Allelopathic effect of aqueous leaf extract of *Tectona grandis* on germination and growth of *Oryza sativa*

NAMRATA A VALVI, VD TRIPATHI, AD RANE, VR NARVANKAR and SS NARKHEDE

College of Forestry, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth
Dapoli, Dist Ratnagiri 415712 Maharashtra, India
Email for correspondence: deepakvishva2003@gmail.com

 Received: 30.09.2022/Accepted: 19.10.2022

ABSTRACT

A study was conducted to evaluate the allelopathic effect of leaf aqueous extract of teak (*Tectona grandis*) on rice (*Oryza sativa*) seeds under laboratory conditions. The leaf aqueous extract showed significant inhibitory effect on germination and other growth parameters of rice. The inhibitory effect was proportional to the concentrations of the extract and the higher concentration had the higher inhibitory effect. Thus teak seems to be a potential threat to the cereals industry under small-scale farming condition. Therefore, it can be recommend that different remedial practices (like removal of excess leaf litter) should be done before sowing rice in the land previously planted with teak in order to reduce the potential risks

Keywords: Phytochemicals; allelopathic effect; rice; teak; aqueous extract

INTRODUCTION

Agroforestry is a dynamic system. It is ecologically-based natural resources management system. The integration of trees on farmlands diversifies and sustains production for increased social, economic and environmental benefits to the farmers. In India, agroforestry systems have been adopted as alternatives to traditional farming system. Agroforestry systems allow the intensification of production through the integrated management of natural resources without environmental degradation.

Allelopathy refers to any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influence the growth and development of agricultural and biological systems which can play an important role in crop productivity, conservation of genetic diversity and maintenance of ecosystem stability (Anaya 1999, Khalid et al 2002).

Teak (*Tectona grandis*) is a large deciduous tree belonging to the family Verbenaceae. It grows up to 40 m in height. Teak is recognised as one of the most valuable timber species (Nidavani and Mahalakshmi 2014). Although native to south and southeast Asia, the significant economic potential of teakwood led the species to be introduced into the agroforestry systems of many countries across tropical Asia, Africa and Central and South America (Pandey and Brown 2000, Healey and Gara 2003, Kenny et al 2014, Newby et al 2014, Udayana et al 2020).

Teak is one of the most important trees in home gardens of south Asia because it is a very precious wood species and important in folk remedies (Kumar et al 1994, Peyre et al 2006, Lakshmi and John 2015). It has also been used as an important plant in Ayurvedic treatments. Hot water extract of teak bark is applied for the treatment of bronchitis, biliousness, hyperacidity, diabetes, dysentery and leprosy. Water extract of teak leaves is used in pruritus, stomatitis, ulcers and wounds. Hot water extract of teak roots is applied for anuria treatment. Oil extract of the flowers is useful for scabies and hair growth (Nidavani and Mahalakshmi 2014, Vyas et al 2019). Evidence of the pharmacological properties of teak plant has been accumulated over the past decades. Ethanol extract of teak leaves has

shown significant wound healing activity (Varma and Giri 2013). Ethanol extract of teak roots has hyperglycemic activity (Varma and Jaybhaye 2010). Many compounds with pharmacological activities were also isolated from various parts of teak plant (Nidavani and Mahalakshmi 2014, Vyas et al 2019, Degbe et al 2018). Some plants have shown excellent weed control abilities as soil additives and/or in intercropping due to their characteristics of allelopathy (Semidey 1999, Caamal-Maldonado et al 2001). Plants produce hundreds of secondary metabolites. Some of these compounds are released into the surrounding environment through root exudation, volatilization, leaching and decomposition of the plants.

Those compounds with allelopathic activity are able to inhibit the growth and germination of neighboring plant species (Field et al 2006, Bais et al 2006, Belz 2007). The teak leaf extract exhibited inhibitory effects on germination and/or on seedling growth of *Casuarina equisetifolia* (Balasubramanian and Ravichandran 1996), *Vigna unguiculata* (Jadhav and Gaynar 1994, Mandal and Brahmachary 1998) and sorghum (Channal et al 2002). The inhibitory effect on the germination and growth of wheat seedlings increased with an increase in leachate concentration of teak (Patil et al 2003). Some of the phenolic acids viz salicylic acid, p-hydroxy benzoic acid, chlorogenic acid, tannic acid, caffeic acid and vanillic acid have been reported to occur in teak as inhibitory or stimulatory bioactive allelochemicals (Mandal and Brahmachary 1998, Tripathi et al 1999).

