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Allelopathic effect of *Robinia pseudoacacia* on germination and growth of some important food crops of the Garhwal Himalayas

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Abstract
The present study was conducted to assess the allelopathic effect of leaf and bark aqueous extracts of *Robinia pseudoacacia* on germination and growth of some important food crops of the Garhwal Himalayas *viz. Triticum aestivum*, *Hordeum vulgare*, *Lens culinaris* and *Brassica rapa* in laboratory and pot culture experiment. Different leaf and bark aqueous extracts (5%, 10%, and 15%) were prepared by soaking 25g, 50g and 75g of dry leaves and bark powder in 500mL of distilled water for 24 hours at room temperature and the resultant leaf and bark extracts were used to irrigate the seeds of various test crops. The results revealed that in laboratory conditions the concentration dependent significant inhibitory effect of all the concentrations of aqueous leaf extracts on germination, root length and shoot length of all the test crops except in *Hordeum vulgare* where, the stimulatory effect of all the concentrations of leaf extract was observed in shoot length. Among all the test crops *Lens culinaris* was found most sensitive with (41.6%) germination and root length (2.1 cm) in the seeds treated with 15% concentration of leaf extract as compared to control having germination (72.3%) and root length (7.2 cm). Similarly the maximum reduction by the 15% concentration of leaf extract was noticed in the shoot length of *Brassica rapa* (5.5 cm) as compared to control (9.1cm). The 15% bark extract showed the maximum inhibitory effect on the germination of *Hordeum vulgare* where germination percentage was reduced (48.0%) as compared to control (81.6%). Similarly, the maximum reduction in root length (2.7 cm) and shoot length (2.1 cm) as compared to control with root length (7.2 cm) and shoot length (6.7 cm) was observed in *Lens culinaris* by 15% bark extract. In pot culture experiment *Hordeum vulgare* was most sensitive with respect to germination percentage (39.2%) in 15% leaf extract as compared to control (77.0). While in root length maximum inhibitory effect was recorded in *Brassica rapa* (3.4 cm) by 5% leaf extract as compare with control (4.2 cm). In general the non-significant stimulatory effect of all the concentrations of leaf extract was observed in all the test crops whereas, in *Lens culenaris* the effect was significant stimulatory with shoot length (19.5cm) in 15% concentration as compared to control (19.0 cm). Similarly 15% bark extract, performed maximum reduction in *Brassica rapa* where the germination percentage was significantly reduced down (40.7%) as compare with control (77.5%). However, the effect of all the concentrations of bark extract showed non-significant effect on root length and shoot length of all the test crops. Therefore, to reduce allopathic effect on all the test crops *viz., Triticum aestivum*, *Hordeum vulgare*, *Lens culinaris* and *Brassica rapa* it is advised to remove the fallen leaves and bark from the field.

Keywords: agricultural crops, allelopathy, bioassay, leaf leachate, *Robinia pseudoacacia*

Introduction
Plants are known to synthesize various allelochemicals which are secondary metabolites and are the by-products of primary metabolic processes (Levin, 1976) [11]. These toxic metabolites are distributed in all the plant parts in various concentrations, but the leaves are considered as the most potent source (Kumar *et al*., 2006) [10]. The allelochemicals present in plants can be released through the process of volatization, stem flow or litter decomposition and form leaf aqueous leachate in the soil. These chemical compounds are released in their environment to keep themselves with a competitive advantage (Kong *et al*., 2004) and to offer resistance against insects, nematodes and pathogens attack.

Robinia pseudoacacia L. (Black locust), family Papilioniodaceae is an exotic nitrogen fixing tree and widely planted to for shelterbelts and land reclamation purposes in agroforestry system. (Nasir *et al*. 2005) [14]. The tree has wider adaptability, fast growing nature and produce qualitative timber. Globally this is a third most planted tree species after hybrid poplar and eucalyptus species. Besides, having many advantages, several allelochemicals *i.e.*, robinatin, myrecetin and quarcetin (Nasir *et al*. 2005) [14] have also been reported from its leaves extracts. So, the present study was conducted to explore the allelopathic effect of *Robinia pseudoacacia* L. leaf and bark extract on germination and growth

of traditional food crops of the Garhwal Himalayas *viz. Triticum aestivum, Hordeum vulgare, Brassica rapa* and *Lens culinaris*.

