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Original Research Article

Allelopathic Effect of Aqueous Root Bark Extract of *Tamarindus indica* L. and Rhizosphere Soil on Germination and Seedling Growth of *Oryza sativa* L.

N.Karmegam[1*], M.Kalpana[1] and M.Prakash[2]

[1]Department of Botany, Government Arts College (Autonomous), Salem- 636 007, Tamil Nadu, India
[2]Department of Microbiology, Kanchi Shri Krishna College of arts and Science, Kilambi, Kancheepuram - 631 551, Tamilnadu, India
Corresponding author

A B S T R A C T

In this study, aqueous root bark extract of *Tamarindus indica* L. and its rhizosphere soil were tested for allelopathic activity in common rice cultivars, ADT-45, IR-20 and Ponni. The aqueous root bark extract of *Tamarindus indica* L. was tested at 0, 5, 10, 15 and 20% concentrations while the rhizosphere soil was tested at 0, 25, 50, 75 and 100% proportions with non-rhizosphere soil. The results reveal that the root bark extract and rhizosphere soil of *Tamarindus indica* L. negatively affects the germination (%), germination index (GI), fresh and dry weight, and shoot and root length of rice seedlings. It is concluded from the study that the aqueous root bark extract of *Tamarindus indica* L. is negatively allelopathic to rice cultivars at lower concentrations (5, 10, 15 and 20%), whereas, rhizosphere soil requires higher proportion (25, 50, 75 and 100%).

Keywords

Allelopathic effect; *Tamarindus indica;* rhizosphere soil; root bark extract.

Introduction

Allelopathy is an important phenomenon involved in plant–plant interaction in the ecosystems (Rice, 1984). To elicit allelopathic activity in nature, plants release chemical compounds into their near environment in least three different ways: exudation, leaching and volatilization (Tukey, 1969). Phytotoxins and allelochemicals are released from either the above-ground (leaf, stem, bark, twigs, flower, pollen, seed, etc.) or under-ground (root, rhizome, tuber, etc.) parts of plants. The production of allelochemicals is an intrinsic determinant of the plant allelopathic effect. Plant roots play a vital role in allelopathy, because allelochemicals produced and exuded as root exudates are involved in the suppression of weed growth near the plant (Wu *et al.*, 2000, 2001).

Tamarindus incida L. (Family: Leguminosae), commonly known as tamarind, is an evergreen fruit tree species cultivated in many countries in the world. It has been recently demonstrated in both laboratory and greenhouse experiments, that the leaves and roots of the tamarind tree possess biologically important potent growth regulators and are involved in creating weed-free surroundings near the trunk of the plant through allelopathy (Parvez *et al.*, 2003 a, 2003 b). In fact, almost every part of this tree has been speculated to possess biological activities and to be of industrial use (Imbabi *et al.*, 1992). This tree has long been popular for its good quality wood and for making houses, furniture, and many wooden materials, particularly in Asian and African countries. The tree is remarkably free from any insect and disease attack and therefore assumed that the bark of the tree might have certain chemical properties for such resistance.

Allelopathic performance of the bark and seed of *Tamarindus indica* L. tree was evaluated by Parvez *et al.* (2004) through bioassay guided studies using seven common agronomic crops (asparagus, cucumber, lettuce, radish, sesame, tomato and welsh onion) and seven weed species (barnyard grass, Chinese milk vetch, perennial ryegrass, phacelia, timothy grass, white clover and wild ginger) under laboratory conditions. Sahoo *et al.* (2011) reported the effect of aqueous-leaf extract of *Tamarindus indica* on *Capsicum annum* L. (Chilli), *Glycine max* (L.) Merr. (Soybean), *Zea mays* L. (Maize), *Oryza sativa* L. (Rice), and *Abelmoschus esculentus* (L.) Moench (Lady's finger)]. Swain *et al.* (2012) studied the allelopathic effect of *Echinochloa colona* weed on *Oryza sativa* L. (variety 'Vandana'). These studies clearly indicated that the effect of bark extract of *Tamarindus indica* and the rhizosphere soil on most common rice cultivars grown in Tamil Nadu are scanty. Hence, the present study has been carried out to study the effect of aqueous root bark extract of *Tamarindus indica* L. and rhizosphere soil on germination and seedling growth of common cultivars of *Oryza sativa* L.

Materials and Methods

Selection of Plant

The plant species selected for the present study, *Tamarindus indica* L. was based on the literature available on its allelopathic effect.

