

Article

Phytotoxicity of Two *Bauhinia* Species on Four *Triticum aestivum* Varieties in Laboratory Bioassay

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Abstract: Tree–crop interaction studies help to determine the effects of trees on the production and yield of agricultural crops and could help indecisions on suitable crops and tree combinations to increase the overall production from agroforestry systems. Different varieties of agricultural crops might show different responses against the phytotoxic effects of *Bauhinia* species. This study was conducted to observe the phytotoxicity of two *Bauhinia* spp., i.e., *Bauhinia retusa* and *Bauhinia variegata*, on some *Triticum aestivum* varieties, i.e., VL-892, VI-829, VL-616, UP-2572, and UP-1109. The leaves and bark of these two species were harvested from the natural population for these experiments. On average, germination and radicle and plumule length of wheat varieties were significantly ($p > 0.05$) reduced by the leaf and bark extracts of both *Bauhinia* species. The effect of leaf and bark extracts of both *Bauhinia* species on seed germination percent of different wheat varieties revealed that the bark and leaf extracts showed maximum toxicity for germination percentage, and minimum influence was observed in radicle and plumule length. However, bark extracts were more toxic as compared to leaf extracts. Under leaf and bark extract concentrations, the VL 829 wheat variety showed stimulatory effects in germination and radicle and plumule growth under both *Bauhinia* species. On average, radicle and plumule growth of the test crop was increased with an increasing concentration of leaf and bark extract of *B. variegata* up to 50%, and thereafter, a decrease in radicle and plumule length was recorded. The VL 829 and UP 1109 varieties showed the lowest allelopathic effects and could be grown under both *Bauhinia* species with minimum yield loss.

Keywords: *Bauhinia variegata*; *B. retusa*; germination; radicle length; plumule length; growth; leaf and bark extracts



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1. Introduction

The *Bauhinia* species (family Fabaceae) is found in tropical and subtropical regions of the Himalayas [1]. *Bauhinia* is an important species, and it is represented by about 15 species in India in the form of trees, shrubs, and climbers. Among these species, *Bauhinia retusa* Roxb. and *Bauhinia variegata* L. are species that are ecologically and economically important. Both *Bauhinia* species are used for fodder during the scarcity of fodder, particularly in the summer months [2]. Due to its importance, it needs to be included in different agroforestry systems [3].

For this purpose, a tree–crop interaction study should be conducted to assess the phytotoxicity of both *Bauhinia* species on different wheat varieties. Very little systematic and organized information is available on these agroforestry species concerning their phytotoxic effect. Allelopathy is the compound alteration of a site to help improve tree growth and control ecological volume and important wealth [4]. This modification is conveyed through biomolecules known as allelochemicals, which come to the soil from plant parts by leaching in rainwater, root exudation, volatilization, decomposition of leaf litter, and other processes in both natural and agricultural systems [5].

The reduction/stimulation in germination and growth of recipient crops is due to different secondary metabolites, i.e., terpenoids, flavonoids, tannins, saponins, reducing sugars, steroids, and cardiac glycosides [6]. In *Leucaena leucocephala*, phenolic acids, flavonoids, and mimosine were found to be efficient allelopathic agents [7]. The bark and leaf extracts of *Ficus auriculata* and *F. semicordata* provided a rich supply of flavonoids and polyphenolic compounds, which had inhibitory and stimulatory effects on *Eleusine coracana* L., *Echinochloa frumentacea* L., *Amaranthus caudatus* L., and *Vigna umbellata* Thunb. [8]. In the leaves and bark of both *Bauhinia* species, secondary metabolites, i.e., water-soluble saponins, hormones, saponins, enzymes, terpenoids, alkaloids, flavonoids, and polyphenols, may be potent sources of phytotoxicity and showed inhibitory and stimulatory effects on test crops. The occurrence of bioactive secondary metabolites such as L-tryptophan, syringing, (-) lariciresinol, and phenolics in *Prosopis juliflora* demonstrated inhibitory effects on weeds, and these were used as organized herbicides [9–11]. Nowadays, phytotoxic effects are being studied to discover both stimulatory and inhibitory effects by assessing the interactions between crops and crops, weeds and crops, and trees and crops [12–14]. Keeping these facts in view, the present study has been undertaken to assess the allelopathic effect of two *Bauhinia* species, i.e., *B. retusa* and *B. variegata*, on different seeds germination and the initial growth of *Triticum aestivum* varieties in an in-vitro condition.

