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Efficacy of Some Forest Species Extracts on Wheat and Two Major Weeds in Arid Zone of NWFP

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ABSTRACT

Studies were undertaken in the Weed Research Laboratory, Department of Weed Science, NWFP Agricultural University, Peshawar, Pakistan to investigate the allelopathic potential of aqueous extracts of the leaves of *Prosopis juliflora* (Sw.) DC. and *Eucalyptus camaldulensis* Dehnh. the bark of *Acacia arabica* (Lam.) Willd. The concentrations studied included 0, 50, 100 and 150 g L^{-1} (w/v). A check, tap water (0 g L^{-1}) was also included for comparison. The dry plant materials were ground and soaked for 24 hours in water. Ten seeds each of wheat (*Triticum aestivum* L. em. Thell.), wild oats (*Avena fatua* L.), and wild safflower (*Carthamus oxyacantha* (Co. Cr.)) were used. Inhibition varied in all the species tested for all parameters studied, but it affected germination percentage most. *C. oxyacantha* was the most inhibited species, whereas wheat was the most tolerant. Only 20% of *C. oxyacantha* seeds as compared to the respective untreated check germinated when exposed to *E. camaldulensis* at 150 g L^{-1}. All other concentrations of *P. juliflora* and *E. camaldulensis* severely inhibited germination of *C. oxyacantha*. Inhibition of seedling length and biomass was observed at higher concentrations of *P. juliflora* and *E. camaldulensis*. *A. arabica* was the weakest species in terms of its capacity to inhibit the growth parameters of all three test species. These findings reveal that the allopathic potential of the effective species could be exploited for weed management in wheat due to the tolerance of wheat and susceptibility of its related weeds to the extracts.

Keywords: *Acacia*, allelopathy, *Eucalyptus*, inhibition, phytotoxicity, *Prosopis*

INTRODUCTION

There is convincing evidence that allelopathic interactions between plants play a crucial role in natural as well as in manipulated ecosystems. In recent times evidence is accumulating that all types of plants, viz. herbs, shrubs and trees, allelopathically affect the patterning of vegetation, largely in their immediate vicinity (Anonymous 2004). One of the most worked out aspects of allelopathy in manipulated ecosystems is the role of allelopathy in agriculture. In this, the effects of weeds on crops, crops on weeds and crops on crops have been invariably emphasized. In addition, the possibility of using allelochemicals as growth regulators and natural pesticides (a number of them are either commercially available or in the process of large-scale manufacture) promotes sustainable agriculture. Allelopathic interactions have been demonstrated to play a crucial role in natural as well as man-made forests. Such interactions are pivotal in determining the composition of the vegetation growing as under storey and in understanding the forest regeneration problems. Some recent findings (Oweyegha-Afunaduula 2008) have demonstrated that tree-crop interactions may have significant bearings on the total productivity of an agroforestry system (simultaneously or sequentially combined production of crops and forest plants). Therefore, it seems essential that the allelopathic compatibility of crops with trees should be checked before being introduced to an agroforestry system. Research is continuing in all these areas and many ideas have been floated in an attempt to understand the phenomenon of allelopathy more deeply and to exploit it more fully to boost the production of manipulated ecosystems. Several reports address the allelopathic potential of trees species. Khan (2003) cited that there are many theories about the advent of *Prosopis juliflora* in the local habitat. Some say that it came into the region (Pakistan) in the fodder for the horses of British soldiers while the government from Australia imported *Eucalyptus* for forestation purposes. Al-Humaid and Warrag (1998) reported that the germination percentage of *Cynodon dactylon* seeds decreased with increasing leaf extract concentration of *P. juliflora*. Chellamuthu *et al*. (1997) reported that germination of black gram (*Vigna mungo*) and sorghum (*Sorghum bicolor*) was inhibited as the rate of water extracts increased. Velu *et al*. (1996) reported the allelopathic effects of *Eucalyptus camaldulensis*, *P. juliflora* and *Acacia arabica* on legumes seeds. Duhan and Lakshminarayana (1995) bioassayed *A. arabica* trees and their bark to test their allelopathic effects on germination and seedling growth of *Cyamopsis tetragonoloba* and *Pennisetum glaucum*. Both types of extracts strongly inhibited seed germination and seedling growth of both test species. Putnam (1984) reported that *Eucalyptus* species released volatile compounds such as benzoic, cinnamic and phenolic acids, compounds which generally inhibit the growth of crops and weeds growing near it. Pawar and Chawan (1999) reported that some forest trees, including *Eucalyptus globulus*, reduced uptake of Ca, Zn and Mg in sorghum resulting in reduced growth. They further added that *E. globulus* caused the greatest reduction in the absorption of Ca in sorghum. Schumann *et al*. (1995) reported that *Eucalyptus grandis* water extracts significantly reduced weed establishment. Cheema *et al*. (2003) advocated the commercial utilization of sorghum water extracts for weed management in wheat. Recent studies undertaken by our group (Khan *et al*. 2004a, 2004b, 2005; Rashid *et al*. 2008) manifest the variable response of extracts on different weed and crop species.

