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Allelopathy of Pearl Millet as Influenced by Vegetative and Reproductive Stage of Crop Growth

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Abstract : The root and shoot aqueous extracts from vegetative and reproductive stages of pearl millet cv. MH 179 were assayed at concentrations of 20, 40, 60 and 80 g L^{-1} (fresh weight basis) for their effects on seed germination and early seedling growth of pearl millet. Rate of germination declined with increase in concentration of both root and shoot extracts while ultimate germination, root and shoot length were maximum at 20 g L^{-1} concentration and decreased with further increase in concentrations with extracts of vegetative stage. These parameters were inversely related with the extracts concentration of reproductive stage and were minimum at the highest concentration. The highest concentration assayed resulted in 17.7 and 29.4% decline over control in germination with root and shoot extracts of vegetative stage. The corresponding decline caused by extracts of reproductive stage was 57 and 25.6%, respectively. The results of the study suggest that extracts of reproductive stage were more phytotoxic than the extracts of vegetative stage.

Key words : Allelopathy, pearl millet, aqueous extracts, germination, seedling growth.

Pearl millet (*Pennisetum glaucum* (L.) R.Br.) is a prominent crop of arid regions and its mono culture is practiced in these regions. Large amounts of pearl millet tissues are left in the field after the harvest which is added to the soil. The problem of reduced germination, plant growth and declined production under monocropping sequence of pearl millet have been observed in arid areas (Saxena *et al*., 1995a). The decomposing stubbles of pearl millet cause phytotoxicity to the succeeding crops. Reduced germination of succeeding pearl millet and thereby declined yield in monocropping sequence may be due to its allelopathy. In field conditions, release of allelopathic chemicals from decomposing crop residues had been reported to inhibit seed germination, growth and yield of soybean (Mallik and Tesfai, 1988), Wheat (Thorne *et al*., 1990) and alfalfa (Hegde and Miller, 1992).

Stubble extracts of pearl millet were found to inhibit the seed germination and shoot length of wheat and lentil (Narwal *et al*., 1989) and pearl millet (Saxena *et al*., 1995b). Information on critical concentration for growth inhibition by pearl millet aqueous extracts is needed in making decisions regarding resowing of pearl millet in a field where stubbles of previous crop are present. The present study was conducted to examine how growth stages at the time of extraction of aqueous extracts affect subsequent response in pearl millet.

Materials and Methods

Root and shoot aqueous extracts of pearl millet from two crop growth stages, vegetative (30 DAS) and reproductive (65 DAS) were used in seed bioassay to determine the auto toxic effects at Central Arid Zone Research Institute, Jodhpur. Fresh root and shoot tissues of pearl millet from the respective growth stages were prepared by soaking 10 g fresh chopped plant material in 100 ml distilled water for 4 h. The extracts were first centrifuged at 20,000 rpm for 10 minutes and filtered through Whatman no. 1 filter paper. The extract thus obtained gave a concentration of 100 g L^{-1} on a tissue fresh weight basis. Bioassay concentrations of 20, 40, 60 and 80 g L^{-1} were prepared.

Ten uniform seeds of pearl millet hybrid (cv. MH 179) were placed in 100 mm petridishes lined with two layers of filter papers moistened with 5 ml distilled water (control) or aqueous

extracts on the first day and after 3 days. The petridishes were kept at 25°C temperature. Treatment combinations consisting of 0,20,40,60 and 80 g L^{-1} root and shoot extracts were laid out in randomised block design with three replications. Daily counts of seed germination were made and root and shoot length of all live seedlings (both root and shoot emerged from seed coat) were recorded after 7 days. From the germination counts the following germination parameters were determined.

1) Ultimate Germination (UG) : The maximum number of seed that germinated during the experiment.

2) Rate of Germination

$$(RG) = \sum_{i=1}^{d} (N_i/D_i)$$

where,
N is daily increase in seedling number, and
D is number of days from seed placement.

3) Percentage Inhibition or Stimulation

= 100 - (UG% in aqueous extracts/UG% in distilled water).

Results and Discussion

Ultimate Germination (UG) and Germination Inhibition/Stimulation

Extracts of vegetative stage : The ultimate germination (UG) was 85% under control. Application of 20 g L^{-1} root aqueous extract had stimulatory effect (5.9%) on seed germination leading to 90% UG (Table 1). Further increase in concentration of the extract led to steady decline in the germination with 70% UG at 80 g L^{-1}. A similar trend of response was observed with shoot extracts. The application of 40,60 and 80 g L^{-1} root extract caused 4.7, 5.9 and 17.7% inhibition in seed germination, respectively, while the corresponding concentrations of shoot extracts caused 9.4, 14.1 and 29.4% inhibition.

Extracts of reproductive stage : Ultimate Germination decreased linearly with increasing concentrations of extracts being minimum with the highest concentration assayed. The highest concentration of 80 g L^{-1} resulted in 57 and 25.6% decline in UG with root and shoot extracts, respectively. Root extract concentration of 40, 60 and 80 g L^{-1} caused 5.6, 25.6 and 44.4% decline in seed germination, while the corresponding decline with shoot extracts were 7.8, 11.1 and 14.4%, respectively. Similar auto toxic inhibitory effects from root and straw extracts of various crops have been reported by Kimbler (1973), Gupta *et al.* (1987), Hegde and Miller (1992), Saxena *et al.* (1995b).

Rate of germination

Extracts of vegetative stage : Increasing concentration of root and shoot extracts decreased the rate of germination. The highest concentration of root extract resulted in slowest rate of germination of 6.8 seeds day^{-1} as against 10.7 seeds day^{-1} with control. Similar trend of adverse influence on RG due to application of shoot extracts was also recorded (Table 1).

