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Allelopathic activity of the leaf powder of *Ficus nitida* on the growth and yield of *Vicia faba* and associated weeds

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

Abstract

Background: Faba bean weeds are considered as serious pests that lead to pronounced damages to its agricultural production since they consume water and nutrients from the soil, reducing not only the yield but also the quality of the crops. So, the aim of this investigation is to control the weeds associated with faba bean plants.

Materials/methods: Two pot experiments were carried out during two successive winter seasons of 2016/2017 and 2017/2018 in the greenhouse of the National Research Centre, Dokki, Giza, Egypt. Treatments were applied by incorporating the dry leaf powder of *Ficus nitida* to the soil surface of pots at the rate of (0, 10, 20, 30, 40, 50, and 60 g/kg soil).

Results: All concentrations used pronouncedly decreased the fresh and dry weight of both *Phalaris minor* and *Malva parviflora*. On the other hand, *Vicia faba* growth as well as its yield and yield components were increased with most concentrations used as compared to their mixed controls. Treatments of 20, 30, and 40 g/kg soil, from *F. nitida* leaf powder, respectively recorded the highest increases in the most growth characters of *V. faba* with both weeds (*P. minor* and *M. parviflora*) at the two growth ages when compared to the healthy control. Also, the best results in all *V. faba* yield components were recorded with 20 g/kg soil of *F. nitida* treatment.

Conclusion: The results of the present study indicate the possibility of using the allelopathic activity of the leaf powder of *Ficus nitida* as a selective bioherbicide for controlling annual weeds accompanied *Vicia faba* plants.

Keywords: Allelopathy, *Ficus nitida*, *Vicia faba*, *Phalaris minor*, *Malva parviflora*, Phenolic content, Flavonoids

Background

Allelopathy has beneficial or harmful effects on plants due to release of allelochemicals which are secondary metabolites, which is present in all plant tissues including leaves, stems, flowers, roots, and seeds (Manikandan and Jayakumar 2011; Mohsin et al. 2016). Allelochemicals are now being used as biopesticides, bioherbicides, and also as growth promoters. Therefore, it is another emerging area of research since most of the chemicals as biopesticides or bioherbicides are known to be specific variety of pests and weeds. The use of allelochemicals as secondary metabolites from plants for this purpose would be environmentally friendly, since natural chemicals are renewable and easily degradable (Manikandan and Jayakumar 2011).

Allelopathy is simply a natural process of inhibition or stimulation of plants by the action of allelochemicals which are produced and released to the environment by different plants (Zeng et al. 2008; Majeed et al. 2017). Moreover, the inhibition or stimulation efficiency of these allelochemicals depends on their type, concentration, and the plants which respond to these allelochemicals (Dawood et al. 2012; Majeed et al. 2012; Muhammad and Majeed 2014; El-Masry et al. 2015; Ahmed et al. 2018; El-Rokiek et al. 2018; Messiha et al. 2018).

Ficus genus contains about 850 species of woody trees, shrubs, vines, epiphytes, and hemi epiphytes in the family Moraceae. *Ficus benghalensis* L. (as an example of Ficus species) possess variety of medicinal

* Correspondence: kowtharelrokiek@gmail.com; ahmed_ezat2000@yahoo.com
Botany Department, National Research Centre, El-Buhouth St., Dokki, P.O. Box 12622, Giza, Egypt

uses. Chemically, *F. benghalensis* stem and bark contain anthocyanidin derivatives, beta-sitosterolglucoside, and mesoinsitol and aliphatic long-chain ketones (Sankar and Nair 2001; Manoj and Urmila 2008; Vishnu and Anupama 2010). In addition, leaves contain crude protein, crude fibers, calcium oxalate, phosphorus, sterols, flavonoids, phenol, tannins, and saponions in large amounts. Moreover, number of researchers observed its anti-inflammatory, anti-helminitin, anti-histaminic, immunomodulatory, anti-microbial, allelopathic, anti-diabetic, antifungal, and antibacterial activities (Manoj and Urmila 2008; Sharma et al. 2009; Taur and Patil 2009; Uma and Prabhakar 2009; Vishnu and Anupama 2010).

Vicia faba (faba bean) is one of the most important legumes in the world especially in developing countries. It is a leading source of food protein. It is also a rich source of dietary fiber, minerals, and some vitamins (Gepts et al. 2008).

On the other hand, weeds are considered a serious pest that leads to pronounced damage to agricultural production because it consumes nutrients from the soil. Thus, reduces the yield of the crops, in addition it reduces the quality and quantity of the crop (Siddiqui et al. 2009; Messiha et al. 2018).

