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ALLELOPATHIC EFFECTS OF EUCALYPTUS (*Eucalyptus camaldulensis* L.) ON GERMINATION AND SEEDLING GROWTH OF WHEAT (*Triticum aestivum* L.)

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ABSTRACT

The allelopathic influence of aqueous extracts of Eucalyptus camaldulensis L. on germination (%) and seedling growth (fresh and dry weight) of wheat have been determined. It was noted that aqueous extracts at a concentration of 10, 15 and 20% had inhibitory effect on wheat seed germination and effect was found significantly higher than untreated control treatment. Fresh and dry weight of seedling was also reduced significantly over control. The inhibitory effects were increased as the extract concentration increased. These findings indicate that wheat sown in fields which had leaf litter of Eucalyptus camaldulensis L. will be adversely affected regarding germination, growth and ultimately yield of wheat.

Key words: *Eucalyptus camaldulensis* L., extract concentration, wheat, allelopathic effects.

INTRODUCTION

Plants live in association in groups depending upon their ecological requirements; they have generally the same structural and morphological adaptations. Whenever two or more plants occupy the same niche in nature, they compete with each other for various life support requirements (Caton *et al.,* 1999). Residues, exudates and leachates of many plants have been reported to effect the germination growth and/or development of the other plants, a wide range of injurious effects on crop growth has been reported as being due to phytotoxic decomposing products, released from leaves, stem, roots, fruit and seeds. Alam and Islam (2002) reported that plants produce chemicals, which interfere with other plants and affect seed germination and seedling growth.

Generally allelochemcials have open chain molecular structures. The role of secondary metabolites in plant-plant, plant-

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soil, plant disease, plant-insect and plant predator interactions that may be beneficial or detrimental to plant (Tang *et al*. 1989, Yaduraju and Ahuja, 1996). These chemicals have harmful effects on crops in the eco-system resulting in the reduction and delayed germination, seedling mortality and reduction in growth and yield (McWhorter, 1984; Herro and Callaway, 2003). Allelochemicals have shown far-reaching effects on the growth and development of plants even at low concentration (Arshad and Frankenberger, 1998).

Eucalyptus belongs to the family Myrtaceae, mostly found in tropical region and is a native to Australia. *Eucalyptus* species grow under a wide range of climatic and edaphic conditions in their natural habitats (Dawar *et al.,* 2007). In Pakistan, the Forest Department of Punjab in 1903 raised a small nursery of *Eucalyptus globulus* (Siddiqui and Hussain, 1980) but during the last two decades a lot of efforts towards its propagation have been made. This species has a high potential of allelochemicals and also essential oils. Iqbal *et al*. (2003) found 16 components in essential oil of *E. camaldulensis* L., out of which five compounds (α-pinene, $^{3}\Delta$-carene, β-phellandrene, 1-8 cineole and p-cymene) were identified. The research carried out in India and Pakistan evidently pointed out about the inhibitory or stimulatory effects of this species on the germination and seedling growth of some crops. Singh *et al*. (1992) reported that aqueous extracts of air dried leaf litter of *E. citirodora* had inhibitory effect on the seed germination, in wheat, mustard and gram. Agro-forestry having *Eucalyptus* trees could be harmful to crops as Nandal (1999) reported that the *Eucalyptus* tree belt had more adverse effect on wheat than did the Poplar tree belt. While Nandal *et al.* (2005) reported the aqueous extracts of poplar leaves adversely affected the germination and seedling growth of some wheat varieties at high extract concentration. However, variable performance of wheat varieties in association with various tree species has been reported by many workers (Nandal *et al.*, 1999; Gill, 1994; Singh, *et al.* 1993). Similar effects have been reported by Huang *et al*. (1997) who studied the effects of leaf extracts of Eucalyptus and other species on wheat and mungbean. He reported that the extract inhibited the rooting rate of wheat cuttings by 100%. Harmful effects of Eucalyptus did not degrade under field conditions (Patel *et al*., 2002). To keep in view the effects of *Eucalyptus* on wheat crop in the light of literature review, the present studies were carried out to determine its harmful or stimulatory effects on 12 wheat varieties

under the ecological conditions of Dera Ismail Khan, NWFP, Pakistan.