Extracts of reproductive stage : The rate of germination (RG) was 9.5 day^{-1} under control.

Table 1. Effects of pearl millet aqueous extracts on germination parameters

Extract concentration (g L^{-1})	Vegetative stage						Reproductive stage					
	UG		Ger I/S		RG		UG		Ger I/S		RG	
	Root*	Shoot*	Root*	Shoot*	Root*	Shoot*	Root*	Shoot*	Root*	Shoot*	Root*	Shoot*
0	85	85	–	–	10.7	10.7	90	90	–	–	9.5	9.5
20	90	90	+5.9	+5.9	8.2	8.3	85	83	-5.6	-7.8	8.2	7.8
40	81	77	-4.7	-9.4	9.7	5.7	67	80	-25.6	-11.1	7.4	6.2
60	80	73	-5.9	-14.1	6.9	4.2	50	77	-44.4	-14.4	7.0	4.9
80	70	60	-17.7	-29.4	6.8	3.9	39	67	-57.0	-25.6	7.0	3.7
CD(p=0.01)	13	19	–	–	1.7	3.2	17	12	–	–	1.7	2.4

UG = Ultimate Germination (%), RG = Rate of Germination (seed day^{-1}),
Ger I/S = Germination inhibition/stimulation, * Extract of root and shoot.

Rate of germination was inversely related to concentrations of root and shoot. The slowest rate of germination (6.8 seeds day^{-1}) was recorded with the highest concentration of root extract. Similar trend of adverse influence on RG with shoot extracts was also observed (Table 1).

Although the rate of germination was adversely influenced by application of 40 g L^{-1} or higher concentrations of root and shoot extracts, yet the concentrations of 20 g L^{-1} caused better ultimate germination compared to control by way of stimulatory effect at lower concentrations which became inhibitory at higher concentrations.

Root length

Extracts of vegetative stage : Maximum root length was recorded at 20 g L^{-1} concentration of both root and shoot extracts. Reduction in root length was rate dependent after a threshold concentration of 20 g L^{-1}, higher concentrations being more inhibitory (Table 2). The highest concentration (80 g L^{-1}) of root and shoot extract caused 13.4 and 57.5% inhibition in root length as compared to control, respectively.

Extracts of reproductive stage : Root length, decreased significantly with increasing concentration of root and shoot extracts. Application of root and shoot extract concentration of 80 g L^{-1} resulted in 60.8 and 30.4% decline in root length, respectively, over control (Table 2). At this stage root extracts were more inhibitory than shoot extracts. From this data it seems that allelopathic compounds synthesized in shoot during vegetative stage and later on they are transported to the roots. Root length was linearly decreased for each unit increase in concentration of the extracts.

Shoot length

Extracts of vegetative stage : Shoot length increased upto extract concentrations of 20 g L^{-1} and thereafter it started declining with increasing concentrations (Table 2). The influence of root and shoot extracts on shoot length were however not significant.

Extracts of reproductive stage : Reciprocal relationship between shoot length and extract concentration was observed. Application of 80 g L^{-1} root and shoot extracts caused decline of 37.7 and 36.5% over control, respectively. An increase of 3.5% was observed in shoot length with 20 g L^{-1} shoot extract while the root extract caused 4.7% decline in shoot length (Table 2).

It is noteworthy that pearl millet root and shoot aqueous extracts at a lower concentration (20 g L^{-1}) stimulated the germination and growth. These data reflect that stimulatory and inhibitory effects of a given plant extract are a function of concentration. This agrees with the views of Rice (1984) who stated "apparently most if not all, organic compounds that are inhibitory at some concentrations are stimulatory to the same process in very small concentrations". The results suggest that the growth inhibition due to auto toxic principle contained in the root and shoot tissue of pearl millet is concentration rate dependent. It implies that the phytotoxic compounds will have to accumulate in sufficient quantity

Table 2. Effect. of pearl millet aqueous extracts on root and shoot length (cm) of pearl millet

Extract concentration (g L^{-1})	Vegetative stage				Reproductive stage			
	Root length		Shoot length		Root length		Shoot length	
	Root*	Shoot*	Root*	Shoot*	Root*	Shoot*	Root*	Shoot*
0	12.7	12.7	8.8	8.8	11.5	11.5	8.5	8.5
20	14.0	12.9	9.0	9.2	10.0	11.2	8.1	8.8
40	11.6	8.1	7.7	7.3	8.6	10.5	6.5	6.3
60	11.4	7.0	7.5	7.0	7.1	10.0	6.2	5.8
80	11.0	5.4	6.2	6.4	4.5	8.0	5.3	5.4
CD (p=0.01)	0.9	2.6	**NS	NS	2.9	1.5	1.1	1.6

* Extract of root and shoot. ** Non significant.

in soil to cause auto toxicity. At lower concentrations, the extracts did not inhibit the growth or rather tended to stimulate, whereas at higher concentrations it inhibited the pearl millet growth.

Since the aqueous extracts of pearl millet root and shoot were used in the experiment, the compound/s responsible for stimulation or inhibition may be water soluble. It is likely that these compounds leach from the plants during the season or during decomposition of residues and add to the rhizosphere zone to cause auto toxicity in field conditions.

Many crop species have allelopathic effects on themselves and other plants and this allelopathic potential makes it essential to return to crop rotation system in farming. Therefore, practices may be developed in agriculture to eliminate some of the problems caused by allelopathy in mono cultures (Rice, 1995). Further, research is needed to identify the compounds responsible for such effects.

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