2. Materials and Methods

The experiments were conducted at the Department of Forestry, Ranichauri, Tehri Garhwal (Uttarakhand). The leaves and bark of *B. retusa* and *B. variegata* were collected from five selected trees in Nagni, Tehri Garhwal to evaluate phytotoxicity. Five *T. aestivum* L. (wheat) varieties, viz., VL-892, VI-829, VL-616, UP-2572, and UP-1109, were collected from Gaja Research Farm of V.C.S.G. Uttarakhand University of Horticulture and Forestry.

The leaves and bark of both *Bauhinia* species were shade-dried and ground separately with the help of a mechanical grinder. Forty-gram samples of bark and leaves of each species were weighed with the help of an electronic weighing machine, mixed with 400 mL of double-distilled water separately, and left for 24 h at room temperature [15]. After 24 h, the brownish and dark extract was filtered through three layers of Whatman no.1 filter paper and stored in conical flasks. The extract was further diluted to 25%, 50%, 75%, and 100% concentrations and stored in a refrigerator (5 °C) in a dark bottle for one week. To examine the toxic effects of leaf and bark extracts on seed germination and radicle and plumule length of *T. aestivum* varieties, in October 2015, 30 seeds (three replicates of 10 seeds each) were placed in Petridishes (9 cm) containing two layers of Whatman no.1 filter paper saturated with a particular extract, and in the control, distilled water was used at room temperature (16 ± 3 °C). Petri dishes were moistened by adding extract or distilled water as needed. The germination of the seed was counted daily for up to 7 days. After that, the observations were stopped, since radicles in petri dishes normally start shriveling at their tips, and any further reading thereafter could introduce errors to the data. The germination percent was calculated by the standard formula, and data were analyzed statistically. The reduction and stimulation were calculated as per the formula by [16]. The data obtained arcsine for normality, and two-way analysis of variance (significance level at $p < 0.05$, and $p < 0.01$) was computed using ICAR Goa online software (V1.0). Duncan's multiple range tests (DMRT) were computed to estimate significance ($p < 0.05$) for numerous comparison means among the varieties.

3. Results

Data represented in Figure 1 depict the stimulation and reduction in the germination of *T. aestivum* variety seeds under *B. retusa* leaf and bark extracts. Maximum (8.11%) stimulation in germination was determined in variety UP 1109 at a 25% bark concentration of *B. retusa*, and minimum (5.26%) stimulation was seen in variety UP 2572 at a 25% concentration. In leaf extract, maximum (3.61%) stimulation was recorded in *T. aestivum* variety UP 2572 at a 25% concentration of *B. retusa*, and minimum (2.56%) stimulation was

seen in variety VL 616 at a 25% concentration. A maximum (35.71%) reduction was noticed in variety VL 892 at 100% bark concentration of *B. retusa*, and a minimum (2.63%) reduction was recorded in variety VL 829 at a 50% bark concentration of *B. retusa*. Meanwhile, leaf extracts had a reduced maximum (26.19%) germination at 25% in VL 892 and a minimum (2.56%) reduction in germination at 50% in VL 616 (Figure 1).