Rice is staple food of India as well as Asia, Latin America, part of Africa and the Middle-East. In India, rice cultivation is taken below sea level (Kerala) up to altitude of 2,000 m amsl (Kashmir). It plays vital role in national food security and it is means of livelihood of millions of people. It is the most important crop for human nutrition and calorie intake providing more than 1/5th of the calories consumed.

Rice thrives in all types of soils ranging from pH 5 to 8 and can be grown under different environmental conditions (Shinde et al 2018). Globally, the highest area under rice is in India (43.86 million ha) followed by China (30.16 million ha) However, highest production of rice is in China (144.85 million tonnes) followed by India (104.80 million tonnes). This is due to higher productivity of rice in China (6.86 tonnes/ha) than India (3.77 tonnes/ha) (Anon 2017).

In Maharashtra, rice is cultivated on 15.56 lakh ha area in all four regions viz Vidarbha (8.15 lakh ha), Konkan (3.69 lakh ha), western Maharashtra (3.55 lakh ha) and Marathwada (0.156 lakh ha). The highest productivity of rough rice is in Konkan region (4.25 tonnes/ha) followed by western Maharashtra (3.5 tonnes/ha) and Vidarbha (3.4 tonnes/ha) (Anon 2017). It is reported to possess allelopathic properties in its root, shoot and leaf exudates.

In the present study, the teak leaf extract was tested on germination and seedling growth of rice.

MATERIAL and METHODS

The experiment was conducted in the laboratory of College of Forestry, Dr Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra (latitude 17^{o}452 N, longitude 73^{o}122 E, altitude 250 m amsl) in the month of March 2021. Dapoli is located in the Konkan region of Maharashtra and is confined in between Sahyadri hills in the east and Arabian sea in the west. Dapoli represents more or less tropical climate having average humidity of 78 per cent throughout the year. The climate is hot and humid with well-expressed three seasons viz summer (March to May), rainy (June to October) and winter (November to February). The average minimum and maximum temperature is 18.5 and 30.8^{o}C respectively with an average annual precipitation 3,500-4,000 mm which is generally received from June to October.

Collection of plant sample for bioassay: For the bioassay experiment, fresh leaves of teak were collected from the biodiversity park of College of Forestry, Dapoli in the month of March 2021 from 15-20 years old trees. All the contaminants like soil, dust particles etc were removed from the collected leaves by dry wiping with soft brush and washing with tap water for few seconds followed by quick rinsing with distilled water. The leaves were shade-dried and ground with the help of grinder. The powdered material was extracted to evaluate the allelopathic activity on the germination of rice. Rice variety Suvarna seeds were purchased from the seed selling shop, Dapoli, Ratnagiri, Maharashtra.

Preparation of aqueous extract: Teak leaf aqueous extract was prepared by soaking 150 g of powder in 1,000 ml distilled water for 24 hours at room

temperature for the preparation of 15 per cent concentration. The solution was firstly passed through the muslin cloth and then further filtered through Whatman number 1 filter paper. Fifteen per cent solution was further diluted for making 10, 5 and 2 per cent concentrations.

Evaluation of bioassay: The uniform and healthy seeds of rice were thoroughly washed with distilled water and put in a uniform diameter Petri dishes (9 cm diameter) which were sterilized at 120°C to eliminate bacterial and fungal contamination. In this way, the treatments consisted of 4 concentrations of leaves (2, 5, 10 and 15%) and distilled water served as control. The experiment was replicated 5 times in completely randomised design. Twenty seeds for each replication were sown uniformly in the Petri plates. The seeds were surface-sterilized with 0.2 per cent (W/V) mercuric chloride before placing in the germination medium of double layer Whatman number 1 filter paper. A measured volume (2 ml) of extract was added uniformly to each Petri plate to form a treatment.

Observations: For laboratory bioassay, the germination was recorded 7th day after sowing and plumule and radicle length was recorded after 15 days. For measurement of the plumule and radicle length, five representative germinated seeds were considered randomly in each Petri dish. The vigour index was calculated by using the formula given by Abdul-Baki and Anderson (1973):

$$\text{Vigour index} = \text{Germination (\%)} \times (\text{Root length} + \text{Shoot length})$$

The Dickson quality index was calculated by using the following formula (Dickson et al 1960):

$$DQI = \frac{\text{Total dry weight (g)}}{\frac{\text{Plant height (cm)}}{\text{Collar diameter (mm)}} + \frac{\text{Shoot dry weight (g)}}{\text{Root dry weight (g)}}}$$

Sturdiness was calculated with the help of following formula:

$$\text{Sturdiness} = \frac{\text{Plant height}}{\text{Collar diameter}}$$

Statistical analysis: Analysis of variance (ANOVA) was carried out to determine treatment and interaction effects using a completely randomize design (CRD) using the statistical package SYSTAT (9.0). When the treatment effect was found significant P ($\leq$0.05), the least significant difference (LSD) was calculated to compare treatment means.

