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Allelopathic Effect of *Commelina benghalensis* L. (Commelinaceae) Aqueous Extract on Seed Germination and Seedling Growth of *Sesamum indicum* L. (Pedaliaceae)

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Abstract

Agricultural productivity reduction due to the toxic weed species is one among the various causes of economic losses. A case study was conducted in the 8 plots with different locations from June to October at Chinyali saur, Uttarkashi, Uttarakhand, to observe the effect of weeds on commercial crop *Sesamum indicum* L. (Pedaliaceae). The different parameters of growth recorded in plots *i.e.,* height of plants and branching per plant, capsules per branch, capsules in whole plant, length of capsule, number of seeds concerning to different plots *viz.,* low weeds diversity, moderate weeds diversity and high weeds diversity. The maximum reduction in all parameters was recorded with high weeds condition. The plots were associated with several weeds but, *Commelina benghalensis* L. (Commelinaceae) is over-dominant in all these plots. Therefore, their impacts on *Sesamum indicum* L. were investigated in vitro. Aqueous extracts of *Commelina benghalensis* at various concentrations (control, 10, 20, 30 and 50%) were obtained to examine their allelopathic effects on the test crop. In this study, the highest germination reduction percentage was 7.5 per cent at the 50 per cent concentration of extracts. While the maximum germination percentage was observed at 10 per cent concentration of weed extract. Similarly, the maximum reduction in plumule length (0.4 cm) and radicle length (0.1cm) was also observed at 50 per cent concentration of aqueous extract, whereas, the maximum plumule length (2.8 cm) and radicle length (1.5 cm) recorded at 10 per cent concentration. Additionally, the result from current experiment revealed that the inhibitory effects are concentration-dependent.

Keywords : Weed, Allelopathic effect, Aqueous extract, Germination, Velocity index, Seed vigor index

Sesame (*Sesamum indicum* L.) is one of the earliest consumption oil and human production crops of the family Pedaliaceae. It is native to the Indian Subcontinent and primarily cultivated in the seasonally dry tropical biome (POWO, 2023). The plant usually referred to as 'til' or 'gingelly.' It is an annual, herbaceous plant that grows upright and yields small flat seeds that resemble as teardrops. It is among the first oilseed crops, cultivated for centuries, particularly in Asia and Africa (Peter, 2006). *S. indicum* is known as the 'queen of oilseeds' because of its high oil content, proteins, carbs and necessary minerals, as well as its flavor and high methionine and tryptophan content etc. It also has a delightful nutty scent. There are secondary metabolites, flavonoids, phenolic compounds, lignans and saponins, among others (Johnson *et al.,* 1979). Sesame oil contains oleic and linoleic acid, as well as polyunsaturated fatty acids and has a nice, moderate taste. Oil stability is a result of naturally occurring antioxidants, such as sesamin, sesamolin and sesamol (Bedigian, 1985). The seeds are added to several foods, while sesame paste is used to decorate bread, biscuits, and desserts (Elleuch *et al.,* 2011). According to Anilakumar *et al*. (2010), sesame seed oil has several uses, including skin softener, oleaginous catalyst for pharmaceuticals, solvent and ingredient in margarine and detergent. Burns and wounds are treated topically with paste and oil derived from sesame seeds (Kiran & Asad, 2008). Historically, people have used sesame fruits as a poultice, laxative and cough remedy (Dzoyem *et al*., 2014). The roots are used to cure asthma, delay the onset of gray hair, and encourage hair growth (Khan *et al.,* 2014). The medicinal potential of sesamin, sesamol and sesamolin, which were extracted from sesame seeds, was specifically demonstrated by their documented pharmacological properties. The abundant lignan found in sesame seed oil is sesamin (Jeng *et al*., 2005). Additionally, sesamin was found to possess antibacterial and insecticidal qualities, which led to its application as a complementary for the pyrethrum pesticide (Morris, 2002 and Anilakumar *et al.,* 2010). In addition to being used as fuel and food, it can be used as a toxin, medication, environmental and societal food source. Raw or roasted sesame seeds are utilized in various food items and they are also employed in industry to make soaps, lubricants, lamp oil, cosmetics, pharmaceuticals and animal feed (Bedigian, 2010).

