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Allelopathic Effects of Selected Weed Species on Seed Germination and Seedling Growth of Mungbean (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A laboratory experiment was conducted at the plant physiology division, Bangladesh Agricultural Research Institute (BARI) during 2019-20 to assess the allelopathic effects of some selected weed species on seed germination and seedling growth of mungbean. Four weed species viz., Durba (*Cynodon dactylon*), White cock's comb (*Celocia argentia*), Shyama (*Echinochloa crusgalli*), Shak notae (*Amaranthus viridis*) were used for mungbean (BARI Mug 6). Boiled and un-boiled weed extracts reduced the germination and primary growth of mungbean. The ranking of weed species in

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respect of inhibitory effect on seed germination of mungbean was *Celocia argentia* (33.4%) > *Cynodon dactylon* (45.4%) > *Amaranthus viridis* (86.3%) > *Echinochloa crusgalli* (88.3%). Durba (*Cynodon dactylon*) and White cock's comb (*Celocia argentia*) had strong detrimental effect on primary growth of mungbean. The extracts of all the parts of weeds inhibited germination and primary growth of this crop. The relative efficiency of inhibition of germination and primary growth by different weed extracts was in the order of stem > whole plant > leaf > root. The reduction of germination and primary growth increased with increasing extract concentrations. So, it could be suggested that *Cynodon dactylon* and *Celocia argentia* had strong detrimental effect on mungbean. Therefore, the cited weeds must be taken into well care and it should be avoided in seed bed for growing Mungbean seedlings. Further studies need to be carried out to explore the effects of allelopathy of selected weeds on seed germination and seedling growth of mungbean.

Keywords: Allelopathic effect; weed species; mungbean; seed germination; seedling growth.

1. INTRODUCTION

Allelopathy is considered as a defenses mechanism available to plants, which release chemicals and influence the growth and development of neighboring plants in both natural and agricultural ecosystems. This process happens through root exudation, leaching, volatilization, residue decomposition and other means by creating direct and indirect effects on the adjacent microenvironment [1] due to chemical substances released by plants Einhelling [2]

Allelochemicals results in detrimental effects and is categorized into two which are true allelopathy and functional allelopathy [3]. The true allelopathy is the release of substances which are toxic in nature from its origin as they are produced in plants [3] Functional allelopathy is the release of toxic things that are resultants of transformation by microorganism [4,5] These chemicals accrue and persevere for a substantial time in the plant, result significant interference on growth and development of neighboring plants [2] that can be either a crop or a weed. With considerable work conducted in past decades, the presence of restrictive compounds in a wide array of plant types and its parts at varying concentrations were investigated and with remarkable attention being paid to allelopathy [4] and its related effects.

As the understanding of the mechanisms of these allelochemicals in plants grew, a great significant attention was given to the potential use of allelopathy as a weed management technique in achieving sustainable agriculture particularly in organic farming [6] Integration of allelopathy into natural and agricultural management systems might be helped to reduce the usage of synthetic agrochemicals. Ultimately, it helps to reduce the negative effects on the environment, especially environment pollution. Exploring crop allelopathy against weeds might be a useful strategy to eliminate problems created by synthetic agro-chemicals [7]. Recently, several crops and weeds showed clear weeds suppressive ability and with strong use in agricultural fields, by exuding allelochemical compounds either from living plants or from decomposing residues [8]. Further, this positive effect on weed control helps to in introduce potential allelopathic crops into crop rotation programmes, either as a cover or mulch to smother crops, or as a green manure in sustainable agricultural practices. This is a very positive and important trend in modern agriculture, which could apply for the benefit of human beings by reducing excess use of chemical usage. Further, it helps to control severe health problems that could be caused due to unsafe handling of agrochemicals [9]. Moreover, the idea of allelopathy can be utilized effectively to produce eco-friendly natural herbicides [10].

During past decades, the suppressive ability of allelochemicals in weeds has drawn significant attention. However, the specific weed or plant species and its unique responses were not clearly studied yet. Therefore, the focus of this study was to assessment the allelopathic effect of some naturally grown weed species that commonly occur in agricultural fields. The objective of the study was to observe the allelopathic effect of four selected common broadleaf weed species on mungbean seeds and seedlings and to identify the weed plant parts which have more allelopathic response on crops.

2. MATERIALS AND METHODS

2.1 Plant Materials

Mungbean is a most important pulse crops containing high nutritive value. It not only plays important role in human diet but also in improving the soil fertility by fixing the atmospheric nitrogen. Its seed is more palatable, nutritive, digestible and non-flatulent than the other pulses. To find out the allelopathic effects of selected weed species on seed germination and seedling growth of Mungbean, BARI Mug 6 variety was used in this experiment which was released by Bangladesh Agricultural Research Institute (BARI).