RESULTS and DISCUSSION

Data on the effect of various concentrations of *T grandis* leaf aqueous extract on germination and seedling growth parameters of rice have been presented in Table 1. Among different concentrations, significantly higher germination was recorded in control (99.00%) and 2 per cent concentration (95.00%) which were at par and minimum in 15 per cent (87.00%), 10 per cent (89.00%) and 5 per cent (91.00%), the three being at par. Higher collar diameter was recorded in control (0.97 mm) as compared to all other treatments which were at par. Lower shoot length of 6.21 and 6.51 cm was recorded in 10 and 15 per cent concentrations respectively which were at par as compared to control (7.24 cm). Root length was significanttly lower (7.25 cm) under 15 per cent concentration as compared to control (8.61 cm), however, former treatment was at par with all other treatments. The root-shoot ratio varied from 1.14 (10%) to 1.25 (2%), but there were no significant differences among the treatments. Higher vigour index was recorded in control (1,570.00) and 2 per cent concentration (1,440.00) which were at par and lower in 15 (1,173.00) and 10 (1,238.00) per cent concentrations, the two being at par. The sturdiness ranged from 164.10 (control) to 178.40 (2%) but there were no significant differences among all the treatments tested for this trait.

Present investigations indicated that the aqueous leaf extract of teak inhibited the germination, vigour index, shoot length, root length, total dry weight and Dickson quality index of rice which is supported by earlier works of Jayakumar et at (1987), Macias et al (2000), Sahoo et al (2007), Lalmuanpuii and Sahoo (2011) and Das et al (2012).

The phenolic compounds have been reported to possess inhibitory effect on the germination of the seeds of other plants (Chaves and Escudero 1997) due to their physiological effect on membrane functions, membrane potential, mineral absorption and plant water relations (Harper and Balke1981, Barkosky and Einhellig 1993, Einhellig 1995). Phenolic acids are considered as one of the major allelochemicals responsible for herbicidal bioactivity (Lin et al 2004,

Table 1. Effect of *Tectona grandis* leaf extract on germination and seedling growth of *Oryza sativa*

Concentration (%)	Germination (%)	Collar diameter (mm)	Shoot length (cm)	Root length (cm)	Root-shoot ratio	Vigour index	Sturdiness
0 (control)	99.00	0.97	7.24	8.61	1.19	1,570.00	164.10
2	95.00	0.86	6.77	8.43	1.25	1,440.00	178.40
5	91.00	0.84	6.65	7.99	1.21	1,332.00	175.50
10	89.00	0.82	6.51	7.42	1.14	1,238.00	170.30
15	87.00	0.78	6.21	7.25	1.17	1,173.00	172.20
$CD_{0.05}$	04.57	0.09	0.63	1.27	NS	150.17	NS

Batish et al 2006) in many plants. But allelopathic inhibition typically results from the combined action of a group of allelochemicals which collectively interfere with several physiological processeses through joint action of allelochemicals (Einhellig 1996). The herbicidal bioactivity observed in the leaf extract of teak and its various fractions can be attributed to the occurrence of the combination of phenolic acids (salicylic acid, phydroxy benzoic acid, tannic acid and chlorogenic acid) which might have been at the optimum level in F4 and disintegrated due to further fractionation (PlP4). The ratio of these phenolic acids present in the active fraction may be useful for future development of bio-herbicides. The chlorofonn fraction of methanol extract of teak deciduous leaves may be considered as a potential pre-emergent allelopathic herbicide for controlling the weed jungle rice in rice field. The allelopathic herbicidal activity can be assigned due to the presence of phenolic acids in various combinations (Kole et al 2011)

CONCLUSION

This preliminary study was carried out to investigate the allelopathic effect of teak on germination and growth of rice. Germination and all the growth parameters of rice were reduced significantly in leaf aqueous extract. The present study revealed that the allelopathy may not be a universal explanation for regeneration failures, delayed seed germination, retarded seedling growth and reduction in productivity but is also not an ignorable phenomenon. The allelopathy could have a pronounced effect on simultaneous and release of chemicals continuously into the environment which directly or indirectly affect the companion crops. Considering the foregoing results, it can be concluded that teak plant has some allelochemicals which inhibit seed germination and seedling growth (both length and mass) of rice. However, long term field-based studies need to be carried out on the allelopathic effects of teak on valuable crops growing in different regions before selecting teak for large scale plantation.