Sesamum indicum field is associated with various weed species, *Commelina benghalensis* L. is one of the weeds of *kharif* crops. *Commelina benghalensis* L., is a crop weed belonging to the family Commelinaceae and commonly known as Benghal dayflower. The native range weed of *Commelina* is tropical and subtropical (POWO, 2023). It is an annual or perennial prostrate or scrambling ascending herb and a troublesome weed with ovate leaves (Webster *et al.,* 2005). In agricultural fields around the world, this plant is the worst weed (Dzoyem *et al.,* 2014). In India, *Commelina benghalensis* is a folk remedy used to treat a range of illnesses *e.g.*, mouth thrush, nose blockage in children, psychosis, epilepsy, inflammation of the conjunctiva (Okello & Ssegawa, 2007), exophthalmia and insanity (Tabuti *et al.,* 2003). Phytochemicals screening of *C. benghalensis* recorded the existence of Alkaloids, Flavonoids, Saponins, Tannins, Steroids, Terpenoids and anti-inflammatory properties (Tiwari *et al.,* 2013).

The crop *Sesamum indicum* is traditionally cultivated in the hill agriculture system as a commercial and subsistence needs of the borderline poor farmer of the regional area. Migration from the area is a major challenge of traditional farming which leads to barren land, subsequently the barren lands are filled with invasive species and affect the associated agricultural land. The selected weed is dominantly growing in the agriculture field of the *S. indicum*. Although prior researchers looked at the phytomorphological, pharmacognostic, and chemical screening properties of *C. benghalensis*, currently there is no scientific evidences about the plant's allelopathic effects on crops. In order to bridge the gap in existing scientific knowledge, the present investigation was conducted to evaluate the allelopathic effect of *C. benghalensis* on the seed germination and the seedling growth of the economically important crop *Sesamum indicum.*

Fig. 1 : (a) Seeds of *Sesamum indicum,* (b) *S. indicum* plant with flower, (c) *S. indicum* with fruit

Material and Methods

Study Area

The field survey was executed in the Chinyali Saur region of Uttarkashi district, Uttarakhand with different altitudinal zones. It encircles an area of 398.39 km^2 with semi-urban settlement and the geography lies between 30°34'21"N latitudes and 78°19'28"E longitudes with elevation ranges from 755-1550m asl.

The laboratory germination assay was performed in the Botany Department, S.R.T. campus, Badshahithaul, Tehri Garhwal, Uttarakhand, India. It is situated with an elevation of 1726 m and lies in between the 30°42-30°52.52 N latitude and 77°502 - 79°32 E longitude. The crop is traditionally cultivated in the hill agriculture system as the subsistence needs of the borderline poor farmer of the regional area. The experiment was carried out at different concentrations of *Commelina benghalensis* on laboratory germination bioassay of the test crop.

Field Observations

A case study in the field was conducted from June to September, 2023 to record the effect of weeds on crops morphological characters and their productivity. A total of 8 plots were observed for the experiment with different locations *i.e.,* Mani (9×10 m), Katkhet (9×10 m), Bareth (6×10 m), Srikot (8×9 m), Chilot (8×8 m), Neri (10×10 m), Sunargaon (9×10 m) and Shyampur (8×8 m). The parameters of the study are height of plant, number of branching, total capsules per branch, total capsules per plant, length of capsule, number of seeds per capsule were recorded from the same plot with three different conditions *viz.,* control condition, with low weed density, moderate, weed density and high weed density. The different condition (*i.e.,* Ctrl, LW, MW, HW) was grouped according to the growth of *Commelina*. The height of plant and length of capsules were measured by a graduated meter scale.

Plant Material Collection and Aqueous Extract Preparation

The *Commelina benghalensis* plant species, which is dominantly growing in the agricultural field of study area were collected at their reproductive stage from various plots. The plant specimens were dried in shade up to 10-15 days and made a fine powder with the help of laboratory grinder. About 10 grams of *C. benghalensis* powder were steeped in 100 ml of hot distilled water and the mixtures was left for 24 hours at room temperature for incubation. After the 24-hour incubation period aqueous extract of leaf was carefully filtrated using Whatman no.1 filter paper (three layers). This filtered extract was then transferd into 250 ml volumetric flasks and stored in refrigerator and considered as a stock solution. After that the dilution series, (*i.e.,* 10, 20, 30 and 50%) concentrations were prepared following Netsere & Mendesil (2011).

