



Phytotoxic impact of leaf extracts of *Bombax ceiba* and *Populus deltoides* on the growth of *Triticum aestivum*

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Abstract

The research aimed to investigate the allelopathic effects of leaf extracts from *Populus deltoides* and *Bombax ceiba* trees in an agroforestry setting during November 2021-2022 at the Department of Forestry and Range Management, University of Agriculture, Faisalabad. The study assessed the impact of both tree species on various growth parameters of wheat, including germination, radicle and plumule length, plant height, number of productive tillers, spike length, spikelets per spike, grains per spike, 100-grain weight, leaf area index, leaf area duration, leaf proline, chlorophyll content, leaf malondialdehyde content, osmotic potential, water potential, and pressure potential. The experiment employed a completely randomized design (CRD), with wheat grown in pots and subjected to four different concentrations of leaf extracts (0g L⁻¹, 5g L⁻¹, 10g L⁻¹, 15 g L⁻¹) for each tree species separately. The results indicated significant inhibitory effects of *Populus deltoides* on wheat compared to *Bombax ceiba*, especially with increasing concentrations of leaf extract from both tree species.

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1. Introduction

Trees emit phytochemicals into the soil that have a detrimental effect on the germination and yield of understory crops (Charan *et al.*, 2012). In agroforestry, allelopathic experiences in tree crop associations have a direct effect on crop production. The release of allelochemicals by several trees has a negative effect on the production of understory crops. Allelopathic influence of *Bombax ceiba* L, *Populus deltoides*, *Eucalyptus camaldulensis*, *Vachellia nilotica* and *Cassia siamea* species have been reported by (Chaudhary and Khadabadi, 2012; Philomina and Munikumari, 2010; Ralhan *et al.*, 1992). Poplar and *Bombax ceiba* are multipurpose, fast-growing, valuable timber species and are considered very significant as one of the best tree species for agrisilviculture in Pakistan. Many other crop rotations used in Pakistan are not as commercially feasible or sustainable as poplar and *Bombax ceiba* based agroforestry system is preferred. In the agroforestry system, farmers use a variety of tree-crop combinations including Poplar and *Bombax ceiba*. Farmers prefer to grow these tree species due to their smaller rotation, and suitable climatic and ecological conditions of the country (Javaid, 2008). Poplar creates a lot of biomass in a short amount of time and recycles soil nutrients by introducing leaf extract from its leaf shed during the winter season.

Wheat is a staple crop and it is cultivated in a large area (8.8 million hectares) and has more importance than any other kind of crop in Pakistan. They are abundant in vitamins, nutrients, carbohydrates, fats, oils, and protein in their natural state. Grain, such as rice, wheat, millet, or maize, provides the bulk of everyday sustenance in some developed countries. Cereal intake in developing countries is modest and varied, but it is still important. Wheat is the most commonly planted crop in the interspaces of poplar during the winter season in Pakistan. Even though agroforestry can improve production, it must compete with food crops. Allelochemicals are found in leaf extracts, and their toxic effects differ by species (Bhatt *et al.*, 1993; Todaria *et al.*, 2005). Before proposing any tree species for an agroforestry program, comprehensive studies on the impact of tree allelochemicals on seed germination, growth, and metabolism of crop plants must be known. Despite a rise in research on allelopathy in agroforestry systems over the last two decades, little work has been done to measure the allelopathic impact of Poplar and *Bombax ceiba* on wheat performance in Faisalabad, which needs to be studied further. As a result, the current research focuses on determining the allelopathic effect of *Populus deltoides* L and *Bombax ceiba* L on the germination and growth characteristics of the cereal crop wheat.

2. Materials and Methods

2.1 Experimental site and climatic conditions

The pot experiment was conducted to investigate the allelopathic potential of Poplar tree species on wheat in the research experimental area of the Department of Forestry and Range Management, University of Agriculture, Faisalabad. This study was carried out in semi-arid climatic conditions with extremely hot and humid summers followed by cool and dry winters. The average temperature range was a maximum of 40.5 °C (104.9 °F) and a minimum of 26.9 °C (80.4 °F) in June while in January the average temperature range was a maximum of 19.4 °C (66.9 °F) and a minimum 4.1 °C (39.4 °F).

2.2 Data Collection

Fresh leaves of *Populus deltoides* and *Bombax ceiba* were collected from healthy, mature trees in the experimental area of the Punjab Forest Research Institute, Faisalabad. The leaves were thoroughly washed with distilled water to remove any surface dirt and contaminants. After washing, the leaves were air-dried at room temperature in a shaded area to prevent degradation of bioactive compounds. The dried leaves were then ground into a fine powder using a mechanical grinder to increase the surface area for extraction. A specific quantity of the powdered leaves was mixed with a suitable solvent (ethanol or methanol) in a ratio of 1:10 (weight/volume). This mixture was placed in a shaker and agitated at room temperature for 24 hours to ensure efficient extraction of the active compounds. After the extraction period, the mixture was filtered using Whatman No. 1 filter paper to remove solid residues and obtain a clear leaf extract solution. The filtrate was concentrated under reduced pressure using a rotary evaporator to remove the solvent, yielding a concentrated leaf extract. The concentrated leaf extract was transferred to airtight glass containers and stored at 4°C until further use in the experimental studies. This standardized method of leaf extract preparation ensured consistency and reliability for subsequent experiments investigating the allelopathic effects on wheat. The pots were filled with 7kg soil with a similar mixed soil. Wheat variety was grown in the pots filled with sandy clay loam soil. The cultivar used for sowing was Ujala 2014. Twenty seeds were planted in each pot on Nov 15, 2021, and harvested on 25 April 2022. The experiment was executed in a complete randomized design (CRD).

