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Allelopathic propensity of *Quercus* species on the performance of traditional food crops of the mid-Himalayan region

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Abstract
A pot experiment was carried out to examine the effect of aqueous leaf extract of three *Quercus* (*Q. leucotrichophora*, *Q. floribunda,* and *Q. serrata*) species on germination and early growth of small millets (*Echinochloa frumentacea, Eleusine coracana, Amaranthus caudatus*) and one cereal crop (*Triticum aestivum*) which are important crops of the mid-Himalayan region. The study revealed that there was a considerable effect of *Quercus* species on seed germination, early growth, and biomass of all the test crops. The increase in extract concentration exhibited a higher inhibitory effect though the lesser concentration slightly stimulated the growth of *E. coracana* and *A. caudatus*. The percentage of inhibition in germination and early growth parameters increased with the increasing concentration of aqueous extract. Among the test crops, *T. aestivum* and *E. frumentacea* were found most susceptible while *E. coracana* and *A. caudatus* were the most resistant test crops. The toxicity of the *Quercus* species was in order of *Q. leucotrichophora* < *Q. floribunda* < *Q. serrata*. In particular, *Q. leucotrichophora* is preferred as fodder and fuelwood thereby, phytotoxic accumulation through leaves would be low to moderate in soil. Based on the suppressive nature of these tree species on test crops, *Q. leucotrichophora* can be screened as prominent agroforestry tree species.

Keywords: Allelopathy, germination, leaf extract, small millet

Introduction
Agroforestry refers to practices, which deliberately or intentionally mix or retain woody perennials on the crop/animal production systems. It combines elements of agriculture crops and/ or animals with elements of forestry in the production system in a unit of land, either simultaneously or sequentially. The term woody perennial includes trees, shrubs, bushes, palm, bamboos, etc. which is an agroforestry context are often referred to as multipurpose trees and shrubs (Wood, 1988) [17]. This practice increases productivity, improves soil fertility, microclimate, nutrient cycling, conserves soil, and increases overall productivity. In crop combination or intercropping systems, the major plant species are crops, and some weeds may also be presented. When the two plant species grow together they interact with each other either inhibiting or stimulating their growth or yield through direct or indirect allelopathic interaction. Allelochemicals are released from the higher plant through volatilization, leaf or stem leachates, root exudates, and decomposition of residues. Allelopathy occurs through the release of biochemicals known as allelochemicals, from plant parts through leaching, root exudation, volatilization, residue decomposition, and other processes (Narwal *et al.* 2011; Thakur *et al.* 2017; Kumar *et al.* 2017) [7, 9, 4].

Q. leucotrichophora is the commonest oak of the western Himalaya, extending eastward to Nepal, chiefly in the outer ranges from 1,000 - 2,400m, but occasionally descending lower in moist situations (Negi and Naithani, 1995) [14]. In Garhwal Himalaya it naturally occurs at 1500-1800 m, 80 per cent dominance (based on relative basal area), between 2000 to 2200 m it may share dominance with *Q. floribunda* and above 2200 m it generally disappears (Singh and Singh, 1992; Zobel and Singh, 1997) [8, 17]. *Q. floribunda* is native of India, Bangladesh, Afghanistan, Nepal, Oman, and Pakistan but its natural range is the temperate region of the Western Himalayas, from Nepal to westwards, at altitudes of 2100-2700 m, descending to about 1700 m, in cool moist areas. *Q. serrata* is native to Southern, Central, Eastern China, Taiwan, Japan, and Korea. It is a deciduous oak tree reaching a height 25 m occupying elevation from 100 to 2000 m. Leaves are up to 17 cm long by 9 cm wide, leathery, elliptical in shape, with serrated margins. These species have been extensively used as shade bearer in and around agriculture fields in the hilly region of Garhwal Himalaya. Besides this, other uses are fuel, fodder, and small timber by local people and help to control erosion.

Being a *Quercus* species are the most prominent species in the Western Himalayan region and farmers are widely using this species for various purposes like fuel, fodder, etc. so it is necessary to know whether this species have any positive or negative impact on crops. Keeping in view of the above mentioned facts, a pot experiment was carried out.

Materials and Methods

The experimental site, College of Forestry, V.C.S.G Uttarakhand University of Horticulture and Forestry, Ranichaury Campus, Tehri Garhwal, is located 10 km away from Chamba (Rishikesh-Gangotri Road) at an altitude of about 2100 m above mean sea level, lying between 300 15' N latitude and 780 30' E longitudes under mid-hill zones of Uttarakhand, India.

