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Allelopathy effect of eucalyptus on seed germination and growth of calendula and marigold

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ABSTRACT

The experiment was carried out to study the allelopathy effect of Eucalyptus on seed germination and growth of calendula and marigold. The germination and growth performance were assessed through petri dish and pot culture experiment. The germination percentage was significantly reduced with increasing concentration of Eucalyptus leachates in calendula and marigold. In Petri dish study, the maximum germination percentage was recorded in control with no leachates, and there was no germination in 75% and 100% bark leachates of Eucalyptus in calendula and marigold. Furthermore, higher shoot and root length and vigour index were recorded in control and lowest was in 100% leaf leachates in marigold and calendula. From this study, it can be concluded that Eucalyptus may be responsible for inhibiting germination and growth of economically important ornamental flower crop calendula and marigold.

Keywords: Eucalyptus, Calendula, Marigold, Allelopathy, Dryland

INTRODUCTION

Agroforestry is gaining more importance rather than sole crop as they provide food, fodder and fuel wood as well as numerous social and environmental benefits to the farmers. At the same time, growing trees with crops are complex on the same piece of land at same time due to the lot of complex interactions such as competition for light, moisture, nutrients, etc. and allelopathy. These interaction among the trees and crops may either promote or inhibit the growth and development of one another (Basavaraju and Gururaj, 3; Jaenicke and Beniest, 11).

The positive or negative effects of a plant on some other plants by release of biochemical in the environment directly or indirectly is called as Allelopathy (Delabays *et al*., 5). These biochemicals produced by the plant parts are called allelochemicals and are released in process of leaching, root and bark exudation, volatilization and residue decomposition in both natural and agricultural systems. Allelochemicals released to the environment can either retard the germination and growth, inhibits the nutrient uptake or may affect the symbiotic relationship (Gholami *et al*., 9). Allelochemicals are species specific since different chemicals affect different crops.

Eucalyptus (*Eucalyptus camaldulensis*), native to Australia, is an evergreen fast growing tree and it grows up to 120-160 meters (Sani *et al*., 17). Because of its fast growth and their rising demand for paper and plywood industries it has been introduced in many countries (Cossalter and Pye-smith, 4). The leaves are commercially used in pharmaceutical and perfume industries due to its rich essential oil. Eucalyptus are grown in agriculture land along with crops due to its high productivity, fast growth and wider adaptability. And also, it fulfills the supply and demand gap of forest raw material (Malik, 12 and Gardner, 8). It has been reported by many researchers that eucalyptus tree contains phenolics, tannins and flavonoids and these chemicals inhibit the growth and germination of some plants (Babu and Kandasamy, 2). In addition to that, eucalyptus is a prolific litter producer and prone to dropping leaves and barks that leads to release of allelochemicals into the soil.

Some depressing effect was observed in calendula and marigold fields in terms of germination and growth near to the Eucalyptus tree. It may be due to some allelopathic effects which may be caused by the fallen leaves through leaf litter decomposition or bark leachates and root exudation. With this background and considering the economic importance of flower plants, the study was formulated to assess the allelopathy effect of Eucalyptus on growth and germination of two economically important ornamental plants in semiarid region of Rajasthan.

MATERIALS AND METHODS

The experiment was conducted at Central Arid Zone Research Institute (CAZRI), Regional Research

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Station, Pali-Marwar (Rajasthan) during February, 2017 Marwar. It receives 460 mm annual average rainfall. The maximum mean temperature (annual) is 42°C and minimum is 7°C. The depth of soil is shallow (30-45cm), bulk density is 1.35-1.5 Mg m^{-3}, pH is 7.7-8.4, 0.15-0.55 dSm^{-1} electrical conductivity. The experiment was conducted at lab, nursery and field conditions to study the allelopathy effect of Eucalyptus on marigold and calendula. Eucalyptus leaf, bark and root powders were mixed in 100 ml distilled water and left for about 12 hours at room temperature. The mixtures were filtered through a double layer muslin cloth and 10%, 25%, 50%, 75% and 100% concentrations were prepared for leaf, bark and root separately. Distilled water was used as control treatment.

The treatment details are TL_1- Leaf extract with 10% concentration, TL_2- Leaf extract with 25% concentration,TL_3- Leaf extract with 50% concentration,TL_4- Leaf extract with 75% concentration, TL_5- Leaf extract with 100% concentration, TB_6- Bark extract with 10% concentration, TB_7- Bark extract with 25% concentration, TB_8- Bark extract with 50% concentration, TB_9- Bark extract with 75% concentration, TB_{10}- Bark extract with 100% concentration, TR_{11}- Root extract with 10% concentration, TR_{12}- Root extract with 25% concentration, TR_{13}- Root extract with 50% concentration, TR_{14}- Root extract with 75% concentration, TR_{15}- Root extract with 100% concentration, TC_{16}- Control with Distilled water.