On the seventh day after sowing, germination and growth parameters were inscribed. The number of germinated seeds was used to determine germination while a ruler was used to measure the length of the radicle and plumule of the germinated crop. Plant height was measured with the help of a meter rod. The number of productive tillers was counted by counting the tillers bearing spikes. Spike length was measured from the base to the uppermost tip of the spikelet with the help of a measuring scale. Spikelets per spike were counted the spikelets from each experimental unit and the average was calculated. Grains per spike were calculated by counting the grains of each experimental unit and the average was calculated. The 100-grain weight of each experimental unit was obtained by using an electric weighing balance. The leaf chlorophyll contents were determined with the help of a chlorophyll meter. Further leaf proline contents were determined by following the technique of Bates *et al.*, 1973. Leaf malondialdehyde contents were examined by following the methodology of Madhava and Sresty, 2000; Barylá *et al.*, 2000. Furthermore, water-related attributes were examined, in which relative water contents were calculated by following the method of Barr and Weatherley, 1962, Osmotic potential was followed by Wenkert, 1980, while water potential was calculated by following Scholander *et al.* (1964).

3. Results

3.1 Growth parameters

The various concentrations of leaf extracts of *Bombax ceiba* and poplar tree species showed a remarkable allelopathic effect on the seed germination of wheat crops thus indicating that the leaf extracts of these selected species have remarkable inhibitory effects

on the crop as compared to control treatment. The seed emergence of the wheat crop did not indicate any positive response due to the leaf extract of both tree species however, poplar extracts showed more inhibitory effects as compared to *Bombax ceiba*. The germination of the wheat seed was highly reduced under the maximum concentration of poplar leaf extract as compared to all other treatments of aqueous leaf extract while minimum inhibition was observed under the aqueous leaf extract of *Bombax ceiba*. In the present study, the lowest seed emergence was observed for T4 (15g L⁻¹ leaf extract) for both tree species. Similar results have been documented by Sharma *et al.* (2000). who described the reduced germination of wheat in a pot experiment under the allelopathic effect of *P. deltoides*. Moreover, the growth reduction effects of *P. deltoides*, *M. alba* and *M. azedarach* on wheat have been documented by several researchers and found the reduction in germination with the increase in the concentration of leaf extract of selected tree species as presented in Table 1.

In the present study, all agronomic traits of the wheat crop: plant height, productive tillers, spike length, spikelets per spike, grain yield, grains per spike, 1000 grain weight and harvest index were highest under control treatment and decreased with an increase in the concentration of leaf extract of both *Bombax ceiba* and poplar tree species. The plant height of the wheat crop was reduced by 24.33 % as compared to the control under 15g L⁻¹ leaf extract of poplar which was higher than 15g L⁻¹ leaf extract of *Bombax ceiba*. Moreover, the order of reduction of all agronomic parameters in wheat regarding tree species was poplar > *Bombax ceiba* and regarding treatment was T4 (15g L⁻¹ leaf extract) > T3 (10g L⁻¹ leaf extract) > T2 (05g L⁻¹ leaf extract) > T1 (control) as demonstrated in table 1. Leaf extract of both selected tree species also showed inhibitory effects on the leaf area index, duration and crop growth rate of the wheat crop, however, this reduction was higher at greater concentration levels of leaf extract. The results of the present study showed that the poplar leaf extract has greater inhibitory effects on leaf area index, duration, crop growth rate and dry matter accumulation as compared to *Bombax ceiba* leaf extract. The reduction in leaf area index and crop growth rate of wheat crops under 15g L⁻¹ leaf extract of *Bombax ceiba* and poplar was 27.25%, 42.5% and 45. 55%, and 52.6% respectively as compared to control as described in Table 1.

3.2 Water-related attributes

3.2.1 Osmotic potential

The data regarding osmotic potential showed that for all the treatments (leaf extracts) concentrations of *P. deltoides* and *B. ceiba* significantly ($p \leq 0.05$) decreased as compared to control (Table 2). The osmotic potential showed significant variation under different concentrations of leaf extracts of both tree species. The higher osmotic potential was computed for control and it gradually decreased with increasing the concentration of leaf extract. The maximum measured osmotic potential was (0.162 for *Bombax ceiba* & 0.157 for Poplar) in control (T1), followed by T2 (5g L⁻¹ leaf extract): 0.142 and 0.080 for *Bombax ceiba* and Poplar respectively. For T3 (10g L⁻¹ leaf extract), and T4 (15g L⁻¹ leaf extract) osmotic potential was reduced by 20.37 % for *Bombax ceiba* and 51.59 % for poplar.

3.2.2 Water potential

The results regarding water potential indicated that all the treatment (leaf extracts) levels of *P. deltoides* and *B. ceiba* significantly ($p \leq 0.05$) increased the water potential as compared to the control (Table 2). It was observed that different concentrations of leaf extracts of both tree species have shown significant variation regarding water potential. The maximum water potential was computed for T4 (15g L⁻¹ leaf extract) and it gradually decreased for the lower level of leaf extract. The highest mean value of water potential was measured at 1.36 for poplar in T4 (15g L⁻¹ leaf extract followed by T3 (10g L⁻¹ leaf extract): 1.23 and 1.30 for *Bombax ceiba* and poplar respectively.

