EFFECT OF AQUEOUS EXTRACT AND COMPOST OF INVASIVE WEED *Ageratina adenophora* ON SEED GERMINATION AND SEEDLING GROWTH OF SOME CROPS AND WEEDS

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Abstract

A study was conducted to investigate the effects of invasive weed *Ageratina adenophora* on the seed germination and seedling growth of *Triticum aestivum*, *Brassica campestris* and on weeds *Ageratum conyzoides*, *Bidens pilosa*, *Galinsoga parviflora and Cyperus rotundus*. The aqueous extracts of *Ageratina* plant's part root, stem and leaf; and compost extract of *Ageratina* on different concentrations (control, 1, 2.5, 5 and 10%) were used to determine its effect on the seed germination, shoot and root length of *Triticum aestivum*, *Brassica campestris* and some common weed seeds under laboratory condition. The compost of *A. adenophora* at different doses viz. 0, 10, 20, 40 and 50g compost/kg soil was also applied to study the effect on the seed germination and seedling growth of *B. campestris* and *T. aestivum* and some weed seeds. The aqueous and compost extracts of *Ageratina* caused significant reduction in the seed germination and seedling length (shoot and root) which increased progressively on increasing the concentration of invasive plant's extract. The stem and leaf extracts of *A. adenophora* have more inhibitory effect on the germination percentage of winter crops as compared to root extract on the test crop seeds under study. In the compost of *A. adenophora*, the weeds showed more reduction in comparison to the crop plants *B. campestris* and *T. aestivum*.

***Key words*:** Invasive, aqueous extract, compost, allelopathy, inhibition.

INTRODUCTION

A total of 190 invasive alien species under 112 genera belonging to 47 families has been recorded from the Indian Himalayan region (Kumar *et al*. 2016, Sekar *et al*. 2012). In China 25 out of 33 highly noxious weeds have significant allelopathic impact on surrounding plants. The release of biochemicals called allelochemicals, reduce the seed germination and seedling growth of surrounding plants (Ferguson *et al*. 2013). The plant species belonging to family Asteraceae produce the substances that are toxic to germination and growth of other plant species (Tripathi *et al.* 1981). Invasive plant parts have allelopathy to continue for their ecological accomplishment.

The allelochemicals discharged from a plant are due to volatilization, leaching, exudation and decomposition (Gill *et al*. 1993). The allelopathic activities of the crude methanol extract of *Chromolaena. odorata*, on the seed germination and seedling growth of tomato have been observed by Tijani and Fawusi (1989).

Ageratina adenophora of Asteraceae family is a troublesome, aggressive, toxic perennial weed. It threatens bio, eco, agro and forestry systems in the tropical and subtropical regions. *Ageratina adenophora* (syn.name- *Eupatorium adenophorum*) weed came to Nepal through Mexico is one of the serious weeds in Asia. It quickly spreads across the terai, midhill and low mountain areas (Bisht *et al.* 2016).

Kumar *et al.* (2016) reported that the loss of plant diversity in both crop and forest areas over the last two to three decades is due to invasive plant. *Parthenium hysterophorus*, *Ageratina adenopha*, *Lantana camara*, *Ageratum conyzoides* and *Bidens pilosa* are degrading valuable crop and fodder plants (especially herbs and grasses). The leachates of *A. adenophora* plant damage cell membrane and influence the endogenous compounds like abscisic acid, indole 3-acetic acid and zeatinriboside of the roots of upland rice (Zheng *et al.* 2012).

The present work was carried out to understand the allelopathic influences of *Ageratina adenophora* on winter crops like mustard (*Brassica campestris*), wheat (*Triticum aestivum*) and four common weeds (*Ageratum*, *Bidens*, *Cyperus* and *Galinsoga*) by using their plant parts (root, stem and leaves) aqueous extract, compost extract and compost.

MATERIAL AND METHODS

The invasive plant *Ageratina adenophora* and mature selected weed seeds were collected from selected sites around Kathmandu valley in Nepal, before flowering in May-June 2014. The matured seeds of *Bidens pilosa*, *Ageratum conyzoides*, *Galinsoga parviflora* and *Cyperus rotundus* were also collected from different sites around Kathmandu valley like Kirtipur and Bhaktapur areas in the months of March and April 2014. In Kirtipur (Machhegaon, Chhobhar, Chhugaon, Dhapla and near Tribhuban University and in Bhaktapur- Lokanthali (Near- Manohara Khola), Thimi, Gatthaghar, Sano Thimi and Balkot the samples were collected from fallow land and from the wheat and mustard fields.