Material and Methods

Present study was conducted in the College of Forestry (V.C.S.G. Uttarakhand University of Horticulture and Forestry) Ranichauri, Tehri Garhwal, Uttarakhand, having geo-coordinates 30^0 15' N latitude and 78^0 30' E longitude at an altitude of about 2100 meter mean above sea level. The metrological data was collected from the observatory of college campus showed the mean monthly maximum and minimum temperature during the study period (August, 2015 to March, 2016) ranges between 22.8 °C to 2.0 °C and annual rainfall between 1.2 to 197 mm. The fresh leaves and bark of *Robinia pseudoacacia* were collected from ten trees at Forestry Nursery Block and the seeds of five agricultural crops were collected from Department of Agriculture and Seed Science of College of Forestry, Ranichauri. Then Healthy leaves and bark were dried at room temperature (25±2 ^{0}C) and grinded in mechanical grinder. To prepare leaf aqueous extract 25g, 50g and 75g of dry leaf and bark powder was soaked in 500mL of distilled water for 24 hours at room temperature. The resultant solution was filtered with a three layers of Whatman filter paper no.1 and stored in a conical flask. The germination trial was conducted in laboratory condition, 25 seeds of each test crop were placed in a petri dish (9 cm diameter) and kept in a germinator at a temperature 25±2° C. Thus, there were different concentrations of leaves and bark extract *viz.,* 0% (Control), 5% and 10%.To moistened the petri dishes 1ml of aqueous extract or distilled water was added in the respective treatment. The experiment was extended over a period till last seed germinated (8 days), the seed was considered as germinated when the radical emerged out. Finally, the shoot and root length of 10 randomly selected seedlings from each replicate were measured at the end of experiment. Similarly in pot culture experiment before sowing of test crop seeds, root trainers were filled with mixture made by sand, rhizospheric soil and FYM in the ratio of 1:2:1 ratio. Twenty seeds per replication of each test crop were sown in root trainers. Each root trainer was added with 100 ml of leaf and bark extracts of different concentrations (i.e. 5%, 10%, and 15%) and 100 ml distill water was used as a control. Then the treatment trainers were irrigated with 100ml of water every alternate day. The experiment was conducted in completely randomized design with three replications in laboratory while four replications in field condition. At the end of field experiment the root and shoot length of 10 seedlings were recorded.

Results

Wheat (*Triticum aestivum*)

In laboratory condition, the leaf and bark extract of *R. pseudoacacia* exhibited significant concentration dependent inhibitory effect on the germination of wheat. Maximum germination percentage was observed in control (78.0%) while minimum in the 15% concentration of leaf extract (50.3%) (Table 1). In case of bark extract the minimum value for germination percentage was noted in seed treated with 15% concentration of extract (48.3%) (Table 2). Similarly, the leaf and bark extract showed significant inhibitory effect in root and shoot length. Maximum root length was observed in control (15.1 cm) while minimum in 15% leaf extract (6.3cm). In case of shoot length maximum shoot length was recorded in control (15.1 cm) while minimum in 5% concentration of leaf extract (10.6 cm) (Table 1).In bark extract maximum shoot length was recorded in control (15.1 cm) while minimum root and shoot length in 10% bark extract (4.4 cm) (Table 2).

In pot culture, both leaf and bark extract showed significant concentration dependent inhibitory effect on wheat germination. Maximum germination (81.0%) was observed in control while minimum in 15% concentration of leaf extract (41.5%) (Table 3), likewise in bark extract minimum germination was recorded under 15% concentration (42.7%) (Table 4).In leaf and bark extract non-significant inhibitory effect was recorded for both root and shoot length. Maximum root length was noted in control (18.1 cm) while minimum in 10% leaf extract (16.4 cm). Maximum shoot length (23.7 cm) recorded in 5% concentration whereas minimum (18.8 cm) was observed in 10% leaf extract (Table 3). Similarly maximum root length (18.4 cm) was recorded in 5% concentration of bark extract while minimum (17.1 cm) in 10% concentration. Likewise, maximum shoot length (27.5 cm) was observed in 5% concentration of bark extract whereas minimum shoot length in control (23.1 cm) (Table 4).

