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ALLELOPATHIC POTENTIAL OF *QUERCUS BALOOT* GRIFF

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Abstract

The allelopathic effects of leaves, shoot and bark of *Quercus baloot* Griff. were evaluated under laboratory conditions on *Lactuca sativa, Setaria italica* and *Pennisetum americanum*. Aqueous extract, plant parts and rain leachate obtained from *Quercus baloot* significantly reduced the germination, plumule and radicle growth of *Lactuca sativa, Setaria italica* and *Pennisetum americanum*. Litter extracts were inhibitory to *Lactuca sativa* and *Setaria italica* and hot water extracts were inhibitory to *Setaria italica* and *Pennisetum americanum.* The soil bed, soil extract, and litter bed were inhibitory to in test conditions. In soil intoxication experiment, the shoot and bark exhibited the highest mortality (16-62%) of *Setaria italica*. The phytotoxicity of *Q. baloot* depended upon the plant parts and test species investigated. It is suggested that *Q. baloot* has strong allelopathic potential and the presence of bare or poor understory might be owing its allelopathic effect.

Key words: Allelopathy, *Quercus baloot*, Phytochemicals, Germination, Growth.

Introduction

Quercus baloot Griff. (Family Fagaceae) forms pure forests in the dry temperate zones of Pakistan (Champion *et al*., 1965). However, they have been extensively destroyed by felling and lopping (Beg & Khan, 1980). It appears that these forests may disappear with the passage of time. *Quercus baloot* is used as fuel, handles, agriculture implements, fodder and source of tannin and helps to control erosion.

Allelopathy defined by Molisch (1937) as a chemical interaction between plants or sometimes between microbes and higher plants that included stimulatory as well as inhibitory influences. Later it was defined as any direct or indirect, harmful or beneficial effect of one plant as a donor plant on another as a recipient plant through the production of chemical compounds that escape into the environment. Allelopathy can play significant role under both natural and manipulated ecosystems mainly by adversely affecting seed germination and seedling growth. It plays a key role in weed control, crop protection, and crop re-establishment. Hence, the study of allelopathy has drawn the attention of many ecologists, botanists, agriculturalists and foresters. However, scientific attention has also been drawn to exploit the positive significant roles of allelopathy and what role this phenomenon can play in enhancing crop productivity (Chon & Nelson, 2010). Evidences concerning the role and importance of allelopathy in vegetational patterning have been widely reported (Putnam *et al*., 1990). A significant allelopathic effect of tree species on growth and yield of agriculture crops has been noticed. McPherson & Thompson (1972) showed that *Quercus stellata* and *Q. morilandica* reduced the germination and growth of understory plants that developed bare areas. Kokino *et al*. (1973) reported that decaying leaves of *Q. robur* were inhibitory and stimulatory to *Lepidium sativum*. Bhatt & Chauhan (2000) reported that aqueous extracts of *Quercus glauca* and *Q. leucotrichophora* dried leaves, leaf litter and bark suppressed the germination, plumule and radicle length of wheat, mustard and lentil. Similarly the rhizosphere soil of both tree species suppressed the dry matter of all test crops. Hook & Stubbs (1967) reported that *Quercus falcata, Q. michauxii, and Q. shumardii* affected various seedlings, shrubs and vines due to allelopathic potential. Lodhi (1976) observed bare areas under *Quercus alba* in a bottomland forest in Missouri. The decaying leaves, leaf leachates and soil under *Quercus alba* reduced seed germination, radicle and seedling growth of selected herbaceous species common to area. Beg & Khan (1984) investigated dry Oak (*Quercus baloot*) forest zone in Swat valley and established three new plant communities and these communities had poor growth of the grasses. The literature review suggested that various *Quercus* species have shown significant allelopathic potential and reduced the growth of different plants in the field. In the present study various locations in lower Swat (800 to 2600m) were visited and it was observed that almost all locations showed a bare understorey beneath *Quercus baloot* particularly at Shagai on the way to Marghazar. Although, many annuals and shrubby plants grew in adjacent areas but without *Quercus baloot* canopy.

