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ALLELOPATHIC POTENTIAL OF *DODONAEA VISCOSA* (L.) JACQ.

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Abstract

Dodonaea viscosa (L.) Jacq., is widespread species forming dense populations in sub tropical regions of Pakistan. Allelopathic studies with aqueous extracts from leaves, bark, flowers, shoot litter and mulches in various experiments, invariably reduced the germination, plumule growth, radical growth, fresh and dry weight of *Pennisetum americanum* (L) Skhyuman, *Setaria italica* (L) P. Beauv and *Sorghum vulgare* Pers, used as the test species. Phytotoxicity of extracts depended upon amount and soaking duration. Generally 48 hour extracts were more inhibitory. Leaves were more toxic than bark and flowers. Hot water extract was more inhibitory than aqueous extract obtained at room temperature. Added litter and mulching experiments also proved inhibitory. It is suggested that *Dodonaea viscosa* has strong allelopathic potential and it might be further tested for its weedicidal and insecticidal activities. Further studies are required to see its allelopathic behavior under field condition against its associated species and to identify the toxic principle, their quantification and its efficacy in the soil.

Introduction

Allelopathy is fascinating and perplexing subject that concern with the interaction of plants as influenced by the chemical substances that they release into the environment (Willis, 2004; Bais *et al.*, 2003; Machado, 2007). Allelopathy can enhance the competitive success of the invader plants, since the release of phytotoxins in the environment may affect the growth and life processes of other community species (Callaway, 2002). The world is still in search of and in the process of developing farming techniques, which are sustainable for environment, crop production and protection as well as socio-economic points of view. Integrated weed management is one of such approaches where allelopathy can play its eco-friendly role in weed management (Hussain *et al*., 2007). The allelopathic properties of plants can be exploited successfully as tool for pathogens and weed reduction (Xaun *et al.*, 2005).

Recent research work identified a number of species including *Cardaria draba* and *Salvia syriaca* (Qasem,2001), *Eucalyptus microtheca* (Gillani *et al.*, 2002), *Ginkgo biloba* (Lin *et al.*, 2003), *Tamarindus indica* (Parvez *et al.*, 2003), *Azadirachta indica* (Xuan *et al.*, 2004), *Broussonetia papyrifera* (Hussain *et al.*, 2004) and *Lactuca sativa* (Chon *et al.*, 2005) as allelopathic against other plants. Tehmina & Bajwa (2005) and Kamal & Bano (2008) worked on the allelopathy of *Helianthus annuus*. Marwat & Azim (2006) demonstrated that leaves of *Prosopis juliflora, Eucalyptus camaldulensis* and *Acacia nilotica* had strong inhibitory efficacy. Hussain *et al*., (2007) investigated *Cassia angustifolia* for its allelopathic potential. Elizabeth *et al*., (2008) tested the phytotoxcity of *Brachiaria decumbens*. Samreen *et al*., (2009) studied the allelopathy of *Calotropis procera*. Hussain & Ilahi (2009) reported that *Cenchrus ciliarus* and *Bothriochloa pertusa* exhibit allelopathy.

The review reveals that no such study was conducted on *Dodonaea viscosa* (L.) Jacq., which is a medium-sized shrub or small tree up to 9 meters tall, forming gregarious patches. It has been observed that there is undergrowth of associated species in its vicinity and with in the thickets. The present study was conducted to investigate its allelopathic potential.

Materials and Methods

Mature leaves, bark and flowers of *Dodonaea viscosa* collected from Batkhela Hills were dried at room temperature (25-30˚C), powdered and stored in paper bags. Glass ware, thoroughly washed with water, was sterilized at 170˚C for at least 4 hours. There were 5 replicates, each with 10 seeds. The Petri dishes were always incubated at 25˚C for 72 hours. All the results were statistically analyzed through LSD in one way ANOVA.

i. Effect of aqueous extracts: Five and 10 gm of each part were separately soaked in 100 ml distilled water at 25˚C for 24 and 48 hours and filtered to get aqueous extracts. These extracts were tested against *Pennisetum americanum*, *Setaria italica* and *Sorghum vulgare* on 2-folds of filter paper in Petri dishes. The filter papers were moistened with the respective extracts or the distilled water as the case may be. Germination, growth of plumule and radical were noted after 72 hours. Twenty seedlings were randomly taken out for fresh and dry weight determination. Seedlings were dried at 65˚C for 72 hours.

ii. Effect of hot water extracts: Five gm of dried plant parts were separately boiled in 100 ml of water for 5 minutes and filtered. The room cooled extracts were applied against the same test species as before.

iii. Effect of litter: Five gm of crushed litter from leaves, bark and flowers were placed in Petri dish and topped with single filter paper.. The dishes were provided with 5 ml in distilled water. In control treatment fine pieces of filter paper were used. The bioassay was run as before.

vi. Effect of mulching: Five gm crushed dried leaves, bark and flowers were separately placed in plastic pots containing sterilized sand. For each treatment five replicates, each with 10 seeds were made. Control consisted of fine pieces of filter paper. The plastic pots were incubated at 25˚C. Germination, plumule and radical growth were measured. Twenty seedlings were randomly taken out for the determination fresh, dry weight and moisture contents.