The seeds of selected crops and weeds were collected, cleaned and dried. The nutrients like protein test method following AOAC (2012), carbohydrate and fat (test method- CFL Manual) per seed was analyzed at the Department of Food Technology and Quality control, Central Food Laboratory, Babarmahal, Kathamandu, Nepal.

The soil texture, pH, humus content in the soil of experimental site was conducted in the laboratory condition. The NPK test was conducted by Forest and Soil Science, Department of Forest Research and Survey, Nepal.

The plant parts (viz. root, stem and leaves) were separated, air dried and ground to make powder. To prepare aqueous extract, 2g of ground air dried leaves, stem and root were separately soaked in 20 ml distilled water for 24 hours. The extract was filtered using Whatman No.1 filter paper and 10% stock solution was prepared. From this stock solution, 5, 2.5 and 1.0% concentrations were prepared by diluting with distilled water.

A pit of 60.96 cm x 91.44 cm x 91.44 cm (length x breadth x depth) was prepared at shady place and was filled with layers of *Ageratina* plant altering with soil. It was left for seven months (March to September, 2015). This decomposed compost was ready to use. From this compost the experiment on compost extract at laboratory was conducted.

Two grams of air dried compost were soaked in 20 ml distilled water for 24 hours. The extract was filtered using Whatman No.1 filter paper and 10% stock solution was prepared. From this stock solution, 5, 2.5 and 1.0 % concentrations were prepared.

Seed germination experiment

i) Weed seeds of *A. conyzoides*, *B. pilosa*, *C. rotundus* and *G. parviflora* and the crop seeds of *B. campestris* and *T. aestivum* were soaked, separately in 2-4% Sodium hypochlorite for two minutes. The seeds were then washed with distilled water thoroughly. The sterilized petridishes were lined with single piece of Whatman No. 1 filter paper and moistened with 5ml of treatment solution. The crops (viz. *B. campestris* and *T. aestivum*) and uniform size weed seeds of *A. conyzoides*, *B. pilosa*, *C. rotundus* and *G. parviflora* were selected and ten seeds of each species were kept in sterilized petridishes containing control, 1, 2.5, 5 and 10% concentrations of **(a)** aqueous extract and **(b)** compost extracts for 10 days. For control, seeds were grown in a piece of filter paper soaked with distilled water. All these experiments were conducted under normal room temperature with five replications. The moisture level in the petridish was maintained by adding distilled water as required.

ii) The seed germination experiment was also conducted in poly bag (35.56 × 17.78 cm) by using different concentrations (viz. 10, 20, 40 and 50 g/kg soil) of *A. adenophora* compost in the month of

November, 2015. There were five replications of each treatment (10 selected seeds of weed and crops were sown). Seed germination and seedling growth were recorded after 30 days. The nutrient like protein, carbohydrate and fat per seed was analyzed at the Department of Food Technology and Quality Control, Central Food Laboratory, Kathmandu, Nepal.

Statistical analysis was done by using SPSS statistical version 20. The data were subjected to one way ANOVA followed by Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The soil of experimental site was sandy loam and loamy type having 6.2 pH and 0.88% humus. Total N.P.K. were recorded 0.140, 0028 and 0.018%, respectively. The crop *T. aestivum* showed more content of moisture, protein, crude fiber and carbohydrate (viz. 0.54, 0.66, 0.30 and 3% per seed, respectively) than *B. campestris* (viz. 0.03, 0.08, 0.007 and 0.09% per seed, respectively) and other weed seeds of *A. conyzoides*, *B. pilosa*, *C. rotundus* and *G. parviflora*. Fat content was more in *B. campestris* (0.16%) than in *T. aestivum* (0.13%) and other weeds. Crude fiber was the highest in *T. aestivum* and lowest in *Brassica*. Among the weeds the protein content ranged from 0.009 to 0.02 %, fat from 0.001 to 0.01% and carbohydrate from 0.018 to 0.103%.

