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ALLELOPATHIC EFFECT OF *EUCALYPTUS TERETICORNIS* CLONES ON GERMINATION AND GROWTH OF *ZEA MAYS*

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ABSTRACT

This study aimed to evaluate the allelopathic effect of various concentrations of an aqueous extract of *Eucalyptus tereticornis* clones (C3, C6, C7 and C10) plant parts *viz.*, leaves, twigs and roots on *Zea mays* (maize) seeds. Different plant part extracts of *E. tereticornis* clones were used to run the experiment under laboratory condition. The aqueous extracts of leaf showed significant inhibitory effect on germination, root and shoot elongation of *Zea mays*. The inhibitory effect was proportional to the concentrations of the extracts and the higher concentration (15%) had the strongest inhibitory effect. In plant part leaf extract had more inhibitory effect compared to twig and root extract. From the obtained results, it can be concluded that, *Eucalyptus* seems to be a potential threat to the cereals industry under small-scale farming condition. Therefore, it could be recommended that different remedial practices (like removal of excess leaf litters) should be done before sowing maize, in land previously planted with *Eucalyptus* in order to reduce the potential risks.

Figure : 00 References : 21 Table : 01
KEY WORDS : Allelopathy, Clone, *Eucalyptus tereticornis*, Germination, *Zea mays*

Introduction

Agroforestry is a dynamic, ecologically based natural resources management system.The integration of trees on farms and agricultural landscapes, diversifies and sustains production for increased social, economic and environmental benefits for farmers. In India, agroforestry systems have been increasingly adopted in recent years as alternatives to traditional farming system.The different agroforestry systems are attractive, because they allow the amortization of the implementation costs through diversified production and these are multifunctional. Agroforestry systems allow the intensification of production through the integrated management of natural resources without environmental degradation.

The species of the genus *Eucalyptus* used in forestry are notable for their rapid growth and excellent adaptation to many types of environmental conditions and for the versatile uses of their wood. Most farmers describe it "life saviour", "safety net" or "tree bank" as it is converted easily and quickly to cash wherever needed. However, there are some public reactions against planting of *Eucalypts*. A forestry practice widely used in integrated systems is artificial pruning. This practice is followed to improve stem form and wood quality. Moreover, it opens a route for solar radiation to reach the understory. After pruning, the branches and leaves are allowed to remain among the rows of *Eucalyptus*. It is believed that these materials can produce allelopathic effects on weeds or crops. Such effects may involve, the abnormal growth of the seedlings or the inhibition of seed germination. Due to the complexity of these mixed systems, knowledge about the interactions of their components is essential, and allelopathy is an important factor that should be investigated. Allelopathy is defined as an inhibitory or beneficial effect, direct or indirect, of a plant on another plant through the production and exudation of chemical compounds[11]. Many previous studies have demonstrated the allelopathic effects of *Eucalyptus* spp. on various crops[5,17-21,]. Certain phenolic acids and volatile oils released from the leaves, bark and roots of certain *Eucalyptus* spp. act as allelopathic agents and are harmful to other plant species[6,12]. Chemically allelochemical compounds have open chain molecular structures. These are secondary metabolites that have role in plant-plant, plant-soil, plant-disease, plant-insect and plant predator interactions that may be beneficial or detrimental to plant[16].

There is significant reduction in the density, root and shoot length, biomass, and economic yield of forage

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TABLE-1 : Effect of various extracts and concentrations of different clones of *E. tereticornis* on *Z. maize*