Results and Discussions

The present study suggested the presence of various allelochemIcals in aqueous extract from leaves, bark and flowers which exhibited allelopathic stress against the germination, seedling growth, fresh and dry weight of tested species. Aqueous extracts from all parts significantly reduced the plumule and radical growth of all test species. The extract from leaves was more inhibitory followed by flowers and bark (Table 1). The aqueous extracts from bark stimulated the seedling growth of *Pennisetum americanum* and *Setaria italica*. Pumule growth of *Sorghum vulgare* and radicle growth of *Setaria italica* were observed to be more sensitive than the others (Table 1). Aqueous extracts from leaves and flowers obtained after 48 hour were more inhibitory than 24 hour extracts (Table 1). Increasing soaking duration and concentration generally enhanced inhibition. Similarly, the phytotoxicity *Azadirachta indica* (Xuan *et al.*, 2004), *Tamarindus indica* (Parvez *et al.*, 2003), *Broussonetia papyrifera* (Hussain *et al.*, 2004) and *Lactuca sativa* (Chon *et al.*, 2005), generally enhanced with soaking duration, and this supports our findings. Marwat & Azim (2006), Hussain *et al*., (2007), Hussain & Ilahi (2009), Elizabeth et *al*., (2008) and Kamal & Bano (2008) also reported similar phytotoxicity for other plant species, which agree with the present results. Samreen *et al*., (2009) also observed that aqueous extracts from shoots of *Calotropis procera* were more toxic than other parts.

Table 1. Effect of aqueous extract of various parts of *Dodonaea viscosa* on germination (%), plumule and radical growth (mm), fresh and dry weight (mg) and moisture contents (%) of test species.

Each value is a mean of 5 replicates, each with 10 seedlings. Fresh weight, dry weight and moisture contents are mean of 20 seedlings.

Soaking duration and concentration	*Pennisetum americanum*				*Setaria italica*				*Sorghum vulgare*			
	5g / 24h	5g / 48h	10g / 24h	10g / 48h	5g / 24h	5g / 48h	10g / 24h	10g / 48h	5g / 24h	5g / 48h	10g / 24h	10g / 48h
	Germination %											
Control	98	96	98	98	98	100	98	98	100	100	100	100
Leaves	80*	88*	78*	84*	82*	72*	94	94	96	92*	96	96
Bark	88*	94	76*	80*	100	88*	96	94	92*	100	96	96
Flower	90	94	80*	80*	88	96	94	92	90*	94	88*	98
LSD value	11.42	9.175	9.943	10.60	12.72	11.99	9.715	14.22	6.704	6.704	5.996	5.996
	Plumule growth (mm)											
Control	50.84	50.84	50.84	50.84	40.48	40.48	40.48	40.48	85.60	85.60	85.60	85.60
Leaves	18.20*	14.98*	5.920*	4.200*	13.20*	4.240*	3.780*	3.960*	11.00*	15.00*	20.38*	16.40*
Bark	41.56*	59.48*	12.00*	15.62*	47.12	42.20	9.960*	11.18*	32.12*	9.28*	28.66*	26.38*
Flower	17.40*	21.74*	12.66*	7.480*	21.86*	23.94*	9.460*	7.180*	21.88*	32.94*	22.26*	19.10*
LSD value	6.914	5.628	6.159	5.362	11.45	9.542	8.120	7.051	13.32	12.99	12.06	11.30
	Radical growth (mm)											
Control	76.46	76.46	76.46	76.46	26.96	26.96	26.96	26.96	71.76	71.76	71.76	71.76
Leaves	21.14*	31.48*	8.680*	4.140*	1.460*	1.800*	9.020*	12.92*	34.08*	45.26*	19.88*	35.00*
Bark	75.50	87.12	25.58*	26.18*	38.20*	36.94*	11.34*	11.18*	57.68*	62.14*	23.68*	27.82*
Flower	31.36*	47.94*	28.88*	20.12*	4.900*	5.240*	3.220*	7.080*	29.30*	38.86*	29.64*	23.90*
LSD value	12.32	11.79	12.39	7.162	7.093	7.980	5.947	6.953	12.58	15.76	10.25	10.16

Table 1. (Cont'd.).

