PHYTOTOXIC INFLUENCE OF *Tectona grandis* L. ON GERMINATION, GROWTH AND BIOCHEMICAL CHANGES OF *Solanum lycopersicum* L. AND *Solanum melongena* L.

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ABSTRACT

The study aims to investigate the phytotoxic influence on seed germination and biochemical changes of two Solanaceae family crops *Solanum lycopersicum* L. and *Solanum melongena* L. with different concentrations (20%, 15%, 10%, 5%, 2%) of aqueous leaf extract of *Tectona grandis* L. The effect of different concentrations of teak leaf extract was compared with control(water). Decreased germination percentage, shoot, and radicle length of the crops were observed to be concentration dependent. All the different extract concentrations caused an inhibitory and stimulatory effect on the crops' germination and morphogenesis compared to control. Biochemical changes and Phytochemical screening of the *T. grandis* leaf extract were equally determined. By this treatment, *S. lycopersicum* showed a more inhibitory effect than *S. melongena*.

Keywords: Allelopathy, *Tectona grandis*, Germination, Phytochemicals, Extract.

RASĀYAN J. Chem., Vol. 14, No.2, 2021

INTRODUCTION

Phytotoxic compounds produced by higher plants are mostly secondary metabolites. Phenolics, quinones, lactones, cyanogenic glycosides, organic acids and volatile terpenes belong to the most active compounds. These compounds are released into neighbouring environments through root exudation, volatilization, leaching and decomposition of plants, and inhibit the growth of neighbouring plants.¹ These chemical substances may inhibit or stimulate the associated plant growth.² Elroy³ reported that the positive or negative effect on another microorganism by liberating biochemical (allelochemicals) into the environment is Allelopathy. Allelopathic chemicals can be present in any part of the plant- leaves, flowers, roots, fruits, or stems and even in the surrounding soil. Florentine and Fox⁴ mentioned that allelochemicals play a significant role in suppressing weed plants' growth in many ways. Nelson⁵ stated that plants' interaction through chemical signals 'allelopathy' has many agricultural and ecological applications. In-allelopathy, the more common inhibitor effects are upon respiration; photosynthesis; water balance and stomatal function; stem conductance of water; cell division and development xylem element flux; membrane permeability; protein synthesis; and enzyme activity alteration. Laboratory bioassays for phytotoxicity/allelopathy are becoming more standardized so that significant comparisons can be made between the allelopathic potentials of diverse plants.⁶ Hamavun *et al.*⁷ observed that different plant species impose a distinct allelopathic effect on recipient plants.

Allelopathy has been studied over the past 50 years, but only a few studies have attempted to understand allelochemical interactions among plants in the context of these broader effects.⁸⁻¹² Several areas of allelopathy have been studied, and some studies are in progress. Moreover, some areas are required to be studied to implicate the mechanism of allelopathy successfully. The potency of competition between agroforestry trees and crops for space, light, moisture, and nutrient will differ under various field conditions, affecting the allelopathic potentiality.

Agroforestry is the growing of both trees and crops on the same piece of land. In the agroforestry system, the yield of crops may be reduced due to competition and allelopathic interaction with trees. However, its

influence varies with tree crop combination. Such inhibitory effects on the understory vegetation have been exhibited in pines.¹³ The reduced yield of most crops in an agroforestry system is due to tree species' allelopathic effect. The phytotoxic chemicals are classified mainly as secondary metabolites (such as alkaloids, isoprenoids, phenolics, flavonoids, terpenoids, etc.).¹⁴ For this study, teak is selected as the agroforestry tree to determine the allelopathic effect on various crops. Teak (*Tectona grandis*), a critical agroforestry tree, is primarily farmed in India's tropical regions and other south Asian countries for its valuable and useful quality timber. It is a massive deciduous tree of the family Verbenaceae. The species is reported to cause some allelopathic effects.¹⁵⁻¹⁹ The teak plant has some allelochemicals that inhibit seed germination and seedling growth of other plants or target plants.

