The Pharma Innovation Journal 2022; 11(12): 4962-4969

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(12): 4962-4969

www.thepharmajournal.com
Received: 24-09-2022
Accepted: 31-10-2022

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Allelopathic potentiality of eucalyptus tree parts on germination and seedlings growth of finger millet (*Eleusine coracana*) and tomato (*Solanum lycopersicum* L.)

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Abstract
The finger millet and tomato are the major crops in Kolar district of Karnataka, India and are being grown on eucalyptus removed lands with poor germination, growth and yield problems. Certain plant secondary metabolites (Allelochemicals) discharged to the soil interfere with the germination, growth or development of other plant species. This study was intended to observe the allelopathic potentiality of eucalyptus tree parts aqueous extracts *viz.*, fresh leaves, juvenile stem bark, roots and their consortium at 0, 5, 10, 15, 25 and 50 percent concentrations on percent seed germination and seedling growth of finger millet and tomato. For this, two separate experiments were conducted under laboratory conditions at College of Horticulture, Kolar, Karnataka, India during the year 2020. The results revealed that the aqueous extracts of eucalyptus tree parts had considerable inhibitory effects on germination and growth of seedlings of both tested crops. Fresh leaves aqueous extract had more effect on germination, finger millet seeds showed zero percent germination even at 15 percent concentration and no germination was observed in tomato seeds at all concentrations tested. The seedling height, root length and dry weight varied from 3.92 to 15.40 cm, 6.33 to 16.00 cm and 0.13 to 0.77 g, respectively for finger millet and 7.76 to 17.86 cm, 7.26 to 11.06 cm and 0.22 to 1.68 g, respectively for tomato due to eucalyptus tree parts aqueous extracts. The phytotoxicity of eucalyptus fresh leaves aqueous extract showed the highest impact affecting seed germination and seedling growth of finger millet and tomato followed by consortium and juvenile stem bark aqueous extract while, roots aqueous extract showed least impact. Among two crops tested, tomato crop was more affected than finger millet.

Keywords: Allelopathy, eucalyptus, aqueous extracts, finger millet, tomato, germination

Introduction

Eucalyptus is a large genus consisting of more than 660 species that include shrubs and tall trees of the myrtle family (Myrtaceae). The genus is native to Australia, Tasmania, and nearby islands (Boland *et al*., 2006) [1]. In India, regular planting of *Eucalyptus* spp. was started in the year 1856 to meet the demands of firewood. In the late 1960s and early 1970s, State Forest Departments gradually increased the planting of eucalyptus in all parts of India (Krishnamurthy, 1996) [11], including Karnataka state. Eucalyptus has become a main plantation timber crop in rain-fed draught-prone areas of Southern Karnataka and the area under cultivation by 2009 was 2.1 lakh hectares in Karnataka (Karajagi *et al*., 2009) [7]. Later, Government of Karnataka has brought resolution to check further spread of eucalyptus plantation in Karnataka because of its allelopathic effects on other crops and depletion in underground water table (Karajagi *et al*., 2009) [7]. There is a report on eucalyptus affecting the germination and growth of other crops when grown in association as mixed crop or adjacent crop due to its allelopathic effect (Khan *et al*., 2008) [9].

Allelopathy is a biological phenomenon by which the organisms produce phytochemicals that control germination, growth, reproduction and existence of other organisms (Einhellig, 1995) [3]. Allelopathy is a Greek word, 'allelo' means 'mutually' and 'pathy' means 'harm'. Allelochemicals are type of phytochemicals belonging to plant secondary metabolites, normally released into the environment through volatilization, leaching, root exudation and decomposition of plant residues in the soil (Kohli, 1990) [10]. The allelochemicals are known to impair respiration, photosynthesis, enzymes activities, stomatal opening, hormone levels, cell division, cell elongation, cell wall permeability, *etc*. (Morsi and Abdelmigid, 2016) [13].

Allelochemicals may be present in leaves, barks, roots, flowers and fruits. A large number of phenolic compounds for instance caffeic, coumaric, gallic, gentisic, hydroxybenzoic, syringic, ferulic and vanillic acids could be found and identified in the leaves and understory soil of eucalyptus plantations (Kohli, 1990) [10].