Lentil (*Lens culinaris*)

In lab bioassay the increasing concentration of leaf and bark extract showed concentration dependent significant inhibitory effect on germination and root length. Maximum germination percentage was recorded in control (72.3%) while minimum in 15% concentration of leaf extract (41.6%) (Table1). Similarly, the germination percentage was reduced down by15% bark extract (46.6%) (Table 2). Maximum root length was observed in control (7.2 cm) while minimum in 15% leaf extract (2.1 cm).In case of shoot length significant stimulatory effect were recorded at lower concentration exceptionally. Maximum shoot length was recorded in 5% concentration (8.4 cm) while, minimum in 15% concentration of leaf extract (6.0 cm) (Table 1). In bark extract significant inhibitory effect was observed in root and shoot length. Maximum root (7.2 cm) and shoot length (6.7 cm) were found in control whereas minimum root (2.7 cm) and shoot length (2.1cm) in seed treated with 15% concentration of extract.

In pot culture the leaf and bark aqueous extract showed concentration dependent significant inhibitory effect on germination. Maximum germination was recorded in control (69.5%) while minimum in 15% concentration of leaf extract (40.7%) (Table 3).Similar results were observed in bark extract where minimum germination was recorded in 15% concentration (39.5%) (Table 4). The leaf extract exceptionally showed significant stimulatory effect at higher concentration on root and shoot length. Maximum root length was observed in 10% concentration (14.7 cm) while minimum in 5% concentration (11.6cm). Similarly maximum shoot length (19.5 cm) was recorded in 15% concentration of leaf extract whereas minimum shoot length in 5% concentration (17.3 cm) (Table 3).In bark extract non-significant inhibitory effect were noted on both root and shoot length. The maximum root length was recorded in control (14.5 cm) while minimum in seeds treated with 5% bark extract (13.7 cm) in shoot length maximum shoot length was recorded in control (19.0 cm) while minimum in 10% bark extract (18.2 cm) (Table 4).

Barley (*Hordeum vulgare*)

In laboratory condition, leaf and bark extract showed significant inhibitory effect on germination percentage of

barley. As the concentration of extract was increased it showed significant decreasing effect of the germination percentage. Maximum germination percent was observed in control (81.6%) while minimum in 15% leaf extract (56.0 cm) (Table 1). Similarly in bark extract minimum germination percent recorded in 15% concentration (48.0%) (Table 2). In root length and shoot length non-significant inhibitory effect of leaf extract was recorded. Maximum root length (8.2 cm) was recorded in control which was at par with and 15% concentration (8.2 cm), while minimum root length was recorded in seed treated with 5% concentration of leaf extract (6.4 cm). Similarly shoot length was recorded maximum in 10% concentration (16.2 cm) while minimum in control (12.5 cm) (Table 1). In bark extract the increased concentration showed non-significant inhibitory effect on root length. Maximum root length was noted in control (12.5 cm) whereas minimum root length in both 5% and 10% concentration (3.9 cm) respectively. Likewise significant inhibitory effect was recorded in shoot length. Maximum shoot length was recorded in control (12.5 cm) while the minimum in 10% bark extract (5.1 cm) (Table 2).

In pot culture, germination percentage of barley were significantly reduced by the leaf and bark extract. Maximum germination percentage was recorded in control (77.0%) while minimum in seed treated with 15% concentration of leaf extract (39.2%) (Table 3). However in bark extract minimum germination percent was observed in 15% concentration level (41.0%) (Table 4). Maximum root length was recorded in 15% concentration (8.4 cm) while minimum in control (7.0 cm). Comparable results were found in shoot length. Maximum shoot length was recorded in 10% concentration (27.6 cm) while minimum in control (21.3 cm) under leaf extract (Table 3). Maximum root length was noted in control (7.0 cm) while minimum root length) in 10% and 15% concentration respectively (6.5 cm). In shoot length maximum value was observed in 5% concentration (25.9 cm) while minimum in control (21.3 cm) (Table 4).

