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Original article

Allelopathic Effects of Jimsonweed (*Datua Stramonium* L.) Seed on Seed Germination and Seedling Growth of Some Leguminous Crops [1]

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Abstract

Laboratory and greenhouse experiments were carried out at the Faculty of Agricultural Sciences, University of Gezira, Sudan in season 2014/15. Laboratory experiments were conducted to study the allelopathic effect of aqueous extract of Jimsonweed (*Datua stramonium* L.) seed on seed germination of common bean (*Phaseolus vulgaris* L.), cowpea (*Vigna sinensis* [L.] Walp.), pigeon pea (*Cajanus cajan* [L.] Millsp.) and alfalfa (*Medicago sativa* L.). Six concentrations (0, 20, 40, 60, 80 and 100%) of the aqueous extract were prepared from the stock solution. Treatments, for each crop, were arranged in completely randomized design with four replicates. The seeds were examined for germination at three days after initial germination. Greenhouse experiments were conducted to study the allelopathic effect of Jimsonweed seed powder on seedling growth of the same crops. Seed powder was incorporated into the soil at rate of 0, 1, 2, 3, 4 and 5% on w/w biases in pots. Treatments, for each crop, were arranged in completely randomized design with four replicates. Experiments were terminated at 30 days after sowing and plant height, number of leaves and root length of crop seedlings were measured as well as plant fresh and dry weight. Data were collected and subjected to analysis of variance procedure. Means were separated for significance using Duncan`s Multiple Range Test at $p \leq 0.5$. The results showed that the aqueous extract of Jimsonweed significantly reduced seed germination of the tested leguminous crops and there was direct negative relationship between concentration seed germination. Also, the results showed that incorporating seed powder into the soil significantly decreased plant height, root length of crop seedlings as well as seedling fresh and dry weight. In addition, the reduction in seedling growth was increased as seed powder increased in the soil. However, the number leaves did not affected. It concludes that Jimsonweed has allelopathic affects on seed germination and seedling growth of the leguminous crops.

Keywords: Allelopathy, Allelopathic, Allelochemicals, Jimsonweed, Datura, Legume, Common Bean, Cowpea, Pigeon Pea, Alfalfa

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INTRODUCTION

Jimsonweed (*Datua stramonium* L.) belonging to the family Solanaceae, commonly known with different names such as Thorn apple, Devil's trumpet, Locoweed and Stinkweed (Oseni *et al.,* 2011). The plant is leafy green plant pink to white flowers. The flowers are all fragrant very hard to mistake with other plant. The seeds are found in small fruit which are completely covered with short, sharp, spines. The stalks are bristly and somewhat thin in comparison to the rest of the plant. The leaves are flat, mostly featureless and can either multi-edged or ovoid (Spina and Taddei, 2007). Jimsonweed is a naturally fast growing weed and is widely distributed in all warm regions of the world. Its presence has been sighted along the boundaries and hedges of the cultivating fields. Subsequently, seeds of this plant have been found as impurities in important agricultural crops (Ahmad et al., 2014).The plant competes for light, nutrients, moisture and space with the crop and thus causes severe losses to yield. (Ahmad et al., 2014). Beside this, the plant can manipulate partners, competitors and ecosystems through a biological natural phenomenon known as allelopathy (Elisante and Ndakidemi, 2014).

Allelopathy refers to direct or indirect positive or negative effect of one plant on another through the release of chemical compounds into the environment (Delabays et. al., 2004). These biochemicals are known as allelochemicals (Singh and Chaundhary, 2011). Allelochemicals are released from plant parts by means of leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems (Chou, 1990). Jimsonweed plant is rich in a variety of secondary metabolites such as tannins, terpenoids, alkaloids, flavonoids, phenols, steroids, glycosides and volatile oils (Banso and Adeymo, 2006). The allelopathic interactions showed that the plant is dangerous and may cause great deal of lose to the economically important crop and its presence in the cultivating fields is a matter of concern (Ahmad, et al., 2014). Tropane alkaloids produced by Jimsonweed have been detected as contaminant in many leguminous crops such as linseed and soybean. The tropane alkaloids present in Jimsonweed are hyoscyamine, atropine and scopolamine and the highest alkaloid concentration found in the seed. Germination and growth of many crops were significantly inhibited by allelochemical extracts of Jimsonweed (You and Wang, 2011). Aqueous seed and leaf extract of Jimsonweed have allelopathic effects on leaf chlorophyll content, root and shoot length, fresh and dry weight of legume species, *Neonotonia wightii* (Elisante *et. al.*, 2013).