Finger millet and tomato are grown under rainfed as well as irrigated conditions in Southern Karnataka. These crops are often grown adjacent to eucalyptus plantations. The allelopathic effect of aqueous extracts of *Eucalyptus camaldulensis* on percent germination and growth of wheat seedlings has been documented by Khan *et al*. (2008) [9]. Ziaebrahimi *et al*. (2007) [18] also noticed the similar results. The study of interaction effect of these crops is important with respect to ecology and distribution of the eucalyptus. Therefore, aqueous extracts of *Eucalyptus* spp. tree parts *viz.*, fresh leaves, juvenile stem bark, root and their mixture were evaluated at different concentrations for their allelopathic effect on seed germination and seedling growth of finger millet and tomato.

Material and Methods

Two separate experiments were undertaken to investigate the allelopathic effects of aqueous extracts of eucalyptus tree parts on germination of seeds and seedling growth of finger millet (var. GPU-28) and tomato (Arka Samrat F_1 hybrid) under laboratory conditions. The fresh leaves and juvenile stem barks were collected by cutting and roots by digging from a 10 years old eucalyptus trees. They were separately dried, powdered and mixed in distilled water to get 5, 10, 15, 25 and 50 percent (w/v) and extracted by following the procedure as described by Nega and Gudeta (2019) [14]. For the preparation of consortium, aqueous extracts of all the three tree parts were mixed in equal proportion to get 5, 10, 15, 25 and 50 percent concentrations. The experiments were laid out in Two Factorial Complete Randomized Design with three replications. The sources of extract *viz.*, fresh leaves, juvenile stem bark, roots and consortium of fresh leaves, juvenile stem bark and root extracts formed the first factor and their extract concentrations *viz.*, 0, 5, 10, 15, 25 and 50 percent (w/v) second factor.

For seed germination study, a total of 48 filter paper covered uniform glass petri dishes, 24 each for finger millet and tomato were used and nine seeds for each dish were sown. The 5 mL aqueous extracts at 5, 10, 15, 25 and 50 percent concentrations were applied to each dish separately as per the treatment and 5 mL of tap water was used for control. The dishes containing seeds were kept in laboratory and arranged in rows independently and fairly labeled. The data on number of seeds germinated were recorded on daily basis and continued for twelve days for thorough monitoring of seed germination.

For seedling growth study, a total of 48 uniform sized polythene covers filled with local top soil, 24 each for finger millet and tomato were arranged in rows separately, sown with nine seeds in every polythene cover and applied aqueous extracts at 5, 10, 15, 25 and 50 percent concentrations to each cover separately as per the treatment until field capacity was reached and tap water was used for control. The covers were kept in green house and fairly labeled. Only five seedlings in each cover were retained and the experiment was continued for 28 days to record growth parameters of seedlings. The experimental data was statistically analyzed by the technique of analysis of variance as given by Fisher and Yates (1963) [5].

Results

A. Germination study

The results indicated that the percent seed germination of finger millet and tomato crops differed significantly with sources and concentrations of eucalyptus tree parts aqueous extracts (Table 1 and Plate 1). Application of aqueous extract obtained by fresh leaves showed significantly lowest (33.30%) germination percentage in finger millet compared to other sources (65.98 to 85.10%). On the other hand, significantly highest (85.10%) germination percentage of finger millet was found in the roots extract treated seeds over fresh leaves extract (33.30%) and consortium of all three extracts (65.98%). However, it was found to be on par with application of juvenile stem bark extract (80.16%). A significantly least (38.85%) germination percentage was observed at higher concentration of 50 percent extract used over lower concentrations of extracts tried (53.65 to 82.32%).

Significantly highest (92.50%) germination percentage of finger millet was found in the control over all other concentrations tried (38.85 to 82.32%). Further, application of fresh leaves aqueous extract at 15, 25 and 50 percent concentrations showed significantly lowest germination percentage (0.00%). However, it was found to be on par with application of 50 percent consortium of extracts (7.40%). The control recorded significantly highest germination percentage (92.50%) over application of fresh leaves extract at all concentrations tried (74.00 to 0.00%), juvenile stem bark extract at 25 and 50 percent concentrations (70.30 and 66.60%, respectively) and consortium of fresh leaves, juvenile stem bark and roots extracts at 15, 25 and 50 percent concentrations (74.00, 59.20 and 7.40%, respectively).

