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Inhibitory effects of *Albizia lebbeck* leaf extracts on germination and growth behavior of some popular agricultural crops

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Abstract: An experiment was conducted to observe the inhibitory effects of the leaf extracts derived from *Albizia lebbeck* (L.) Benth. on germination and growth behavior of some popular agricultural crops (receptor) of Bangladesh. Experiments were set on sterilized petridishes with a photoperiod of 24 h at room temperature of 27–30°C. The effects of the different concentrations of aqueous extracts were compared to distil 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.

Keywords: *Albizia lebbeck* (L.) Benth.; Allelopathic effect; Leaf extracts; Germination; Growth behavior

Introduction

Albizia lebbeck (L.) Benth. (Mimosaceae) is a medium-sized to large deciduous tree that reaches 30 m in height in tropical rain forests. The tree develops a straight bole when growing in dense forests, but it is spreading and low branching in the open. Unless coppiced frequently, trees will annually produce an abundance of seed from papery pods about 20 cm long and 3 cm wide (Prinsen 1988). The species is native to India, Myanmar and the Andaman Island and naturalized in many other tropical and subtropical areas (Streets 1962). In these regions *A. lebbeck*, also known as "Siris" or "Indian Siris", grows in a wide range of climates, covering an annual rainfall range of 600-2 500 mm. However, it also has been grown successfully in areas with an annual rainfall as low as 400 mm. The species is adapted to a wide range of soil types, from acid soils to alkaline and saline conditions (Prinsen 1986). In Bangladesh, *A. lebbeck* is planted in roadsides as shade tree, in village forests for fuel wood production and in front school or college premises as ornamental tree. Although, the species grows on all types of soils of Bangladesh, but frequently planted on the northern and southern parts of the country (Khan *et al.* 1996; Das *et al.* 2001) 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 programs 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. lebbek* has not yet been investigated, although much research of leguminous plants has been carried out in many parts of the world (see; Swaminathan *et al*. 1989; Rizvi *et al*. 1990; Koul *et al*. 1991; Chaturvedi and Jha 1992; Chou 1992; Jadhab and Gaynar 1992; Joshi and Prakash 1992; Singh and Nadal 1993). Since, the occurrence of *A. lebbeck* in natural agro-ecosystems shows some suppressive effect on agricultural crops as well as on ground vegetation which consequently indicated a possible allelopathic influence exerted by *A. lebbeck* so, before selecting as a tree in agroforestry system, it is essential to check its allelopathic compatibility in natural agro-ecosystem (King 1979; Gaba 1987 and Uddin *et al.* 2000). The purpose of our present study was to elucidate the inhibitory effects of different concentration of leaf extracts of *A. lebbeck* on different popular agricultural crops in Bangladesh.

Materials and methods

Test environment and plants used in the experiment

Our experiments were set at a room temperature of about 27□30ºC. *A. lebbeck* was the donor plant for the experiment. Besides, the following agricultural crops were considered as the receptors; *Brassica juncea* (L.) Czern. (Indian mustard), *Cucumis sativus* L. (Cucumber), *Phaseolus mungo* L. (Black gram), *Raphanus sativus* L. (Radish), and *Vigna unguiculata* (L.) Walp. (Cow pea). These species are common among the agricultural crops and frequently planted in most of the country's agrofor-

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estry plots. For this cause we selected them as the receptor plants.

Preparation of the *A. lebbeck* plant extracts and treatments

The aqueous extracts for the experiment were prepared from the fresh leaf of *A. lebbeck* plant. For the preparation of extracts 100 gram of fresh leaves of the species were soaked in 500 mL of distilled water and kept at room temperature of 27–30°C without allowing any possible chemical changes. After 24 hours the aqueous extract was filtered through the sieve and then some extracts were diluted to make the concentration of 10%, 25%, 50% and 75% (on the basis of volume) and stored for seed treatment experiments. The following treatments were used in the experiment:

T_0- Seeds of receptor plants grown in distil water only (Control);

T_1- Seeds of receptor plants grown in leaf extracts of 10% concentration;

T_2- Seeds of receptor plants grown in leaf extracts of 25% concentration;

T_3 - Seeds of receptor plants grown in leaf extracts of 50% concentration;

T_4- Seeds of receptor plants grown in leaf extracts of 75% concentration;

T_5- Seeds of receptor plants grown in leaf extracts of 100% concentration.

Germination and growth records

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 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 distilled water only. 20 seeds of each agricultural crop were placed in the petridish and each treatment was replicated five times. The germination was recorded daily and the seeds were considered as germinated when the radicle emerged.