Based on a literature review performed as active allelopathic materials weed species were chosen. Aqueous extracts of Durba *(Cynodon dactylon),* White cock's comb (*Celocia argentia),* Shyama (*Echinochloa crusgalli*), Shak notae *(Amaranthus viridis)* considered as allelopathic materials.

2.1.1 Experimental treatment

The boiled and un-boiled selected weed extracts were used. Stem, leaf, root and whole plant extracts of different weed species were considered.

2.1.2 Collection of weeds and preparation of weed extracts

Weed species collected from the research field, Bangladesh Agricultural Research Institute (BARI), Gazipur. After collecting they were washed in distilled water for removing dust and soil particles, then chopped and macerated. In a set fresh weed mass (250g) of each weed species was boiled in 1 litre water and kept for 3 days with intermittent stirring. The extracts were filtered through filter paper. The filtrates were used as boiled extracts of weeds. In another set, 250g fresh weed mass were decomposed in 1 litre water for 7 days at normal room temperature (28 ± 1^0C). The extracts were filtered and used as un-boiled extract. Thus boiled and un-boiled extracts of each weed species were prepared and used in this experiment following the technique as stated by Prasad and Srivastava [11].

2.2 Experimental Procedure

To assess the allelopathic effects of selected weeds on seed germination and seedling growth of mungbean, a petri-dish experiment was conducted at the laboratory of plant physiology division, Bangladesh Agricultural Research Institute (BARI) during 2019-20. There are two sets of trials, each with un-boiled and boiled extracts for each crop, were performed. Twenty five seeds of each test crops were placed in each petri-dish with double layer of filter paper and treated with weed extracts. A control set with distilled water was set simultaneously every time. The filter papers were kept moist with distilled water constantly. The experiment was arranged in a completely randomized design (CRD) with 3 replications at room temperature (28 ± 1^0C).

2.3 Parameters

a) Germination (%)
b) Days to complete germination
c) Seedling growth and weight

   i. Root and shoot lengths
   ii. Root and shoot weights

d) Chlorophyll content

In this experiment, 10 plants were selected to each parameter and the average results were calculated from these collected plants. The number of germinated seeds was counted from the beginning of the seed germination up to completion of the seed germination. The root and shoot lengths, fresh & dry weights of respective root and shoot of mungbean seedlings were measured after 7 and 14 days respectively of the germination setting.

2.4 Determination of Chlorophylls

Chlorophyll was estimated by Arnon's method [12] 0.5gm of sample grinds into 5.0ml of 80% acetone in clean mortar and pestle. It was centrifuged at 5000 rpm for 10 minutes and supernatant was used for read the absorbance at 645 and 663 nm against the solvent (80% Acetone) blank.

3. RESULTS AND DISCUSSION

3.1 Effect on Seed Germination

The experimental data of effect of boiled and un-boiled weed extracts on seed germination have been shown in Table 1. It was found that the seed germination varied significantly due to the effect of boiled and un-boiled weed extracts on seed germination of mungbean. The allelopathic effect of different species of weeds induced significant reduction in mungbean seed germination. Maximum germination rate (98.80 %) was observed in control treatment while the minimum (33.40%) was obtained in *Celocia argentia* extract treated seeds. The ranking of the weed species in respect of inhibitory effect on seed germination of mungbean was *Celocia argentia* > *Cynodon dactylon* > *Amaranthus viridis* > *Echinochloa crusgalli*. Again the number of days required to complete the germination of seeds was also affected significantly by the weed extracts. The number of days required to complete the germination was recorded minimum (3.0 days) in control treatment whereas it was maximum (5.50 days) due to the effect of *Cynodon dactylon* extract which was statistically similar with that of *Celocia argentia*. Similar inhibitory effect of weed species on seed germination was noted by Lalbiakdika *et al* [13] Hazarika & Sannigrahi [14] found the inhibitory effect on germination and seedling growth of vegetables by different weed species.

On the other hand, the effect of boiled and un-boiled extracts of different weed species induced significant variation in germination rate and number of days required to complete the germination of mungbean seeds which have been shown in Table 2. Highest germination rate (99.20%) was recorded in control treatment (boiled water) which was statistically similar with that of control (un-boiled water). On the other hand, the lowest germination rate was found (30.0%) due to the effect of un-boiled extract of *Celocia argentia*. The number of days required to complete germination was also significant in boiled and un-boiled extracts of different weed species. Maximum days (5.7 days) required to complete the germination was noted due to the effect of un-boiled extract of *Cynodon dactylon* which was statistically similar with un-boiled extract of *Celocia argentia* and minimum days (3.0 days) in control treatment (both boiled and un-boiled water).