Similarly, application of aqueous extract obtained by fresh leaves showed significantly lowest (12.95%) germination percentage in tomato compared to other sources (28.98 to 58.58%). In contrary, highest (58.58%) germination percentage of tomato seeds was found in the roots extract applied seeds over juvenile stem bark extract (32.68%), consortium of different eucalyptus tree parts extracts (28.98%) and fresh leaves extract (12.95%). A significantly least (8.32%) seed germination percentage of tomato was observed at higher extract concentration of 50 percent used over lower concentrations of 5 and 10 percent extracts tried (48.10 and 38.85%, respectively). However, it was found to be on par with application of 25 and 15 percent concentrations of extracts tried (11.10 and 15.72%, respectively). On the other hand, significantly highest (77.70%) germination percentage was found in the control over all other concentrations tried (8.32 to 48.10%). Application of aqueous extracts of fresh leaves at all concentrations, juvenile stem bark extract at 50 percent concentration and consortium of fresh leaves, juvenile stem bark and roots extracts at 15, 25 and 50 percent concentrations were recorded significantly lowest germination percentage (0.00%). However, it was found to be on par with application of 15 and 25 percent juvenile stem bark extracts and both were recorded seed germination percentage of 3.70 percent. On the other hand, control recorded significantly highest germination percentage of 77.70 percent. However, it was found to be on par with application of aqueous extracts of roots at 5 and 10 percent concentrations (74.00 and 66.60%, respectively) and juvenile stem bark extract at 5 percent concentration (66.60%).

B. Seedling growth study

Application of different parts of eucalyptus aqueous extracts at six different concentrations (0, 5, 10, 15, 25 and 50%) exhibited the significant allelopathic effect on seedling growth parameters such as seedling height, shoot length, root length, fresh weight and dry weight of finger millet and tomato at 28 days after sowing (Tables 2 to 4 and Plates 2 to 4).

Seedling height

At 28 days after sowing, the height of both finger millet and tomato seedlings differed significantly due to aqueous extracts of eucalyptus tree parts and their concentrations (Table 2). The significantly shortest (10.74 cm) height was recorded in the finger millet seedlings applied with fresh leaves aqueous extract over other eucalyptus tree parts aqueous extracts (11.61 to 13.04 cm). On the other hand, significantly longest (13.04 cm) height was recorded in the finger millet seedlings applied with roots extract over fresh leaves extract applied seedlings. While, juvenile stem bark (12.50 cm) and consortium of extracts (11.61 cm) applied seedlings were intermediate in height. A significantly shortest (6.20 cm) height was observed in the finger millet seedlings which received higher extract concentration of 50 percent than the seedlings which received lower concentrations of extracts (9.40 to 14.58 cm). On the other hand, significantly longest (17.32 cm) seedling height was found in the control over all other concentrations of eucalyptus tree parts aqueous extracts tried (6.20 to 14.58 cm). Application of fresh leaves aqueous extract at 50 percent concentration was recorded significantly shortest (3.92 cm) seedling height while, control recorded significantly longest seedling height (17.32 cm).
With regard to tomato, the significantly shortest (11.29 cm) height was found in the seedlings applied with fresh leaves aqueous extract over other tree parts aqueous extracts applied seedlings (13.21 to 15.95 cm). On the other hand, significantly longest (15.95 cm) seedling height was found in the tomato seedlings applied with roots extract. While, juvenile stem bark (15.29 cm) and consortium of extracts (13.21 cm) applied seedlings were intermediate in height. A significantly shortest (9.97 cm) height was observed in the seedlings which received higher extract concentration of 50 percent over lower concentrations of extracts applied seedlings (11.84 to 15.72 cm). On the other hand, significantly longest (18.21 cm) seedling height was found in the control over all other concentrations of eucalyptus tree parts aqueous extracts tried (9.97 to 15.72 cm). Application of fresh leaves extract at 50 percent concentration was recorded significantly shortest (7.76 cm) seedling height. However, it was found to be on par with application of consortium of fresh leaves, juvenile stem bark and root aqueous extracts at 50 percent concentration (8.03 cm). On the other hand, control recorded significantly longest (18.21 cm) seedling height. However, it was found to be on par with application of 5 percent aqueous extract of roots (17.86 cm) and juvenile stem bark extract (17.33 cm).

