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Allelopathic Suppression of Wheat and Mustard by *Rumex dentatus* ssp. *klotzschianus*

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Laboratory studies were conducted to see the allelopathic suppression of wheat and mustard by *Rumex dentatus* ssp. *klotzschianus* (Meissn) Rech. It was observed that aqueous extracts, rain leachates and litter from dried and fresh shoot and roots invariably inhibited the germination and seedling growth of both the crop species. Soil collected from beneath *Rumex dentatus* also proved harmful for the germination and seedling growth. It is suggested that *Rumex dentatus* ssp. *klotzschianus* exhibits allelopathy against wheat and mustard.

Keywords: allelopathic suppression, wheat, mustard, *Rumex dentatus* ssp. *klotzschianus*

Weeds not only compete with crops but also exhibit allelopathy (Zimdhahl, 1980) to reduce the growth and yield. Decomposition of weeds litter in the fields apparently improve the nutrient status of the soil. However, some weeds like *Canabis, Xanthium* and *Silybum* (Inam *et al.* 1987, 1989; Inam and Hussain, 1988) and many others (Hicks *et al.*, 1986; Bradow and Connick, 1988; Dharamraj *et al.*, 1988; Qaseem, 1993 a, b, 1994; Behrooz and Argund, 1993; Bhatia *et al.*, 1982, 1984) were allelopathic to various crops including wheat (Hussain *et al.*, 1990).

Some Polygonaceous plants including *Rumex* have been described as allelopathic. *Rumex obtusilobus* reduced the germination of *Lolium* (Lutts *et al.*, 1987). While *R. crispes* exhibited allelopathy against wheat, barley, sorghum and oat (Einhellig and Rasmussen, 1973). *Rumex obtusifolium* inhibited some grasses and controlled their spatial distribution (Carral *et al.*, 1988; Carballeria *et al.*, 1988). Alsaadawi *et al.* (1983) observed that *Polygonum aviculare* inhibited test species. Likewise, *Eupatorium odoratum* suppressed the growth of various test species (Nakamura and Nemoto, 1994). Lettuce was inhibited by root exudates from *Polygonum schalinense* (Inove *et al.*, 1992). Caffeic, ferulic and chlorogenic acids were identified as allelopathic principle in *Fagopyron cymosum* (Tsuzuki and Yamamoto, 1987).

Rumex dentatus ssp. *klotzschianus* is a perennial weed of cultivation including wheat and mustard. Besides seed germination it regenerates vegetatively from underground parts. Its growing period is almost similar to that of wheat and mustard. Many weeds allelopathically suppress the germination of wheat. *Chenopodium murale* and *Lepedium draba* were inhibitory to various cultivars of wheat and barley (Qaseem, 1993 a, b, 1994). Similarly, *Sasa* (Li *et al.*, 1992) and *Medicago sativa* (Waller *et al.*, 1993) reduced growth of wheat. Likewise other weeds (Behrooz and Argund, 1993; Bhatia *et al.*, 1982, 1984) were also inhibitory to the growth of wheat. On the other hand there are examples whereby wheat straw inhibited many weeds (Muminovic, 1991; Rambakuzibga, 1988).

Keeping in mind the tendency of Polygonaceous and other weeds to exhibit allelopathy, it was desired to see if *Rumex dentatus* ssp. *klotzschianus* also manifests allelopathy against wheat and mustard and to identify the possible phytotoxins.

MATERIALS AND METHODS

Mature and apparently disease free plants of *R. dentatus* were collected from wheat fields in Peshawar. Shoots and roots were separately dried at room temperature (15-20°C). Glassware was sterilized at 170 °C for 4 h. While heat labile substances were autoclaved at 115 lbs for 30 min. The germination means were compared using Z-test while growth means were subjected to t-test (Cox, 1967).

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Effect of aqueous extracts

Five g fresh or dried shoots or roots were separately soaked in 100 ml distilled water (DW) for 24 h at 25°C and filtered. In another set 5 g dried shoots or roots were boiled in 100 ml DW for 5 min., filtered and cooled to room temperature. These extracts were stored at 5-10°C. They were generally used within a few days.

Seeds of wheat (*Triticum aestivum*) and mustard (*Brassica campestris*) were placed on 2-folds of Whatmann No. 1 filter paper beds in Petri dishes and moistened with 10 ml DW (Control) or respective extract (Test). Germination, radicle and plumule growth were recorded after 72 h incubation at 25°C. There were 10 replicates, each with 10 seeds.

