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Assessment of the Allelopathic Effect of Sweet and Bitter Lupine Seed Powder on Controlling Canarygrass Associated Faba Bean

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ABSTRACT

The aim of this work is to study the allelopathic effects of incorporation of the seed powder of sweet and bitter lupine on the growth of canarygrass (*Phalaris minor*) associated faba bean (*Vicia faba* L.). For this purpose, the experiments were conducted in the greenhouse of the National Research Centre, Giza, Egypt in the two winter successive seasons, 2017/2018 and 2018/2019. The seed powder of sweet and bitter lupine was incorporated to the soil surface at rates of 5, 10, 15, 20 and 25g/kg soil. The results indicated reduction in canarygrass growth by both sweet and bitter lupine. Weed growth inhibition increased by increasing the concentration of the two seed powder. The highest rate of bitter or sweet lupine seed powder at 25g/kg soil gave the highest growth inhibition which controlled more than 80 and 60% of canarygrass. Weed growth suppression of canarygrass was associated with increasing in faba bean growth. The results also revealed increasing in number of pods/plant, weight of pods / plant, weight of seeds / plant and weight of 100 seeds that represented yield and yield components of faba bean. The results suggested that sweet and bitter lupine could be alternated chemical herbicides in controlling canarygrass.

Keywords: faba bean, sweet lupine, bitter lupine, Allelopathy, Canarygrass

1. Introduction

Faba bean (*Vicia faba* L.) is considered as an important source of protein in the Egyptian food. Weed competition reduced faba bean yield by more than 40% (El-Rokiek *et al*., 2015). So, controlling weeds in faba bean as well as other crops is a strategy for increasing crop yield and quality (Singh and Jolly, 2004).

Weeds are important problems in agricultural production systems (Oerke, 2006) because they compete for the available resources that are fundamental for plant growth as water, light and nutrient uptake (Korav *et al*., 2018). The extensive use of herbicides for controlling weeds resulted in environmental pollution and moreover herbicide resistant weed species (Khanh *et al*., 2005; Mortensen *et al*., 2012). Consequently, approaches to use better weed management methods must be developed to overcome the problems of resistant weeds as well as environmental pollution (Duke *et al*., 2002). One of these methods is the allelopathic activity at which allelopathic plants suppress the growth of other plants (Jabran *et al*., 2015). Allelopathic plants can suppress weed growth by the release of allelochemicals through decomposition of different plant residues, shoots, roots and or seeds (Khanh *et al*., 2005; El-Rokiek and El-Nagdi, 2011; Ahmed *et al*., 2018). Generally, growth inhibition of certain weeds by allelopathic plants and their residues is well documented by several workers (Xuan *et al*., 2004; Kumar *et al.,* 2006; Hernández-Aro *et al*., 2016). Recent studies have provided evidence that allelochemicals are found in all parts of the lupine plant in leaves, stems, flowers, seeds and roots (Ferreira *et al*., 2018). Very strong suppression of lettuce seedling growth, especially the roots, was observed with the high concentrations of the bitter lupine seed (Stobiecki *et*

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al., 1993). In field experiment it was reported that plots planted with lupine reduced ryegrass weed type as well as total grass weeds (Ferreira and Reinhardt, 2010). The authors added that lupine seed leachate had strong inhibitory effects on cumulative germination of canola which was reduced by 65% compared to the control. Also, radicle length of canola, lucerne (alfalfa) and ryegrass was significantly reduced by lupine compared to the control (Ferreira *et al*., 2018). Several documented results were reported on the allelopathic effect of legume plants, as for example, aqueous extracts of both fresh and dried material of different varieties of alfalfa plants significantly inhibited both germination and growth of lettuce (*Lactuca sativa* L.). Leachates from germinating seeds of different alfalfa varieties inhibited elongation of the radicle (Xuan and Suzuki, 2002).

Objective

The objective of this work is to study the allelopathic potentiality of lupine species (bitter and sweet) on the growth and yield of faba bean as well as canarygrass weed.