Keeping in view the importance of the allelopathic potential of some forest tree species, an experiment was con-

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ducted under laboratory conditions with the objective of appraising the allelopathic status of different forest trees and assessing the behaviour of wheat and some of its major weeds under varying regimes of allelopathins.

MATERIALS AND METHODS

Laboratory experiments were conducted during October/November 2003 in the Weed Research Laboratory, Department of Weed Science, NWFP Agricultural University Peshawar, Pakistan to investigate the allelopathic potential of some forest species on wheat and some of its worst weeds. The experiments were laid out in a completely randomized design, using Petri dishes. The seeds of the crop and weeds tested in this experiment were collected during April-May 2003 from the arid zone and stored at room temperature. The experiment was repeated under ambient conditions at room temperature (~25°C). Ten seeds each of wheat (*Triticum aestivum* L. em. Thell.), wild oats (*Avena fatua* L.), and wild safflower [*Carthamus oxyacantha* (Co. Cr.)] were placed on blotting paper in Petri dishes. The seeds of the test species were treated with fungicide Topsin-M 70% at 2 g kg^{-1} to safeguard from fungal attack. The leaves and bark were collected during the flowering stage of the trees. The ground dry (in shade) leaves of mesquite *Prosopis juliflora* (Sw.) DC. and river red gum *Eucalyptus camaldulensis* Dehnh. and ground bark of babul *Acacia arabica* (Lam.) Willd. were soaked for 24 hours in tap water at room temperature. Since fungus once attacked the aqueous extracts of leaves of *P. juliflora*, once again powder leaves was soaked and fungicide was added to each extract at the same concentration. The concentrations of *P. juliflora*, *E. camaldulensis* and *A. arabica* were 0, 50, 100 and 150 g L^{-1} (tap water) [v/v]. The first run comprised 3 species and 3 rates highlighted as above in a completely randomized design with 4 repeats. The second run was undertaken with the same protocol. Each treatment comprised of a single Petri dish for each species and to which the different of extracts were applied. Controls (0 g L^{-1}) consisted of tap water. After 18 days, data on seed germination percentage, seedling length (mm) and biomass yield per seedling (mg) were recorded during the course of studies. The data for each parameter were converted to a percentage of the untreated check and subsequently mean data for two runs were subjected to ANOVA and the means were separated by the Student Newmann Keul's Multiple Range test by using MSTATC software (Steel and Torrie 1980).