The lack of herbaceous plants and grasses under *Q. baloot* suggested that *Quercus baloot* might have affected the germination and growth of these plants including medicinal herbs. The lower Swat valley revealed that the lowest temperature was -2ºC. The coldest months were November to March and snowfall occurred during this period. Rainfall was much more during winter than summer. Due to excessive rainfall the soil becomes moist and acts as an absorption and accumulation medium. *Quercus baloot* requires a precipitation zone of 200-1000mm/year or more. The rain leachates of *Q. baloot* might reduce the germination and growth of the other plants that can be useful as fodder, food and for ethnomedicinal purposes particularly for the local people. Considering all these factors it was thought to first investigate the phytotoxic effect of *Q. baloot* against sensitive test species. The present study was undertaken to see if there is any role of allelopathy in the creation of poor or lack of understory by *Quercus baloot*. No reference exists regarding the allelopathic potential of *Quercus baloot* against the *Lactuca sativa, Setaria italica* and *Pennisetum americanum.*

Materials and Methods

Swat occupies the rich floristically rich southern extention Hindu Raj of the Hindukash series and can be traced in between 34º 7′to 35º 7′ N and 71º 4′ to 73º 5′ E. Phytogeographically the area comes under Sino-Japanese regions having Irano-Turanian regions in the north/north west and Saharo-Sindian region in the south. Climatically, Swat is situated in humid subtropical, sub-humid subtropical, humid temperate, subhumid temperate and sub humid subalpine tract (Awan *et al.* 2001).The summer in lower Swat valley is short and moderate while it is cool and refreshing in the upper northern part. The hottest month is June with mean maximum and minimum temperature of 33°C and 16°C, respectively. The coldest month is January with mean maximum and minimum temperature of 11°C and -2°C, respectively. The winter season is long and extends from November to March, rain and snowfall occurs during this season. The amount of rainfall received during winter season is more than that of summer season. The highest rainfall recorded during the month of March is about 242 mm. Agriculture is an economic activity highly dependent on climatic conditions. Changing climate has threatened the productivity of agriculture sector making it vulnerable both economically and physically to climate unevenness and change. Productivity is being affected by a number of climate change variables including rainfall pattern, temperature hike, changes in sowing and harvesting dates, water availability and land suitability. Similarly, low levels of precipitation have a negative effect on the germination of seeds. Production of rice, maize and wheat will go down due to temperature rise. The higher temperatures would likely result in a decline in dairy production, reduced animal weight gain and reproduction (Aydinalp & Cresser, 2008).

Effect of aqueous extract, soil bed, plant part and litter bed, hot water extract, rain leachate, and soil intoxication on germination and growth of *Lactuca sativa, Setaria italica* and *Pennisetum americanum*: Plant parts such as leaves, shoots and barks of *Q. baloot* were collected along with litter from underneath of *Q. baloot* from Swat, KP in 2012. Aqueous extracts were stored at 5-10ºC and used against *Lactuca sativa*, *Setaria italica* and *Pennisetum americanum*. Aqueous extracts, prepared by soaking 5g dried powdered leaves, shoots and barks in 100 ml distilled water for 24, 48, 72 and 96 hours at 25ºC, were used. Control had distilled water in all the experiments. Germination, plumule and radicle growth of 10 seeds in 5 replicates were recorded after 72 hours incubation at 25ºC (Hussain & Gadoon, 1981). In soil bed 20g of control or test soil was uniformly spread in a Petri dish. Seeds were grown in these soils extracts. Similarly, half g powdered leaves, shoots, bark and litter was spread in a Petri dish. In hot water bioassay 5g of powdered leaves, shoots and barks were boiled in 100 ml of distilled water and filtered. The germination, plumule and radicle growth of test species was recorded after 72 hours. In soil intoxication experiment (A) Two g crushed shoots and bark were spread on top of sand in polyethylene pots. Control pots had 2 g fine crushed filter papers. Pots were incubated at 25ºC. (B) Five g powdered barks and shoots were extracted with water and mixed with Hoagland solution. These mixtures were added to the pots. Control pots had distilled water and Hoagland solution. The germination of test species was recorded after 1 week in both bioassays.

On month old seedlings of *Lactuca sativa* were transferred to glass vials. Aqueous extract from shoots and bark was obtained as before. Test and control solutions were prepared by mixing equal volume of extract or distilled water with Hoagland solutions. After 4 weeks, length of seedlings, length and breadth of leaf, root length and mortality of seedling was recorded. In another separate experiment soil extracts & shoots, barks extracts were mixed with Hoagland solution to avoid nutrient deficiency. The control vials had control soil extract, distilled water and Hoagland. The rest of the procedure is similar to the previous experiment. In rain leachate experiment fifteen g of dried leaves, shoots and barks were crushed and placed in large funnels over a single sheet of filter paper. A conical flask was placed below the funnel to collect the rain leachate. Simple rainwater acted as a control. The germination, plumule and radicle growth of the test species was recorded.