Soaking duration and concentration	*Pennisetum americanum*				*Setaria italica*				*Sorghum vulgare*			
	5g / 24h	5g / 48h	10g / 24h	10g / 48h	5g / 24h	5g / 48h	10g / 24h	10g / 48h	5g / 24h	5g / 48h	10g / 24h	10g / 48h
	Fresh weight (% of control)											
Leaves	46	54	34	44	77.77	40	100	100	51.21	51.21	60.97	51.21
Bark	84	84	54	54	104.44	100	50	100	45.12	91.46	57.31	87.8
Flower	60	44	44	54	100	80	100	100	69.51	47.56	60.97	63.41
	Dry weight (% of control)											
Leaves	76.47	58.82	58.82	64.7	90	100	140	200	94.59	94.59	94.59	86.48
Bark	58.82	76.47	76.47	58.82	100	100	180	175	72.97	148.6	86.48	89.18
Flower	70.58	70.58	58.82	70.58	100	100	140	200	100	94.59	94.59	113.8
	Moisture content (% of control)											
Leaves	31.25	53.12	21.87	37.5	132	25	40	62.5	15.55	15.55	33.33	22.22
Bark	100	90.6	43.75	53.12	62.5	100	62.5	50	22.22	44.44	33.33	86.66
Flower	53.12	31.25	37.5	46.87	100	75	90	62.5	44.44	8.88	33.33	33.33

*Significantly different from control at alpha 0.050 according to LSD method in one way ANOVA.

Fresh weight except that of *Setaria italica* was not affected, dry weight and moisture contents of test species were also retarded by the aqueous extracts from all parts. However, bark extract having concentration 10 g soaked for 24 and 48 hour promoted the dry weight of *Setaria italica*. Similarly, dry weight of *Sorghum vulgare* was unaffected but fresh weight and moisture contents significantly declined (Table 1). These findings are in line with the results of Pervez *et al*., (2003), Hussain *et al*., (2004), Hussain & Ilahi (2009) and Samreen *et al*., (2009) who reported similarly in their studies.

Hot water extracts from various tested parts significantly inhibited the germination and seedling growth of test species with the exception of *Setaria italica* in bark extracts. Similarly, germination of *Sorghum vulgare* remained unaffected in the flower extract. It was also seen that hot water extracts especially from leaves has more inhibitory effect than cold water extracts (Table 2). Chung *et al*., (2007) Peneva (2007), Hussain *et al*., (2004) and Hussain & Ilahi (2009) also reported hot water extracts to be allelopathic against test species. The use of hot water extract is unnatural but it reduces the time period for extraction of allelochemicals.

Fresh weight, dry weight and moisture contents of tested plant seedlings generally reduced in various treatments. However, the inhibition was related to test species. The dry weight of *Sorghum vulgare* remained unaffected in the leaves and bark extracts. Similarly, there was no significant change in dry weight and fresh weight of *Setaria italica* in the flower and leaves extracts, respectively (Table 2). Similar findings for *Broussonetia papyrifera* (Hussain *et al*., 2004), *Cenchrus ciliaris* and *Bothriochloa pertusa* (Hussain & Ilahi, 2009) and *Calotropis procera* (Samreen *et al*., 2009) have also been reported.

Plant litter generally increases soil fertility during decay but it has been seen that many species release phytotoxic substances before decay. It was observed that litter from leaves, bark and flowers when used as growth medium significantly reduced the germination, radical and plumule growth of all test species. Fresh weight, dry weight and moisture contents of all test species also got retarded (Table 3). These results agree with Kaul & Bansal (2002), who reported that *Ageratina adenphora* litter reduced growth of *Lantana camara*. Similarly, Maciel *et al*., (2003) also reached to similar results. Litter from *Cenchrus ciliaris* and *Bothriochloa pertusa* (Hussain & Ilahi, 2009) proved inhibitory to test species.

Allelopathic substances released by the plants accumulate in the soil to physiologicaly activity level (Hussain *et al*., 2004; Hussain & Ilahi, 2009; Samreen *et al*., 2009). Inderjit & Duke (2003) stated that plants release phytochemicals from dead tissues, and their incorporation to the soil could be accelerated by leaching thus facilitating their harmful effects in the field. This aspect when tested by using *Dodonaea viscosa* mulch in experiments significantly inhibited test species. These findings agree with those of Hussain *et al*., (2004) and Eppard *et al*., (2005) who also observed similar phytotoxicity by other plants.