The aim of the present investigation is to assess the allelopathic potentiality of the leaves of *Ficus nitida* (a widely and common tree in Egypt) on the growth of *Vicia faba* associated by two annual weeds *Phalaris minor* and *Malva parviflora*.

Materials and methods

Two pot experiments were carried out during two successive winter seasons of 2016/2017 and 2017/2018 in the greenhouse of the National Research Centre, Dokki, Giza, Egypt, to study the possibility of controlling two weeds, i.e., *Phalaris minor* and *Malva parviflora* growing with *Vicia faba* by using the dry leaf powder of *Ficus nitida*. *Vicia faba* seeds (var. Giza 843) were obtained from Agricultural Research Centre, Giza, Egypt. Dry leaves of *Ficus nitida* was grinded to fine powder and was immediately incorporated to the soil surface of the pots before sowing at the rate of 0, 10, 20, 30, 40, 50, and 60 g/kg soil. The pots, 30 cm in diameter and 30 cm in height, contained equal amounts of sieved soil (2: 1 *v*/*v* clay and sand). Seven seeds of *V. faba* were sown on 20th and 19th of November in the first and second seasons, respectively. The pots were infested with a constant weight from each weed, i.e., *P. minor* and *M. parviflora*. The seeds of both weeds were sown simultaneously and mixed thoroughly at a depth 2 cm in the soil. The experiment consisted of eight treatments for each weed including two untreated controls, healthy plant (weed-free faba bean), faba bean with *P. minor* or *M. parviflora* (unweeded treatment). The other six treatments were leaf powder of *Ficus nitida* at concentrations 10, 20, 30, 40, 50, and 60 g/kg soil. All pots were distributed in a complete randomized design. Faba bean seedlings were thinned 2 weeks after sowing so that three homogeneous seedlings were left per pot. Three replicates were collected from each treatment at 30 and 60 days after sowing and at harvest. The normal cultural practices of growing *V. faba* plants were followed especially fertilization and irrigation.

Weed characters studied

Three replicates were collected from each treatment at 30 and 60 days after sowing (DAS), fresh and dry weight of both *P. minor* and *M. parviflora* (g/pot) were recorded.

Vicia faba characters studied

Plant growth

Samples from *V. faba* plants were collected from each treatment at 30 and 60 (DAS) to determine plant height (cm), number of leaves/plant, number of branches/plant, as well as fresh and dry weight of plant (g).

Yield and yield components

On April 27 and 25 in the first and second season, respectively, samples from *V. faba* plants were taken at harvest from each treatment to determine the number of pods/plant, weight of pods/plant (g), length of pod (cm), number of seeds/ pod, weight of seeds/plant (g), weight of seeds/10 pods (g), and weight of 100 seeds (g).

Chemical analysis

Determination of total phenolic contents and total flavonoids in the leaf powder of F. nitida

Total phenol and total flavonoids were determined in the leaf powder of *F. nitida* according to Srisawat et al. (2010).

Statistical analysis

Data of the two seasons were subjected to analysis of variance (ANOVA) according to Gomez and Gomez (1984), using CoStat software program. The differences among means were compared using LSD test at 0.05 probability level.

Results

Weed growth characters

The results in Tables 1 and 2 showed that all concentrations used from the leaf powder of *Ficus nitida* (10 to 60 g/kg soil) significantly decreased fresh and dry weight of both weeds, i.e., *Phalaris*

Table 1 Effect of *Ficus nitida* leaf powder on fresh and dry weight of grassy leaved weed *Phalaris minor* associated with *Vicia faba* plants (average of the two seasons)

Treatments		At 30 DAS		At 60 DAS	
Plants	Concentrations of *Ficus nitida* (g/kg soil)	FW (g)	DW (g)	FW (g)	DW (g)
Phalaris minor only	–	6.45	1.36	17.26	9.40
Phalaris minor + *Vicia faba*	–	4.35	0.71	8.75	3.48
	10	3.92	0.58	6.57	2.59
	20	2.99	0.47	6.01	2.38
	30	2.51	0.45	5.53	2.21
	40	1.88	0.33	4.73	1.88
	50	1.57	0.30	4.42	1.74
	60	1.26	0.16	2.66	1.05
LSD at 5%		0.83	0.16	1.31	0.78

minor and *Malva parviflora* at both growth ages (30 and 60 DAS), except the lowest concentration (10 g/kg soil) with *P. minor* at 30 DAS, as compared to the mixed control. The rate of reduction in weed growth of both *P. minor* and *M. parviflora* depends on the concentration used. The maximum reduction in the fresh and dry weight of both weeds at both growth ages was recorded with the highest concentration (60 g/kg soil) of *F. nitida* leaf powder, that reached to 69.6 and 69.8% for *P. minor* and 79.5 and 80.3% for *M. parviflora* respectively, as compared to their corresponding control at the second growth age (60 DAS).