Measuring germination and growth values

The results of the experiment 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). We calculated the ratio of germination and elongation of treatments as suggested by Rho and Kil (1986).

$$R = (T / Tr) \times 100 \quad (1)$$

where, R is the relative ratio, T the test ratio of treatment plant, and Tr the test ratio of control.

Calculations of inhibitory effect

The 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):

$$I = 100 - (E_2 \times 100/E_1) \quad (2)$$

where, I is % inhibition, E_1 the response of control plant, and E_2 the response of treatment plant.

Results

Germination

The germination percentage of the five-receptor plants is shown in Table1. The study revealed that the highest inhibition was exerted by T_5 treatment in all cases except in *V. unguiculata.* Among the survivors, the highest inhibitory effect (–98.33%) was recorded from *B. juncea* at T_5 treatment. While the lowest (-1.67%) was from *B. juncea* at T_2 treatment. The maximum (128.57%) Relative Germination Ratio (RGR) was found in C. sativus at T1 treatment while the minimum (1.67%) was found in *B. juncea* at T_5 treatment (Fig. 1).

Table 1. Germination percentage of receptor agricultural crops to distil water (T_0) and different concentrations of *A. lebbeck* leaf extracts (T_1-T_5). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments

Treatment	Agricultural crops				
	C. sativus	*R. sativus*	*V. unguiculata*	*P. mungo*	*B. juncea*
T_0	70.00 bc	83.33 a	98.33 a	98.33 a	100.00 a
T_1	90.00 a*; (+28.57)	85.00 a; (+2.00)	83.33 ab; (-15.25)	96.67 a; (-1.69)	96.67 a; (-3.33)
T_2	83.33 ab; (+19.04)	88.33 a; (+6.00)	70.00 bc; (-28.81)	96.67 a; (-1.69)	98.33 a; (-1.67)
T_3	75.00 abc; (+7.14)	31.67 b; (-61.99)	73.33 bc; (-25.42)	91.67 a; (-6.77)	56.67 b; (-43.33)
T_4	75.00 abc; (+7.14)	5.00 c; (-93.99)	25.00 d; (-74.58)	90.00 ab; (-8.47)	21.67 c; (-78.33)
T_5	65.00 c(-7.14)	1.67 c; (-98.00)	56.67 c; (-42.37)	83.33 b; (-15.25)	1.67 d; (-98.33)

Notes: * 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)

Shoot elongation

The average shoot lengths (cm) of the germinated seedlings of all the receptor crops are shown in Table 2. Statistically pronounced significant effect was found at T_5 treatment followed by T_3 and T_4 treatment in all cases and complete inhibition (-100%) of shoot development was occurred in *R. sativus* and *B. juncea* at T_4 and T_5 treatment. Among the survivors, the highest inhibitory effect (-99.40%) was found on *B. juncea* at T_3 treatment while the lowest (-0.75%) was on *V. unguiculata* at T_1 treatment. The highest stimulatory effect (+36.92%) was found in *R. sativus* at T_2 treatment followed by (+34.11%) on *C. sativus* at T_1 treatment. Maximum (136.92%) Relative Elongation Ratio (RER) of shoot

was observed maximum in *R. sativus* at T_2 treatment while the minimum (0.59%) was in *B. juncea* at T_3 treatment (Fig. 2).

Table 2. Shoot elongation (cm) of receptor agricultural crops to distil water (T_0) and different concentrations of *A. lebbeck* leaf extracts (T_1-T_5)

Treatment	Agricultural crops				
	C. sativus	*R. sativus*	*V. unguiculata*	*P. mungo*	*B. juncea*
T_0	7.27 b*	6.69 b	17.37 a	17.32 a;	3.37 a;
T_1	9.75 a; (+34.11)	7.18 b; (+7.32)	17.24 a; (-0.75)	17.15 a; (-0.98)	3.43 a; (+1.78)
T_2	8.59 ab; (+18.16)	9.16 a; (+36.92)	18.27 a; (+5.18)	15.36 b; (-11.32)	2.92 a; (-13.35)
T_3	3.63 c; (-50.07)	1.75 c; (-73.84)	15.76 a; (-9.27)	12.35 c; (-28.70)	2.00E-02 b; (-99.40)
T_4	1.95 cd; (-73.18)	0.00 d; (-100)	6.47 b; (-62.75)	8.07 d; (-53.41)	0.00 b; (-100)
T_5	0.71 d; (-90.23)	0.00 d; (-100)	6.77 b; (-61.02)	6.61d; (-61.84)	0.00 b; (-100)

Notes: * 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).
Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatment

Root elongation

Root development was completely inhibited (-100%) in *R. sativus* and *B. juncea* at T_5 and T_4 treatment. Among the survivors, the highest inhibitory effect (-99.65%) was found in *B. juncea* at T_3 treatment followed by (-96.65%) on *C. sativus* at T_5 treatment while the minimum (-38.02%) was found in *R. sativus* at T_1 treatment (Table 3). Maximum (117.83%) Relative Elongation Ratio (RER) of root was found in *C. sativus* at T_1 treatment while the minimum (0.39%) was found in *B. juncea* at T_3 treatment (Fig. 3).