Understanding well the mechanism of allelopathic interactions between weeds and crops will enable to come up with proper and effective management ways to prevent further infestations. Considering the economic importance of leguminous crops, these studies were carried out to investigate the allelopathic effect of Jimsonweed seed on seed germination and seedling growth of some leguminous crops, particularly common bean (*Phaseolus vulgaris* L.), cowpea (*Vigna sinensis* [L.] Walp.), pigeon pea (*Cajanus cajan* [L.] Millsp.) and alfalfa (*Medicago sativa* L.).

Material and Methods

Experimental site

A series of experiment was carried out at Faculty of Agricultural Sciences (FAS), University of Gezira (UofG), Sudan, comprised germination tests and pot experiments. The germination tests were conducted in the biology laboratory having an average temperature range of 25 - 30°C and the relative humidity ranging from 60 to 70 %. The pot experiments were conducted in a greenhouse of horticulture nursery under field conditions. The experimental site was located at Latitude 14° 24′ N, Longitude 33° 29′ E and 407m asl. The climate of the region is semi-desert with a mean annual precipitation of 100-250 mm/year, with the rainy season extended from June to October and the dry season from March to June. The mean annual evapotranspiration is 2400 mm/year. The mean annual minimum and maximum temperatures are 12 °C in January and 42°C in May, respectively. The soil of the area is characterized by heavy clay soil (clay 60%), with pH 8-8.5, low organic matter and nitrogen, adequate potassium and low available phosphorous (Elbasher, 2016).

Materials collection

Matured fruits of Jimsonweed plants were collected from Experimental Farm of the FAS in season 2014/15. Fruits were transferred to the biology laboratory of the FAS. Seed were retrieved from fruits and then washed with distilled sterilized water, dried on bench for 15 days at room temperature and in a dark room to avoid the direct sun light that might cause undesired reactions. Dried seeds were then crushed into powder and kept in brown bottles till used. Certified commercial seeds of common bean, cowpea, pigeon pea and alfalfa, that having a germination percentage of 98-100% and purity of 100%, were obtained from the central market of Wed Medani city, Gezira stat, Sudan. The seeds were surface sterilized by sodium hypochlorite, (NaOCl) 1% (v/v), solution, for 3 min continuously agitated to reduce fungal infection. Subsequently the seeds were washed with sterilized distilled water for several times and stored at room temperature till used.

Laboratory experiments

These experiments were conducted in the biology laboratory to study the allelopathic effects of aqueous extract of Jimsonweed seed on seed germination of common bean, cowpea, pigeon pea and alfalfa. Fifty grams of seed powder of Jimsonweed were placed in a conical flask, sterilized distilled water was added to give a volume of 1000 ml and then flasks were shaken for 24 hours at room temperature (27±3°C) by an orbital shaker (160 rpm). The extracts were drained through double layers of cheese cloth and then through 2 layers of Whatman no-2 filter paper to remove solid material. The filtrate was centrifuged at 3000 rpm for 20 min. The supernatant was collected and filtered through a 0.22 µm membrane filter paper. The stock solution was stored at 4°C until further use. Six concentrations (0, 20, 40, 60, 80 and 100%) of the aqueous extract were prepared from the stock solution. Seeds of

common bean, cowpea, pigeon pea and alfalfa (100 seeds each) were sprinkled on Glass Fiber Filter Paper (GFFP) (Whatman GF/C) placed in a glass Petri-dish (GPD), 9 cm internal diameter (i.d). Each GPD moistened with 20 ml of Jimsonweed seed aqueous extract, sealed with Parafilm, covered with black polyethylene bag, were incubated at 30^0C in the dark. Treatments, for each crop, were arranged in completely randomized design with four replicates. The seeds were examined for germination at three days after initial germination.