Root and shoot lengths

The seedlings root and shoot lengths of both crops significantly responded to aqueous extracts of eucalyptus and the degree of response varied depending on source and concentration (Table 3). Among the sources, significantly minimum root length was noticed in both finger millet and tomato seedlings when fresh leaves aqueous extract used (10.43 and 8.97 cm, respectively) over other sources. However, it was found to be on par with application of consortium of fresh leaves, juvenile stem bark and root extracts in tomato (9.14 cm). On the other hand, significantly maximum root length was found in the both finger millet and tomato seedlings applied with root extract (12.30 and 9.79 cm, respectively). Among the varied concentrations tried, significantly minimum root length in both finger millet and tomato seedlings was noticed under higher extract concentration of 50 percent (7.48 and 7.56 cm, respectively) over lower concentrations. However, significantly maximum seedling root length of finger millet and tomato was found in control (16.73 and 11.61 cm, respectively) over all other concentrations of eucalyptus tree parts aqueous extracts tried. The interaction between tree parts aqueous extracts and their concentrations differed significantly with respect to root length of finger millet and tomato seedlings. Application of fresh leaves aqueous extract at 50 percent concentration recorded significantly minimum root length in both finger millet and tomato seedlings (6.33 and 7.26 cm, respectively). However, it was found to be on par with application of consortium of extracts at 50 percent concentration in case of finger millet and consortium of extracts, root extract and juvenile stem bark extract at 50 percent concentration in case of tomato. On the other hand, control recorded significantly maximum root length in both finger millet and tomato seedlings (16.73 and 11.61 cm, respectively). However, it was found to be on par with application of roots extract at 5 percent concentration in both the crops.
The shoot length of finger millet and tomato seedlings differed significantly due to application of eucalyptus tree parts aqueous extracts. The significantly minimum shoot length was found in both finger millet and tomato seedlings when fresh leaves aqueous extract used (2.91 and 6.01 cm, respectively) over other eucalyptus tree parts extracts tried. However, it was found to be on par with application of consortium of fresh leaves, juvenile stem bark and root extracts in case of tomato. On the other hand, significantly maximum shoot length was found in both finger millet and tomato seedlings which received roots extract (3.62 and 7.05 cm, respectively) over other tree parts extracts tried. While, seedlings applied with juvenile stem bark extract and consortium of fresh leaves, juvenile stem bark and root extracts were intermediate in shoot length. Among the varied concentrations tried, significantly minimum shoot length was observed in both finger millet and tomato seedlings which received higher extract concentration of 50 percent (2.21 and 5.00 cm, respectively) over lower concentrations of extracts tried. On the other hand, significantly maximum shoot length in both finger millet and tomato seedlings was found in the control (4.28 and 7.90 cm, respectively) over other concentrations of eucalyptus tree parts aqueous extracts tried. The interaction between eucalyptus tree parts aqueous extracts and their concentrations did not differ significantly with respect to shoot length of finger millet and tomato seedlings.

Seedling weight

The fresh weight and dry weight of finger millet and tomato seedlings at 28 days after sowing differed significantly due to eucalyptus tree parts aqueous extracts and their concentrations (Table 4). Among tree parts aqueous extracts, significantly minimum fresh weight was recorded in both finger millet and tomato seedlings when fresh leaves aqueous extract used (5.97 and 9.34 g, respectively) over other tree parts aqueous extracts. On the other hand, significantly maximum fresh weight of finger millet and tomato seedlings was recorded which received root aqueous extract (8.84 and 11.40 g, respectively) over other tree parts aqueous extracts applied seedlings. Among varied concentrations of extracts used, significantly minimum fresh weight of finger millet and tomato seedlings was recorded which received higher extract concentration of 50 percent (4.31 and 5.42 g, respectively) over lower concentrations of extracts applied seedlings. On the other hand, significantly maximum fresh weight of finger millet and tomato seedlings was recorded in the control (11.51 and 15.94 g, respectively) over other concentrations of eucalyptus tree parts aqueous extracts tried. The interaction between eucalyptus tree parts aqueous extracts and their concentrations differed significantly with respect to fresh weight of finger millet and tomato seedlings. Application of fresh leaves aqueous extract at 50 percent concentration recorded significantly minimum fresh weight of both finger millet and tomato seedlings (2.28 and 3.86 g, respectively). However, it was found to be on par with application of 25 percent fresh leaves aqueous extract in case of finger millet and 25 percent fresh leaves extract and 50 percent consortium of fresh leaves, juvenile stem bark and root extracts in case of tomato. On the other hand, control recorded the significantly maximum fresh weight of both finger millet and tomato seedlings (11.51 and 15.94 g, respectively) over all other treatment concentrations tried.