Laboratory Germination Assay

The allelopathic inhibitory impact of *C. benghalensis* aqueous extracts on germination of seeds and seedlings growth on the performance of *S. indicum* was performed to put down about 40 seeds of test crop were placed in petridishes. The three replicates in 5 petridishes containing blotting paper with 5 ml of each concentration of weed aqueous extracts (*i.e.*, 10, 20, 30 & 50%), whereas distilled water was used as control treatment. The examination was organized in a completely randomized design (CRD) and finally, petridishes were put down for incubation at laboratory of Botany Department, S.R.T. Campus, Badshahithaul, at room temperature. Each petridishes were continued moisture by putting 1 ml of each aqueous extract concentrations and for control conditions distilled water was used. The assessment was continued over the 14 days as after that the growth of radicle seems to be shrinking. The germination of seeds was observed daily and germination was considered as the radicle emerged from the seeds (Singh *et al.,* 2006).

Data Analysis

At the end of the test period (14 days after seeding), it represents the percentage of sowed seeds that have germinated. AOSA, (2017) provided the formula used to compute the germination percentage.

$$\text{Germination percentage (GP)} = \frac{\text{Total count of germinated seeds}}{\text{Total count of seeds sown}} \times 100$$

The formula of Marin *et al.* (2018) was utilized to determine the mean germination time (MGT), whereas Tan *et al*. (2017) was used to calculate the germination energy (GE).

$$\text{Mean germination time (MGT)} = \frac{\sum(nxd)}{N}$$

Where,

n = number of seeds germinated on each day

d = number of days from beginning of the test

N = total number of seeds germinated

$$\text{Germination Energy (GE)} = \frac{\text{No.of seeds germinated on each day}}{\text{Total no of seeds tested}} \times 100$$

The GVI was calculated using the formula recommended by the Association of Official Seed Analysts (AOSA, 1983) and Seed vigor index (SVI) was calculated by the formula given by Abdul-Baki & Anderson (1973).

$$\text{GVI} = \frac{\text{Total number of germinated seeds}}{\text{Number of days}}$$

$$\text{SVI} = \frac{\text{Seedling length (radicle + plumule)} \times \text{germination\%}}{100}$$

The length of the radicle and plumule was measured using a graduated scale. After 14 days of the incubation period, three germinated seeds from each dish were selected randomly, and their respective radicle and plumule lengths were measured. The means of these measurements were then calculated. Subsequently, these measurements were converted into percentage growth compared to the control condition following Mustafa *et al*. (2019).

$$\text{Radicle length (\%)} = \frac{\text{Average radicle length at respective treatment}}{\text{Average radicle length at control}} \times 100$$

$$\text{Plumule length (\%)} = \frac{\text{Average plumule length at respective treatment}}{\text{Average plumule length at control}} \times 100$$

Table 1

Weeds associated with *Sesamum indicum* field

Botanical Name	Family	Vernacular/common name	Flowering-fruiting	Status	Habitat	Life cycle
Ageratum conyzoides L.	Asteraceae	Pajina/goatweed	July-Sep	Abundant	Herb	Annual
Bidens pilosa L.	Asteraceae	Magna/Beggar ticks	July-August	Abundant	Herb	Annual
Cleome viscosa L.	Cleomaceae	Jakhya/Tick weed	June-Aug	Common	Herb	Annual
Commelina benghalensis L.	Commelinaceae	Randlya/Spiderwort	June-Oct	Abundant	Herb	Annual
Cynodon dactylon (L.) Pers.	Poaceae	Doop/Bermuda grass	April-July	Common	Creeper	Perennial
Cyperus rotundus L.	Cyperaceae	Moru/Purple nutsedge	Aug-Oct	Abundant	Herb	Annual
Eleusine indica (L.) Gaertn	Poaceae	Crabgrass/Goosegrass	July-Nov	Abundant	Grass	Annual
Euphorbia heterophylla L.	Euphorbiaceae	Chopya/Milkweed	Aug-Oct	Common	Herb	Annual
Galinsoga parviflora Cav.	Asteraceae	Chyanru/Quick weed	Aug-Nov	Common	Herb	Annual
Parthenium hysterophorus L.	Asteraceae	Gajar ghas/Congress grass	Jan-Dec	Common	Herb	Annual
Sida acuta Burm.f.	Malvaceae	Kareta/Wireweed	July-Sep	Uncommon	Undershrub	Perennial
Urochloa ramosa (L.) T.Q. Nguyen	Poaceae	Kagila/Browntop millets	July-Oct	Common	Herb	Annual