In the present study, *Solanum lycopersicum* (Tomato) and *Solanum melongena* (Eggplant), are selected to study the allelopathic effect of *Tectona grandis*. Tomato and Eggplant belong to the same family Solanaceae. Tomato antioxidants defend against a variety of deadly diseases, including cancer, diabetes, and heart disease, to name a few. Tomatoes are rich in vitamin C and, as a result, in the phytochemical lycopene. The fruits are commonly used in salads, as a cooked vegetable, as an ingredient in a variety of prepared dishes, and as a pickle. *S. melongena* contains phenolic compounds, which are antioxidants. Eggplants contain potassium, vitamin C, vitamin B-6, fiber, and antioxidants, all of which are beneficial to heart health. Polyphenols found in eggplant can help the body battle cancer. Anthocyanins and chlorogenic acid protect cells from damage caused by free radicals. This study aims to determine the allelopathic potential of *Tectona grandis*, a common woody tree widely grown in Tamil Nadu's Tirunelveli District, on tomato and eggplant vegetable crops. Many farmers will benefit from this knowledge when choosing better tree varieties for agroforestry. The study aims to see how different concentrations of aqueous extract of *T. grandis* leaf influence the germination, morphological, and biochemical growth of *S. lycopersicum* and *S. melongena*.

EXPERIMENTAL

Study Area

A greenhouse study was conducted at PG Research Department of Botany, Rani Anna Govt. college for women, Tirunelveli District on Longitude 8.7139° N and Latitude 77.7567° E.

Preparation of the Aqueous Leaf Extract

Fresh leaf samples of *T. grandis* were collected at the vegetative stage from Tirunelveli districts of Tamil Nadu. Then the leaves were shade dried and were grounded by using mortar and pestle and passed through a 2mm mesh sieve. In a 1000ml conical flask, different quantities of ground teak leaves (20g/1000ml, 15g/1000ml, 10g/1000ml, 5g/1000ml, and 2g/1000ml) were dissolved in sterilized distilled water. The percentages of leaf extracts were 20 percent, 15 percent, 10 percent, 5 percent, and 2 percent, with water as a control. The mixture was then shaken at regular intervals and allowed to stand at room temperature for 24 hours. Later, layers of muslin cloth and No. 1 Whatman filter paper were used to filter the suspensions.²⁰

Collection, Sterilization of Seeds and Germination Study

The certified seeds of Tomato (*Solanum lycopersicum* L. – CO-3) and Eggplant (*Solanum melongena* L.-PLR. 1) were gained from Tamil Nadu Agricultural University, Coimbatore. Earthen Pots (40×25cm) were filled with garden soil having silt, humus, and sand (pH-7.3, N - 0.13, P- 0.29, K - 0.09, and OC-1.86%). Healthy and uniform Tomato and Eggplant seeds were chosen. The seeds were sterilized for 15 minutes with 1 percent sodium hypochlorite, then rinsed thoroughly with distilled water to remove the excess chemical and dried to prevent fungal attacks. The seeds were presoaked for two hours in distilled water before being soaked for three hours in various amounts of aqueous leaf extracts. The crop seeds were then sown @ 20/ Pots and uniformly irrigated with different concentrations of *T. grandis* aqueous leaf extracts, and three replicates of each procedure, including control, were retained. Distilled water was used to irrigate the control pot. On the seventh day after the seed was sown, germination was observed. On the 15th day after germination, growth parameters such as root length, shoot length, dry biomass, and biochemical constituents of test crop seedlings such as chlorophylls, carotenoids, sugars, starch, protein, amino acids, and enzymes were measured. All measurements were taken on samples that were drawn five times and repeated.

Phytochemical Screening

A round bottom flask containing 200 cm³ of methanol was filled with 30g of powdered leaves and mixed. The flask was put in a flask shaker and agitated for four hours before being set aside overnight. The extract was then filtered and tested for bioactive components using phytochemical tests.²¹⁻²³

Statistical Analysis

Statistical analysis was performed employing a one-way analysis of variance (ANOVA). The least significant test was used at 5% to identify significant variations between means. All values are expressed as mean $\pm$ variance.