Table 1: In laboratory bioassay effect of leaf extract of *Robinia pseudoacacia* on germination and growth parameters of test crops.

Extract levels	Leaf											
	Triticum aestivum			*Lens culinaris*			*Hordeum vulgare*			*Brassica rapa*		
	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)
Control	78.0	15.1	15.1	72.3	7.2	6.7	81.6	8.2	12.5	79.6	8.8	9.1
5%	72.6	8.3	10.6	67.3	5.4	8.4	75.0	6.4	14.3	76.3	5.1	7.8
10%	62.6	7.4	13.5	51.3	3.3	6.3	64.0	7.1	16.2	64.3	3.2	6.9
15%	50.3	6.3	11.7	41.6	2.1	6.0	56.0	8.2	15.1	51.6	2.2	5.5
Mean	65.9	9.3	12.7	58.0	4.5	6.8	69.1	7.5	14.5	68.0	4.8	7.3
SE±	2.4	0.5	0.5	1.3	0.5	0.2	2.6	1.2	0.8	2.4	0.5	0.3
CD@ (5%)	7.9**	1.7**	1.7**	4.4**	1.7**	0.9**	8.7**	3.9NS	2.7NS	8.0**	1.9**	1.1**

Table 2: In laboratory bioassay effect of bark extract of *Robinia pseudoacacia* on germination and growth perameters of test crops.

Extract levels	Bark											
	Triticum aestivum			*Lens culinaris*			*Hordeum vulgare*			*Brassica rapa*		
	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)
Control	78.0	15.1	15.1	72.3	7.2	6.7	81.6	8.2	12.5	79.6	8.8	9.1
5%	72.6	5.6	6.5	68.6	3.0	3.3	71.0	3.9	7.4	79.0	3.7	3.9
10%	62.3	4.4	4.4	58.6	3.6	2.6	53.3	3.9	5.1	64.3	3.8	4.8
15%	48.3	5.9	5.1	46.6	2.7	2.1	48.0	4.1	8.2	54.6	3.6	3.8
Mean	65.3	5.9	6.1	61.2	3.5	3.7	62.2	4.3	8.0	69.0	3.9	4.6
SE±	2.0	0.5	0.4	2.0	0.4	0.8	2.7	0.3	0.6	2.0	0.2	0.2
CD@ (5%)	6.6**	1.7**	1.5*	6.5**	1.5*	2.8*	9.0**	1.1NS	2.2**	6.7**	0.9NS	0.9**

Table 3: In field bioassay effect of leaf extract of *Robinia pseudoacacia* on germination and growth perameters of test crops.

Extract levels	*Triticum aestivum*			*Lens culinaris*			*Hordeum vulgare*			*Brassica rapa*		
	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)
Control	81.0	18.1	23.1	69.5	14.5	19.0	77.0	7.0	21.3	77.5	4.2	13.2
5%	69.5	17.4	23.7	68.5	11.6	17.3	75.5	8.1	26.4	70.2	3.4	14.0
10%	53.7	16.4	18.8	48.7	14.7	18.5	54.5	7.8	27.6	55.5	3.6	13.3
15%	41.5	17.3	20.5	40.7	14.6	19.5	39.2	8.4	26.9	43.5	4.0	13.4
Mean	61.4	17.3	21.5	56.8	13.8	18.6	61.5	7.8	25.5	61.6	3.8	13.5
SE±	1.5	0.6	1.7	1.5	0.4	0.4	1.7	0.5	1.6	2.7	0.2	0.4
CD@ (5%)	4.6 **	1.9 NS	5.3 NS	4.9**	1.4 **	1.4*	5.4**	1.6 NS	5.1 NS	8.6 **	0.7 NS	1.2 NS

Table 4: In field bioassay effect of bark extract of *Robinia pseudoacacia* on germination and growth perameters of test crops.