RESULTS AND DISCUSSION

Germination percentage

Plant extracts from different species, their concentrations and interaction had a significant (P≤0.05) effect on germination of *T. aestivum*, *A. fatua*, and *C. oxyacantha*. The highest inhibition of germination was observed in *C. oxyacantha* (54.86%); germination was highest in wheat (**Table 1**). Among the extract concentrations, the seed germination in 150 g L^{-1} extracts of *P. juliflora* and *E. camaldulensis* was significantly lower than untreated check (**Table 1**). Regarding the interaction of extracts with the test species, germination as a percentage of the untreated check varied between 92.98 (*P. juliflora* at 150 g L^{-1}) to as high as 102.56% (*A. arabica* at 50 g L^{-1}) [**Table 1**] in *T. aestivum*, while a drastic inhibition was observed in *C. oxyacantha*, whose germination ranged between 20.51 (*E. camaldulensis* at 150 g L^{-1}) and 79.49% (*A. arabica* at 100 g L^{-1}). In *A. fatua* the inhibition was moderate ranging from 40.32 (*P. juliflora* at 150 g L^{-1} to 109.68% of the untreated check (*A. arabica* at 50 g L^{-1}). The interaction means indicated that 150 and 100 g L^{-1} of either *P. juliflora* or *E. camaldulensis* strongly inhibited seed germination of all three species tested, but to different levels (**Table 1**). The remaining concentrations of these species and all the three concentrations of *A. arabica* failed to inhibit germination of the species under reference. The germination of *C. oxyacantha* was inhibited most, in general. The data support that any concentration of extracts from the species tested failed to inhibit the germination of wheat, which implies that these tree species could be intercultivated in wheat without harming the wheat crop in a farm agro-forestry system. Moreover, the benefit of their adverse effect on *A. fatua* and *C. oxyacantha* will contribute further to wheat productivity. Noor *et al*. (1995) and Khan *et al*. (2005) also reported that leaf extracts of *P. juliflora* had no drastic effect on wheat seed germination when applied at 10%. Al-Humaid and Warrag (1998) reported that seed germination of *Cynodon dactylon* decreased with increasing leaf extract concentration of *P. juliflora*. Chellamuthu *et al*. (1997) suggested that the allelopathic effect of *P. juliflora* leaf litter is due to the presence of phenolic compounds.

Seedling length

Plant extracts from different species, concentrations and their interaction had a significant (P≤0.05) effect on seedling length of *T. aestivum*, *C. oxyacantha* and *A. fatua*. For the main effects of species the seedling length as a percentage of check data has been presented in **Table 2**. It was noted that the highest inhibition in seedling length was observed in *C. oxyacantha* (74.32%), while the least inhibition in the seedling length was in wheat. Among the extract

Table 1 Effect of different tree species, concentrations and species × extracts interaction on germination percentage of *Triticum aestivum*, *Avena fatua*, and *Carthamus oxyacantha*.

Species extract (g L^{-1})	*T. aestivum*		*C. oxyacantha*		*A. fatua*		Concentration means	
	Germination %	% of untreated check	Germination %	% of untreated check	Germination %	% of untreated check	Germination %	% of untreated check
P. juliflora 150	92.50 ab	92.98	18.75 jk	38.48	31.25 h-j	40.32	47.50 de	63.69
P. juliflora 100	93.75 ab	96.15	20.00 jk	41.03	46.26 e-h	59.69	53.33 de	71.51
P. juliflora 50	93.75 ab	96.15	32.50 g-j	66.67	58.75 de	75.81	61.67 bc	82.69
E. camaldulensis 150	92.50 ab	94.87	10.00 k	20.51	35.00 g-j	45.16	45.83 e	61.45
E. camaldulensis 100	95.00 ab	97.44	17.50 jk	35.90	53.75 ef	69.35	55.42 cd	74.31
E. camaldulensis 50	96.25 a	98.72	21.25 i-k	43.59	71.25 cd	91.94	62.92 bc	84.37
A. nilotica 150	98.75 a	101.28	30.00 h-j	61.54	73.75 cd	95.16	67.50 ab	91.51
A. nilotica 100	95.00 ab	97.44	38.75 f-i	79.49	73.75 cd	95.16	69.17 ab	92.75
A. nilotica 50	100.0 a	102.56	27.50 ij	56.41	85.00 a-c	109.68	70.83 ab	94.97
0 (Check)	97.50 a	100.00	48.75 e-g	100.00	77.50 bc	100.00	74.58 a	100.00
Species Means	95.50 a	97.76	26.50 c	54.86	60.63 b	78.22	-	81.72
$S.E_{0.05}$ for Species germination	± 1.309							
$S.E_{0.05}$ for conc. On germination	± 2.390							
$S.E_{0.05}$ for Interaction on germination	± 4.139							

