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PHYTOTOXICITY OF *SILYBUM MARIANUM* GAERTN., ON WHEAT

S.M. CHAGHTAI, ABDUS SADIQ AND JEHANDAR SHAH

Department of Botany,
Islamia College, University of Peshawar, Peshawar.

Abstract

Allelopathic effect of *Silybum marianum* Gaertn., was studied in laboratory and field experiments. The aqueous extracts from different plant parts significantly inhibited seed germination and radicle growth of *Triticum aestivum* L. cv. Blue Silver. The toxicity varied from part to part and was related to concentration, soaking duration and the freshness of the plant material assayed. Stem exudates were highly toxic followed by leaves, inflorescence and the roots. Leachates from fruit and fruit parts did not show toxicity. Interference test confirmed the capability of weeds in retarding the growth of wheat in mixed roots cultures. In field, decomposing litter from *S. marianum* showed significant reduction of height, length of 3 top internodes, length of earhead, dry biomass and number of grains per earhead of wheat.

Introduction

Weeds which compete with crop plants for nutrients and environmental variables are also known to change the soil environment by releasing chemicals toxic to the germination and growth of crop plants but sometimes impair their own growth (Rice, 1974). After the death, the decomposing litter of weeds adds toxins to the soil which inhibits the growth of the crop in the following years. Root leachates from weeds have long been reported to inhibit the growth of crops in the field. The allelopathic potential of several weeds has been studied in laboratory as well as under field conditions (Chaghtai *et al.*, 1985, 1986, 1987; Masood-ur-Rahman, 1987). The present report describes the phytotoxicity of *Silybum marianum* commonly known as 'Milk Thistle' an annual, erect, glabrous and stout plant, 30-100 cm high. *S. marianum* is a very common and truculent weed of wheat fields in Pakistan. Besides young leaves are used as salad the leaf stalks are palatable and nutritious, and the fruits are accredited with medicinal properties (Ikram *et al.*, 1984).

Materials and Methods

Relative Toxicity of Plant Parts: Aqueous extracts were prepared by soaking separately 5 g and 10 g portions of crushed fresh and dried roots, stem, leaves, inflorescence and the whole plant in 100 ml double distilled cold water for 48 and 72h at 26°C. Toxicity of the filterate was tested against *Triticum aestivum* L. cv. Blue Silver, in standard filter paper bioassay following Khan (1982) and Shaukat *et al.*, (1985). There were 5 replicates of each treatment. Petri dish containing 5 seeds per dish were incubated for 48 h at 26°C (± 2.0) in complete darkness. Germination and the growth of the radicle were recorded.

Fruit and Embryo Extract Bioassay: Five g of crushed fruits of *S. marianum*, pericarp and testa and embryo each were separately soaked in 100 ml of distilled water for 48 and 72 h. The filterate was used in filter paper bioassay against wheat following Shaukat *et al.*, (1985).

Interference Test: Roots of the test and the interacting species were separated by polythene sheet partitions in earthen pots of 18 x 20 cm filled with an equal volume of garden loam and one half of the pot contained 5 plants of wheat whereas other half had 5 plants of *S. marianum*. In mixed roots treatment, each pot contained 5 plants of test species intermixed with 5 plants of interacting species. Pots containing wheat plants served as control. There were 5 replicates of each treatment. Seedlings were raised from seeds and later thinned out to the desired number. Pots were watered regularly and nutrient deficiency avoided by adding Hoagland's solution. Observations were recorded after 15 weeks growth.

Litter Toxicity: To ascertain toxic potential of decomposing litter, 100 g dried and crushed stem was spread over garden loam soil in 2 x 1 m field plots and the surface was covered by a thin layer of soil. Six months later, wheat cv. Blue Silver was sown in 13 rows with 13 seeds in each row keeping a distance of 15 cm between rows and 7.5 cm between seeds. A nearby plot, having no stem of *S. marianum*, served as control. Treatment had 5 replications. At the end of the growing season the plots were watered and plants pulled out. Observations on different parameters were recorded.