Clones	Plant part of *E. tereticornis*															Grand mean
	Leaf					Twig					Root					
	Concentrations (%)															
	15	**10**	**5**	**0**	**Mean**	**15**	**10**	**5**	**0**	**Mean**	**15**	**10**	**5**	**0**	**Mean**	
Germination %																
C3	25	31	33	71	40	40	40	46	71	49	32	38	38	71	45	45
C6	39	44	51	71	51	43	48	51	71	53	45	46	51	71	53	53
C7	22	28	39	71	40	28	34	39	71	43	42	42	45	71	50	44
C10	6	11	20	71	27	11	32	42	71	39	20	23	29	71	36	34
Mean	23	28	36	71	40	31	39	45	71	46	34	37	41	71	46	
Pooled mean	29	35	40	71												
Vigour index																
C3	114	266	310	2553	811	376	491	874	2553	1073	299	511	677	2553	1010	965
C6	260	475	909	2553	1049	570	1202	1332	2553	1415	525	992	1368	2553	1360	1275
C7	76	159	408	2553	799	202	273	981	2553	915	483	744	981	2553	1190	968
C10	10	31	93	2553	672	88	290	594	2553	881	142	228	369	2553	823	792
Mean	115	233	430	2553	833	309	564	858	2553	1071	363	619	849	2553	1096	
Pooled mean	262	472	712	2553												
Collar diameter (mm)																
C3	1.9	2.1	2.3	2.8	2.3	2.1	2.1	2.3	2.8	2.3	2.2	2.3	2.4	2.8	2.4	2.3
C6	2.0	2.3	2.3	2.8	2.3	2.2	2.3	2.5	2.8	2.4	2.2	2.4	2.5	2.8	2.5	2.4
C7	1.8	1.9	2.1	2.8	2.2	1.9	1.9	2.2	2.8	2.2	2.1	2.2	2.4	2.8	2.4	2.2

Clones	**Plant part of *E. tereticornis***															**Grand mean**
	Leaf					**Twig**					**Root**					
	Concentrations (%)															
	15	**10**	**5**	**0**	**Mean**	**15**	**10**	**5**	**0**	**Mean**	**15**	**10**	**5**	**0**	**Mean**	
C10	0.4	0.8	1.7	2.8	1.4	0.4	1.8	1.8	2.8	1.7	0.9	1.3	1.4	2.8	1.6	1.6
Mean	1.5	1.8	2.1	2.8	2.0	1.7	2.0	2.2	2.8	2.2	1.9	2.1	2.2	2.8	2.2	
Pooled mean	1.7	2.0	2.2	2.8												
Shoot length (cm)																
C3	3.0	3.2	3.3	8.0	4.4	3.6	4.2	5.8	8.0	5.4	4.3	5.6	5.9	8.0	6.0	5.2
C6	2.9	4.6	5.3	8.0	5.2	5.0	5.5	5.9	8.0	6.1	4.3	4.7	6.0	8.0	5.8	5.7
C7	2.2	3.0	3.9	8.0	4.3	3.0	3.3	5.4	8.0	4.9	4.6	5.2	5.8	8.0	5.9	5.0
C10	0.5	1.0	3.0	8.0	3.1	0.5	3.1	3.5	8.0	3.8	1.2	2.4	2.8	8.0	3.6	3.5
Mean	2.2	2.9	3.9	8.0	4.2	3.0	4.0	5.1	8.0	5.1	3.6	4.5	5.1	8.0	5.3	
Pooled mean	2.9	3.8	4.7	8.0												
Root length (cm)																
C3	3.5	6.3	7.1	21.0	9.5	5.4	7.4	11.2	21.0	11.3	6.2	7.6	12.4	21.0	11.8	10.8
C6	3.6	5.3	9.9	21.0	9.9	7.4	16.0	16.4	21.0	15.2	6.2	14.2	16.8	21.0	14.5	13.2
C7	3.3	4.3	6.2	21.0	8.7	5.6	5.6	10.2	21.0	10.6	6.3	11.8	13.7	21.0	13.2	10.8
C10	0.5	1.0	2.4	21.0	6.2	1.3	4.3	6.0	21.0	8.1	1.6	3.7	4.1	21.0	7.6	7.3
Mean	2.7	4.2	6.4	21.0	8.6	4.9	8.3	11.0	21.0	11.3	5.1	9.3	11.8	21.0	11.8	
Pooled mean	4.2	7.3	9.7	21.0												
Shoot dry weight (mg/5 seedlings)																
C3	52.2	67.6	95.4	1253.3	367.1	65.9	82.0	97.3	1253.3	374.6	63.9	79.3	157.0	1253.3	388.4	376.7

