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Allelopathic effects of Teak (*Tectona grandis* L.f.) on germination and seedling growth of *Plumbago zeylanica* L.

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Abstract

The present study investigated the allelopathic effects of Teak (*Tectona grandis* Linnaeus f., Verbenaceae) on the germination and seedling growth of *Plumbago zeylanica* Linnaeus (Plumbaginaceae). Surface sterilized healthy seeds were allowed to germinate in different concentration of Teak leaf extract along with a control set up. The aqueous leaf extract showed inhibitory effect on seed germination and seedling growth. Shoot vigour index, root vigour index, seedling vigour index and inhibition of biomass production under different treatment supported the allelopathic effect of teak on the receiver plant. The study suggested long term field based investigation on the allelopathic effect of teak on such valuable medicinal herbs of Sub-Himalayan belt.

Key words: Allelopathic effect, *Tectona grandis*, *Plumbago zeylanica*, Seed germination, Seedling growth

INTRODUCTION

Allelopathy is a natural phenomenon whereby one plant releases some biochemical substance which has inhibitory and/or stimulatory effects on some other plants (Rice 1984a; Mensah *et al*. 2015). It involves the ecological communications between species which can positively or negatively influence growth, behaviour, reproduction, and survival of associated species. In trees and forests it is an important health care issue (www.forestry.uga.edu/efr). Allelopathy acts by addition of phytotoxic substances to the environment and most of those phytotoxins inhibit germination and growth and are termed as allelochemics or allelochemicals (Whittaker & Feney 1971; Manimegalai *et al.* 2012).

A large number of higher plants as well as microorganisms have been reported to have allelopathic effects due to their capacity to produce some allelochemicals by several authors (Muller 1969; Levin 1976; Rice 1984b; Devasagayam & Ebenezar 1996; Joshi *et al*. 1992; Pande *et al*. 1996**;** Yadav *et al*. 1996).

Teak (*Tectona grandis* Linnaeus f., Verbenaceae), which is an important agroforestry tree and is largely cultivated in the tropical regions of India and other south Asian countries for its valuable and good quality timber (Leela & Arumugam 2014). The species is reported to have some allelopathic effects (Jayakumar *et at*. 1987; Macias *et al*. 2000; Sahoo *et al*. 2007; Lalmuanpuii & Sahoo 2011; Das *et al*. 2012; Manimegalai *et al.* 2012).

On the other hand, *Plumbago zeylanica* Linnaeus [Plumbaginaceae] is an important local medicinal herb and naturally grows in forests of biodiversity rich Terai-Duars belt of West Bengal. Local and the tribal people use stem, leaves, roots and root bark of this herb in different ailments – loss of appetite, gastric ulcer, diarrhoea, dysentery, fever, piles, swelling, elephantiasis, hydrocele, dyspepsia, leprosy, scabies, puerperal disease, leucoderma, rheumatism, paralysis and for abortion (Ghosh & Das 2004; Das *et al*. 2006). Local medicine men or *ojhaas*, who are involved with the practice of the traditional knowledge related to this medicinal herb, they grow it in their household gardens as they have started to realize that it is not easy to find it out just here and there as before. Differences in distributional pattern of some important medicinal herbs in plantation and natural vegetation was noted during recent survey on medicinal plants in different MPCAs, and sampling of different natural forests and plantations in Terai-Duars belt (Das *et al*. 2010). The present study aimed to investigate the allelopathic effect of Teak on the germination and seedling growth of *P. zeylanica*, which is locally known as *Chita* or *Chitu* and *Sada chita*.

MATERIALS AND METHODS

For the present study, the allelopathic effects of the leaf extract of Teak (*Tectona grandis*) on the seed germination and growth of *Plumbago zeylanic*a, all the experiments were conducted in the Taxonomy and Environmental Biology Laboratory, Department of Botany, University of North Bengal. Some plants of *P. zeylanica*, collected from Duars, were introduced into the NBU Garden of Medicinal Plants and the mature and ripen seeds were collected during January – March 2015. Seeds with uniform size, colour and weight were selected and stored in a desiccator. The mature fresh leaves of teak were collected from the plantations in Terai-Duars region of West Bengal.