The mode of action of allelochemicals spans over a wide range of actions including cell lysis, blistering or growth inhibition (Wu *et al*., 2003). *Dodonaea viscosa* contains natural resins, tanins, palmatic, stearic, behanic and other solid unsaturated acids (Haq & Mahboob, 1990), diterpenoid- and flavonoid-derivatives (Getie *et al*, 2002). Aerial parts of *D. viscosa* contain several flavonoids, diterpenoid acids, some biologically active saponins and plant acids, a novel *p*-coumarin acid ester, essential oils, sterols and tannins. These substances might be responsible for its allelopathy.

Table 2. Effect of hot water extract of various parts of *Dodonaea viscosa* on germination (%), plumule and radical growth (mm), fresh and dry weight (mg) and moisture contents (%) of test species.
Each value is a mean of 5 replicates, each with 10 seedlings. Fresh weight, dry weight and moisture contents are mean of 20 seedlings.

Test species	*Pennisetum americanum*	*Setaria italica*	*Sorghum vulgare*
	Germination %		
Control	98	98	100
Leaves	78*	84*	84*
Bark	88*	88*	80*
Flower	82*	88*	100
LSD value	10.17	9.240	5.996
	Plumule growth (mm)		
Control	50.84	40.48	85.10
Leaves	14.84*	12.12*	10.08*
Bark	35.08*	38.68	19.34*
Flower	20.84*	17.32*	18.22*
LSD value	5.814	7.441	9.617
	Radical growth (mm)		
Control	76.46	26.96	71.76
Leaves	4.120*	1.380*	34.74*
Bark	54.84*	29.34	21.38*
Flower	28.12*	2.100*	27.70*
LSD value	8.236	4.690	11.00
	Fresh weight (% of control)		
Leaves	50	88.88	51.21
Bark	70	55.55	57.31
Flower	44	44.44	40.24
	Dry weight (% of control)		
Leaves	70.58	75	94.59
Bark	88.23	25	89.18
Flower	64.70	100	29.72
	Moisture content (% of control)		
Leaves	40.62	100	15.55
Bark	62.5	80	31.11
Flower	34.37	32	48.88

*Significantly different from control at alpha 0.050 according to LSD method in one way ANOVA.

The present study suggests that *Dodonaea viscosa* is allelopathic plant, which is capable of suppressing the germination and growth of various test species. Allelophathic effects depended upon the parts assayed, test species and physiological process involved. Germination and growth were independently affected. Although the present results are laboratory based, yet it indicates the capability of *D. viscosa* to release allelopathic substances through water. In nature, it is quite possible that the poor seedling stands with in the thickets and its vicinity might partly be due to its allelopathy. However, further study is needed to explain allelopathic mechanism and to identify the allelopathic principle. It may also be investigated to test its efficacy as a weeds, pests and disease control agent.

Table 3. Effect of litter and mulch of *Dodonaea viscosa* on germination (%), plumule and radical growth (mm), fresh and dry weight (mg) and moisture contents (%) of test species. Each value is a mean of 5 replicates, each with 10 seedlings. Fresh weight, dry weight and moisture contents are mean of 20 seedlings

Treatment	Litter			Mulch		
Test species	*Pennisetum americanum*	*Setaria italica*	*Sorghum vulgare*	*Pennisetum americanum*	*Setaria italica*	*Sorghum vulgare*
	Germination %					
Control	98	98	100	94	94	94
Test	78*	90	82*	56*	84	80*
LSD value	6.522	8.628	4.612	18.16	16.63	11.76
	Plumule growth (mm)					
Control	50.84	40.48	85.60	76.76	60.20	99.38
Test	13.08*	20.50*	7.400*	11.40*	24.80*	17.88*
LSD value	5.483	8.681	13.36	9.126	6.811	6.138
	Radical growth (mm)					
Control	76.48	26.96	71,76	56.98	36.30	75.66
Test	10.20*	16.90*	16.34*	13.04*	9.120*	14.56*
LSD value	10.00	10.45	11.53	11.24	4.569	14.81
	Fresh weight (% of control)					
Test	24	81.39	79.26	20	71.11	55
	Dry weight (% of control)					
Test	29.41	68.18	116.21	27.7	69.23	48.88
	Moisture content (% of control)					
Test	21.87	95.23	48.85	15.2	63.63	32.35

*Significantly different from control at alpha 0.050 according to LSD method in one way ANOVA.

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