Ageratina adenopnora aqueous extract

The seed germination, shoot and root length of germinated seeds mostly decreased with the increase in the concentration of *Ageratina* root, stem and leaf aqueous extract in both tested crops *B. campestris* and *T. aestivum*, and weeds *A. conyzoides*, *B. pilosa*, *C. rotundus* and *G. parviflora* (Tables 2 and 3).

Seed germination

i.a) Impact of aqueous extract on the seed germination of crops- the seed germination of *B. campestr* is reduced insignificantly in 2.5 and 5% of *A. adenophora* root and stem extract, respectively but in leaf extract it was 5 and 10% (Table 3). The seed germination of *Brassica* seed was higher in stem extract than in root and leaf extracts. The shoot and root length of the germinated seeds of *B. campestris* reduced significantly in all treatments in comparison to the control. Mostly, insignificant reduction in the shoot and root lengths of seedlings was 5 and 10% in root and stem extracts, respectively. In leaf extract, the root length of *B. campestris* decreased significantly in all treatments, but insignificant reduction was observed in 1 and 2.5% concentrations (Table 1).

Reduction in the percentage germination of *Triticum* seeds was more on root extract than in stem and leaf extract treatments. Significant decrease in seed germination was 5 and 10% in root and leaf extracts. The shoot and root length of *T. aestivum* seedlings reduced significantly in all treatments. The root length was reduced significantly in all treatments of *A. adenophora* plant parts (Table 1).

Impact of the aqueous extract of *A. adenophora* was more or less similar on all weeds. The seed germination of *A. conyzoides* decreased insignificantly with all treatments in root extracts. Reduction was the same in stem and leaf extracts and decreased significantly ($p=0.05$) with their higher concentrations. There was complete inhibition at 10% of stem and leaf extracts. Seed germination in leaf extract was less than in root or stem extract with 1% concentration, but the seed germination was reduced insignificantly ($p=0.05$) at 2.5 and 5% concentration of stem extract. The shoot length of seedlings decreased significantly at root, stem and leaf extracts (Table 2).

The seed germination of the weed *B. pilosa* decreased insignificantly at 1 and 2.5% concentrations of the root, stem and leaf extracts of *A. adenophora*. The percentage of germination declined significantly in all the treatments up to 2.5% of root, stem and leaf extracts of *A. adenophora*. The shoot

and root length of the seedlings decreased significantly (p=0.05) in all treatments with increase in concentration (Table 2).

Table 1. Effect of root, stem and leaf extracts of *A. adenophora* on the seed germination (SG mean ±SD**), shoot length (SL mean** ±SD **) and root length (RL mean** ±SD**) of crops (*B. campestris* and *T. aestivum*) after 10 days.**

Species	Plant organs		Concentration (%)				
			0	**1**	**2.5**	**5**	**10**
Brassica campestries	Root extract	SG (%)	92.5±5.00 c	85±5.77 c	72.5±5.00 b	67.5±9.57 b	55±5.77 a
		SL(cm)	11.63±2.25 e	8.76±2.47d	5.32±2.15 c	4.11±1.05 b	2.21±0.49 a
		RL(cm)	9.01±0.92 e	8.36±2.06 d	4.65±1.01 c	2.91±0.47 b	2.21±0.49 a
	Stem extract	SG(%)	92.5±5.00 c	85±5.77bc	75.5±5.77 b	67.5±5.00 a	60±0.16 a
		SL(cm)	6.49±0.62 d	5±0.73 c	3.94±0.86 b	3.68±0.45 ab	3.4±0.42 a
		RL(cm)	5.63±0.62d	4.83±0.51 c	3.14±0.78 b	2.96±0.66 b	2.58±0.74 a
	Leaf Extract	SG(%)	95±5.77 d	80±8.16 c	70±8.16 bc	60±11.54 ab	52.5±5.00 a
		SL(cm)	6.89±0.51 e	5.82±0.51 d	4.24±0.19 c	3.38±0.36 b	2.21±0.23 a
		RL(cm)	4.14±0.45 d	3.45±0.31 c	3.3±0.10 c	2.4±0.32 b	1.85±0.22 a
Triticum aestivum	Root extract	SG(%)	90±8.16 d	82.5±9.57cd	72.5±5.00 bc	65±5.77 ab	55±10.00 a
		SL(cm)	11.83±1.69 d	9.44±1.97 c	7.9± 1.45 b	4.45±0.88 a	4.08±1.00 a
		RL(cm)	7.57±0.68 d	5.72±1.58 c	4.47±0.41 b	3.56±0.94 a	3.51±0.54 a
	Stem extract	SG(%)	95±5.77 d	85±5.77 cd	77.5±5.00 bc	70±11.54 b	55±5.77 a
		SL(cm)	14.27±1.51 e	11.98±1.50 d	9.13±0.83 c	7.81±0.96 b	4.21±0.50 a
		RL(cm)	12.5±1.47 e	9.6±1.24 d	7.89±1.04 c	7.16±0.78 b	3.77±0.37 a
	Leaf Extract	SG(%)	95±5.00 c	85±5.77 bc	80±11.54 bc	67.5±15.00 ab	60±5.00 a
		SL(cm)	9.46±0.63 e	7.88±0.45 d	6.25±0.09 c	4.47±1.00 b	3.35±0.40 a
		RL(cm)	6.15±0.69 e	5.08±0.57 d	4.58±0.55 c	3.64±0.43 b	3.2±0.17 a