2. Materials and Methods

Two pot experiments were carried out during two successive seasons of (2017/2018) and (2018/2019) in the greenhouse of the National Research Centre, Dokki, Giza, Egypt. Faba bean (*Vicia faba*) cv. Giza 3 seeds as well as bitter and sweet lupine (*Lupinus albus*) seeds and canarygrass seeds were obtained from Agriculture Research Centre, Giza, Egypt. Clean seeds of lupine were grinded to fine powder then the powder was immediately incorporated in the soil surface before sowing faba bean seeds at rates of 0, 5, 10, 15, 20 and 25g/kg soil. In the same time, the seeds of faba bean, *Phalaris minor* were sown 2cm deep in plastic pots filled with 2kg soil. The experiment consisted of 13 treatments including free plants from weeds (control); each treatment consisted of 9 replicates. All pots were distributed in a complete randomized block design. The normal cultural practices of growing faba bean plants were followed especially fertilization and irrigation.

2.1 Characters studied

2.1.1. Weeds

Three replicates samples were collected from each treatment at 40 days after sowing (DAS) and at harvest. Both fresh and dry weight of the weed were recorded (g/pot) at the two growth ages.

2.1.2 Faba bean plants

2.1.2.1 Plant growth

Samples of faba bean plants at 40 and 95 DAS were collected from each treatment to determine: plant height (cm), number of leaves/plant, fresh weight and dry weight of plant (g).

2.1.2.2 Yield and yield components

At harvest, samples of faba bean plants were taken from each treatment to determine: Number of pods/plant, number of seeds/pod, weight of dry pods/plant (g), weight of seeds/plant (g) and weight of 100 seeds (g).

2.2. Chemical analysis

Determination of total phenols, total flavonoids and total alkaloids contents in the seed powder of sweet and bitter lupine

Total phenols and total flavonoids were determined in sweet and bitter lupines seed powder according to Srisawat *et al.,* (2010).

The total alkaloids content was determined in sweet and bitter lupines seed powder according to Harborne (2005).

2.3. Statistical analysis

All data were statistically analyzed according to Snedecor and Cochran (1980) and the treatments were compared by using LSD at 5% probability.

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3. Results

3.1. Weed growth

The results in Table (1) showed that all the rates used (5 to25g/kg soil) of sweet lupine seed powder (SLSP) or bitter lupine seed powder (BLSP) significantly reduced both fresh and dry weight of the canarygrass (*Phalaris minor*) at the two growth ages (40 DAS and harvest) as compared to mixed pots. In general, BLSP showed more activity against canarygrass than SLSP in comparison to the untreated pots (control). The reduction in the growth of canarygrass was rate dependent. The canarygrass dry weight in the pots treated with the highest rate of BLSP at 25g attained maximum significant reduction as compared to the untreated pots which reached to 78.57 at 40 DAS. Whearas, the reduction in the same parameter due to the previous treatment reached to 82.63 at harvest as compared to the mixed control. Weed growth was persisting during the experimental period.

Table 1: Fresh and dry weight of canarygrass associated faba bean growth as affected by bitter and sweet lupine seed powder (Average of the two seasons).

Treatments		Rate (g/Kg soil)	At 40 DAS		At harvest	
			F.W. (g/pot)	D.W. (g/pot)	F.W. (g/pot)	D.W. (g/pot)
Canarygrass alone		0	13.10	3.800	48.66	9.233
Faba bean alone		0	---	---	---	---
Canarygrass + Faba bean		0	11.25	3.15	29.00	7.100
	Sweet lupine	5	9.95	2.00	28.65	4.266
		10	8.90	1.850	22.16	4.067
		15	8.40	1.750	16.60	2.933
		20	7.3	1.15	15.45	2.467
		25	6.25	0.850	11.90	2.83
	Bitter lupine	5	8.95	1.800	26.33	5.000
		10	7.10	1.650	19.6	3.900
		15	6.3	1.300	15.35	2.800
		20	5.08	0.90	13.86	1.933
		25	4.55	0.675	9.04	1.233
LSD at 5%			0.70	0.437	1.56	0.613

