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ALLELOPATHIC EFFECTS OF *DICHANTHIUM ANNULATUM* (FORSK) STAPF ON SOME CULTIVATED PLANTS

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Dichanthium annulatum, a range grass, is a weed in the moist lowland and plains of Pakistan. Experiments revealed that shoot extracts, root exudates and soil under the grass cover contained growth and germination inhibitors. The aqueous extracts from shoot and soil taken from grassed areas inhibited the growth and germination of *Pennisetum typhoideum, Setaria italica, Lactuca sativa* and *Brassica campestris*. The extracts retarded the seedling water absorption and reduced the plant moisture contents. However, the extract toxicity depended upon the amount of material used, soaking duration and the susceptibility of the test species. Therefore, during weeding the litter of this grass should be removed from the fields due to its allelopathic affects.

INTRODUCTION

Dichanthium annulatum (Forsk) Stapf, a member of Graminae family, grows in the tropical countries of the world including Pakistan. It is used by range managers for production of forage because it is easy to propagate, can withstand grazing, drought and is a good soil binder. As a weed, it competes with crops reducing the yield and will replace an improperly weeded crop. The growth and germination of other plants has been shown to be inhibited through biochemical mechanism and competition might play a secondary role [3,8,14–16]. Tinnin and Muller [19], have pointed out the allelopathic effects of *Avena fatua*. Similarly, *Cenchrus ciliaris, Chrysopogon aucheri, Sorghum almum* and *Panicum antidotale* have been reported to inhibit the growth and germination of other species [3,4,17]. The importance of allelopathy has been recognised in agriculture [20] and natural plant communities [13]. Therefore, the present investigation was started to determine the mechanism of the inhibitory effects of this grass against some cultivated plants.

MATERIALS AND METHODS

Interference by *Dichanthium annulatum* was tested in the following 2 experiments by growing it with a test species.

Interference Pot Experiment. Pots of 20×22 cm were filled with equal volume of similar loamy soil. After removing the litter, the soil was thoroughly washed with water to leach out any water-soluble phytotoxic substances. An effort was, however, made not to use the soil which had plants in them previously. *Dichanthium annulatum* was grown in combination with *Hyparrhenia rufa*. The roots of the two species were either separated by polyethylene partitions which divided the soil into 2 equal parts or allowed to mix with each other, without the polyethylene partitions. Each treatment was replicated 5 times, with 5 plants of each species in each half of the pot. Each treatment was supplied with Hoagland's solution and kept under uniform conditions in the department nursery. Plants were harvested after 4 months. After determining heights and fresh weights the same plants were dried at 60° for 72 hr and reweighed for dry weights.

Field Plot Interference Experiment. D. annulatum was grown in mixed culture in alternating rows with *Hyparrhenia rufa* in 12×6 ft plots. A monoculture of each species was grown next to the mixed culture for controls. Each row was used as a replicate. Water and Hoagland's solution was provided to avoid water and nutrient competition. All plots were weeded by hand. After 4 months, five plants were harvested objectively from each row in each treatment following Naqvi [15]. Heights, fresh and dry weights of the plants from each row were determined.

Allelopathic Studies Dichanthium annulatum shoot were dried at room temperature. Petri dishes and other glass were sterilized at 170° for 4 hr [12]. Extracts of room-dried shoot were made by soaking in distilled water. After filtration, the extracts were used in different bioassays and experiments. When not in use, the extracts were stored at 5–10°.

Seeds of the test species were placed on twice folded Whatman filter paper No. 1 seed-beds. The test seed-beds were moistened with extract and the control with distilled

water. The dishes were sealed with parafilm, "M" to avoid moisture loss and reduce fungus infestation. There were always three replicates, with 10 seeds per replicate unless otherwise stated. The results of the bioassays and experiments were statistically analysed using Z and t-tests [7].

Aqueous Shoot Extract Bioassay. Five g dried shoots were crushed and soaked in 100-ml distilled water for 12, 24, 48 and 72 hr at room temperature (25–30°). The extracts, thus obtained were used against *Pennisetum typhoideum, Setaria italica, Lactuca sativa* and *Brassica campestris* using the filter paper bioassay method. The dishes were incubated at 25° for 48 hr followed by recording germination and radicle growth.

Effect of Concentration on Toxicity. Dried shoot material (5,10 and 15 g) was soaked in 100 ml distilled water for 24 hr. The extracts were used against the same 4 test species using the filter paper bioassay method.

Soil Residual Toxicity. The test soil was collected to a depth of 10 cm from soil where the grass had grown for the last 6 months. The soil was dried and sieved through 2-mm mesh. The control soil was collected in the same way but did not have plants grown on it. Following experiments were conducted:

Soil Extract Bioassay: Twenty g soil (test or control) was soaked in 100 ml distilled water separately and shaked thoroughly for 24 hr. After filtration of the extract, it was tested against *Brassica campestris* and *Lactuca sativa* using the filter paper bioassay. Germination and radicle growth was recorded after 48-hr incubation at 25°.