3.1.1 Effect on root and shoot lengths

Root and shoot lengths of Mungbean seedlings reduced significantly due to the allelopathic effect of boiled and un-boiled weed extracts as presented in Tables 1 & 2. The highest root length (6.87cm) was observed in control treatment while it was lowest (0.21 cm) in the extract of *Celocia argentia*. Again, the highest shoot length (16.72 cm) was found in control and the lowest (1.15 cm) was found in that of *Celocia argentia* (Table 1).

The effect of boiled and un-boiled extracts of weeds on BARI mung 6 have been presented in Table 2 indicating significant variation in root and shoot lengths of seedlings. Maximum root length (7.63 cm) was recorded in control while the minimum (0.16 cm) was in boiled extract of *Celocia argentia*. Minimum root length was statistically similar with those of un-boiled and boiled extract of *Celocia argentia*. Maximum shoot length (18.12 cm) was also observed in control and the minimum (1.09 cm) was due to the effect of boiled extract of *Celocia argentia.* Minimum shoot length was statistically similar with that of un-boiled extract of *Celocia argentia*.

3.1.2 Effect on fresh and dry weights of root

Fresh and dry weights of roots of mungbean reduced significantly due to the allelopathic effect of boiled and un-boiled weed extracts as have been presented in Tables 1 & 2. Maximum fresh (44.90 mg) and dry (4.35 mg) weights were observed in control while the minimum fresh (14.80 mg) and dry (1.12 mg) weights of root were found in aqueous extract of *Celocia argentia* (Table 1). The effect of boiled and un-boiled extracts of weeds on Mungbean (Table 2) reflecting significant reduction in fresh and dry weights of roots of seedlings. Maximum fresh (45.60 mg) and dry (4.60 mg) weights of root were recorded in boiled water control. On the other hand, minimum fresh (14.40 mg) and dry (1.06 mg) weights were due to the effect of boiled extract of *Celocia argentia*.

3.1.3 Effect on fresh and dry weights of shoot

Fresh and dry weights of shoot of mungbean seedling were reduced significantly due to the allelopathic effect of different weed species. Maximum fresh (284.70 mg) and dry (31.60 mg) weights were observed in control. Again, the minimum fresh (99.30 mg) and dry (13.90 mg) weights of shoot was found in extract of *Celocia argentia* (Table 1). The effects of boiled and un-boiled extracts of weeds on mungbean have been presented in Table 2 indicating significant inhibition on the fresh and dry weights of shoot of seedlings. Maximum fresh (285.10 mg) and dry (32.20 mg) weights of shoot were recorded in boiled water control treatment. On the other hand, the minimum fresh (98.4 mg) and dry (13.80 mg) weights were recorded due to the effect of boiled extract of *Celocia argentia*.

Table 1. Effect of extract of different weed species on germination and primary growth of Mungbean

Weed extracts	Germination (%)	Days to complete germination	Root length (cm)	Shoot length (cm)	Fresh wt. of root (mg)	Dry wt. of root (mg)	Fresh wt. of shoot (mg)	Dry wt. of shoot (mg)	Total Chlorophyll content
Control (water)	98.8	3.0	6.87	16.72	44.90	4.35	284.70	31.60	14.63
Cynodon dactylon	45.4	5.5	1.28	4.29	16.95	1.53	110.25	15.25	11.57
Celocia argentia	33.4	5.3	0.21	1.15	14.8	1.12	99.3	13.9	9.48
Echinochloa crusgalli	88.3	4.1	3.77	7.91	36.2	3.49	270.5	27.05	13.76
Amaranthus viridis	86.3	4.3	4.34	8.72	39.15	3.86	265.9	26.65	14.50
Level of significance	**	**	**	**	**	**	**	**	**
CV (%)	0.69	3.42	10.30	3.78	0.29	3.26	0.30	2.52	0.62

***Significant at 1% level of probability*

Table 2. Effect of boiled weed extracts (BW) and un-boiled weed extracts (UBW) on germination and primary growth of Mungbean

