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Effect of Aqueous Extract of Grass Weeds on Seed Germination and Seedling Growth of Vegetable Crops

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Authors' contributions

This work was carried out in collaboration among all authors. Author MAA designed the study, performed the statistical analysis and wrote the draft of the manuscript. Author AKMAA collected the data on germination performance. Author MHRP wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Toxicity of grass weeds on crop growth through root exudates occurs naturally but no such study was conducted on the seed germination and seedling growth of some important vegetables of Bangladesh. Therefore, the aim of the research was to evaluate the effects of some grass weed extracts like crabgrass (*Eleusine indica*), nutgrass (*Cyperus rotundus*) and bermudagrass (*Cynodon dactylon*) on the germination and seedling growth of some vegetable crops like okra (*Abelmoschus esculentus*), radish (*Raphanus sativus*), water spinach (*Ipomoea aquatica*) and red amaranth (*Amaranthus gangeticus*).
Study Design: The experiment was laid out in a Completely Randomized Design (CRD) where each treatment was replicated five times.
Place and Duration of Study: The experiment was conducted in the Plant Ecology Laboratory, Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during July 2015 to November 2015.

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Methodology: Paste of 100 g of each of grass weed was prepared with distilled water taking in mortar and pestle. Final volume was made 100 mL which was treated as absolute extract (100%). Five levels of test solutions were prepared from each absolute weed extract. The test solutions were (i) control (distilled water), (ii) absolute weed extract 100% from each weed and its dilution (iii) 50%, (iv) 25%, and (v) 12.5% with distilled water. Ten mL test solution was used to moisten the tissue papers placing them in each petri dish. Theses treated petri dishes were used for the germination and seedling growth of the vegetable seeds at ambient conditions.
Results: Germination percentage in all the vegetable crops was significantly inhibited by the grass weed extracts in a concentration dependent manner. The germination of the seed and seedling growth were decreased with increase in concentration of the extracts and the highest inhibitory effects were observed in 100% concentration. Among the extracts of three different grass weeds, nutgrass showed more toxic effect on the seed germination and seedling growth of test crops than other weeds. Radish seedling was more susceptible than other vegetable crops to the said weed extracts.
Conclusion: The aqueous extracts from grass weeds had inhibitory effect on both germination and seedling growth of vegetable crops.

Keywords: Exudates; germination; phytotoxicity; plumule; radical; grass weeds.

1. INTRODUCTION

Crop and weed seeds germinate at about the same time and they grow simultaneously in the same place. Almost all crops are sensitive to weed infestation. At certain stage, crop growth may totally be prejudiced under severe weed infestation resulting in poor growth or no harvest. That is weeds have much potential to compete with crop plants and thus measures are taken to control weeds at threshold level for better crop production. Reduction in crop production can be due to weed infestation caused for the exudation of toxic chemicals by weeds into the environment, among another factors like light, mineral and water competition. The toxicity of weeds on crop through the phytotoxic exudates was reported by many workers like Rao and Kumar [1] and Rani et al. [2]. These effects are selective and concentration dependent and may have inhibitory or stimulatory effect on the growth of subsequent crops or weeds [3-5]. More than fifteen thousand chemicals have been identified and found to release from crops through volatilization, leaching, decomposition of crop residues and root exudation.

Rice [6] defines allelopathy as any direct or indirect harmful effect by one plant to another through the production of chemical compounds that escape into environment. Komai et al. [7] isolated and identified some chemicals from purple nutsedge tubers like *Cyperone,* β-selinene, Cyperenone, α-Cyperone and these chemicals were found to inhibit the germination and root growth of crop plants. Gaffer [8] conducted a comprehensive study on crops and field weeds. It is well known that most of the organic, bio-organic and also different types of toxic compounds are present in natural source especially in plant kingdom. The compounds present in root of crop seedlings and also in weed seedlings may cause different types of interaction to produce allelochemicals which may interrupt for germination of seeds. Some growth inhibitory chemicals identified in Johnsongrass (*Sorghum* halepense (L.) Pers.) are chlorogenic acid, P-coumaric acid P-hydroxy benzaldehyde which are capable of affecting the growth and development of other associated plants [9]. A weed named *Borreria articularis* (L. f.) F. N. Williams is reported to reduce the growth of tomato, lettuce and corn by releasing water soluble chemicals from the roots in field condition [10]. Hakim et al. [11] reported that aqueous extracts of some common weeds strongly inhibit the growth and development of vegetable crops.

