were estimated in defatted canola meal according to Zhang and Wang (2001) and Bouknana*et al*. 2014) by using Folin and Ciocalteu phenol reagent.

2.3. Statistical analysis

Using the CoStat Software Program Version 6.303 (2004), the data were statistically evaluated in accordance with Snedecor and Cochran's (1980) guidelines, and the treatment means were compared using LSD with a 5% probability.

3. Results

3.1. Weed growth parameters

The results in Table 1 demonstrated the potential impact of integrating various rates (5 to 45 g/kg soil) of *Brassica napus* as well as Basamid treatment (0.2 g/pot) to the soil on suppressing *Orobanche crenata* in *Pisum sativum* plants. The results shown in Table 1 showed that all *B. napus* rates (5 to 45 g/kg soil) and Basamid treatment (0.2 g/pot) significantly reduced *O. crenata* infestation and decreased the number, fresh and dry weight of *O. crenata* tubercles per pot at the two ages of growth (90 DAS and at harvest) and length of *O. crenata* tubercles at harvest in *P. sativum* compared to corresponding infected control. The reduction in *O. crenata* characteristics at the two growth ages was rate dependent. The greatest decrease in all growth parameters of *O. crenata* tubercles/pot in comparison to the infected control, were recorded with the higher *B. napus* rates (45, 40, 30 and 25g/kg soil) and Basamid treatment (0.2 g/pot) at the two ages of the growth. The maximum rate of reduction of *O. crenata* tubercles dry weight at harvest was recorded with 45 g of B. napus, followed by 40, 30, 25 and 20 g/kg soil, which reached 99.7, 99.0, 97.6, 95.6 and 94.1% respectively. The reduction of the same character recorded with Basamid herbicide (0.2 g/pot) reached 92.1% as compared to the corresponding infected control. Controlling *O. crenata* that is parasitizing *P. sativum* with these superior treatments produced better outcomes than the Basamid treatment at 0.2 g/pot. It is obvious from the results that the difference between the reduction caused by *B. napus* treatment at 45 soil and 40g/kg soil in all *O. crenata* parameters at harvest were non-significant.

Table 1: Effect of different rates of *Brassica napus* seed powder and Basamid herbicide on *Orobanche crenata* tubercles in *Pisum sativum* L. at 90 days after sowing and at harvest (combined analysis of two seasons)

Treatments	**Rate of *B. napus* (g/kg soil)**	**No. of *O. crenata* tubercles/pot**		**F.W. of *O. crenata* tubercles/pot (g)**		**D.W. of *O. crenata* tubercles/pot (g)**		**Length of *O. crenata* tubercles (cm)**
		at 90 DAS	**at harvest**	**at 90 DAS**	**at harvest**	**at 90 DAS**	**at harvest**	**at harvest**
***Pisum sativum* alone(*P.*) (Healthy control)**	…………..	0.0	0.0	0.00	0.00	0.00	0.000	0.0
(*P*)+ *Orobanche crenata* (*O.*) (Infected control)	…………..	29.2	37.2	15.63	36.52	3.38	9.75	8.31
***P.+ O.+* Basamid at 0.2g/pot**	…………..	13.6	7.5	7.96	4.57	1.93	0.77	3.68
P.+ O.+ B. napus	5	24.5	17.0	13.17	9.12	2.62	1.53	4.51
P.+ O.+ B. napus	10	21.9	12.0	10.26	5.73	2.02	1.00	4.32
P.+ O.+ B. napus	15	19.0	10.5	7.43	3.56	1.72	0.61	3.25
P.+ O.+ B. napus	20	15.3	9.0	7.19	3.48	1.33	0.58	3.17
P.+ O.+ B. napus	25	11.4	6.5	4.64	2.52	1.25	0.43	3.01
P.+ O.+ B. napus	30	10.7	6.0	3.95	1.36	1.06	0.23	2.70
P.+ O.+ B. napus	40	3.4	2.5	1.43	0.59	0.38	0.10	1.86
P.+ O.+ B. napus	45	2.1	1.5	0.29	0.14	0.09	0.03	1.00
LSD at 5%		1.47	1.4	0.93	0.87	0.38	0.33	0.83