Mean ±SD in the same column followed by the same letter does not differ significantly according to Duncan's Multiple Range Test at p=0.05 followed after ANOVA.

The application of *A. adenophora* plant part extract severely affected the germination, seedling growth of weed the of *C. rotundus*. The seed germination of *C. rotundus* was reduced as the concentration increases, but insignificant reduction was observed in all treatments of stem extract. Total inhibition was observed at 5 and 10% treatments on stem and leaf extracts. The growth of *C. rotundus* seedling was inhibited at higher concentration of aqueous extract (Table 2). The germination percentage of the seed of *G. parviflora* decreased with increase in concentration of the root, stem and leaf extracts of *A. adenophora*. Seed germination in the root extract was more than in the stem and leaf extracts. The leaf extract showed more allelopathic effects than the root or stem extracts. Total inhibition was observed in 5% concentration in stem extract and 5 and 10 % leaf extract. Shoot and root length exhibited insignificant reduction in 1, 2.5, 5 and 10% root extract in comparison to the control. At leaf extract significant reduction was observed in shoot and root lengths (Table 2).

ib) Effects of A. adenophora compost extract on the seed germination and seedling growth of crops and weeds- Crop and weed seed germination and seedling growth under laboratory conditions with different concentrations of compost aqueous extract ranging from 1 to 10% showed different responses. Seed germination, shoot and root lengths decrease more in the weed seeds (*A. conyzoides*, *B. pilosa*, *C. rotundus* and *G. parviflora*) than in the crops *B. campestris* and *T. aestivum* with the increase in concentration of *A. adenophora* compost extract (Table 3).

The seed germination of the crop *B. campestris* showed insignificant reduction with 1, 2.5 and 5% of compost extracts, but seed germination was completely inhibited at 10% *A. adenophora* compost extract. The seed germination of *T. aestivum* reduced significantly (p=0.05) at 1%, but at higher

concentrations (2.5, 5 and 10%) reducion was insignificant. The seed germination of weed *A. conyzoides* and *G. parviflora* reduced insignificantly up to 2.5 %. The seeds of *B. pilosa* showed insignificant reduction with 1, 2.5 and 5% concentrations. The total inhibition of seed germination of *Bidens* weed was observed at 10%. The seed germination of *C. rotundus* was reduced insignificantly at 1% concentration of *Ageratina* compost extract in control (Table 3).

Table 2. Effect of root, stem and leaf extracts of *A. adenophora* on the seed germination (SG mean ±SD), shoot length (SL mean ±SD) and root length (RL mean ±SD) of weeds (viz. *A. conyzoides*, *B. pilosa*, *C. rotundus* and *G. parviflora*) after 10 days.

