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Effect of tree leachates on growth performance of commonly grown cereal crops in northern Karnataka

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Abstract
The experiment was conducted to study the effect of tree leachates on the performance of growth of commonly grown cereal crops. The experiment was conducted for two years in green house in University of Agricultural Sciences, Dharwad. It was found that amongst the tested tree leachates, Eucalyptus tree leachates had more inhibitory effect on the emergence, dry matter, shoot and root length of the crops. Root + Leaf leachate had significantly higher inhibitory effect than root leachate alone. The inhibitory effect of leachates was more during earlier stage of crop growth (15 DAS) and later stages the effect was reduced in monsoon, but, in winter crop like wheat the inhibitory effect was observed even in later stages of crop growth (30 DAS).

Keywords: Tree leachates, growth performance, commonly grown cereal crops

Introduction
India is losing about 50 million tonnes of food grains each year on account of loss of top fertile soil caused by deforestation which is a result of increasing population pressure. So to safeguard the long range interest of environment the National Forest Policy envisaged that an area of 110 million ha should be under forests keeping future social, economic and environmental requirements. Keeping the long-range interest of both agriculture and forestry, the National Commission on Agriculture laid greater emphasis on "Agroforestry" to meet the needs of rural lot besides conserving natural resources.

Agroforestry combines the production of crops and forest/fruit trees simultaneously on the same unit of land and applies management practices compatible with the local cultural practices (King and Chandler, 1998) [3].

Despite the fact that agroforestry gives supplementary returns per unit of land it has been criticized for adverse effects of trees for dominating the understorey field crops in utilizing the limited growth resources (nutrients, moisture and light) (Rao *et al*., 1998) [8]. Added to this, release of organic compounds with inhibitory effects on other organisms (allelopathy) is considered as an additional factor affecting growth conditions in any plant-plant environment (Rice, 1984) [9]. Tree-crops interactions, which are quite complex in nature, are of paramount importance in any agroforestry system to understand clearly (Tripathi *et al.*, 1998) [11].

The research work carried out in the recent years has shown that it is not only the competition for physical growth resources but also interference of allelochemicals released by tree parts determines the performance of associated crops. This phenomenon of interference (phytotoxicity) was termed as "allelopathy" by Molisch in 1937 [5].

Allelopathy is the effect of one plant on other associated plants and/or micro-organisms through release of chemicals and their breakdown metabolites.

With the increased recognition of agroforestry as an alternative land use system, several scientists have focused their attention on trees (Palmberg, 1980) [6]. Like any living plant/organism, trees also release several phytotoxins or allelochemicals from leaves, stem, bark, roots, flowers, seeds, pollens and fruits which influence the growth of understorey vegetation (Suresh and Rai, 1988) [10].

Allelochemicals mostly refer to the secondary metabolites produced by plants and are by-products of primary metabolic processes which are produced by all kinds of trees and tree parts with leaf being the main source and they escape into environment (soil) through exudation, leaching, volatilisation and decaying/decomposition which again depends on climatic and soil factors.

Hence, the pot experiment was carried out to evaluate the effect of eucalyptus, teak and casuarina leachates on commonly grown cereal crops like maize, sorghum, wheat and bajra.

Material and Methods

The experiment was carried out in greenhouse at University of Agricultural Sciences Dharwad, Karnataka. The plastic pots were filled with sand and washed with distilled water. The seedlings of three years each tree species were planted in the pots individually and allowed to establish for two months. These pots were placed at higher elevation and were connected by nylon tubes to convey the leachate to the pots placed lower than these pots (which were also filled with sand washed with distilled water) in which cereal crop seeds were sown to test the effect of tree species root and root + leaf leachates on germination and initial growth of crops. The crops were grown without supplying any external nutrient.