All the results were analysed statistically by employing 't' test.

Results and Discussion

Relative Toxicity of Plant Parts: In filter paper bioassay, aqueous extracts from *S. marianum* inhibited germination and growth of the radicle of wheat suggesting the presence of water-soluble toxins in different plant parts (Table 1). The toxicity of the leachate was related to plant part assayed, freshness of material, concentration and the soaking period. Growth retarded in all the treatments except where extract from fresh root was used. Root exudates in low concentration and shorter soaking period increased the growth of radicle. (Naqvi & Muller, 1975; Rice, 1974; Shaukat *et al.*, 1985). Toxicity effect was not the same on germination and growth. Germination was retarded in some treatments significantly but the adverse effect was more pronounced on radicle growth in all concentrations and soaking periods. The extracts from dried leaves affected germination and growth equally, otherwise the inhibitory effect on germination and radicle growth was selective and not uniform (Ahmed *et al.*, 1984; Hussain *et al.*, 1984; Chaghtai *et al.*, 1986). Germination was greatly affected where leaf extract was used with maximum retardation of radicle growth in stem extracts. Similarly exudates from various plant parts retarded

Table 1. Effect of aqueous extracts from various parts of *Silybum marianum* on germination and radicle growth of wheat. Data is expressed as % of control; figures in parentheses represent % germination.

Plant Part	Concentration (g/100 ml water)	FRESH Soaking Hours		DRY Soaking Hours	
		48	72	48	72
Roots	5	109. 6 (100.0)	91.5 (100.0)	28.6+ (93.3)	40.9+ (93.3)
	10	60.2+ (100.0)	78.7 (100.0)	16.4+ (100.0)	31.4+ (93.3)
Stem	5	62.5+ (100.0)	78.8 (100.0)	10.7+ (86.6)	39.2+ (80.0)
	10	69.5* (100.0)	84.4 (100.0)	3.4+ (80.0)	8.8+ (80.0)
Leaves	5	77.9 (100.0)	85.9 (100.0)	10.8+ (46.6)+	27.0+ (86.6)
	10	63.8+ (93.3)	59.4+ (93.3)	7.0+ (20.0)+	10.8+ (6.6)+
Inflorescence	5	45.9+ (100.0)	48.3+ (100.0)	26.5+ (86.6)	41.2+ (100.0)
	10	24.3+ (93.3)	31.0+ (93.3)	13.8+ (66.6)	32.9+ (86.6)
Whole Plant	5	70.0+ (100.0)	76.7* (100.0)	38.8+ (100.0)	39.6+ (93.3)
	10	44.4+ (100.0)	49.8+ (100.0)	7.1+ (46.6)+	18.2+ (73.3)

+, significant at p = 0.01; *, significant at p = 0.05

growth of radicle significantly, whereas germination was either not affected or in certain cases was enhanced (Hussain *et al.*, 1979; Shaukat *et al.*, 1985; Chaghtai *et al.*, 1986).

Leachates from dried plant material were relatively more toxic than those from fresh parts. Similar observations have been made by Hussain *et al.*, (1984) and Chaghtai *et al.*, (1985, 1987). The growth inhibiting substances in fresh material were in a low concentration and thus failed to exhibit toxicity. During drying, the concentration of toxic substances increases to produce toxicity. There are also reports when extracts from fresh plant material were more harmful than those from dry parts (Bokhari, 1978; Khanum *et al.*, 1979).

