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Allelopathic potential of few tree leaf leachates on germination and early seedling growth of paddy

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ABSTRACT

Experiments were conducted under *in vitro* condition to evaluate the allelopathic potential of leaf leachates (20% w/v) of three multiple-use trees, neem (*Azadirachta indica*), sandal (*Santalum album*), and poovarasu (*Thespesia populnea*) on paddy (*Oryza sativa* L.) var. ponmani. Both, fresh and dry leaf leachates of *Santalum* showed the most promotery effect on seed germination and seedling growth parameters of paddy as compared to control and other (neem and poovarasu) leaf leachates either alone or in combination. Among the leaf leachates (fresh and dry) of multiple-use trees tested on paddy, the dry leaf leachates showed more stimulatory (negative allelopathic) effect than the fresh leaf leachates.

KEY WORDS: Allelopathy, *Azadirachta indica,* leachates, neem, *Oryza sativa,* paddy, poovarasu, *Santalum, Santalum album, Thespesia populnea*

INTRODUCTION

One of the common practices found in the Indian agriculture is the application of fresh plant parts (leaf, young shoots, flowers, etc.) of various plant species in soil as natural fertilizers (green manure) to increase the soil fertility and so to increase the growth and productivity of crop plants, especially in paddy cultivation. Therefore, it is important to understand the nature of allelopathic potential of these green manure plants. Several workers have studied the effect of allelopathic interactions between the aqueous leachates of root, stem, and leaf of some common weeds and crops in India. Though several papers have been published during the past decades, a right approach on allelopathy in dry land forming is still to be made [1]. Under field condition, release of phytotoxic substances from plant residues often cause inhibition or delay of seed germination (SG) and result in poor crop stand. Inhibitory effects of some weeds on germination and seedling growth of growths were reported by many workers [2-6]. Neill and Rice [7] reported that soil associated with certain weeds inhibited germination and growth of other plants. Rice [8] further demonstrated that decaying shoots of *Andropogon* were highly inhibitory to a number of plant species. Jackson and Willemsen [9] also found that *Ambrosia* and *Aster* associated soil had strong allelopathic properties and that extract from these plants were inhibitory to SG and early growth. The leachate escaping from weed plant parts enter into the soil and exert an allelopathic influence on the germination and growth of subsequent crops [10,11]. Allelopathic studies with diffusates of *Ipomoea cornea* [12], extracts of aquatic weed – *Pistia stratiotes* [13], and *Hydrilla verticillata* [14] show both positive (stimulatory-at high concentration) and negative (stimulatory-at low concentration) allelopathic effect on germination and early seedling growth of paddy varieties. In this study, experiments were carried out to assess the allelopathic effect of leaf extracts of three multiple-use plants: Neem (*Azadirachta indica* [Ai] A. Juss.), Sandal (*Santalum album* [Sa] L.), and Poovarasu (*Thespesia populnea* [Tp] (Roxb) Kostel) either alone or in combination on SG and early seedling growth of paddy (*Oryza sativa*, L.) var. ponmani.

MATERIALS AND METHODS

Preparation of Fresh Leaf Leachate of Multipurpose Trees

Fresh leaves of Ai, Si, and Tp were collected from S.T. Hindu College campus, at Nagercoil, washed with tap water to remove the dust, remove the moisture using blotting paper, cut into small bits and take 20 g of fresh leaf from each plant, mixed with 100 ml water, and kept for 24 h with intermittent shaking. Then, the leachate was

filtered separately, and the volume was made up to 100 ml. This solution was used as 20% stock for seed treatment with paddy.

Preparation of Dry Leaf Leachate of Multipurpose Trees

Similarly, another set of washed plant leaves of three plants were kept in a hot air oven for 48 h at 80°C to dry. Then, the dried leaves were powdered, 20 g dry leaf powder of each plant was mixed with 100 ml of distilled water, incubated for 24 h with intermittent shaking, and then the leachate was filtered, made up to 100 ml and used as 20% stock solution for seed treatment with paddy.

Seed Treatments

Fresh and dry leaf leachates were used to give seed treatments in the following combinations:
T-1: Control
T-2: Ai 10 ml at 20% level
T-3: Si 10 ml at 20% level
T-4: Tp 10 ml at 20% level
T-5: Ai + Si 1:1 ratio (10 ml) at 20% level
T-6: Ai + Tp 1:1 ratio (10 ml) at 20% level
T-7: Si + Tp 1:1 ratio (10 ml) at 20% level
T-8: Ai + Si + Tp 1:1:1 ratio (10 ml) at 20% level.