The pots with tree sp. when connected to the pots below with the test crops delivered the root leachate when they were watered. In order to deliver root + leaf leachate, a known quantity of leaf litter (powdered) was mixed in the pots having crop seedlings (the quantity was worked out based on the litter observed in 3-6 m distance from the tree rows in the field). In case of the control, the leachate came from pots having no tree species. Crop seeds (ten) were dibbled in pots, which were placed at lower elevation (placed on the ground). The crop germination was recorded after seven days of sowing and retained six seedlings out of ten. The crop observations recorded were plant dry weight (dg/pl), root length and shoot length at 15 and 30 days after sowing.

The experiment was conducted for two years and the data was pooled and analyzed. Details of the experiments are as below

Tree species (Factor A): Three

1. Eucalyptus (*Eucalyptus tereticornis*)
2. Teak (*Tectona grandis*)
3. Casuarina (*Casuarina equisetifolia*).

Treatments (Factor B): Two

1. Root leachate (RL)
2. Root + Leaf leachate (RL + LL).

Control: One control in each crop was maintained for all three-tree species.

Crops

1. Wheat (variety: DWR-162)
2. Maize (variety: DMH-2)
3. Sorghum (variety: M-35-1)
4. Bajra (variety: ICTP-8203)

Replication: Three

Design: Two factor single control (RBD).

Results and Discussion

All the arable crops tested for trees leachates were significantly varied with respect treatments. Leachates recorded significantly lower emergence (Table-1) was recorded in wheat (5.44) and bajra (7.06) compared to control (8.00 and 7.33 cm in wheat and bajra respectively). Whereas, sorghum and maize shown significantly higher emergence in leachates (6.89 & 7.83 respectively) compared to their control (6.33 & 6.00 in sorghum and maize respectively). RL+LL recorded lower emergence in wheat (32 percent).

At the initial stages *i. e.,* 15 DAS (Table. 2-7), shoot length (cm), root length (cm) and dry matter (dg/pl) were varied significantly. Shoot length (SL) was significantly lower in sorghum and wheat (9 percent) compared to control followed by maize (7 percent). Root length was significantly lower in wheat (19 percent) followed by maize (17 percent). Dry matter was significantly lower in wheat (11 percent) followed by bajra and maize (4 percent). This may be due to inhibitory effect on the growth parameters at 15 DAS. Similar results were recorded in the experiment conducted by Mandal *et al.*, 1998, aqueous extracts of dry teak leaves inhibited the root and shoot growth of rice seedlings developing from seeds germinated on filter paper soaked in extracts. Panneerselvam *et al.* (1998) [7] showed that aqueous extracts of root and fully mature leaf leachate of *Tectona grandis* reduced the shoot length, root length, leaf area and chlorophyll content of peanut and maize seedlings.

At 30 DAS, leachates recorded significantly lower shoot length (10 percent) and root length (14 percent). The dry matter was reduced by 4 percent in wheat followed by maize (3 percent) and bajra (2 percent). While, sorghum recorded significantly higher dry matter (2 percent) than their respective control. By this it is proven that the inhibitory effect of leachates on crop growth was reduced by the increased number of days. Tripathi *et al.* (1999) [12] reported that polyphenols and glycosides were present in root, leaf and soil extracts of teak and their concentration was in the order of root and leaves and soil. HPLC revealed the presence of four phenolic acids in leaves, six in roots and six in soil extracts.

Root + Leaf leachates (RL + LL) had more detrimental effect than root leachate (RL) alone. At 15 DAS, shoot length was significantly reduced in sorghum (12 percent) followed by bajra (11 percent) and maize (8 percent) compared to leaf leachates. Root length was significantly higher in bajra (15 percent) followed by sorghum (4 percent) compared to LL.

At 30 DAS, wheat recorded significantly lower shoot (12 percent) and root length (16 percent) in RL+LL compared to LL. While in remaining crops the inhibitory effect of trees leachates was reduced or they may had stimulatory effect. Channal *et al.* (2000) [2] opined that the leaf extract of teak at 5 to 10 percent promoted germination in sorghum (15-32% over the control), but decreased seedling length of sorghum and also dry matter in sorghum and rice at both concentrations.