Greenhouse experiments

These experiments were conducted at the greenhouse of horticulture nursery to study the allelopathic effects of seed powder of Jimsonweed on seedling growth of common bean, cowpea, pigeon pea and alfalfa. Plastic pots, 10 cm internal diameter and 18 cm high with drainage holes at the bottom, were filled with Gezira soil and river silt that mixed in the ratio 1:1, oven dried at 120 C for 48 h and screened to pass a 2-mm sieve. Jimsonweed seed powder was incorporated into the soil at rate of 0, 1, 2, 3, 4 and 5% on w/w biases. Five seeds of each crop were sown in a pot. The pots were kept weed free, irrigated and the seedlings were thinned to 3 plants per pot, 7 days after emergence. Treatments, for each crop, were arranged in completely randomized design with four replicates. At 30 days after sowing the experiments were terminated and plant height (mm), number of leaves and root length (mm) of crop seedlings were measured as well as plant fresh and dry weight (mg).

Statistical analysis

Data were collected and subjected to analysis of variance procedure. Means were separated for significance using Duncan`s Multiple Range Test at $p \leq 0.05$. The statistical analysis was done using the Statistical Analysis System software v.9.0 (SAS, 2004).

Results

Laboratory experiments

The results of laboratory experiments, at 30 days after sowing, showed that the aqueous extract of Jimsonweed seed significantly reduced seed germination of the leguminous crops tested compared to the controls (table 1). The reduction in seed germination increased with concentration of aqueous seeds extract. The highest seed germination was observed in the corresponding controls. However, the highest concentration (100%) displayed lowest seed germination which was 50.0, 48.8, 46.3 and 53.8% in common bean, cowpea, pigeon pea and alfalfa, respectively. Also, the results showed direct relationship between concentration and reduction in germination (fig. 1).

Table 1. Allelopathic effects of seed aqueous extract of Jimsonweed on seed germination of some leguminous crops

Concentration of aqueous (w/v)	Seed germination (%)			
	Common bean	Cowpea	Pigeon pea	Alfalfa
0%	100.0 a	100.0 a	100.0 a	100.0 a
20%	91.3 b	91.3 b	92.5 b	91.3 b
40%	81.3 c	82.5 c	82.5 c	82.5 c
60%	71.3 d	75.0 d	77.5 c	73.8 d
80%	58.8 e	65.0 e	66.3 d	63.8 e
100%	50.0 f	48.8 f	46.3 e	53.8 f
$SE_{\pm}$	1.34	1.72	1.72	1.86
$CV_{\%}$	3.49	4.46	4.43	4.81

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

Greenhouse experiments

The results of the greenhouse experiments showed that incorporating seed powder of Jimsonweed into the soil significantly ($P \leq 0.05$) decreased seedling growth attributes of tested leguminous crops compared to control treatments (Table 2, 4, 5 and 6).

