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ALLELOPATHIC POTENTIAL OF *POPULUS EUPHRATICA* OLIVIER

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Abstract

Populus euphratica Olivier is frequently cultivated deciduous tree in Pakistan on agricultural land for its shade, fodder, timber and fuel wood. A relatively reduced understorey is often observed below it. Therefore the present study was conducted to assess the allelopathic potential of *Popolus euphratica* against some crop species. Plant material of *Popolus euphratica* were collected from the agriculture fields of Lahor, District Swabi in 2008 and were dried at room temperature (25˚C-30˚C). Allelopathic studies conducted by using aqueous extracts from various parts including young leaves, mature leaves, bark, litter and mulching in various experiments invariably retarded the germination, plumule, radical growth, fresh and dry weight of *Sorghum vulgare* Perse, *Setaria italica* (L.) P. Beauv and *Triticum aestivum* L., in laboratory experiments. The aqueous extracts obtained after 48 h were more inhibitory than 24 h. Leaves were more toxic than bark. Litter and mulching experiments also proved to be inhibitory. It is suggested that the various assayed parts of *Populus euphratica* have strong allelopathic potential at least against the tested species. Further investigation is required to see its allelopathic behavior under field condition against its associated species and to identify the toxic principles.

Introduction

The antagonistic effects of certain tree species such as walnut tree (*Juglan* spp.) on understorey plants and nearby crops were known to human centuries ago (Hussain *et al.*, 1991; Rizvi & Rizvi, 1992; Willis, 2000, 2004; Jabeen *et al*., 2011). Allelopathy governs the community dynamics, pattern and productivity in natural and agroecosystem (Duke *et al*., 2001; Irshad & Cheema, 2004; Rice, 1984; Willis, 2000 ;). Many trees such as *Juglan regia* (Hussain *et al.*, 1991), *Broussonetia papyrifera* (Hussain *et al.*, 2004), *Melia azedarch* (Hussain *et al.*, 1987), *Eucalyptus Sp*. (Malik & Shah, 1995; Gilani *et al*., 2002; Shah, 1991) are known to exhibit allelopathy to preclude the associated species by reducing their regeneration, growth and yield. Aqueous shoot extracts of *Imperata cylindrica* is responsible for observed reduced root and shoot growth, yield, nodulation and VA mycorrhiza in *Vigna radiata* and *Phaseolus vulgaris* due to its inhibitory effect (Bushra *et al.*, 2000). Allelopathic properties of *Sorghum* is used to control weeds in irrigated wheat (Cheema & Khaliq, 2000). Experiments were conducted to evaluate the impact of allelopathic potential of *Parthenium hysterophorus* on germination, growth and yield of maize (*Zea mays* L.) as well as the role of Vesicular Arbuscular Mycorrhiza (VAM) in alleviating allelopathic stress (Rukhsna *et al.*, 2003). There are evidences of allelopathy as ecological factor in plant invasion (Bias *et al.*, 2002, 2003; Callaway & Aschehoug, 2000; Vivanco *et al*., 2004).

Popolar (*Popolus euphratica*) is frequently cultivated deciduous tree in Pakistan on agricultural land for its shade, fodder, timber and fuel wood. A relatively reduced under storey is often observed below it. We suspected an allelopathic mechanism in *Popolus euphratica* that might affect the susceptible species. Therefore, the present study was conducted to assess the allelopathic potential of *Popolus euphratica* against some crop species.

Materials and Methods

Young and mature leaves and bark of *Popolus euphratica* were collected from the agriculture fields of Lahor District Swabi and were dried at root temperature (25˚C-30˚C). They were powdered and stored in paper bags. Glassware, thoroughly washed with tap water, was sterilized at 170˚C for at least 4 hours. All the results were statistically analyzed using Bartlett's test in one-way ANOVA.

Effect of aqueous extracts: Five and 10 gm of each part of plant was 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 *Sorghum vulgare*, *Setaria italica* and *Triticum aestivum* on 2-folds of filter paper in Petri dishes. The filter papers were moistened with the respective extracts, while distilled water was used as a control. For each treatment, five replicates, each with 10 seeds were made. The Petri dishes were incubated at 25˚C. After 72 hours, % germination, growth of plumule and radicle were noted. Twenty seedlings were randomly taken out for fresh and dry weight determination. Seedlings were dried at 65˚C for 72 hours.