Table 1: Allelopathic effect of tree seedlings on emergence of cereals at 6 days after sowing

Treatment Tree	Maize			Wheat			Sorghum			Bajra		
	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean	T1	T2	Mean
Eucalyptus	8.67	5.67	7.17	5.67	4.00	4.83	6.00	4.33	5.17	6.00	5.00	5.50
	(+44)*	(-6)	(+19)	(-29)	(-50)	(-40)	(-5)	(-31)	(-18)	(-18)	(-32)	(-25)
Teak	9.67	7.00	8.33	6.00	4.67	5.33	8.33	6.67	7.50	8.33	6.00	7.17
	(+61)	(+17)	(+39)	(-25)	(-42)	(-33)	(+32)	(+5)	(+18)	(+14)	(-18)	(-2)
Casuarina	9.33	6.67	8.00	6.67	5.67	6.17	8.67	7.33	8.00	9.33	7.67	8.50
	(+56)	(+11)	(+33)	(-17)	(-29)	(-23)	(+37)	(+16)	(+26)	(+27)	(+5)	(+16)
Mean	9.22	6.44	7.83	6.11	4.78	5.44	7.67	6.11	6.89	7.89	6.22	7.06
	(+54)	(+7)	(+31)	(-24)	(-40)	(-32)	(+21)	(-3)	(+9)	(+8)	(-15)	(-4)
Control			6.00			8.00			6.33			7.33
			(100)			(100)			(100)			(100)
	SEm±	C.D. (5%)		SEm±	C.D. (5%)		SEm±	C.D. (5%)		SEm±	C.D. (5%)	
Tree	0.35	1.07		0.43	1.32		0.48	1.48		0.54	1.65	
Treatment	0.29	0.88		0.35	1.07		0.39	1.21		0.44	1.35	
Interaction	0.49	1.50		0.60	1.84		0.68	2.09		0.76	2.33	
	SEd±			SEd±			SEd±			SEd±		
Control V/S Rest	0.49	1.06		0.59	1.30		0.68	1.48		0.75	NS	

T_1- Root Leachate; T_2- Root +Leaf Leachate; * - Values in parenthesis percent (+ for stimulation effect; - for inhibition effect; 0- for no effect)

Table 2: Allelopathic effect of tree seedlings on shoot and root length (cm) of maize at 15 and 30 DAS

Treatment Tree	15 DAS						30 DAS					
	SL			RL			SL			RL		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
Eucalyptus	8.90	8.70	8.80	7.37	7.17	7.27	22.00	20.12	21.06	11.63	9.93	10.78
	(-3)*	(-6)	(-4)	(-23)	(-25)	(-24)	(+4)	(-5)	(100)	(-5)	(-19)	(-12)
Teak	9.00	8.90	8.95	8.27	7.33	7.80	22.45	21.67	22.06	12.53	11.70	12.12
	(-2)	(-3)	(-3)	(-14)	(-24)	(-19)	(+6)	(+3)	(+5)	(+3)	(-4)	(-1)
Casuarina	8.40	7.70	8.05	8.80	8.70	8.75	23.77	22.37	23.07	15.43	13.27	14.35
	(-9)	(-16)	(-13)	(-8)	(-9)	(-9)	(+13)	(+6)	(+9)	(+26)	(+9)	(+17)
Mean	8.77	8.43	8.60	8.14	7.73	7.94	22.74	21.38	22.06	13.20	11.63	12.42
	(-5)	(-8)	(-7)	(-15)	(-19)	(-17)	(+8)	(+1)	(+5)	(+8)	(-5)	(+2)
Control			9.22			9.60			21.10			12.23
			(100)			(100)			(100)			(100)
	SEm±	C.D. (5%)		SEm±	C.D. (5%)		SEm±	C.D. (5%)		SEm±	C.D. (5%)	
Tree	0.14	0.43		0.38	1.16		0.32	0.98		0.32	1.00	
Treatment	0.11	0.35		0.31	NS		0.26	0.80		0.26	0.81	
Interaction	0.20	0.61		0.53	NS		0.45	1.38		0.46	1.41	
	SEd±			SEd±			SEd±			SEd±		
Control V/S Rest	0.18	0.40		0.53	1.15		0.44	NS		0.44	NS	