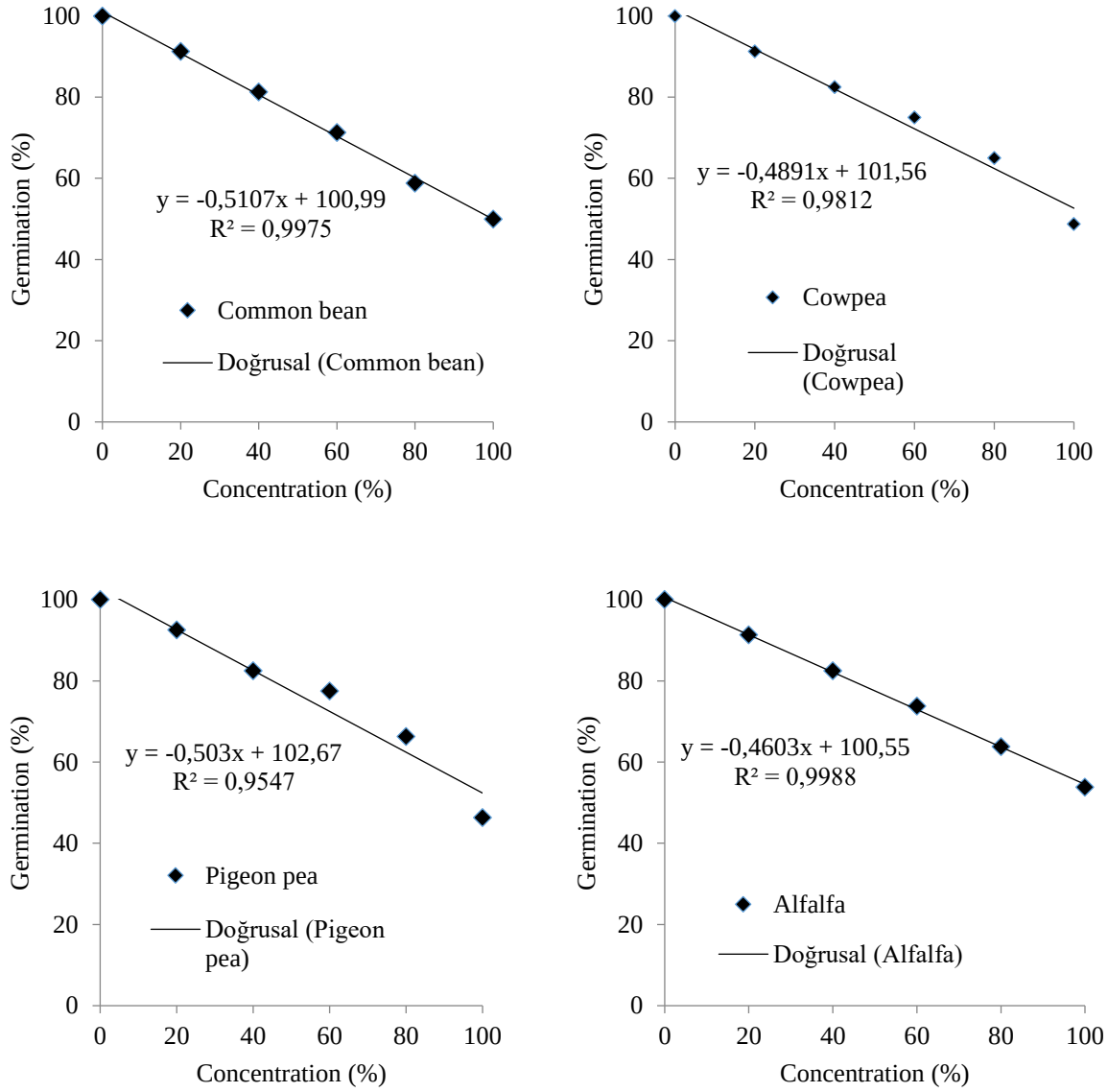

Figure 1. Allelopathic effects of seed aqueous extract of Jimsonweed on seed germination of some leguminous crops

Effects on plant height

At 30 days after sowing, the highest plant crop seedlings were observed in the control treatments (Table 2). The plant height of common bean, cowpea, pigeon pea and alfalfa in the control treatments was 287.5, 151.0, 198.8 and 248.5 mm, respectively. Incorporating the seed powder into the soil at rate of 1% significantly decreased the plant height of leguminous crops in comparison to control treatments. Moreover, the reduction in the plant height was increased as seed powder increased in the soil. The greatest reduction in plant height was observed when seed powder was added to the soil at the rate of 5%. The plant height was decreased to 210.3 mm in common bean, 94.3 mm in cowpea, 139.0 mm pigeon pea and 85.0 mm in alfalfa seedlings ($P \leq 0.05$).

Table 2. Allelopathic effects of incorporated seed powder of Jimsonweed into the soil on plant height of some leguminous crops

Concentration of the powder (w/w)	Plant height (mm)			
	Common bean	Cowpea	Pigeon pea	Alfalfa
0 %	287.5 a	151.0 a	198.8 a	248.5 a
1 %	277.5 b	140.5 b	180.5 b	218.8 b
2 %	269.5 b	129.5 c	169.3 c	187.5 c
3 %	252.5 c	116.0 d	155.5 d	158.5 d
4 %	230.8 d	109.0 e	149.8 d	127.5 e
5 %	210.3 e	94.3 f	139.0 e	85.0 f
$SE_{\pm}$	1.72	2.3	1.96	3.28
$CV_{\%}$	2.3	3.3	2.4	3.8

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

Effects on number of leaves

At 30 days after sowing, the results showed that incorporating Jimsonweed seed powder into the soil at rate of 1, 2, 3, 4 and 5% dose not affected the leave number of seedlings of the leguminous crops tested compared to control treatments (Table 3). Furthermore, there were no significance differences in the number of leaves between crop seedlings grown soil treated with different rates of Jimsonweed seed powder ($P \leq 0.05$).