Collection of plant material and preparation of extract

Fresh and matured leaves of *Q. leucotrichophora*, *Q. floribunda*, and *Q. serrata* were collected from different areas of the College of Forestry, Ranichaury campus. The collected leaves were sun-dried for about a week and made into a fine powder using an electrical grinder. Aqueous extract was prepared by soaking 200 g of grounded leaf litter in 1L distilled water. The extract was filtered through Muslin cloth and filtrates were considered as 100 per cent concentration. Further dilutions of 10%, 25%, 50%, and 75% were prepared with distilled water. The extract concentrations used were: T_1-control (distilled water), T_2- 10%, T_3- 25%, T_4- 50%, T_5-75%, and T_6- 100% concentrations of leaf and bark extract.

The pot experiment was conducted in CRD with three replications. The plants of each test crop were grown in pots at the forest nursery of the Department of Forestry, College of Forestry, Ranichaury, Tehri Garhwal. Before the sowing of seeds, the pots were filled with a mixture made by sand, soil, and farmyard manure in the ratio of 1:2:1 ratio. 75 seeds of each crop in each treatment with three replications were sown in the pots and each pot was irrigated with 100 ml aqueous extract. Seed germination was recorded daily to a minimum of 21 days. The weeding and watering (extracts of different concentrations were used to irrigate the seeds) of pots were done manually when needed untill the completion of the experiment (21 days). After 21 days, data were taken for shoot length and root length. Further, the fresh weight of seedlings was recorded and samples were taken to the laboratory and kept in a hot air oven at 60° C till constant weight arrived. The dry weight was recorded by using an electrical single pan balance and the mean dry weight of seedling was determined.

Statistical Analysis

The average data obtained from the experiment were subjected to statistical analysis. The performance of tree leaf extract over the test crop was determined by applying ANOVA in the WASP statistical software, WASP version 1.0 (ICAR GOA, India). Percentage inhibition or stimulation relative to control was calculated by using the formula:

$I = 100 (R_2-R_1)/R_1$

Where, I= percentage inhibition or stimulation, R_1= response of control crop, and R_2= response of tested crop.

Results and Discussion

Effect of leaf extracts of *Quercus* species on germination and early growth parameters of test crops

The aqueous leaf extract in pot culture exhibited a significant ($P<0.05$) inhibitory effect on germination and growth parameters *viz*., shoot and root length, and seedling dry weight of test crops (Table 1, 2 and 3).

Q. leucotrichophora

The data introduced in Table 1 pointed out that the germination per cent was significantly affected by leaf and bark extracts. Over control (T_6), the maximum germination (96.67%) was recorded in *E. coracana* followed by *A. caudatus* (95%) in T_1 (10% concentration), while minimum germination (41.57%) was recorded in *T. aestivum* under hundred per cent concentration of leaf extract (T_5). However, a sharp reduction (46.80%) was also observed in *T. aestivum* followed by *E. frumentacea* (32.30%), *A. caudatus* (22.42%), and *E. coracana* (22.02%), under 100% leaf extracts (T_5). On the other hand, the leaf extracts also exhibited a significant inhibitory effect on shoot, root, and total dry biomass of germinated seedlings (Table 2 and 3). The maximum root and shoot length (14.25 and 24.25 cm, respectively) and dry biomass (0.323 g) was recorded for *T. aestivum* in T_1 while minimum (1.45 cm) root length, shoot length (2.89 cm), and dry weight (0.06 g) was recorded in T_5 (100% concentration).

Quercus floribunda

Over control, the leaf extract of *Q. floribunda* significantly inhibited the germination and growth traits of all the test crops except for *E. coracana*. The maximum (95%) germination per cent was found in *E. coracana* and *A. caudatus* under the 10 per cent concentration (T_1), while minimum germination (43.33%) was recorded for *T. aestivum* in T_5 over control (Table 1). On the other hand, the maximum (20.77 cm) root length was recorded in *T. aestivum*, shoot length (18.96cm) in *E. frumentacea*, and dry weight (0.380 g) of seedlings was recorded for *T. aestivum* in T_1, though minimum (3.93cm) root length was recorded in *A. caudatus*, shoot (7.34cm) length in *E. coracana* and dry matter (0.053 g) was recorded for *E. coracana* in T_5 (Table 2 and 3)