Extract levels	*Triticum aestivum*			*Lens culinaris*			*Hordeum vulgare*			*Brassica rapa*		
	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)	Ger %	Root length (cm)	Shoot length (cm)
Control	81.0	18.1	23.1	69.5	14.5	19.0	77.0	7.0	21.3	77.5	4.2	13.2
5%	72.5	18.4	27.5	68.7	13.7	18.5	75.7	6.8	25.9	73.0	3.4	12.5
10%	55.5	17.1	23.5	55.0	13.8	18.2	58.7	6.5	21.9	59.7	3.3	12.0
15%	42.7	17.9	25.6	39.5	14.0	18.5	41.0	6.5	23.6	40.7	3.5	11.4
Mean	62.9	17.9	24.9	58.1	14.0	18.5	63.1	6.7	23.2	62.7	3.6	12.3
SE±	1.8	0.3	1.3	1.7	0.3	0.6	1.6	0.3	1.9	2.1	0.2	0.4
CD@ (5%)	5.6**	1.0 NS	4.2 NS	5.5**	1.0 NS	1.8 NS	5.0**	1.1 NS	5.9 NS	6.6**	0.9 NS	1.4 NS

Toria (*Brassica rapa*)

In crop *Brassica rapa*, results showed proportionate significant inhibitiory effect on germination percentage, root and shoot length with increasing the concentration of leaf and bark extract. Maximum germination was observed in control (79.6%) while minimum in 15% concentration (51.6%) (Table 1). In case of bark extract minimum germination percentage in 15% concentration level (54.6%) (Table 2). Maximum root length was recorded in control (8.8 cm) while minimum in 15% concentration (2.2cm). Likewise in shoot length, maximum shoot length was recorded in control (9.1 cm) while minimum (5.5 cm) in 15% leaf extract (Table 1). In the bark extract results showed non- significant inhibitory effect on root length. Maximum root length was recorded in control (8.8 cm) while minimum (3.6 cm) in 15% concentration (13.6 cm). Maximum shoot length was recorded in control (9.1 cm) while minimum in 15% bark extract (3.8 cm) (Table 2).

In pot culture, the effect of leaf and bark extract showed rapid decreasing effect on germination percentage. The maximum increasing the concentration of leaf extract germination percentage was observed maximum in control (77.5%) while minimum germination in 15% concentration (43.5%) (Table 3). Similarly in bark extract the minimum germination percentage was recorded in 15% concentration (40.7%) (Table 4). Maximum root length was found in control (4.2 cm) while minimum in seeds treated with 5% concentration (3.3 cm). Similarly, in shoot length non-significant stimulatory effect was recorded in different concentrations. Maximum shoot length was recorded in 5% concentration (14.0 cm) while minimum in control (13.2 cm) (Table 3). Maximum root length was recorded in control (4.2 cm) while minimum in 10% concentration of bark extract (3.3 cm). Whereas in case of shoot length maximum shoot length was recorded in control (13.2 cm) while minimum shoot length in 15% concentration (11.4 cm) (Table 4).

Discussion

Present study clearly revealed that in laboratory condition leaf and bark extract of *Robinia pseudoacacia* showed a concentration dependent significant inhibition on germination percentage, root length and shoot length as compare to control in all the test crops exceptionally in *Lens culinaris* and *Hordeum vulgare*, where stimulatory effect were observed in shoot length towards the increasing concentration of leaf extract. These inhibitory effects observed might be due to the presence of different allelochemicals present in leaves of *Robinia pseudoacacia.* The allelopathic effect was more pronounced to the germination and emergence of root and its development. The senstivity of test crops towards the allelopathic effect of different concentration varied in both leaf and bark extract. Similar results were also observed by Ismail and Maitali (2014) [6], where they reported the effect of aqueous leaf extract of *Acacia mangium* showed significant reduction in germination of Paddy varieties as leaf extract concentration increased from 10% to 12%. Mishra (2014) [13] also found inhibitory effect of aqueous leaf extract of *Azadirachta indica* on germination of *Pistum sativum*, *Pennisetum americannum*, *Raphanus sativus* and *Cicer arietinum* and significant inhibition on root length on 100% concentration. Comparable results were also in line with *Mandal et al.,* (2003) [12] where they reported the inhibitory effect of three agroforestry species (Viz, *Dalbergia sissoo*, *Acacia lenticuleris*. L and *Bombax ceiba.* L) On germination of wheat. Similar results were also reported by Bhatt and Singh (2009) [4], where they suggested the allelopathic effect of *Michelia champaca* and *Tectona grandis* leaf extract significantly reduced the germination and seedling length of *Arachis hypogeae*, *Brassica compastris*, *Oryza sativa*, *Vigna radiate* and *Vigna umbellata.* The magnitude of sensitivity towards the increasing concentration of leaf extract on germination present in a following order: *Lens culinaris >Triticum aestivum >Brassica rapa >Hordeum vulgare*. However, in bark extract *Brassica rapa >Lens culinaris >Triticum aestivum >Hordeum vulgare*.