Table 3. Allelopathic effects of incorporated seed powder of Jimsonweed into the soil on number of leaves of some leguminous crops

Concentration of the powder (w/w)	Number of leaves			
	Common bean	Cowpea	Pigeon pea	Alfalfa
0 %	6.3 a	10.5 a	8.5 a	7.3 a
1 %	6.3 a	10.3 a	8.0 a	7.0 a
2 %	6.0 a	10.3 a	8.3 a	6.8 a
3 %	5.8 a	10.3 a	8.0 a	7.0 a
4 %	6.3 a	10.3 a	8.0 a	7.0 a
5 %	5.8 a	10.0 a	8.3 a	6.8 a
$SE_{\pm}$	0.50	0.73	0.75	0.65
$CV_{\%}$	19.8	14.2	18.4	18.6

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

Effects on root length

Incorporation of the powder of Jimsonweed into the soil significantly reduced root length of leguminous crops (Table 4). The reduction in root lengths was increased with concentration of the powder of Jimsonweed into the soil. At 30 days after sowing, the longest root lengths of crop seedlings were observed in the control treatments. The root length of common bean, cowpea, pigeon pea and

alfalfa in the control treatments was 132.0, 86.5, 115.8 and 76.3 mm, respectively. Incorporating the seed powder into the soil at rate of 1% significantly decreased the plant height of leguminous crops in comparison to control treatments. In addition, the reduction in the root length was increased with further increase of Jimsonweed seed powder in the soil. The greatest reduction in root length was observed when seed powder was added to the soil at the rate of 5%. The root length was decreased to 51.0 mm in common bean, 30.5 mm in cowpea, 81.3 mm pigeon pea and 59.8 mm in alfalfa seedlings ($P \leq 0.05$).

Table 4. Allelopathic effects of incorporated seed powder of Jimsonweed into the soil on root length of some leguminous crops

Concentration of the powder (w/w)	Seedlings root length (mm)			
	Common bean	Cowpea	Pigeon pea	Alfalfa
0 %	167.5 a	81.5 a	99.3 a	80.3 a
1 %	165.3 ab	74.5 b	95.0 b	75.0 b
2 %	162.3 bc	70.3 c	86.3 c	70.5 bc
3 %	158.0 c	64.5 d	78.8 d	65.8 cd
4 %	150.3 d	59.8 e	75.8 d	63.8 de
5 %	145.0 e	59.5 e	69.5 e	59.3 e
$SE_{\pm}$	1.35	1.36	1.35	1.65
$CV_{\%}$	1.9	4.0	3.2	4.8

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

Effects on fresh weight

The greatest fresh weights of crop seedlings, at 30 days after sowing, were recorded in control treatments (Table 5). Incorporating Jimsonweed seed powder in soil at the rate of 1% significantly reduced fresh weight of common bean, cowpea, and pigeon pea in comparison to control treatments. While, significant reduction in fresh weight of alfalfa seedlings were obtained when seed powder incorporated in soil at the rate of 3% or more compared to control treatment. Moreover, the reduction in the fresh weight was increased as seed powder increased in the soil and the most significant effect was observed at the rate of 5%. The corresponding reduction in seedling fresh weights in common bean, cowpea, pigeon pea and alfalfa was 51.0, 30.5, 81.3 and 59.8mg, respectively ($P \leq 0.05$).