3.2. Growth of Pisum sativum

The recorded results in Table 2 indicated that all growth parameters of *P. sativum* such as shoot height (cm), root length (cm), number of leaves/plant, number of branches/plant as well as fresh and dry weight of plant (g) were significantly stimulated by treating with all *B. napus* successive rates (5 to 45 g/kg soil) and Basamid herbicide at 0.2 g/pot at the first ages (60) DAS as compared with their corresponding infected control. Treatments of *B. napus* at 45g followed by 40, 30, 25 and 20g/kg soil recorded the highest increases in the investigated growth parameters as compared with healthy control and recommended the herbicidal Basamid treatment. At 90 DAS, the results in Table 3 showed that all growth parameters of *P. sativum* (except number of branches/plant at the lower rate of *B. napus* (5 g/kg soil) were significantly stimulated by treating with all *B. napus* successive rates (5 to 45 g/kg soil) and Basamid herbicide at 0.2 g/pot when compared to their corresponding infected control. The largest increases in all growth parameters of *P. sativum* plant were produced by *B. napus* at 30g, followed by 40, 45 and 25g/kg soil, respectively. The previous treatments induced maximum increases in dry weight (shoot + root) of *P. sativum* plant which reached to 49.3, 41.2, 14.5 and 5.8%, respectively over the corresponding healthy control. Not only these treatments alleviated the harmful effect of *O. crenata* infestation, but also induced significant increases in all growth parameters of *P. sativum* at the two growth ages as compared to their corresponding healthy control and Basamid herbicide treatments.

Table 2: Effect of different rates of *Brassica napus* seed powder and Basamid herbicide on growth parameters of *Pisum sativum* at 60 days after sowing (combined analysis of two seasons)

Treatments	Rate of *B. napus* (g/kg soil)	Growth parameters					
		Shoot height of plant (cm)	Root length (cm)	No. of leaves/plant	No. of branches/plant	F.W. of plant (g)	D.W. of plant (g)
***Pisum sativum* alone(*P.*) (Healthy control)**	…………..	47.5	15.6	11.1	1.4	7.35	1.348
(*P.*)+*Orobanche crenata* (*O.*)(Infected control)	…………..	32.2	9.7	6.8	1.0	2.03	0.347
***P.*+ *O.*+ Basamid at 0.2g/pot**	…………..	46.2	15.3	10.6	1.3	5.41	0.926
P.+ O.+ B. napus	5	39.8	11.9	9.3	1.2	3.24	0.555
P.+ O.+ B. napus	10	42.6	13.7	9.7	1.2	3.76	0.644
P.+ O.+ B. napus	15	44.4	14.8	10.0	1.3	4.17	0.715
P.+ O.+ B. napus	20	48.5	17.3	11.8	1.3	7.87	1.566
P.+ O.+ B. napus	25	56.5	17.8	12.4	1.4	9.15	1.681
P.+ O.+ B. napus	30	60.8	18.5	12.7	1.4	9.83	1.693
P.+ O.+ B. napus	40	67.0	18.7	13.3	1.5	11.35	1.944
P.+ O.+ B. napus	45	68.8	23.5	14.5	1.6	12.01	2.056
LSD at 5%		2.1	1.5	1.2	0.2	0.96	0.130

3.3. Yield of Pisum sativum

At harvest, *P. sativum*'s yield and yield components, including number of pods/plants, length of pod (cm), fresh weight of pods/ plant (g), number of seeds/pod and dry weight of seeds/ plant (g), were measured and recorded. The findings are shown in Table 4. In comparison to the untreated infected control, all of these yield parameters were considerably improved by the application of *B. napus* at successive rates (5 to 45 g/kg soil) and Basamid herbicide at 0.2 g/pot. It is worthy to mention that both *B.napus* seed powder treatments at 25 and 45 g/kg soil achieved approximately equal increases in most yield parameters of *P. sativum* plant and these increases reached to corresponding healthy control. So, economically we prefer using *B. napus* seed powder treatment at 25 g/kg soil instead of 45 g/kg soil. *B. napus* at 30g/kg soil produced the greatest results for *P. sativum* yield components, followed by 40, 45 and 25 g/kg soil. In addition to reduce the negative effects of *O. crenata* infestation, these treatments also increased plant yield in comparison to the matching healthy control. The prior treatments also produced the highest increases in fresh weight of pods/plant (g) of 44.5, 31.1, 23.4 and 18.1% and dry weight of seeds/plant (g) of 29.1, 17.1, 13.1 and 10.1%, above the equivalent healthy control, respectively.