MATERIALS AND METHODS

The leaves were collected from the *E. camaldulensis* L. trees growing alongside the road in the Faculty of Agriculture, Gomal University Dera Ismail Khan. These leaves were washed and then sun-dried for two weeks, ground and stored at room temperature. Good quality seeds of 12 wheat varieties were obtained from the Agricultural Research Institute, Ratta Kulachi, Dera Ismail Khan. Twenty-five seeds of each variety were sown on 25th October, 2005 in steel trays. These trays were filled with washed sand as a growth medium. The experiment was laid out in RCB design with factorial arrangements, and replicated four times. The ground/powdered leaves material was soaked in distilled water in the ratio of 1:20 and kept for 24 hours. The filtrate was designated as stock solution of 100% concentration. From this stock solution, other concentrations viz., 10, 15 and 20% were prepared by diluting it with distilled water and the control contained only distilled water (Hussain and Gadoon, 1981). The data were recorded on germination count, germination (%), fresh and dry weight (g) of wheat seedlings. The data recorded were statistically analyzed and significant means were separated by using Least Significant Difference Test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Germination Counts (%): All 12 varieties responded to the applied aqueous extract application (Table-1). The varieties Daman 98, Dera 98, Punjab 96, Inqilab 91, Soghat, Fakher-e-sarhad, MH-97 and Tatara had lower counts and remained at par statistically among themselves. These varieties did not differ significantly from Bakhtawar 92, Suleman 98, and Pirsabak 91. The variety Raj 99, Bakhtawar 92, Suleman 98 and Pirsabak 91 showed tolerance to the allelopathic effect (Table-1). The interaction clearly indicated that Raj 99 produced the maximum while Suleman 98 and Tatara resulted in the lowest number of normal seedlings as compared to the control/untreated treatments over water applied seedlings. Interactions also show that reduction in germination counts became more pronounced with increasing levels of Eucalyptus aqueous extract concentration. At 20% concentration all wheat varieties had a significant reduction in germination counts as compared to the control. MH-97, Inqilab-91 and Soghat were worst affected at the highest concentration (20%) of Eucalyptus extract. Evidently all

wheat varieties were adversely affected by extract application regarding the number of normal seedling over control. There was direct relationship between number of normal seedlings and extract concentration. These results could lead to the thought that *E. camaldulensis* L. leaf aqueous extract could reduce normal seedlings even in low concentration. These results are in conformity with those reported by McWhorter (1984) and Nanadl *et al.* 1999a; 1999b*).*

Table-1. Allelopathetic effects of Eucalyptus on germination counts of wheat varieties.

Varieties	0% (Control)	Concentration of Eucalyptus extract			Varietal Means
		10%	15%	20%	
Daman 98	21.0 ab	16.0 d-g	11.2 j-n	8.0 m-r	14.0 b
Dera 98	22.2 a	16.2 d-f	9.7 l-o	7.2 o-r	13.8 b
Punjab 96	20.0 a-c	15.0 d-h	12.0 h-l	5.7 p-r	13.1 b
Inqilab 91	22.5 a	14.5 e-i	12.2 g-l	4.7 r	13.5 b
Soghat	23.0 a	15.7 d-g	12.7 g-l	4.7 r	14.0 b
Fakhar-e-Sarhad	22.5 a	16.0 d-g	10.0 k-o	5.5 qr	13.5 b
Bakhtawar 92	23.5 a	16.7 c-e	11.2 j-n	8.0 m-r	14.8 ab
Raj 99	23.0 a	18.5 b-d	15.5 d-h	9.0 l-q	16.5 a
Suleman 98	21.7 ab	12.5 g-l	13.7 e-j	11.0 j-o	14.7 ab
MH- 97	23.0 a	15.2 d-h	9.2 l-q	4.5 r	13.0 b
Pirsabak 91	22.5 a	15.2 d-h	11.7 i-m	9.0 l-q	14.6 ab
Tatara	23.5 a	12.5 g-l	9.5 l-p	7.5 n-r	13.2 b
Conc. Means	**22.38 a**	**15.35 b**	**11.58 c**	**7.08 d**	**-**

CV. = 16.73%
$LSD_{0.05}$for varieties = 2.073
$LSD_{0.05}$ for Concentrations = 0.954
$LSD_{0.05}$ for Interaction = 3.306
Means sharing a letter in common in the respective category do not differ significantly by the LSD test at 1% probability level.