Vicia faba growth

The results recorded in Tables 3 and 4 illustrated that most *V. faba* growth characters, represented by plant height (cm), number of leaves/plant, number of branches/plant, as well as fresh and dry weight/plant (g), were significantly increased with all concentrations of *F. nitida* leaf powder (10 to 60 g/kg soil) as compared to their mixed control with both weeds, *P. minor* and *M. parviflora* at both growth ages (30 and 60 DAS). Treatments of 20, 30, and 40 g/kg soil, from *F. nitida* leaf powder, respectively recorded the highest increases in the most growth characters of *V. faba* with both weeds (*P. minor* and *M. parviflora*) at the two growth ages when compared to the healthy control. It is worthy to mention that the best results in most growth characters at the two growth ages with both weeds was recorded with treatment (20 g/kg soil) from *F. nitida* leaf powder as compared with healthy control. At 60 DAS, the increases in the dry weight of *V. faba* plant due to this treatment reached to 12.27 and 25.38%, respectively over the healthy control with *P. minor* and *M. parviflora* weeds.

Vicia faba yield and yield components

The results of yield and yield components, i.e., number of pods/plant, weight of pods/plant (g), length of pod (cm), number of seeds/pod, weight of seeds/plant (g), weight of seeds/10 pods (g), and weight of 100 seeds (g) recorded in Tables 5 and 6, showed

Table 2 Effect of *Ficus nitida* leaf powder on fresh and dry weight of broad leaved weed *Malva parviflora* associated with *Vicia faba* plants (average of the two seasons)

Treatments		At 30 DAS		At 60 DAS	
Plants	Concentrations of *Ficus nitida* (g/kg soil)	FW (g)	DW (g)	FW (g)	DW (g)
Malva parviflora only	–	6.25	1.05	18.45	3.11
Malva parviflora + *Vicia faba*	–	3.13	0.46	6.65	1.17
	10	2.12	0.34	4.17	0.72
	20	1.75	0.27	3.47	0.61
	30	1.56	0.24	2.65	0.45
	40	1.26	0.19	2.26	0.38
	50	0.85	0.13	2.07	0.34
	60	0.73	0.10	1.36	0.23
LSD at 5%		0.78	0.06	0.94	0.35

Table 3 Effect of *Ficus nitida* leaf powder on some growth parameters of *Vicia faba* plants associated with *Phalaris minor* at 30 and 60 days after sowing (average of the two seasons)

Treatments		Growth parameters of *Vicia faba*				
Plants	Concentrations of *Ficus nitida* (g/kg soil)	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	F.W. of plant (g)	D.W. of plant (g)
At 30 DAS						
Vicia faba only	–	33.75	10.8	1.58	8.83	1.22
Vicia faba + *Phalaris minor*	–	24.63	8.0	1.10	6.52	0.78
	10	29.38	10.4	1.40	8.39	1.06
	20	35.38	11.6	1.73	10.12	1.38
	30	34.86	11.3	1.71	9.68	1.31
	40	34.29	11.0	1.62	8.94	1.26
	50	28.88	10.2	1.27	8.35	1.04
	60	27.25	9.6	1.15	8.01	0.99
LSD at 5%		1.43	0.91	0.20	1.12	0.14
At 60 DAS						
Vicia faba only	–	59.15	19.52	2.03	22.65	5.95
Vicia faba + *Phalaris minor*	–	37.17	15.20	1.38	12.28	3.32
	10	52.80	18.00	1.90	20.27	5.23
	20	63.75	20.33	2.33	24.97	6.68
	30	63.25	20.00	2.24	23.83	6.36
	40	61.28	19.67	2.07	22.74	5.99
	50	50.81	16.92	1.83	19.65	5.16
	60	45.20	15.87	1.67	18.04	4.76
LSD at 5%		1.69	1.45	0.18	1.52	0.86