Table 3: Effect of different rates of *Brassica napus* seed powder and Basamid herbicide on growth parameters of *Pisum sativum* at 90 days after sowing (combined analysis of two seasons)

Treatments	Rate of *B. napus* (g/kg soil)	Growth parameters					
		Shoot height of plant (cm)	Root length (cm)	No. of leaves/plant	No. of branches/plant	F.W. of plant (g)	D.W. of plant (g)
***Pisum sativum* alone(*P.*) (Healthy control)**	…………..	61.3	19.0	12.7	1.9	12.29	6.390
(*P.*)+*Orobanche crenata* (*O.*) (Infected control)	…………..	36.7	10.3	8.0	1.2	3.86	1.778
***P.*+ *O.*+ Basamid at 0.2g/pot**	…………..	55.4	18.7	12.2	1.8	11.18	5.767
P.*+ *O.*+ *B. napus	5	45.5	14.1	10.5	1.5	5.75	3.028
P.*+ *O.*+ *B. napus	10	47.9	16.5	10.8	1.6	6.49	3.429
P.*+ *O.*+ *B. napus	15	48.3	17.3	11.3	1.7	6.67	3.536
P.*+ *O.*+ *B. napus	20	52.4	18.1	11.7	1.8	8.94	4.692
P.*+ *O.*+ *B. napus	25	64.5	20.0	13.6	1.9	12.74	6.762
P.*+ *O.*+ *B. napus	30	82.0	30.6	16.8	2.0	18.11	9.541
P.*+ *O.*+ *B. napus	40	75.0	26.3	15.2	2.0	17.06	9.023
P.*+ *O.*+ *B. napus	45	69.0	21.4	14.0	1.9	15.26	7.319
LSD at 5%		1.9	1.4	1.3	0.4	1.45	0.731

In general, it is evident from the findings presented in Tables 2, 3 and 4 that *B. napus* application at rates of 30, 40, 45and 25 g/kg soil resulted in higher growth parameters, yield and yield components for *P. sativum* than did applications of a healthy control and Basamid herbicide at (0.2 g/pot). Both treatments of *B. napus* seed powder 30 and 40g/kg soil recorded maximum increases in all *P. sativum* yield components over the corresponding healthy control and the differences of these increases between the two treatments (30 and 40g/kg soil) were non-significant in all *P. sativum* yield parameters except the fresh weight of pods/plant (g) that was significant.

Table 4: Effect of different rates of *Brassica napus* seed powder and Basamid herbicide on yield and yield components of *Pisum sativum* at harvest (combined analysis of two seasons)

Treatments	Rate of *B. napus* (g/kg soil	Yield and yield components of *Pisum sativum*					%of yield increment
		No. of pods/plant	Length of pod (cm)	F.W. of pods/plant (g)	No. of seeds/pod	D.W. of seeds/plant (g)	
***Pisum sativum* alone (*P.*) (Healthy control)**	…………..	4.08	6.5	9.32	4.99	1.99	161.8
(*P.*) +*Orobanche crenata* (*O.*) (Infected control)	…………..	1.73	3.4	3.25	2.07	0.76	00.0
***P.*+ *O.*+ Basamid at 0.2g/pot**	…………..	3.96	6.3	8.98	4.62	1.86	144.7
P.*+ *O.*+ *B. napus	5	2.69	5.0	5.49	3.51	1.39	82.9
P.*+ *O.*+ *B. napus	10	3.25	5.4	7.24	3.95	1.51	98.7
P.*+ *O.*+ *B. napus	15	3.70	5.8	7.68	4.21	1.67	119.7
P.*+ *O.*+ *B. napus	20	3.87	6.1	8.24	4.42	1.79	135.5
P.*+ *O.*+ *B. napus	25	4.28	6.7	11.01	5.23	2.19	188.2
P.*+ *O.*+ *B. napus	30	6.00	7.9	13.47	6.70	2.57	238.2
P.*+ *O.*+ *B. napus	40	5.41	7.4	12.22	6.42	2.33	206. 6
P.*+ *O.*+ *B. napus	45	4.72	6.9	11.50	5.93	2.25	196.1
LSD at 5%		0.69	1.31	0.9	1.31	0.61	00.0