Plants synthesize, store and exude various kinds of organic compounds in their surroundings. Some of the exuded compounds (allelochemicals) inhibit the growth of the source plants (auto-toxicity) or the other species grown in the vicinity of source plants. Weed commonly inhibits the growth of crop plants. Severe weed infestation in crop field during crop production is common in Bangladesh. Severity of weed infestation and crop growth inhibition vary with the weed species. Among them some grass weeds like crabgrass (*Eleusine indica*), nutgrass (*Cyperus rotundus*) and bermudagrass (*Cynodon dactylon*) are common and treated as noxious weeds in crop fields of Bangladesh. They strongly inhibit the growth of crop plants in the

field. However their level of inhibition to the crop growth especially on germination and seedling growth are not well documented. Therefore, a research was undertaken to study the effect of weed extracts of crabgrass, nutgrass and bermudagrass on seed germination and seedling growth of some important vegetable crops like radish (*Raphanus sativus*), okra (*Abelmoschus esculentus*), water spinach (*Ipomoea aquatica*) and red amaranth (*Amaranthus gangeticus*).

2. MATERIALS AND METHODS

The experiment was conducted at the Plant Ecology Laboratory of the Department of Crop Botany, Bangladesh Agricultural University (BAU), Mymensingh during the period extended from July 2015 to November 2015.

2.1 Source of Test Plant Materials

Disease free, clean and fresh seeds of four common vegetables of Bangladesh viz. water spinach or Chinese spinach locally called kalmishak (*Ipomoea aquatica* Forssk., Convolvulaceae), red amaranth locally called lalshak (*Amaranthus gangeticus* L., Amaranthaceae), radish (*Raphanus sativus* L., Brassicaceae) and lady's finger or okra (*Abelmoschus esculentus* (L.) Moench, Malvaceae) were collected from registered seed company.

2.2 Preparation of Weed Extracts

Three grass weeds viz. or crabgrass or silver crabgrass or goose grass or wiregrass locally called chapra (*Eleusine indica* (L.) Gaertn., Poaceae), nutgrass or purple nutsedge locally called mutha (*Cyperus rotundus Hook. f.*, Cyperaceae) and bermudagrass locally called durba (*Cynodon dactylon* (L.) Pers., Poaceae) were collected from Farm areas or Field Laboratories of Bangladesh Agricultural University, Mymensingh. Hundred gram each of the weeds (whole plants including fruits and nuts) was chopped into small pieces and ground to paste with distilled water in a mortar and pestle separately. The mixture was filtered through filter paper Whatman no. 1 and the filtrates were collected in measuring cylinder. The extract volume was adjusted to 100 mL with distilled water for the bioassay and this was considered as stock solution for absolute concentration.

2.3 Experimental Treatments and Design

The final extract of 100 mL each from the weeds of crabgrass, bermudagrass and nutgrass were used as stock solution. Five levels of test solution 12.5%, 25%, 50% 100% and control (distilled water) were prepared for experimental treatment. The experiment was laid out in a Completely Randomized Design (CRD) where each treatment was replicated five times. All the treatments were distributed in the petri dishes according to the principle of randomization.

2.4 Bioassay Procedure

Glass petri dishes of 15 cm diameter were used. Double layers of tissue papers were used as the medium of germination in each petri dish. Ten milliliters of each test solution (extract) as per treatments were added to moisten the substratum (i.e. tissue papers). Twenty seeds of red amaranth were placed uniformly by a pair of forceps in each treated petri dish with five replications and were kept in racks in dark at room temperature. Germination was recorded daily. A seed was said to be germinated when the length of emerged radicle was about 2 mm. After four days, radicle and plumule lengths of some selected seedlings from each petri dish were recorded to evaluate inhibition potential of the extract. The same bioassay procedure was followed for radish, okra and water spinach with all grass weed extracts.

2.5 Data Collection on Seed Germination

Data on the germination were taken at 48, 72 and 96 h after sowing and continued up to completion of germination. Germination percentage was calculated using the following formula:

$$\% \text{ Germination} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds sown}} \times 100$$

2.6 Sampling for Seedling Growth

The petri dishes were carefully taken out from the racks at dark place after four days of sowing. Ten seedlings were selected randomly from each petri dish and were uprooted carefully by a pair of forceps in order to ensure intact radicle to be available. The radicle and plumule lengths of the uprooted seedlings were recorded by a graduated scale. Radicle length was measured from radicle-plumule junction to the radicle tip. Similarly, plumule length was measured from plumule-radicle junction to the plumule tip.