Weed extracts	Germination (%)	Days to complete germination	Root length (cm)	Shoot length (cm)	Fresh wt. of root (mg)	Dry wt. of root (mg)	Fresh wt. of shoot (mg)	Dry wt. of shoot (mg)
Control (water)								
BW	98.5	3.0	7.63	18.12	44.2	4.1	284.3	31.0
UBW	99.2	3.0	6.1	15.32	45.6	4.6	285.1	32.2
Cynodon dactylon								
BE	46.3	5.3	1.17	4.37	16.3	1.44	109	14.2
UBE	44.5	5.7	1.38	4.21	17.6	1.62	111.5	16.3
Celocia argentia								
BE	36.8	5.0	0.16	1.09	14.40	1.06	98.4	13.8
UBE	30.0	5.6	0.25	1.21	15.20	1.18	100.2	14.0
Echinochloa crusgalli								
BE	84.6	4.0	2.65	6.68	35.80	3.43	266.6	26.7
UBE	88.0	4.2	4.89	9.14	36.60	3.56	274.4	27.4
Amaranthus viridis								
BE	90.3	4.0	3.05	7.55	38.00	3.78	256.8	25.4
UBE	82.3	4.6	5.62	9.88	40.30	3.94	275.0	27.9
Level of significance	**	**	**	**	**	**	**	**
CV (%)	0.69	3.42	10.30	3.78	0.29	3.26	0.30	2.52

BE = Boiled Extract; UBE= Un-Boiled Extract; BW= Boiled Water; UBW= Un-Boiled Water;
***Significant at 1% level of probability*

Minimum dry weight of shoot was statistically similar with those of boiled and un-boiled extract of *Cynodon dactylon* and un-boiled extract of *Celocia argentia*.

3.2 Chlorophyll Content

Total Chlorophyll content of mungbean seedlings was reduced significantly by the allelopathic effect of different weed species. Maximum Chlorophyll content (14.63) was observed in control and minimum rate (9.48) was found in *Celocia argentia* extract treated seeds (Table 1). It was observed that the chlorophyll content was comparatively higher due to less allelopathic effect of *Echinochloa crusgalli* (13.76), *Amaranthus viridis* (14.50) extract treated seeds. The ranking of weed species in respect of inhibitory effect on seed germination of mungbean was *Cynodon dactylon* > *Celocia argentia* > *Amaranthus viridis* > *Echinochloa crusgalli*.

3.3 Allelopathic Effect of Different Weed-Plant Parts on Mungbean

Celocia argentia and *Cynodon dactylon* showed more inhibitory effect on mungbean compared to other weed species, these two weed species were selected further study.

3.3.1 Effect on germination

Celocia argentia and *Cynodon dactylon* showed more inhibitory effect on mungbean compared to other weed species, the results revealed that the germination of mungbean was suppressed significantly due to the extract of different weed plant parts as presented in Tables 3 & 4. Highest germination rate (98.85%) was observed in control and the lowest (30.05%) was in stem extract of different weeds (Table 3). The variation in germination of mungbean seed (BARI mug 6) was significant at 1% due to the interaction between different plant parts of two weeds species. Highest germination rate (98.85%) was found in control while the lowest (24.30%) was in stem extract of *Celocia argentia* (Table 4). Samad et al [15]. observed that the mass of stem of the weed species was more detrimental than leaf and root. The germination of mungbean seed was delayed by the allelopathic effect of extract of different weed plant parts. Maximum days required (6.1 days) to complete the germination was recorded in aqueous extract of stem and the minimum days (3.0 days) were found in control as presented in Table 3.

3.3.2 Effect on root and shoot lengths

Root and shoot lengths of mungbean seedlings were reduced significantly by the allelopathic effect of different plant parts. Highest root length (6.87 cm) was observed in control and the lowest length (0.84 cm) was found in stem extract of weeds. Lowest length of root was statistically similar with leaf, root and whole plant extracts of weeds. Again the highest shoot length (16.72 cm) was observed in control and the lowest length (2.26 cm) was found in stem extract of weeds. Lowest shoot length was also similar with that of leaf extract of weeds (Table 3). While considering the effect of plant parts of two species of weeds it was observed that the variation in root and shoot lengths of mungbean seedling was significant at 1%. Highest root (6.87cm) and shoot (16.72 cm) lengths were recorded in control and the lowest root (0.55 cm) and shoot (1.07 cm) lengths were found in stem extract of *Celocia argentia.* Minimum length of root and shoot was statistically similar with that of leaf, root and whole plant extracts of *Celocia argentia* (Table 4).

3.3.3 Effect on fresh and dry weights of root

Fresh and dry weights of root of mungbean seedling were significantly inhibited due to the allelopathic effect of weed plant parts as presented in Table 3. Maximum fresh (44.90 mg) and dry (4.28 mg) weights of root were recorded in control and minimum fresh (16.40 mg) and dry (1.24 mg) weights were recorded due to the root extract of two different weeds. The inhibition of fresh and dry weight of root of BARI mug 6 seedling as reduced by the extract of different plant parts of two weed species have been shown in Table 4. Maximum fresh (44.90 mg) and dry (4.28 mg) weights were found in control. Minimum fresh (15.30 mg) weight found in root extracts of *Cynodon dactylon* and dry weights (1.05 mg) was found in root extract of *Celocia argentia*.