Quantitative estimation of total glucosinolates and total phenolic contents in *Brassica napus* seed powder. Table 5 shows the quantity of total glucosinolates (9.40 µmol/g defatted dried meal) and total phenolic contents (1.93 /% defatted dried meal) in the seed powder of *Brassica napus.*

Table 5: Contents of glucosinolates and phenolic compounds in defatted canola meal

Glucosinolates (µ mole/g defatted dried meal)	**9.40**
phenolic compounds (%defatted dried meal)	**1.93**

4. Discussion

Orobanche crenata, is one of the most important parasitic weeds in the Orobanche genus, that responsible for severe yield losses in legume crops, such as faba bean, lentil, pea and common vetch (Aksoy *et al*. 2016). The control of Orobanche is exceptionally very difficult due to its underground location as well as to the complete association with the host plant roots. 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). Several researches showed the potentiality of using the allelopathic technique as a component of integrated weed management as bioherbicide to suppress weeds in crops (Messiha *et al.* 2013 & 2023; El-Masry *et al.* 2015 & 2019b; Ahmed *et al.* 2016 & 2022; El-Rokiek *et al*.2017; Ullah *et al*.2020; Abbas *et al.* 2021; Scavo and Mauromicale, 2021**;** El-Wakeel *et al*. 2023). Our earlier research ensured the allelopathic efficiency of seed powder of some Brassicaceae plants, including *Raphanus sativus*, *Sinapis alba*, *Eruca sativa* and *Brassica rapa*, in controlling both annual and perennial weeds (Messiha *et al*. 2013; El-Masry *et al*. 2015; Ahmed *et al*. 2016, 2018 & 2022 ; El-Rokiek *et al*. 2017 & 2018; Allah *et al*. 2020; Abbas *et al*. 2021) as well as parasitic weeds as some Orobanche species (*O. crenata* and *O. ramosa*) parasitizing faba bean, pea and tomato plants (Messiha *et al*. 2018; El-Dabaa *et al*. 2019; El-Masry *et al*. 2019 a; Ahmed *et al*. 2020; Saudy *et al*. 2022 ; Telib 2023). The results of the present investigation reveal that one of the Brassicaceae plant seeds, (*Brassica napus*) has useful allelopathic properties that can be used to manage *Pisum sativum* that has been infected with *Orobanche crenata* when added to the soil. Incorporating *B. napus* to the soil at rates from 5 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). Although Brassicaceae plants have the same mode of action of Basamid synthetic herbicide, most rates of *B. napus* were more effective than Basamid in controlling *O. crenata parasitic* weed (Table 1). The mode of action depends on the induction of isothiocyanates, which recently proved its effectiveness in controlling the growth of parasitic and non-parasitic weeds (Khalaf *et al.* 1994).

In this regard, it is important to note that the natural allelochemicals in Brassicaceae plants, primarily glucosinolates and phenolic compounds, were thought to be responsible for their allelopathic effects (Table 5). Glucosinolates hydrolyzed by endogenous enzyme myrosinase to a number of products. The main breakdown products are isothiocyanates, which are phytotoxic and achieved good results in controlling weeds (Martinez-Ballesta *et al*. 2013; Messiha *et al*. 2013; El-Masry *et al*. 2015 & 2019a; Ahmed *et al*. 2016; El-Rokiek *et al*. 2017; Rehman *et al*. 2018), Moreover, the results of present research reveal that all growth parameters ,as well as yield and yield components of *P. sativum* (except number of branches per plant at 90 DAS with 5g/kg soil) were significantly increased by different concentrations of *B. napus* and the herbicidal Basamid applied at 0.2 g/pot (Tables 2, 3 and 4). The best treatments were recorded with *B. napus* at 30, 40, 45 and 25 g/kg soil, respectively as compared to healthy control. The inhibition of weed growth by chemical or biological means increased the competitive ability of the plant and consequently improved the growth and yield according to Messiha *et al*. (2013), El-Masry *et al*. (2015) & (2019a), Ahmed *et al*. (2020). Moreover, it is worthy to mention also that improving the growth and yield of *P. sativum* may be 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 same or different species at different concentrations (Messiha *et al*. 2013, 2018 & 2023; Baeshen 2014; El-Masry *et al*. 2015 & 2019a; Ahmed *et al*. 2016; 2020 &2022; El-Rokiek *et al*. 2017 & 2018; El-Dabaa *et al*. 2019; El-Wakeel *et al*. 2019 &2023; Ahmed *et al*. 2020).