Rejila and Vijaykumar (2011) [18] also reported the aqueous leaf extract of *Jatropa curcus* stimulate the shoot length of *Sesamum indicum*. Shruthi *et al*., (2014), found that the aqueous leaf extract of *Azadirachta indica* showed stimulatory effect on shoot growth of *Vigna radiate* at 5% concentration. Rawat *et al.* (2016) [16] also found the stimulatory effect of lower concentration (25%) of *Dendrocalamus stocksii* (Munro.) on plumule length of paddy.

In pot culture, the results depicted significant inhibitory effect in germination percentage in both leaf and bark extract. The magnitude of sensitivity towards the increasing concentration of leaf extract on germination present in a following order: *Lens culinaris > Brassica rapa > Triticum aestivum >Hordeum vulgare*. However, in bark extract *Lens culinaris >Hordeum vulgare >Triticum aestivum >Brassica rapa*. In general, the concentration dependent significant (p=0.05) inhibition were recorded in *Triticum aestivum* and *Brassica rapa* it means that the roots of these test crops might be susceptible towards the increasing effect of allelochemicals present in leaf extract of *Robinia pseudoacacia* while in *Lens culinaris* and *Hordeum vulgare* there is a significant stimulatory effect were observed in root length which is directly proportional towards the increasing concentrations. However in shoot length stimulatory effect were observed in different concentration for all test crops but the results were non-significant. Similarly in bark extract non-significant inhibitory effect were recorded in root length except in *Triticum aestivum* where stimulatory effect was recorded in

lower concentration. Similarly, leaf and bark aqueous extract of *Quercus glauca* and *Quercus leucotricophora* have depressive allelopathic effect on germination and radical plumule length of *Triticum aestivum*, *Brassica compastris* and *Lens culinaris* have been reported by Bhatt and Chauhan (2000) [2]. Similar results were also in line with Bhatt *et al.*, (1993) where they reported the inhibitory effect of *Grewia optiva* aqueous extract on germination percentage of *Glycine max.* According to Singh *et al.,* (2006) [20] the results revealed that *Dalbergia sissoo*, *Bombax ceiba* and *Acacia catechu* possess inhibitory allelopathic effect on germination and seedling growth of *Triticum aestivum*, *Brassica compastris*, *Lens culinaris* and *Hordeum vulgare*. Similar results were also found by Sarkar *et al*., (2012) [19] where they showed inhibitory effect of different leaf concentration of *Cassia tora* on seed germination, root and shoot length of mustard. They also depicted that roots were more affected than shoots and the extract taken from leaves was more suppressive than that taken from other plant parts. The present findings support the earliest report by Kaushal *et al*., (2011) [8] where they observed stimulatory effect of aqueous leaf leachates of *Morus alba*, *Grewia optiva*, *Toona ciliate* on seedling growth parameters of *Zea mays* and *Glycine max* at lower concentrations. Similar results were proposed by Bhat *et al*., (2011) where they suggested the allelopathic effect of *Anogeissus latifolia* aqueous leaf extract stimulated radical growth of *Vigna unguiculata* at lower concentration. Rawat *et al.* (2018) also found the stimulatory effect of lower concentration (25%) of *Dendrocalamus stocksii* (Munro.) on radicle length of *Vigna unguiculata.*

Conclusion

Finally, it is concluded that the aqueous leaf and bark extract of *Robinia pseudoacacia* showed depressive effect on germination, emergence of radical, plumule and their development in laboratory as well as in pot culture experiment. Therefore, to reduce allopathic effect on all the test crops *viz., Triticum aestivum*, *Hordeum vulgare*, *Lens culinaris* and *Brassica rapa* it is advised to remove the fallen leaves and bark from the field.

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