2.7 Evaluation of Potential Effect of Test Solutions on Test Crops

After taking the data on germination and seedling growth, the potential effect of each extract solution on the test crops was calculated as percent inhibition in germination and growth over control treatment (distilled water):

$$\text{Inhibition (\%)} = \frac{\text{Germination or growth in control} - \text{Germination or growth in test solution}}{\text{Germination or growth in control}} \times 100$$

2.8 Statistical Analyses

Data recorded on germination and seedling growth were compiled and tabulated for statistical analysis. Analysis of variance was done following Completely Randomized Design (CRD) with aid of statistical package MSTAT-C software. The mean differences among the treatments were tested using Duncan's Multiple Range Test [12].

3. RESULTS AND DISCUSSION

3.1 Effect of Weed Extracts on Seed Germination of Different Crops

The effect of weed extracts of crabgrass, bermudagrass and nutgrass on seed germination of radish, okra, water spinach and red amaranth were evaluated and found that germination percentages of these vegetable seeds were decreased with increasing the concentration of the weed extracts (Table 1). Control showed the highest germination percentage at 72 and 96 hours followed by 12.5% weed extracts. On the other hand, the most concentrated (100%) extract showed strongest inhibition of germination to these crops. Among the weed extracts, nutgrass exerted significantly highest inhibition on seed germination where crabgrass inhibited the lowest. Challa and Ravindra [13] applied leaf and root leachates and extracts of bermudagrass (*Cynodon dactylon* L.) and *Echinochloa colonum* L. on onion, radish and knol-khol and observed reduced germination of the seeds. The allelopathic potential of *Cynodon dactylon* was also tested against black gram (*Vigna mungo*) and result revealed that seed germination was significantly reduced by the weed extract [14]. Mubeen et al. [15] found that aqueous extract of *Eleusine indica* weed played an allelopathic effect and inhibited the seed germination of rice (*Oryza sativa* L.). Pego and Fialho [16] applied weed extracts of *Cyperus rotundus* and *Oxalis latifolia* on snapdragon seed and observed inhibitory effects of germination.

3.2 Effect of Weed Extracts on Radicular Growth

Irrespective of source of the extracts, the radicular growth of the test crops was significantly affected by the weed extracts. The length of the radicle of radish seedling in control (distilled water) was about 1.36 cm which was significantly reduced by absolute concentrated extract (100%) to 0.46 cm, 0.33 cm and 0.23 cm for the extracts from crabgrass, bermudagrass and nutgrass, respectively (Table 2) indicating that the weed extracts had a steady inhibitory effect on radicular growth. Strongest inhibitory effects about 66.18%, 72.50% and 80.17% over control were observed at 100% concentration of the extracts from crabgrass, bermudagrass and nutgrass, respectively, followed by 50% concentration of these weed extracts. The lowest inhibitions about 11.76%, 8.33% and 19.83% over control in radicle length were found in radish at 12.5% weed extract from crabgrass, bermudagrass and nutgrass, respectively. The radicle length of okra seedling was significantly decreased with increased in the concentration of the different weed extracts. Hundred percent concentrated extract had showed the strongest inhibitory effect about 22.73%, 15.00% and 44.44% over control on the radicular growth of okra seedlings and resulted in 0.17 cm, 0.17 cm and 0.15 cm radicle length from extract from crabgrass, bermudagrass and nutgrass, respectively followed by 50% weed extract (Table 2). The lowest inhibition about 4.55%, 0% and 33.33% over control in okra radicle length was found for the extract from crabgrass, bermudagrass and nutgrass, respectively at 12.5% concentration of the absolute extract (100%). Similar results were also found in case of water spinach and red amaranth where 100% concentration of the weed extract exhibited the strongest radicular growth inhibition followed by 50% concentration and the lowest inhibition was found for 12.5% extract of the different grass weeds.