Fresh and thoroughly washed 100 g leaves of teak were crushed in 250 ml of distilled water using Sandoz mixer grinder machine, filtered through muslin cloth and then Whatman No.1 filter paper and the final volume was adjusted to 1000 ml and used as mother or stock solution (100 %). Then different solution of desired concentrations 25 %, 50 %, 75 %, were prepared by proper dilution with distilled water from the stock solution (Hoque *et al*. 2003).

The methodology as suggested and used by Putnam & Duke (1978); Kadir (2001); Datta & Ghosh (1987) and Ghosh (2006) were followed for the present assay. Ten healthy seeds, which were surface sterilized in 0.1 % $HgCl_2$ solution and then washed with 1 % $AgNO_3$ solution, were placed in sterile 15 cm glass petriplates lined with single layer of Whatman filter paper moistened sufficiently by adding 15 ml of the test solution. This was set in three replicates along with a control in which the filter paper was moistened with 15 ml of distilled water. The entire set up was kept under room temperature and normal light for germination during April – May 2015 and were observed for 15 days for recording different parameters like number of seeds germinated, length of roots and shoots, seedlings etc. Germination was indicated by the emergence of radical. Different formulae which were used to calculate germination percentage, percentage of inhibition of germination, percentage of inhibition of shoot length and root length, shoot and root vigour index following Saxena *et al*. (1995), Acharyya (1998), Thind and Malik (1998), Lama (2004), Ghosh (2006) and Bajpai *et al*. (1995) and are mentioned below.

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

$$\% \text{ of inhibition/ stimulation} = \frac{\text{Germination \% in desired solution} - \text{Germination \% in Control solution}}{\text{Germination \% in control solution}} \times 100$$

$$\text{Inhibition or stimulation of root length (\%)} = \frac{\text{Root length in desired solution} - \text{Root Length in Control solution}}{\text{Length of root in Control solution}} \times 100$$

$$\text{Inhibition or stimulation of shoot length (\%)} = \frac{\text{Shoot length in desired solution} - \text{Shoot Length in Control solution}}{\text{Length of shoot in Control solution}} \times 100$$

$$\text{Inhibition /stimulation of seedling length (\%)} = \frac{\text{Seedling Length in desired solution} - \text{Seedling Length in Control solution}}{\text{Length of seedling in Control solution}} \times 100$$

Shoot Vigour Index = Percentage of germination × shoot length

Root Vigour Index = Percentage of germination × root length

Seedling Vigour Index = Percentage of germination × seedling length

Then the mass of data collected from the experiment were processed and analysed using MS Excel 2007. Statistical analysis was performed employing one way ANOVA test using Minitab 17 Statistical Software. Tukey Pairwise comparison was followed for separation of means at 95 % confidence.

RESULT AND DISCUSSION

The result of the present study, summarized in Figures 1 – 5 and in Table 1, indicated the effect of teak on seed germination and seedling growth of *P. zeylanica*. Figure 1 represents the germination percentage in different concentration of Teak leaf extract. While in control set 98 % seeds were germinated, it was decreased with the increase of extract concentration and the minimum of 58 % was noted with the highest concentration of teak extract (100 % or the undiluted stock solution). So, the inhibition of seed germination (Figure 2) was inversely proportional to the concentration of extract solution having recorded highest value of 40.82

Table 1. Shoot Vigour Index, Root Vigour Index and Seedling Vigour Index along with inhibition of shoot, root and seedling elongation and Biomass production in different concentration of teak leaf extracts