Germination (%)

Seed germination is considered to be the most critical stage especially under stress conditions. During germination, biochemical

changes take place, which provides the basic framework for subsequent growth and development. The initial metabolic changes that occur immediately after the imbibitions of water are the increase in the hydrolytic enzymes such as alpha-amylase and protease. Alpha-amylase is an important starch degrading enzyme in the endosperm of cereal grains. The reaction products provide substrate and an energy source for the embryo during germination. Inhibition of seed germination of crop plants is also due to disturbance in the activities of peroxidase, alpha-amylase and acid phosphates (Alam and Islam, 2002). The results presented in Table-2 show that wheat varieties have been influenced by different aqueous extracts of *E. camaldulansis* L. treatments. All the concentrations had inhibitory effect on the germination of all varieties as compared to the control treatment. It can be seen from the data in Table-2 that only wheat variety Raj 99 produced maximum number of seedlings (66%) over all other varieties which was non-significantly different from Bakhtawar 92, Suleman 98 and Pisabak 91. This indicates that these varieties had some tplerance to the adverse influence of allelochemicals contained in the extract. Punjab 96 and MH-97 were found most sensitive towards extract application. It is very clear from these results that wheat crop sown near or under the Eucalyptus trees will be adversely affected and its germination (%) will be reduced upto about 50%. The interaction also showed that each concentration of extract had injurious effect on all wheat varieties than control treatment. The interaction among various concentration of Eucalyptus extract and wheat varieties depicted that Eucalyptus water extract at lower level (10%) has lower inhibitory effect as compared to higher concentration (20%) in all wheat varieties. MH-97, inqilab-91 and soghat were more adversely affected at all levels of concentration. This gradual decrease in germination (%) was due to allelopathic effects of Eucalyptus extracts from lower concentration (10%) to higher concentration (20%) as compared to control. Tongma *et al.* (1998) also reported that germination (%) of tested plant species decreased when grown with sunflower. It can be summarized from the results that extract having any concentration of allelochemcial will reduce the wheat germination and ultimately reduction in yield. The variation in germination of different varieties might be due to the variation of genetics of these twelve varieties. These results are in agreement with those of Singh *et al*. (1992), Nandal (1999) and Patel *et al*. (2002) who all observed reduction in germination percentagewithEucalyptusextract/leachates application to wheat seed.

Table-2. Allelopathetic effects of Eucalyptus on germination (%) of wheat varieties.

Varieties	Control	Concentration of Eucalyptus extract			Mean
		10%	15%	20%	
Daman 98	84.0 ab	64.0 d-g	45.0 i-m	32.0 m-r	**56.2 b**
Dera 98	89.0 a	65.0 d-f	39.0 l-o	29.0 o-r	**55.5 b**
Punjab 96	80.0 a-c	60.0 d-i	48.0 g-l	23.0 p-r	**52.7 b**
Inqilab 91	90.0 a	58.0 e-j	49.0 f-l	19.0 r	**54.0 b**
Soghat	92.0 a	63.0 d-g	51.0 f-l	19.0 r	**56.2 b**
Fakhar-e-Sarhad	90.0 a	64.0 d-g	40.0 k-o	22.0 qr	**54.0 b**
Bakhtawar 92	94.0 a	67.0 c-e	45.0 i-n	32.0 m-r	**59.5 ab**
Raj 99	92.0 a	74.0 b-d	62.0 d-h	36.0 l-q	**66.0 a**
Suleman 98	87.0 ab	50.0 f-l	55.0 e-k	44.0 j-o	**59.0 ab**
MH- 97	92.0 a	61.0 d-h	37.0 l-q	18.0 r	**52.0 b**
Pirsabak 91	90.0 a	61.0 d-h	47.0 h-m	36.0 l-q	**58.5 ab**
Tatara	94.0 a	50.0 f-l	38.0 l-p	30.0 n-r	**53.0 b**
Mean	**89.5 a**	**61.4 b**	**46.3 c**	**28.3 d**	**-**