Species	Plant organs		Concentration (%)				
			0	1	2.5	5	10
Ageratum conyzoides	Root extract	SG (%)	67.5±15.00 a	57.5±9.57 a	57.5±5.00 a	55±5.77 a	52.5±9.57 a
		SL(cm)	2.94±0.21 e	2.76±0.18 d	1.76±0.12 c	1.55±0.11 b	1.29±0.05 a
		RL(cm)	2.54±0.36 e	1.79±0.23 d	1.5±0.13 c	1.23±0.09 b	1.07±0.07 a
	Stem extract	SG(%)	72.5±9.57 c	65±5.77 c	55±10.00 ab	50±8.16 a	NG
		SL(cm)	1.87±0.50 c	1.67±0.35 c	1.19±0.30 b	0.92±0.11 a	NG
		RL(cm)	1.68±0.45 d	1.54±0.31 c	1.04±0.28 b	0.74±0.09 a	NG
	Leaf Extract	SG(%)	75±5.77 c	55±5.77 b	52.5±5.00 ab	45±5.77 a	NG
		SL(cm)	1.81±1.04 d	1.12±0.42 c	0.91±0.20 b	0.84±0.08 a	NG
		RL(cm)	1.61±0.08 c	1±0.23 b	0.77±0.18 ab	0.71±0.07 a	NG
Bidens pilosa	Root extract	SG(%)	80±8.16 c	75±5.77 c	70±11.54 bc	62.5±5.00ab	55±5.77 a
		SL(cm)	9.18±1.85 e	7.96±1.55 d	6.32±0.32 c	5.27±0.40 b	4.38±0.27a
		RL(cm)	8.36±1.68 d	7.06±1.43 c	4.36±0.59 b	3.42±0.16 a	2.92±0.55 a
	Stem extract	SG(%)	80±11.54 c	72.5±5.00 bc	67.5±5.00 bc	62.5±9.57 ab	52.5±9.57 a
		SL(cm)	8.33±0.51 e	7.03±1.38 d	5.65±1.57 c	4.73±1.09 b	2.63±0.21 a
		RL(cm)	7.4±0.79 e	6.31±1.74 d	3.68±1.08 bc	3.1±0.70 b	2.28±0.24 a
	Leaf Extract	SG(%)	85±5.77 b	75±5.77 ab	67.5±9.57 ab	57.5±26.29 a	55±5.77 a
		SL(cm)	8.5±1.07 e	6.76±0.66 d	5.7±1.51 c	4.27±0.84 b	2.89±0.64 a
		RL(cm)	6.7±1.55 c	5.76±1.23 b	5.11±1.53 b	2.86±0.48 a	2.53±0.58 a
Cyperus rotundus	Root extract	SG (%)	65±5.77 c	62.5±5.00 bc	55±5.77abc	50±11.54 ab	47.5±9.57 a
		SL(cm)	1.44±0.05 e	1.27±0.05 d	0.85±0.05 c	0.65±0.09 b	0.45±0.05 a
		RL(cm)	1.26±0.06 e	1.13±0.09 d	0.65±0.06 c	0.43±0.10 b	0.25±0.05 a
	Stem extract	SG(%)	62.5±5.00 a	57.5±9.57 a	55±5.77 a	NG	NG
		SL(cm)	1.43±0.42 b	1.08±0.40 a	0.91±0.09 a	NG	NG
		RL(cm)	1.26±0.37 c	0.92±0.35 b	0.73±0.07 a	NG	NG
	Leaf Extract	SG(%)	75±5.77 b	57.5±9.57 a	55±5.77 a	NG	NG
		SL(cm)	1.5±0.08 b	1.25±0.27 a	1.21±0.10 a	NG	NG
		RL(cm)	1.35±0.07 c	1.15±0.25 b	0.86±0.19 a	NG	NG
Galinsoga parviflora	Root extract	SG(%)	72.5±5.00 c	62.5±5.00 bc	60±8.16 ab	55±10.00 ab	50±8.16 a
		SL(cm)	1.69±0.06 c	1.46±0.32 b	1.32±0.28 b	1.21±0.28 a	1.21±0.11 a
		RL(cm)	1.52±0.04 c	1.25±0.27 b	1.18±0.25 b	0.98±0.32 a	1±0.09 a
	Stem extract	SG(%)	57.5±5.00 a	55±5.77 a	52.5±9.57 a	52.5 ±5.00 a	NG
		SL(cm)	1.96±0.73 c	1.27±0.19 b	1.03±0.14 ab	0.94±0.06 a	NG
		RL(cm)	1.43±0.66 c	1.07±0.14 b	0.82±0.13 a	0.78±0.09 a	NG
	Leaf Extract	SG(%)	70±11.54 b	65±5.77 ab	52.5±5.00 a	NG	NG
		SL(cm)	1.4±0.62 a	1.28±0.28 a	1.18±0.06 a	NG	NG
		RL(cm)	1.31±0.50 b	1.16±0.24 ab	1±0.08 a	NG	NG