RESULTS AND DISCUSSION

T. grandis had both inhibitory and stimulatory allelopathic effects on *S. lycopersicum* L. and *S. melongena*, according to the findings. Every day after treatment, the number of seeds that germinated was counted, and the total was used to measure the final germination percentage in each treatment. Seed germination of *S. lycopersicum* and *S. melongena* showed no significant differences when treated with lower concentrations (5% and 10%) of *T. grandis* leaf extract, but the leaf extract at 20% concentration caused a significant reduction in germination (Table-1). The leaf extract of *T. grandis* significantly reduced the *S. lycopersicum* germination above 2% concentration in both test species, the leaf extract at a concentration of 2% extract does not decrease germination but increases germination percentage. The germination of test species was significantly decreased by *T. grandis* leaf extract, and this inhibition was concentration dependent. Ferreira²⁴ studied that changes in the germination process may be caused by membrane permeability, DNA transcription, protein translation, secondary messengers activity, metabolism, enzyme conformation and receptors in the membranes, or joint action of these changes. When treated with water extracts of *C. odorata* leaves and stems, Adetayo *et al.*²⁵ found that cowpea and soybean seed germination was reduced by 14% and 8%, respectively. The delay in seed germination can have major biological and ecological effects, according to Chaves *et al.*²⁶, since it can affect seedlings' ability to develop themselves in natural conditions. With increasing concentrations of aqueous extracts, decreasing water absorption by *S. lycopersicum* and *S. melongena* seeds could indicate the impact of *T. grandis* leaf allelopathy on seed imbibition, the leading factor in delaying or decreasing germination of test plants. Chon *et al.*²⁶ reported in their study the inhibition of water uptake by allelopathic species.

Table-1: Seed Germination
Allelopathic Influence of *Tectona grandis* Leaf Extracts on Germination (%) of
Solanum lycopersicum and *Solanum melongena*

Extract Concentration	<i>S. lycopersicum</i>	<i>S. melongena</i>
Control	92	95
2%	96 (4.3)	99 (4.2)
5%	90 (-2.2)	97(2.1)
10%	76(-17.4)	83(-12.6)
15%	58(-37.0)	65(-31.6)
20%	33(64.1)	42(-55.8)

Data in parentheses indicate % increase/decrease over control.

On the 20th day after the seed was sown, shoot length (Fig.-1) was measured from the soil level to the upper point of the seedling's terminal bud, and root length was measured from the soil level to the lower point of the root tip using a meter ruler. When 2% leaf extract was used, two test species stimulated the root length (8.57% in *S. lycopersicum* and 13.04% in *S. melongena*) and shoot length (5.95% in *S. lycopersicum* and *S. melongena* 6.79%) moreover control.

Fig.-1: Allelopathic Influence of *T. grandis* Leaf Extracts on Root Length(cm/seedling) and Shoot Length(cm/seedling) of *Solanum lycopersicum* and *Solanum melongena*

Table-2: Allelopathic Influence of *T. grandis* Leaf Extracts on Fresh Weight (mg/seedling) and Dry Weight (mg/seedling) of *Solanum lycopersicum* and *Solanum melongena*

Extract Concentration	<i>S. lycopersicum</i>		<i>S. melongena</i>	
	Fresh weight (mg/plant)	Dry weight (mg/plant)	Fresh weight (mg/plant)	Dry weight (mg/plant)
Control	3.06	0.25	3.24	1.25
2%	3.10 (1.3)	0.27 (8.0)	3.53 (9.0)	1.30(4.0)
5%	2.75 (-10.3)	0.21 (-16.0)	3.30(1.9)	1.23(-1.6)
10%	2.06(-32.7)	0.19 (-24.0)	2.89(-10.8)	0.99(-20.8)
15%	1.45(-52.6)	0.11(-56.0)	2.25(-30.6)	0.75(-40.0)
20%	0.80 (-73.9)	0.07 (-72.0)	1.40(-56.8)	0.27(-68.0)

Data in parentheses indicate % increase/decrease over control.

Fig.-2: Allelopathic Influence of *T. grandis* Leaf Extract on Chl.a, Chl.b and Total Chlorophyll and Carotenoids (mg/g fr. wt.) of *S. lycopersicum*.

These results showed the stimulatory and inhibitory effects of *T. grandis* on tomato and eggplant. Eucalyptus leaf extracts inhibited seed germination and seedling development in some herbaceous plants, according to Siddiqui *et al.*²⁸ Their work is in support of this research. Allelochemicals contained in *T. grandis* leaf extract include phenol, steroids, Tannin, flavonoids, saponin, coumarins, leucoanthocyanin, alkaloids, amino acids, proteins, and others. These secondary metabolites strongly inhibited all the stages of mitosis of the root cells and shoot cells.

Fig.-3: Allelopathic Influence of *T. grandis* Leaf Extract on Chl.a, Chl.b and Total Chlorophyll and Carotenoids (mg/g fr.wt.) of *S. melongena*.