Results and Discussion

Field Observations : The present investigation was recorded from the 8 plots with different locations. All the 8 observed plots showed various weed species but *Commelina benghalensis* was over dominated in all plots which is listed in (Table 1).

The study recorded that the plot with the highest weed diversity subsequently reduces the growth parameters of test crop followed by moderate weed diversity and then low weed diversity (Table 2, Fig. 2).

Among the all 8 plots, the maximum reduction in growth of *S. indicum* was observed with high weed (HW) condition with all parameters *viz.,* height of plants (152), number of branching (5.5), number of capsules (13.2), length of capsules (51), number of seed per capsules (57) and minimum reduction observed with control condition and low weed (LW) condition (Table 3).

The study underscores the significant inhibitory impact of weeds on the growth and development of the *S. indicum* plant in field condition. All the examined parameters are remarkably reduced by the associations of weeds. All the recorded weeds are not allelopathic weeds but most of them show allelopathy and reduces the growth and productivity of main crops as they interfere with the crop by various means *i.e.,* by competing for the same resources, by releasing allelochemicals (Leachates, decomposition, volatilization, root exudates). Weeds discharge a significant amount of allelochemicals into the soil and surrounding vegetation, which can negatively impact the growth of crops (Alam and Shaikh, 2007). Due to weed and their weed-crop competition, weeds reduce productivity. However, it can be challenging to identify the reason behind a decrease in crop production in field conditions. There are several reasons but weeds interference plays a vital role in decreased yield. The reductions in the length, number of productive capsules per unit area, number of seeds per capsule and seed weight could all be contributing factors to the decline in crop production. The currents outcomes correlated with the results of Ali *et al.* (2015), who revealed that critical levels crop-weed competition resulted in to decrease in crop yield.

Table 2

Effect of weeds on *S. indicum* plant in natural field condition

Plots	Type of area	Standard numbers of plants	Average height of plant(cm)	Branching/ plant	No of Capsule/ Branch	No. of capsule/ plant	Length of capsule (mm)	No. of seeds/ Capsule
Plot no-1	*S. indicum* with Ctrl.	16	165	8	15	65	5	70
	S. indicum with LW	12	157	5	14	52	4	55
	S. indicum with MW	15	65	3	5	16	3	40
	S. indicum with HW	12	28	2	3	6	1	23
Plot no-2	*S. indicum* with Ctrl.	15	166	6	14	54	4	72
	S. indicum with LW	16	150	6	11	50	4	56
	S. indicum with MW	15	57	4	4	14	2	41
	S. indicum with HW	11	25	1	4	4	2	22
Plot no-3	*S. indicum* with Ctrl.	16	158	10	16	58	6	65
	S. indicum with LW	14	142	5	14	53	5	58
	S. indicum with MW	16	50	3	4	15	3	38
	S. indicum with HW	17	22	2	2	5	2	20
Plot no-4	*S. indicum* with Ctrl.	14	150	8	18	62	5	68
	S. indicum with LW	18	130	5	15	55	4	51

Continued....

TABLE 2 Continued....

Plots	Type of area	Standard numbers of plants	Average height of plant(cm)	Branching/ plant	No of Capsule/ Branch	No. of capsule/ plant	Length of capsule (mm)	No. of seeds/ Capsule
	S. indicum with MW	12	58	3	6	15	2	32
	S. indicum with HW	11	24	1	6	6	1	18
Plot no-5	*S. indicum* with Ctrl.	15	168	10	12	52	7	60
	S. indicum with LW	14	158	6	6	40	5	57
	S. indicum with MW	13	60	4	3	12	3	26
	S. indicum with HW	14	19	2	2	4	2	20
Plot no-6	*S. indicum* with Ctrl.	16	160	8	18	56	8	67
	S. indicum with LW	15	162	6	15	55	6	62
	S. indicum with MW	14	56	3	7	18	4	48
	S. indicum with HW	12	27	1	4	4	2	35
Plot no-7	*S. indicum* with Ctrl.	14	172	8	17	60	6	64
	S. indicum with LW	13	167	5	16	57	6	57
	S. indicum with MW	14	62	3	8	22	3	40
	S. indicum with HW	11	21	2	5	10	1	18
Plot no-8	*S. indicum* with Ctrl.	15	165	7	18	56	5	70
	S. indicum with LW	15	155	6	14	50	4	60
	S. indicum with MW	13	52	5	4	15	3	42
	S. indicum with HW	11	15	2	3	5	1	23