Effect of litter: Five gm litter from young and mature leaves, and bark were crushed and spread on one fold of filter paper in a Petri dish. The filter papers were moistened with 5ml distilled water. In control treatment fine pieces of filter paper were used. For each treatment, five replicates, each with 10 seeds were made. The Petri dishes were incubated at 25˚C. After 72 hours, % germination, growth of plumule and radicle were recorded. Twenty seedlings were randomly taken out for fresh and dry weight determination as earlier.

Effect of hot water extracts: Five gm 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.

Effect of mulching: Five gm crushed dried young and mature leaves, and bark were placed in plastic glasses containing sterilized moist sand for test. Control consisted of sand only. For each treatment five replicates, each with 10 seeds was made. The plastic glasses were incubated at 25˚C and daily observed for germination. After germination the glasses were transferred to light at room temperature (25-30˚C). Plumule and radicle growth were measured after 15 days. Twenty seedlings were randomly taken out for determining fresh and dry weight and moisture contents.

Results

Effect of aqueous extracts: The present study suggested that all the tested parts of *Popolus euphratica* exhibited had inhibitory effect against plumule and radicle growth. However, the effect on germination was variable. Aqueous extracts with 5 g concentration soaked for 24h from all the three parts did not affect the germination of S*orghum vulgare* and *Setaria italica* while there was significant reduction in the germination of *Triticum aestivum.* Aqueous extracts with 5 g concentration soaked for 48 hours reduced germination of *Triticum aestivum.* Bark did not reduce the germination of S*orghum vulgare* and *Setaria italica.* Young leaves significantly reduced the germination in S*orghum vulgare* and *Setaria italica.* Aqueous extracts with 10 g concentration soaked for 24 and 48 h of all the three parts significantly reduced the germination of S*orghum vulgare* and *Setaria italica* while completely inhibited the germination of *Triticum aestivum.* Fresh and dry weights of all the test species were significantly reduced by aqueous extracts. However, aqueous extracts with 5 g concentration soaked for 24h from bark stimulated fresh and dry weight of *Setaria italica*. Moisture contents of the seedlings increased in *Setaria italica* but decreased in S*orghum vulgare*. Inconsistent results observed for *Triticum aestivum* (Table 1).

Table 1. Effect of aqueous extract on germination, plumule & radical growth, fresh and dry weight and moisture contents of the test species. Each value is a mean of 10 replicates each with 10 seedlings.

Test species	*Sorghum vulgare*			*Setaria italica*			*Triticum aestivum*		
Concentration (g) & soaking duration	**Young leaves**	**Mature leaves**	**Bark**	**Young leaves**	**Mature leaves**	**Bark**	**Young leaves**	**Mature leaves**	**Bark**
	Germination %								
Control	100	100	100	94	96	94	94	94	94
5g/24h	92	90	98	90	88	100	*80	*86	*72
5g/48h	*72	92	98	*78	*78	100	*84	*78	*80
10g/24h	*66	*86	*88	*68	*82	*72	0	0	*80
10g/48h	*72	*76	*70	*70	*76	*76	0	0	*74
LSD value	13.71	9.873	8.550	13.45	9.695	7.917	8.550	5.277	11.50
	Radical growth (mm)								
Control	56.50	57.90	62.50	50.36	48.14	49.64	24.76	24.86	25.68
5g/24h	*21.04	*14.40	*25.12	*8.94	*9.02	*54.96	*0.96	*0.92	*8.84
5g/48h	*7.62	*22.42	*27.28	*7.56	*6.92	*16.62	*3.94	*4.46	*3.9
10g/24h	*7.70	*10.38	*28.52	*4.16	*7.20	*12.92	0	0	*2.08
10g/48h	*5.64	*5.64	*11.76	*1.38	*5.16	*11.12	0	0	*2.16
LSD value	10.44	17.36	8.58	4.915	2.838	3.959	5.894	4.987	4.549
	Plumule growth (mm)								
Control	59.16	55.96	57.2	36.78	36.02	31.54	36.26	33.72	32.38
5g/24h	*8.82	*6.8	50.04	*1.14	*1.48	34.02	*9.18	*8.84	*22.3
5g/48h	*1.68	*7.12	*40.18	*1.86	*1.60	*21.56	*1.30	*1.72	*9.8
10g/24h	*0.60	*4.08	*19.72	*0.02	*0.94	*10.46	0	0	*5.54
10g/48h	*2.78	*1.76	*16.04	0	*0.42	*1.52	0	0	*6.86
LSD value	3.859	6.006	8.930	3.540	2.790	5.079	3.275	3.042	4.230
	Fresh weight (% of control)								
5g/24h	48.57	56.81	88	85.71	93.33	111.76	75.86	86.20	75.86
5g/48h	54.28	62.50	80	85.71	93.33	94.11	82.75	82.75	68.96
10g/24h	34.28	51.13	88	78.57	100	88.23	0	0	65.51
10g/48h	40	34.09	72	71.42	93.33	82.35	0	0	62.06
	Dry weight ((% of control)								
5g/24h	56	67.46	87.50	79.36	92.30	106.66	103.44	137.5	82.35
5g/48h	64	71.42	81.25	79.36	100	86.66	114.94	125	70.58
10g/24h	40	55.55	100	71.42	100	80	0	0	64.70
10g/48h	44	39.68	75	63.49	84.61	86.66	0	0	58.82
	Moisture contents ((% of control)								
5g/24h	53.55	44.45	101.58	180.01	108.32	140.66	33.33	16.76	80.95
5g/48h	39.45	55.99	95.71	180.01	500	173.06	30	24.61	94.44
10g/24h	50	72	66.66	200	100	187.54	0	0	103.03
10g/48h	68.17	50.40	88.88	225.02	177.30	576.89	0	0	113.34