Toxicity increased with concentration (Dirvi & Hussain, 1979; Khanum *et al.*, 1979; Chaghtai *et al.*, 1987). Shorter soaking periods produced more toxicity which is contrary to the findings of others (Dirvi & Hussain, 1979; Hussain *et al.*, 1985; Chaghtai *et al.*, 1986). In longer soaking periods, the inhibitory effect of phytotoxins was considerably reduced probably by the loss of some fraction of volatile and chemically unstable toxic substances (McPherson *et al.*, 1971; Friedman *et al.*, 1977). However, in another study mixed trend was noticed with regard to toxicity and soaking periods and it also varied in different plant parts (Chaghtai *et al.*, 1985).

In the present study, highest toxicity was induced by stem exudates followed by leaves, inflorescence, whole plant and roots as also observed by Chaghtai *et al.*, (1985) and Shaukat *et al.*, (1985). However, it is contrary to certain reports where roots and/or leaf extracts showed maximum inhibition (Rovira, 1969; Chaghtai *et al.*, 1986). Highest inhibition of radicle growth occurred in dried stem extracts in 10 g fraction and 48 h soaking combination and the germination was minimum in leachates from dried leaves in 10 g fraction when soaked for 72 h.

Fruit and Embryo Extract Bioassay: Extracts from fruit, fruit parts and seed parts did not significantly inhibit germination and growth of the test species (Table 2) which is contrary to the reports of others (Hussain *et al.*, 1985; Mubarak & Hussain, 1978). Of all the plant parts, fruits proved to be least toxic. It would suggest that the fruits of *S. marianum*, lying in the soil, do not effect germination of wheat under natural conditions in a field.

Interference Test: In mixed roots treatment, adverse effect on all observed characters of wheat except on leaf breadth, number of leaves per plant and the number of nodes was observed (Table 3). Since the competition was minimized by the addition of water and nutrient solution, the detrimental effect may primarily be due to toxic substances released by *S. marianum* into the environment. All characters were not equally affected by phytotoxins; greatest reduction occurred in the number of tillers produced and fresh and dry biomass of wheat which were respectively 51.8, 63.8 and 59.1% of the control. In mixed

Table 2. Effect of aqueous extacts of fruit parts of *Silybum marianum* on germination and radicle growth of wheat. Data is expressed as % of conrol; figures in parentheses represent % germination.

Plant Part	Soaking Hours	
	48	72
Whole Fruit	99.0 n.s. (93.0) n.s.	89.0 n.s. (100.0) n.s.
Pericarp and Testa	97.0 n.s. (93.3) n.s.	87.2 n.s. (100.0) n.s.
Embryo	107.0 n.s. (93.3) n.s.	95.7 n.s. (100.0) n.s.

n.s. = non-significant at p = 0.05

roots treatment, a number of interfering species have been known to reduce the height and fresh and dry biomass of test species (Dirvi & Hussain, 1979; Hussain *et al.*, 1979; Khanum *et al.*, 1979). In this treatment, toxicity was largely caused by the toxins released from the roots in the soil; it was slightly supplemented by rain drippings which also carry small amount of toxic substances to the soil. However the total amount of toxins added to the soil remained low and it failed to produce adverse effects on plant characters such as leaf breadth, number of leaves and nodes. Toxic potency of root exudates in the soil have been reported to be reduced by soil microbes, temperature and texture (Chou & Muller, 1972; Khan, 1982). The number of nodes per plant remained unchanged in mixed roots treatment but number of leaves per plant was reduced because of less number of tillers produced in treatment than the control. Masood-ur-Rehman (1987) also made similar observations while studying the allelopathic effect of *Sissymbrium irio* on wheat.

Table 3. Effect of *Silybum marianum* on some selected charactres of wheat cv. Blue Silver.