T_1- Root Leachate; T_2- Root +Leaf Leachate; * - Values in parenthesis percent (+ for stimulation effect; - for inhibition effect; 0 for no effect)
SL –Shoot length: RL – Root length

Table 3: Allelopathic effect of tree seedlings on shoot and root length (cm) of wheat at 15 and 30 DAS

Treatment Tree	15 DAS						30 DAS					
	SL			RL			SL			RL		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
Eucalyptus	6.20	6.00	6.10	5.70	5.02	5.36	12.00	11.00	11.50	9.25	8.24	8.75
	(-16)*	(-19)	(-18)	(-10)	(-21)	(-15)	(-11)	(-19)	(-15)	(-16)	(-26)	(-21)
Teak	7.00	6.83	6.92	5.26	5.20	5.23	12.50	12.30	12.40	9.45	9.10	9.28
	(-5)	(-7)	(-6)	(-17)	(-18)	(-17)	(-8)	(-9)	(-8)	(-15)	(-18)	(-16)
Casuarina	7.15	7.10	7.13	5.13	4.50	4.82	13.30	12.20	12.75	10.75	10.64	10.70
	(-3)	(-4)	(-3)	(-19)	(-29)	(-24)	(-2)	(-10)	(-6)	(-3)	(-4)	(-3)
Mean	6.78	6.64	6.71	5.37	4.91	5.14	12.60	11.83	12.22	9.82	9.33	9.57
	(-8)	(-10)	(-9)	(-15)	(-22)	(-19)	(-7)	(-12)	(-10)	(-11)	(-16)	(-14)
Control			7.37			6.33			13.53			11.08
			(100)			(100)			(100)			(100)
	SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)	
Tree	0.11	0.33		0.22	NS		0.11	0.34		0.18	0.56	
Treatment	0.09	NS		0.18	NS		0.09	0.28		0.15	0.46	
Interaction	0.15	NS		0.31	NS		0.16	0..48		0.26	0.80	
	SEd±			SEd±			SEd±			SEd±		
Control V/S Rest	0.15	0.33		0.30	0.66		0.15	0.33		0.27	0.59	

T_1- Root Leachate; T_2- Root +Leaf Leachate; * - Values in parenthesis percent (+ for stimulation effect; - for inhibition effect; 0 for no effect)
SL –Shoot length: RL–Root length

Table 4: Allelopathic effect of tree seedlings on shoot and root length (cm) of sorghum at 15 and 30 DAS

Treatment/Tree	15 DAS						30 DAS					
	SL			RL			SL			RL		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
Eucalyptus	5.80	5.24	5.52	4.67	3.30	3.98	16.40	16.93	16.67	10.13	9.33	9.73
	(-3)*	(-12)	(-7)	(+21)	(-15)	(+3)	(-6)	(-3)	(-5)	(-3)	(-11)	(-7)
Teak	5.22	5.10	5.16	4.87	3.17	4.02	18.50	18.20	18.35	10.67	9.80	10.23
	(-12)	(-14)	(-13)	(+26)	(-18)	(+4)	(+6)	(+4)	(+5)	(+2)	(-7)	(-3)
Casuarina	5.65	5.40	5.53	4.87	4.70	4.78	20.00	19.03	19.52	12.43	11.27	11.85
	(-5)	(-9)	(-7)	(+26)	(+22)	(+24)	(+14)	(+9)	(+11)	(+18)	(+7)	(+13)
Mean	5.56	5.25	5.40	4.80	3.72	4.26	18.30	18.06	18.18	11.08	10.13	10.61
	(-7)	(-12)	(-9)	(+24)	(-4)	(+10)	(+4)	(+3)	(+4)	(+6)	(-3)	(+1)
Control			5.97			3.87			17.53			10.50
			(100)			(100)			(100)			(100)
	SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)	
Tree	0.08	0.25		0.33	NS		0.47	1.46		0.20	0.61	
Treatment	0.07	0.20		0.27	0.83		0.39	NS		0.16	0.50	
Interaction	0.11	0.34		0.46	NS		0.67	NS		0.28	0.86	
	SEd±			SEd±			SEd±			SEd±		
Control V/S Rest	0.11	0.24		0.45	NS		0.66	NS		0.29	NS	