The seeds of marigold and calendula were washed thoroughly by distilled water. Seed outer surface was sterilized with 90% ethanol (2 minutes) followed by soaking in 5% sodium hypochlorite solution for 5 minutes, then rinsed with distilled water four times.

Completely Randomized Block Design with three replications and sixteen different treatments. In lab experiment, three types of Eucalyptus extracts (leaf, bark and root) were used with five concentrations.

Pot experiment in nursery conditions with same extracts that was used in lab experiment and at the same time. A Completely Randomized Block Design was used with three replications and sixteen treatments. Pots were filled with sand, soil and FYM in the ratio of 1:2:1 and kept in the shade net. The germination and growth parameters were recorded on 5th day after sowing and 12th day after sowing.

Growth performance of marigold and calendula plants were assessed near to eucalyptus tree in the distance of 1m, 5m and 10 m in open field condition. Three plants were uprooted and observations for growth parameters were recorded.

RESULTS AND DISCUSSION

The germination (%) was significantly reduced with increasing concentration of eucalyptus leaf, bark and root leachates in calendula and marigold (Fig. 1). In Calendula, the lowest germination percentage was observed in highest concentration (100%) of leaf and bark leachates (0.000). There was no germination in 100% leaf leachates and 100, 75, 50% bark leachates. The maximum germination percentage was recorded in control (70%). Maximum germination index and mean daily germination was observed in the corresponding controls (1.975 and 0.875 respectively) followed by 10%, 25% and 50% concentration of root leachates (Table 1). Maximum shoot length (6.7cm), root length (6.375 cm) and vigor index (915.2) was observed in control whereas minimum shoot length and root length was in 25% bark leachates (1.15cm and 1.1cm respectively) in calendula under Petri dish experiment (Table 4). Calendula seeds were highly affected by 50%, 75% and 100% aqueous solution of eucalyptus bark leachates in comparison with other leachates.

There were significant differences among germination percentage in all the aqueous solutions which is extracted from eucalyptus with all concentration in marigold (Fig. 2). Highest germination percentage was reported in control (56.66%) and lowest was registered in 75% and 100% bark leachates (0.000). The speed of germination and mean daily germination was recorded as significantly very low in leaf leachates of Eucalyptus with 50%, 75% and 100% concentrations compared to control (1.908 and 0.708 respectively) in marigold (Table 1). Higher shoot length, root length and vigor index were recorded in control while lowest was in 100% leaf leachates (1.9 cm, 2.4 cm and 43 respectively) in marigold (Table 4). Plumule and radicle is the first organ which is exposed from seeds and when it is exposed to allelochemicals, its growth will be reduced. Plumule length may reduce due to several reasons such as inhibiting cell divisions, cell elongation, decreasing hormones (acetic acids

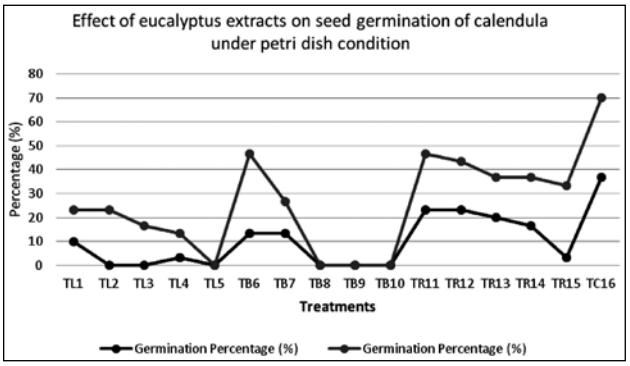

Fig. 1. Effect of eucalyptus extracts on seed germination of calendula under petri dish condition.

Table 1. Effect of eucalyptus leachates on seed germination and growth of calendula and marigold in petri dish.