3.2. Faba bean growth

The results in Table (2) illustrated that most growth characters of faba bean were significantly increased with all treatments of either SLSP or BLSP over the unweeded control after 40 DAS. The highest values in the growth characters of faba bean were recorded with treatments of BLSP at 25g as compared to other treatments. Table (3) cleared that the treatments used significantly increased all growth characters of faba bean at 95 DAS as compared to the mixed control. It is worthy to mention that BLSP showed more activity with faba bean plants than SLSP in comparison to the untreated pots (control). The increase in the growth of faba bean parameters was rate dependent. Treatments of BLSP at 25g/kg soil showed the highest values of different growth characteristics of faba bean at 95 DAS, followed by faba bean alone as compared to other treatments. These treatments increased dry weight of plant by 100.03, 70.88%, compared to untreated pots. On the contrary, mixed control recorded the lowest values of all growth characters of faba bean plants at the two ages of growth.

Table 2: Different growth character of faba bean at 40 days after sowing as affected by bitter and sweet lupine seed powder (Average of the two seasons).

Treatments		Rate (g/Kg soil)	Plant height (cm)	No. of branches/plant	No. of leaves/ plant	F.W./plant (g)	D.W./plant (g)
Faba bean alone		0	37.33	2.00	15.33	19.83	2.360
Canarygrass alone		0	---	---	---	---	---
Faba bean + Canarygrass	**Sweet lupine**	0	32.00	1.33	11.00	12.50	1.070
		5	33.50	1.66	12.00	13.15	1.100
		10	35.00	2.33	14.00	14.75	1.210
		15	35.50	2.33	15.00	16.86	1.638
		20	37.00	2.66	16.33	18.06	1.930
		25	40.33	2.66	12.00	20.40	2.350
	Bitter lupine	5	37.33	1.66	12.66	14.65	1.200
		10	36.33	2.00	13.00	15.53	1.516
		15	39.33	2.33	16.33	17.50	1.790
		20	40.00	2.33	16.33	19.16	2.316
		25	44.16	2.66	18.43	21.37	2.853
LSD at 5%			2.60	0.61	0.81	1.29	0.605

Table 3: Different growth character of faba bean at 95 days after sowing as affected by bitter and sweet lupine seed powder (Average of the two seasons).

Treatments		Rate (g/Kg soil)	Plant height (cm)	No. of branches/plant	No. of leaves/ plant	F.W./plant (g)	D.W./plant (g)
Faba bean alone		0	71.66	3.33	27.00	71.27	6.550
Canarygrass alone		0	---	---	---	---	---
Faba bean + Canarygrass		0	52.00	2.33	19.00	50.16	3.833
	Sweet lupine	5	55.00	2.66	21.00	54.33	4.323
		10	59.00	2.66	22.33	60.16	4.900
		15	64.66	3.00	25.66	63.5	5.350
		20	69.66	3.00	27.00	64.86	5.750
		25	74.00	3.00	27.50	67.26	6.416
	Bitter lupine	5	59.33	2.66	22.66	55.36	4.660
		10	66.00	3.00	25.00	62.50	5.175
		15	67.66	3.33	27.00	65.50	5.623
		20	72.16	3.33	29.00	66.33	5.876
		25	77.00	3.66	29.33	76.00	7.667
LSD at 5%			2.44	0.47	1.35	2.34	0.707