Clones	Plant part of *E. tereticornis*															Grand mean
	Leaf					Twig					Root					
	Concentrations (%)															
	15	**10**	**5**	**0**	**Mean**	**15**	**10**	**5**	**0**	**Mean**	**15**	**10**	**5**	**0**	**Mean**	
C6	62.1	88.8	92.6	1253.3	374.2	80.5	95.0	128.3	1253.3	389.3	99.9	154.1	189.1	1253.3	424.1	395.9
C7	44.1	63.7	69.4	1253.3	357.6	51.0	74.1	106.2	1253.3	371.2	93.1	112.0	135.6	1253.3	398.5	375.8
C10	17.5	22.5	50.7	1253.3	336.0	17.7	54.7	68.2	1253.3	348.5	27.2	55.0	110.2	1253.3	361.4	348.6
Mean	44.0	60.6	77.0	1253.3	358.7	53.8	76.4	100.0	1253.3	370.9	71.0	100.1	148.0	1253.3	393.1	
Pooled mean	56.3	79.1	108.3	1253.3												
Root dry weight (mg/5 seedlings)																
C3	1129.8	1288.0	1336.0	1911.8	1416.4	1393.4	1456.2	1485.5	1911.8	1561.7	1354.9	1462.0	1555.1	1911.8	1571.0	1516.4
C6	1157.3	1462.4	1605.5	1911.8	1534.3	1444.4	1526.1	1633.6	1911.8	1629.0	1396.7	1566.4	1757.9	1911.8	1658.2	1607.2
C7	1048.3	1099.9	1219.2	1911.8	1319.8	1141.2	1162.4	1502.1	1911.8	1429.4	1276.4	1412.9	1554.0	1911.8	1538.8	1429.3
C10	260.2	424.1	1076.3	1911.8	918.1	288.2	1177.3	1218.1	1911.8	1148.9	643.0	930.1	1113.3	1911.8	1149.6	1072.2
Mean	898.9	1068.6	1309.3	1911.8	1297.2	1066.8	1330.5	1459.8	1911.8	1442.2	1167.7	1342.9	1495.1	1911.8	1479.4	
Pooled mean	1044.5	1247.3	1421.4	1911.8												
Total dry weight (mg/5 seedlings)																
C3	1182.0	1355.6	1431.4	3165.2	1783.6	1459.2	1538.2	1582.9	3165.2	1936.4	1418.8	1541.3	1712.0	3165.2	1959.3	1893.1
C6	1219.4	1551.2	1698.2	3165.2	19.08.5	1524.9	1621.1	1761.9	3165.2	2018.2	1496.6	1720.6	1947.0	3165.2	2082.3	2003.0
C7	1092.5	1163.6	1288.6	3165.2	1677.5	1192.2	1236.5	1608.3	3165.2	1800.5	1369.7	1525.0	1689.6	3165.2	1937.3	1805.1
C10	277.7	446.7	1127.0	3165.2	1254.1	306.0	1232.0	1286.3	3165.2	1497.3	670.1	985.1	1223.5	3165.2	1511.0	1420.8
Mean	942.9	1129.3	1386.3	3165.2	1655.9	1120.6	1406.9	1559.8	3165.2	1813.1	1238.8	1443.0	1643.0	3165.2	1872.5	

Clones	Plant part of *E. tereticornis*															Grand mean
	Leaf					Twig					Root					
	Concentrations (%)															
	15	10	5	0	Mean	15	10	5	0	Mean	15	10	5	0	Mean	
Pooled mean	1100.7	1326.4	1529.7	3165.2												
Root: shoot ratio																
C3	1.2	2.0	2.2	2.7	2.0	1.5	1.8	1.9	2.7	2.0	1.4	1.4	2.2	2.7	1.9	2.0
C6	1.3	1.2	1.9	2.7	1.7	1.5	3.0	2.8	2.7	2.5	1.5	3.0	2.8	2.7	2.5	2.2
C7	1.5	1.4	1.6	2.7	1.8	1.9	1.4	1.9	2.7	2.0	1.4	2.3	2.4	2.7	2.2	2.0
C10	0.2	0.4	0.6	2.7	1.0	0.6	1.1	1.4	2.7	1.4	0.6	1.0	0.9	2.7	1.3	1.2
Mean	1.0	1.3	1.6	2.7	1.6	1.4	1.8	2.0	2.7	2.0	1.2	1.9	2.1	2.7	2.0	
Pooled mean	1.2	1.7	1.9	2.7												
Sturdiness																
C3	15.5	15.2	14.4	29.0	18.5	16.9	19.8	25.0	29.0	22.7	19.4	24.0	24.5	29.0	24.2	21.8
C6	14.7	20.1	23.4	29.0	21.8	23.1	23.5	23.6	29.0	24.8	19.4	19.7	24.5	29.0	23.2	23.3
C7	12.1	15.4	19.0	29.0	18.9	15.5	13.9	24.2	29.0	20.7	21.7	23.1	24.4	29.0	24.6	21.4
C10	02.8	05.2	13.7	29.0	12.7	2.1	13.9	15.4	29.0	15.1	05.5	10.8	11.6	29.0	14.2	14.0
Mean	11.3	14.0	17.6	29.0	18.0	14.4	17.8	22.1	29.0	20.8	16.5	19.4	21.3	29.0	21.6	
Pooled mean	14.1	17.1	20.3	29.0												
Dickson quality index																
C3	0.749	0.863	0.949	0.896	0.864	0.843	0.763	0.621	0.896	0.781	0.720	0.643	0.688	0.896	0.737	0.794
C6	0.809	0.756	0.720	0.896	0.795	0.649	0.690	0.731	0.896	0.742	0.766	0.843	0.785	0.896	0.822	0.786
C7	0.874	0.731	0.661	0.896	0.790	0.571	0.687	0.648	0.896	0.746	0.608	0.641	0.670	0.896	0.704	0.747