Extract Conc.	Germination (%)	Germination Inhibition (%)	Inhibition of root Elongation (%)	Inhibition of shoot elongation (%)	inhibition of seedling length (%)	Shoot-Vigour Index	Root-Vigour Index	Seedling-Vigour Index	Biomass Production (g)
Control	98a	00.00a	00.00a	00.00a	00.00a	3420a	2000a	5420a	0.5018a
25%	90ab	-08.16ab	-03.36a	-00.59ab	-01.61a	3113.9a (-306.52)	1787a (-212.62)	4901a (-519.14)	0.40683ab (-0.095)
50%	76bc	-22.45bc	-08.02ab	-17.28ab	-13.86a	2192b (-1228.54)	1431ab (-880.38)	3623b (-1797)	0.39333ab (-0.108)
75%	66cd	-32.65cd	-30.06b	-29.06b	-29.43b	1644b (-1776.14)	947.6b (-1052.4)	2592c (-2828.54)	0.3670b (-0.135)
100%	58d	-40.82d	-0.28ab	-14.60ab	-11.53a	1737b (-1683.52)	11034b (-896.54)	2840bc (-2580.06)	0.34770b (-0.154)

[Values in the parenthesis indicate the inhibitory effects in comparison to control. Values that do not share a letter in the same column are significantly different at $P<0.05$]

% and lowest 8.16 % in 100 % and 25 % concentrations, respectively and the percentage of inhibition in undiluted extract concentration only was statistically significant at P<0.05.

Both, shoot and root elongation was affected by the aqueous extracts of teak leaves (Figure 3). Degree of reduction of shoot and root length increase along with the rise of extract concentration up to 75 % at which point the highest value of inhibition were recorded (29.06 % and 30.06 % for shoot and root length respectively). Further increases in extract concentration decrease the shoot and root inhibition. As shoot and root elongation were affected and seedling is the total length of these two, similar allelopathic effect was found in case of seedling elongation also (Figure 4). Extract having concentration of 75 % was found to exert the significant degree of 29.43% inhibition of seedling length.

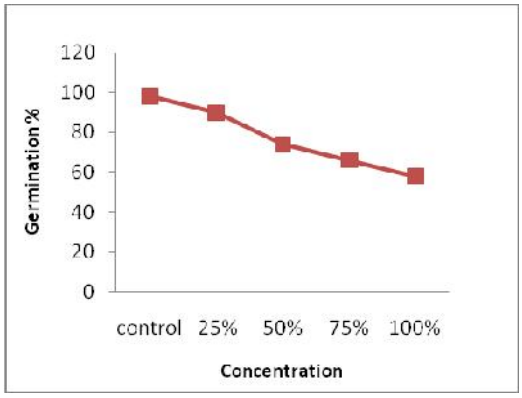

Figure 1. Percentage of seed germination in different concentration of extract

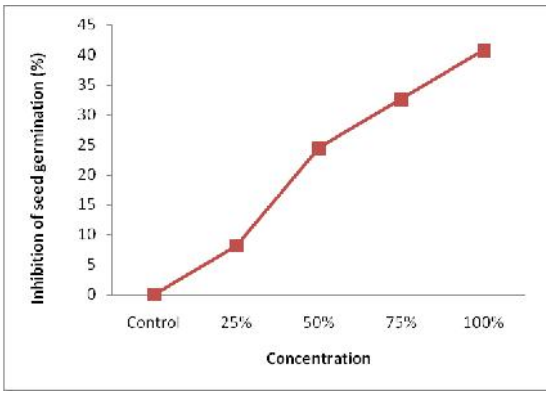

Figure 2. Percentage of inhibition of seed germination in different concentration of extract

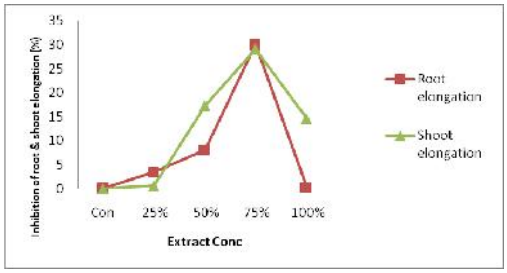

Figure 3. Inhibition of shoot and root length in different concentration of extract