that all applied treatments used of *F. nitida* leaf powder (from10 to 60 g/kg soil) significantly increased all yield parameters of *V. faba*, except the highest concentration (60 g/kg soil), as compared to their mixed control with both weeds, *P. minor* and *M. parviflora*. The best results in all *V. faba* yield components were recorded with 20 g/kg soil of *F. nitida* treatment. Not only this treatment alleviated the harmful effect of both weeds (*P. minor* and *M. parviflora*) but also significantly increased all plant yield parameters over the corresponding healthy control. The maximum increases in the weight of seeds/plant (g) and weight of seeds/10 pods (g) of *V. faba* associated with *P. minor* weed reached to 41.28 and 36.0%, respectively, while with *M. parviflora* weed reached to 48.16 and 50.40%, respectively over the corresponding healthy control. Treatments with 30 and 40 g/kg soil from *F. nitida* leaf powder also achieved good results with all *V. faba* yield components, associated with both weeds, equal or exceed than the corresponding healthy control in some yield components.

Therefore, it could be concluded *that F. nitida* leaf powder at (20, 30, and 40 g/kg soil) incorporated to the soil caused moderate reduction in the growth of both weeds (*P. minor* and *M. parviflora*) as shown in Tables 1 and 2 and consequently accompanied by the maximum increases in *V. faba* growth as well as yield and yield components (Tables 3, 4, 5, and 6).

Discussion

Our previous work at the Botany department of the National Research Centre of Egypt showed clearly that using the dry leaves and seeds powder of some allelopathic plants achieved good results in controlling some annual, perennial, as well as parasitic weeds associated different economic crops and could improve their growth as well as yield (El-Masry et al. 2015; Ahmed et al. 2018; Messiha et al. 2018).

The results of the present investigation reveal that *Ficus nitida* leaf powder possess to great extent allelopathic effect in controlling the growth of the two annual weeds *Phalaris minor* and *Malva parviflora* associating *Vicia faba* plants when added to the soil. The rate of reduction in the fresh and dry weight of both weeds at the two ages increased by increasing the *F. nitida* leaf powder concentration. Maximum

Table 4 Effect of *Ficus nitida* leaf powder on some growth parameters of *Vicia faba* plants associated with *Malva parviflora* at 30 and 60 days after sowing (average of the two seasons)

Treatments		Growth parameters of *Vicia faba*				
Plants	Concentrations of *Ficus nitida* (g/kg soil)	Plant height (cm)	No. of leaves/plant	No. of branches/plant	F.W. of plant (g)	D.W. of plant (g)
At 30 DAS						
Vicia faba only	–	33.75	10.8	1.58	8.83	1.22
Vicia faba + *Malva parviflora*	–	26.83	8.6	1.10	6.86	0.81
	10	30.75	10.5	1.45	8.48	1.08
	20	37.67	12.5	2.03	12.18	1.62
	30	37.33	11.9	1.87	10.51	1.43
	40	34.64	11.1	1.70	9.26	1.29
	50	33.57	10.6	1.53	8.54	1.10
	60	28.19	10.2	1.25	8.33	1.01
LSD at 5%		1.49	1.1	0.18	1.21	0.14
At 60 DAS						
Vicia faba only	–	59.15	19.52	2.03	22.65	5.95
Vicia faba + *Malva parviflora*	–	39.32	15.35	1.57	15.31	3.91
	10	55.63	18.33	1.92	21.44	5.63
	20	67.82	22.40	2.60	27.98	7.46
	30	67.43	20.67	2.35	26.95	7.18
	40	62.25	19.80	2.18	23.24	6.13
	50	56.84	18.83	2.00	21.52	5.67
	60	49.22	16.03	1.73	18.55	4.89
LSD at 5%		1.93	1.66	0.19	1.74	0.79

reduction recorded with the highest *F. nitida* leaf powder concentration (60 g/kg soil) reached to 69.8 and 80.3% respectively in the dry weight of *P. minor* and *M. parviflora* at 60 DAS as compared to their mixed control (Tables 1 and 2). These results are in agreement with the results reported by Manikandan and Jayakumar (2011); they showed the inhibitory effect of the methanolic leaf and bark extracts of *F. bengalensis* on seed germination, shoot and root length, as well as the biomass weight in *Ipomoea pentaphylla* seedling. They concluded that the inhibitory effect on weed species is directly proportional to increase the concentration used and this may be due to the presence of methanolic soluble allelochemicals

Table 5 Effect of *Ficus nitida* leaf powder on yield components of *Vicia faba* plants associated with *Phalaris minor* at harvest (average of the two seasons)