Clones	Plant part of *E. tereticornis*															Grand mean
	Leaf					Twig					Root					
	Concentrations (%)															
	15	10	5	0	Mean	15	10	5	0	Mean	15	10	5	0	Mean	
C10	0.191	0.334	0.647	0.896	0.517	0.272	0.691	0.661	0.896	0.630	0.472	0.584	0.606	0.896	0.640	0.596
Mean	0.656	0.671	0.744	0.896	0.742	0.629	0.708	0.665	0.896	0.725	0.642	0.678	0.687	0.896	0.726	
Pooled mean	0.462	0.686	0.699	0.896												
							$LSD_{0.05}$									
	G%	VI	CD	SL	RL	SDW	RDW	TDW	R:S	STRD	DQI					
C	3.87	77.81	0.18	0.42	0.51	28.86	123.13	132.75	0.17	1.67	0.0868					
P	3.35	67.39	ns	0.36	0.44	24.99	106.63	114.97	0.15	1.44	ns					
N	3.87	77.81	0.18	0.42	0.51	28.86	123.13	132.75	0.17	1.67	0.0868					
CxP	ns	134.77	ns	ns	0.89	ns	ns	ns	0.30	ns	ns					
PxN	ns	134.77	ns	0.72	0.89	ns	ns	ns	0.30	ns	ns					
CxN	7.75	155.62	0.36	0.83	1.03	ns	246.25	265.50	0.34	3.33	0.1736					
CxPxN	ns	ns	ns	ns	1.78	ns	ns	ns	0.59	ns	ns					

crops under *E. tereticornis* clones[21].However, there is no information about the allelopathic effects of *E. tereticornis* clones on maize, and studies of allelopathic interactions in agroforestry systems are lacking. Accordingly, this study aims to address these topics. The objective of this study was to evaluate the allelopathic effects of concentrations of an aqueous extract of *E. tereticornis* clonesplant parts on *Zia mays*.

Materials and Methods

The experiment was conducted at ICAR-Central Agroforestry Research Institute (CAFRI), Jhansi, India. The experiment was conducted in the general laboratory having an average temperature range of 30-32^{0}C. The CAFRI is located at about 24^{0} 11' N latitude and 78^{0} 17' E longitudes and an elevation of 271 meters above sea level (msl). Mean annual rainfall is 960 mm with an average of 52 rainy days per year. Mean maximum temperature ranges from 47.4^{0}C (June) to 23.5^{0}C (January) and mean minimum temperature from 27.2^{0}C (June) to 4.1^{0}C (December).

Seeds of *Zea mays*(Var. Shipli) were used. The seeds were thoroughly washed with distilled water and surface sterilized with mercuric chloride for 2 minutes and rinsed four times with distilled water.

The *Eucalyptus tereticornis*clones plant parts aqueous extract were prepared as follows. Fifty, hundred and one hundred fifty grams of air-dried

E. tereticornis clones plant parts *viz.,* leaf, twig and root powder were separately soaked in one litre of distilled water for about 24 hours at room temperature. The mixtures were filtered through a double layer muslin cloth to obtain 5%, 10% and 15% concentrations of different plant parts. A complete randomised design was used for this experiment. This experiment was a laboratory bioassay. Four types of extracts from different parts of *E. tereticornis* clones were prepared. Ten seeds of maize were arranged in 9 cm diameter Petri-dishes on two layers of filter papers under normal laboratory conditions and replicated 10 times.