It should be noted that the limitation of competitive agent between *O. crenata* weed and *P. sativum* plants induced growth parameters and consequently *P. sativum* yield (Messiha *et al*. 2004; Ahmed *et al*. 2020).

Conclusion

Incorporating *Brassica napus* seed powder to the soil is considered as a safe and effective method to control *Orobanche crenata* parasitizing *Pisum sativum* and also significantly increase the growth and yield of the plants. The most effective rate of *Brassica napus* seed powder (30 g/kg soil) is recommended to be investigated through the field level to manage *Orobanche crenata* infecting *Pisum sativum* plants.

- **Ethics approval and consent to participate**: Not applicable
- **Consent for publication:** Not applicable
- **Availability of data and materials** : Not applicable
- **Competing Interests** : The authors declare that they have no competing interests
- **Funding Information** : No funding was received

References

Abbas T, Ahmad A, Kamal A (2021) Ways to use allelopathic potential for weed management: a review. Int J Food Sci Agric 5:492–498. https://doi.org/10.26855/ijfsa.2021.09.020

Ahmed S. A., El-Wakeel M. A., Mohamed S. A., Messiha N. K. (2022). Impact of phenolic compounds and glucosinolates of two brassicaceae powders in controlling two annual weeds associating *Lupinus albus* plants. *Egypt. J. Chem*., 65 (9), 707-714. DOI: 10.21608/EJCHEM.2022.116122.5283

Ahmed S. A., Messiha N. K., El-Rokiek K. G., Mohamed S. A., El-Masry R. R. (2016) The allelopathic efficiency of two Brassicaceae plant seeds in controlling weeds associating sunflower plants. *Res. J. Pharm. Biol. Chem., Sci.* 7(5), 158-165.https://www.rjpbcs.com/pdf/2016_7(5)/%5B21%5D.pdf

Ahmed S. A., Messiha N. K., El-Masry R. R., El-Dabaa M. A. T. (2020) The dual allelopathic capacity of two Brassicaceae plants' seed powder in controlling *Orobanche crenata* infesting *Pisum sativum* as well as stimulating its growth and yield. *Bull NRC.*, 44:17. https://doi.org/10.1186/s42269-020-0276-6

Ahmed S. A., El-Masry R. R., Messiha N. K., El-Rokiek K. G. (2018) Evaluating the allelopathic efficiency of the seed powder of *Raphanus sativus* L. in controlling some weeds associating *Phaseolus vulgaris* L. *Int. J. Environ*., 7 (3), 87-94.https://journalofscience.org/index.php/GJSFR/article/view/2372

Aksoy E., Arslan Z. F., Tetik O., Eymirli S. (2016) Using the possibilities of some trap, catch and Brassicaceaen crops for controlling crenate broomrape a problem in lentil fields. *Int. J. Plant Prod.*, 10(1), 53-62. DOI: 10.22069/IJPP.2016.2553

Baeshen A. A. (2014) Morphological and elements constituent effects of allelopathic activity of some medicinal plants extracts on *Zea mays*. *Int. Curr. Res. Aca. Rev*. 2(4), 135-145. 145. http://www.ijcrar.com/vol-2-4/Areej%20Ali%2 0Baeshen.pdf

Biswas P. K., Morshed M .M ,.Ullah M .J ,.Irin I .J . (2014) . Allelopathic effect of brassica on weed control and yield of wheat. *Bangladesh Agron. J.*, 17(1), 73-80. DOI:10.3329/baj. v17i1.23679

Bones A. M., Rossiter J.T. (2006) The enzymic and chemically induced decomposition of glucosinolates, *Phytochem*.,67,1053–1067. https://doi.org/10.1016/j.phytochem.2006.02.024