At 28 days after sowing, dry weight of finger millet and tomato seedlings differed significantly due to application of eucalyptus tree parts aqueous extracts and their concentrations (Table 4). Among the sources, significantly minimum dry weight of finger millet and tomato seedlings was recorded when fresh leaves aqueous extract used (0.40 and 1.09 g, respectively) over other tree parts extracts. However, it was found to be on par with application of consortium of extracts in case of finger millet. On the other hand, significantly maximum dry weight of finger millet and tomato seedlings was found in the seedlings applied with root extract (0.63 and 1.33 g, respectively) over other eucalyptus tree parts aqueous extracts. However, it was found to be on par with application of juvenile stem bark extract in both the crops. Among varied concentrations of extracts, a significantly minimum dry weight of finger millet and tomato seedlings was recorded in seedlings which received 50 percent aqueous extract concentration (0.25 and 0.61 g, respectively) over lower concentrations. However, it was found to be on par with application of 25 percent aqueous extracts of eucalyptus tree parts in case of finger millet. On the other hand, significantly maximum dry weight of finger millet and tomato seedlings was recorded in the control (0.98 and 1.85 g, respectively) over other concentrations of eucalyptus tree parts aqueous extracts tried. The interaction between tree parts aqueous extracts and their concentrations differed significantly with respect to dry weight of finger millet and tomato seedlings. Application of fresh leaves aqueous extract at 50 percent concentration recorded significantly minimum dry weight of finger millet and tomato seedlings (0.13 and 0.22 g, respectively) over other treatment combinations tried. However, it was found to be on par with application of 15 and 25 percent fresh leaves aqueous extracts, 25 and 50 percent consortium of fresh leaves, juvenile stem bark and root extracts and 50 percent juvenile stem bark extract in case of finger millet.

Discussion

A. Seed germination

The aqueous extracts of eucalyptus tree parts such as fresh leaves, juvenile stem bark, roots and their consortium had inhibitory response on germination percentage of both finger millet and tomato seeds which could be attributed to the existence of allelochemicals in all parts of eucalyptus tree. Further, the allelopathic effect was more severe with increasing concentration of extracts that might be attributed to the fact that allelopathy is a concentration dependent phenomenon (Table 1). Among different sources of eucalyptus tree parts aqueous extracts, fresh leaves aqueous extract at 15, 25 and 50 percent concentrations highly reduced the germination percentage of finger millet in which no seed was germinated followed by consortium of fresh leaves, juvenile stem bark and root extracts at 50 percent concentration. Similarly, fresh leaf aqueous extract at all concentrations tried (5, 10, 15, 25 and 50%) followed by consortium of fresh leaves, juvenile stem bark and root extracts at 15, 25 and 50 percent concentrations and juvenile stem bark at 50 percent concentration highly reduced the germination percentages of tomato in which no seed was germinated. On the other hand, the least reduction in seed germination percentage was noticed due to application of roots extracts. This indicated that fresh leaves aqueous extract produced inhibitory action substantially on percent germination of seeds in both crops and it might be due to presence of high concentration of phenolic compounds in leaves compared to other parts of eucalyptus. Kohli (1990) [10] identified a number of phenolic compounds like gallic, coumaric, caffeic, gentisic, ferulic, syringic, hydroxybenzoic and vanillic acids in the eucalyptus leaves in high concentrations compared to other parts of the tree. The above compounds can bring down the germination of seeds as well as growth of seedlings (Crawley, 1997) [2] by inhibiting a few physiological processes for example division of cells, carbohydrate synthesis, protein synthesis and nucleic acids synthesis (Sasikumar *et al.*, 2002) [15]. The similar impact of eucalyptus leaves aqueous extract was observed by Morsi and Abdelmigid (2016) [13] on *Hordeum vulgare* and Sorecha and Bayissa (2017) [17] on peanut and soybean. Among two tested crops, finger millet had the highest seed germination percentage compared to tomato due to application of different sources of eucalyptus tree parts aqueous extracts indicated that inhibitory effect is more on tomato than finger millet seed germination. This might be due to the fact that finger millet is a hardy crop compared to tomato.

B. Seedling growth

The potential inhibitory effects of eucalyptus tree parts on seedling height, root length, shoot length, fresh weight and dry weight of the target crop species increased gradually with increasing the extract concentration of all parts tried. The study indicated that the concentration of all the eucalyptus tree parts *viz.*, fresh leaves, juvenile stem bark and roots starting from the lowest level of concentration (5%) inhibited the growth of both target crop species. Solomon (2016) [16] observed the same results and the secondary metabolic products of aqueous extracts would have inhibited the growth and development of seedlings (Morsi and Abdelmigid, 2016; Sorecha and Bayissa, 2017) [13, 17]. Significant reductions of all growth parameters except shoot length were recorded at all concentrations compared to control. The seedling growth of finger millet and tomato inhibition was more pronounced under 50 percent concentration of eucalyptus tree parts aqueous extracts. However, more growth inhibition was noticed under fresh leaves aqueous extract followed by mixture of fresh leaves, juvenile stem bark and roots extracts and juvenile stem bark extract while, least growth inhibition was noticed in root extract at all levels of concentration tried. Numerous allelochemicals of volatile and non-volatile nature from eucalyptus trees have been reported and have significant allelopathic effects (Kohli, 1990) [10]. A variety of phenols *viz*., coumaric, hydroxybenzoic, gentisic, caffeic, gallic, syringic, ferulic and vanillic acids have been extracted and identified from the leaves and understory soil of eucalyptus plantations (Kohli, 1990) [10]. These compounds are observed to be reason for clogging of stomata, electrolyte leakage and impairment of photosynthetic and energy machinery (Kaur *et al*., 2012) [8] apart from hampering a few physiological activities *viz*., division of cell, synthesis of carbohydrates, proteins and nucleic acids in addition to the phosphorylations pathway interference (Sasikimar *et al*., 2002) [15]. These inhibitory effects can mediate by phenolic compounds (El-Darier, 2002) [4] and these phenolic compounds reduce seed germination and growth of seedlings (Crawley, 1997) [2]. Therefore, the higher inhibitory effect of aqueous extract of eucalyptus fresh leaves can be attributed to the higher amounts of phenolic compounds in leaves.