Effect of litter: The germination, plumule and radicle growth of all test species significantly declined when grown on litter beds (Table 2). Except the dry weight of *Triticum aestivum*, the fresh and dry weight of all the test species was also retarded. Moisture contents of *Setaria italica* and *Triticum aestivum* declined while that of *Sorghum vulgare* were increased (Table 2).

Effect of hot water extracts: The germination and seedling growth of all test species was inhibited by hot water extracts from all parts. It appeared that hot water extracts had more inhibitory effect than cold water extracts. Furthermore, hot water extracts from leaves were more toxic than bark. Fresh weight of all the test species declined and dry weight of *Setaria italica* and *Triticum aestivum* decreased. Moisture contents of S*orghum vulgare* declined while that of *Setaria italica* and *Triticum aestivum* increased (Table 3). It was concluded that hot water extracts exhibited more inhibitory effects on test species than cold water extracts.

Table 2. Effect of litter on germination, plumule and radical growth, fresh and dry weight and moisture contents of test seedlings. Each value is a mean of five replicates each with 10 seedlings.

Test species	*Sorghum vulgare*	*Setaria italica*	*Triticum aestivum*
	Germination %		
Control	84	88	84
Test	*76	80	74
LSD value	7.988	11.30	10.82
	Plumule growth (mm)		
Control	67.74	69.04	8.1
Test	*19.02	*16.5	*2.16
LSD value	8.898	10.71	2.586
	Radical growth (mm)		
Control	44.3	23.2	15.94
Test	*12.3	*7.26	*6.94
LSD value	12.36	4.127	4.275
	Fresh weight (% of control)		
Test	85.71	73.17	96.15
	Dry weight (% of control)		
Test	76.92	76.92	105.88
	Moisture contents (% of control)		
Test	260.01	76.48	73.44

Effect of mulching: The added plant materials significantly reduced the germination in all the test species except the germination of S*orghum vulgare* by mature leaves and bark (Table 3). Plumule and radicle growth is significantly declined. Fresh and dry weight, and moisture contents of all the test species decreased in all the treatments (Table 3).

Discussion

Allelopathy involves the addition of some toxic substances into the habitat to render it unfavorable. The present study shows that the germination and seedling growth of the tested species was significantly arrested by the aqueous extract obtained from various parts of *Popolus euphratica.* Similar trend was observed for *Prosopis juliflora, Eucalyptus camaldulensis, Acacia nilotica* and *Euclyptus* (Gillani *et al.*, 2002; Marwat & Azim, 2006; Rukhsana & Iffat, 2005). These findings are also in line with the results for *Broussonetia papyrifera* (Hussain *et al.*, 2004) and *Artemsia iwayomogi* (Yoo *et al*., 2000). These results suggest that toxicity of various parts depended upon the part assayed, concentration, soaking time and sensitivity of test species.