Bouknana D., Hammouti B., Messali M., Aouniti A., Sbaa M. (2014), Phenolic and non-Phenolic Fractions of the Olive Oil Mill Wastewaters as Corrosion Inhibitor for Steel in HCl medium, *Port. Electrochim. Acta*, 32(1), 1-19. DOI:10.4152/pea.201401001

Cartea M. E., Velasco P. (2008) Glucosinolates in brassica foods: Bioavailability in food and significance for human health. *Phytochem. Review*., 7, 213-229. DOI:10.1007/s11101-007-9072-2

Cheng F., Cheng Z. (2016) Corrigendum: research progress on the use of plant allelopathy in agriculture and the physiological and ecological mechanisms of allelopathy. *Front. Plant Sc*i., 7(1697), 1–16. https://doi.org/10.3389/fpls.2016.01697

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. DOI: 10.1021/bk-1995-0582.ch007

Einhellig F. A. (2004) Mode of allelochemical action of phenolic compounds. In: Macias FA, Galindo JCG, Molinillo JMG, Cutler HG (eds) Allelopathy, chemistry and mode of action of allelochemicals. CRC Press, Boca Raton, pp 217–239. DOI:10.1201/9780203492789.ch11

El-Dabaa M. A. T., Ahmed S. A., Messiha N. K., El-Masry R. R. (2019) The allelopathic efficiency of *Eruca sativa* seed powder in controlling *Orobanche crenata* infected *Vicia faba* cultivars. *Bull. NRC.*, 43(37), (2019). https://doi.org/10.1186/s42269-019-0079-9

El-Masry R. R., El-Desoki E. R., El-Dabaa M. A. T., Messiha N. K., Ahmed S. A. (2019a) Evaluating the allelopathic potentiality of seed powder of two Brassicaceae plants in controlling *Orobanche ramosa* parasitizing *Lycopersicon esculentum* Mill. Plants. *Bull. NRC.*, 43(101), 1–8. https://doi.org/10.1186/s42269-019-0144.4

El-Masry R. R., Messiha N. K., El-Rokiek K. G., Ahmed S. A. Mohamed S. A. (2015) The Allelopathic Effect of *Eruca sativa*. Seed Powder on Growth and Yield of *Phaseolus vulgaris* and Associated Weeds. *Curr. Sci. Int*., 4, 485-490. www.curresweb.com/csi/csi/2015/485-490.pdf

El-Masry R .R ,.Ahmed S .A., El-Rokiek K .G., Messiha N .K ,.Mohamed S .A .(2019 b) Allelopathic activity of the leaf powder of *Ficus nitida* on the growth and yield of *Vicia faba* and associated weeds . *Bull . NRC* ,.1-7. DOI:10.1186/s42269-019-0114-x

El Ouariachi E., J. Paolini, M. Bouklah, A. Elidrissi, A. Bouyanzer, B. Hammouti, J-M. Desjobert, J. Costa (2010), Adsorption properties of Rosmarinus officinalis oil as green corrosion inhibitors on C38 steel in 0.5M H2SO4, *Acta Mettallurgica Sinica*, 23 N°1, 13-21.

El-Rokiek K. G., Ahmed S. A., Messiha N. K., Mohamed S. A., El-Masry R. R. (2017) Controlling the Grassy weed *Avena fatua* associating wheat plants with the seed powder of two brassicaceae plants *Brassica rapa* and *Sinapis alba*. *Middle East J. Agric. Res.*, 6 (4), 1014-1020. http://www.curresweb.com/mejar/mejar/2017/1014-1020.pdf

El-Rokiek K .G ,.Saad El-Din S .A. (2017) Allelopathic activity of*Eucalyptus globulus*leaf water extract on *Pisum sativum* growth, yield and associated weeds .*Middle East J. Appl. Sci.*, 7(4), 907–913. https://www.curresweb.com/mejas/mejas/2017/907-913.pdf

El-Rokiek K. G., Saad El-Din S. A., El-Wakeel M. A., Dawood M. G., El-Awadi M. (2018) Allelopathic effect of the two medicinal plants *Plectranthus amboinicus* (Lour.) and *Ocimum basilicum* L. on the growth of *Pisum sativum* L. and associated weeds. *Middle East J. Agric. Res*., 7(3), 1146–1153. https://api.semanticscholar.org/CorpusID:204920046