Botanical Description of the Plant

Tamarind is an evergreen tree, slow growing, which can measure between 5 and 25 meters high. This is a very long-living tree, with thick trunk that can reach a circumference of 7.5 meters. It has a rough bark, dark gray. It has deep roots and strong branches, flexible to withstand the winds. Its leaves are alternate, glabrous, paripinnate, with 10 to 20 pairs of oblong leaflets, opposite, apex rounded, asymmetrical base and entire margin. Flowers are arranged in small clusters, hermaphrodite, yellowish, venation pink or orange. Individual flowers are about 2.5 cm in diameter. They have three stamens and five petals.

The tamarind tree produces fruits when the tree is 3-5 years old, or so. Indehiscent fruits are pods curved and with protuberances due to seed inside. They are between 8 and 20 cm long. The pericarp is thin, tan or brown, brown-gray, which becomes a brittle shell at fruit maturity. Tamarind seeds are hard, brown and wrapped in protective endocarp layer. A sheath generally contains between 2 and 10 seeds of 1 cm diameter each.

Collection of Root Bark of *Tamarindus indica* L.

Root barks of *Tamarindus indica* L. was collected from the roots branching out from the main root. The root barks were cut into small pieces, air dried, powdered and stored in airtight containers till use.

Preparation of Aqueous Root Bark Extract

The dried and powdered root bark was macerated with known quantity of distilled water, filtered through Whatman No. 1 filter paper and made into concentrations, 0% (control, distilled water), 5, 10, 15 and 20%.

Collection of Rhizosphere and Non-rhizosphere Soil and Preparation Soil Test Media:

The rhizosphere soil from *Tamarindus indica* L. was collected, air dried and stored in plastic container till use. The soil from the crop field out of range of *Tamarindus indica* L. (Non-rhizosphere soil) was also collected for preparing different concentrations of rhizosphere soil, *viz.,* 0, 25, 50, 75 and 100%.

Selection and Collection of Rice Seeds:

The most common cultivars of rice (*Oryza sativa* L.), ADT-45, IR-20 and Ponni (short) were selected for the present study and seeds were procured from Arunai Agro-marketing Private Limited, Salem and stored in air-tight containers till use.

Germination Bioassay using Soil Test Method

Treatments with root bark extracts

The seeds of three rice cultivars were individually soaked in aqueous extract concentrations of 0, 5, 10, 15 and 20% for 24 hrs. The standard egg box (germination test container) of 5 × 6 rows was used for seed germination tests. Equal quantity (10g) of non-rhizosphere soil was filled in each furrow of egg box, watered and the seeds were sown, cultivar and concentration-wise, in five replicates of three seeds each.

Treatment with rhizosphere soil

The rhizosphere soil concentrations of 0, 25, 50, 75 and 100% were filled in the furrows of egg box as described above for each rice cultivar separately.

All the treatment sets were kept in an environmentally controlled room and observed for germination every day up to seven days. After seven days, the seedlings were carefully removed from the culture container and gently washed to remove adhering soil (Fig. 1). The root length, shoot length, fresh weight and dry weight of the seedlings were measured and recorded.

Germination Percentage

The germination percentage of rice cultivars in all treatments were calculated as per the method described in UAF (2010).

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds tested}} \times 100$$

Germination Index (GI)

The germination index for each rice cultivar was determined using the following formula (AOSA, 1983).

$$\text{Germination Index (GI)} \quad GI = \Sigma \left(\frac{GT}{Tt} \right)$$

$$\text{Or} \quad \left[\frac{\text{No.of germinated seed}}{\text{Days of final or last count}}\right] + \ldots\ldots + \left[\frac{\text{No.of germinated seed}}{\text{Days of final or last count}}\right]$$

Statistical Analysis

The data obtained were subjected to statistical analysis using computer software (MS-Excel 2003).

Results and Discussion

percentage germination of rice cultivars showed variation with respect to the concentration of aqueous root bark extract of *Tamarindus indica* L. and the proportion of rhizosphere soil (Tables 1 and 2). The seeds of rice cultivars without extract treatment and 5% treatment showed 100% germination except Ponni. The germination percentage decreased with the increase of aqueous root bark extract of *Tamarindus indica* L. In 20% extract concentration the germination was found to be 53.3, 46.7 and 46.7% respectively for ADT-45, IR-20 and Ponni (Table 1).