3.3. Faba bean yield

Yield and yield components represented by number of pods/plant, number of seeds/pod, weight of dry pods/plant, weight of seeds/plant (yield/plant) as well as weight of 100 seeds were significantly enhanced by SLSP or BLSP at all rates (5 to 25g/kg soil). The results in Table (4) showed that all applied treatments significantly increased all yield and yield components of faba bean plants except SLSP or BLSP at the lowest rate (5g/kg soil) as compared to the mixed control. Treatments of BLSP at 25g, SLSP at 25g, BLSP at 20g/kg soil and faba bean alone recorded the highest values of all yield and yield components as compared to other treatments. The previous treatments increased weight of seed/plant to about 90.00, 72.13, 69.84 and 55.41%, respectively. The weight of 100 seeds increased to about 69.33, 64.88, 61.06 and 56.81% by BLSP and SLSP 25g/kg soil, faba bean only and BLSP at 20g/kg soil, respectively comparing with untreated plants. However, there is no significant difference between the treatments of BLSP at 20 and 25 g/kg soil as well as at 25g/kg soil of SLSP in both number of pods/plant and number of seeds/pod. On the other side, untreated pots gave the lowest values of yield and yield components of faba bean.

It is worthy to mention that the use of bitter lupine seed powder (BLSP) at different rates led to better results in growth, yield and yield components of faba bean plants than the effect of sweet lupine seed powder (SLSP).

Table 4: Yield and yield components of faba bean as affected by bitter and sweet lupine seed powder (Average of the two seasons).

Treatments		Rate (g/Kg soil)	No of pods/ plant	No. of seeds/pod	Wt. of Dry pods/plant (g)	Wt. of seeds/plant (g)	Wt. of 100 seeds(g)
Faba bean alone		0	7.66	3.66	19.87	9.48	85.44
Canarygrass alone		0	---	---	---	---	---
Faba bean + Canarygrass	**Sweet lupine**	0	3.66	2.33	9.56	6.10	53.05
		5	5.33	2.73	10.32	6.21	68.28
		10	6.66	3.00	11.67	7.03	75.83
		15	7.66	3.33	13.27	7.50	76.12
		20	8.33	3.33	18.35	9.03	81.25
		25	8.33	3.66	23.25	10.50	87.47
	Bitter lupine	5	6.33	3.00	11.06	6.29	71.09
		10	6.66	3.33	11.92	7.44	77.66
		15	8.00	3.66	15.92	8.46	80.61
		20	8.33	4.00	21.73	10.36	83.19
		25	8.66	4.33	24.54	11.59	89.83
LSD at 5%			0.79	0.60	1.19	0.76	3.39

3.4. Total phenols, flavonoids and alkaloids in lupine seed powder

The results in Table (5) show that the content of both phenolic and flavonoids compounds in BLSP were higher than their correspondence in SLSP. It is worthy to mention that the total alkaloids in BLSP were many folds than that in SLSP.

Table 5: Total phenols and flavonoids, and alkaloids in both sweet and bitter seeds of lupines

Lupine seeds	Total phenols as mg/100g dry weight	Total flavonoids as mg /100g dry weight	Total alkaloids mg/g dry weight
Sweet	129.36	29.04	0.648
Bitter	170.44	40.94	20.700

4. Discussion

The persistent use of herbicides in crop fields has created shifts in weed populations and the evolvement of severe herbicide resistance. So, there is interest in the exploitation of allelopathic activity as it is possible to use it in weed management agriculture (Kong *et al.,* 2008).

The results of the present study illustrated that the activity of the added materials had high strong inhibitory action on the canarygrass *P. minor* (Table 1). The results revealed that the highest concentration of BLSP or SLSP controlled more than 80 and 60 % of this grass weed. In general, these results are in consistent with a field assessment by Ferreira and Reinhardt (2010). Similar results also in laboratory experiment were documented by Ferreira *et al.,* (2018). It was reported that crop allelopathy controls weeds by releasing of allelochemicals from intact roots of living plants and/or through decomposition of allelopathic plant residues (Khanh *et al*., 2005; Batish *et al*., 2006). In addition, several documented results were reported on the allelopathic effect of legumes (Yasmin *et al*., 1999; Xuan *et al*., 2003; Yan and Yang, 2008). In this connection, Stobiecki *et al.,* (1993) reported very strong suppression of seedling growth, especially the roots for higher concentrations of the lupine seed. The authors isolated the phenolic acids, including hydroxybenzoic and 4-hydroxycinnamic acids and their derivatives, such as 6, 7-dihydroxycoumarin and 1,2-dihydroxybenzene, from bitter lupine seeds and attributed the strong inhibition of lettuce seedlings to these phenolic acids. The analysis of the seed powder of SLSP or BLSP revealed the presence of phenolic compounds in both extracts, flavonoids and alkaloids (Table 5). These results are in agreements with that documented by several workers (Kwee and Niemeyer, 2011; Roby *et al*., 2013; El-Rokiek *et al*., 2018). The results also revealed the contents of phenolic compounds and flavonoids in the BLSP extract were higher than their correspondence in SLSP that may be explained the excess inhibition by BLSP.