El-Wakeel M. A., Ahmed S. A., El-Desoki E. R. (2019) Allelopathic efficiency of *Eruca sativa* in controlling two weeds associated *Pisum sativum* plants. *J. Plant Protect. Res.*, 59(2), 1–7. https://doi.org/10.24425/jppr.2019.129283

El -Wakeel M. A., Ahmed S. A., Messiha N. K. (2023) Evaluation of *Ficus nitida* allelopathic potential and the most efficient application method for controlling weeds associated with sunflower plant. *Gesunde Pflanzen*, https:/doi.org/10.1007/s10343-023-00830-7

García-Robles H, Cañadas EM, Lorite J, Fernández-Ondoño E. (2022) Trade-Off between Facilitation and Interference of Allelopathic Compounds in Vegetation Recovery: The Case of Rosmarinus officinalis in Degraded Gypsum Habitats. *Plants (Basel).* 11(3), 459. doi: 10.3390/plants11030459

Han H., Baik B.K. (2008) Antioxidant activity and phenolic content of lentils (*Lens culinaris*), chickpeas (*Cicer arietinum* L.), peas (*Pisum sativum* L.) and soybeans (*Glycine max)* and their quantitative changes during processing International. *J. Food Sci. Tech*., 43,1971–1978. https://doi.org/10.1111/j.1365-2621.2008.01800.x

Jabran K ,.Mahajan G ,.Sardana V ,.Chauhan B .S) .2015 (Allelopathy for weed control in agricultural systems . *Crop Prot*,.72 ,57–65 . https://doi.org/10.1016/j.cropro. 2015.03.004

Kandil E. E., Kordy A. M., Abou Zied A. A. (2015) New approach for controlling broomrape plants in faba bean. *Alex. Sci Exchange J.*, 36(3), 282–291. DOI: 10.21608/ASEJAIQJSAE.2015.2916

Khalaf K . A., El-Masry R .R ,.Messiha N .K. (1994) The effect of soil treatment with Basamid (dazomet) on *Orobanche crenata* and *Cuscuta planiflora*. Proc. 3rd *Inter. Workshop on Orobanche and related Striga Res* .Amsterdam, pp.: 576-579.

Khanh T. D., Chung M. I., Xuan I. D., Tawata S. (2005) The exploitation of crop allelopathy in sustainable productions. *J. Agron. Crop Sci.*, 191, 172–184. https://doi.org/10.1111/j.1439-037X.2005.00172.x

Linke K. H., Saxena M. C. (1991) Study on viability and longevity of Orobanche seed under laboratory conditions, pp. 110–114. In: proceedings of International Workshop in Orobanche Research (Eds. Wegmann K and Musselman LJ), Tubingen, Germany: Eberhard- Karls- Universitat

Martinez-Ballesta M., Moreno D. A., Carvajal M. (2013) The Physiological Importance of Glucosinolates on Plant Response to Abiotic Stress in Brassica, *Int. J Mol. Sci.*, 14, 11607-11625. https://doi.org/10.3390/ijms140611607

Messiha N. K., Sharara F. A., El Gayar S. H. (2004). Effect of glyphosate, fosamine ammonium and their mixture for controlling *Orobanche crenata* in pea (*Pisum sativum* L.), J. *Agric. Sci. Mansoura Univ.* 29(7), 3979-3991.

Messiha N. K., El-Rokiek K. G., Abel Rahman S. M., El-Mary R. R., Ahmed S. A. (2023) The dual allelopathic efficiency of *Bougainvillea glabra* leaf powder on the growth and yield of *Vigna unguiculata* L. Walp. plant and the associated perennial weed *Cyperus rotundus* L., *J. Mater. Environ. Sci.*, 14(2), 161-172. http://www.jmaterenvironsci.com

Messiha N. K., El-Dabaa M. A. T., El-Masry R. R., Ahmed S. A. (2018) The allelopathic influence of *Sinapis alba* seed powder (white mustard) on the growth and yield of *Vicia faba* (faba bean) infected with *Orobanche crenata* (broomrape). *Middle East J. Appl. Sci.*, 8 (2), 418-425. http://www.curresweb.com/mejas/mejas/2018/418-425.pdf

Messiha N .K., Ahmed S A. El-Rokiek K .G ,.Dawood M .G ,.El-Masry R .R. (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 Appl. Sci. J.* (26) 9, 1142-1149, https://doi.org/10.5829/idosi.wasj.2013.26. 09.13548

Nasirullah, Krishnamurthy MN (1996) A method for estimating glucosinolates in mustard/rapeseeds and cake . *J .Food Sci .Technol*,.33) 6 ,(498-500).