Statistical analysis: All the results were statistically analyzed using "t" test and "Z" test. For germination means were compared using "Z" test while plumule and radicle growth means were subjected to "t" test and t-test was used to compare the treatments with control to find out significance and insignificance following (Bluman, 2009).

The objective of this study was (i) to determine the effect of soaking duration of aqueous extracts of various parts of *Quercus baloot* (ii) to observe the effect of soil bed, soil extract and litter bed collected under *Q. baloot* and (iii) to assess the effect of plant parts bed, hot water extract and rain leachates on the germination and growth of test species and similarly (iv) to determine the effect of plant parts extracts and test soil the on leaf length, breadth, seedling and root length of *Lactuca sativa* in two bioassays (v) to detect phytochemicals in bark extract.

Identification of phytotoxins: Aqueous extract of bark prepared earlier was concentrated to 1/3rd of its original volume and acidified with 1N HCl to pH 2-3. Later on to this concentrate double amount of ether was added. Mixture was vigorously re-flux shaken for at least 30 min in separation flask and then separating flask was left till the separation of two layers viz., ether and aqueous layers. The ether layer was saved for concentration while the aqueous fraction was shaken for another two extractions. All the three ether fractions were combined and concentrated in rotavapor. The dry residue, taken in methanol, was spotted on Whatman No.1 filter paper strips along with standard compounds namely caffeic acid, ferulic acid, *p*-OH Benzoic acid, *p*-coumaric acid, chlorogenic acid, ellagic acid, vanillic acid, benzoic acid and quercetin. Chromatograms were run in 6% acetic acid (6% V/V acetic acid) and BAW (*n*-butanol:acetic acid:water = 63:10:27 ml) solvent system in descending order. The chromatograms were inspected under long (366 nm) and short (254 nm) UV light. The chromatograms were then sprayed with spraying reagent

for further confirmation. The different colors and Rf values of standard and unknown compounds were compared for identification (Hussain *et al*., 2011b).

Results and Discussion

In aqueous extract germination of all test species was significantly inhibited by shoot, bark and leaf extracts. Shoot extract inhibited the germination of *P. americanum* seeds followed by *S. italica*, and it stimulated the germination of *L. sativa*. Bark and leaf extracts were more toxic to germination of *S. italica* followed by *L. sativa* and *P. americanum*. Bark and leaf extracts were more toxic to plumule growth of *S. italica* (Table 1). It agrees with Hussain *et al.* (2010) who reported that *Cenchrus ciliaris* and *Bothriochloa pertusa* leaf and root extracts influenced the growth of *Setaria*. In the present study the shoot, bark and leaf extracts retarded significantly the radicle growth of *L. sativa*. This is supported by Zhong-Qun *et al.* (2012), who reported that hot pepper root also inhibited the germination and growth of lettuce seedlings. The allelopathic effect varied among the soaking durations of the extracts and the plant part used. The increasing soaking duration and dose generally increased inhibition of seeds. Similarly, phytotoxicity by *Achillea millifolium* (Sousa *et al*., 2011), *Lantana camara* (Hussain *et al.*, 2011b) increased with soaking duration and this has strongly strengthened the present findings.

In soil bed and extract bioassay germination of all test species except *S. italica* was inhibited. Plumule and radicle growth of all test species was significantly reduced by soil extract as compare to soil bed. The radicle growth of *L. sativa* was significantly influenced by soil bed and soil extract (Table 2). Kitou & Yoshida (1998) reported that water extracts of soil amended with *Artemisia princeps*, *Glycine max, Zea mays* and *Acacia morisima* inhibited the lettuce germination and radicle growth. Wille *et al*. (2013) reported that soil near *Heracleum* reduced germination of *Urtica dioica*. Many workers like Li *et al.* (2010); Xuan *et al*. (2005) confirmed the presence of toxic compounds in the soil owing to allelopathy.

Table 1. Effect of aqueous extracts on germination and growth of test species. Each value expressed as (% of control) is mean of 5 replicates with 10 seeds.