Means sharing a letter in common in the respective category do not differ significantly by SNK multiple range test.

Table 2 Effect of different tree species, concentrations and Species x Extracts interaction on seedling length (mm) plant^{-1} of *Triticum aestivum*, *Avena fatua*, and *Carthamus oxyacantha*.

Species extract (g L^{-1})	*T. aestivum*		*C. oxyacantha*		*A. fatua*		Conc. means	
	Seedling length	**% of untreated check**	**Seedling length**	**% of untreated check**	**Seedling length**	**% of untreated check**	**Seedling length**	**% untreated check**
P. juliflora 150	49.88 d-g	73.62	13.63 hi	75.18	29.38 g-I[1]	32.92	30.96 cd	53.32
P. juliflora 100	50.88 d-g	75.10	11.13 hi	61.39	54.25 d-g	60.78	38.75 bc	66.38
P. juliflora 50	58.75 c-f	86.72	17.75 hi	97.9	75.50 a-d	84.59	50.67 ab	86.79
E. camaldulensis 150	37.50 f-h	55.35	6.50 i	35.85	30.00 g-i	33.61	24.67 d	42.26
E. camaldulensis 100	44.88 e-g	66.24	13.38 hi	73.80	66.13 b-e	74.10	41.46 bc	71.02
E. camaldulensis 50	52.38 d-g	77.32	18.00 hi	99.28	81.38 a-c	91.18	50.58 ab	86.64
A. nilotica 150	54.00 d-g	79.70	12.38 hi	68.28	85.13 ab	95.38	50.50 ab	86.50
A. nilotica 100	62.75 b-f	92.62	14.88 hi	82.07	93.38 a	104.63	57.00 a	97.64
A. nilotica 50	57.88 c-f	85.43	9.00 hi	49.64	88.75 ab	99.44	51.88 ab	88.87
0 (Check)	67.75 a-e	100.00	18.13 hi	100.00	89.25 ab	100.00	58.38 a	100.00
Species Means	53.66 b	79.21	13.48 c	74.32	69.31 a	69.31	-	77.94
$S.E_{0.05}$ for Species seedling length	± 1.924							
$S.E_{0.05}$ for conc. on seedling length	± 3.513							
$S.E_{0.05}$ for Interaction on seedling length	± 6.085							

Means sharing a letter in common in the respective category do not differ significantly by SNK multiple range test.

Table 3 Effect of different tree species, concentrations and Species x Extracts interaction on biomass yield (mg plant^{-1}) of *Triticum aestivum*, *Avena fatua*, and *Carthamus oxyacantha.*