Effect on SG

Experiments on SG of paddy was performed with fresh and dry leaf leachate of tree plants. The sterilized paddy seeds were spread in sterilized plastic cups (5 × 7 cm) lined with double layered filter paper and treated with 10 ml of 20% leaf leachates of tree plants at different combinations as mentioned above and with water as a control. For each treatment, 20 seeds/cup was used. Thereafter, water was used to maintain moister level including control throughout the period of observation. Three replications were maintained for each treatment including control. The treated seeds were incubated at room temperature (28°C ± 2°C) for 10 days. The protrusion of radical through seed coat was taken as the criterion of germination. The percentage of SG was calculated at the end of 10th day of observation.

Effect on Early Seedling Growth

Early seedling growth parameters of paddy were recorded at the end of 10th day of observation. For each treatment, 10 seedlings from each replication were selected for recording the following morphological parameters: Seedling growth (root, shoot, and total seedling length), biomass (seedling fresh weight [FW] and dry weight [DW]), seedling vigour index (SVI) [15], and seedling tolerance index [16] against leachates were determined to assess the growth performance of paddy. All experimental data were analyzed statistically using the one-way ANOVA.

RESULTS AND DISCUSSION

Seed treatment with Si leaf leachates (fresh and dry) showed more promotery effect on SG (91.7% and 93.3%) and seedling growth (17.73 cm/pl and 19.44 cm/pl) of paddy, respectively, than control and all other leachates either alone or in combination. Maximum SVI was noted in Si fresh (1634.3) and dry (1819.7) leachates than other treatments and control. A similar trend was also recorded in the tolerance level of paddy seedlings toward the leachates of Si while to other extracts paddy seedlings show less tolerance. The biomass production of paddy seedlings was more when the seeds treated with Si leachates than other leachates ad control (Table 1).

Table 1: *In vitro* effect of aqueous fresh leaf leachate of certain tree plants on germination and early seedling growth[#] of paddy var. ponmani

Treatment with fresh leaf leachate of plants[$]	SG (%)	Seedling growth (cm/pl)			Root/shoot ratio	SVI	STI	Biomass (mg/pl)	
		RL	SL	TL				FW	DW
T-1 Control	90.0±4.08	6.68±0.43	7.42±0.35	14.10±0.43	0.90±0.08	1267.0±21.3	1.00±0.00	85.7±9.18	13.7±0.94
T-2 Ai	90.0±0.00	6.80±0.57	7.42±0.32	14.22±0.53	0.92±0.10	1279.3±47.9	1.02±0.12	84.0±4.08	14.0±0.82
T-3 Sa	91.7±6.24	9.63±0.71	8.10±1.18	17.73±1.60	1.21±0.15	1634.3±248.0	1.45±0.13	99.3±2.62	15.3±0.47
T-4 Tp	91.7±4.71	6.42±0.85	7.54±0.86	13.96±1.44	0.86±0.12	1282.0±171.6	0.96±0.14	80.0±9.42	13.7±0.94
T-5 Ai+Sa (1:1)	78.3±2.36	8.02±0.76	7.50±0.51	15.52±0.57	1.08±0.16	1216.0±53.8	1.21±0.16	93.7±6.85	14.7±1.25
T-6 Ai+Tp (1:1)	85.0±4.08	6.25±1.21	6.07±0.87	12.32±2.01	1.03±0.12	1043.3±149.1	0.92±0.17	88.3±8.81	14.0±0.82
T-7 Sa+Tp (1:1)	86.7±6.24	7.19±0.38	7.76±0.78	14.95±0.89	0.94±0.10	1299.7±153.9	1.08±0.02	97.7±4.11	15.0±2.16
T-8 Ai+Sa+Tp (1:1:1)	88.3±6.24	7.20±1.01	7.00±0.57	14.20±1.58	1.02±0.06	1252.3±152.6	1.08±0.10	74.3±8.96	13.0±0.00
CD (*P*=0.05)	10.4	1.68	1.57	2.63	0.26	311.5	0.27	9.93	2.20
F value	1.68^{NS}	3.98**	1.37^{NS}	3.22*	1.79^{NS}	2.531^{NS}	3.57*	7.02**	1.15^{NS}