Soil Bed Bioassay: Instead of using soil extract, soil was used for seedbeds. Twenty g soil (control or test) was evenly spread in petri dishes, watered with 12 ml distilled water and covered with a single sheet of Whatman filter paper No. 1. Seeds of the test plants were placed on this substrate. The dishes were sealed with parafilm, 'M' and incubated at 25°. Germination and radicle growth of *Brassica campestris* and *Lactuca sativa* were recorded after 48 hr.

Mulching Experiment. Plastic bags (8×6 cm) were filled with 200 g coarse river sand which had been thoroughly washed and subjected to dry heat sterilization at 170° for 4 hr. The seeds of either *Pennisetum typhoideum, Setaria italica* or *Lactuca sativa* were placed in each bag. Tests were made by covering the sand with 1 g powdered grass shoot. The control contained the same amount of powdered filter paper instead of grass shoot. Sixty ml distilled water was added to each bag. Each treatment was replicated 5 times. The bags were incubated at 25° for 5 days. Seedlings were then thinned to 4 per bag and exposed to light for 16 hr daily. Hoagland's solution and water was added to each bag weekly. After 4 weeks, the plants were harvested and dried at 60° for 72 hr to determine dry weight.

Aqueous Culture Experiment. Shoot extracts were obtained by soaking 5 g powdered shoot in 100 ml distilled water for 24 hr. Test solutions were made by mixing equal volumes of the extract and Hoagland's solution. The control consisted of mixing equal volumes of distilled water and Hoagland's solution. Twenty ml of either test or control solution was placed into 8×1.6 cm sterilized glass vials. A single seedling of either *Pennisetum typhoideum* or *Setaria italica* was transferred to each vial. One month old seedlings were selected for their uniformity. The vials were cotton-plugged and placed in 16-hr light period for 4 days. Each test was replicated 10 times. Fresh weight, oven dry weight and % moisture was calculated.

RESULTS

Interference Experiments. In pot and plot experiments, *Dichanthium annulatum* suppressed the growth of *Hyparrhenia rufa* significantly (P 0.05) when the roots were mixed (Table 1). However, *Hyparrhenia* had also retarded the growth of *Dichanthium.* The observed inhibition could not be merely due to direct competition for physical factor but to some biochemical suppression mechanism. The growth suppression could be due to some root exudates of the grass.

Allelopathic Studies

Aqueous Shoot Extract Bioassay. The germination and radicle growth of all the species was reduced significantly except 12-hr extract in some cases *(S. italica).* The toxicity of the extracts increased with increasing soaking time (Table 2) and extract concentrations (Table 3). In concentrated extracts, the seeds did not germinate. Apparently the

Table 1. Height, fresh and dry weights of the interacting species in pot and plot interference experiments.

Plant	Height	Fresh weight	Dry weight
Pot Experiment			
D. annulatum	91.84	136.16*	145.83*
H. rufa	91.71	50.56*	52.63*
Plot Experiment			
D. annulatum	103.89	85.76*	70.46*
H. rufa	98.04	75.09*	75.89*

*Significantly different from control at P 0.05

Each value is a mean of 5 replicates, each with 5 plants, expressed as % of their control. Per cent of control was calculated on the basis of root separated or monoculture values.

Table 2. Effect of aqueous shoot extract of *Dichanthium annulatum* on germination and growth of the test species.

Plant	Soaking Time (hr) 12	24	48	72
Germination (Control %)				
P. typhoideum.	81.82*[a]	62.18*[b]	68.18*[b]	45.45†[c]
S. italica.	100.00[a]	83.33*[b]	93.33[ab]	93.33[ab]
L. sativa	93.33[a]	80.00*[b]	96.00*[b]	3.33*[c]
B. campestris.	93.33[a]	83.33*[a]	80.00*[b]	76.66*[b]
Average Radicale Growth (Control %)				
P. typhoideum.	60.18*[a]	50.92*[b]	29.16†[c]	24.53†[c]
S. italica.	91.13[a]	74.50*[b]	25.84†[c]	23.52†[c]
L. sativa.	59.61*[a]	57.45*[a]	42.33*[b]	1.29†[c]
B. campestris.	35.71†a	34.36†[a]	30.89†[ab]	25.89†[b]

*Significant at P 0.05 †Significant at P 0.01

Table 3. Effect of increasing concentration of *Dichanthium* shoot extract on germination and radicle growth of the test species.