Test species	Shoot extract				Bark extract				Leaf extract			
	Soaking duration (h)				Soaking duration (h)				Soaking duration (h)			
	24	48	72	96	24	48	72	96	24	48	72	96
	Germination (%)											
Lactuca sativa	94.4	94.0	90.0	80.0	80.0	80.0	84.0	94.0	84.0	84.0	88.0	76.0
Setaria italica	62.2	100.0	96.0	96.0	66.0	16.0	80.0	96.0	80.0	36.0	80.0	76.0
Pennisetum americanum	90.0	68.0	76.0	84.0	100.0	68.0	84.0	86.0	100.0	66.0	90.0	90.0
	Plumule growth (mm)											
Lactuca sativa	119.2	163.7	102.7	123.0*	127.5	164.0	109.5	107.0	133.0	165.9	109.5	167.6
Setaria italica	79.2	89.6	150.0	167.4*	121.6	413.0*	116.6	43.0	578.0*	37.9*	100.0	84.8
Pennisetum americanum	113.9	111.8	120.0	118.2	49.9	26.7	113.3	50.0	61.0	57.7	13.3	115.0
	Radicle growth (mm)											
Lactuca sativa	100.0	121.4*	100.0	131.2*	123.0	128.5*	111.7	125.0*	123.0*	135.7*	111.7	118.0
Setaria italica	81.8	54.3*	208.3*	102.9	78.7	65.2*	141.6	72.2*	66.6*	28.2*	125.0*	112.2
Pennisetum americanum	112.7	110.4	137.5	101.7	89.9	58.3	113.0	58.3	21.6	74.0	81.9	84.3

* = Significant at $p<0.05$ (plumule and radicle growth)

Table 2. Germination and early growth of test species in soil bed, soil extract and litter bed bioassays. Each value, expressed as percent of control, is a mean of 5 replicates each with 10 seeds.

Test species	Germination (%)	Plumule growth (mm)	Radicle growth (mm)
a. Soil bed bioassay			
Lactuca sativa	84.0	100.0	156.3**
Setaria italica	100.0	94.1	110.2
Pennisetum americanum	88.0	98.6	730.1
b. Soil extract bioassay			
Lactuca sativa	60.0	61.5	60.0**
Setaria italica	96.0	86.9	96.9
Pennisetum americanum	74.0	54.7	57.14
c. Litter bed bioassay			
Lactuca sativa	40.0*	81.3	29.38
Setaria italica	16.0*	33.3**	24.70**
Pennisetum americanum	78.0*	45.1**	45.1**

* = Significant at $p<0.01$ (Z-test for germination); ** = Significant at $p<0.05$ and $p<0.01$ (T-test for plumule and radicle growth)

In litter bed, the germination of all test species was significantly inhibited by litter bed. Germination of *S. italica* was reduced more than other test species. The plumules and radicles of *S. italica* and *P. americanum* were reduced (Table 2). Zhang & Fu (2010) and Pérez-Corona *et al*. (2013) reported that leaf litter extracts of *Eucalyptus* species inhibited germination speed of radish and cabbage while *Ulmus pumila* suppressed the radicle growth of *T. repens* and *D. glomerata*. In the present study among the test species, *Setaria* was found to be most sensitive than other seeds. Leaves inhibited the germination of test species more than shoot and bark. It suggested that phytotoxicity of *Q. baloot* depends on the plant part and the test species investigated. This agrees with (Sher *et al.*, 2014; Ahmad *et al*., 2014).

The hot water extract of shoot and bark inhibited significantly the germination of *L. sativa* and *S. italica*. The extracts from bark and shoot were more inhibitory than leaf extracts. The plumule growth of *L. sativa* was significantly decreased by all the tested parts showing its sensitivity as compare to other test species. The radicle growth of all test species, except *S. italica* in shoot and *L. sativa* in leaf, shoot and bark was significantly reduced by the extracts (Table 3). It agreed with Sultana & Asaduzzaman (2012) who reported that hot water extracts of *Silybum marianum* decreased the root growth of ryegrass. Similarly, the toxins released from hot water extracts significantly inhibited the germination and growth of the test species. This suggested that phytotoxins were heat resistant and can be obtained quickly. In the plant parts bed bioassay, the leaf inhibited significantly the germination of test species more than shoot and bark. The lowest germination was recorded for *P. americanum* (64%). Plumule growth of *P. americanum* and *S. italica* was affected significantly by shoot and leaf. Radicle growth of *P. americanum* and *S. italica* was significantly affected by all plant parts (Table 3).

