

## PHYTOTOXIC POTENTIAL OF *POPULUS DELTOIDES* BARTR. EX MARSH. I. COMPARATIVE CONTRIBUTION OF DIFFERENT PARTS

R.K. Kohli, H.P. Singh and Daizy R. Batish

Department of Botany, Panjab University, Chandigarh - 160 014, India.

### Abstract

The aqueous leachates prepared from different parts of *Populus deltoides* retard the germination and growth of mung bean (*Phaseolus aureus*). However, the impact varied depending upon concentration and tree part used. The leachates prepared from leaves exhibited strong inhibitory potential compared to other parts, viz., bark, buds, root and stem. Since different parts possess different water contents, the leachates prepared from fresh tree parts were equalized on the basis of dry weights. The content of organic component of leachable allelochemicals (aglycones) depict a great variability with maximum amount being extracted from leaves and least from stem. The relative allelopathic potentiality of each part was concomitant with respective amounts of aglycones in each part.

### Introduction

*Populus* (*Populus deltoides* Bartr. ex Marsh.) - an exotic from North America is fast emerging as a famous agroforestry tree in India, particularly the Northern regions. Its fast growth rate and good economic returns coupled with the incentives given by some private entrepreneurs are the probable reasons for its fame. The intensity of its plantations during the recent past has increased enormously without giving much consideration to the edapho-climatic suitability and the environmental sustainability. However, some recent reports indicate the adverse effect of the tree on the understorey vegetation (Kohli *et al.*, 1996) and the associated/ adjoining crops in agroecosystems (Singh *et al.*, 1993; Singh 1995). Allelopathy by this tree has been alleged to play a vital role in growth suppression of associated crops and/or understorey vegetation.

The available countable reports on allelopathy exhibited by *Populus deltoides* so far leave a few gaps, particularly, as regards the relative comparative contribution of different parts of the tree towards the phenomenon. Virtually all parts of plant, viz., leaf, stem, root, bark, flowers, buds, etc., are reported to release allelochemicals (Tukey, 1970).

The present study was, therefore, conducted to compare the allelopathic potential of different parts of the tree on mung bean (*Phaseolus aureus* Roxb.) - an important agricultural crop.

### Materials and Methods

The aqueous leachates were prepared from different parts of *Populus deltoides* as per Kumari and Kohli (1987). Fresh and healthy parts of root, stem, leaf, bark and buds of the tree were collected and surface cleaned. The dry weights of each of these parts were determined per unit fresh weight by oven drying the pre-weighed samples. For this purpose, fresh material equivalent to 0.25 g dry weight per ml of pure water (conductivity <0.05  $\mu$ S, purified from Millipore's Milli Q Water Purification System) was used to make stock solution. From the stock solution, dilutions were made so as to obtain concentrations equal to 0.125 and 0.0625 g dry weight ml<sup>-1</sup>.

Certified seeds of *Phaseolus aureus* var. SML-32 were used for bioefficacy studies as per IS A rules (ISTA, 1993). For each treatment solution, 400 seeds were soaked in relevant concentration of aqueous leachates at room temperature (25°C) for 8

hrs. Soaking in pure water served as control. The soaked seeds of each treatment were placed in four 15 cm diameter Petridishes lined with a thin absorbent cotton wad and overlined with a Whatman No. 40 filter paper disc. The bed was moistened with 15 ml of respective treatment solution. In each Petridish 100 seeds were arranged in concentric circles maintaining almost equal interseed distance. The entire set up was maintained in a seed germinator programmed temperature of  $25 \pm 2^\circ\text{C}$ , 75% relative humidity and 16 hrs. photoperiod. Daily observations on the number of seeds germinated were made and the final observations were taken after eight days. At the time of termination, the lengths of radicle and plumule were measured, and the per cent seed germination, and seed vigour (as per Agrawal, 1980) were calculated.

For assessing the organic component of leachable allelochemicals (i.e. aglycones) 100 ml of aqueous leachates of concentration 0.25 g dry weight  $\text{ml}^{-1}$  prepared from each part were used. To 100 ml of aqueous leachates was added equal volume of pre-chilled 3N HCl. The precipitates, thus, obtained were washed, dried and weighed.

The data obtained in the experiment were subjected to ANOVA followed by multiple range test (Duncan, 1955) and determination of correlation co-efficient.

## Results

Like control where all the seeds germinated on the first day registering 100% germination and seed vigour, no change in the germination was observed in the seeds treated with any of the concentration of leachates from stem or root or bud. Likewise, the seeds treated with 0.125 g.  $\text{ml}^{-1}$  or lower concentration of bark leachates did not show any change in the germination whereas those treated with 0.25 g.  $\text{ml}^{-1}$  leachates showed about 85% germination (Table-1). In contrast, none of the seeds treated with leaf leachates of 0.125 g dry weight  $\text{ml}^{-1}$  or higher concentration germinated. Even with lower concentration of 0.0625 g dry weight  $\text{ml}^{-1}$  only about 57% seeds germinated. With every increasing concentration, the germination percentage showed a decline as is otherwise also apparent from the strong correlation co-efficient (Table-1).