3.2.3 Pressure potential

The results showed that all the treatment (leaf extracts) levels of *P. deltoides* and *B. ceiba* significantly ($p \leq 0.05$) increased the pressure potential of the wheat crop as compared to the control (Table 2). It was observed that different concentrations of leaf extracts of both tree species have shown significant variations in pressure potential. The maximum pressure potential was computed for T4 (15g L⁻¹ leaf extract) and it gradually decreased for the lower level of leaf extract. The highest mean value of pressure potential was measured (1.30 for poplar in T4 (15g L⁻¹ leaf extract) followed by T3 (10g L⁻¹ leaf extract): 1.10 and 1.22 for *Bombax ceiba* and poplar respectively. as described in Table 2.

Table 1. Effect of allelochemicals present in leaf extract extracts of *Populus deltoides*. L and *Bombax ceiba*. L on germination and growth parameters of wheat crop

Treatments			Growth Parameters																			
	Germination (%)		Radicle length (cm)		Plumule length (cm)		Plant Height (cm)		No. of Productive Tillers		Spike Length (cm)		Spikelets per spike		Grains per spike		100 grains weight (g)		Leaf Area Index		Leaf Area Duration	
	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>
0g L ⁻¹ leaf extracts (Control) (T ₁)	91.4a	90.8c	4.2a	4.15a	3.18b	3.17b	76.08b	74.34b	9.87a	9.696c	11.74d	11.53a	15.88a	15.74b	36.52a	36.46b	43.37a	4.89a	5.77b	5.73a	240c	236a
5g L ⁻¹ leaf extracts (T ₂)	86.4c	78.6b	3.91a	3.72a	2.92c	2.78a	70.82a	68.62b	8.86a	7.90b	10.8c	10.20a	15.32a	15.07a	33.72c	35.50c	42.75c	4.35d	5.44a	5.33b	233a	228c
10g L ⁻¹ leaf extracts (T ₃)	80.8a	73.6b	3.48c	3.22a	2.34a	2.12c	67.28a	60.98a	7.514b	7.154a	9.88a	9.64b	14.45c	14.156a	31.55a	28.31a	41.06a	3.46c	5.23d	5.06a	221d	217a
15g L ⁻¹ leaf extracts (T ₄)	70a	61.8a	2.95a	2.49b	1.89a	1.68a	64.6b	58.92c	7.03c	6.97a	9.55a	9.32c	13.89b	13.548b	27.86d	24.66c	37.25b	2.67a	4.75c	4.61a	212a	205d
LSD (p ≤0.05)	2.26**	2.42**	0.59*	0.75**	1.04**	1.13**	2.66**	2.20**	1.85**	1.69**	1.38**	1.24**	1.24**	1.48**	1.60**	1.44**	1.67**	1.14**	1.11**	0.86**	6.02**	5.15**

Table 2. Effect of allelochemicals present in leaf extract of *Populus deltoides*. L and *Bombax ceiba*. L on water-related attributes.

Treatments	Water-related attributes					
	Osmotic Potential (-MPa)		Water Potential (-MPa)		Pressure Potential (-MPa)	
	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>	<i>B. ceiba</i>	<i>P. deltoides</i>
0g L ⁻¹ leaf extracts (Control) (T ₁)	0.17a	0.168d	1.03a	0.972c	0.864a	0.81a
5g L ⁻¹ leaf extracts (T ₂)	0.156c	0.087c	1.23c	1.142a	1.076b	1.061b
10g L ⁻¹ leaf extracts (T ₃)	0.139a	0.081a	1.36a	1.31a	1.223c	1.16c
15g L ⁻¹ leaf extracts (T ₄)	0.11d	0.077b	1.44b	1.4b	1.33a	1.30a
LSD (p ≤ 0.05)	0.174764**	0.099382**	0.070595**	0.076323**	0.084162**	0.087794**

3.3 Biochemical attributes

3.3.1 Leaf proline

The results regarding leaf proline content indicated that all the treatment (leaf extracts) levels of *P. deltoides* and *B. ceiba* significantly ($p \leq 0.05$) increased the leaf proline content as compared to the control. It was observed that different concentrations of leaf extracts of both tree species have shown significant variations in proline content as shown in figure 1.

3.3.2 Chlorophyll a

It was found that the chlorophyll a content decreased gradually with the increase of concentration of tree leaf extract, however, this reduction was greater for poplar leaf extract as compared to *Bombax ceiba*. The maximum chlorophyll a ($0.286 \mu\text{g g}^{-1}$ & $0.280 \mu\text{g g}^{-1}$) was recorded for T₁ (control) for both species. It reduced gradually with the increase in the concentration of leaf extract for both species. as demonstrated in Figure 2.

3.3.3 Chlorophyll b

It was estimated that all the treatment (leaf extracts) levels of both tree species showed significant ($p \leq 0.05$) effects on chlorophyll b. It was found that the chlorophyll b decreased gradually with the increase of concentration of tree leaf extract, however, this reduction was greater for poplar leaf extract as compared to *Bombax ceiba* (Figure 3). The maximum chlorophyll b ($0.216 \mu\text{g g}^{-1}$ & $0.211 \mu\text{g g}^{-1}$) was recorded for T₁ (control) for both species. It reduced gradually with the increase in the concentration of leaf extract for both species.