Note : Ctrl. = Control condition, LW = Low weeds, MW = Moderate weeds, HW = High weeds

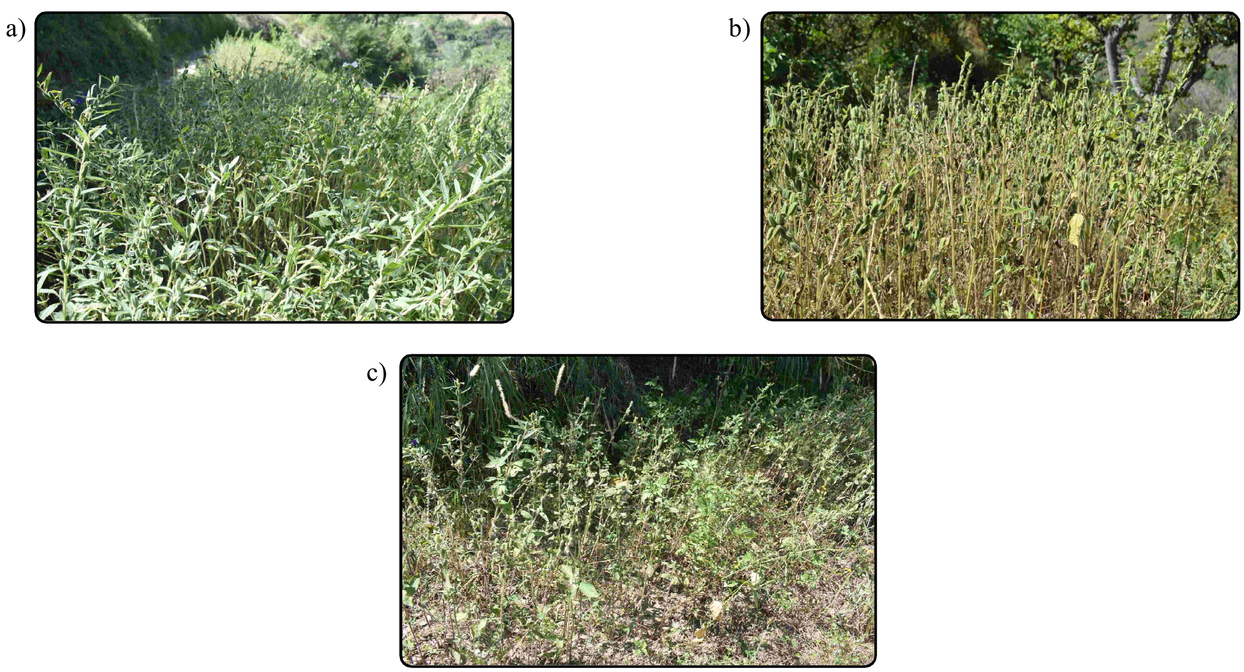

Fig. 2 : *Sesamum indicum* field (a) with low weeds intensity, (b) with moderate weed intensity, (c) with high weed intensity

Fig. 3 : Effect of weeds on Capsules of *S. indicum* (a) with low weeds intensity, (b) moderate weed intensity, (c) high weed intensity

TABLE 3

Mean value of the all parameters of Table 2

Area types	Standard numbers of plants	Average height of plant (cm)	No Branching/ plant	Capsule/ Branch	Total capsules/ plant	Length of capsules	No. of seeds/ Capsule
S. indicum with Ctrl.	16	163	8	16	57	7	67
S. indicum L. with LW	14	152	5.5	13	51	5.2	57
S. indicum L. with MW	15	57.5	4	5.25	15.9	2.9	38
S. indicum L. with HW	12	22	1.6	3.6	5.5	1.5	23