The germination was 100% in control (0%) and 25% proportion of rhizoshpere soil for the rice cultivars, ADT-45, IR-20 and Ponni (Table 2). A maximum of 73.3% germination was observed in IR-20 in 100% rhizosphere soil followed by ADT-45 (66.7%) and Ponni (60.0%). Overall, the percent germination showed decline towards higher proportion of rhizosphere soil (Table 2).

In the present study, the germination index (GI) of rice cultivars observed in both aqueous root bark extract and rhizosphere soil treatments showed direct correlation with the concentration gradient (Figs. 2 and 3). Overall, the GI ranged between 1.95 and 4.73. In control, i.e., 0% aqueous root bark extract treatment, GI was higher than other treatments (GI for ADT-42: 4.43; IR-20: 4.32; Ponni: 4.27). The lowest GI of 1.95 was observed in 20% extract treated IR-20 and Ponni whereas ADT-42 showed a GI value of 2.32 (Fig. 2).

The germination index in rhizosphere soil treatment also showed decline towards higher from lower proportion. In control without rhizosphere soil, the GI recorded was 4.73, 4.33 and 4.60 for ADT-42, IR-20 and Ponni respectively.

The GI for IR-20 was 4.33, 4.21, 3.66, 3.65 and 2.73 in 0, 25, 50, 75 and 100% rhizosphere soil respectively (Fig. 3). The results of the present study on the germination index of rice cultivars clearly showed that both root bark and rhizosphere soil had negative allelopathic effect.

As a measure of seedling growth, fresh weight, dry weight, root length and shoot length were recorded for aqueous root bark extract and for rhizosphere soil treatment (Tables 3 to 6). All the growth parameters of rice seedling growth were found to decrease towards higher concentration.

A maximum fresh weight of 202.3 mg/seedling was found in the treatment without extract (0%) for Ponni followed by IR-20 (190.2 mg/seedling) (Table 3). The dry weight also showed decline towards higher concentration and the dry weight of rice seedlings ranged from 6.3 mg/seedling (IR-20 @ 20% extract treatment) to 30.4 mg/seedling (Ponni @ 20% extract treatment). Similar trend of results were observed for seedling root and

Fig.1 Rice seedlings (DAS – 7) germinated in (a) *Tamarindus indica* L. root bark extract and in (b) rhizosphere soil

a

b

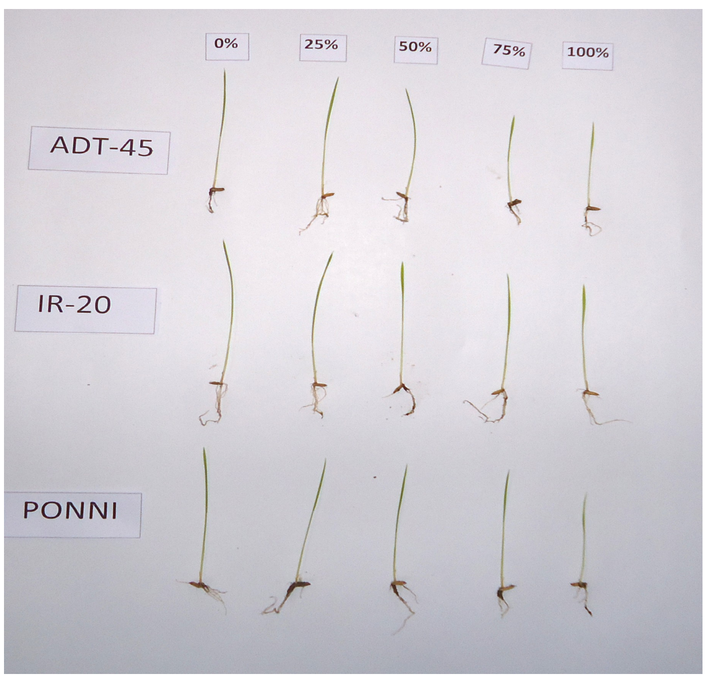

Table.1 Germination percentage of rice cultivars in aqueous root bark extract of *Tamarindus indica* L. (Values are Mean of five replicates).

Concentration of extract (%)	Germination of rice cultivars (%)		
	ADT-45	IR-20	PONNI
0	100.0	100.0	93.3
5	100.0	100.0	86.7
10	86.7	80.0	80.0
15	66.7	60.0	53.3
20	53.3	46.7	46.7

Table.2 Germination percentage of rice cultivars in *Tamarindus indica* L. rhizosphere soil (Values are Mean of five replicates).