[#]Data recorded on 10th DAS±SD, ^{NS}Non-significance, [$]Concentration leaf leachate is 10% (w/v) level, *,**Significance at 1% and 5% level, respectively. SD: Standard deviation. Ai: *Azadirachta indica*, SA: *Santalum album*, Tp: *Thespesia populnea*, RL: Root length, SL: Shoot length, TL: Total length, STI: Stress tolerance index, SVI: Seedling vigour index, DW: Dry weight, FW: Fresh weight, SG: Seed germination

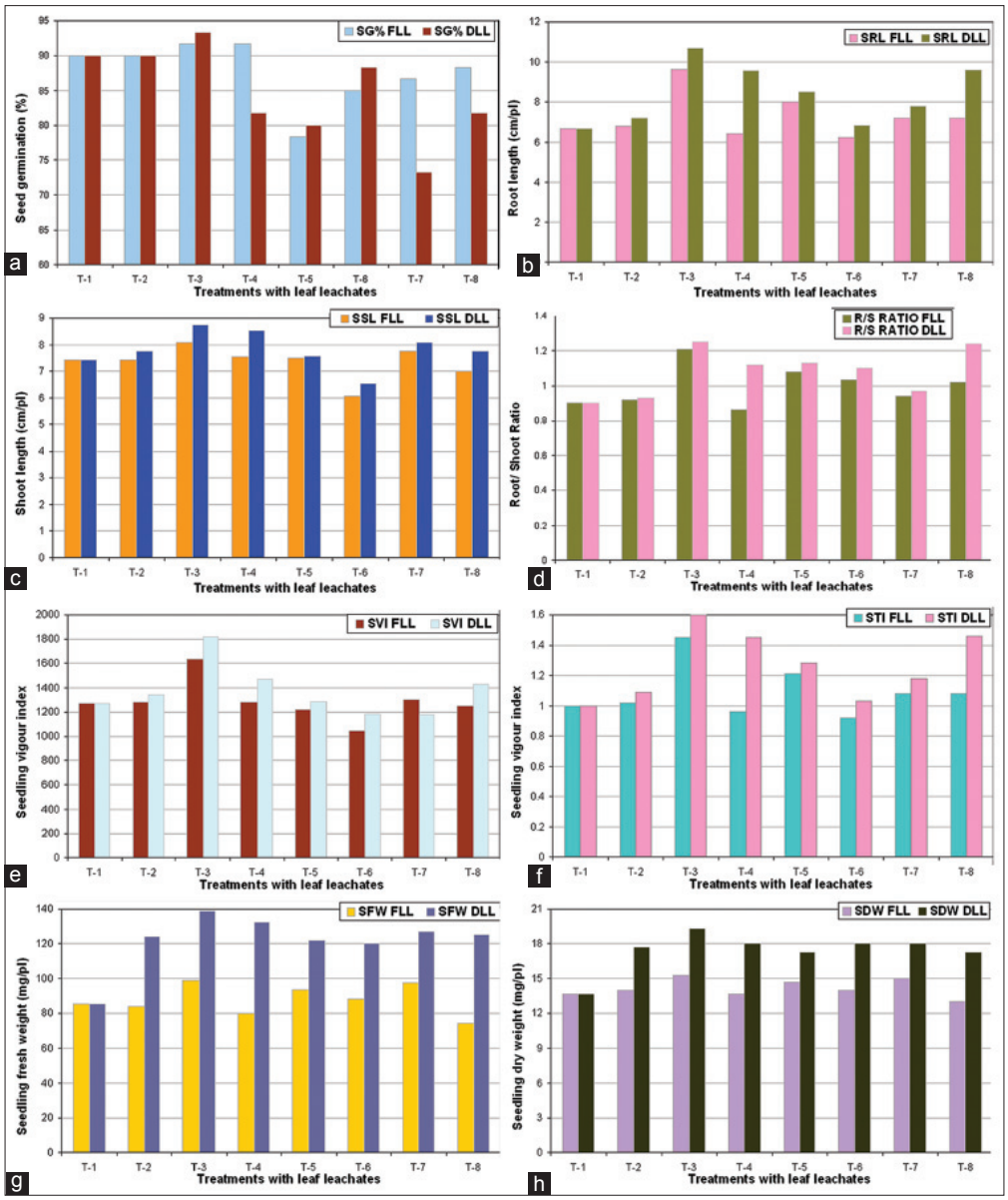

Figure 1: (a-h) Effect of fresh/dry leaf leachates of multipurpose trees on biometric parameters of paddy var. ponmani

Table 2: *In vitro* effect of aqueous dry leaf leachate of certain tree plants on germination and early seedling growth[#] of paddy var. ponmani