Effect of root exudates

Bioassay I

Rumex plants were carefully rooted out and their roots washed thoroughly with DW. Four *Rumex* plants were then transplanted to 14.5×6.5 cm sterilized glass bottles containing 400 ml half strength Hoagland's solution. The bottles were plugged with cotton and wrapped with black paper to avoid light penetration. After 2 weeks growth at 25°C with 10 h photoperiod, the solutions from all the 4 bottles were mixed. These solutions were then used against same test species as described in aqueous extract bioassay. Control consisted of half strength Hoagland's solution.

Bioassay II

Four *Rumex* plants were inserted in between 2-folds of filter paper in large plastic containers (8×25 cm) in such a way so that their shoots projected out without touching the filter papers. They were allowed to grow for 1 week as before. Thereafter, *Rumex* was removed and 50 seeds/replicate of each test species were placed directly on these filter papers. Control containers were incubated similarly but without *Rumex* plants in them. Germination and seedling growth were measured after 72 h incubation at 25°C.

Soil residual toxicity

Soil affected with (Test) or without (Control) *Rumex* was collected, dried and litter removed. These soils were used as growth medium for test species using soil bed and soil extract bioassay following (Hussain *et al.*, 1984).

Chromatographic identification

Rain leachates were concentrated to 1/3 of their original volume in rotavapor. It was acidified to pH 2.5 and extracted three times with sufficient ether by reflux shaking. The etherial fraction was dried in rotavapor. Chromatograms were developed following the methods as out lined in Hussain *et al.* (1991).

RESULTS AND DISCUSSION

Hot water extracts from roots significantly decreased the germination of wheat and mustard. While mustard also showed poor germination in shoot extract (Table 1). No inhibition was observed in the remaining treatments.

The radicle growth of both the test species was significantly retarded in various extracts. The extracts from dried and fresh shoots and roots and hot water extracts from both roots and shoots significantly suppressed the plumule growth of wheat. Whereas extracts from dried roots and hot water extracts from shoots and roots retarded plumule growth of mustard. In the remaining treatments there was stimula-

Table 1. Effect of aqueous extracts from roots and shoots of *Rumex dentatus* on the germination and seedling growth of test species

Test Species	Dried		Fresh		Hot Water	
	Roots	Shoots	Roots	Shoots	Roots	Shoots
	Germination					
Wheat	104	101	96	101	72*	90
Mustard	89	93	102	92	56*	27*
	Radicle Growth					
Wheat	70*	81*	58*	82*	47*	23*
Mustard	46*	52*	42*	48*	22*	5*
	Plumule Growth					
Wheat	71*	81	71*	95	35*	3*
Mustard	68*	119	140*	167*	40*	4*

Each value is a mean of 10 replicates, each with 10 seeds, all expressed as % of control.
*Significant at P=0.05.

Table 2. Effect of root exudates of *Rumex dentatus* on the germination and seedling growth of test species

	Bioaasy I			Bioassay II		
	Control	Test	% of Control	Control	Test	% of Control
Mustard						
Germination (%)	71	71	100	78	78	100
Radicle Growth (mm)	12.79	8.75	68.41*	8.7	5.32	61.15*
Plumule Growth (mm)	5.09	4.79	94.11	2.94	2.98	101.36
Wheat						
Germination (%)	80	82	102.50	88	86	97.73
Radicle Growth (mm)	18	10	55.56	19	8.5	44.74
Plumule Growth (mm)	20	18	90.00	18	16.9	93.89

Each value is a mean of 10 replicates, each with 10 seeds.
*Significant at P=0.05.

tion. Our findings agree with those of Inam *et al.* (1987, 1988) who observed that aqueous extracts from *Silybum* and *Xanthium* were inhibitory to some test crop species. Hot water extracts bioassays although an unnatural way of obtaining toxins from plants have been frequently used in allelopathic studies due to ease of extraction and retention of phytotoxicity of the inhibitors. It was observed that extracts from fresh and dried parts had similar toxicity. Qaseem (1993 a, b; 1994) reported that the extracts from fresh parts *Chenopodium* and *Lepidium* were more inhibitory than dried parts.