CV. = 16.73%
$LSD_{0.05}$ = 1.476 (Varieties)
$LSD_{0.05}$ = 3.818 (Concentration levels)
$LSD_{0.05}$ = 13.22 (Interaction)
Means followed by the same letters in the respective category are not significantly different from each other at 1% of probability by DMRT.

Fresh weight (g plant^{-1})

Two weeks old seedlings were uprooted and data were recorded, analyzed according to the RCBD. The results are presented in Table-3 show that Eucalyptus extract had decreased the fresh weight. The wheat variety Bakhtawar 92 was more adversely affected than all other varieties. The extract concentration of 10, 15 and 20% decreased the fresh weight of all varieties. Significant effect was noted among wheat varieties and Eucalyptus extract at different concentration levels. The interaction showed direct relationship between concentration and decrease in fresh weight. Raj 99 proved to be the more fresh weight producing variety as compared to other varieties at 20% concentrated extract. At lower level (10%) concentration, comparatively less reduction in their fresh weights was observed. This has indicated that wheat seedlings affected by Eucalyptus extract can tolerate stress up to some extents, but as concentration increases, significant reduction in fresh weight and growth of seedling occurs in twelve wheat varieties. Aqueous Eucalyptus extract of various concentrations inhibited the germination of twelve wheat varieties and also negatively affected their fresh weights. Similar results were obtained by Yang *et al.* (2002) after treatment of rice plant with three allelopathic phenolics.

Dry weight (g plant^{-1})

The data in Table-4 revealed that aqueous extracts of different concentration significantly reduced the dry weight of wheat seedlings over control. The interaction among wheat varieties and concentration was also found to be significant and significant reduction in dry weight of twelve wheat varieties from control to higher concentration. The adverse effect gradually increased which resulted decreased in the dry weight of seedlings. The reason could be the decrease in fresh weight of seedling. Another probable reason could be the inhibitory effect of allelochemicals in uptake of water by seedling and reduction in other physiological processes of wheat varieties. Similar findings have been reported by Patel *et al*. (2002) who reported that Eucalyptus trees reduced germination, growth and yield of wheat crop. This harmful effect of different aqueous extract pointed out that allelochemicals in any concentration present in soil could decrease the dry weight and yield of any wheat genotype. Several studies have reported that many secondary metabolites are released into the environment, either as exudation from living plant tissues or by decomposition of plant material under certain conditions (Einhelling, 1995).

Table-3. Allelopathetic effects of Eucalyptus on fresh weight (g plant^{-1}) of wheat varieties.

Varieties	Control	Concentration of Eucalyptus extract			Mean
		10%	15%	20%	
Daman 98	7.45 a	4.18 f-l	2.98 l-p	1.47 pq	**4.02 b-d**
Dera 98	6.96 ab	6.37 a-d	3.41 i-n	1.79 o-q	**4.63 ab**
Punjab 96	6.63 a-c	5.02 d-h	3.44 h-n	1.82 o-q	**4.23 a-c**
Inqilab 91	5.48 b-f	4.78 d-k	2.52 m-q	1.93 n-q	**3.67 b-d**
Soghat	6.05 a-e	5.44 b-f	2.88 l-p	1.22 q	**3.90 b-d**
Fakhar-e-Sarhad	6.08 a-e	5.66 b-f	4.81 d-j	1.59 pq	**4.53 ab**
Bakhtawar 92	5.16 c-g	3.52 h-n	2.35 m-q	1.16 q	**3.04 d**
Raj 99	7.58 a	6.31 a-e	4.17 f-l	2.44 m-q	**5.12 a**
Suleman 98	4.80 d-k	4.32 f-l	3.65 g-m	1.26 q	**3.50 cd**
MH- 97	5.40 b-f	3.21 k-o	3.26 j-o	1.16 q	**3.26 cd**
Pirsabak 91	5.39 b-f	4.83 d-j	4.70 e-k	1.47 pq	**4.00 bc**
Tatara	4.93 d-i	4.25 f-l	2.99 l-p	1.20 q	**3.34 cd**
Mean	**5.99 a**	**4.82 b**	**3.43 c**	**1.54 d**	-