Quercus serrata

Per cent germination was significantly reduced under all the concentrations of leaf extract in *T. aestivam* and *E. frumentacea* as compared to control whereas, *E. coracana* and *A. caudatus* remain unaffected under the lower concentration (10%) of leaf extract (T_1). Outcomes revealed that the maximum germination (98.33%) was recorded in *E. coracana* and *A. caudatus* followed by *E. frumentacea* (91.67%) and *T. aestivum* (65%), while the minimum germination (41.67%) with a maximum reduction (46.80%) was found in *T. aestivum* (T_5) though minimum reduction (1.69%) was calculated for *E. coracana* in T_2 (Table 1). Likewise, the maximum (20.17 cm) root length, shoot length (26.25 cm), and biomass (0.470 g) was found in *T. aestivum* (T_1) while the minimum (3.06 cm) root length was observed in *A. caudatus*, shoot length (4.32cm) in *E. coracana* and seedling biomass in *E. frumentcea* and *E. coracana* (0.103 g) in T_5 (Table 2 and 3). For an improved agroforestry management system, it is essential to identify local tree crops with minimum addition of toxins in the topsoil. Many researchers reported the inhibitory effect of *Eucalyptus*, *Bambusa* spp., *Tectona grandis, Acacia nilotica, Dalbergia sissoo, Morus alba, Bauhinia variegata, Ficus bengalensis, Poplus deltoides, Salix babylonica*, and *Leucaena leucocephala* on germination and seedling growth of certain cereal crops (Hossain *et al*. 2002) [3].

The outcomes of the present study revealed that the extent of inhibition on germination and early growth and biomass production of seedlings decreased with an incremental aqueous extract concentration. It showed the concentration-dependent effect of aqueous leaf and bark extract. Similar findings were reported by Singh *et al*. (2016) [12] and Pratap *et al.* (2020) [15] as they revealed the concentration-dependent inhibitory effect of leaf and bark extracts of *Quercus species* on germination and seedling growth of small millets. Among all the test crops, *E. coracana* showed a stimulatory effect under all the concentration of leaf extracts of *Q. serrata* concerning root-shoot growth whereas, the root of *A. caudatus* also found stimulatory under all concentrations of these species. Findings of the present experiment, experienced in germination and growth of the test crops are corroborated by earlier findings (Singh *et al*., 2009; Bano *et al*. (2012) [11, 1]. This study revealed that the leaf extracts of *Q. leucotrichophora* and *Q. serrata* found more toxic. Earlier results were reported by Kaletha *et al*. (1996) [5], where they observed the aqueous extracts of leaf and bark of *Grewia oppositifolia*, *Ficus roxburghii*, *Bauhinia variegata*, and *Kydia calycina* on *E. frumentacea*, *E. coracana*, *Zea mays*, *Vigna unguiculata*, and *Glycine max* and found that the leaf and bark are most toxic to food crops.

Associated results were additionally stated by Bhatt and Chauhan (2000) [2], where the phytotoxic effect of *Quercus* species on *T. aestivum, Brassica campastris,* and *Lens culinaris* inhibited the germination, root, and shoot length of all food crops. Likewise, the aqueous leaf extract of *Acacia nilotica* has an inhibitory allelopathic effect on seed germination and radicle length of *T. aestivum* (Sazada *et al.,* 2009) [13]. Similarly, findings of this study have revealed that leaf extracts of *Q. leucotrichophora* and *Q. floribunda* were found most toxic for germination root-shoot growth. Under the leaf extract of *Q. serrata, A. caudatus* and *E. coracana* were found less affected concerning root and shoot growth, however, germination was significantly reduced as compared to control. Among all the test crops, the maximum dry weight was obtained from 10 per cent of leaf extracts of all three tree crops, while minimum dry weight belonged to all the test crops under, 100 per cent concentration of leaf and bark extract. The degree of inhibition increased as the concentration increased. Several earlier studies have suggested that the degree of inhibition increases with increasing extract concentrations (Laosinwattana *et al.,* 2009; Teerarak *et al.,* 2010) [6, 16]. Among the test crop, *E. coracana* and *A. caudatus* had shown more resistance in germination as well as root and shoot growth, as compared to the other crops.