Mean ±SD in the same column followed by the same letter does not differ significantly according to Duncan's Multiple Range Test at p=0.05 followed after ANOVA. NG-No Germination.

The shoot length was reduced significantly, but root length of *B. campestris* reduced significantly with 1 and 2.5% concentrations. In *T. aestivum*, the shoot and root lengths reduced significantly at all

concentrations (viz. 1, 2.5, 5 and 10%). The shoot and root lengths of weed's shoot and root length reduced significantly with increasing concentrations of compost extracts. The *Bidens* seed germination and shoot lengths were reduced insignificantly, but root length reduced significantly at higher concentration (2.5 and 5%) (Table 3).

Table 3. Effect of *A. adenophora* compost extract on the seed germination (SG mean ±SD**), shoot length (SL mean** ±SD**) and root length (RL mean** ±SD**) of selected crop and weed seeds after 10 days.**

Species		Concentration (%)				
		0	1	2.5	5	10
Brassica campestris	SG (%)	75±5.77 b	62.5 ±5.00 a	57.5±5.00 a	55± 5.77 a	NG
	SL(cm)	6.59 ±0.24 d	3.78 ±0.22 c	2.41 ±0.61 b	2.09 ±0.11 a	NG
	RL(cm)	5.50 ±0.12 d	3.00 ±0.60 b	2.23 ±0.55 b	2.20 ±0.02 a	NG
Triticum aestivum	SG(%)	77.5±5.00 c	70±11.54 bc	62.5±5.00 ab	60±11.54 ab	55±10.00 a
	SL(cm)	7.81±0.38 e	6.89±0.13 d	5.83±0.39 c	4.94±0.10 b	3.26±0.91 a
	RL(cm)	7.66±0.29 e	6.51±0.50 d	5.41±0.14 c	4.62±0.49 b	3.04±0.48 a
Ageratum conyzoides	SG(%)	57.5±9.57 a	55±12.90 a	52.5±5.00 a	NG	NG
	SL(cm)	3.21±0.07 c	2.87±0.06 b	1.68±0.42 a	NG	NG
	RL(cm)	3.06±0.05 c	2.91±0.19 b	1.31±0.30 a	NG	NG
Bidens pilosa	SG(%)	77.5±5.00 b	57.5±9.57 a	55±5.77 a	52.5±5.00 a	NG
	SL(cm)	3.55±0.13 d	2.55±0.56 c	1.28±0.46 b	0.99±0.06 a	NG
	RL(cm)	2.60±0.10 c	2.18±0.39 b	1.13±0.36 a	1.00±0.03 a	NG
Cyperus rotundus	SG(%)	57.5±5.00 a	52.5±9.57 a	NG	NG	NG
	SL(cm)	1.81±0.08 b	1.00±0.07 a	NG	NG	NG
	RL(cm)	1.66±0.10 b	0.89±0.13 a	NG	NG	NG
Galinsoga parviflora	SG(%)	67.5±9.57 a	55±12.90 a	50±14.14 a	NG	NG
	SL(cm)	2.48±0.11 c	1.81±0.20 b	0.84±0.22 a	NG	NG
	RL(cm)	2.11±0.09 c	1.46±0.24 b	0.45±0.06 a	NG	NG

Mean ±SD in the same row followed by the same letter does not differ significantly according to Duncan's Multiple Range Test at P=0.05 followed after ANOVA. NG-No Germination.

ii) Effects of Ageratina compost amended with soil on seed germination and seedling growth

The seed germination of *B. campestris* and *T. aestivum* reduced insignificantly with 10, 20 and 40 g compost/kg soil concentration. The seed germination of *B. campestris* was completely inhibited at 50 g/kg soil treatment (Table 4).

