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Inhibition of Germination and Growth Behavior of Some Agricultural Crops Through Application of *Albizia saman* Leaf Water Extracts

Rafiqul Hoque, A.T.M., Romel Ahmed, Mohammad Belal Uddin and M.K. Hossain
Institute of Forestry and Environmental Sciences,
University of Chittagong, Chittagong-4331, Bangladesh

Abstract: Investigations were carried out to study the inhibitory effects of *Albizia saman*'s leaf extracts on the germination and growth behavior of agricultural crops e.g. *Brassica juncea* (L.) Czern and Coss; *Phaseolus mungo* L.; *Raphanus sativus* L.; *Vigna unguiculata* (L.) Walp. and *Cicer arietinum* L. The experiments were conducted in sterilized petridishes with a photoperiod of 24 h at room temperature of 27-28°C. The effects of the different concentrations of aqueous extracts were compared to distill water (control). The aqueous extracts of leaf caused significant inhibitory effect on germination, root and shoot elongation and development of lateral roots of receptor plants. Bioassays indicated that the inhibitory effect was proportional to the concentrations of the extracts and higher concentration (50-100%) had the stronger inhibitory effect whereas the lower concentration (10-25%) showed stimulatory effect in some cases. The study also revealed that inhibitory effect was much pronounced in root and lateral root development rather than germination and shoot growth.

Key words: *Albizia saman*, leaf extract, germination, shoot elongation, root elongation, development of lateral roots

Introduction

Albizia saman (Mimosoidae, Leguminosae) a deciduous, fast growing large tree about 25-40 m tall with umbrella-shaped canopy of shady leaves, is well known as an ornamental plant throughout the tropical and sub-tropical region of the world. It is a native of Brazil (Troups, 1986) planted in roadside as shade tree, at school campuses as ornamental tree and in village for fuel wood in Bangladesh. It grows on all types of soils of Bangladesh. But it is usually planted on the southern part of the country (Khan and Alam, 1996) especially on the wet damped soils of the village areas of greater Barishal, Patuakhali and Noakhali district. Pulp of the pod is sweet and sugary when ripe, much relished by the children and also eaten by cows (NAS, 1979). Leaves used as cattle fodder (Benthal, 1933). For this reason it is being incorporated in various traditional agroforestry program as an associated species but it seems that it has some suppressive effect on agricultural crops and ground vegetation which might have been caused by secondary metabolites (allelochemicals) either from fallen leaves or plant leachates or root exudates.

Many species within the leguminosae family contain secondary plant products that have allelopathic potential (Rice, 1984). The test of allelopathy in *A. saman* has not yet been investigated, although much research of leguminosae plants has been carried out in many parts of

the world (Swaminathan *et al.*, 1989; Rizvi *et al.*, 1990; Koul *et al.*, 1991; Chaturvedi and Jha, 1992; Chou, 1992; Jadhav and Gaynar, 1992; Joshi and Prakash, 1992; Singh and Nadal, 1993). But the phenomenon of suppressive effect on agricultural crops and ground vegetation in the nature indicated a possible allelopathic influence exerted by *Albizia saman*. Before selecting as a tree in agroforestry system, it is essential to check its allelopathic compatibility (King, 1979; Gaba, 1987; Uddin *et al.*, 2000). So the purpose of the present study was to elucidate the inhibitory effects of different concentration of leaf extracts of *Albizia saman* on some common agricultural crops used in Bangladesh.

Materials and Methods

Albizia saman was considered as the donor plant and the receptor agricultural crops selected were Indian mustard (*Brassica juncea* (L.) Czern and Coss), Chickpea (*Cicer arietinum* L.) Black gram (*Phaseolus mungo* L.), Radish (*Raphanus sativus* L.), and Falen (*Vigna unguiculata* (L.) Walp.). The aqueous extracts were prepared from fresh leaf of *Albizia saman* plant. 100 gram of fresh leaves of the species were soaked in 500 ml of distill water and kept at room temperature of 28-30°C. After 24 h the aqueous extract was filtered through the sieve and then some extracts were diluted to make the concentration of 10, 25, 50 and 75% and stored for seed treatment experiments.