Treatments	Germination Percentage (%)		Speed of Germination/ Germination Index		Mean Daily Germination	
	Calendula	*Marigold*	*Calendula*	*Marigold*	*Calendula*	*Marigold*
TL_1	23.33	36.66	0.591	1.058	0.291	0.458
TL_2	23.33	23.33	0.291	0.291	0.291	0.291
TL_3	16.66	16.66	0.208	0.208	0.208	0.208
TL_4	13.33	10.00	0.266	0.125	0.166	0.125
TL_5	0.000	10.00	0.000	0.125	0.000	0.125
TB_6	46.66	43.33	0.983	1.441	0.583	0.541
TB_7	26.66	23.33	0.733	0.991	0.333	0.291
TB_8	0.000	23.33	0.000	0.791	0.000	0.291
TB_9	0.000	0.000	0.000	0.000	0.000	0.000
TB_{10}	0.000	0.000	0.000	0.000	0.000	0.000
TR_{11}	46.66	36.66	1.283	1.158	0.583	0.458
TR_{12}	43.33	26.66	1.241	1.033	0.541	0.333
TR_{13}	36.66	23.33	1.058	0.891	0.458	0.291
TR_{14}	36.66	13.33	0.958	0.666	0.458	0.166
TR_{15}	33.33	26.66	0.516	0.333	0.416	0.333
TC_{16}	70.00	56.66	1.975	1.908	0.875	0.708
Mean	26.04	23.12	0.631	0.689	0.325	0.289
SD	20.55	15.22	0.580	0.564	0.256	0.190
CD (5%)	6.612	9.674	0.218	0.304	0.086	0.129

SD- Standard deviation, CD- Critical difference

and gibberellins) which may be caused by release of allelochemicals to the plants (Saberi *et al*., 15). The marigold and calendula seeds were less affected by root leachates of eucalyptus compared to other two leachates in Petri dish study. Sale (16) reported that presence of phytotoxic substances of eucalyptus bark and leaf reduces the germination and growth of *Phaseolus vulgaris* due to allelopathic effect.

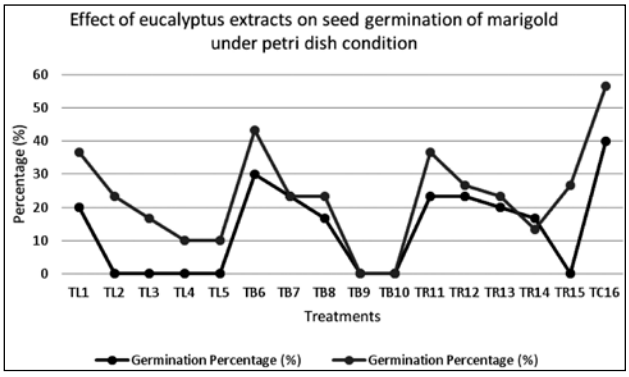

Fig. 2. Effect of eucalyptus extracts on seed germination of marigold under petri dish condition.

The results indicated that presence of some allelochemicals from leaf and bark such as phenolics, terpenoids, organic acids, etc., may be responsible for inhibiting germination and growth of ornamental plants. Similar findings were reported by Ashrafi *et al*., (1); Ziaebrahimi *et al*., (18) and Gurmu (10) in some agricultural crops due to allelopathy effect of eucalyptus.

A significant difference was observed on germination percentage among the different eucalyptus extracts concentration, so that germination of calendula and marigold decreased by increasing concentration (Fig.3). Highest germination percentage was recorded in control (70.00%). There was no germination in 100% leaf leachates and lowest germination percentage was observed in 75% leaf leachates (10.00%). Maximum value was observed in 75% root leachates (2.550) under speed of germination followed by other concentration of root leachates in calendula (Table 2). The seeds of calendula were affected more due to the allelopathy effect of eucalyptus leaf leachates followed by bark leachates during the pot experiment. Due to inhibitive effect of allelochemical compounds, hormones (gibberins) may decrease

the germination of crops. (El-Khatib *et al*. 7). In pot experiment, maximum growth was observed in control while minimum was in different concentration of leaf leachates in calendula (Table 5).

There was no germination in 100% leaf leachates and 100% bark leachates in marigold seeds but higher germination was observed in control (46.66%) (Fig.4). Speed of germination was more in control (1.783) and less in 100% leaf and bark leachates (0.000) (Table 2). Minimum shoot length was registered in 75% leaf leachates (1.25cm) and root length was in 75% bark leachates (1.3cm) in marigold under pot experiment (Table 5). The calendula and marigold seeds were highly affected by leaf and bark leachates of Eucalyptus under pot experiment with increasing concentration. Similar finding was observed by Gurmu (10) on haricot bean and maize. He also observed that the increased powder of eucalyptus leaves leads to reduction in seedling germination and growth. Muhammed *et al*., (13) reported that inhibitory effect was increased as the concentration of extract increased. They also observed that wheat sown in fields was adversely affected in terms of germination, growth and ultimately yield due to leaf litter of eucalyptus.