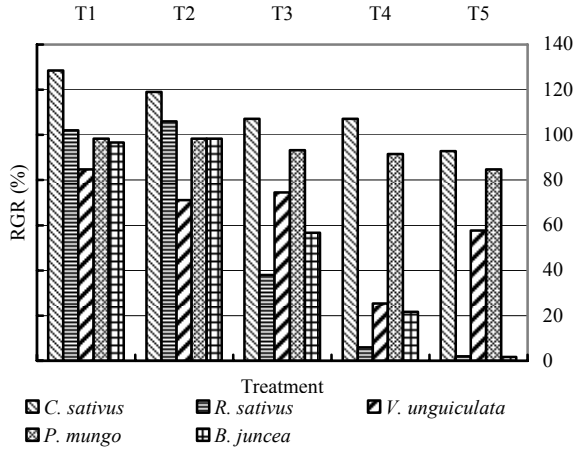

Fig. 1 Relative germination ratio (RGR) of bioassay species grown in petridishes at different concentrations of *A. lebbeck* leaf extracts

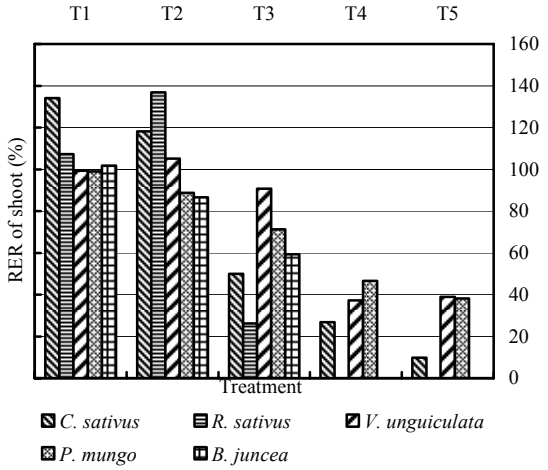

Fig. 2 Relative elongation ratio (RER) of shoot of bioassay species grown in petridishes at different concentrations of *A. lebbeck* leaf extracts

Development of lateral roots

Complete inhibition of lateral root development was found in *R. sativus* and *B. juncea* at T_4 and T_5 treatment (Table 4). Among the survivors, the highest inhibitory effect on lateral root development was recorded from *R. sativus* (-96.34%) at T_3 treatment followed by *C. sativus* (-88.46) and *V. unguiculata* (-86.63%) at T_5 and T_4 treatment respectively while the lowest inhibitory effect was found in *P. mungo* (-21.72%) at T_1 treatment.

Table 3. Root elongation (cm) of receptor agricultural crops to distil water (T_0) and different concentrations of *A. lebbeck* leaf extracts (T_1-T_5)

Treatment	Agricultural crops				
	C. sativus	*R. sativus*	*V. unguiculata*	*P. mungo*	*B. juncea*
T_0	7.46 a*	19.15 a	16.21 a	7.57 a	8.64 a
T_1	8.79 a; (+17.83)	11.87 b; (-38.02)	4.91 b; (-69.71)	4.57 b; (-39.63)	4.58 b; (-46.99)
T_2	2.99 b; (-59.92)	10.29 b; (-46.27)	4.71 b; (-70.94)	3.19 c; (-57.86)	0.93 c; (-89.24)
T_3	1.52 b; (-79.63)	1.09 c; (-94.31)	4.39 b; (-72.92)	0.97 d; (-87.19)	3.33E-02 d; (-99.65)
T_4	0.49 b; (-93.43)	0.00 c; (-100)	1.06 c; (-93.46)	0.45 d; (-94.06)	0.00 d; (-100)
T_5	0.25 b; (-96.65)	0.00 c; (-100)	1.27 c; (-92.17)	0.31 d; (-95.90)	0.00 d; (-100)

Notes: * 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).
Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments

Table 4. Number of lateral roots developed in receptor agricultural crops to distil water (T_0) and different concentrations of *A. lebbeck* leaf extracts (T_1-T_5).