Litter generally increase the soil fertility but might also exhibit toxicity during decomposition (Saxena, 2000; Jabeen & Ahmed, 2009). *Broussonetia papyrifera* reduced germination and growth of *Pennisetum americanum, Setaria italica* and *Lactuca sativa* (Hussain *et al*., 2004). Toxic substances released by the plants accumulate in the soil to physiologically active level (Hussain *et al*., 2004: Fujii, 2001; Jefferson & Pennacchio, 2003; Startsev *et al.*, 2008). Since hot water extracts inhibited the germination and seedling growth of test species, therefore it appeared that hot water extracts retained phytotoxicity and that they were more inhibitory than the cold water extracts. Our findings agree with other workers in this respect (Hussain *et al*., 2004; Jefferson & Pennacchio, 2003; Startsev *et al.*, 2008; Hussain *et al.*, 1987; Tseng *et al*., 2003).

Allelochemicals may inhibit plant growth by affecting the division, elongation and ultra-structure of cells or by altering the normal physiological processes such as photosynthesis, respiration, mineral uptake and enzyme activity (Tseng *et al.*, 2003). Toxins might affect chlorophyll contents of susceptible plants that also lead to reduction of growth. The poor moisture contents of seedlings might be due to some disorders in the water absorption mechanism by roots or the toxins might have created physiological drought for the affected seedlings and this could be true for *Popolus euphratica* that has reduced the moisture contents of susceptible species. Low moisture contents imbalance physiological functions leading to adverse effects on growth of plants. The findings suggested that *Popolus euphratica* exhibits

strong allelopathy through the release of some water soluble allelochemicals from the live parts and litter into the immediate soil (Barkatullah *et al.*, 2010; Hussain *et al.*, 2010). It is suggested that the various assayed parts of *Populus euphratica* have strong allelopathic potential at least against the test species. Further investigation is required to see its allelopathic behavior under field cultivation against its associated species and to identify the toxic principle.

Table 3. Effect of hot water extract and soil intoxication on germination, plumule and radical growth, fresh and dry weight and moisture contents of test seedlings. Each value is a mean of five replicates each with 10 seedlings.

Parameters	Hot water extract			Soil intoxication		
Test species	***Sorghum vulgare***	***Setaria italica***	***Triticum aestivum***	***Sorghum vulgare***	***Setaria italica***	***Triticum aestivum***
	Germination %					
Control	96	94	94	60	60	70
Young leaves	*82	*78	*74	*14	0	0
Mature Leaves	*80	*78	*46	*54	*38	0
Bark	*80	*70	*64	*50	0	*10
LSD value	8.210	8.741	9.943	22.33	20.33	20.11
	Plumule growth (mm)					
Control	61.60	50.26	24.78	89.70	47.28	94.58
Young leaves	*16.52	*7.8	*1	*7.8	0	0
Mature Leaves	*18.86	*6.38	*0.56	*40.88	*16.54	0
Bark	*13.28	*12	*0.9	*31.8	0	*8
LSD value	6.360	5.188	6.590	27.79	15.30	23.73
	Radical growth (mm)					
Control	39.50	36.14	36.44	28	23.5	45.06
Young leaves	5.04	*0.38	*3.56	*2.4	0	0
Mature Leaves	4.96	0	*0.84	*12.24	*8.98	0
Bark	40.24	*5.16	*3.3	*7.66	0	*10
LSD value	5.018	4.061	3.660	9.565	6.177	17.78
	Fresh weight (% of control)					
Young leaves	88	94.11	80	60	0	0
Mature Leaves	92	94.11	68	80	80	0
Bark	88	94.11	48	77.5	0	34.52
	Dry weight (% of control)					
Young leaves	94.11	87.5	68.42	88.23	0	0
Mature Leaves	105.88	93.75	63.15	94.11	94.11	0
Bark	105.88	93.75	52.63	88.23	0	45.16
	Moisture contents (% of control)					
Young leaves	79.70	228.48	169.40	44.34	0	0
Mature Leaves	59.02	106.56	131.96	73.91	73.91	0
Bark	47.22	106.56	63.35	78.83	0	62.66

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