Species extract (g L^{-1})	*T. aestivum*		*C. oxyacantha*		*A. fatua*		Conc. means	
	Biomass	**% of untreated check**	***Biomass***	**% of untreated check**	***Biomass***	**% of untreated check**	***Biomass***	**% of untreated check**
P. juliflora 150	57.88 a-e	85.27	22.25 e-g	70.63	25.38 d-g[1]	43.20	35.17 bc	66.72
P. juliflora 100	60.00 a-e	88.39	17.88 fg	56.76	52.13 a-f	88.73	43.33 ab	84.10
P. juliflora 50	77.13 a	113.63	29.75 b-g	94.44	64.88 ab	110.43	57.25 a	108.61
E. camaldulensis 150	41.25 a-g	60.77	9.375 g	29.75	26.00 c-g	44.26	25.54 c	48.45
E. camaldulensis 100	50.75 a-f	74.76	19.50 fg	61.90	46.88 a-f	79.80	39.04 a-c	74.07
E. camaldulensis 50	59.00 a-e	86.92	24.75 d-g	78.57	64.25 a-c	109.36	49.33 ab	93.59
A. nilotica 150	67.63 ab	99.63	21.13 e-g	67.08	62.38 a-d	106.18	50.38 ab	95.58
A. nilotica 100	67.88 ab	100.00	25.50 d-g	80.95	59.63 a-e	101.50	51.00 ab	96.76
A. nilotica 50	63.88 a-c	94.11	14.63 fg	46.44	50.88 a-f	86.60	43.13 ab	81.83
0 (Check)	67.88 ab	100.00	31.50 b-g	100.00	58.75 a-e	100.00	52.71 ab	100.00
Species Means	61.33 a	90.37	21.63 c	68.68	51.11 b	87.04	-	84.97
$S.E_{0.05}$ for Species	± 2.401							
$S.E_{0.05}$ for Concentrations	± 4.384							
$S.E_{0.05}$ for Interaction	± 7.593							

Means sharing a letter in common in the respective category do not differ significantly by SNK multiple range test.

concentrations, seedling length (compared to the untreated check) was strongly inhibited in 150 g L^{-1} extracts of *P. juliflora* and *E. camaldulensis* (53.32 and 42.26%, respectively) (**Table 2**). Only slight inhibition in seedling length was observed across all concentrations of *A. arabica*. For the interaction of extracts with test species, the seedling as the percent of untreated check varied between 55.35 (*E. camaldulensis* at 150 g L^{-1}) to as high as 92.62% (*A. arabica* at 100 g L^{-1}) (**Table 2**) in *T. aestivum*, while a drastic inhibition was observed in *A. fatua*, 32.92 and 33.61% in *P. juliflora* and *E. camadulensis* extracts, both at 150 g L^{-1}. In *C. oxyacantha*, inhibition was only severe under *E. camaldulensis* 150 g L^{-1} (**Table 2**). The remaining concentrations of these species and all the three concentrations of *A. arabica* failed to inhibit the seedling length of *T. aestivum*, *A. fatua* and *C. oxyacantha*. The data again support that any concentration of extracts from the species tested failed to inhibit the germination of wheat, which implies that these tree species could be inter-cultivated in wheat without harming the wheat crop in a farm agro-forestry system. Moreover, the benefit of their adverse effect on *A. fatua* and *C. oxyacantha* will have a positive impact on wheat productivity. These findings are corroborated by the work of El-Fadl (1997) who reported that water extracts of *Prosopis* inhibit germination and retard seedling development when applied at concentrations greater than 5%. Moreover, the findings of Khan *et al*. (2003) exhibit the inhibitory effect of *E. camaldulensis* at 10% solution on the growth parameters of maize. Pawar and Chawan (1999) reported that some forest trees, including *Eucalyptus globulus*, reduced nutrient uptake in sorghum resulting in reduced growth. Our inferences are further supported by the findings of Babu and Kandasamy (1997) who reported that 20 and 40% (w/v) leachate of fresh leaves of *E. globulus* significantly suppressed the establishment of *Cyperus rotundus* L. and *Cynodon dactyllon* L.