Parameters	Control		Roots Separated		Root Mixed		Control
	Mean	SE ±	Mean	SE ±	Mean	SE ±	%
Leaf breadth (cm)	1.1	0.23	1.1	0.17	1.0	0.15	96.3
Leaf length (cm)	15.0	2.01	14.3	2.73	13.0+	2.13	86.3
Number of leaves/plant	5.2	0.74	5.3	0.59	4.8	0.97	92.3
Plant height (cm)	57.8	6.85	60.4	11.48	43.2+	10.68	74.7
Number of tillers/plant	1.9	0.57	0.8	0.74	1.0+	1.26	51.8
Length of internodes (cm)	7.5	3.00	6.6	3.00	5.37+	2.71	71.3
Number of nodes/plant	4.0	0.24	4.8	0.33	4.0	0.24	100.0
Fresh biomass (g)	3.3	0.68	3.7	2.65	2.1+	0.22	63.8
Dry biomass (g)	2.2	0.43	2.2	1.34	1.3+	0.50	59.1

Each value is a mean of 5 replicates, each with 5 plants of test or interacting species in each half of pot in root separated treatment; 10 plants – 5 wheat and 5 *S. marianum* in root mixed treatment; and 5 plants of wheat in control.

+, significant at p = 0.01

Table 4. Effect of decomposing litter of *Silybum marianum* on some selected characters of wheat cv. Blue Silver.

Parameters	Control		Treatment		Control
	Mean	SE ±	Mean	SE ±	%
Germination (%)	100.0	0.00	100.0	0.00	100.0
Number of tillers/plant	0.3	0.48	Nil	—	—
Plant height (cm)	75.2	8.10	63.9+	9.70	84.9
Length of top internode (cm)	33.2	4.77	28.4+	5.28	85.5
Length of second internode from top (cm)	17.3	2.19	15.5+	2.60	89.5
Length of third internode from top (cm)	9.6	1.98	9.0*	1.95	93.7
Length of earhead (cm)	5.0	1.09	3.7+	0.75	73.0
Dry biomass (g)	2.2	0.77	1.3+	0.36	59.3
Number of grains/earhead	20.7	7.25	14.6+	5.26	70.4
Weight of 100 grains (g)	3.3	0.11	3.3	0.13	100.0

+, significant at p = 0.01

*, significant at p = 0.05

Litter Toxicity: The decomposing litter from *S. marianum,* which remained in the soil for about 6 months, showed adverse effect on all characters of wheat except weight of the grain and the germination frequency (Table 4). Decaying parts of many plants are known to inhibit the growth and germination of many associated species (Lodhi, 1976, 1978; Anaya & del Amo, 1978). The inhibition of growth of wheat as manifested by the reduction in plant height, size of internodes and the loss of biomass is largely due to inhibition of cell division and cell expansion. In treated seedlings, the number and size of the cells was significantly reduced due to the slowing of the process of cell division and expansion (Ramaut *et al.*, 1974; Hussain *et al.*, 1984). Dry biomass of treated wheat plant was 59.3% of the control indicating that the production of straw, an important byproduct of wheat crop, would be about 40% less than that of a wheat field without *S. marianum.* Similarly the yield, was also reduced by 30% causing a net loss of 38.5% of grains by weight.

Tiller formation was most adversely effected since, not a single tiller was produced in the treatment and the reduced yield, as manifested by the number of earheads per plant, was the main reason. Length of the earhead declined by 73% consequently reducing the number of grains per earhead to 70.4% of the control; but the size and weight of a grain remained unchanged.

In the present study germination frequency of wheat remained unaltered which is contrary to previous reports (Lodhi, 1978; Hussain *et al.*, 1984, 1986). Perhaps the amount of decomposing litter used in the experiment was not sufficient to retard germination. But, in nature, the amount of litter from *S. marianum* added to wheat field on per

unit area basis is far greater than that used in this experiment which would retard germination and increase the harmful effect on wheat.

The litter from *S. marianum*, allowed to decompose in the soil for 6 summer months, released toxins in the soil which significantly arrested growth of wheat. How long *Silybum* infested soil would remain toxic to wheat crop needs study. It is suggested that either the weed should be removed from the field at an early stage of its growth or if allowed to grow to maturity, it should be harvested and removed completely at the time of harvesting of the wheat crop.

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