3.3.4 Malondialdehyde (MDA)

It was observed that different concentrations of leaf extracts of both tree species have shown significant variation in MDA content. The maximum MDA was computed for control and it gradually decreased with increasing the concentration of leaf extract. The highest leaf MDA was calculated ($5.26 \mu\text{mol g}^{-1}$ for *Bombax ceiba* & $5.25 \mu\text{mol g}^{-1}$ for poplar) in control (T₁), followed by T₂ (5g L⁻¹ leaf extract): $4.73 \mu\text{mol g}^{-1}$ and $4.47 \mu\text{mol g}^{-1}$ for *Bombax ceiba* and poplar respectively. The lowest mean MDA value was estimated for T₄ (15g L⁻¹ leaf extract) for both tree species. The reduction in MDA under 15g L⁻¹ leaf extract of *Bombax ceiba* and poplar was 30.60 % and 54.28 % as compared to control as compared to control as presented in figure 4.

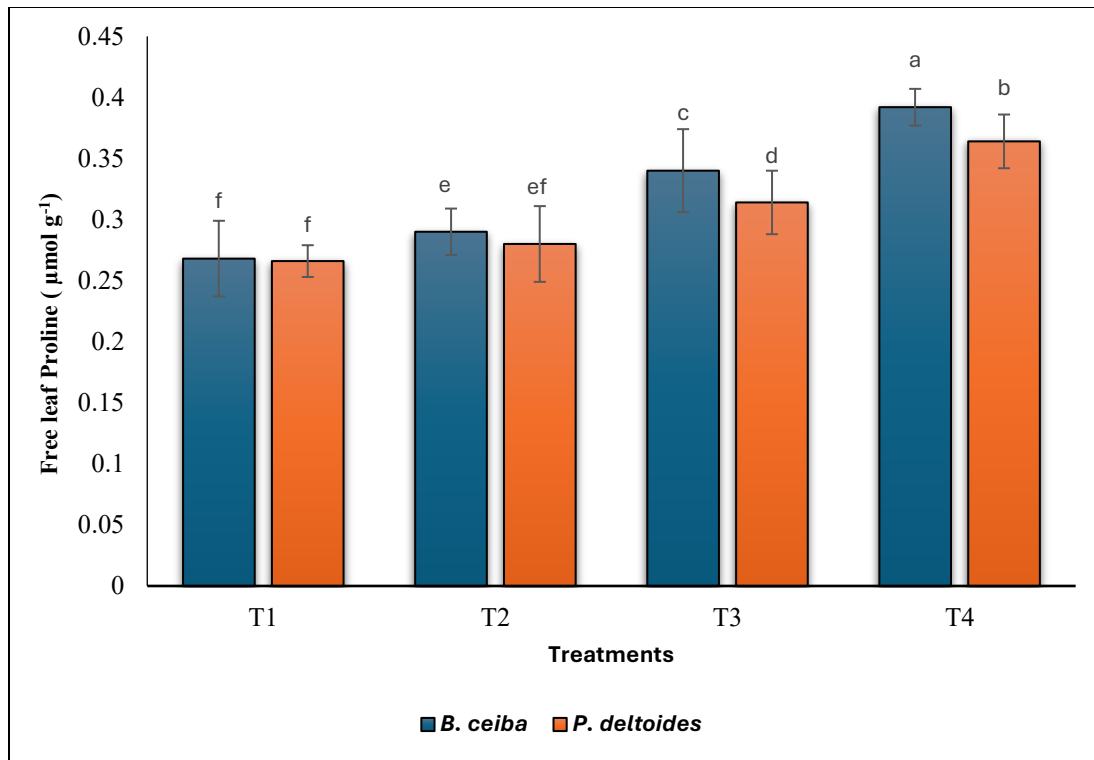


Figure 1. Effect of leaf extracts from *P. deltoides* and *B. ceiba* trees on the Leaf proline content in wheat.

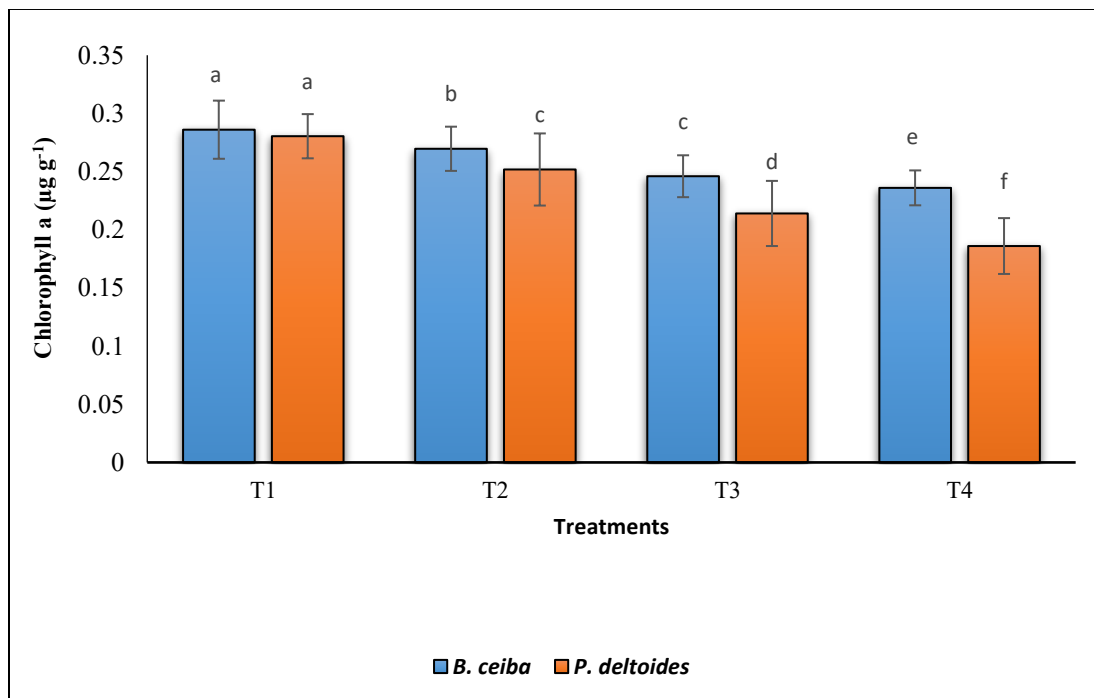


Figure 2. Effect of leaf extracts from *Populus deltoides* and *Bombax ceiba* trees on the Chlorophyll content in wheat.