REFERENCES

Abdul-Baki AA and Anderson JD 1973. Vigour determination in soybean seed by multiple criteria. Crop Science **13(6):** 630-633.

Anaya AL 1999. Allelopathy as a tool in the management of biotic resources in agroecosystems. Critical Reviews in Plant Sciences **18(6):** 697-739.

Anonymous 2017. World agricultural production. Circular Series WAP 06-17, Foreign Agricultural Service, United States Department of Agriculture, Washington, DC, United States.

Bais HP, Weir TL, Perry LG, Gilroy S and Vivanco JM 2006. The role of root exudates in rhizosphere interactions with plants and other organisms. Annual Review of Plant Biology **57:** 233-266.

Balasubramanian A and Ravichandran VK 1996. Allelopathic significance of six agroforestry trees on *Casuarin aequisetifolia* growth and nodulation. Madras Agricultural Journal **83:** 84-87.

Barkosky RR and Einhellig FA 1993. Effects of salicylic acid on plant-water relationships. Journal of Chemical Ecology **19:** 237-247.

Batish DR, Singh HP, Rana N and Kohli RK 2006. Assessment of allelopathic interference of *Chenopodium album* through its leachates, debris extracts, rhizosphere and amended soil. Archives of Agronomy and Soil Science **52(6):** 705-715.

Belz RG 2007. Allelopathy in crop/weed interactions – an update. Pest Management Science **63(4):** 308-326.

Caamal-Maldonado JA, Jimenez-Osornio JJ, Torres-Barragan A and Anaya AL 2001. The use of allelopathic

legume cover and mulch species for weed control in cropping systems. Agronomy Journal **93(1):** 27-36.

Channal HT, Kurdikeri MB, Hunshal CS, Sarangamath PA and Patil SA 2002. Allelopathic influence of tree leaf extracts on green gram and pigeon pea. Karnataka Journal of Agricultural Sciences **15(2):** 375-378.

Chaves N and Escudero JC 1997. Allelopathic effect of *Cistus ladanifer* on seed germination. Functional Ecology **11(4):** 432-440.

Das CR, Mondal NK, Aditya A, Datta JK, Banerjee A and Das K 2012. Allelopathic potentialities of leachates of leaf litter of some selected tree species under laboratory conditions. Asian Journal of Experimental Biological Sciences **3(1):** 59-65.

Degbe M, Debierre-Grockiego F, Tete-Benissan A, Debare H, Aklikokou K, Dimier-Poisson I and Gbeassor M 2018. Extracts of *Tectona grandis* and *Vernonia amygdalina* have anti-toxoplasma and pro-inflammatory properties in vitro. Parasite **25:** 11; doi: 10.1051/parasite/2018014.

Dickson A, Leaf AL and Hosner JF 1960. Quality appraisal of white spruce and white pine seedling stock in nurseries. Forestry Chronicle **36(1):** 10-13.

Einhellig FA 1995. Mechanism of action of allelochemicals in allelopathy. In: Allelopathy: organisms, processes, and applications (Inderjit, KMM Dakshini and FA Einhellig, eds), Allelopathy Symposium, ACS Symposium Series 582, 1-5 Aug 1993, Ames, Iowa, Botanical Society of America, Washington, DC, pp 96-116.

Einhellig FA 1996. Interactions involving allelopathy in cropping systems. Agronomy Journal **88(6):** 886-893.

Field B, Jordan F and Osbourn A 2006. First encounters – deployment of defence-related natural products by plants. New Phytologist **172(2):** 193-207.

Harper JR and Balke NE 1981. Characterization of the inhibition of K^+ absorption in oat roots by salicylic acid. Plant Physiology **68(6):** 1349-1353.

Healey SP and Gara RI 2003. The effect of a teak (*Tectona grandis*) plantation on the establishment of native species in an abandoned pasture in Costa Rica. Forest Ecology and Management **176(1-3):** 497-507.

Jadhav BB and Gaynar DG 1994. Effect of *Tectona grandis* (L) leaf leachates on rice and cowpea. Allelopathy Journal **1:** 66-69.

Jayakumar M, Eyini M and Pannirselvam S 1987. Allelopathic effect of teak leaf extract on the seedling of groundnut and corn. Geobios **14(1):** 66-69.

Kenny AL, Pickens JB and Orr B 2014. Land allocation with the introduction of teak: a case study of smallholder farms in southern Togo. Journal of Sustainable Forestry **33(8):** 776-795.