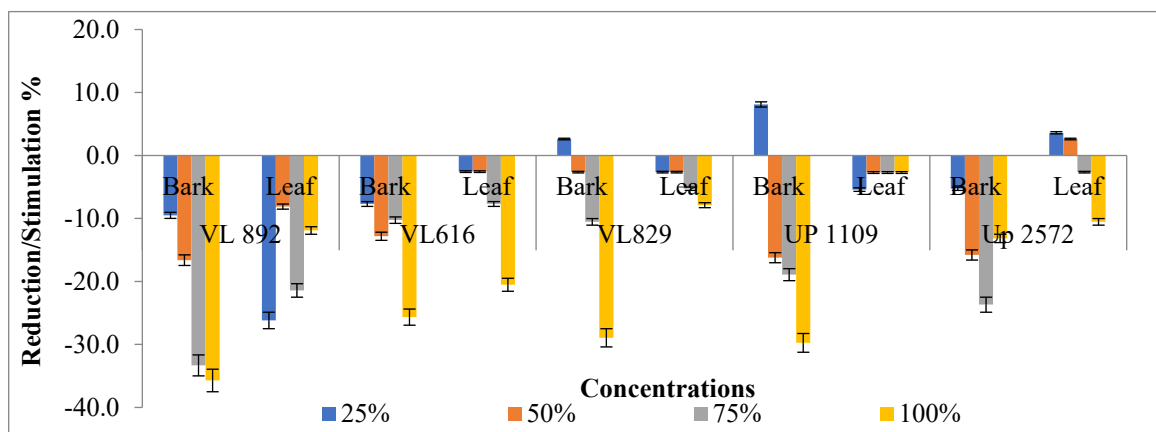


Figure 1. Effect of leaf and bark extracts of *B. retusa* on reduction in and stimulation of germination percent in different *T. aestivum* varieties (vertical bar indicates SD).

Leaf extract concentration was recorded as maximum (8.11%) stimulation in variety UP 1109 at a 75% concentration of *B. variegata*, and minimum (3.61%) stimulation in germination was observed in *T. aestivum* variety UP1109 at a 50% concentration of *B. variegata*. The bark extracts at 25% showed maximum (5.41%) stimulation in UP 1109 and minimum (2.56%) stimulation in VL 616 at 25% concentration. A maximum (38.10%) reduction in germination was recorded for VL 892 in a 75% bark concentration of *B. variegata*, and a minimum (2.63%) was observed at UP 2572 in a 25% bark concentration of *B. variegata*. Maximum (30.59%) reductions were noted in variety VL 892 in a 100% leaf concentration of *B. variegata*, and minimum (3.51%) reductions were recorded in UP 2572 at a 50% leaf concentration of *B. variegata* (Figure 2).

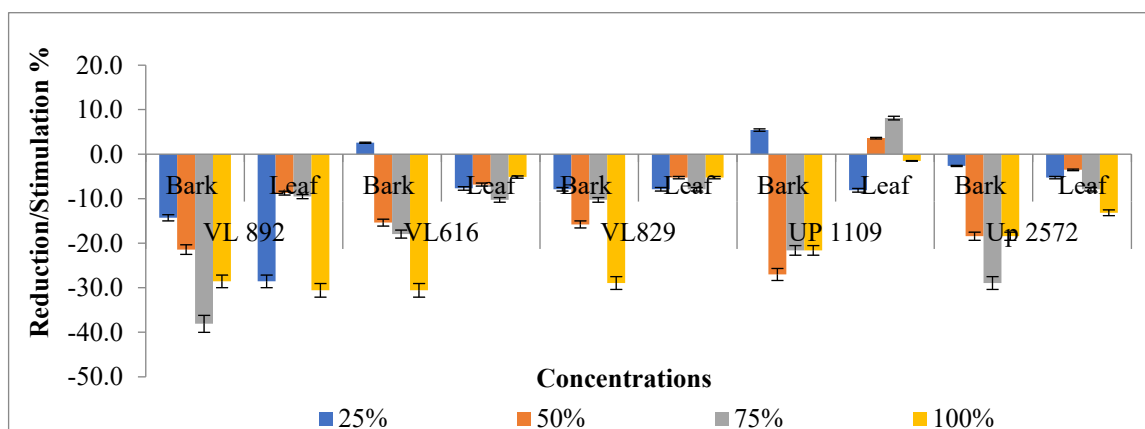


Figure 2. Effect of leaf and bark extracts of *B. variegata* on reduction in and stimulation of germination percent in different *T. aestivum* varieties (vertical bar indicates SD).