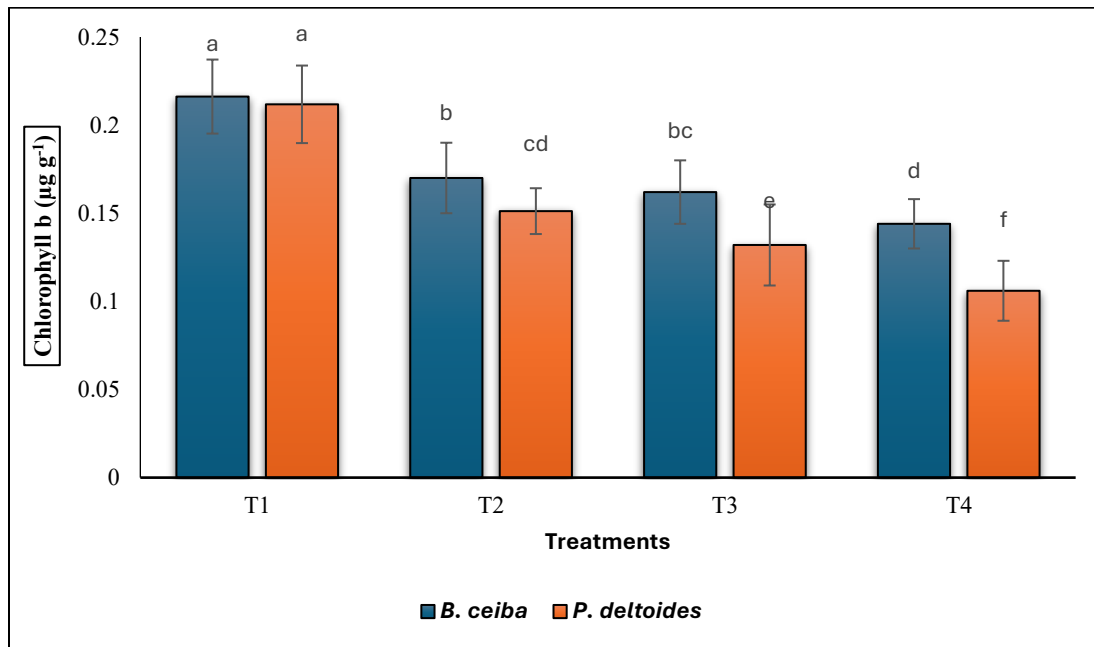


Figure 3. Effect leaf extracts from *Populus deltoides* and *Bombax ceiba* trees on the Chlorophyll b contents in wheat.

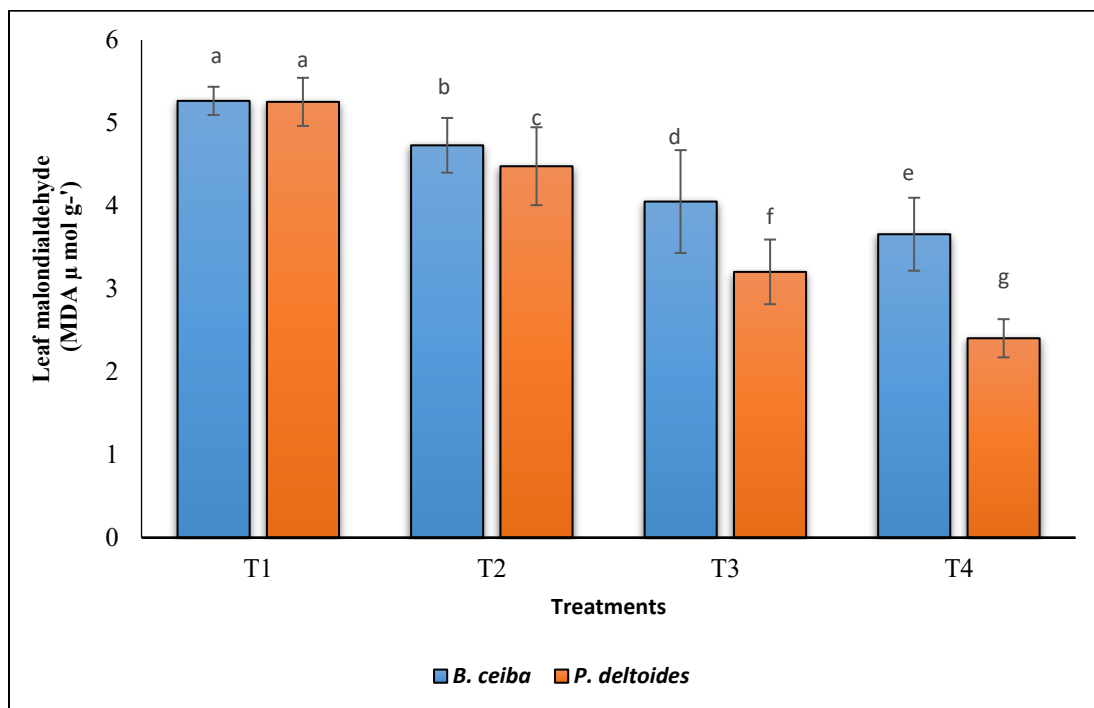


Figure 4. Effect of leaf extracts from *Populus deltoides* and *Bombax ceiba* trees on the MDA contents in wheat.