Table 1. Effect of aqueous extracts of various grass weeds on the seed germination (%) of different vegetable crops assayed through petri dish method

Weeds	Extract conc.	Radish			Okra			Water spinach			Red amaranth		
		48 h	72 h	96 h	48 h	72 h	96 h	48 h	72 h	96 h	48 h	72 h	96 h
Crabgrass	Control	25.0a	41.5a	66.7a	45.0a	73.4a	81.7a	18.3a	51.7a	80.0a	26.7a	41.7a	85.0a
	12.5%	20.0b	40.0a	65.0a	40.0ab	51.7b	65.0b	15.0b	35.0b	73.4ab	21.7ab	35.0ab	73.4b
	25%	15.0c	35.0ab	51.7b	33.3bc	46.7b	60.0b	11.7bc	31.7bc	63.4bc	16.7bc	31.7b	61.7c
	50%	8.0d	30.0b	45.0bc	26.7d	35.0c	40.0c	8.3c	26.7c	53.4c	11.7cd	30.0bc	50.0d
	100%	0.0e	11.7c	36.7c	13.3d	26.7d	33.3c	0.0d	16.7d	25.0d	6.7d	23.3c	38.3e
Bermudagrass	Control	23.3a	41.7a	66.7a	43.3a	70.0a	81.7a	16.7a	48.3a	76.7a	26.7a	41.7a	81.7a
	12.5%	16.7b	33.3ab	55.0b	35.0b	41.7b	53.5b	13.3b	31.7b	66.7b	16.7b	30.0b	65.0b
	25%	11.7c	30.0bc	46.7b	26.7c	41.7b	51.7b	11.7b	21.7bc	55.0c	11.7c	26.7b	41.7c
	50%	6.7d	23.3c	35.0c	16.7d	31.7c	36.7c	8.3c	16.7c	45.0d	8.3c	25.0bc	35.4d
	100%	0.0e	8.3d	31.7c	11.7d	21.7d	31.7c	0.0d	13.3d	217.7e	6.7d	18.4c	33.4e
Nutgrass	Control	26.7a	41.7a	65.0a	36.7a	70.0a	78.4a	18.3a	45.0a	78.4a	23.3a	40.0a	80.0a
	12.5%	15.0b	28.4b	45.0b	26.7b	33.3b	46.7b	10.0b	26.7b	55.0b	13.3b	26.7b	58.4b
	25%	10.0c	23.3bc	40.0b	21.7bc	30.0bc	41.7bc	8.4bc	21.7bc	46.7c	10.0bc	21.7b	45.0c
	50%	6.7d	18.3c	36.7bc	16.7c	25.0c	35.0cd	6.7c	16.7c	38.4d	6.7cd	21.7b	36.7d
	100%	0.0e	6.5d	16.7c	8.3d	15.0d	30.0d	0.0d	10.0d	16.7e	5.0d	13.4c	28.4e

The figures in a column having the same letter (s) do not differ significantly as per DMRT at 5% level of probability (P<0.05)

Table 2. Effect of aqueous extracts of various grass weeds at different concentrations on the radicular growth of different vegetable crops grown in petri dishes at ambient condition

Weeds	Extracts conc.	Radish		Okra		Water spinach		Red amaranth	
		Radicle (cm)	Inhibition (%)	Radicle (cm)	Inhibition (%)	Radicle (cm)	Inhibition (%)	Radicle (cm)	Inhibition (%)
Crabgrass	Control	1.36 a	0	0.22 a	0	1.83 a	0	1.60 a	0
	12.5%	1.20 a	11.76	0.21 a	4.55	1.66 a	9.29	1.40 a	12.50
	25%	0.90 b	33.82	0.21 a	4.55	1.11 b	39.34	1.17 b	26.88
	50%	0.70 c	48.53	0.18 b	18.18	1.10 b	39.89	0.90 c	43.75
	100%	0.46 d	66.18	0.17 b	22.73	0.73 c	60.11	0.80 c	50.00
Bermudagrass	Control	1.20 a	0	0.20 a	0	1.83 a	0	1.47 a	0
	12.5%	1.10 a	8.33	0.20 a	0	1.70 a	7.10	1.37 a	6.80
	25%	0.80 b	33.33	0.19 b	5.00	1.46 b	20.22	1.27 a	13.61
	50%	0.60 b	50.00	0.18 ab	10.00	1.10 c	39.89	0.90 b	38.78
	100%	0.33 c	72.50	0.17 ab	15.00	0.70 d	61.75	0.76 b	48.30
Nutgrass	Control	1.16 a	0	0.27 a	0	1.90 a	0	1.46 a	0
	12.5%	0.93 b	19.83	0.18 b	33.33	1.70 b	10.53	1.30 a	10.96
	25%	0.80 b	31.03	0.17 b	37.04	1.40 b	26.32	0.90 b	38.36
	50%	0.56 c	51.72	0.16 bc	40.74	0.90 c	52.63	0.80 bc	45.21
	100%	0.23 d	80.17	0.15 c	44.44	0.70 d	63.16	0.70 c	52.05