**Table-1:** Effect of different concentrations of aqueous leachates derived from different parts of *Populus deltoides* on per cent germination of *Phaseolus aureus*

Concentration (g. $\text{ml}^{-1}$ )	Leachates from tree part under use				
	Root	Stem	Leaf	Bark	Bud
0 (Control)	100*	100*	100*	100*	100*
0.0625	100*	100*	57.14*	94.44*	100*
0.125	100*	100*	-	89.68*	100*
0.250	95.24*	100*	-	84.92*	91.44*
'r'	-0.8783	0	-0.8746	-0.9771	-0.9783

Similar superscripts on values in a column represent insignificant difference at 5% level of significance (Duncan, 1955).

'r' represents correlation co-efficient between different concentrations and respective values of germination.

The trend of changes in the seed vigour (a measure of speed of germination) values were almost similar to those of germination (Table-2). By and large, the impact on the speed of germination was relatively more than that on per cent germination in the respective cases of treatment. Only 39% seed vigour was recorded in response to the lowest concentration of leaf leachates (Table-2).

**Table-2:** Effect of different concentrations of aqueous leachates derive from different parts of *Populus deltoides* on per cent seed vigour of *Phaseolus aureus*

Concentration (g. $\text{ml}^{-1}$ )	Leachates from tree part under use				
	Root	Stem	Leaf	Bark	Bud
0 (Control)	100*	100*	100*	100*	100*
0.0625	100*	100*	38.89*	94.44*	91.53*
0.125	97.62*	100*	-	82.34*	89.95*
0.250	92.86*	100*	-	78.97*	84.28*
'r'	-0.9661	0	-0.8439	-0.9353	-0.9467

Similar superscripts on values in a column represent insignificant difference at 5% level of significance (Duncan, 1955).

'r' represents correlation co-efficient between different concentrations and respective values of seed vigour.

The radicle length of water treated control seeds after eight days of germination was  $7.82 \pm 0.97$  cm. In contrast, in any of the treated seeds irrespective of the concentration it was short compared to those of

control (Table-3). It decrease with every increase in concentration of leachates derived from any of the part under observation. However, in response to the lowermost concentration of leaf leachated, the radicle length was only 32.48% of control. On the other hand, in case of seeds treated with highest concentration of bark leachates it was only 50% of that of control (Table-3).

**Table-3 :** Effect of different concentrations of aqueous leachates derived from different parts of *Populus deltoides* on per cent radicle length of *Phaseolus aureus*. Value in control :  $7.82 \pm 0.96$

Concentration (g.ml <sup>-1</sup> )	Leachates from tree part under use				
	Root	Stem	Leaf	Bark	Bud
0 (Control)	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>
0.0625	80.31 <sup>ab</sup>	92.58 <sup>a</sup>	32.48 <sup>b</sup>	70.84 <sup>b</sup>	83.12 <sup>ab</sup>
0.125	74.17 <sup>a</sup>	88.49 <sup>a</sup>	-	65.22 <sup>b</sup>	73.15 <sup>ac</sup>
0.250	65.22 <sup>a</sup>	86.44 <sup>a</sup>	-	51.15 <sup>b</sup>	58.82 <sup>c</sup>
'r'	-0.9257	-0.9071	-0.8254	-0.9192	-0.9775

Similar superscripts on values in a column represent insignificant difference at 5% level of significance (Duncan, 1955).

'r' represents correlation co-efficient between different concentrations and respective value of radicle length.

The trend of length of plumule was almost similar to that of radicle. However, in case of plumule length the effect was relatively more and with every increase in concentration, a consistent decrease was noticed (Table-4). With the highest concentration of leachates from bark; bud or root, it was less than 50% of control. However, at the lowest concentration of leaf leachates tried, the plumule length was only 28% of the control (Table-4).

Compared to  $31.55 \pm 0.71$  mg in control, the dry weight of seedlings raised from seeds treated with any of the leachates recorded significantly reduced biomass (Table-5). With every increase in concentration of leachates from any part, a consistent decrease in dry weight was noticed. At the lowest concentration of leaf leachates the average dry weight per seedling was only 29% of that of control. However, at the highest concentration of the leachates from any part other than leaves, it was reduced to nearly 60% of that of control (Table-5).