Different bark extract concentrations resulted in the maximum (64.13%) stimulation in radicle growth recorded in *T. aestivum* variety VL 829 at a 50% concentration of *B. retusa*, and minimum (6.39%) stimulation was seen in variety VL 892 at 25% bark extracts of *B. retusa*. A maximum (−64.05%) reduction in radicle growth was found in variety VL 616 at 100% concentration of *B. retusa*, and a minimum (13.02%) reduction was seen in variety VL

892 at a 50% concentration of *B. retusa*. On average, maximum radicle growth was recorded at 25% concentration; after that, increasing the concentration of bark extract, radicle growth was decreased as compared to the control (Table 1).

Table 1. Effect of leaf and bark extracts of *Bauhinia* species on the radicle and plumule growth (cm) (mean $\pm$ SD) of different *T. aestivum* varieties.

Variety	Plant Parts	Tree Crops		<i>B.</i>	<i>B.</i>	<i>B.</i>	<i>B.</i>	<i>B.</i>	<i>B.</i>	<i>B.</i>	<i>B.</i>
				<i>retusa</i>	<i>variegata</i>	<i>retusa</i>	<i>variegata</i>	<i>retusa</i>	<i>variegata</i>	<i>retusa</i>	<i>variegata</i>
		Extract Concentrations									
		0%	25%	25%	50%	50%	75%	75%	100%	100%	
VL 892	Bark	R	4.1 ± 0.40	4.3 ± 0.39 (+6.39)	4.2 ± 1.06 (+1.97)	3.5 ± 0.62 (−13.02)	6.5 ± 0.50 (+59.71)	2.9 ± 0.6 (−29.48)	3.5 ± 0.1 (−14.74)	3.2 ± 0.64 (−20.24)	4.5 ± 0.0 (11.30)
		P	3.7 ± 0.22	3.4 ± 0.45 (−6.28)	3.6 ± 0.36 (−1.91)	2.8 ± 0.58 (−24.04)	5.4 ± 1.03 (+47.54)	2.6 ± 0.5 (−29.78)	4.7 ± 0.2 (+27.60)	3.6 ± 0.21 (−2.46)	4.0 ± 0.7 (+9.56)
	Leaves	R	4.1 ± 0.40	4.2 ± 1.04 (+1.97)	4.9 ± 0.49 (+23.83)	4.3 ± 0.60 (+4.67)	4.9 ± 0.58 (+22.60)	5.4 ± 0.2 (+33.17)	4.9 ± 0.8 (+20.39)	2.5 ± 2.46 (−39.31)	4.1 ± 1.7 (+5.16)
		P	3.7 ± 0.22	4.3 ± 0.63 (+16.94)	5.4 ± 1.68 (+48.91)	4.8 ± 0.85 (+31.15)	4.5 ± 1.05 (+23.22)	6.2 ± 1.0 (+69.95)	3.7 ± 0.8 (+2.73)	4.9 ± 1.57 (+36.34)	3.1 ± 0.1 (−14.21)
VL 616	Bark	R	5.7 ± 0.44	4.5 ± 0.51 (−20.94)	4.6 ± 0.63 (−19.90)	2.4 ± 0.17 (−58.81)	7.1 ± 0.84 (+23.56)	3.5 ± 0.9 (−39.44)	5.2 ± 1.6 (−8.73)	2.1 ± 0.60 (−64.05)	5.2 ± 0.9 (−9.42)
		P	4.4 ± 0.82	4.2 ± 0.94 (−5.18)	3.9 ± 1.20 (−11.26)	2.5 ± 0.70 (−43.92)	6.9 ± 0.68 (+55.86)	3.3 ± 0.0 (−25.00)	5.6 ± 0.4 (+25.23)	2.4 ± 1 (−45.95)	4.0 ± 0.7 (−9.68)
	Leaves	R	5.7 ± 0.44	4.1 ± 0.11 (−27.92)	4.6 ± 0.50 (−19.37)	6.8 ± 0.61 (+19.02)	6.9 ± 0.43 (+22.16)	7.5 ± 0.7 (+30.89)	4.5 ± 0.8 (−21.82)	5.6 ± 1.25 (−1.40)	5.3 ± 0.3 (−6.98)