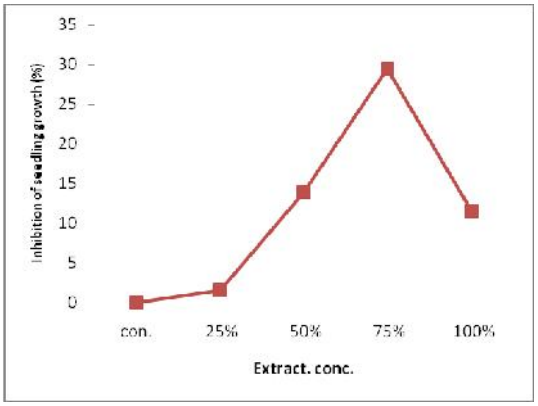

Figure 4. Inhibition of seedling elongation in different concentration of teak leafe extract

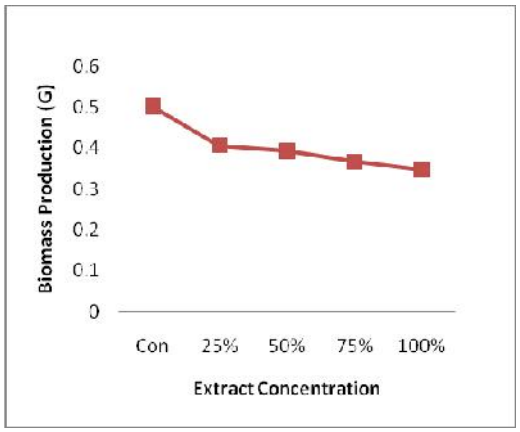

Figure 5. Biomass production in different concentration of Teak extracts

Not only the elongation of seedling but the biomass (fresh weight) production by *P. zeylanica* seedlings were also reduced by allelochemicals present in teak leaves (Figure 5). Production of biomass was hieghest in control solution and gradually decreased with the increase of extract concentration. Highest concentration of teak leaf extract reduced the biomass production to 0.3477 g only whereas in control solution it was estimated to 0.5018 g. Significant level of inhibition of biomass production was noted in 75 % and 100 % extract concentration only.

Influences on Shoot, Root and Seedling Vigour Indices are presented in Table 1. Calculated values of indices for shoot, root and seedling in control solution were 3420, 2000 and 5420 respectively. Teak leaf extract were found to have some inhibitory effect on the vigour indices and are indicated by negative (–) sign. The measures of reduction are mentioned within parenthesis. Significant and highest degree of inhibition was recorded in 75 % concentration of extract; and shoot, root and seedling vigour indices were decreased by 1776.14, 1052.4 and 2828.54 respectively.

Findings from the present investigation indicated the inhibitory effect of aqueous extracts of teak leaves on seed germination and seedling growth of *P. zeylanica* and that is corroborated by earlier reports by Jayakumar *et at*. (1987); Sahoo *et al*. (2007); Macias *et al*. (2000); Lalmuanpuii & Sahoo (2011); Das *et al*. (2012) and Manimegalai *et al.* (2012). Inhibitory effect on seed germination was directly proportional to the extract concentration, though Manimegalai *et al.* (2012) noted the stimulation of seed germination of black gram in lower concentration of teak leaf extract. On the other hand in present study teak leaf extract was found to exert inhibitory effects only.

Teak leaf extract was found to exert similar type of inhibitory effect on shoot, root and seedling elongation also. But, highest degree of inhibition was found in moderately high concentration (75 %). Suppression of seed germination, shoot, root and seedling elongation are also supported by suppression of biomass production following the same pattern. The determined Shoot Vigour Index, Root Vigour Index and Seedling Vigour Index also supported the allelopathic effects of teak extract on *P. zeylanica.*

CONCLUSION

Considering the foregoing result, it can be concluded that teak plant has some allelochemicals those inhibit seed germination and seedling growth (both length and mass) of *P. zeylanica* which is one of the important and widely used local medicinal plants growing in different forests of Terai-Duars belt. However, long term field based studies must be carried out on the allelopathic effects of teak on valuable medicinal herbs growing in this region before selecting teak for large scale plantation, especially when the area is falling within the IUCN recognised Himalaya Biodiversity Hotspot.

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