4. Discussion

Several secondary metabolites compounds are present in agroforestry trees in sufficient quantities, which not only alter or disturb the composition and growth attributes of adjacent crops and other plant species due to the allelopathic effects but also act as an important factor regarding soil fertility (Paramathma *et al.*, 2000). Though, all these allelochemical compounds are present in all plant parts, however, the amount of these metabolites seems to be higher in leaves due to the various astonishing metabolic reactions that take place in the plant. Many researchers have documented the concentration of various allelochemicals and their inhibitory effect on the seed germination and morphology of adjacent plants. Mostly, it depends upon the type and amount of allelochemicals also known as secondary metabolic compounds excreted by other plants (Majeed, and Muhammad 2014; Dawar *et al.*, 2007 and Jabeen and Ahmad, 2009).

The various concentrations of leaf extracts of *Bombax ceiba* and poplar tree species showed a remarkable allelopathic effect on the seed germination of wheat crops and thus indicating that the leaf extracts of these selected species have remarkable inhibitory effects on the crop as compared to control treatment. The seed emergence of the wheat crop did not indicate any positive response due to the leaf extract of both tree species however, poplar extracts showed more inhibitory effects as compared to *Bombax ceiba*. The germination of the wheat seed was highly reduced under the maximum concentration of poplar leaf extract as compared to all other treatments of aqueous leaf extract while minimum inhibition was observed under the aqueous leaf extract of *Bombax ceiba*. In the present study, the lowest seed emergence was observed for T4 (15g L⁻¹ leaf extract) for both tree species. Similar results have been documented by Sharma *et al.* (2000). who described the reduced germination of wheat in a pot experiment under the allelopathic effect of *P. deltoides*. Moreover, the growth reduction effects of *P. deltoides*, *M. alba* and *M. azedarach* on wheat have been documented by several researchers and found the reduction in germination with the increase in the concentration of leaf extract of selected tree species (Shafique *et al.*, 2007; Nakafeero *et al.*, 2007; Singh *et al.*, 2001). In the present study, all agronomic traits of the wheat crop: plant height, productive tillers, spike length, spikelets per spike, grain yield, grains per spike, 1000 grain weight and harvest index were highest under control treatment and decreased with an increase in the concentration of leaf extract of both *Bombax ceiba* and poplar tree species. The plant height of the wheat crop was reduced by 24.33 % as compared to the control under 15g L⁻¹ leaf extract of poplar which was higher than 15g L⁻¹ leaf extract of *Bombax ceiba*. Moreover, the order of reduction of all agronomic parameters in wheat regarding tree species was poplar > *Bombax ceiba* and regarding treatment was T4 (15g L⁻¹ leaf extract) > T3 (10g L⁻¹ leaf extract) > T2 (5g L⁻¹ leaf extract) > T1 (control). The higher concentration of leaf extract of *P. deltoides*, *M. alba* and *M. azedarach* inhibit the plant height, productive tillers and grain yield of wheat crop (Singh *et al.*, 2009).

The findings reported by Lungu *et al.* (2011) showed that lower plant height under the higher concentration of leaf extract of poplar as compared to control. Similar results have been documented by Singh and Sharma (2007) who found a greater inhibitory effect of *P. deltoides* leaf extract on growth and germination of the wheat crop both in laboratory and field experiments. On the other hand, Nandal and Dhillon (2005) described that lower concentrations of tree leaf extracts of poplar had stimulatory effects on crop growth, especially, since the higher concentration of leaf extract showed the inhibitory effects on various wheat cultivars. Previous studies demonstrated that the leaf extract of *Dodonaea viscosa* prepared in both hot and cold water inhibited the lettuce root germination and hypocotyls (Singh *et al.*, 2001). Ashraf and Akhlaq (2007) obtained a remarkable reduction in grain yield in response to the water extract of different parts of the sorghum crop. They reported a 12% less grain yield with the application of water extract of sorghum root while a 20% less yield under the combined application of stem, leaf and root of sorghum as compared to control treatment. In general, seed emergence along with initial growth and yield parameters of the wheat crop was dependent on leaf extract concentrations. The findings of this study are in agreement with Ashraf and Akhlaq (2007) who documented a greater inhibitory effect at higher concentrations of aqueous extract of different tree species. The results of the present study revealed a greater reduction in germination and other growth and yield parameters compared with control, in all the treatments, 15 days after sowing. It was found that the inhibition was concentration-dependent, which means an increase in the concentration of leaf extract resulted in a decrease in germination and growth (Einhelling, 1996). Similarly, Nakafeero *et al.* (2007) also found a remarkable reduction in the growth and yield of wheat crops under the higher concentrations of leaf and stem extract.