Khalid S, Ahmad T and Shad RA 2002. Use of allelopathy in agriculture. Asian Journal of Plant Sciences **1(3):** 292-97.

Kole RK, Karmakar PR, Poi R and Mazumdar D 2011. Allelopathic inhibition of teak leaf extract: a potential pre-emergent herbicide. Journal of Crop and Weed **7(1):** 101-109.

Kumar BM, George SJ and Chinnamani S 1994. Diversity, structure and standing stock of wood in the homegardens of Kerala in peninsular India. Indian Agroforestry Systems **25:** 243-262.

Lakshmi PGS and John J 2015. Allelopathic effect of leaf loppings of homestead trees on turmeric (*Curcuma longa* Linn). Journal of Tropical Agriculture **53(2):** 227-232.

Lalmuanpuii R and Sahoo UK 2011. Allelopathic effects of *Tectona grandis* L and *Mikania micrantha* L on germination of *Zea mays* L and *Oryza sativa* L under laboratory condition. Science Vision **11(4):** 208-213.

Lin D, Tsuzuki E, Sugimoto Y, Dong Y, Matsuo M and Terao H 2004. Elementary identification of phenolic allelochemicals from dwarf lilyturf plant (*Ophiopogon japonicas* K) and their growth-inhibiting effects for two weeds in paddy rice field. Plant Production Science **7(3):** 260-265.

Macias FA, Lacret R, Varela RM and Nogueiras C 2000. Allelopathic potential of teak (*Tectona grandis*). In: Allelopathy from understanding to application, Proceedings of the 2nd Europe Allelopathy Symposium, 3-5 June 2004, Pulaway, Poland, pp 140.

Mandal S and Brahmachary RL 1998. Growth stimulators in shed leaves of teak (*Tectona grandis*). Indian Forester **124:** 267-269.

Newby JC, Cramb R and Sakanphet S 2014. Forest transitions and rural livelihoods: Multiple pathways of smallholder teak expansion in northern Laos. Land **3(2):** 482-503.

Nidavani RB and Mahalakshmi AM 2014. Teak (*Tectona grandis* Linn.): a renowned timber plant with potential medicinal values. International Journal of Pharmacy and Pharmaceutical Sciences **6(1):** 48-54.

Pandey D and Brown C 2000. Teak: a global overview. Unasylva **51(201):** 3-13.

Patil RH, Hunshal CS and Itnal CJ 2003. Allelopathic effects of tree litter leachates on wheat crop. Journal of Maharashtra Agricultural Universities **28(2):** 182-184.

Peyre A, Guidal A, Wiersum KF and Bongers F 2006. Dynamics of homegarden structure and function in Kerala, India. Indian Agroforestry Systems **66:** 101-115.

Sahoo UK, Upadhyaya K and Meitei CD 2007. Allelopathic effects of *Leucaena leucocephala* and *Tectona grandis* on germination and growth of maize. Allelopathy Journal **20(1):** 135-143.

Semidey N 1999. Allelopathic crops for weed management in cropping systems. In: Allelopathy update, Vol 2, Basic and applied aspects (SS Narwal, ed), Science Publishers Inc, Enfield, NH, USA, pp 271-281.

Shinde AK, Kunkerkar RL, Thorat VA, Chavan LS, Talathi M, Mandvakar P, Devrukhkar AC, Patil VK, Rane AD, Dodake SB, Talathi JM, Haldankar PM and Bhattacharyya T 2018. Technological interventions: boon for rice production in Konkan region. Advanced Agricultural Research and Technology Journal **2(2):** 128-140.

Tripathi S, Tripathi A and Kori DC 1999. Allelopathic evaluation of *Tectona grandis* leaf, root and soil aqueous extracts on soybean. Indian Journal Forestry **22:** 366-374.

Udayana C, Andreassen HP and Skarpe C 2020. Understory diversity and composition after planting of teak and mahogany in Yogyakarta, Indonesia. Journal of Sustainable Forestry **39(5):** 494-510.

Varma SB and Giri SP 2013. Study of wound healing activity of *Tectona grandis* Linn leaf extract on rats. Ancient Science of Life **32(4):** 241-244.

Varma SB and Jaybhaye DL 2010. Antihyperglycemic activity of *Tectona grandis* Linn bark extract on alloxan induced diabetes in rats. International Journal of Ayurveda Research **1(3):** 163-166.

Vyas P, Yadav DK and Khandelwal P 2019. *Tectona grandis* (teak) – a review on its phytochemical and therapeutic potential. Natural Product Research **33(16):** 2338-2354.