Table 1: Effect of leaf extract of *Quercus* species on germination of test crops in pot culture.

Germination (%)	***Q. leucotrichophora***			
	Triticum aestivum	***Echinochloa frumentacea***	***Eleusine coracana***	***Ameranthus caudatus***
T_1 (10%)	75.00^{ab}	90.00^{ab}	96.67^{a}	95.00^{a}
	-4.25	-8.47	-1.69	-1.73
T_2 (25%)	65.00a^{bc}	88.33^{abc}	88.33^{ab}	90.00^{ab}
	-17.02	-10.17	-10.17	-6.90
T_3 (50%)	56.67^{abc}	80.00^{acd}	85.00^{bc}	86.67^{ab}
	-27.65	-18.64	-13.56	-10.34
T_4 (75%)	53.33^{bc}	75.00^{cd}	78.33^{bc}	83.33^{bc}
	-31.92	-23.73	-20.34	-13.80
T_5 (100%)	41.67^{c}	66.67^{d}	76.67^{c}	75.00^{c}
	-46.80	-32.20	-22.03	-22.42
T_6 (Control)	78.33^{a}	98.33^{a}	98.33^{a}	96.67^{a}
	Q. floribunda			
T_1 (10%)	70.00^{a}	83.33^{a}	95.00^{NS}	95.00^{a}
	-2.33	-1.96	-1.73	0.00
T_2 (25%)	65.00^{ab}	68.33^{ab}	93.33^{NS}	91.67^{ab}
	-9.31	-19.61	-3.45	-3.51
T_3 (50%)	60.00^{ab}	63.33^{b}	91.67^{NS}	90.00^{ab}
	-16.28	-25.49	-5.17	-5.26
T_4 (75%)	53.33^{bc}	61.67^{b}	90.00^{NS}	81.67^{bc}
	-25.59	-27.45	-6.90	-14.03
T_5 (100%)	43.33^{c}	60.00^{b}	83.33^{NS}	75.00^{c}
	-39.54	-29.41	-13.80	-21.05
T_6 (Control)	71.67^{a}	85.00^{a}	96.67^{a}	95.00^{a}
	Q. serrata			
T_1 (10%)	65.00^{ab}	91.67^{a}	98.33^{a}	98.33^{a}
	-17.02	-6.77	0.00	+1.72
T_2 (25%)	61.67^{abc}	71.67^{b}	96.67^{a}	91.67^{ab}
	-21.27	-27.11	-1.69	-5.17
T_3 (50%)	48.33^{bc}	70.00^{b}	93.33^{a}	90.00^{ab}
	-38.30	-28.81	-5.08	-6.90
T_4 (75%)	45.00^{bc}	66.67^{b}	83.33^{b}	86.67^{b}
	-42.55	-32.20	-15.25	-10.34
T_5 (100%)	41.67^{c}	60.00^{b}	75.00^{c}	75.00^{c}
	-46.80	-38.98	-23.73	-22.42
T_6 (Control)	78.33^{a}	98.33^{a}	98.33^{a}	96.67^{ab}

(Plus and minus indicate % stimulation (+) and % reduction (-) in per cent germination over control). Different letters in column indicate significant difference among treatments at $P<0.05$ and $P<0.01$).

Table 2: Effect of leaf extracts of *Quercus* species on root and shoots length (cm) of test crops in pot culture.