Proportion of rhizosphere soil (%)	Germination of rice cultivars (%)		
	ADT-45	IR-20	PONNI
0	100.0	100.0	100.0
25	100.0	100.0	100.0
50	93.3	93.3	86.7
75	86.7	89.0	80.0
100	66.7	73.3	60.0

Fig.2 Germination Index (GI) of rice cultivars in aqueous root bark extract of *Tamarindus indica* L. (Values are Mean of total seedlings collected from five replicates; Error bars indicate±SD).

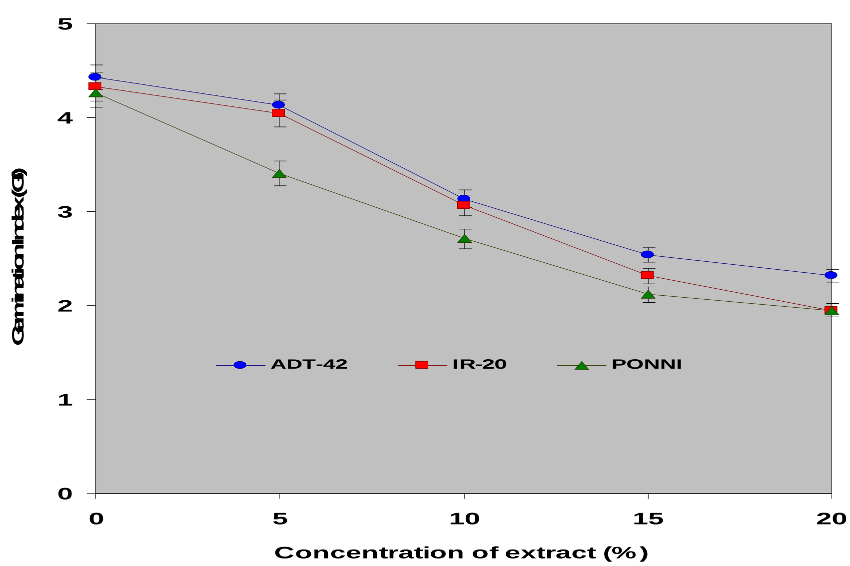

Fig.3 Germination Index (GI) of rice cultivars in *Tamarindus indica* L. rhizosphere soil (Values are Mean of total seedlings collected from five replicates; Error bars indicate±SD)

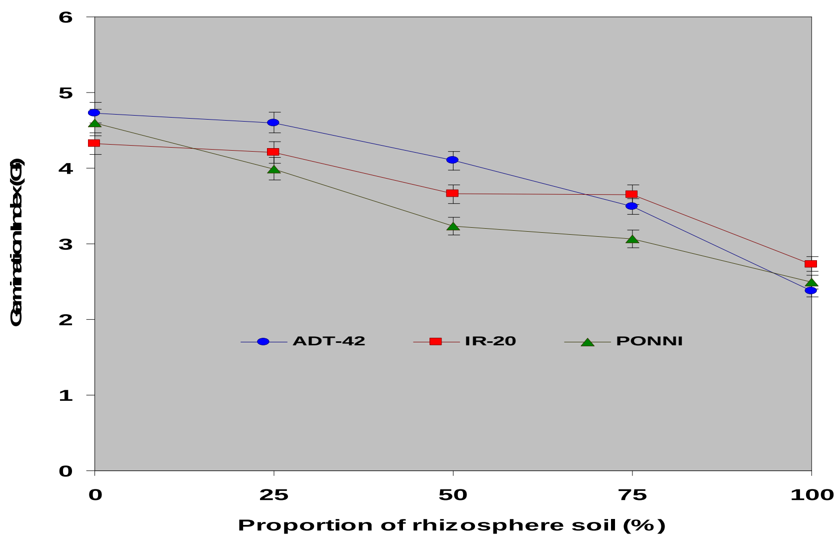

Table.3 Effect of aqueous root bark extract of *Tamarindus indica* L. on seedling weight of rice cultivars (Values are Mean of total seedlings collected from five replicates).

Concentration of extract (%)	Fresh Weight (mg/seedling)			Dry Weight (mg/seedling)		
	ADT-45	IR-20	PONNI	ADT-45	IR-20	PONNI
0	184.6	190.2	202.3	27.7	28.5	30.4
5	170.6	173.4	180.8	25.6	26.0	27.1
10	146.8	142.6	136.4	22.02	21.4	20.5
15	84.0	90.6	86.4	12.6	13.6	12.9
20	55.4	42.0	61.2	8.3	6.3	9.2

Table.4 Effect of rhizosphere soil of *Tamarindus indica* L. on seedling weight of rice cultivars (Values are Mean of total seedlings collected from five replicates).