The following treatments were used in the experiment:

- T₀ = Seeds of receptor plants grown in distil water only (Control)
- T₁ = Seeds of receptor plants grown in leaf extracts of 10% concentration
- T₂ = Seeds of receptor plants grown in leaf extracts of 25% concentration
- T₃ = Seeds of receptor plants grown in leaf extracts of 50% concentration
- T₄ = Seeds of receptor plants grown in leaf extracts of 75% concentration
- T₅ = Seeds of receptor plants grown in leaf extracts of 100% concentration

Germination and growth records: The germination test was carried out in sterile petridishes of 12 cm in size placing a Whatman no.3 filter paper on petridishes. The extract of each concentration was added to each Petridish of respective treatment daily in such an amount just to wet the seed. The control was treated with distil water only. 20 seeds of each agricultural crop were placed in the Petridish and each treatment was replicated five times. The petridishes were set in the analytical laboratory of the Institute of Forestry and Environmental Sciences, Chittagong University (IFESCU), Bangladesh at a room temperature of 28-30°C. The experiment extended over a period of ten days to allow the last seed germination and the measurement of the shoot and root length. The seed was considered as germinated when the radicle emerged and the germination was recorded daily. The results were determined by counting the number of germinated seeds, number of lateral roots and measuring the length of primary root and main shoot on 10th day of the experiment. The data were subjected to analysis of variance and Duncan's multiple range test (DMRT). Ratio of germination and elongation were calculated as suggested by Rho and Kil (1986).

$$\text{Relative Germination Ratio (RGR)} = \frac{\text{Germination ratio of tested plant}}{\text{Germination ratio of control}} \times 100$$

$$\text{Relative Elongation Ratio (RER) of shoot} = \frac{\text{Mean shoot length of tested plant}}{\text{Mean length of control}} \times 100$$

$$\text{Relative Elongation Ratio (RER) of root} = \frac{\text{Mean length of root of tested plant}}{\text{Mean length of control}} \times 100$$

For the calculation of percentage of inhibitory effect on germination and growth parameters of treatment plants to control was calculated as per formula evolved by Surendra and Pota (1978):

$$I = 100 - (E_2 \times 100 / E_1)$$

Where

- I = % inhibition,
- E₁ = response of control plant and
- E₂ = response of treatment plant.

Results

Germination: The germination percentage of the five-receptor plants was shown in Table 1. In most of the cases the inhibitory effect was significantly increased with the increasing concentration of the extract. The study revealed that the highest inhibition was exerted by T₅ treatment and complete inhibition (-100%) was occurred in *R. sativus* at T₄ and T₅ treatment and *C. arietinum* at T₅ treatment. Among the survivors, the highest inhibitory effect (-98.21%) was recorded from *B. juncea* at T₅ treatment while the lowest (-3.39%) was from *P. mungo* at T₃ treatment. Maximum (101.70%) Relative Germination Ratio (RGR) was found in *P. mungo* at T₁ treatment while the minimum (1.79%) was found in *B. juncea* at T₅ treatment (Fig. 1).

Table 1: Germination percentage of receptor agricultural crops to distil water (T₀) and different concentrations of *Albizia saman* extracts (T₁-T₅). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments

Treatment	<i>C. arietinum</i>	<i>R. sativus</i>	<i>V. unguiculata</i>	<i>B. juncea</i>	<i>P. mungo</i>
T ₀	83.33a	80.00a	96.67a	93.33a	98.33a
T ₁	35.00bc (-58.00)	75.00a (-6.25)	81.67ab (-15.52)	93.33a (0)	100.00a (+1.70)
T ₂	23.33abc (-72.00)	53.33b (-33.34)	58.33b (-39.67)	88.33a (-5.36)	98.33a (0)
T ₃	40.00b (-52.00)	1.67c (-97.91)	80.00ab (-17.24)	61.67b (-33.92)	95.00ab (-3.39)
T ₄	10.00cd (-88.00)	0.00c (-100)	76.67ab (-20.69)	30.00c (-67.86)	91.67ab (-6.67)
T ₅	0.00d (-100)	0.00c (-100)	70.00ab (-27.59)	1.67d (-98.21)	88.33b (-10.17)