Rauchberger Y ,.Mokady S ,.Cogan U. (1979) The effect of aqueous leaching of glucosinolates on the nutritive quality of rapeseed meal . *J .Sci .Food Agric* ,.30 ,31-39.https://doi.org/10.1002/jsfa.2740300107

Rehman S., Shahzad B., Bajwa A.A., Hussain S., Rehman A.; Cheema S.A.; Abbas T.; Ali A.; Shah L., Adkins S. (2018) Utilizing the allelopathic potential of Brassica species for sustainable crop production: A review. J. Plant Growth Regul. 38, 343–356. https://doi.org/10.1007/s00344-018-9798-7

Rice E. (1995) Biological control of weeds and plant diseases. Advances in Applied Allelopathy Norman, OK: University of Oklahoma Press. https://lib.ugent.be/catalog/rug01:000351620

Rubiales D., Fernandez-Aparicio M., Haddad A. (2009a) Parasitic weeds. The Lentil Botany, Production and Uses. Edited by William Erskine, Fred Muehlbauer, Ashutosh Sarker and Balram Sharma. CAB International, pp. 343–349.

Rubiales D., Fernandez-Aparicio M., Wegmann K., Joel D. M. (2009b) Revisiting strategies for reducing the seed bank of Orobanche and Phelipanche spp. *Weed Res.*, 49(1):23–33. https://doi.org/10.1111/j.1365-3180.2009.00742.x

Saudy H.S., El-Metwally I. M., Sobieh S. T., Abd Alwahed S. H. A. (2022). Mycorrhiza, charcoal, and rocket salad powder as eco-friendly methods for controlling broomrape weed in inter-planted faba bean with flax. *J. Soil. Sci. Plant Nutr.*, https://doi.org/10.1007/s42729-022-00995-6

Scavo A, Mauromicale G (2021) Crop allelopathy for sustainable weed management in agroecosystems: knowing the present with a view to the future. *Agronomy* 11, 2104. https://doi.org/10.3390/agronomy11112104

Singh H. P., Batish D. R., Kaur S., Kohli R. K. (2003) Phytotoxic interference of Ageratum conyzoides with wheat (*Triticum aestivum*). *J. Agron. Crop Sci.*, 189(5), 341–346. https://onlinelibrary.wiley.com/doi/full/10.1046/j.1439- 037X.2003.00054.x

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

Telib S. T. (2023) Using some practices for managing broomrape in faba bean. M.Sc. Thesis Fac. of Agric. Ain Shams Univ., Cairo.
Ullah R., Zubair A, Mansoor M, Qamar Z, Safdar B, Waseem H, Zhongbing C.S (2020) Sustainable Weed Control and Enhancing Nutrient Use Efficiency in Crops through Brassica (*Brassica compestris* L.) Allelopathy. Sustainability, 12, 5763; https://doi.org/10.3390/su12145763
Velasco P., Soengas P., Vilar M., Cartea M. E. (2008) Comparison of glucosinolate profiles in leaf and seed tissues of different Brassica napus crops. *J. Am. Soc. Hort. Sci.*, 133(4), 551–558. DOI:10.21273/JASHS.133.4.551
Zhang W., Wang S.Y. (2001) Antioxidant activity and phenolic compounds in selected herbs. *J. Agri. Food. Chem*., 49(11), 5165-5170. https://doi.org/10.1021/jf010697n
Zhou Y., Wang Y., Li J., Xue Y. J. (2011) Allelopathy of garlic root exudates. *Yingyong Shengtai Xuebao*., 22(5):1368–1372. https://www.ncbi.nlm.nih.gov/pubmed/21812318

(2024); http://www.jmaterenvironsci.com