T_1- Root Leachate; T_2- Root +Leaf Leachate; * - Values in parenthesis percent (+ for stimulation effect; - for inhibition effect; 0 for no effect)
SL –Shoot length : RL – Root length

Table 5: Allelopathic effect of tree seedlings on shoot and root length (cm) of bajra at 15 and 30 DAS

Treatment Tree	15 DAS						30 DAS					
	SL			RL			SL			RL		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
Eucalyptus	4.50	4.08	4.29	2.07	1.93	2.00	10.93	9.67	10.30	6.43	5.75	6.09
	(-2)*	(-11)	(-7)	(-35)	(-40)	(-37)	(+3)	(-9)	(-3)	(+8)	(-4)	(+2)
Teak	4.34	4.11	4.23	2.63	1.60	2.12	12.37	10.17	11.27	6.44	5.58	6.01
	(-6)	(-11)	(-8)	(-18)	(-50)	(-34)	(+17)	(-4)	(+16)	(+8)	(-7)	(+1)
Casuarina	4.70	4.15	4.43	5.33	4.63	4.98	12.07	10.44	11.25	7.45	6.26	6.86
	(+2)	(-10)	(-4)	(+67)	(+45)	(+56)	(+14)	(-2)	(+6)	(+25)	(+5)	(+15)
Mean	4.51	4.11	4.31	3.34	2.72	3.03	11.79	10.09	10.94	6.77	5.86	6.32
	(-2)	(-11)	(-6)	(+5)	(-15)	(-5)	(+11)	(-5)	(+3)	(+13)	(-2)	(+6)
Control			4.60			3.20			10.62			5.98
			(100)			(100)			(100)			(100)
	SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)	
Tree	0.15	NS		0.19	0.58		0.28	0.87		0.17	0.54	
Treatment	0.12	0.38		0.15	0.47		0.23	0.71		0.14	0.44	
Interaction	0.21	NS		0.27	0.83		0.40	1.23		0.25	0.77	
	SEd±			SEd±			SEd±			SEd±		
Control V/S Rest	0.49	NS		0.27	NS		0.39	NS		0.24	NS	

T_1- Root Leachate; T_2- Root +Leaf Leachate; * - Values in parenthesis percent (+ for stimulation effect; - for inhibition effect; 0 for no effect)
SL –Shoot length: RL – Root length

Table 6: Allelopathic effect of tree seedlings on dry weight (dg/pl) of maize and wheat at 15 and 30 DAS