Table 2: Shoot elongation (cm) of receptor agricultural crops to distil water (T₀) and different concentrations of *Albizia saman* leaf extracts (T₁-T₅). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatment

Treatment	<i>C. arietinum</i>	<i>R. sativus</i>	<i>V. unguiculata</i>	<i>B. juncea</i>	<i>P. mungo</i>
T ₀	15.93a	6.78ab	16.21a	2.89ab	14.92ab
T ₁	4.83b (-69.68)	7.08a (+4.42)	18.39a (+13.45)	3.6a (-44.53)	15.47a (+3.69)
T ₂	5.14b (-67.73)	5.27b (-22.27)	18.37a (+13.33)	1.98bc (-69.49)	14.51ab (-2.75)
T ₃	4.8b (-69.87)	0.83c (-87.76)	17.99a (+10.98)	1.17cd (-81.97)	12.67ab (-15.08)
T ₄	2.93b (-81.61)	0.00c (-100)	14.68a (-9.44)	0.17d (-97.38)	12.35bc (-17.22)
T ₅	0.00c (-100)	0.00c (-100)	10.68a (-34.11)	0.00d (-100)	9.73c (-34.78)

Values in the columns followed by the same letter(s) are not significantly different (P ≤ 0.05) according to Duncan's multiple range test (DMRT).

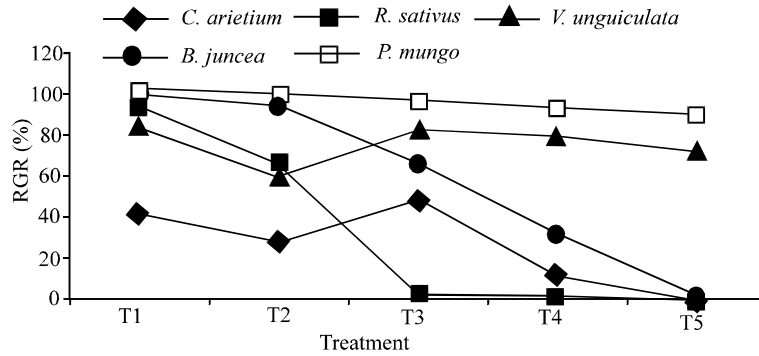


Fig. 1: Relative Germination Ratio (RGR) of bioassay species grown in petridishes at different concentrations of *Albizia saman* extracts

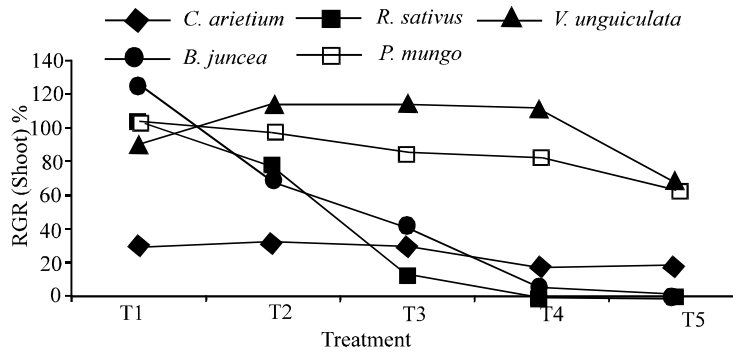


Fig. 2: Relative Elongation Ratio (RER) of shoot of bioassay species grown in petridishes at different concentrations of *Albizia saman* extracts