Treatments		Yield components of *Vicia faba*						
Plants	Concentrations of *Ficus nitida* (g/kg soil)	No. of pods/plant	Wt. of pods/plant (g)	Length of pod (cm)	No. of seeds/pod	Wt. of seeds/plant (g)	Wt. of seeds/10 pods (g)	Wt. of 100 seeds (g)
Vicia faba only	–	6.8	12.16	8.70	3.71	10.32	24.16	74.15
Vicia faba + *Phalaris minor*	–	3.5	6.69	4.70	1.92	5.15	9.24	62.18
	10	6.1	10.97	7.40	3.15	9.45	19.41	71.36
	20	7.7	17.47	10.90	4.21	14.58	32.86	82.27
	30	7.4	15.26	10.60	4.00	12.81	29.16	78.54
	40	7.0	12.81	10.00	3.74	10.46	27.22	74.98
	50	5.8	9.57	6.20	2.81	8.19	17.56	69.75
	60	4.7	7.88	5.80	2.43	6.11	12.23	68.96
LSD at 5%		0.87	1.61	0.97	0.80	1.71	1.70	2.20

Table 6 Effect of *Ficus nitida* leaf powder on yield components of *Vicia faba* plants associated with *Malva parviflora* at harvest (average of the two seasons)

Treatments		Yield components of *Vicia faba*						
Plants	Concentrations of *Ficus nitida* (g/kg soil)	No. of pods/plant	Wt. of pods/plant (g)	Length of pod (cm)	No. of seeds/pod	Wt. of seeds/plant (g)	Wt. of seeds/10 pods (g)	Wt. of 100 seeds (g)
Vicia faba only	–	6.8	12.16	8.70	3.71	10.32	24.16	74.15
Vicia faba + *Malva parviflora*	–	4.0	7.02	5.0	2.00	5.45	10.54	63.24
	10	6.4	11.26	7.7	3.40	9.64	19.62	71.79
	20	9.7	18.23	11.5	4.66	15.29	36.34	83.72
	30	8.3	17.85	11.2	4.32	14.87	35.02	83.16
	40	7.2	13.94	10.2	3.80	11.52	27.68	76.51
	50	6.6	11.47	8.0	3.62	9.93	22.08	72.64
	60	4.9	8.52	6.0	2.75	7.06	13.22	69.25
LSD at 5%		1.0	1.29	1.2	0.97	1.16	1.92	2.06

like phenolic acids. Analysis of the dry leaf extract of *F. nitida* in the present study revealed the presence of total phenolic acids content (53.90 mg/100 g dry weight) and total flavonoids (18.83 mg/100 g dry weight). The reducing effect of *F. nitida* leaf powder on the growth of both weeds, i.e., *P. minor* and *M. parviflora*, could be attributed to these natural allelochemicals. These results were confirmed by El-Rokiek et al. (2016). Another confirming results were found also by some researcher that leaves and bark extracts of *F. bengalensis* have different allelopathic effect on seed germination percentage and early seedling growth parameters of some economic crop plants as maize (*Zea mays*), mung bean (*Vigna radiata*), and sunflower (*Helianthus annuus*), and these allelopathic effects are due to their allelochemicals mainly the total phenolic acids content that proportion to the concentration (Mohsin et al. 2016; Muhammad et al. 2018).

The results of the present study confirm this idea and reveal that different treatments of *F. nitida* leaf powder not only achieved good results in controlling the two annual weeds, i.e., *P. minor* and *M. parviflora*, but also increased *V. faba* growth and consequently improved its yield and yield components (Tables 3, 4, 5, and 6) especially at 20, 30, and 40 g/kg soil concentrations. It is worthy to mention that improving the plant growth and consequently increasing its yield is not only due to the inhibition of weeds growth by chemical or biological means, that lead to increase the competitive ability of the plant, but also due to the selectivity of the allelochemicals in their action and the plant in their responses (Einhellig 1995). Allelochemicals which inhibit the growth of same or different species at certain concentration may stimulate the growth of same or different species at different concentrations (Ahmed et al. 2014; Bashen 2014; El-Masry et al. 2015; Messiha et al. 2018).

Conclusion

The results of the present work indicate the possibility of using allelopathic activity of *F. nitida* leaves powder as selective bioherbicide in controlling weeds.

Abbreviations

DAS: Days after sowing; DW: Dry weight; *F. nitida*: *Ficus nitida*; FW: Fresh weight; *V. faba*: *Vicia faba*; Wt.: Weight; var.: Variety

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Availability of data and materials

All data supporting the results are included within the article.

Authors' contributions

All authors have contributed significantly to the idea and design of the study. All authors contributed equally in all parts of this study. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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