Extract	*Q. leucotrichophora*							
	Triticum aestivum		***Echinochloa frumentacea***		***Eleusine coracana***		***Amaranthus caudatus***	
	Root (cm)	**Shoot (cm)**	**Root (cm)**	**Shoot (cm)**	**Root (cm)**	**Shoot (cm)**	**Shoot (cm)**	**Shoot (cm)**
T_1 (10%)	14.25^{ab}	24.25^{a}	4.60^{a}	9.19^{b}	3.53^{a}	3.88^{ab}	2.35^{a}	5.20^{ab}
	-4.17	-3.77	-8.00	-29.85	-6.37	-7.84	-7.11	-8.93
T_2 (25%)	13.35^{ab}	22.07^{ab}	4.06^{a}	9.10^{b}	3.30^{a}	3.78^{ab}	1.96^{ab}	5.38^{ab}
	-10.22	-12.42	-18.80	-30.53	-12.47	-10.21	-22.53	-5.78
T_3 (50%)	12.41^{abc}	19.59^{b}	4.01^{a}	8.13^{bc}	2.51^{b}	3.48^{abc}	1.59^{b}	5.11^{bc}
	-16.54	-22.26	-19.80	-37.94	-33.42	-17.34	-37.15	-10.51
T_4 (75%)	11.99^{bc}	15.69^{c}	3.52^{ab}	7.84^{bc}	2.32^{b}	3.28^{bc}	1.49^{b}	4.64^{cd}
	-19.37	-37.74	-29.60	-40.15	-38.46	-22.09	-41.11	-18.74
T_5 (100%)	10.63^{c}	14.09^{c}	2.46^{b}	6.88^{c}	2.21^{b}	2.89^{c}	1.45^{b}	4.33^{d}
	-28.51	-44.09	-50.80	-47.48	-41.38	-31.35	-42.69	-24.17
T_6 (Control)	14.87^{a}	25.20^{a}	5.00^{a}	13.10^{a}	3.77^{a}	4.21^{a}	2.53^{a}	5.71^{a}
	Q. floribunda							
T_1 (10%)	20.77^{ab}	18.26^{ab}	10.83^{a}	18.96^{b}	7.07^{ab}	11.48^{a}	4.83^{ab}	10.12^{a}
	-2.99	-10.80	+1.21	-26.00	-2.21	+0.97	-8.17	-2.88
T_2 (25%)	17.21^{bc}	17.03^{b}	9.93^{ab}	18.33^{bc}	6.67^{abc}	10.21^{bc}	4.56^{abc}	9.08ab
	-19.62	-16.81	-7.20	-28.45	-7.75	-10.20	-13.31	-12.86
T_3 (50%)	16.77^{c}	16.86^{b}	8.40^{bc}	16.60^{bcd}	6.39^{bc}	10.11^{cd}	4.52^{abc}	8.32^{b}
	-21.67	-17.64	-21.50	-35.21	-11.62	-11.08	-14.07	-20.15
T_4 (75%)	16.24^{c}	15.67^{b}	7.73^{c}	16.33^{cd}	6.31^{c}	8.97^{d}	4.13^{bc}	7.61^{b}
	-24.15	-23.45	-27.76	-36.26	-12.72	-21.11	-21.48	-26.97
T_5 (100%)	16.21^{c}	15.65^{b}	7.63^{c}	15.07^{d}	5.48^{d}	7.34^{e}	3.93^{c}	7.51^{b}
	-24.29	-23.55	-28.69	-41.18	-24.20	-35.44	-25.29	-27.93
T_6 (Control)	21.41^{a}	20.47^{a}	10.70^{a}	25.62^{a}	7.23^{a}	11.37^{ab}	5.26^{a}	10.42^{a}
	Q. serrata							
T_1 (10%)	20.17^{a}	26.25^{a}	6.51^{a}	11.97^{ab}	5.69^{a}	5.71^{a}	4.44^{a}	6.83^{a}
	+35.64	+4.17	+30.20	-8.63	+50.93	+35.63	+75.49	+19.61
T_2 (25%)	17.25^{ab}	24.67^{a}	4.79^{bc}	11.31^{b}	5.52^{ab}	5.56^{a}	3.81^{ab}	6.55^{ab}
	+16.01	-2.10	-4.20	-13.66	+46.42	+32.07	+50.59	+14.71
T_3 (50%)	14.37^{b}	24.01^{ab}	4.52^{bc}	10.95^{b}	4.39^{bc}	5.51^{a}	3.77^{ab}	6.17^{abc}
	-3.36	-4.72	-9.60	-16.41	+16.45	+30.88	+49.01	+8.06
T_4 (75%)	13.84^{b}	23.86^{ab}	4.24^{bc}	10.85^{b}	4.21^{c}	4.41^{b}	3.54^{abc}	5.21^{cd}
	-6.93	-5.32	-15.20	-17.18	+11.67	+4.75	+39.92	-8.76
T_5 (100%)	13.49^{b}	21.91^{b}	3.69^{c}	10.58^{b}	3.93^{c}	4.32^{b}	+3.06^{bc}	5.05^{d}
	-9.28	-13.06	-26.20	-19.24	+4.24	+2.61	20.95	-11.56
T_6 (Control)	14.87^{b}	25.20^{a}	5.00^{b}	13.10^{a}	3.77^{c}	4.21^{b}	2.53^{c}	5.71^{bcd}

(Plus and minus indicate % stimulation (+) and % reduction (-) in per cent germination over control). Different letters in column indicate significant difference among treatments at $P < 0.05$ and $P < 0.01$).