3.3.4 Effect on fresh and dry weights of shoot

Fresh and dry weights of shoot of seedling of mungbean were significantly reduced due to the allelopathic effect of plant parts of two weed species. Maximum fresh (274.10 mg) and dry (30.80 mg) weights of shoot was observed in control while the minimum fresh (105.24 mg) and dry (12.62 mg) weights was recorded due to the root extract of different weeds (Table 3). The variation in fresh and dry weights of shoot of

Table 3. Effects of extract of different weed plant parts on germination and primary growth of Mungbean

Weed extracts	Germination (%)	Days to complete germination	Root length (cm)	Shoot length (cm)	Fresh wt. of root (mg)	Dry wt. of root (mg)	Fresh wt. of shoot (mg)	Dry wt. of shoot (mg)
Control (water)	98.85	3.00	6.87	16.72	44.90	4.28	274.10	30.80
Stem Extract	30.05	6.1	0.84	2.26	16.40	1.24	110.60	14.50
Leaf Extract	33.70	5.9	0.95	2.42	17.70	1.45	116.35	19.54
Root Extract	42.80	5.6	1.52	2.61	19.30	1.62	105.24	12.62
Whole weed Extract	32.90	5.4	1.0	2.49	18.44	1.51	115.20	15.90
Level of significance	**	**	**	**	**	**	**	**
CV (%)	0.62	3.42	2.02	1.76	0.28	3.30	0.31	2.58

***Significant at 1% level of probability*

Table 4. Interaction *effect* of weeds species and weed plants parts on germination and primary growth of Mungbean

Weed extracts	Germination (%)	Days to complete germination	Root length (cm)	Shoot length (cm)	Fresh wt. of root (mg)	Dry wt. of root (mg)	Fresh wt. of shoot (mg)	Dry wt. of shoot (mg)
Control (water)	98.85	3.00	6.87	16.72	44.90	4.28	274.10	30.80
Extract of *Cynodon dactylon*								
Stem	40.20	6.0	1.11	3.34	16.70	1.34	112.60	16.50
Leaf	44.10	5.8	1.19	3.47	17.65	1.55	115.35	19.34
Root	48.50	5.3	1.13	4.95	15.30	1.19	103.21	13.60
Whole plant	42.00	5.5	1.21	3.98	17.10	1.48	117.20	21.10
Extract of *Celocia argentia*								
Stem	24.30	6.1	0.55	1.07	16.50	1.28	116.20	15.32
Leaf	26.70	5.7	0.63	1.12	17.10	1.44	122.85	21.17
Root	36.40	5.6	0.71	1.17	16.80	1.05	116.00	15.32
Whole plant	28.00	5.5	0.69	1.21	17.30	1.33	115.30	14.79
Level of significance	**	**	**	**	**	**	**	**
CV (%)	0.62	3.42	2.02	1.76	0.28	3.30	0.31	2.58

***Significant at 1% level of probability* mungbean seedlings was significant at 1% due to the effect of extract of different plant parts of two weed species. Maximum fresh (274.10 mg) and dry (30.80 mg) weights were found in control treatment. Minimum fresh (103.21 mg) and dry (13.60 mg) weights of root were recorded in root extract of Cynodon dactylon. Respectively, Minimum dry weight of shoot was statistically similar with that of whole plant extract of Celocia argentia (Table 4).

4. CONCLUSIONS

The allelopathic influences of Durba (*Cynodon dactylon*), White cock's comb (*Celocia argentia*), Shyama (*Echinochloa crusgalli*), Shak notae (*Amaranthus viridis*) were tested in bioassays on Mungbean. The aqueous extracts of above weeds significantly suppressed the seed and seedlings of above crops. All the selected weeds had more or less inhibitory effect on seed germination, number of days to complete germination, root and shoot lengths, fresh and dry weights of root and shoot of mungbean. Among the plant parts, stem extract was most inhibitory followed by leaves. From the above findings of the present experiment it could be suggested that *Cynodon dactylon* and *Celocia argentia* had strong detrimental effect on mungbean cultivation. Therefore the cited weeds must be taken into well care and it should be avoided in seed bed for growing mungbean seedlings. The results of this experiment proved that it was important to exclude these allelopathic weeds specially *Cynodon dactylon* and *Celocia argentia*.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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