The figures in a column having the same letter (s) do not differ significantly as per DMRT at 5% level of probability (P<0.05)

Among the grass weed extracts, the extract from nutgrass exerted the strongest inhibition than other two weed extracts. It seems that the extract from nutgrass might have some more toxic effect of allelochemicals. Crabgrass showed lowest inhibition and highest germination of those vegetables, as a result highest radicle length of the vegetables crops was observed. In contrast, lowest radicle length was observed when the radicle of test crops was affected by nutgrass extract. It was also observed that radicle length was gradually decreased with the increasing concentration of the extract (Table 2). Among the crops, the highest inhibition about 80.17% over control was recorded in radish followed by water spinach (63.16%), red amaranth (52.05%) and okra (44.44%) from nutgrass extract at 100% concentration. Similar results were also observed by Darmanti et al. [17]. They applied aqueous tuber extract of *Cyperus rotundus* L. on soybean and observed the adverse effect of the extract on seedling growth including radicle length.

3.3 Effect of Weed Extracts on Plumule Growth

The effects of extracts from crabgrass, bermudagrass and nutgrass on plumule length of all test crops were found statistically significant (Table 3). The plumule length of radish had shown decreasing trend with increasing the concentration of weed extracts. The tallest plumule of 3.16 cm was observed in control treatment followed by 12.5% concentration. Absolute concentrated extracts (100%) had shown the shortest plumules about 1.10 cm, 0.96 cm and 0.90 cm for the extracts of crabgrass, bermudagrass and nutgrass, respectively. The highest percent of adverse effects about 65.19% 67.57% and 69.59% over control were found for hundred percent concentration of the extract from crabgrass, bermudagrass and nutgrass, respectively, and the lowest inhibitory effects about 6.33%, 5.41% and 12.16% over control were noticed at 12.5% of the concentration. The plumule length of okra was reduced to 0.43 cm, 0.33 cm and 0.26 cm when treated with 100% concentration extract from crabgrass, bermudagrass and nutgrass, respectively which indicated the adverse effect of these grass weed extracts to plumule growth. The highest percentages of adverse effects about 77.72%, 82.63% and 86.32% over control on okra were found for 100% concentration of the extract from crabgrass, bermudagrass and nutgrass, respectively, and the lowest percentage of inhibition about 24.35%, 31.58% and 38.95% over control was found with 12.5% of concentration. Similar result was found in case of water spinach and red amaranth where 100% concentration of weed extracts boldly inhibited the plumule length followed by 50% concentration of weed extract and the lowest was found in 12.5% extracts from different grass weeds. Among the weed extract, nutgrass extract had strongest inhibitory effect than other two weed extracts. Among the crops, highest inhibition proportional was recorded in okra (86.32%) followed by radish (69.59%) or red amaranth (69.28%) and lowest was found in water spinach (68.20%) from 100% extract of nutgrass.

The result is similar with the finding of Darmanti et al. [17] who applied aqueous tuber extract of nutgrass weed on *Glycine max* L. cv. Grobogan and observed the toxic effect of extract leading to reduction of seedling growth including plumule elongation. The root exudates of *Cyperus rotundus* significantly reduced the root and shoot growth of tomato and cucumber plants, while, its residues incorporated with 3 and 6 g/kg soil inhibited the seedling growth of sorghum, soybean and cowpea [18]. The volatile compounds released from shoot and tubers of *Cyperus rotundus* significantly reduced the seedling growth of mungbean. Afrin et al. [19] applied weed extract of *Eleusine indica* (L.) Gaertn, *Cyperus rotundus* L. and *Cynodon dactylon* L. on red amaranth, radish and tomato, and found that the plumule length of these vegetable plants was significantly inhibited. Rezaie and Yarnia [20] observed that the aqueous extracts from root and shoot of *Cynodon dactylon* significantly affected the shoot growth of safflower (*Carthamus tinctorius* L.) due to the presence of some allelopathic agents. Similar results were also observed in other plants by Prasad and Srivastava [21], Babu et al. [22] and Sardoei et al. [23].