Table 3: Effect of leaf extracts of *Quercus* species on seedling dry weight (g) of test crops.

Extract Concentrations	*Q. leucotrichophora*			
	Triticum aestivum	***Echinochloa frumentacea***	***Eleusine coracana***	***Ameranthus caudatus***
	Dry weight (g)	**Dry weight (g)**	**Dry weight (g)**	**Dry weight (g)**
T_1 (10%)	0.323^{b}	0.127^{b}	0.103^{b}	0.103^{b}
	-48.97	-38.65	-42.78	-40.46
T_2 (25%)	0.253^{b}	0.117^{b}	0.093^{b}	0.093^{b}
	-60.03	-43.48	-48.33	-46.24
T_3 (50%)	0.263^{b}	0.107^{b}	0.087^{bc}	0.087^{b}
	-58.45	-58.45	-58.45	-58.45
T_4 (75%)	0.257^{b}	0.100^{b}	0.083^{bc}	0.080^{b}
	-59.40	-51.69	-53.89	-53.76
T_5 (100%)	0.220^{b}	0.063^{c}	0.057^{c}	0.063^{b}
	-65.24	-69.57	-68.33	-63.58
T_6 (Control)	0.633^{a}	0.207^{a}	0.180^{a}	0.173^{a}
Q. floribunda				
T_1 (10%)	0.380^{a}	0.217^{ab}	0.107^{b}	0.107^{b}
	-4.28	-12.15	-17.69	-19.55
T_2 (25%)	0.340^{a}	0.207^{abc}	0.100^{b}	0.100^{b}
	-14.36	-16.19	-23.08	-24.81
T_3 (50%)	0.320^{a}	0.157^{bc}	0.097^{b}	0.090^{bc}
	-19.40	-36.44	-25.38	-32.33
T_4 (75%)	0.307^{ab}	0.153^{c}	0.063^{c}	0.067^{cd}
	-22.67	-38.06	-51.54	-49.62
T_5 (100%)	0.227^{b}	0.150^{c}	0.053^{c}	0.063^{d}
	-42.82	-39.27	-59.23	-52.63

T_6 (Control)	0.397^{a}	0.247^{a}	0.130^{a}	0.133^{a}
Q. serrata				
T_1 (10%)	0.470^{NS}	0.207^{a}	0.160^{ab}	0.170^{a}
	-25.75	0.00	-11.11	-1.73
T_2 (25%)	0.300^{NS}	0.197^{ab}	0.140^{bc}	0.167^{a}
	-52.61	-4.83	-22.22	-3.47
T_3 (50%)	0.357^{NS}	0.163^{bc}	0.120^{cd}	0.157^{a}
	-43.60	-21.26	-33.33	-9.25
T_4 (75%)	0.317^{NS}	0.133^{cd}	0.113^{cd}	0.150^{ab}
	-49.92	-35.75	-37.22	-13.29
T_5 (100%)	0.280^{NS}	0.103^{d}	0.103^{c}	0.117^{b}
	-55.77	-50.24	-42.78	-32.37
T_6 (Control)	0.633^{a}	0.207^{a}	0.180^{a}	0.173^{a}

(Plus and minus indicate % stimulation (+) and % reduction (-) in per cent germination over control). Different letters in column indicate significant difference among treatments at $P<0.05$ and $P<0.01$).

Conclusion

It has been concluded that the higher concentration of leaf extract of all the three *Quercus* species inhibited the germination, initial growth, and biomass of all the test crops. *Q. floribunda* and *Q. serrata* was the most toxic tree species. The leaf extract of these tree species significantly inhibited the germination, root, and shoot growth of test crops. The magnitude of suppression over control in germination and early growth traits increased with an increase in extract concentration and was greatest at maximum concentration of leaf extract (100%). Among the test crops, *T. aestivum* and *E. frumentaceae* were found most susceptible, *E. coracana* showed moderate resistance while *A. caudatus* was the most resistant test crop. It would be worth mentioning here that these tree species are more often than not used as fodder and fuelwood and thereby, phytotoxic accumulation through leaves would be low to moderate in soil. Even so, whatever phytotoxin is accumulated in the soil under tree species comes from bark which would be less in amount.

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