		P	4.4 ± 0.82	5.4 ± 0.74 (+22.30)	4.6 ± 1.18 (+4.50)	6.4 ± 0.64 (+44.37)	7.9 ± 0.66 (+79.95)	7.2 ± 0.4 (+61.71)	3.6 ± 0.7 (−18.92)	4.7 ± 0.45 (+6.98)	5.1 ± 0.0 (+15.32)
VL 829	Bark	R	4.1 ± 0.40	5.3 ± 0.78 (+54.79)	5.5 ± 1.30 (+34.89)	4.9 ± 0.54 (−19.90)	6.7 ± 0.52 (+64.13)	4.5 ± 1.8 (−41.77)	3.9 ± 0.5 (−2.70)	2.2 ± 0.57 (−45.21)	4.9 ± 0.4 (21.62)
		P	3.7 ± 0.22	6.5 ± 1.12 (+77.60)	5.1 ± 0.54 (+39.07)	2.9 ± 0.32 (−19.95)	5.9 ± 1.21 (+61.48)	3.1 ± 1.5 (−15.85)	5.4 ± 0.6 (+48.36)	2.3 ± 0.67 (−36.07)	3.7 ± 0.8 (+2.19)
	Leaves	R	4.1 ± 0.40	5.7 ± 0.48 (+39.56)	4.9 ± 0.32 (+20.15)	7 ± 0.51 (+71.99)	5.4 ± 0.91 (+31.45)	8.0 ± 0.0 (+97.79)	5.8 ± 0.0 (+43.98)	4.6 ± 1.43 (+13.76)	4.7 ± 0.9 (+17.69)
		P	3.7 ± 0.22	6.2 ± 0.91 (+68.85)	5.7 ± 0.54 (+55.74)	6.8 ± 0.72 (+87.43)	5.3 ± 0.97 (+43.72)	6.8 ± 0.1 (+84.97)	4.7 ± 0.2 (+29.23)	6.2 ± 1.87 (+68.58)	3.7 ± 0.2 (+3.55)
UP 1109	Bark	R	4.6 ± 0.63	4.9 ± 0.40 (+8.28)	5.3 ± 1.06 (+14.38)	2.9 ± 0.34 (−35.73)	5.3 ± 1.01 (+15.25)	3.2 ± 0.7 (−31.37)	5.0 ± 0.3 (+9.80)	3.5 ± 0.10 (−23.75)	4.2 ± 0.6 (−8.28)
		P	4.3 ± 0.75	6.7 ± 0.52 (+56.88)	3.7 ± 0.73 (−12.82)	3.1 ± 0.84 (−23.81)	4.2 ± 0.59 (−3.03)	2.6 ± 0.2 (−38.23)	4.2 ± 0.6 (−3.03)	4.3 ± 0.40 (+0.23)	3.3 ± 0.8 (−22.14)
	Leaves	R	4.6 ± 0.63	4.3 ± 0.32 (−6.32)	5.1 ± 0.95 (+11.33)	5.7 ± 2.28 (+23.53)	5.4 ± 0.89 (+17.43)	6.2 ± 1.5 (+34.64)	4.9 ± 0.4 (−4.58)	5.3 ± 0.86 (+15.90)	4.9 ± 0.9 (+7.19)
		P	4.3 ± 0.75	5.1 ± 1.46 (+19.35)	5.9 ± 1.01 (+38.69)	5.6 ± 1.03 (+30.77)	6.4 ± 0.98 (+48.48)	7.5 ± 1 (+75.76)	3.8 ± 0.2 (−10.96)	4.1 ± 0.21 (−3.73)	3.8 ± 0.7 (−10.26)
UP 2572	Bark	R	4.7 ± 0.44	5.1 ± 0.14 (+7.91)	4.3 ± 0.83 (+7.48)	3.7 ± 0.19 (−20.09)	5.8 ± 1.50 (+25.00)	2.9 ± 0.5 (−38.03)	4.5 ± 1.4 (−3.42)	2.6 ± 0.57 (−43.80)	4.5 ± 0.59 (−4.27)
		P	3.9 ± 0.53	4.5 ± 0.54 (+13.35)	4.0 ± 1.05 (+1.26)	2.8 ± 0.35 (−28.21)	5.9 ± 0.47 (+50.88)	2.8 ± 0.1 (−29.22)	4.4 ± 1.5 (+10.08)	2.9 ± 0.17 (−29.95)	3.7 ± 0.48 (−5.29)
	Leaves	R	4.7 ± 0.44	5.5 ± 0.96 (−4.56)	4.9 ± 0.86 (+4.91)	4.6 ± 0.15 (−2.56)	6.8 ± 0.47 (+45.73)	5.5 ± 0.5 (+17.74)	4.9 ± 0.2 (+5.56)	4.2 ± 0.24 (−9.62)	5.2 ± 0.93 (+11.11)
		P	3.9 ± 0.53	5.3 ± 1.03 (+32.75)	4.9 ± 1.83 (+24.18)	4.9 ± 0.43 (+25.69)	5.9 ± 0.58 (+50.88)	7.5 ± 0.3 (+89.42)	3.8 ± 0.4 (−3.78)	3.5 ± 0.04 (−12.34)	4.1 ± 0.54 (+2.02)