The survival and growth performance of calendula and marigold plants under the canopy of eucalyptus was studied. Some reduced growth of plants was observed that was planted near to eucalyptus tree. Plant growth parameters were recorded and it was registered lower in 1m distance and higher in 10m distance from Eucalyptus tree which indicated that some negative allelopathy effect of Eucalyptus on

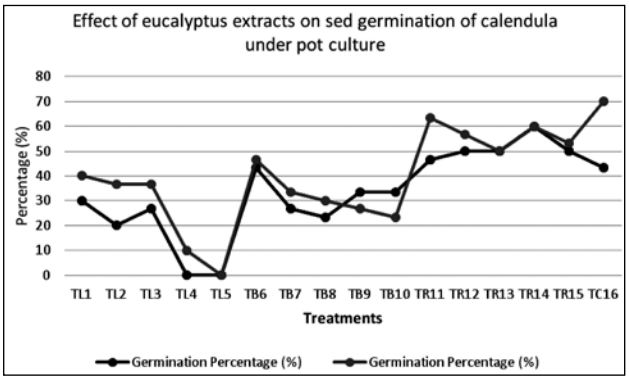

Fig. 3. Effect of eucalyptus extracts on seed germination of calendula under pot culture.

Table 2. Effect of eucalyptus leachates on seed germination and growth of calendula and marigold in pot culture.

Treatments	Germination Percentage (%)		Speed of Germination/ Germination Index		Mean Daily Germination	
	Calendula	Marigold	Calendula	Marigold	*Calendula*	*Marigold*
TL_1	40.00	23.33	1.400	1.091	0.500	0.291
TL_2	36.66	20.00	1.058	0.950	0.458	0.250
TL_3	36.66	10.00	1.258	0.325	0.458	0.125
TL_4	10.00	6.666	0.125	0.283	0.125	0.083
TL_5	0.000	0.000	0.000	0.000	0.000	0.000
TB_6	46.66	30.00	1.883	1.075	0.583	0.375
TB_7	33.33	20.00	1.216	0.650	0.416	0.250
TB_8	30.00	16.66	1.075	0.708	0.375	0.208
TB_9	26.66	13.33	1.333	0.666	0.333	0.166
TB_{10}	23.33	0.000	1.291	0.000	0.291	0.000
TR_{11}	63.33	23.33	2.191	0.691	0.791	0.291
TR_{12}	56.66	23.33	2.208	0.891	0.708	0.291
TR_{13}	50.00	13.33	2.125	0.666	0.625	0.166
TR_{14}	60.00	10.00	2.550	0.425	0.750	0.125
TR_{15}	53.33	6.666	2.166	0.283	0.666	0.083
TC_{16}	70.00	46.66	2.175	1.783	0.875	0.583
Mean	39.79	16.45	1.503	0.655	0.497	0.205
SD	19.26	11.83	0.741	0.453	0.240	0.147
CD (5%)	10.303	8.284	0.292	0.440	0.127	0.105

SD- Standard deviation, CD- Critical difference

calendula and marigold plants (Table 3). The presence of deep leaf litter and the leaves of tree produced the inhibitive chemicals might be the reason of this problem. El-Khawas and Shehata (6) also found that there no or limited vegetation only occurs under the canopy of eucalyptus in larger area. It shows that the phenolic compounds may be having deleterious effect on crops due to their interference with growth and process of phytohormones and enzymes. Similar trends were observed by Rafiqul *et al*. (14).

The concentrations of Eucalyptus extracts created the direct negative effect on the ornamental flower crops calendula and marigold. Increased concentration of bark and leaf extracts significantly reduced the growth and germination of calendula and marigold. The good rate of germination and growth was observed in calendula and marigold plants with increased distance from Eucalyptus tree. From this study, it can be concluded that the economically important flower crops may be planted with increased distance from Eucalyptus for obtaining better growth and yield of flowers due to its less negative effects. And also, further study may conduct for isolation and identification of

Table 3. Effect of eucalyptus on seed germination and growth of calendula and marigold in field condition.

Characteristics/ Distance (m)	Calendula			Marigold		
	1m	5m	10m	1m	5m	10m
Plant Height (cm)	13.10	22.40	57.40	25.40	52.40	86.30
Collar Diameter (mm)	6.550	8.810	15.24	5.390	10.20	14.56
Number of Branches	6.000	7.000	9.000	0.000	2.000	3.000
Root length (cm)	5.400	11.80	15.70	8.200	13.60	16.80
Fresh Shoot weight (g)	20.11	42.72	112.7	11.60	45.50	108.5
Fresh Root weight (g)	1.790	3.420	5.750	0.920	2.530	6.210

Table 4. Growth parameters of calendula and marigold in petri dish.