Treatment with dry leaf leachate of plants[$]	SG (%)	Seedling growth (cm/pl)			Root/shoot ratio	SVI	STI	Biomass (mg/pl)	
		RL	SL	TL				FW	DW
T-1 control	90.0±4.08	6.68±0.43	7.42±0.35	14.10±0.43	0.90±0.08	1267.0±21.3	1.00±0.00	85.7±9.18	13.7±0.94
T-2 Ai	90.0±8.16	7.19±0.84	7.75±0.54	14.95±0.99	0.93±0.13	1341.3±109.2	1.09±0.19	124.3±14.97	17.7±0.47
T-3 Sa	93.3±2.36	10.69±1.63	8.75±1.36	19.44±2.05	1.25±0.29	1819.7±233.5	1.60±0.27	138.7±6.24	19.3±0.94
T-4 Tp	81.7±4.71	9.56±2.27	8.53±0.96	18.08±2.79	1.12±0.23	1465.7±161.9	1.45±0.41	132.3±0.47	18.0±0.00
T-5 Ai+Sa (1:1)	80.0±12.25	8.50±0.38	7.55±0.50	16.05±0.73	1.13±0.07	1287.0±229.0	1.28±0.13	122.0±8.49	17.3±0.47
T-6 Ai+Tp (1:1)	88.3±6.24	6.83±1.63	6.53±0.85	13.36±0.85	1.10±0.42	1181.3±127.4	1.03±0.28	120.0±1.63	18.0±0.00
T-7 Sa+Tp (1:1)	73.3±8.50	7.81±0.28	8.09±1.07	15.90±1.34	0.97±0.09	1177.0±239.2	1.18±0.10	127.0±4.08	18.0±0005
T-8 Ai+Sa+Tp (1:1:1)	81.7±8.50	9.62±1.00	7.75±0.60	17.37±1.60	1.24±0.03	1430.3±260.5	1.46±0.24	125.3±6.24	17.3±0.47
CD (P=0.05)	14.19	2.60	1.79	3.14	0.43	368.2	0.40	16.91	1.17
F value	2.05[NS]	2.98*	1.37[NS]	4.02**	0.87[NS]	2.97*	2.82*	8.19**	18.08**

[#]Data recorded on 10[th] DAS±SD, [NS]Non-significance, [$]Concentration leaf leachate is 10% (w/v) level, *,**Significance at 1% and 5% level, respectively. SD: Standard deviation. Ai: *Azadirachta indica*, SA: *Santalum album*, Tp: *Thespesia populnea*, RL: Root length, SL: Shoot length, TL: Total length, STI: Stress tolerance index, SVI: Seedling vigour index, DW: Dry weight, FW: Fresh weight, SG: Seed germination

In general, the fresh leaf leachates of multiple-use trees show no significant effect on SG, shoot growth, r/s ratio, SVI, and dry matter production of paddy seedlings either alone or in combination as compared to control, while the dry leaf leachates has no significant effect on SG, shoot growth and r/s ratio of paddy seedling. Among the two leaf leachates (fresh and dry) of multipurpose trees tested, the dry leaf leachates either alone or in combination, showed more favorable effect than the fresh leachates.

The phytochemicals and bio-pesticides have recently been given much emphasis for used as chemical fungicides and pesticides due to their eco-friendliness. The various alternative biochemicals have successfully inhibited the growth of a number of pathogens [17-19]. However, many of these phytochemicals have been reported to have allelopathic effects, which inhibit SG and growth in many other crop plants [20-22]. In this study, the seed treatment with aqueous leaf leachates (fresh and dry) of multipurpose trees either alone or in combination showed both negative (stimulatory) as well as positive (inhibitory) allelopathic effect on SG and seedling growth parameters of paddy. This might be due to the presence of some water soluble allelochemicals present in the leachates as suggested by Oudhia [23,24] (Figure 1).

The negative (stimulatory) allelopathy of multipurpose tree leaf leachates on crop plants as seed treatment can be utilized to increase the rate of germination, SVI and biomass production. Similarly, positive (inhibitory) allelopathic effects of multipurpose tree leaf leachates on the crop plants can be exploited to develop eco-friendly, natural, cheep and effective plant protectants or green herbicides as foliar treatment at higher concentrations. In general, the results of this study clearly indicates that off the leachates of multipurpose trees, Si either alone or in combination with Ai and/or Tp leaf leachates may be used as growth promoting agents by seed treatment at lower (1-10%) concentrations (Table 2).

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