Laboratory Germination Test

The laboratory germination experiment indicates that with the control condition, *S. indicum* seeds manifest the maximum germination rate (94.1%), while the minimum germination rate (17%) was recorded when treated to the highest concentration (50%) of *C. benghalensis* extract. The germination rate followed the toxicity percentage with 50%> 30%> 20%> 10%> control conditions. (Table 5, Fig. 4). The mean germination time (MGT) was observed minimum (9.9) at 0 per cent concentration and maximum (11.6) at 50 per cent concentration of weed extract. The germination energy (GE) and Germination rate index (GRE) were also observed minimum (2.5) and (1.6), respectively when treated with 50 per cent concentration whereas, the maximum value was recorded at 0 per cent and 10 per cent concentration of extract (Table 4).

The germination velocity index (GVI) recorded its maximum value (2.42) when treated with the 10 per cent extract of *C. benghalensis*. The lowest valve (0.214) was recorded at the 50 per cent concentration of the same aqueous extract (Table 5). The various concentrations of weed extract had varying effects on the seedling's growth of the test crop. The plumule length (0.4 cm) was observed more negatively impacted by 50 per cent concentration of aqueous extract, whereas the maximum length (2.8 cm) was recorded at 10 per cent concentration of weed extract. In comparison to plumule length radicle length of the seedling was more affected by weed extract. The length was found to be longest (1.5 cm) when treated with 10 per cent concentration of *C. benghalensis* extract. While the minimum radicle length (0.1cm) was observed at the 50 per cent concentration of weed aqueous extract (Table 5, Fig. 2). Seed vigor index (SVI) reached its maximum value (4.07) in 10 per cent extract of *C. benghalensis*, whereas the minimum value (0.03) was recorded at 50 per cent concentration of extract. The application of weed extract with higher concentrations remarkably resulted in a notable reduction in the fresh weight of the seedlings. The most substantial reduction in fresh weight (5 mg) was observed when the seed was treated with 50 per cent concentration of

TABLE 4

Effects of leaf extract on following seed germination parameters

Treatments	Replication	24 hrs.	48 hrs.	4 Days	6 Days	8 Days	10 Days	12 Days	14 Days	GP (%)	GE	GRI	MGT
T1(C)	R1	0	1	11	15	25	27	35	38	95	37.5	17.2	10.3
	R2	0	2	15	18	28	31	34	38	95	45	19.9	9.9
	R3	0	3	16	20	29	30	31	37	92	50	20.7	9.7
T2	R1	0	1	10	15	20	23	28	33	82	37.5	15.0	10.2
	R2	0	2	12	17	20	25	29	34	85	42.5	16.7	10.0
	R3	0	1	15	17	21	23	29	33	82	42.5	16.8	9.9
T3	R1	0	0	1	4	11	13	18	23	57	10	6.7	11.2
	R2	0	0	1	5	9	13	15	22	55	12.5	6.3	11.1
	R3	0	0	2	5	12	13	17	23	57	12.5	7.2	11.0
T4	R1	0	0	0	1	5	9	12	15	37	2.5	3.8	11.7
	R2	0	0	0	0	6	9	13	14	35	0	3.7	11.7
	R3	0	0	0	1	4	7	12	12	30	2.5	3.2	11.7
T5	R1	0	0	0	0	2	3	4	8	20	0	1.5	12.1
	R2	0	0	0	1	3	4	5	7	17	2.5	1.9	11.4
	R3	0	0	0	1	3	3	3	6	15	2.5	1.5	11.3

Note : T1 = Control, T2 = 10%, T3 = 20%, T4 = 30%, T5 = 50%, GP = Germination percentage, GE = Germination energy, GRI = Germination rate index, MGT = Mean germination time

C. benghalensis, subsequently 30 per cent, 20 per cent and 10 per cent concentration, respectively whereas, the maximum fresh weight (30 mg) obtained from 10 per cent concentration of weed aqueous extract (Table 5).