Values in parenthesis indicate % reduction or stimulation as compared to control, R = radicle; P = plumule.

Among all varieties, maximum (77.60%) stimulation of plumule growth was recorded in variety VL 829 at a 25% concentration of *B. retusa*, and minimum (0.23%) stimulation was seen in UP 1109 at a 100% concentration of *B. retusa*. A maximum (45.95%) reduction in plumule growth was observed in VL 616 at a 100% concentration of *B. retusa*, and a minimum (2.46%) reduction was seen in VL 892 at a 100% concentration of *B. retusa*. On average, maximum plumule growth was recorded in lower concentrations, whereas when increasing the concentration, plumule growth was lower as compared to the control (Table 1).

Different concentrations of leaf extract of *B. retusa* had a consequence on radicle growth. The upper limit (97.79%) of radicle growth was stimulated at 75% in variety VL 829, and the lower limit (1.97%) was stimulated at 25% concentration in variety VL 892. In radicle growth, a maximum (39.31%) reduction was observed at 100% concentration in variety VL 892, and a lower (27.92%) reduction was recorded at variety VL 616 in a 25% concentration of *B. retusa*. On average, the radicle growth of test crops increased when increasing the leaf extract concentration of *B. retusa* to a 75% concentration, and after that, the radicle growth of test crops declined (Table 1).

Different concentrations of *B. retusa* leaf extract also influenced the plumule growth of different varieties. Higher (87.43%) stimulation of plumule growth was shown at 50% concentration in variety VL 829, and lower (6.98%) stimulation was recorded in variety VL 616 at 100% concentration. Reduction in plumule growth was recorded to be the maximum (12.34%) in variety UP 2572 at a 100% concentration of *B. retusa* leaf extract, and a minimum (3.73%) reduction was recorded at 100% concentration in variety UP 1107 (Table 1).