Our findings are also in conformity with observations of Ziaebrahimi *et al.* (2007) [18] who evaluated the allelopathic effect of eucalyptus leaf extract and reported the decreased percent seed germination and seedling growth of wheat cultivars. Similarly, Khan *et al.* (2008) [9] reported that *Eucalyptus camaldulensis* aqueous extracts had inhibited the seed germination percentage and seedling growth of wheat at 10, 15 and 20 percent concentrations and the effects were increased with increase in concentration. Mohamadi and Rajaie (2009) [12] studied the allelopathic effect of *Eucalyptus camaldulensis* leaf leachate at 5, 10 and 20 percent concentrations on seed germination and growth of sorghum and Kidney-bean and compared with control consisting of only sterilized distilled water. They observed considerable decline in the germination of seeds, dry matter of seedlings, shoot/root length at all concentrations studied in both species. Consequently, the chlorophyll content and soluble sugar contents were decreased as a result of which the protein content was proportional to the increase in concentration of leaf leachate in both species. Gurmu (2015) [6] studied the effects of leaves powder of *Eucalyptus camaldulensis* and *Eucalyptus grandis* on haricot bean and maize and he observed the remarkable inhibition of seed germination and growth of the seedlings of both crops. However, the low concentration of powdered leaves of either tree species had low effect on both crops. Sorecha and Bayissa (2017) [17] noticed strong inhibition of germination and growth of peanut and soybean by extract of *Eucalyptus* spp.

Table 1: Germination percentage of finger millet and tomato seeds in response to aqueous extracts of eucalyptus

Sources of extract (A) / Concentrations (B)	**Germination percentage of finger millet seeds**							**Germination percentage of tomato seeds**						
	0%	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**	**0%**	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**
Fresh leaves	92.50	74.00	33.30	0.00	0.00	0.00	33.30	77.70	0.00	0.00	0.00	0.00	0.00	12.95
Juvenile stem bark	92.50	85.10	85.10	81.40	70.30	66.60	80.16	77.70	66.60	44.40	3.70	3.70	0.00	32.68
Roots	92.50	88.80	81.40	81.40	85.10	81.40	85.10	77.70	74.00	66.60	59.20	40.70	33.30	58.58
Consortium	92.50	81.40	81.40	74.00	59.20	7.40	65.98	77.70	51.80	44.40	0.00	0.00	0.00	28.98
Mean	92.50	82.32	70.30	59.20	53.65	38.85		77.70	48.10	38.85	15.72	11.10	8.32	
	S.Em±			C.D. @ 5%				S.Em±			C.D. @ 5%			
Factor A	1.93			5.51				2.17			6.19			
Factor B	2.36			6.75				2.65			7.59			
Factor A × B	4.73			13.51				5.31			15.18			

Table 2: Height (cm) of finger millet and tomato seedlings in response to aqueous extracts of eucalyptus

Sources of extract (A) / Concentrations (B)	**Seedlings height of finger millet (cm)**							**Seedlings height of tomato (cm)**						
	0%	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**	**0%**	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**
Fresh leaves	17.32	13.93	11.73	9.80	7.76	3.92	10.74	18.21	11.46	10.77	10.43	9.13	7.76	11.29
Juvenile stem bark	17.32	14.66	13.50	12.50	10.23	6.80	12.50	18.21	17.33	15.96	14.76	13.63	11.86	15.29
Roots	17.32	15.40	13.73	12.66	10.93	8.20	13.04	18.21	17.86	16.63	16.03	14.73	12.26	15.95
Consortium	17.32	14.36	12.73	10.70	8.70	5.90	11.61	18.21	16.23	14.46	12.46	9.90	8.03	13.21
Mean	17.32	14.58	12.92	11.41	9.40	6.20		18.21	15.72	14.45	13.42	11.84	9.97	
	S.Em±			C.D. @ 5%				S.Em±			C.D. @ 5%			
Factor A	0.18			0.53				0.13			0.39			
Factor B	0.22			0.65				0.16			0.48			
Factor A × B	0.45			1.30				0.33			0.96			