Rain is one of the transporting mechanisms of toxins from plants or parts which inhibits growth of vegetation (Moral & Muller, 1969; Bhadhonia 2011; Rice, 1984 and Fujii & Hiradate, 2007). The rain leachates inhibited the germination of all test species. Bark leachates significantly inhibited the germination of *S. italica*. Plumule growth of the *L.sativa* was significantly reduced by shoot leachates and similarly, *P. americanum* was significantly affected by bark leachate. Radicle growth of all test species, except that of *S. italica* in shoot, *L. sativa* in bark and leaf and *P. americanum* in shoot, bark and leaf was arrested significantly by rain leachates (Table 3). It agrees with Hussain *et al.* (2011a) who reported that rain leachates from *Cenchrus ciliaris* and *Bothriochloa pertusa* had inhibitory effect on *L. sativa, S. italica* and *P. americanum* seeds. This suppression could be due to the presence of water soluble toxins released by rainwater.

In the aqueous culture bioassay plant parts extracts were tested against *L. sativa* only and revealed that the shoot and bark extract significantly inhibited the leaf and root length of *L. sativa* (Table 4). The test soil extract reduced significantly only the seedling length of *L. sativa*. The test soils when mixed with shoot bark extracts and it affected significantly the root length only. The seedlings died later on (Table 4). It agrees with Wakjira *et al*. (2005) who observed that *Parthenium hysterophorus* inhibited root and shoot length of lettuce. Similar findings were reported by (Omezzine *et al*., 2011; Pukclai & Kato-Noguchi, 2013) who observed that seedling growth of lettuce was strongly retarded by various plants species. Wilting of the seedling was observed in test soil extracts.

In soil intoxication bioassay germination for *S. italica* and *L. sativa* was significantly reduced by shoot and bark. *Lactuca sativa* had poor germination as compare to other test species. In another bioassay shoot and bark extracts with Hoagland solution were also more inhibitory to *L. sativa* than other test species (Table 5). The results are in line with Ladhari *et al*. (2011) who reported phytotoxic potential of *Thymelaea hirsuta* through incorporating leaves, and other parts into soil (12.5, 25, 50 g/Kg) and irrigated by their aqueous extracts (50g/L), on the growth of *Lactuca sativa* and it was observed that at the highest dose, leaves residues caused total inhibition for lettuce seedling growth.

Table 3. Germination and growth of test species in three bioassays. Each value, expressed as percent of control is a mean of 5 replicates each with 10 seeds.

Test species	Plant parts bed			Hot water extract			Rain leachate		
	Shoot	Bark	Leaf	Shoot	Bark	Leaf	Shoot	Bark	Leaf
	Germination (%)								
Lactuca sativa	100.0	100.0	100.0	80.0*	78.0*	88.0	80.0	78.0	88.0
Setaria italica	90.0	96.0	92.0	76.0*	84.0*	89.0	76.0	86.0*	89.0
Pennisetum americanum	92.0	88.0	64.0*	94.0	100.0	82.0	94.0	100.0	82.0
	Plumule growth (mm)								
Lactuca sativa	144.4	144.4	57.5	138.5*	115.4*	123.0*	71.8**	76.9	33.3
Setaria italica	137.0	100.0	37.4**	121.4	78.6	89.6	155.0	76.0	90.0
Pennisetum americanum	40.0**	91.4	25.7	103.8	100.0	103.8	92.3	34.6**	103.0
	Radicle growth (mm)								
Lactuca sativa	100.0	115.5	39.0	75.0	75.0	141.6	57.6**	69.6	60.6
Setaria italica	139.0**	34.8**	17.4**	103.7	88.8*	62.9*	140.0	60.0**	90.0**
Pennisetum americanum	63.0**	86.9*	30.4**	70.8*	89.6*	72.6*	86.3	39.2	47.05

* = Significant at $p<0.05$ (germination in three bioassays); * = Significant at $p<0.05$ (radicle) and ** = Significant at $p<0.05$ and $p<0.01$ (plumule and radicle in plant part); * = Significant at $p<0.05$ only (plumule and radicle in hot water); ** = Significant at $p<0.05$ only (plumule and radicle in rain leachate)

Table 4. Effect of plant part extracts of *Quercus baloot* and test soils extract on leaf length, breadth, seedling and root length of *Lactuca sativa* in vials. Each value, expressed as percent of control, is a mean of 5 replicates.