The seed germination of weeds *B. pilosa* and *G. parviflora* reduced insignificantly at 10 and 20 g compost/kg soil treatments. The seed germination of *A.conyzoides* and *C. rotundus* was completely inhibited at higher concentration of compost (viz. 20, 40 and 50 g/kg soil) (Table 4).

The shoot and root length of *B. campestris* significantly increased with 10 compost/kg soil concentration, but reduced significantly at high concentrations (20 compost/kg and above).The shoot and root lengths of *T. aestivum* showed not much differences in compost 10 g/kg soil in both crops. The shoot and root length of weeds *A. conyzoides*, and *C. rotundus* showed significant reduction at 10g compost/kg soil concentration, but in case of *B. pilosa* shoot and root length significantly reduced in 10, 20 and 40g compost/kg soil concentrations in comparison to control. In *G. parviflora* significant reduction was observed in 10 and 20 g compost/kg soil concentrations in comparison to control, but insignificant reduction in between 10 and 20 g compost/kg soil concentrations (Table 4).

The alkaloids are more in leaves comparatively over the stem and root of the same plant species (Achakzai *et al*. 2009). Forty five volatile compounds are found in *Ageratina adenophora* plants. The compounds identified from the stem and leaves of this species are octacosanoic acid, hydroxycinnamic acid, ferulicacid, cafeicacid etc. (Subba 2012). The presence of flavonoid glycosides in the leaves was also reported by Nair *et al.* (1995). Seed germination in *T. aestivum* was higher in stem than the root and

leaf extracts of *A. adenophora*. Seed germination was observed in stem and leaf extract even at higher concentration (2.5-10%), in comparison to root extract. Seed germination was reduced significantly in comparison to control, but the germination of both crops was observed even at higher concentration. The shoot and root lengths of both crops were significantly reduced in the aqueous extract of *A. adenophora* plant's part.

Table 4. Effect of *A. adenophora* compost (amended with 0, 10, 20, 40 and 50 g/kg soil) on the seed germination (SG mean ±SD), shoot length (SL mean ±SD) and root length (RL mean ±SD) of selected crops and weed seeds after 30 days.

Species		Concentration(g/kg soil)				
		0	**10**	**20**	**40**	**50**
Brassica campestris	SG (%)	60±8.16 a	55±10.00 a	52.5±5.00 a	50±0.00 a	NG
	SL(cm)	16.58±1.96 c	17.25±1.09 c	12.71±1.36 b	4.41±1.49 a	NG
	RL(cm)	14.40±2.11 c	15.10±1.34 c	11.53±1.16 b	3.46±0.91 a	NG
Triticum aestivum	SG(%)	62.5±9.57 a	57.5±5.00 a	55±12.90 a	52.5±5.00 a	50±11.54 a
	SL(cm)	17.99±0.50 c	17.59±0.91 c	13.20±4.37 b	5.60±1.54 a	4.44±0.19 a
	RL(cm)	17.41±0.56 c	17.10±0.73 c	12.68±4.23 b	5.27±1.49 a	4.25 ±0.19 a
Ageratum conyzoides	SG(%)	55±12.90 a	52.5±5.00 a	NG	NG	NG
	SL(cm)	3.15±0.24 b	2.14±0.10 a	NG	NG	NG
	RL(cm)	2.92±0.25 b	1.75±0.41 a	NG	NG	NG
Bidens pilosa	SG(%)	57.5±5.00 b	55±5.77 ab	52.5±5.00 ab	50±0.00 a	NG
	SL(cm)	13.19±0.79 d	8.94±0.79 c	3.62±0.98 b	2.30±0.19 a	NG
	RL(cm)	12.37±0.55 d	8.74±0.91 c	3.21±0.93 b	2.02±0.21 a	NG
Cyperus rotundus	SG(%)	55±10.00 a	52.5±5.00 a	NG	NG	NG
	SL(cm)	3.86±0.44 b	3.01±0.27 a	NG	NG	NG
	RL(cm)	3.55±0.45 b	2.97±0.53 a	NG	NG	NG
Galinsoga parviflora	SG(%)	65±5.77 b	55±5.77 ab	39±23.41 a	NG	NG
	SL(cm)	4.64±0.70 b	3.01±0.27 a	2.81±0.07 a	NG	NG
	RL(cm)	4.32±0.71 b	2.77±0.29 a	2.51±0.16 a	NG	NG

Mean ±SD in the same row followed by same letter does not differ significantly according to Duncan's Multiple Range Test at P=0.05 followed after ANOVA; NG-No Germination.