Biomass yield

As for the other plant parameters studied, statistical analysis of data showed that plant extracts from different species, concentrations and their interaction had a significant ($P \leq 0.05$) effect on biomass yield of *T. aestivum*, *A. fatua*, and *C. oxyacantha*. The species varied in their genetic potential to accumulate biomass. However highest biomass (61.33) was recorded in *T. aestivum* followed by *A. fatua* and *C. oxyacantha* (**Table 3**). The data computed as % of untreated check exhibited least inhibition in wheat

(90.37%), while the highest inhibition was recorded in *C. oxyacantha* (68.68%). Across the concentrations, the lowest biomass (25.54 mg) was obtained in *E. camaldulensis* at 150 g L^{-1}. It was however, statistically comparable with the extract of the same species at 100 g L^{-1} and *P. juliflora* at 150 g L^{-1} (**Table 3**). The percentage data also exhibited maximum inhibition in the two preceding concentrations, 48.45 and 66.72%, respectively. The interaction of species x concentration revealed that biomass was mostly not affected by different concentrations. Conversely, in *A. fatua* there was a stimulatory effect under the lower concentrations of the extracts of toxic tree species viz. *P. juliflora* and *E. camaldulensis*. There was stimulatory effect of *Parthenium* root extracts on shoot length of maize (Rashid *et al*. 2008). However, the highest concentrations of these tree species emerged very lethal to *A. fatua* and the highest concentration of *E. camaldulensis* depressed *C. oxyacantha* as well (**Table 3**). These results are analogous to those reported by Noor *et al.* (1995) who reported that water extracts of *Prosopis juliflora* L. fruit and seed at 10% solution delayed and reduced germination, root, shoot and seedling growth of different cultivars of wheat and maize.

CONCLUSIONS

Our findings indicate that plant growth parameters are inhibited by exposure of their seeds to the extracts of *P. juliflora* and *E. camaldulensis*. *A. arabica* bark extracts failed to inhibit any of the plants at almost any of the concentrations. The inhibition of *T. aestivum* growth was either non-existent or very moderate compared to the tested weed species. Thus, the differential response of wheat, wild oats and wild safflower to the extracts exhibits the potential of the test species as natural herbicides for weed management in wheat cropping systems. Further studies are proposed to streamline the feasibility of the commercial utilization of *P. juliflora* and *E. camaldulensis* as natural herbicides and identify the inhibitors to use as templates for the synthetic herbicides.

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JAPANESE ABSTRACT

パキスタン、ペシャワールの NWFP 農業大学雑草科学科雑草研究室において、*Prosopis juliflora* (Sw.) DC. および *Eucalyptus camaldulensis* Dehnh. の葉および *Acacia arabica* (Lam.) Willd.の外皮から得られた計 3 種の水溶性抽出物を用いてアレロパシー活性試験を行った。植物体をそれぞれ乾燥・粉砕し、0, 50, 100 および 150 g L^{-1} (w/v) の各濃度にて 24 時間水に浸漬し抽出液を得た。比較対照として水道水（0 g L^{-1}）を用いて濃度依存性を調べた。生物試験にはコムギ (*Triticum aestivum* L. em. Thell.)、野性エンバク(*Avena fatua* L.)、および野生サフラワー(*Carthamus oxycantha* (Co. Cr.))の 3 種の種子を各 10 粒ずつ用いた。その結果試験植物ごとに、また指標となる全ての試験項目において差異がみられ、中でも発芽率に最も高い影響が認められた。サフラワーが最も強く水溶性抽出物による阻害を被るとともに、逆にコムギが最も高い耐性を示した。*E. camaldulensis* の抽出液 150 g L^{-1} に暴露した場合、サフラワーの発芽率は非処理区と比較してわずか 20%にまで低下した。また *P. juliflora* および *E. camaldulensis* 抽出液では試験した全ての濃度においてサフラワー種子の発芽に対し著しい阻害活性を示し、幼植物体の伸長および新鮮重の増加の阻害が高濃度域で観察された。*A. arabica* の抽出液では生物試験に用いた植物全 3 種の各成長指標において最も弱い阻害効果を示した。上記の抽出液に対しコムギが耐性を示し、他方コムギ栽培に影響する雑草種が感受性を示したところから、有効なアレロパシー活性を示す植物種を用いて、コムギ栽培における雑草管理技術の開発がなされる可能性があることが明らかとなった。