Treatment Tree	Maize						Wheat					
	15 DAS			30 DAS			15 DAS			30 DAS		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
Eucalyptus	23.00	21.80	22.40	45.83	44.23	45.03	16.40	16.07	16.23	33.50	33.10	33.30
	(-2)*	(-7)	(-5)	(-2)	(-5)	(-4)	(-13)	(-14)	(-13)	(-6)	(-7)	(-6)
Teak	22.80	22.40	22.60	45.00	44.73	44.87	16.83	16.27	16.55	34.73	34.30	34.52
	(-3)	(-5)	(-4)	(-4)	(-4)	(-4)	(-10)	(-13)	(-12)	(-2)	(-4)	(-3)
Casuarina	23.10	22.20	22.65	46.67	46.40	46.53	17.60	17.10	17.35	34.80	34.43	34.62
	(-2)	(-5)	(-4)	(100)	(-1)	(100)	(-6)	(-9)	(-7)	(-2)	(-3)	(-3)
Mean	22.97	22.13	22.55	45.83	45.12	45.48	16.94	16.48	16.71	34.34	33.94	34.14
	(-2)	(-6)	(-4)	(-2)	(-3)	(-3)	(-10)	(-12)	(-11)	(-4)	(-5)	(-4)
Control			23.50			46.70			18.77			35.63
			(100)			(100)			(100)			(100)
	SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)	
Tree	0.20	NS		0.20	0.61		0.15	0.47		0.11	0.35	
Treatment	0.16	0.50		0.16	0.50		0.12	0.38		0.09	0.28	
Interaction	0.28	0.86		0.28	0.86		0.22	NS		0.16	NS	
	SEd±			SEd±			SEd±			SEd±		
Control V/S Rest	0.28	0.61		0.28	0.61		0.22	0.47		0.15	0.33	

T_1- Root Leachate; T_2- Root +Leaf Leachate; * - Values in parenthesis percent (+ for stimulation effect; - for inhibition effect; 0 for no effect)

Table 7: Allelopathic effect of tree seedlings on dry weight (dg/pl) of sorghum and bajra at 15 and 30 DAS

Treatment Tree	Sorghum						Bajra					
	15 DAS			30 DAS			15 DAS			30 DAS		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
Eucalyptus	20.52	20.10	20.31	39.57	38.83	39.20	19.02	18.38	18.70	30.53	30.70	30.30
	(-2)*	(-4)	(-3)	(+6)	(+4)	(+5)	(-3)	(-6)	(-5)	(-11)	(-11)	(-11)
Teak	20.05	19.54	19.80	36.20	35.97	36.08	19.24	18.45	18.85	35.97	33.73	34.85
	(-4)	(-7)	(-6)	(-3)	(-4)	(-3)	(-2)	(-6)	(-4)	(+5)	(-2)	(+1)
Casuarina	20.80	20.46	20.63	39.90	38.07	38.98	19.40	18.67	19.04	36.04	35.53	35.97
	(-1)	(-3)	(-2)	(+7)	(+2)	(+4)	(-1)	(-5)	(-3)	(+5)	(+3)	(+5)
Mean	20.46	20.03	20.25	38.56	37.62	38.09	19.22	18.50	18.86	34.30	33.11	33.71
	(-3)	(-5)	(-4)	(+3)	(+1)	(+2)	(-2)	(-6)	(-4)	(-1)	(-4)	(-2)
Control			21.00			37.40			19.60			34.40
			(100)			(100)			(100)			(100)
	SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)		SEm±	C.D.(5%)	
Tree	0.27	NS		0.16	0.48		0.15	NS		0.11	0.34	
Treatment	0.22	NS		0.13	0.39		0.13	0.38		0.09	0.27	
Interaction	0.39	NS		0.24	0.68		0.22	NS		0.15	0.47	
	SEd±			SEd±			SEd±			SEd±		
Control V/S Rest	0.38	NS		0.22	0.47		0.22	0.47		0.15	0.33	

T_1- Root Leachate; T_2- Root +Leaf Leachate; * - Values in parenthesis percent (+ for stimulation effect; - for inhibition effect; 0 for no effect)

Conclusion

The leachates study was clearly indicates that the inhibitory effect was more during initial stages of crop and later stage (30 DAS) the effect was reduced may be due to dilution effects during monsoon season. On the other hand the rabi crop wheat shows inhibitory effects even later stages of the crop. Still the inhibitory effect during earlier stages may detrimentally affects on yield of the crops due to restricted vegetative growth.

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