Treatment	Agricultural crops				
	C. sativus	*R. sativus*	*V. unguiculata*	*P. mungo*	*B. juncea*
T_0	16.73 ab	40.13 a	41.87 a	14.73 a	7.20 a
T_1	24.87 a*; (+48.66)	22.53 b; (-43.86)	18.47 b; (-55.89)	11.53 b; (-21.72)	4.87 b; (-32.36)
T_2	11.33 bc; (-32.28)	20.53 b; (-48.84)	15.60 b; (-62.74)	8.20 c; (-44.33)	1.87 c; (-74.03)
T_3	8.73 bc; (-47.82)	1.47c; (-96.34)	16.20 b; (-61.31)	6.47 cd; (-56.08)	0.00 d; (-100)
T_4	4.40 c; (-73.70)	0.0 c; (-100)	5.60 c; (-86.63)	5.20 cd; (-64.70)	0.00 d; (-100)
T_5	1.93 c; (-88.46)	0.00 c; (-100)	9.07 c; (-78.34)	4.60 d; (-68.77)	0.00 d; (-100)

Notes: * 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). Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control (T_0) treatments

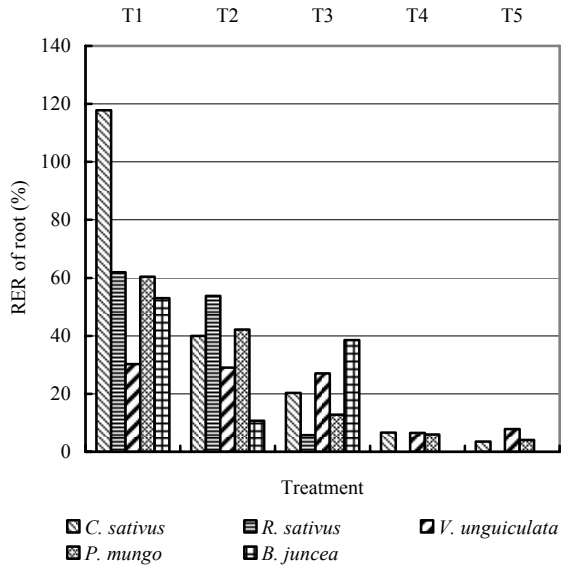

Fig. 3 Relative elongation ratio (RER) of root of bioassay species grown in petridishes at different concentrations of *A. lebbeck* leaf extracts

Discussion

The experiment revealed that, the different concentration of leaf extract inhibits the germination of crop seeds to a certain extent which in some cases found to causes complete inhibition of the species. Overall growth rate of seedlings was also reduced in almost all the treatments compared to control. The survivors exhibited varying degree of necrosis and chlorosis, thin and grayish in color. Many seedlings lost their ability to develop normally as a result of reduced radicle elongation and root necrosis. So, it was inferred that, the inhibition of seed germination and seedling growth is dependent on the concentration 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 (1992), Waller (1987), Rice (1984), Chou and Kuo (1984) and Chou and Waller (1980), 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 *C. sativus* was the least sensitive to the aqueous extract followed by *P. mungo* and *V. unguiculata* while *R. sativus* and *B. juncea* was the most sensitive. 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 *A. lebbeck* 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 (Einhelliing 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 *A. lebbeck* in any agroforestry system.

References

Benthal, A.P. 1933. The trees of Calcutta and its neighborhood. London: Thacker-Spink and Co. Ltd.. pp140–225.

Chaturvedi, O.P., and Jha, A.N. 1992. Studies on allelopathic potential of an important agroforestry species. *Forest Ecology and Management*, **53**: 91–98.

Chou, C.H. 1992. Allelopathy in relation to agricultural productivity in Taiwan: Problems and Prospects. In: Rizvi, S.J.H. and Rizvi, V. (eds.), Allelopathy: *Basic and Applied Aspects*. London: Chapman and Hall, pp179–204.

Chou, C.H. and Kuo, Y.L. 1984. Allelopathic exclusion of understory by *Leucaena leucocephala* (Lam) de Wit. *J. Chem. Ecol.*, **12**: 1431–1448.

Chou, C.H., and Waller, G.R. 1980. Possible allelopathic constituents of *Coffea Arabica*. *J. Chem. Ecol*., **6**: 643–654.

Daniel, W.G. 1999. *Historical review and current models of forest succession and interference.* Florida: CRC Press, pp237–251.

Das, D.K. and Alam, M.K. 2001. *Trees of Bangladesh*. Bangladesh: Bangladesh Forest Research Institute (BFRI), Chittagong, pp25–26.