Table-3: Allelopathic Influence of *T. grandis* Leaf Extracts on Starch, Protein, Amino Acid and Sugar (mg/g fr.wt.) of *S. lycopersicum* and *S. melongena*

Extract Concentrations	<i>S. lycopersicum</i>				<i>S. melongena</i>			
	Starch	Protein	Amino acid	Sugar	Starch	Protein	Amino acid	Sugar
Control	0.372	0.754	0.211	0.145	0.411	0.223	0.296	0.018
2%	0.389 (3.4)	0.757 (0.4)	0.215 (1.9)	0.148 (2.0)	0.418 (1.7)	0.230 (3.1)	0.304 (2.7)	0.021 (16.7)
5%	0.372 (-1.1)	0.740 (-1.9)	0.204 (-3.3)	0.131 (-9.7)	0.416 (1.2)	0.227 (1.8)	0.297 (0.3)	0.019 (5.6)
10%	0.340 (-9.6)	0.718 (-4.8)	0.185 (-12.3)	0.106 (-26.9)	0.390 (-5.1)	0.215 (-3.6)	0.282 (-4.7)	0.013 (-27.8)
15%	0.305 (-18.9)	0.680 (-9.8)	0.163 (-22.7)	0.080 (-44.8)	0.367 (-10.7)	0.184 (-17.5)	0.255 (-13.9)	0.009 (-50.0)
20%	0.247 (-34.3)	0.627 (-16.8)	0.122 (-42.2)	0.041 (-71.7)	0.326 (-20.7)	0.129 (-42.2)	0.209 (-29.4)	0.005 (-72.2)

Data in parentheses indicate % increase/decrease over control.

Changes in DNA synthesis in the nucleus were responsible for the inhibitory effect. As a result, the length and growth of seedlings in the test species were affected. According to Abraham²⁹, -pinene is even more toxic and lipophilic. As a result, these chemicals can easily penetrate mitochondrial membranes, causing respiratory problems. Sarmin³⁰ investigated the relationship between *Moringa oleifera* and *Triticum aestivum* by using five different concentrations of *Moringa* leaf, bark, and root extracts (0 %, i.e., freshwater, 25 %, 50 %, 75 %, and 100 %) to research the impact on germination and growth of *Triticum aestivum*. The results of the present study were similar to those of Muoghalu and Chuba³¹, Zachariades *et al.*³² who found that different concentrations of *C. odorata* leaf aqueous extract significantly inhibited the germination, root and shoot elongation and development of lateral roots of *Cicer arietinum*, *Brassica juncea*, *Cucumis sativus*, *Phaseolus mungo*, *Raphanus sativus*, and *Vigna unguiculata* L. Walp.

The Teak leaf extract treatments reduced the fresh and dry weight of the test crop seedling. The degree of inhibition depends on the concentrations of the extracts. The more reduction of fresh weight and dry weight of *S. lycopersicum* and *S. melongena* at 20% extract concentration were 73.8%, 56.8% (fresh weight), and 72.0%, 64.8% (dry weight) respectively. A more inhibitory effect was observed in *S. lycopersicum* seedlings than *S. melongena* seedlings. Zohabib *et al.*³³ found that profuse allelochemicals hinder seed germination, plant growth, and biomass production through disruption of various physiological functions taking place within the plant body. This present study is paralleled with their study. The findings of this study matched those of Malik³⁴, El-Khawas and Shehata³⁵, and Yamagushi.³⁶ The stem and whole plant

extract of *Trianthema portulacastrum* reduced the dry matter yield on Soybean, according to Umarani and Selvaraj.³⁷ The presence of a higher concentration of volatiles, chemicals, or phenolic compounds could be inhibiting seedling length and biomass. The current research backs up del Moral and Muller's earlier findings.³⁸ *S. lycopersicum* treated with *T. grandis* 20 % concentration of leaf extracts showed the most severe adverse effect, followed by 15%, 10%, 5%, and 2 %. The results of Phytochemical analysis showed the presence of Phenol, flavonoids, amino acids, alkaloids, steroids, Tannin, Protein, saponin, coumarins, phytosterol, leucoanthocyanin, chalcone, propanal, butanal, acetic anhydride, formic acid, 2-pentanone, propanoic acid, butanoic acid, etc. in *T. grandis*.