Table 3: Root and shoot lengths (cm) of finger millet and tomato seedlings in response to aqueous extracts of eucalyptus

Sources of extract (A) / Concentrations (B)	**Finger millet**													
	Root length (cm)							**Shoot length (cm)**						
	0%	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**	**0%**	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**
Fresh leaves	16.73	14.43	9.30	8.63	7.16	6.33	10.43	4.28	3.30	3.10	2.90	2.70	1.23	2.91
Juvenile stem bark	16.73	14.93	11.63	10.26	9.40	8.43	11.89	4.28	3.80	3.60	3.23	3.00	2.43	3.39
Roots	16.73	16.00	12.50	10.30	9.46	8.83	12.30	4.28	4.13	3.73	3.70	3.10	2.80	3.62
Consortium	16.73	14.90	10.26	9.33	8.63	6.36	11.03	4.28	3.60	3.43	3.16	2.86	2.40	3.28

Mean	16.73	15.06	10.92	9.63	8.66	7.48		4.28	3.70	3.46	3.24	2.91	2.21	
	S.Em±			C.D. @ 5%				S.Em±			C.D. @ 5%			
Factor A	0.10			0.31				0.07			0.20			
Factor B	0.13			0.38				0.08			0.25			
Factor A × B	0.26			0.76				0.17			NS			
Sources of extract (A) / Concentrations (B)	**Tomato**													
	Root length (cm)							**Shoot length (cm)**						
	0%	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**	**0%**	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**
Fresh leaves	11.61	9.83	8.76	8.30	8.10	7.26	8.97	7.90	6.73	6.10	5.80	5.20	4.30	6.01
Juvenile stem bark	11.61	11.00	9.93	9.20	8.16	7.56	9.57	7.90	7.70	6.80	5.90	5.70	5.30	6.55
Roots	11.61	11.06	10.23	9.26	8.90	7.70	9.79	7.90	7.80	7.50	6.90	6.50	5.70	7.05
Consortium	11.61	9.86	8.90	8.50	8.26	7.73	9.14	7.90	6.80	6.50	6.00	5.36	4.50	6.18
Mean	11.61	10.43	9.45	8.81	8.35	7.56		7.90	7.25	6.72	6.15	5.73	5.00	
	S.Em±			C.D. @ 5%				S.Em±			C.D. @ 5%			
Factor A	0.08			0.23				0.11			0.33			
Factor B	0.10			0.29				0.14			0.41			
Factor A × B	0.20			0.58				0.29			NS			

Table 4: Fresh and dry weights (g) of finger millet and tomato seedlings in response to aqueous extracts of eucalyptus

Sources of extract (A) / Concentrations (B)	**Finger millet**													
	Fresh weight (g)							**Dry weight (g)**						
	0%	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**	**0%**	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**
Fresh leaves	11.51	8.63	6.24	4.22	2.92	2.28	5.97	0.98	0.47	0.35	0.26	0.18	0.13	0.40
Juvenile stem bark	11.51	8.92	7.73	7.29	6.40	5.31	7.86	0.98	0.70	0.63	0.54	0.37	0.30	0.59
Roots	11.51	10.18	9.61	8.99	6.69	6.09	8.84	0.98	0.77	0.72	0.55	0.40	0.36	0.63
Consortium	11.51	7.82	6.56	6.16	5.25	3.59	6.81	0.98	0.57	0.43	0.34	0.29	0.22	0.47
Mean	11.51	8.88	7.53	6.66	5.31	4.31		0.98	0.62	0.53	0.42	0.31	0.25	
	S.Em±			C.D. @ 5%				S.Em±			C.D. @ 5%			
Factor A	0.10			0.28				0.02			0.07			
Factor B	0.12			0.35				0.03			0.09			
Factor A × B	0.24			0.70				0.06			0.19			
Sources of extract (A) / Concentrations (B)	**Tomato**													
	Fresh weight (g)							**Dry weight (g)**						
	0%	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**	**0%**	**5%**	**10%**	**15%**	**25%**	**50%**	**Mean**
Fresh leaves	15.94	11.44	10.79	9.06	4.95	3.86	9.34	1.85	1.50	1.24	0.95	0.77	0.22	1.09
Juvenile stem bark	15.94	14.44	11.65	8.85	7.88	6.22	10.83	1.85	1.61	1.31	1.05	0.99	0.79	1.27
Roots	15.94	14.76	12.95	8.97	8.86	6.97	11.40	1.85	1.68	1.36	1.13	1.00	0.94	1.33
Consortium	15.94	13.66	11.38	9.25	6.48	4.63	10.22	1.85	1.53	1.26	1.04	0.85	0.51	1.17
Mean	15.94	13.57	11.69	9.03	7.04	5.42		1.85	1.58	1.29	1.04	0.90	0.61	
	S.Em±			C.D. @ 5%				S.Em±			C.D. @ 5%			
Factor A	0.16			0.47				0.02			0.06			
Factor B	0.20			0.58				0.02			0.07			
Factor A × B	0.40			1.16				0.05			0.15			