The outcomes from the present investigation under line the noteworthy inhibitory effects of *C. benghalensis* on the seed germination and seedling growth of *S. indicum*. Germination rate was reduced with each treated extract concentration as compared to the control. The present results disclose that the maximum degree of inhibition in seed germination occurred at elevated concentrations of aqueous extracts. The probable causes of diminished germination percentage may be due to the existence of secondary metabolites in allelopathic plants (Walker & Evenson, 1985; Hasan *et al.,* 2010 and Hossain *et al.,* 2014). These investigations emphasize the significance of aqueous extract concentration when evaluating their inhibitory impact on the germination of target crops with providing important insights for weed control strategies in agricultural contexts. Similar observations, where aqueous extract with high concentrations of weed exhibits more detrimental effect on seed germination and seedlings growth in comparison to control condition, have been recorded in different studies (Gulzar & Siddiqui, 2017 and Jali *et al.,* 2021). Dar *et al*. (2023) recorded that *Euphorbia hirta* with 7 per cent extract shows highest suppressive effects on the seed germination of *C. arietinum*, followed by 5 per cent and 3 per cent extract concentrations. Mistica *et al.* (2023) reported that the *Lantana camara* aqueous extract exhibits the strong inhibition of the seed germination of *Zea mays* (Maize).

Mean germination time (MGT) is a measure of how quickly germination occurs. It represents this relationship inversely, with lower MGT indicating faster germination. The germination index and germination percentage have a direct correlation. The MGT is significantly diminished with the higher concentration treatment of weeds. The germination percentage, mean germination time and germination index of *Triticum aestivum* L., *Cicer arietinum*,

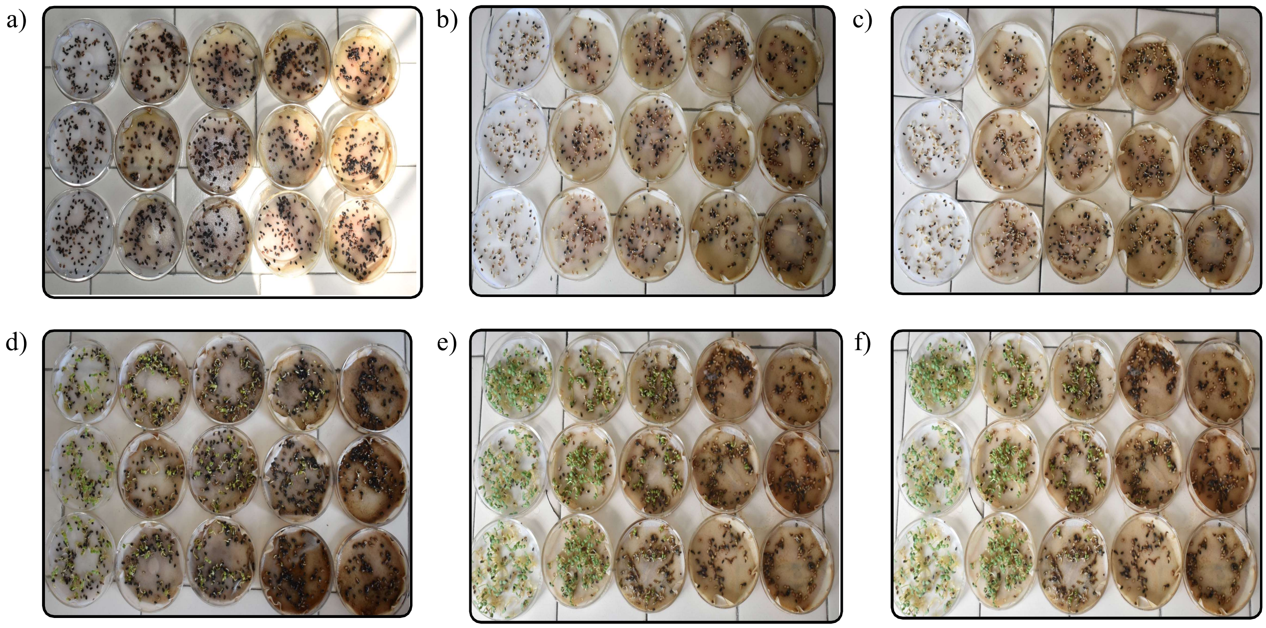

Fig. 4 : *S. indicum* seeds treated with *C. benghalensis* aqueous extract (a) Seeds after 48 hours of incubation, (b) Seeds following four days of incubation, (c) Seeds following five days of incubation, (d) Seeds after seven days of incubation, (e) Seedlings after ten days of incubation, (f) Seedlings after 2 weeks of incubation