Plant	Extract concn (g/100 ml). 5	10	15
Germination (Control %)			
P. typhoideum	83.33*[a]	37.33†[b]	25.66†[c]
S. italica.	83.33*[a]	66.66*[b]	14.33†[c]
L. sativa.	77.77*[a]	†b	†b
B. campestris.	82.60*[a]	34.78†[b]	17.39†[c]
Average Radicle Growth (Control %).			
P. typhoideum	50.00*[a]	37.32†[b]	19.42†[c]
S. italica.	85.13*[a]	25.34†[b]	9.06†[c]
L. sativa.	64.32*[a]	†b	†b
B. campestris.	48.76*[a]	14.61†[b]	4.04†[c]

*Significantly different from control at P 0.05

†Significantly different from control at P 0.01. Means followed by the same letters are not significantly different from each other at P 0.05 (Each value is the mean of 3 replicates, each with 10 seeds).

straw had one or more water-soluble toxins which inhibited germination and radicle growth.

Soil Residual Toxicity. The results of the soil residual toxicity revealed the toxic nature of the soil due to leaching of toxins from grass (Table 4.) in both the experiments the germination and growth of the test species were significantly inhibited (P 0.01). A better growth observed in control soil indicated the presence of nutrients and non-toxic nature of the soil. Comparatively less growth in distilled water than control soil was due to the absence of nutrients in the distilled water.

Mulching Experiment. The grass mulch significantly retarded (P 0.05) the growth of all the test species. The mechanical pressure of the straw could not be responsible for the observed growth inhibition as control had the same weight (Table 5).

Aqueous Culture Experiment. The grass extract significantly reduced (P 0.05) the fresh weight and moisture contents of the seedlings (Table 6). The reduction in fresl

Table 5. Effect of *Dichanthium annulatum* mulch on the dry weights of *Pennisetum typhoideum, Setaria italica* and *Lactuca sativa.*

Plant	Control (mg)	Test (mg)	Control (%)
P. typhoideum	3.81±0.25	3.15±0.13	82.67*
S. italica.	1.70±0.09	1.45±0.05	85.29*
L. sativa.	1.85±0.03	1.01±0.01	54.86†

*Significantly different from control at P 0.05

*†Significantly different from control at P 0.01

Values are means of 5 replicates, and 4 plants per replicate.

Table 4. Residual toxicity of *Dichanthium annulatum* soil on germination and growth of *Brassica campestris* and *Lactuca sativa.*

Plant	Germination (%) Distilled water	Control	Test	Average radicle growth ± SD Distilled water (mm)	Control soil (mm)	Test soil (mm)	Control (%)
Soil Extract Bioassay							
B. campestris	96.66	96.66	70.00†	4.50±0.50	4.53±0.75	0.76±0.05	16.77†
L. sativa	86.66	90.00	53.33†	7.86±1.53	10.56±2.53	0.53±0.01	5.01*
Soil Bed Bioassay							
B. campestris.	93.33	90.00	73.33*	4.79±1.11	6.40±1.19	1.30±1.13	20.31†
L. sativa	50.33	46.66	10.00†	1.35±0.02	1.46±0.04	0.20±0.01	13.69†

*Significant at P 0.05 †Significant at P 0.01 Values are means of 3 replicates, 10 seeds per replicate.

Table 6. Effect of *Dichanthium annulatum* shoot aqueous extract on the water absorption and moisture contents of *Pennisetum typhoideum* and *Setaria italica.*

Plant	Fresh Weight			Moisture		
	Control (g)	Test (g)	Control (g)	Control (%)	Test (%)	Control (%)
P. typhoideum.	337.20	279.90	83.00†	515.83	343.57	66.60*
±SD	23.25	20.95		30.56	26.17	
S. italica.	442.16	289.77	65.53*	455.37	235.79	51.77*
±SD	28.13	19.65		21.59	19.18	

*Significantly different from control at P=0.05. Each value is a mean of 10 replicates, each with a single seedling.

weight and moisture content suggested a possible inhibition of water absorption by the test species.

DISCUSSION

Competition alone cannot explain the reduction in growth and germination under the favourable physical environment [1, 8, 15–17]. Some other mechanism seemed to be either partially or wholly responsible for growth reduction. In nature toxins are released from dead or living parts of grasses in moisture droplets from plant and during litter decomposition. In the laboratory, the toxins extraction from dried shoot was similar to the natural conditions and the germination and plant growth results confirm the toxicity of the *D. annulatum.* The grass extract inhibited germination, growth and water absorption capacity of the seedlings. Similar results were obtained by Lodhi and Nickell [11] and Dirvi [8]. Productivity loss by phytotoxins has been reported by Lodhi [10]. Chou and Young [6], Bokhari [5] and our results agree concerning the allelopathic effects of the grasses. Allelopathy, therefore, plays a major role in inhibiting growth and germination of the susceptible plants and that toxicity is related to species. The toxins accumulate in significant amount after release and inhibit the growth of other plants. In the present study, the soil from grassed areas was phytotoxic. Similar results have been reported by others [9, 10, 21]. Our investigation has shown that *Dichanthium annulatum* is a phytotoxic weed and its litter would inhibit its function as a nurse crop. However, its cultivation as a range grass for fodder and for erosion control would be acceptable.

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