Allelopathic effects are probably caused by some biochemical compounds released or secreted by the weed plants. A high-performance liquid chromatography analysis showed that *Cyperous rotundus* foliage contains some phenolic acids like caffeic, ferulic, coumaric, benzoic, vanelic, chlorogenic and cinnamic, and tubers of *C. rotundus* contain hydroxybenzoic, caffeic, ferulic, vanelic and chlorogenic [24]. Phytochemical analysis showed that *Cynodon dactylon* contains flavanoids, alkaloids, glycosides, terpenoides, triterpenoids steroids, saponins, tannins, resins, phytosterols, reducing sugars, carbohydrates,

Table 3. Effect of aqueous extracts of various grass weeds at different concentrations on the growth of plumule of different vegetable crops grown in petri dishes at ambient condition

Weeds	Extracts conc.	Radish		Okra		Water spinach		Red amaranth	
		Plumule (cm)	Inhibition (%)	Plumule (cm)	Inhibition (%)	Plumule (cm)	Inhibition (%)	Plumule (cm)	Inhibition (%)
Crabgrass	Control	3.16 a	0	1.93 a	0	2.93 a	0	3.10 a	0
	12.5%	2.96 a	6.33	1.46 b	24.35	2.66 b	9.22	2.83 b	8.71
	25%	2.40 b	24.05	1.10 c	43.01	2.10 c	28.33	2.73 b	11.94
	50%	1.63 c	48.42	0.60 d	68.91	1.58 d	46.08	1.40 c	54.84
	100%	1.10 d	65.19	0.43 e	77.72	1.10 e	62.46	1.03 d	66.77
Bermudagrass	Control	2.96 a	0	1.90 a	0	2.93 a	0	2.93 a	0
	12.5%	2.80 a	5.41	1.30 b	31.58	2.66 a	9.22	2.76 a	5.80
	25%	2.13 b	28.04	1.10 c	42.11	2.00 b	31.74	2.43 b	17.06
	50%	1.80 b	39.19	0.53 d	72.11	1.60 c	45.39	1.33 c	54.61
	100%	0.96 c	67.57	0.33 e	82.63	1.06 d	63.82	1.03 d	64.85
Nutgrass	Control	2.96 a	0	1.90 a	0	2.83 a	0	2.93 a	0
	12.5%	2.60 a	12.16	1.16 b	38.95	2.50 b	11.66	2.83 a	3.41
	25%	2.13 b	28.04	0.96 c	49.47	1.90 c	32.86	2.23 b	23.89
	50%	1.73 c	41.55	0.46 d	75.79	1.43 d	49.47	1.16 c	60.41
	100%	0.90 d	69.59	0.26 e	86.32	0.90 e	68.20	0.90 c	69.28

The figures in a column having the same letter (s) do not differ significantly as per DMRT at 5% level of probability (P<0.05)

proteins, volatile oils and fixed oils [25]. The action of these compounds is depend on decaying, retention, transformation concentration and soil conditions. Phenolic acids can reduce the growth of roots, leading to reduction mineral absorption and transport of food to other parts of the plant [26]. Root growth is done by the rate of cell division of apical meristem. Some allelopathic substances such as coumarins lower cells mitosis rate leading to decreased root growth [27]. Weeds reduce yield and quality of associated crops through interference i.e. competing for resources (water, nutrient, space and light) and releases phytochemicals or allelochemicals into the environment, which have direct or indirect harmful effects on crop plants [14]. Thus it can be said that biochemical compounds released by weed species may affect the growth of neighbouring plants (if crops species are there) in various ways.

4. CONCLUSION

Weed extracts showed adverse effect on seed germination percentage, radicle and plumule growth of radish, okra, water spinach and red amaranth. Irrespective of nature of extracts radicular growth of these vegetable crops except radish was more inhibited than the plumule. In contrast, radicular growth of radish was much affected by the weed extracts especially by the extracts of bermudagrass and nutgrass. Irrespective of the vegetable species, nutgrass extract exerted strongest inhibition to germination, and radicle and plumule lengths were highly reduced by the extract of nutgrass as compared to other weeds. The order of inhibition of aqueous weed extracts was as follows: Nutgrass> Bermudagrass > Crabgrass extracts. The order of susceptibility of vegetable crops to the said weed extracts was as follows: Okra>Radish>Red amaranth>Water spinach for plumule growth, and Radish > Water spinach > Red amaranth > Okra for ridiculer growth.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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