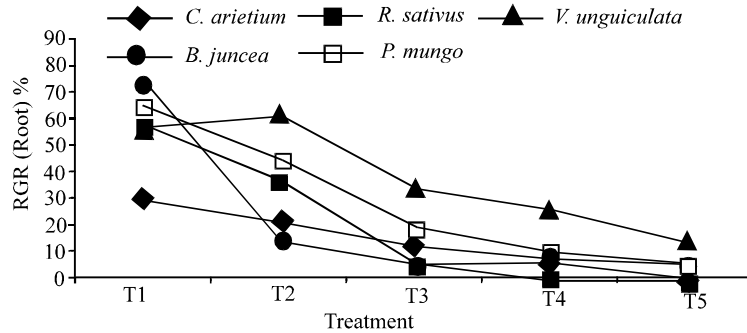


Fig. 3: Relative Elongation Ratio (RER) of root of bioassay species grown in petridishes at different concentrations of *Albizia saman* extracts

Shoot elongation (cm): Table 2 shows the average shoot length of receptor crops. The study revealed that T₁ treatment showed stimulatory effect in most cases and inhibitory effect increased with the increase of extract concentration. Among the survivors the highest inhibitory effect (-97.38%) was found on *B. juncea* at T₄ treatment followed by (-87.76%) on *R. sativus* at T₃ treatment while the lowest (-2.75%) was on *P. mungo* at T₂ treatment. The highest stimulatory effect (+13.45%) was found in *V. unguiculata* at T₁ treatment followed by the same crop (+13.33%) at T₂ treatment. Maximum (124.57%)

Relative Elongation Ratio (RER) of shoot was observed in *B. juncea* at T₁ treatment while the minimum (5.88%) was in the same crop at T₄ treatment (Fig. 2).

Root elongation (cm): The root lengths of all the five-bioassay species were significantly inhibited with the increasing concentration of extract. The inhibitory effect was much more pronounced at T₅ treatment followed by T₄, T₃ and T₂ treatment in a descending order. Among the survivors the highest inhibitory effect (-94.42%) was found in *R. sativus* at T₃ treatment followed by (-93.97%)

Table 3: Root elongation (cm) of receptor agricultural crops to distil water (T₀) and different concentrations of *Albizia saman* extracts (T₁-T₅). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments

Agricultural crops					
Treatment	<i>C. arietinum</i>	<i>R. sativus</i>	<i>V. unguiculata</i>	<i>B. juncea</i>	<i>P. mungo</i>
T ₀	13.06a	14.16a	12.02a	5.85a	9.45a
T ₁	4.4b	9.02b	7.53ab	4.71a	6.87b
	(-66.31)	(-36.30)	(-37.35)	(-19.49)	(-27.30)
T ₂	3.10bc	5.73c	8.15ab	0.93b	4.66c
	(-76.26)	(-59.53)	(-32.20)	(-84.10)	(-50.69)
T ₃	1.73bc	0.79d	4.55ab	0.39b	1.95d
	(-86.75)	(-94.42)	(-62.15)	(-93.33)	(-79.37)
T ₄	0.88c	0.00d	3.57b	0.50b	0.99de
	(-93.26)	(-100)	(-70.30)	(-91.45)	(-88.52)
T ₅	0.00c	0.00d	1.97b	0.00b	0.57e
	(-100)	(-100)	(-83.61)	(-100)	(-93.97)

Table 4: Number of lateral roots developed in receptor agricultural crops to distil water (T₀) and different concentrations of *Albizia saman* extracts (T₁-T₅). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T₀) treatments

Agricultural crops					
Treatment	<i>C. arietinum</i>	<i>R. sativus</i>	<i>V. unguiculata</i>	<i>B. juncea</i>	<i>P. mungo</i>
T ₀	17.20a	23.27a	24.41a	5.00a	12.73a
T ₁	7.18b	15.00b	24.60a	4.53a	14.00a
	(-58.26)	(-35.54)	(+0.78)	(-9.4)	(+9.98)
T ₂	5.05b	9.21b	22.13a	2.20b	13.00a
	(-70.64)	(-60.42)	(-9.34)	(-56.0)	(+2.12)
T ₃	5.93b	1.33c	13.67a	0.27b	9.60ab
	(-65.52)	(-94.28)	(-44.00)	(-94.6)	(-24.59)
T ₄	3.80b	0.0c	17.20a	0.00b	10.47ab
	(-77.91)	(-100)	(-29.58)	(-100)	(-17.75)
T ₅	2.67b	0.00c	8.87a	0.00b	6.67b
	(-84.48)	(-100)	(-63.66)	(-100)	(-47.60)

Values in the columns followed by the same letter(s) are not significantly different (P≤0.05) according to Duncan's multiple range test (DMRT).