Einhellig, F.A. and Rusmussen, J.A. 1978. Synergistic inhibitory effects of

vanilic and p-hydroxybenzoic acids on radish and grain sorghum. *J. Chem. Ecol*., **4**: 425–436.

Gaba, R.K. 1987. Role of allelopathy in social forestry. In: Khosla, P.K. and Kohli, R.K.(eds.), *Social forestry for rural development*. Solan,: ISTS, pp 228–234.

Jadhav, B.B. and Gaynar, D.G. 1992. Allelopathic effects of *Acacia auriculiformis* on germination of rice and cowpea. *Indian Journal of Plant Physiology*, **35**: 86–89.

Joshi, P.C. and Prakash, O. 1992. Allelopathic effects of litter extract of some tree species on germination and seedling growth of agricultural crops. In: Tauro, P., Narwal, S.S. (eds.), *Proceedings of the First National Symposium on Allelopathy in Agroecosystem, Hisar*, India: Indian Society of Alleolopathy, pp127–128.

Khan, M.S. and Alam, M.K. 1996. *Homestead Flora of Bangladesh*. Bangladesh: BARC, IDRC, SDC, Dhaka, Bangladesh, pp 37–38.

King, K.F.S. 1979. Agroforestry and the utilization of fragile ecosystems. *Forest Ecology Management*, **2**: 161–168.

Koul, V.K., Raina, A., Khanna, Y.P. Tickoo, M.L. and Singh, H. 1991. Evaluation of allelopathic influence of certain farm grown tree species on rice (*Oryza sativa* L. cv. PC-19). *Indian Journal of Forestry*, **14**: 54–57.

NAS. 1979. *Tropical legumes: Resources for the future*. Washington D.C: National Academy of Science, Washington D.C., 331p.

Prinsen, J.H. 1986. Potential of *Albizia Lebbeck* (*Mimosaceae*) as a tropical fodder tree - a review of literature. *Trop. Grasslands*, **20**(2): 78–83.

Prinsen, J.H. 1988. *Albizia Lebbeck ¨*C A promising fodder tree for semi-arid regions. *Nirtogen fixation tree highlights series 11*. Hawai: Nitrogen Fixation Tree Association (NFTA), pp 88–93.

Rho, B.J. and Kil, B.S. 1986. Influence of phytotoxin from *Pinus rigida* on the selected plants. *Journal of Natural Science*, **5**: 19–27.

Rice, E.L. 1984. *Allelopathy (second edition*). Orlando, Florida: Academic Press, 422p.

Rizvi, S.J. Sinha, H.R.C. and Rizvi, V. 1990. Implication of mimosine allelopathy in agroforestry In *Proc. 19th World Congress on Forestry*, **2**: 22–27.

Singh, R.P., and Nadal, D.P.S. 1993. Allelopathic effects of aqueous leaf extract of important agroforestry tree species on some fodder crops. *Forage Research*, **19**: 59–61.

Streets, R.J. 1962. *Exotic Forest Trees in the British Commonwealth*. Oxford: Clarendon Press, , pp169–170.

Surendra, M.P. and Pota, K.B. 1978. The allelopathic potentials of root exudates from different ages of *Celosia argenta* Linn. *Nat. Acad. Sci. Lett*., **1**(2): 56–58.

Swaminathan, C., Rai, R.S.V., and Suresh, K.K. 1989. Allelopathic potentialities of *Acacia nilotica* (L.) wills ex Del. *Journal of Tropical Forest Science*, **2**: 56–60.

Swami-Rao, N. and Reddy, P.C. 1984. Studies on the inhibitory effect of *Eucalyptus* (hybrid) leaf extracts on the germination of certain food crops. *Indian Forester*, **110** (2): 218–222.

Uddin, M.B., Ahmed, R. and Hossain, M.K. 2000. Allelopathic potential of water extracts of *Leocaena leococephala* leaf on some agricultural crops in Bangladesh. *The Chittagong University Journal of Science*, **24**(1): 121–127.

Waller, G.R. (ed.). 1987. *Allelochemicals: Role in Agriculture and Forestry*. Washington, D.C.: American Chemical Society, ACS Symposium Series-330, 606p.

Williamson, G.B. 1990. Allelopathy, Koch's postulates and the neck riddle. In: Grace, J.B. and Tilman, D. (eds.), *Perspective on plant competition*. New York: Academic Press, New York, pp143–162.

Zackrisson, O. and Nilsson, M.C. 1992. Allelopathic effects by *Empetrum hermaphroditum* on seed germination of two boreal tree species. *Canadian Journal of Forest Research*, **22**: 44–56.