Parameters (cm)	Shoot extract	Bark extract	Test soil extract	Test soil extract, bark extract, Hoagland solution	Test soil extract, shoot extract, Hoagland solution
Leaf length	107.0**	3166.6	40.38	14.86	100.5
Leaf breadth	128.6	79.7	217.0	113.6	83.15
Seedling length	9.84	10.08	78.48**	99.8	99.0
Root length	97.26	202.0**	77.02	11.98**	99.0**

** = Significant at $p<0.05$ and $p<0.01$

Table 5. Effect of plant parts and plant parts extracts of *Quercus baloot* on germination (%) of *Lactuca sativa* in soil intoxication experiment. Each value, expressed as percent of control, is a mean of 5 replicates with 10 seeds.

Test species	Germination (%)			
	Plant parts		Plant parts extracts	
	Shoot	Bark	Shoot extract and Hoagland solution	Bark extract and Hoagland Solution
Lactuca sativa	38.0*	30.0*	36.0*	46.0*
Setaria italica	62.0*	46.0*	56.0*	72.0*
Pennisetum americanum	86.4	72.7	70.0*	60.0*

* = Significant at $p<0.05$ (germination in two bioassays)

The phytochemical study showed the presence of *p*-OH-benzoic acid, benzoic acid, *p*-coumaric acid, coumaric acid, caffeic acid, vanillic acid, ferulic acid, chlorogenic acid, ellagic acid, quercetine and unidentified spots in the present study. These phytochemicals could be responsible for the inhibition of the germination and growth of the test species in the present study. The literature review suggests that these compounds were found in various allelopathic plants (Ali *et al*., 2013; Yan *et al*., 2013) and exhibited inhibitory activity against many test species. Allelochemicals interfere with seed germination and growth of neighbouring or successional plants by releasing allelochemicals in their environment (Chandra *et al*., 2012). Yukiko *et al*. (2001) reported phenolic compounds in the soil beneath the trees of *Quercus mongolica* var. *grosseserrata*, that inhibited the seeds germination of *Betula platyphylla* var. *japonica*. Similarly, Djurdjević *et al*. (2005) reported that leaves of *Quercus conferta* and *Q. cerris* had *p*-coumaric, ferulic, syringic and vanillic acids. Phenolics of oaks are the main allelochemicals, which regulate the composition and structure of plant communities. No phenolics have been previously detected in *Quercus baloot*.

The present study indicated that aqueous extract, plant parts and rain leachate obtained from *Quercus baloot* inhibited significantly the germination, plumule and radicle growth of *L. sativa, S. italica* and *P. americanum*. In addition, litter collected below *Q. baloot* reduced only *L. sativa* and *S. italica* growth and hot water extracts were inhibitory to *S. italica* and *P. americanum.* The effect of soil was also significant as soil bed, soil extract, reduced germination and growth of test species. Many factors can influence the allelopathic activity from the donor perspective, as well as influence the response of the receptor organism. The concentration of the compounds, may vary along the day and season, or may be influenced by environmental conditions (light, water, temperature and nutrients), genetic factors or even by the age of the plant or the organ (Souza, 2010). The low and high temperatures and shading conditions influenced the inhibiting effects of allelochemicals of *Ageratum conyzoides* on tested plants (Hu & Kong, 2002). However, herbivores, pathogens and microorganisms can also increase or reduce the concentration of the allelochemicals (Rice, 1984). The differential allelopathic potential of *Q. baloot* that affected the germination and growth of the test species in different experiments in the present research could be due to the present environmental conditions as there is a lot of variation in water availability, temperature, rainfall, shading conditions, sunshine time and soil environment in the study area. All such factors strongly affect the allelopathic capability of plants in nature.

Allelopathy can affect occurrence, growth, the structure of plant communities, dominance, diversity and plant productivity. Many of the forestry species have negative allelopathic effects on food and fodder crops. Early research showed poor regeneration of forest species, crop damage, yield reductions and other related changes in vegetation. The present investigation revealed that *Q. baloot* plant parts, rain leachate, litter, soil bed and soil extract significantly reduced the growth of test species in the laboratory experiments but the field experiments need to be done to confirm the inhibitory effects. Keeping in view the inhibitory potential of *Q. baloot* and to confirm the occurrence of the allelopathic activity, it is necessary to verify whether, in natural conditions, the compounds are released and accumulated in the environment at levels which could actually affect the individuals of the community (Souza, 2010). The present results also suggest *Q. baloot* may affect the growth, occurrence and diversity of plants as some plant species may be dominant in one season may not be dominant in another season due to *Q. baloot* allelopathy and it may alter the community structure.

Therefore, the present investigation suggests that *Quercus baloot* showed strong allelopathy through water leachable toxins. In addition, volatile substances can also play role in its allelopathy which were not tested in the present study.

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