The effects of different concentrations of *B. variegata* bark extract are presented in Table 1. The results indicated that the radicle growth of different varieties was influenced by the different bark concentration treatments. Between different varieties and concentrations, maximum (64.13%) stimulation of radicle growth was recorded at 50% concentration in variety VL 892, and minimum (1.72%) stimulation was recorded at 25% concentration in variety VL 892. Maximum reduction (19.90%) in variety VL 616 and minimum reduction (2.70%) in variety VL 829 were recorded at 25% and 75% concentrations, respectively. Among all the varieties, higher radicle growth was recorded in VL 829 as compared to other varieties (Table 1).

Data represented in Table 1 depict the fact that plumule development and stimulation were determined to be the maximum (61.48%) in *T. aestivum* variety VL 829 at 50% concentration and the minimum (1.26%) at 25% concentration in variety UP 2572. A maximum (22.14%) reduction was seen in variety UP 1109 at 100% concentration, and a minimum (1.91%) reduction was recorded in variety VL 892 at 25%. The most prominent growth was recorded in VL 829 as compared to other *T. aestivum* varieties (Table 1).

Different concentrations of leaf and bark extracts of *B. retusa* significantly ($p < 0.01$) affected the germination, radicle, and plumule growth of different wheat varieties. Similarly, different concentrations of leaf and bark extracts of *Bauhinia retusa* species significantly ($p < 0.01$) affected the germination and radicle and plumule growth of different wheat varieties. Among the varieties, radicle and plumule growth was significantly ($p < 0.01$) influenced (Table 2).

Table 2. Two-way analysis of variance (ANOVA) for germination and radicle and plumule growth of different *T. aestivum* varieties under leaf and bark concentration of *Bauhinia* species.

Source of Variation	Degree of Freedom	F-Value					
		<i>B. retusa</i>			<i>B. variegata</i>		
		Germination	Radical	Plumule	Germination	Radical	Plumule
Treatments	1	38.64 **	110.25 **	195.81 **	1.41 ^{NS}	2.47 ^{NS}	1.79 ^{NS}
Concentration	4	12.41 **	11.26 **	13.28 **	26.05 **	19.71 **	29.28 **
Varieties	4	0.33 ^{NS}	8.20 **	10.10 **	1.36 ^{NS}	9.65 **	7.80 **
Treatment × Con.	4	21.81 **	30.88 **	39.62 **	0.75 ^{NS}	2.02 ^{NS}	7.48 **
Treatment × varieties	4	0.24 ^{NS}	6.79 **	3.16 *	0.04 ^{NS}	1.59 ^{NS}	1.71 ^{NS}
Con. × Varieties	16	1.36 ^{NS}	2.41 *	2.13 *	0.72 ^{NS}	2.08 *	2.84 **
Treatment × con. × varieties	16	0.59 ^{NS}	2.90 *	2.48 *	0.97 ^{NS}	2.47 **	1.49 ^{NS}

* Significant at $p < 0.05$, ** Significant at $p < 0.01$, ^{NS} = Non-significant value.

4. Discussion

In the present study, a series of different concentrations (0%, 25%, 50%, 75%, and 100%) of *B. retusa* and *B. variegata* leaf and bark extracts were applied to investigate their allelopathic effects on the germination percentage and plumule and radicle lengths of five

T. aestivum varieties. For all cultivars, germination percent, plumule length, and radicle length were significantly affected by different concentrations of leaf and bark extracts of *Bauhinia* species. The present study results indicated that the leaves of both *Bauhinia* species release phytotoxic substances and negatively affect the germination percent and seedling length of the studied wheat cultivars. Similar studies were conducted to evaluate the allelopathic effects of different concentrations of aqueous extract of *Zygophyllum album* on *T. aestivum* and *Bromus tectorum*. These revealed that the maximum inhibition was recorded in germination percentage and radicle and plumule growth of the test crops [17].