For laboratory bioassay, the germination percentage recorded 7th day after sowing and plumule length and radicale length were recorded after 15 day. 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 following formula[1].

Vigour index = Germination % X (Root length + Shoot length)

The dickson quality index was calculated by using following formula[3]

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

Data of germination and growth parameters were subjected to ANOVA using SYATAT statistical program. Comparison of the mean was performed using Least Significant Difference (LSD) with the control.

Result and Discussion

Effect of clones: Among the clones, maximum germination percent was recorded in C6 (53%) followed by C3 (45%), C7 (44%) and C10 (34%). Vigour index, shoot length, root length and root shoot ratio were also found in same trend. The maximum collar diameter was observed in C6 (2.4 mm) which was at par with C3 and C7 while, the minimum in C10 (1.6 mm). Similar trend was found in root dry weight and total dry weight. More shoot dry weight was found in C6 (395.9 mg/5sedlings) followed by C3 (376.7 mg/5sedlings), C7 (375.8 mg/ 5sedlings) and C10 (348.6 mg/5sedlings) which was at par with each other. Maximum sturdiness was recorded in C6 (23.3) which was at par with C3 and C7 while, the minimum in C10 (14.0). Higher dickson quality index was observed in C3 (0.794) which was at par with C6 and C7 however, lower in C10 (0.596) (Table-1).

Effect of plant parts of clones: Among the plant parts, higher germination percent was recorded in twig extract (46%) which was at par with root extract while, lower in leaf extract (40%). Vigour index, shoot length, root dry weight, root: shoot ratio and sturdiness were also recorded in the same trend. The longest root length was found in root extract (11.8 cm) while, shortest in leaf extract (8.6 cm). More shoot dry weight was recorded in root extract (393.1 mg/5 seedlings) which was at par with twig and leaf extract. The maximum total dry weight was observed in root extract (1872.5 mg/5seedlings) which was at par with twig extract while, minimum in leaf extract (1655.9 mg/5seedlings) (Table-1).

Effect of concentrations: Among the concentrations, maximum germination was recorded at Control 0% (71%) followed by 5% (40%), 10% (35%) and 15% (29%). Similar trend was recorded in most of the parameters except shoot dry weight, root dry weight, total dry weight and dickson quality index. In dickson quality index higher value was recorded at 0% (0.896) followed by 5% (0.699), 10% (0.686), which was at par with each other while, minimum at 15% (0.462) (Table-1).

Present investigation indicated that the aqueous leaf extract of *E. tereticornis* clones inhibited the germination, vigour index, shoot length, root length, total dry weight and dickson quality index of both the test crops. Differential effect of each clones and level of concentrations on inhibition was recorded. Inhibitory compounds such as volatile oils have been identified as isolated from the leaves of *Eucalyptus*[2]. Later a number of phenolics compounds *viz.,*coffecic, coumaric, ferric, gallic, gentisic, hydroxybenyoic, syringic and vanillic acids and catechol in bark, fresh leaves, root and seed leachates of *Eucalyptus* spp. were identified in the soil and leaves of *Eucalyptus*[8,14].

Here, introduced the results similar inhibitory mechanism of *Eucalyptus* spp. on test crops were already reported by many researchers [3,4,6,7,10,12,13]. *Eucalyptus tereticornis* clones inhibited the growth parameters of forage crops and subabul[17,21].

Conclusion

This preliminary study was carried out to investigate the Phyto-toxicity of *Eucalyptus tereticornis* clones on germination and growth of maize. Germination and all the growth parameters of maize was reduced significantly under 15% leaf aqueous extract. The sequence of phytoxicity of *Eucalyptus tereticornis* clones was C10>C7>C3>C6. Among the plant parts, the maximum toxicity was exhibited by leaf. Toxicity of the extract was in the order of leaves > twigs > roots and the concentration was in the order of 15% > 10% > 5% > 0%.The result advocated that maize is suitable for intercropping with C6 clone of *E. tereticornis.*

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