P. mungo at T₅ treatment while the minimum (- 19.49%) was found in *B. juncea* at T₁ treatment (Table 3). In all cases the highest root length was observed at Control (T₀). Maximum (80.51%) Relative Elongation Ratio (RER) of root was found in *B. juncea* at T₁ treatment while the minimum (5.58%) was found in *R. sativus* at T₃ treatment (Fig. 3).

Development of lateral roots: In most of the cases the numbers of lateral root development were considerably inhibited except T₁ and T₂ treatment of *P. mungo* and T₁ treatment of *V. unguiculata*. Side by side it was found that the inhibitory effect progressively increased with the increasing concentration of extract (Table 4). Stimulatory effect was found in *P. mungo* (+9.98%) and in *V. unguiculata* (+0.78%) at T₁ and *P. mungo* L. (+2.12%) at T₂ treatment in comparison to control. Among the survivors the highest inhibitory effect on lateral root development was recorded from *B. juncea* (-94.6%) followed by *R. sativus* (-94.28%) at T₃ treatment while the lowest inhibitory effect was found in *V. unguiculata* (-9.34%) at T₂ treatment.

Discussion

The results revealed that the different concentration of leaf extracts inhibit germination of crop seeds to a certain extent and even in some cases complete inhibition was occurred. Overall growth rate of seedlings was also reduced in almost all the treatments compared to control. It was also inferred that the inhibition of seed germination and seedling growth was concentration – dependent i.e., inhibition was more as the concentration increased. These findings coincided with the report of Daniel (1999) who reported that Allelopathy includes both promoting and inhibitory activities and is a concentration-dependent phenomenon. Mortality of the seedlings and reduced vigor under laboratory conditions indicated the accumulation of toxic substances (allelopathic potential) of the donor plant is harmful to the growth of seedlings of receptor plants. These findings correlated with the report of Chou and Waller (1980), Rice (1984), Chou and Kuo (1984), Waller (1987) and Chou (1992) who found that many species within the Leguminosae family contain secondary plant products that have allelopathic potential. Response of the bioassay species to the aqueous extracts varied among the five species.

Considering the overall treatment among the five bioassay species the *P. mungo* was the least sensitive to the aqueous extract followed by *V. unguiculata* while *C. arietinum* was the most sensitive followed by *R. sativus* and *B. juncea*. Marked reduction in root length was noticed in most of the seedlings compared to shoot length and germination. This result also coincided with the result of Swami Rao and Reddy (1984) who found the inhibitory effect of leaf extracts of *Eucalyptus* (hybrid) on the germination of certain food crops. Zackrisson and Nilsson (1992) supported higher sensitivity of root growth than seed germination. So, it may be concluded that the water soluble leachates from the fresh leaves of *Albizia saman* has the allelopathic potential that reduce the germination as well as suppress the growth and development of agricultural crops. Allelopathics are often due to synergistic activity of allelochemicals rather than to single compounds (Williamson, 1990). Under field conditions, additive or synergistic effects become significant even at low concentrations (Einhellig and Rasmussen, 1978). However, while the potential of an allelopathic influence exist, it exists as a part of ecological but not so prominent as to be singled out as the most important factor affecting stand characteristics as in the case of some other system (Rice, 1984). Though laboratory bioassays in allelopathic research are of great importance, long-term field studies must be recommended to carry out before incorporating *Albizia saman* in any agroforestry system.

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