The results of our investigation reveal that different concentrations of leaf and bark extracts of both *Bauhinia* species have different effects (inhibitory/stimulatory) on germination and radicle and plumule length of different *T. aestivum* varieties. These stimulatory or inhibitory influences in germination by different concentrations of leaf and bark extracts may be due to the occurrence of different metabolic substances, i.e., tannins, flavonoids, reducing sugars, terpenoids, saponins, steroids, and cardiac glycosides [6]. These findings revealed that germination was more affected as compared to the radicle and plumule growth. Among the tested wheat varieties, VL 829 had more resistance in germination percent and radicle and plumule length, followed by UP 1109. However, higher concentrations (100%) exhibited higher toxicity as compared to the other studied concentrations of leaf and bark extracts of both *Bauhinia* species.

The radicle and plumule lengths of the studied wheat varieties were significantly stimulated by the lower concentration. However, by increasing the leaf and bark concentrations, the reduction was also increased in the radicle and plumule length of the wheat varieties. On average, the bark extract of *B. variegata* was more toxic to the radicle and plumule length of the wheat varieties compared to leaf extract. The leaf extracts are persuasive sources of phytotoxic chemicals, and their properties are concentration-dependent and species-specific [18,19]. The allelochemicals found in plants have a large diversity and are leached from plants to the soil by organic and inorganic compounds [20].

Additionally, Tanveer et al. [21] obtained a significant reduction regarding the effect of *Euphorbia helioscopia* leaf aqueous extract on the seedling growth of *Triticum aestivum*, *Lens culinaris*, and *Cicer arietinum*. The significant reduction in seedling growth in the present study may be due to the inhibitory effect of allelochemicals found in leaves of both *Bauhinia* species, which could affect growth directly or by altering the mobilization of storage compounds during germination. The secondary metabolites present in different concentrations of aqueous extracts of different donor plant species have been influenced by various physiological activities by the effects of enzymes accountable for synthesizing different phytohormones. These allelochemicals also inhibited the absorption of nutrients and ions and affected the plasma membrane permeability [22,23]. The inhibition percentage (IP) of the plant's effects may be due to interruptions in the actions of peroxidase, alpha-amylase, and acid phosphates [24]. The reduction and stimulation in germination and growth of the seedling may depend on the concentrations of secondary metabolite compounds or plant metabolites present in the extracts [25]. The diterpene steviol glycoside stevioside, obtained from *Stevia rebaudiana*, has an inhibitory action against gibberellins, a plant hormone that regulates growth [26].

The data of seed germination and seedling growth in the control were higher and aqueous leachates of leaves and bark of both *Bauhinia* species inhibited the germination efficiency and growth characteristics of the selected wheat varieties. However, long-term field experiments are needed to examine the allelopathic effects, especially under natural conditions. The phytochemical characteristics of the soil and the effect of microbial activity in mitigating or intensifying this effect also need to be evaluated [27]. The allelopathic potential of *Bauhinia* species' root and rhizosphere soils and the irrelative importance in the inhibition of crop growth also need to be examined in the future.

5. Conclusions

The results of the present study showed that the allelopathic effects of leaves and bark of both *Bauhinia* species were different in different wheat varieties. The stimulation in germination and seedling growth were higher with lower concentrations, and maximum reduction was recorded at higher concentrations. The allelopathic effect of leaf and bark extracts of agroforestry trees should be examined before considering plantation in the agroforestry system to make these systems more profitable for farmers. In addition, the different crops were also tested to evaluate the allelopathic potential of donor plants on receiver plants. These two *Bauhinia* species are a good source of fodder, and they are helpful in providing monetary benefits to the poor rural farmers of the region. Therefore, *Bauhinia* species are very important in improving farmers' incomes and the sustainable development of the agroforestry system of Garhwal Himalayas. The allelopathic effects of trees that promote plantation in this system should be examined, and a resistant variety of different crops also needs to be found. Both *Bauhinia* species are economically beneficial to poor farmers of the region and must be planted on a large scale. Varieties like UP 1109 and VL 829 might be grown.

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