Leaf extract of both selected tree species also showed inhibitory effects on the leaf area index, duration and crop growth rate of the wheat crop, however, this reduction was higher at greater concentration levels of leaf extract. The results of the present study showed that the poplar leaf extract has greater inhibitory effects on leaf area index, duration, crop growth rate and dry matter accumulation as compared to *Bombax ceiba* leaf extract. The reduction in leaf area index and crop growth rate of wheat crops under 15g L⁻¹ leaf extract of *Bombax ceiba* and poplar was 27.25%, 42.5% and 45.55%, 52.6% respectively as compared to control. Barkat *et al.* (2010) described the related results by applying the leaf extract of *Dodonaea viscosa* and explored the effect of different allelochemicals of *Dodonaea viscosa* on different crops. They evaluated that the inhibition depends upon the amount of allelochemicals secreted by *Dodonaea viscosa*. According to Iqbal *et al.* (2010), the concentration of leaf extract of *Dodonaea viscosa* prepared in both hot and cold water reduced the lettuce germination along with the reduction in leaf area index and leaf area duration. Similar findings have been reported by Khan *et al.* (2008) who studied the allelopathic effect of *Eucalyptus camaldulensis* at various concentrations (5, 10, 15 and 20%) and found that the leaf extract concentration of *Eucalyptus camaldulensis* showed a greater reduction in the germination and yield attributes. This reduction increased with the increase of leaf extract concentration. Similar inhibition in wheat and other crops has been studied under the allelopathic tree species such as *Eucalyptus camaldulensis* (Majeed *et al.*, 2012; Haq *et al.*, 2010 and Khan *et al.*, 2016).

Similar to morphological and growth parameters, biochemical attributes: like MDA contents, soluble phenolics, chlorophyll a and b also decreased with the increase in the concentration of leaf extract except for leaf proline which showed antagonistic results as compared to other parameters, however, this reduction was lower under *Bombax ceiba* leaf extract as compared to poplar. Chlorophyll a and b contents were higher under control and reduced with the increase of concentration of leaf extract of both species. The results of the present study showed that chlorophyll a, b and MDA content was 21.73 %, 30.55 % 30.67 % calculated for T4 (15g L⁻¹ leaf extract) for poplar and was lower when compared with 15g L⁻¹ leaf extract of *Bombax ceiba*. These results are in agreement with the findings explained by Tian *et al.* (2013) who described the reduction in biochemical attributes under higher leaf extract concentration as compared to control. Similar inhibitory results for Eucalyptus and some other allelopathic trees were observed in wheat and other crops (Limin and Flower, 2006; Awan *et al.*, 2012; Srivastava, 2002 and Shafique *et al.*, 2007).

Conclusion

Allelopathy refers to the release of chemicals by one plant that hinders the growth of another. According to this study, both *Populus deltoides* L. and *Bombax ceiba* L. possess allelopathic properties that negatively impact wheat crop production. The allelochemicals in these tree species were found to suppress wheat germination, radicle, and plumule length. However, the study also indicated that the leaf extracts of *Populus deltoides* L. had a more pronounced inhibitory effect on wheat germination and growth parameters compared to *Bombax ceiba* L. These findings suggest that allelopathy is a concentration-dependent process, with the adverse effects on receptor plants increasing as the concentration of leaf extract from these tree species rises.

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References

- Ashraf, M. and M. Aklaq. 2007. Effects of sorghum leaves, roots and stems water extract, hand weeding and herbicide on weeds suppression and yield of wheat. *Sarhad J. Agri.* 23:321-328.
- Awan, F.K., M. Rasheed, M. Ashraf and M.Y. Khurshid. 2012. Efficacy of brassica sorghum and sunflower aqueous extracts to control wheat weeds under rainfed conditions of Pothwar, Pak. *J. Anim. Pl. Sci.* 22: 715-721.
- Barkat, U., F. Hussain and M. Ibrar. 2010. Allelopathic potential of *DedoneaViscosa*. *Pak. J. Bot.* 42: 2383-2390.
- Barr, H.D. and P.E. Weatherley. 1962. A re-examination of the relative turgidity technique for estimating water deficits in leaves. *Aust. J. Biol. Sci.* 15:413-428.
- Baryla, A., C. Laborde, J.L. Montillet. 2000. Triantaphylides, C. and Chagvardieff, P. Evaluation of lipid peroxidation as a toxicity bioassay for plants exposed to copper. *Environ Pollut* 109(1): 131-135.
- Bates, L. R. Waldren and I. Teare. 1973. Rapid determination of free proline for water-stress studies. *Plant Soil* 39: 205-207.
- Charan, S., K. Dadhwal, R. Dhiman, K. Raj and R. Avasthe. 2012. Allelopathic effects of Paulownia and poplar on wheat and maize crops under agroforestry systems in Doon Valley. *Indian forester.* 138:986-990.
- Chaudhary, Pankaj H., and Somshekhar S. Khadabadi. 2012. "*Bombax ceiba* Linn.: ethnobotany and phyto-pharmacology." *Pharmacognosy Communications* 2:2-9.
- Dawar, S., M. Summaira. Y. Tariq and M.J. Zaki. 2007. Use of Eucalyptus sp. in the control of root infecting fungi on mungbean and chick-pea. *Pak J. Bot.* 39: 975-979.
- Einhelling, F.A. 1995. Mechanism of action of allelochemicals in allelopathy. In *Allelopathy: organisms, processes, and applications*. K. Inderjit, M.M. Dakshini and F.A. Einhellig (eds.). American Chemical Society. pp. 96-116.
- ema, M.N. Mushtaq and M. Farooq. 2010. Mulberry leaf water extract inhibits Bermuda grass and promotes wheat growth. *Weed Biol. Manage.* 10: 234-240.
- Haq, R.A., M. Hussain, Z.A. Che Limin, A.E. and D.B. Fowler. 2006. Low-temperature tolerance and genetic potential in wheat (*Triticum aestivum* L.): Response to photoperiod, vernalization, and plant development. *Planta.* 224:360-366.
- Iqbal, J., F. Karim and S. Hussain. 2010. Response of wheat crop (*Triticum aestivum* L.) and its weeds to allelopathic crop water extracts in combination with reduced herbicide rates. *Pak. J. Agri. Sci.* 47:309-316.
- Jabeen, N. and M. Ahmed. 2009. Possible allelopathic effects of three different weeds on germination and growth of maize (*Zea mays*) cultivars. *Pak. J. Bot.* 41: 1677-1683.
- Khan M, M. Zakaria, F. Ali, F. Hussain, Imdadullah, S. Musharaf. 2016. Allelopathic Effect of *Populus nigra* Bark on *Zea mays* in Agroforestry Ecosystems. *Global Journal of Science Frontier Research: C Biological Science.* 16:34-41.
- Khan, A.L., J. Hussain, M. Hamayun, Z.K. Shinwari, H. Khan, Y. Kang, S.M. Kang and I. Lee. 2009. Inorganic profile and allelopathic effect of endemic *InulaKoelzii* from Himalaya Pakistan. *Pak. J. Bot.* 41:2517-2527.
- Lungu, L., C. Pop, J. Morris and M. Savoii. 2011. Evaluation of phytotoxic activity of *Melia azedarach* L. extracts on *Lactuca sativa* L. *Romanian Biotech. Letters.* 16:60-89.
- Madhava Rao, K. V. and Sresty, T. V. (2000). Antioxidative parameters in the seedlings of pigeonpea (*Cajanus cajan*(L.) Millspaughin response to Zn and Ni stresses. *Plant Sci* 157(1): 113-128.
- Majeed, A., Z. Chaudhry and Z. Muhammad. 2012. Allelopathic assessment of fresh aqueous extracts of *Chenopodium album* L. for growth and yield of wheat (*Triticum aestivum* L.). *Pak. J. Bot.* 44: 165-167.