Shoot leachates from *Polygonum* inhibited associated plants (Alsaadawi *et al.*, 1983). Similarly extracts from *Rumex crispus* were allelopathic to wheat (Muminovic, 1991). Our findings regarding the inhibition of wheat and mustard by *R. dentatus* are supported by them. However, in most cases germination was not inhibited. Qaseem (1993 a, b; 1994) observed inhibited germination of wheat by aqueous extracts of *Chenopodium* and *Lepidium*. Furthermore, root exudates enhanced soil toxicity. The germination of both the test species was not affected by the root exudates but, wheat declined to 55% and 44% in bioassays I and II, respectively. While that of mustard reduced to 68% and 61% of control in bioassays I and II (Table 2). It was also observed that extracts from roots were generally more inhibitory than above ground parts. This agrees with the findings of Inove *et al.* (1992) who reported that roots exudates from

Table 3. The effect of *Rumex*-affected soil on the germination and seedling growth of test species

Test Species		Dist. Water	Control Soil	% of Control[a]	Test Soil	% of Control[b]
	Germination (%)					
Wheat	SB	100	100	100	100	100
	SE	93	89	96*	70	78.7*
Mustard	SB	100	98	98	100	100
	SE	78	64	82.1*	53	82.8*
	Radicle Growth (mm)					
Wheat	SB	37.9	31.7	83.6*	23.1	72.9*
	SE	28.9	27.3	94.5	17.1	62.6*
Mustard	SB	52.0	48.1	92.5	37.8	78.6
	SE	15.0	13.0	86.7*	8.8	67.7*
	Plumule Growth (mm)					
Wheat	SB	22.9	18.5	80.8*	11.6	62.7*
	SE	15.5	12.9	83.2*	7.3	56.5*
Mustard	SB	24.6	23.3	94.7*	13.1	56.2*
	SE	6.4	5.1	79.7*	2.4	47.4*

*Significant at P=0.05.
a=based on DW control. SB=soil bed.
b=based on control soil. SE=soil extract.
Each value is a mean of 10 replicates, each with 10 seeds.

Polygonum sachalinense were more inhibitory to many test species.

Phytotoxins from plants accumulate in the soil. However, in the present study the germination of both the test species was not reduced in soil bed bioassays, whereas soil extract decreased the germination to 78.7% and 82.8% in wheat and mustard, respectively (Table 3). The radicle growth of both the test species declined significantly when they grew directly upon affected soil beds or their extracts. The germination and seedling growth were almost identical in control soil and distilled water treatment. While signigicant inhibition occurred prevailed in the germination and radicle growth of test species due to *Rumex* affected soil. This suggests that soil turned undesirable due to growth of *Rumex*. *Lepidium* extract when applied to soil inhibited the growth of wheat and this agrees with our findings (Qaseem, 1994).

The identification of caffeic, p-coumaric, p-hydroxybenzoic, chlorogenic, syringic, ferulic, vanillic and o-coumaric acids in rain leachates of *Rumex dentatus* ssp. *klotzschianus* suggest the allelopathy by this weed against wheat and mustard (Fig. 1).

Parallel studies made on other Polygonaceous species also suggest the presence of phenolic and fatty acids as the possible allelopathic agents (Alsaadawi, 1983). It is suggested that *Rumex* dentatus containted inhibitors as root exudates, rain leachates from living and dead parts. On the other hand there is an equal possibility that wheat (Muminovic, 1991) and other crucifers (Grodinsky, 1992) including mustard might also be allelopathic to *Rumex* and other associated weeds. This possibility was however not tested in the present study. The present findings suggest that *R. dentaus* is strongly allelopathic to wheat and mustard. However, Bhatia *et al.*, (1982, 1984) reported that *R. dentatus* promoted the growth of wheat and nitrogenase activity. This contradiction could be due to variation in the climate, differences wheat seeds and season of collection of *Rumex* material. All such factors strongly affect the allelopathic capability of plants in nature. Weed-crop interaction needs very careful investigation due to its complexity.

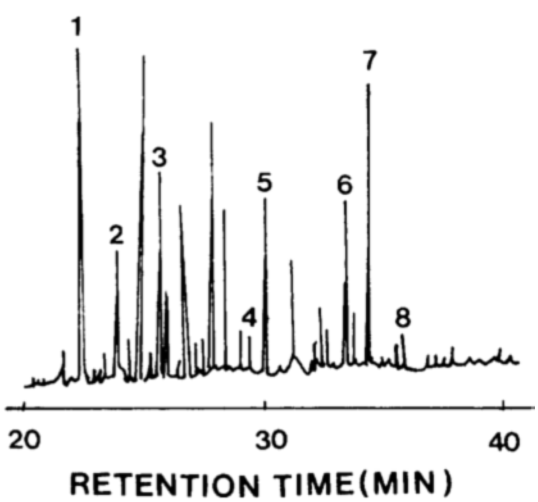

Fig. 1. Phenolic compounds identified from *Rumex dentatus* ssp. *klotzschianus* rain leachates by gas chromstography. Key to number: 1, p-hydroxybenzoic acid; 2, chlorogenic acid; 3, vanillic acid; 4, syringic acid; 5, o-coumaric acid; 6, p-coumaric acid; 7, ferulic acid; 8, caffeic acid.

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