CV. = 23.80%
$LSD_{0.05}$ = 0.8739 (Varieties)
$LSD_{0.05}$ = 0.3800 (Concentration levels)
$LSD_{0.05}$ = 1.2400 (Interaction)
Means followed by the same letters are not significantly different from each other at 1% of probability by DMRT.

Table-4. Allelopathetic effects of Eucalyptus on dry weight (g plant^{-1}) of wheat varieties.

Varieties	Control	Concentration of Eucalyptus extract			Mean
		10%	15%	20%	
Daman 98	1.42 a-c	0.90 e-l	0.66 j-n	0.23 p-s	**0.80 ab**
Dera 98	1.25 a-e	1.08 b-g	0.58 k-q	0.23 p-s	**0.78 ab**
Punjab 96	1.27 a-e	0.78 f-m	0.60 k-p	0.22 p-s	**0.72 bc**
Inqilab 91	1.33 a-d	0.94 e-k	0.61 k-o	0.29 n-s	**0.79 ab**
Soghat	1.15 b-f	1.03 d-j	0.69 h-m	0.16 s	**0.76 a-c**
Fakhar-e-Sarhad	1.28 a-e	1.05 c-i	1.06 c-h	0.21 q-s	**0.90 a**
Bakhtawar 92	1.44 ab	0.60 k-p	0.58 k-q	0.19 rs	**0.70 bc**
Raj 99	1.53 a	0.91 e-l	1.01 d-j	0.26 p-s	**0.93 a**
Suleman 98	1.19 a-e	0.80 e-m	0.61 i-n	0.18 rs	**0.71 bc**
MH- 97	1.24 a-e	0.55 l-r	0.50 l-s	0.13 s	**0.60 c**
Pirsabak 91	1.22 a-e	0.59 k-p	0.69 h-m	0.21 q-s	**0.68 bc**
Tatara	1.25 a-e	0.77 g-m	0.60 k-p	0.15 s	**0.69 bc**
Mean	**1.30 a**	**0.83 b**	**0.69 c**	**0.20 d**	**-**

CV. = 29.86%
$LSD_{0.05}$ = 0.1543 (Varieties)
$LSD_{0.05}$ = 0.09137 (Concentration levels)
$LSD_{0.05}$ = 0.3165 (Interaction)
Means followed by the same letters are not significantly different from each other at 1% of probability by DMRT.

These chemicals like phenolics, terpenoids and alkaloids and their derivatives are potential inhibitors of germination, seedling growth, fresh weights and dry weights (Herro and Callaway, 2003; Siddiqui and Zaman, 2004; Siddiqui and Zaman, 2005). Dawar *et al.* (2007) observed that aqueous Eucalyptus extract was effective in general to cause growth inhibition. But all plants of same species were not equally susceptible to aqueous extracts of Eucalyptus.

CONCLUSIONS

The present investigation revealed that aqueous extract of *Eucalyptus camaldulensis* at various concentration levels inhibited the germination, reduced fresh weights and dry weights of wheat seedlings. Its effectiveness on germination and growth suggests that leaves of *Eucalyptus camaldulensis* may act as an allelochemicals after being released into soil or after decomposition. The presence of this material goes on negatively affecting the neighboring or successional plants.There is a need to provide information's to farmers about plantation of Eucalyptus sp. and their allelopathic effects. Further studies are needed to investigate the possible physiological mechanism related to allelopathic effect on plants.

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