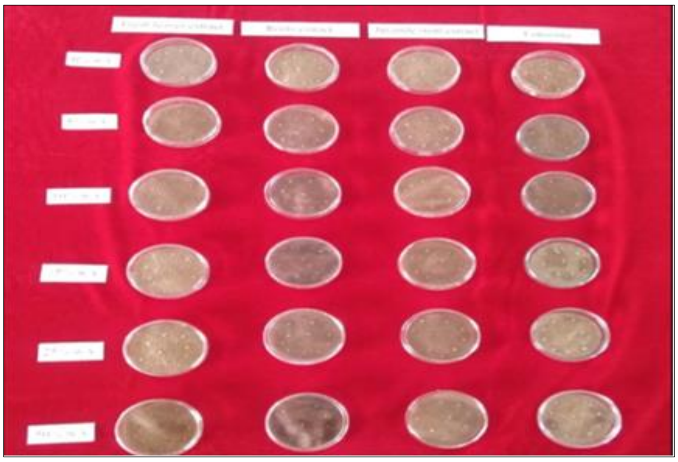

Plate 1: General view of the seed germination studies

Plate 2: General view of seedling growth studies

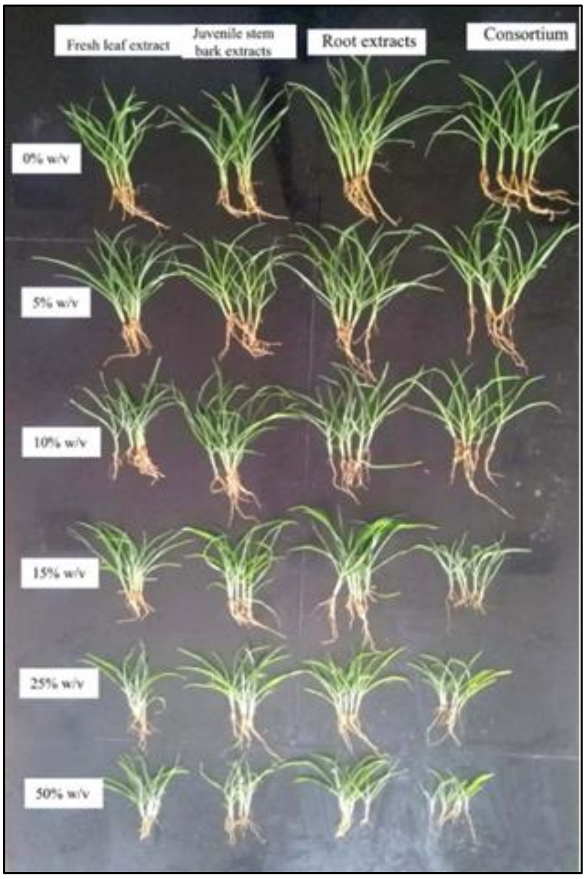

Plate 3: Growth of finger millet seedlings at 28 days after treating with eucalyptus tree parts aqueous extracts

Plate 4: Growth of tomato seedlings at 28 days after treating with eucalyptus tree parts aqueous extracts

Conclusion

Based on results of the present study, it can be inferred that aqueous extracts of different parts of eucalyptus tree had different degrees of inhibition on seed germination and seedling growth of both crops tested. Further, inhibition effect was high in leaf extract compared to bark and roots extracts and the effect was increased with increasing the concentration of all eucalyptus tree parts extracts. The inhibitory effects were more on tomatoes than finger millet.

Conflict of interest

The authors declare that they have no conflict of interest.

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