- Majeed, A., Z. Muhammad, M. Hussain and H. Ahmad. 2017. In vitro allelopathic effect of aqueous extracts of sugarcane on germination parameters of wheat. *Acta Agric. Slov.* 109: 349-356.
- Nakafeero, A. L., M.S. Reed and N.M. Moleele. 2007. Allelopathic potential of five agroforestry trees, Botswana. *African. J. Ecol.* 45:590-593.
- Nakafeero, A. L., M.S. Reed and N.M. Moleele. 2007. Allelopathic potential of five agroforestry trees, Botswana. *African. J. Ecol.* 45:590-593.
- Nandal, D. P. S. and A. Dhillon A. 2005. Allelopathic effects of poplar (*Populus deltoides* Bartr Ex Marsh): an assessment on the response of wheat varieties under laboratory and field conditions. In *Fourth World Congress in Allelopathy* (August), Wagga Wagga, NSW Australia.
- Paramathma, M. J.A. Amal and M. Rajkumar. 2000. Tree allelopathy in agroforestry. In *Allelopathy in Ecological Agriculture and Forestry* (pp. 229-235). Springer Netherlands.
- Philomina, N. and A. Munikumari. 2010. Allelopathic studies on agroforestry species effect of leaf leachates on seedling growth of crop plants. *JMBFS.* 12:1-4.
- Ralhan, P., A. Singh and R. Dhanda. 1992. Performance of wheat as intercrop under poplar (*Populus deltoides* Bartr.) plantations in Punjab (India). *J. Agrofor sys.* 19:217-222.
- Scholander, P.F., H.T. Hammel, E.A. Hemmingsen and E.D. Bradstreet. 1964. Hydrostatic pressure and osmotic potential in leaves of mangroves and some other plants. *PROC. NationalAcad. Sci.* 52:119-125.
- Shafique, S., A. Javaid, R. Bajwa and S. Shafique. 2007. Effect of aqueous leaf extracts of allelopathic trees on germination and seed-borne mycoflora of wheat. *Pak. J. Bot.* 39: 2619-2624.
- Shafique, S., A. Javaid, R. Bajwa and S. Shafique. 2007. Effect of aqueous leaf extracts of allelopathic trees on germination and seed-borne mycoflora of wheat. *Pak. J. Bot.* 39: 2619-2624.
- Sharma, N., H. Singh and K. Dadhwal. 2000. Effect of poplar (*Populus deltoides*) on wheat growth at an early stage. *Indian Journal of Soil Conservation.* 28:221-225.
- Singh H. P. Kohli R. K. Batish D. R. 2001. Allelopathic interference of *Populus deltoides* with some winter season crops. *Agrono,* 21:139-146.
- Singh H. P. Kohli R. K. Batish D. R. 2001. Allelopathic interference of *Populus deltoides* with some winter season crops. *Agrono,* 21:139-146.
- Singh, B. and K.N. Sharma. 2007. Tree growth and nutrient status of soil in a poplar (*Populus deltoides* Bartr.) based agroforestry system in Punjab, India. *Agrofor. Sys.* 70:125-134.
- Singh, B., V. Jhaldiyal and M. Kumar. 2009. Effects of aqueous leachates of multi-purpose trees on test crops. *Estonian J. Eco.* 58:38-46
- Srivastava, L.M. 2002. Environmental regulation of plant growth. In: *Plant Growth and Development: Hormones and Environment.* Academic Press, U.S.A. 4:665-710.
- Tian, N., Z. Liu, J. Li and T.J. Shi. 2013. Allelopathic effects of tree-leaf extract on the germination and seedling phase of wheat in inter-planted systems of trees (fruits trees) and grain crops. *Zhongguo Shengtai Nongye Xuebao/Chinese Journal of Eco-Agriculture.* 21:707-714.
- Wenkert, William. 1980. "Measurement of tissue osmotic pressure." *Plant Physio.* 1:614-617.



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