**Table-4:** Effect of different concentrations of aqueous leachates derived from different parts of *Populus deltoides* on per cent plumule length of *Phaseolus aureus*. Value in control:  $10.42 \pm 1.42$  cm

Concentration (g.ml <sup>-1</sup> )	Leachates from tree part under use				
	Root	Stem	Leaf	Bark	Bud
0 (Control)	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>
0.0625	77.26 <sup>ab</sup>	81.09 <sup>ab</sup>	28.31 <sup>b</sup>	71.98 <sup>b</sup>	72.65 <sup>b</sup>
0.125	71.50 <sup>ac</sup>	77.54 <sup>ab</sup>	-	50.86 <sup>c</sup>	62.67 <sup>bc</sup>
0.250	51.82 <sup>c</sup>	66.51 <sup>b</sup>	-	46.07 <sup>c</sup>	49.90 <sup>c</sup>
'r'	-0.9693	-0.9354	-0.8113	-0.8943	-0.9315

Similar superscripts on values in a column represent insignificant difference at 5% level of significance (Duncan, 1955).

'r' represents correlation co-efficient between concentrations and respective values of plumule length.

**Table-5 :** Effect of different concentrations of aqueous leachates derived from different parts of *Populus deltoides* on per cent dry weight per seedling of *Phaseolus aureus*. Value in control:  $31.55 \pm 0.31$  mg

Concentration (g.ml <sup>-1</sup> )	Leachates from tree part under use				
	Root	Stem	Leaf	Bark	Bud
0 (Control)	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>	100 <sup>a</sup>
0.0625	93.50 <sup>a</sup>	92.33 <sup>a</sup>	29.32 <sup>b</sup>	84.22 <sup>b</sup>	82.00 <sup>b</sup>
0.125	78.07 <sup>a</sup>	75.94 <sup>a</sup>	-	68.87 <sup>b</sup>	73.36 <sup>b</sup>
0.250	62.38 <sup>a</sup>	64.60 <sup>a</sup>	-	61.33 <sup>a</sup>	62.28 <sup>a</sup>
'r'	-0.9898	-0.9772	-0.8149	-0.9441	-0.9515

Similar superscripts on values in a column represent insignificant difference at 5% level of significance (Duncan, 1955).

'r' represents correlation co-efficient between different concentrations and respective values of dry weight per seedling.

The least amount of aglycons was extracted from the stem and the maximum from the leaves (Table-6). The amount of organic component in the leaves was over two times of that in bark or bud and over 3 or 4 times than from root or stem, respectively. In stem, it was nearly half of that in the buds (Table-6).

Table-6: Amount of organic component of aqueous leachates (concentration 0.25 g.ml<sup>-1</sup>) of different parts of *Populus deltoides*

Tree Part	Amount (mg)
Root	47.00 ± 1.42
Stem	35.06 ± 1.83
Leaf	155.52 ± 1.97
Bark	64.00 ± 1.88
Bud	68.00 ± 1.56

± represents standard error of the Mean

## Discussion

The phenomenon of allelopathy, in nature, is executed by the release of allelochemicals which are secondary metabolites (Rice 1984). These are released in the environment by many ways. Leachate through the natural agencies of rain, dew, fog, stemflow and snow is one such common mode of release (Rice 1979, 1984). Through the present study, it is clear that aqueous leachates prepared from various parts, viz., root, stem, leaves, bark or buds show inhibitory mechanism, though to a varying degree. For comparison, the leachates were prepared from fresh plant parts weighed according to their dry weight equivalents (because in the fresh material the content of water is bound to vary with season, time period of the day, place, age and other factors).

The leachates possess chemicals/ allelochemicals in the water soluble forms (Niemen 1952; Kumari and Kohli 1987; Daizy 1990; Pariana 1993). Through the Anthrone Reagent test, it was found that water soluble forms are glycosidic in nature. Goss (1973) reported that secondary metabolites/ allelochemicals in plants occur as glycosides (sugar molecules attached to compound) as these bonds facilitate their movement within or outside the plant and prevent intra-plant toxicity. In nature, after release from the plant the glycosidic bonds are broken by enzymatic or microbial action. In the present study, these bonds were broken by the cold acid hydrolysis (Pre-chilled and diluted) to find out the leachable content of organic components (aglycones) in different parts.

From the results it is seen that leaves, possess maximum amount of organic component/aglycones followed by buds and bark, whereas, root and stem possessed the least amount. From the study it becomes apparent that leaves play a major role in imparting allelopathic property to the tree. In nature also, the leaves fall on ground and remain there for some time. However, through this experiment total biomass of plant parts falling on ground and amount of leachate actually occurring could not be assessed.

The leachates from different parts of the tree were found to be potential inhibitors of germination and growth of *P. aureus* particularly at highest concentration of 0.25 g.ml<sup>-1</sup>. The potential of inhibition was concomitant with relative amounts of organic component in different parts. Maximum effect was exhibited by leaves and least by stem. Presumably, this variation in the effect exhibited by leachates from different tree parts is likely on account of the varying content of the leachable component in different parts.

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