Proportion of rhizosphere soil (%)	Fresh Weight (mg/seedling)			Dry Weight (mg/seedling)		
	ADT-45	IR-20	PONNI	ADT-45	IR-20	PONNI
0	192.6	183.5	206.2	28.9	27.525	30.9
25	183.8	182.2	193.5	27.6	27.33	29.0
50	170.8	167.8	185.4	25.6	25.17	27.8
75	125.4	136.4	146.2	18.8	20.46	21.9
100	93.2	88.8	93.0	13.9	13.32	13.9

Table.5 Effect of aqueous root bark extract of *Tamarindus indica* L. on seedling length of rice cultivars (Values are Mean of total seedlings collected from five replicates).

Concentration of extract (%)	Shoot Length (cm/seedling)			Root Length (cm/seedling)		
	ADT-45	IR-20	PONNI	ADT-45	IR-20	PONNI
0	4.8	4.5	5.2	2.4	2.2	3.1
5	3.1	3.4	4.6	1.8	1.6	2.0
10	2.6	2.2	2.9	1.4	1.2	1.7
15	2.1	1.9	2.4	1.0	0.9	1.2
20	1.4	1.2	1.5	0.8	0.7	1.0

Table.6 Effect of rhizosphere soil of *Tamarindus indica* L. on seedling length of rice cultivars (Values are Mean of total seedlings collected from five replicates).

Proportion of rhizosphere soil (%)	Shoot Length (cm/seedling)			Root Length (cm/seedling)		
	ADT-45	IR-20	PONNI	ADT-45	IR-20	PONNI
0	5.1	4.7	5.0	3.2	2.5	2.8
25	4.6	4.8	3.9	2.8	2.4	2.1
50	3.3	4.0	3.7	2.3	2.0	1.8
75	2.4	2.9	3.0	1.9	1.3	1.0
100	2.2	2.3	2.8	1.2	1.0	0.7

shoot length (Table 4). Among the rice cultivars tested, Ponni showed higher shoot length and root length in aqueous extract and rhizosphere soil treatments (Tables 5 and 6). The shoot length was 5.2, 4.6, 2.9, 2.4 and 1.5 cm/seedling in 0,5,10, 15 and 20% extract concentrations. Similar trend has been observed in rhizosphere soil treatment also (Table 6).

Allelopathy is one of the expressed phenomena of chemical interaction exhibiting widespread significance in natural eco-systems (Dayan *et al*., 2000; Parvez *et al*., 2003a). In nature, the released allelochemicals function on other plants, weeds or micro-organisms in inhibitory or excitatory ways. The chemical compounds are believed to act additively or synergistically for the allelopathic expression (Rice, 1984).

In the present study, an attempt has been made to study the effect of aqueous root bark extracts and rhizosphere soil of *Tamarindus indica* L. The current study clearly indicated that the aqueous root bark extract of *Tamarindus indica* L. at concentrations less than 20% is able to negatively affect the rice cultivars (ADT-45, IR-20 and Ponni) invariably with slight variations. The allelopathic effect of root bark extract of *Tamarindus indica* L. is clearly observed in germination percentage, germination index and seedling growth.

Parvez *et al.* (2004) reported that the bark and seed of tamarind tree is exhibiting strong allelopathic potentiality and these two materials display differential allelopathic effects (inhibitory or excitatory) in the species tested, it is evident that certain biologically active chemical compounds are either additively or synergistically involved in the plant-specific expression, particularly in the seed. In addition, in the present study, the rhizosphere soil from *Tamarindus indica* L. has also been tested for its effect on selected rice cultivars. The results of this study showed that the rhizosphere soil is also negatively allelopathic to rice cultivars tested.

It was observed that the effect was concentration gradient. From this, it is very clear that one or more allelochemicals exuded through the root bark acts as a biological factor to control or inhibit the growth of rice. It is a known phenomenon that the rice itself is an allelopathic plant, which is reported to inhibit weed growth in field (Khanh *et al.*, 2007). However, the rice germination and seedling growth is suppressed by aqueous root bark extract of *Tamarindus indica* L. and rhizosphere soil. This phenomenon indicates that the negative interaction among plant communities is different from one another.

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