In addition, the results in Table 5 reveal many folds of total alkaloids higher than their correspondence in SLSP. In accordance to these results, the extra growth suppression of canarygrass may be attributed to these allelochemical compounds. Alkaloids are a large group of natural products that contain at least one basic nitrogen atom. Mao *et al.,* (2006) reported possible links between allelochemicals, e. g. phenolic compounds, flavonoids and alkaloids in the Crude extracts of *Astragalus mongholicus* and germination, growth inhibition of wheat. Previous studies suggested that the presence of allelopathic phytochemicals e.g. phenolic compounds, flavonoids and alkaloids in the extracts of four medicinal plants *Ageratum conyzoides*, *Eclipta prostrata*, *Cannabis sativa* and *Woodfordia fructicosa* were responsible for the inhibitory effect on seed germination and seedling growth of *Triticum aestivum* (wheat) and *Pisum sativum* (Sharma and Devkota, 2014). Furthermore, it is assumed that lupine alkaloids are potential compounds of plant-plant allelopathy; Wink (1983) reported that lupine alkaloids inhibited germination of lettuce by 20, 45 and 100% according to the type. Sarmentine, a nitrogen-containing natural product isolated from the fruit of Piper species. Moreover, it was found that phytotoxicity of sarmentine isolated from dry long pepper (*Piper longum* L.) possessed broad-spectrum herbicidal activity against variety of seedlings of field crops and weeds (Huang *et al*., 2010). Accordinly, it was concluded that sarmentine inhibits growth of pigweed (*Amaranthus retroflexus* L.), barnyard grass (*Echinochloa crus-galli* L.), bindweed (*Convolvulus arvensis* L.), crabgrass (*Digitaria san-guinalis* L.), dandelion *(Taraxacum officinale* F.), lambsquarter (*Chenopodium album* L.), annual bluegrass (*Poa annua* L.), wild mustard (*Brassica kaber* L.), black nightshade (*Solanum nigrum* L.), curly dock (*Rumex crispus* L.) and horseweed (*Conyza canadensis* L.). Some of the symptoms observed in these weeds included bent stems, closed leaves and tiny black spots. These symptoms are visible between 1 and 2 h after exposure (Dayan *et al*., 2015).

The current results indicated that canarygrass growth inhibition (Table 1) by SLSP or BLSP was accompanied by growth enhancement of faba bean as well as increase in yield and yield components (Tables 2, 3 and 4). Controlling weeds decreased the competition of weeds against the crop plants and consequently greater increase in growth and yield in comparison to unweeded plants. These results were confirmed by several workers (Ahmed *et al*., 2018, El-Rokiek *et al*., 2016 & 2018; El-Masry *et al*., 2019a).

In this connection, it is worthy to mention that improving the plant growth and consequently increasing its yield and yield components is not only due to controlling the weed growth by chemical or biological means but also due to the selectivity of the allelochemicals in their action and the plants in their responses (Einhellig, 1995). Allelochemicals which inhibit the growth of some species at certain concentration may stimulate the growth of some or different species at different concentrations (Ahmed *et al*., 2012 & 2014; Messiha *et al*., 2013 & 2018; Bashen, 2014 and El-Masry *et al*., 2015 & 2019b)

5. Conclusion

The present work indicates the possibility of using allelopathic activity of sweet and bitter lupine seed powder as a selective bioherbicide in controlling canarygrass associated faba bean.

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