TABLE 5

Inhibitory impact of *C. benghalensis* aqueous extract on seed germination attributes of *S. indicum*

Conc	Germ. (%)	Inhibitory (%)	GVI	SVI	PL (cm)	PL (%)	RL (cm)	RL (%)	PT (%)	FW (mg)
Control	94	0	2.78	4.38	3.0	100	1.5	100	0	30
10%	83	11.8	2.42	4.07	2.8	93	1.5	100	0	28
20%	56	40.5	1.78	2.49	2.0	66.6	0.8	53.3	46.7	18
30%	34	63.7	0.85	0.89	0.8	26.6	0.3	20	80	10
50%	17	82	0.214	0.03	0.4	13.3	0.1	6.66	93.4	5

Note : Conc. = Concentrations, Germ. = Germination (%), RL = Radicle length, PL = Plumule length, GVI = Germination velocity index, SVI = Seedling vigor index, PT = Phytotoxicity, FW =Fresh weight

Avena sativa and *Hordeum vulgare* showed comparable effects of extracts from *Lantana camara* and *Parthenium hysterophorus* (Hayyat *et al.,* 2020) and *Chenopodium album* on *Triticum aestivum* (Majeed *et al.,* 2012). The germination velocity index (GVI), serves as the indicator of germination speed, reflecting the suppressive influence of higher concentration of aqueous extract on seed germination. The highest value of GVI was observed at the 10 per cent aqueous extract or control condition. While the lowest GVI value was recorded at 50 per cent concentration of extract. Similar results were also reported by Sidhu *et al*. (2023), who revealed that *Amaranthus viridis* with high concentration reduces the GVI value of *Oryza sativa*. Our study also aligns with the finding of Siddiqui *et al.* (2009), who reported that the leaf extract of *Prosopis juliflora* reduces the GVI value of wheat seedlings.

The seedling vigour index (SVI) is a measure of seed viability and quality. In the current study we observed a decline in SVI with an increase in the aqueous extract concentration of weed. These findings correlated with the finding of Scavo *et al.* (2018), who suggested that the SVI value of *Solanum nigrum*, *Amaranthus retroflexus* and *Brassica campestris* declines with the increase concentration of *Cynara cardunculus*. In this investigation, we observed that the length of the radicle was more crucially impacted by the weed aqueous extract as compare to the control condition. Thakur *et al.* (2017), revealed that the presence of phytochemical substances, including omega-3 fatty acids, phenolic acids with their derivatives and alkaloids in *Melia composita* extract, likely explains that why the radicle length had more effect than plumule length. This is because the underground parts of the seedlings are initially exposed to these phytochemicals. Like other parameters, plumule-radicle length was also concentration-dependent. Our results aligned with the finding of Han *et al*. (2008), who suggested that the higher concentration of ginger aqueous extract had more pronounced effect on radicle and plumule length. The remarkable reduction in fresh weight of seedlings with more detrimental effects was observed at the 50 per cent concentration of *C. benghalensis* aqueous extract. Reduction in fresh weight was also dose-dependent. Similar finding was also reported by Bogatek *et al.* (2006), who concluded that aqueous extract of sunflower with elevated concentration reduces the fresh weight of mustard seedlings. The substantial reduction in fresh weight of *S. indicum* strongly indicates the existence of chemical substances in experimented weed, which interfere with the physiological activity of the seedlings.

A case study of field observation concluded that the *S. indicum* field was associated with several weed species but *C. benghalensis* was observed dominated due to its allelopathy and hindering nature for the other plant's growth. All the observed parameters were significantly reduced with the elevated weed density. Similarly, the outcomes from laboratory experiment concluded that all the examined parameters show pronounced poor growth under the various concentrations of *C. benghalensis* aqueous extract, indicative of the poor growth condition possibly due to the existence of allelochemicals. It is evidently concluded that the weed inhibitory effects are both dose-dependent and crop-specific. These findings emphasize the need for effective management strategies to reduce the *C. benghalensis* and other weeds density in the agriculture field, with the aim of mitigating their detrimental impacts on agricultural productivity.

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