Treatments	Calendula			Marigold		
	Shoot length	Root Length	Vigour Index	Shoot length	Root Length	Vigour Index
TL_1	5.150	5.700	253.1	4.650	4.500	335.5
TL_2	4.600	2.900	175.0	4.350	3.850	191.3
TL_3	2.250	1.900	69.16	4.350	3.900	137.5
TL_4	1.350	1.300	35.33	3.900	3.150	70.50
TL_5	0.000	0.000	0.000	1.900	2.400	43.00
TB_6	3.600	4.500	378.0	4.450	5.250	420.3
TB_7	1.150	1.100	60.00	4.100	3.500	177.3
TB_8	0.000	0.000	0.000	3.200	3.550	157.5
TB_9	0.000	0.000	0.000	0.000	0.000	0.000
TB_{10}	0.000	0.000	0.000	0.000	0.000	0.000
TR_{11}	4.425	3.900	388.5	4.400	4.650	331.8
TR_{12}	5.000	5.950	474.5	3.950	4.350	221.3
TR_{13}	4.450	4.900	342.8	3.500	4.000	175.0
TR_{14}	4.800	4.610	345.0	3.350	2.900	83.33
TR_{15}	3.850	3.650	250.0	4.450	3.400	209.3
TC_{16}	6.700	6.375	915.2	5.415	4.100	539.1
Mean	2.957	2.924	230.4	3.497	3.343	193.3
SD	2.251	2.319	246.3	1.569	1.479	150.8
CD (5%)	0.473	0.365	75.858	0.478	0.442	83.753

SD- Standard deviation, CD- Critical difference

Table 5. Growth parameters of calendula and marigold in pot culture.

Treatments	Calendula			Marigold		
	Shoot length	Root Length	Vigour Index	Shoot length	Root Length	Vigour Index
TL_1	6.100	2.280	335.2	2.750	1.900	108.5
TL_2	5.180	1.830	257.0	2.450	1.800	85.00
TL_3	3.435	1.730	189.3	1.900	1.400	33.00
TL_4	2.300	1.250	35.50	1.250	1.500	18.33
TL_5	0.000	0.000	0.000	0.000	0.000	0.000
TB_6	5.150	2.575	360.5	3.800	2.075	176.2
TB_7	4.850	2.050	230.0	2.100	1.700	76.00
TB_8	4.350	1.830	185.4	3.500	1.550	84.16
TB_9	4.300	1.565	156.4	1.400	1.300	36.00
TB_{10}	2.425	1.900	100.9	0.000	0.000	0.000
TR_{11}	6.350	2.390	553.5	3.800	2.300	142.3
TR_{12}	5.580	2.065	433.2	3.250	2.100	124.8
TR_{13}	5.250	2.200	372.5	2.405	1.900	57.40
TR_{14}	4.280	1.715	359.7	2.800	1.650	44.50
TR_{15}	4.065	2.345	341.8	2.050	1.900	26.33
TC_{16}	7.250	6.900	990.5	5.300	6.150	534.3
Mean	4.429	2.164	306.3	2.422	1.826	96.68
SD	1.770	1.397	234.6	1.386	1.327	127.3
CD (5%)	0.435	0.408	92.135	0.551	0.371	80.217

SD- Standard deviation, CD- Critical difference

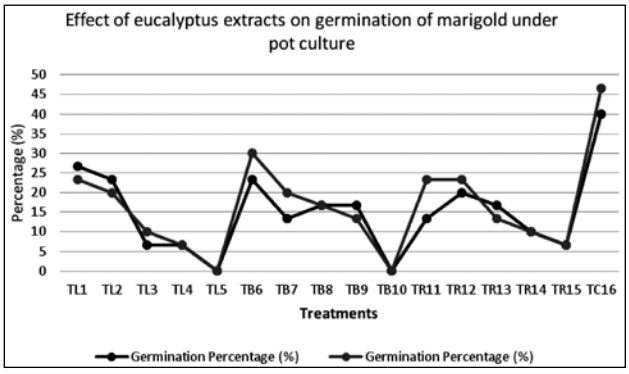

Fig. 4. Effect of eucalyptus extracts on seed germination of marigold under pot culture

allelochemicals from leaf, bark and root to formulate bio herbicides to reduce the negative effects of Eucalyptus leachates in future.

AUTHORS' CONTRIBUTION

Conceptualization of research (MBN, AKS, BLJ), Designing of the experiments (MBN), Contribution of experimental materials (MBN, AKS, BLJ), Execution of field/lab experiments and data collection (MBN, VK), Analysis of data and interpretation (MBN, VK), Preparation of the manuscript (MBN).

DECLARATION

The authors are declare no conflict of interest.

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