The biochemical studies of *S. lycopersicum* and *S. melongena* like chl-a, chl-b, Total chlorophyll, starch, protein, sugar, and amino acids were determined after 25 days of germination. The highest decreasing percentage was noticed at 20% extract concentrations in both test crops. In tomato chl- b and protein reduction percentage was barely noticed than eggplant seedlings. At the same time, the observed amino acid and starch reduction percentage in *S. melongena* was significantly less at 20% extract treatment. Results were found that were similar to Venkateshwarlu's findings³⁹, who reported inhibition in chlorophyll a and chl. b content (41.66 % and 11.36 %, respectively) in radish when treated with *M. indica* leaf extract (200 ppm). The decrease in chlorophyll content observed in a few combinations may be due to the degradation or reduction in synthesis of chlorophyll pigments, as well as the action of flavonoids, terpenoids, or other phytochemicals present in leaf extracts.⁴⁰ Reduction in chlorophylls may decrease the photosynthesis, resulting in a significant reduction in all metabolites, including total sugars, proteins, and soluble amino acids.⁴¹

The 20 % extract treatment had the strongest inhibitory effect, followed by 15 %, 10 %, and 5 % extract treatments when compared to the control. The solvent extract (water) had the most allelopathic effects on the test species' germination and seedling growth, according to this report. With rising concentration, inhibition increased. These results agree with those obtained by Mohamadi and Rajaie⁴² that studied the effect of leaf extract of *E. camaldulensis* on sorghum and kidney bean. Abdalla⁴³ reported that fertilization of *Eruca vesicaria* plants with 2% leaf and 3% twig aqueous extracts of *Moringa oleifera* potentially increased the plant height, fresh and dry herb weight, photosynthetic rates, stomatal conductance, chlorophyll a and b, carotenoids, total sugars, total protein, phenols, ascorbic acid, nitrogen, phosphorus, potassium, calcium, magnesium, iron as well as growth-promoting hormones (auxins, gibberellins, and cytokinins) *Tithonia diversifolia* (Hemsl) A. Gray and *Chromolaena odorata* (L.). The present work also supported Abdalla's work. Djanaguiraman *et al.*⁴⁴ found that chlorophyll conversion intolerant species chl-a to chlorophyll -b may occur during stressful situations. At more elevated concentrations, allelochemicals may act as photosynthetic inhibitors that block electron acceptors, act as energy uncouplers, and reduce photosynthetic pigments and enzymes.⁴⁵ Otusanya *et al.*⁴⁶ reported water root exudates of *T. diversifolia* significantly inhibited the germination, growth, and chlorophyll accumulation of tomato. Bais *et al.*⁴⁷ revealed that allelochemicals could affect germination, growth, physiology, and even genetic factors of neighboring plants. Allelopathic inhibition is complicated and involves the interaction of allelochemicals like phenolic compounds, flavonoids, terpenoids, alkaloids, steroids, carbohydrates, and amino acids, with mixtures of various compounds. Allelopathic effects can differ in severity, duration, and developmental stage during plant development, according to studies. The allelopathic effect refers to the inhibitory and stimulatory effects of compounds obtained from a plant's metabolism products on another plant species.

CONCLUSION

The present investigation revealed that aqueous leaf extract of *T. grandis* at different concentration levels inhibited seedling growth while at low concentration stimulated the germination, seedling length, biomass, pigments, starch, protein and amino acid contents of *S. lycopersicum* (2% extract treatment) and *S. melongene* (2% & 5% extracts treatment) seedlings. Therefore, the study indicated the beneficial and adverse effects of *Tectona* leaf extract on *S. lycopersicum* and *S. melongena*. The inhibitory effect of various concentrations of the extract was unequal, showing the most violent inhibition in *S. lycopersicum*, while the lowest in *S. melongena*. The promotory effect was observed in eggplant seedlings in 2% and 5% extract concentration while in tomato seedlings, only at 2% extract concentration over control. Therefore this present study concluded that the stimulatory and inhibitory effect was based on the crop species and is not

the same for all species. The inhibitory and stimulatory effects of *T. grandis* leaf extracts may be due to the presence of allelochemicals in the extracts. Between the two test crops, *S. lycopersicum* had a stronger inhibitory effect than *S. melongena*. Detailed field experiments are needed to better understand the potential soil-mediated physiological allelopathy and mode of action of individual allelochemicals from tree leaves on crop plants.

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[RJC-6285/2020]