The weeds *A. conyzoides* and *C. rotundus* were fully inhibited at higher concentration in leaf extract. In 1% aqueous concentration, the seed germination of *A. conyzoides* was higher in stem extract. In *B. pilosa* seed germination reduced significantly as the concentration increases, but was not completely inhibited even at higher concentration as found in the case of other weeds.

This may be due to the size of the seed. Katoch (2012) also reported that the large seed size was least sensitive to germinate and growth. The *C. rotundus* and *G. parviflora* were completely inhibited at 10% aqueous stem and leaf extract of *A.adenophora.* A number of researchers reported that large amount of allelochemicals released from the leaves which inhibit the growth (Zhao *et al.* 2009). The antioxidant activities of methanol, extracts from the leaves of *Ageratina* also inhibited the seed germination and seedling growth of other species (Ralte 2014).

The compost extract of *A. adenophora* showed detrimental effect more in the weeds studied than winter crops. Seed germination of *B. campestris* was inhibited at higher concentration, but *Triticum* did not. *Ageratum* and *Galinsoga* significantly reduced at lower concentration, but completely inhibited at higher concentration. In *B. pilosa,* seed germination was also inhibited at higher concentration. The seed germination of *C. rotundus* was observed only at lower concentration of *Ageratina* compost extract. Similar results found by Zhang *et al.* (2008) showed that the aqueous leachates of the stems and leaves of *A. adenophora* inhibited seed germination and seedling growth of *Neocheiropteris palmatopedata.* The inhibitory effects increased with increasing leachate concentrations.

The reduction of seed germination, seedling growth of *B. campestris* and *T. aestivum* increases with the increase of concentration in the soil amended compost of *A. adenophora*. It might be due to the allelochemicals released by *Ageratina* plant residues into the soil. It affects the germination and seedling growth processes by reducing cell division or auxin induced growth of roots (Katoch 2012, McCalla and Haskins 1964). At higher concentration (50g compost/kg soil), the seed germination of *B. campestris* fully inhibited, but *Triticum* germinated. In comparison to *Brassica* and other weed seeds, nutrient content (carbohydrate and protein) and seed weight per seed were higher in *T. aestivum (*Table 1). Presence of defensins and more nutrient content in seed possibly overcome the adverse impact of phenolic compounds on the seed germination of *T. aestivum*. The seed germination, shoot and root length of *A. conyzoides* and *C. rotundus* were germinated at lower concentration only (10g compost/kg). Besides *B. pilosa* and *G. parviflora* totally inhibited at higher concentrations (5 and 10g compost/kg soil). It might be possible due to the additive and synergistic effects become significant at lower concentration (Einhelling and Rasmussen, 1978). *G. parviflora* germination was higher in sandy and loamy soil and able to germinate in 4-10mm depth (De Cauwer *et al.* 2013). *Eupatorium adenophorum* plant was rich in phenolic compound like 2-hydroxycoumaric acid which inhibited the crop and surrounding plant's seed germination and seedling growth (Zheng *et al*. 2012).

It can be concluded that the plant part of *A.adenophora,* particularly stem and leaves contains more allelochemicals than root. The allelochemicals of *A.adenophora* severely affected seed germination as well as shoot and root length of all tested weeds and crops. Aqueous extract of *A. adenophora* had more inhibitory effect on the growth of shoot as well as root. Seed germination, shoot length and root length of *A. conyzoides, G. parviflora* and *C. rotundus* were fully suppressed. *B. pilosa* was less reduced in *A. adenophora* extract. The seed germination of *B. campestris* and weeds *A. conyzoides, G. parviflora* and *C. rotundus* were completely suppressed at higher concentrations, but the crop *T. aestivum* could germinate and survived even at 50 g compost/ kg soil treatment. Seed germination was higher in crops than in weeds indicating that there is a possibility of using the compost of *A. adenophora* in wheat and mustard fields as utilizes the invasive weeds as compost and reduces the population of other weeds due to its allelopathic effect.

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