Effects on dry weight

The results of incorporated seed powder of Jimsonweed into the soil at rate of 1, 2, 3, 4 and 5% on seedling dry weight had same trend as seedlings fresh weight (Table 6). Incorporating Jimsonweed seed powder in soil at the rate of 1% significantly reduced fresh weight of common bean, cowpea, and alfalfa in comparison to control treatments. While, significant reduction in dry weight of pigeon pea seedlings were obtained when seed powder incorporated in soil at the rate of 2% or more compared to control treatment. The dry weight was decreased to 6.3mg in common bean, 20.8mg in cowpea, 15.5mg pigeon pea and 10.3mg in alfalfa seedlings ($P \leq 0.05$).

Table 5. Allelopathic effects of incorporated seed powder of Jimsonweed into the soil on fresh weight of some leguminous crops

Concentration of the powder (w/w)	Seedlings fresh weight (mg)			
	Common bean	Cowpea	Pigeon pea	Alfalfa
0 %	132.0 a	86.5 a	115.8 a	76.3 a
1 %	119.5 b	70.8 b	100.5 b	73.5 a
2 %	110.0 b	64.5 c	94.8 b	71.3 a
3 %	82.5 c	51.8 d	84.5 c	65.8 b
4 %	60.8 d	39.8 e	83.5 c	64.8 bc
5 %	51.0 d	30.5 f	81.3 c	59.8 c
$SE_{\pm}$	3.47	1.32	2.01	1.78
$CV_{\%}$	7.5	4.6	4.3	5.2

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

Table 6. Allelopathic effects of incorporated seed powder of Jimsonweed into the soil on dry weight of some leguminous crops

Concentration of the powder (w/w)	Seedlings dry weight (mg)			
	Common bean	Cowpea	Pigeon pea	Alfalfa
0 %	25.8 a	68.3 a	49.5 a	39.8 a
1 %	19.3 b	59.5 b	44.8 a	30.0 b
2 %	15.5 bc	50.8 c	35.5 b	24.8 c
3 %	11.0 cd	39.3 d	32.3 b	21.0 c
4 %	8.3 d	30.8 e	19.5 c	15.8 d
5 %	6.3 d	20.8 f	15.5 c	10.3 e
$SE_{\pm}$	1.36	1.78	1.90	1.64
$CV_{\%}$	19.2	8.0	11.6	13.9

* Means in the same column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test ($P \leq 0.05$).

Discussion

The results of these studies revealed that the aqueous extract of Jimsonweed seed significantly reduced seed germination of the leguminous crops tested and there was direct relationship between concentration and reduction in germination. This finding was in line with observation made by Oudhia et al. (1998) who reported that the aqueous leachates of different parts of Jimsonweed produced a significant inhibition effect on germination of chickpea. Ahmad et al. (2014) found that the aqueous extracts of the aerial parts of Jimsonweed pose significant and varying allelopathic effects on seed germination and seedling vigour of wheat. Germination was inhibited as well as delayed according to the extract concentrations. The same authors also pointed out that the extracts inhibited germination process and the plant should be eradicated even if found near to the growing fields because the seeds

contain the dangerous alkaloids and can be dispersed in the fields during seed dispersal. These seeds remain in dormant stage for years and when their dormant stage is over they grow vigorously and could make the precious fields toxic for the crop species.

This study indicated that incorporating seed powder of Jimsonweed into the soil at rate of 1, 2, 3, 4 and 5% (w/w) significantly decreased plant height, root length of crop seedlings as well as plant fresh and dry weight. In addition, the reduction in seedling growth was increased as seed powder increased in the soil. This finding was in agreement with observation made by Elisante et al. (2013) who carried out a pot experiment to determine the allelopathic effects of Jimsonweed on leaf chlorophyll content, root and shoot elongation, fresh and dry weight of two wild plant species: *Cenchrus ciliaris* and *Neonotonia wightii*. Different concentrations (0%, 25%, 50%, 75% and 100%) from seed and leaf extracts of Jimsonweed were used. The total chlorophyll content of *C. ciliaris* and *N. wightii* was significantly reduced in all plants treated with both aqueous seed and leaf extracts of Jimsonweed. Relative to the control treatments, there was greater reduction in root and shoot length which was observed in higher concentrations of aqueous seed and leaf extracts. Fresh and dry weight of tested species significantly decreased after being treated with both seed and leaf aqueous extracts of Jimsonweed. It was found that the allelopathic effect of aqueous seed and leaf extracts from Jimsonweed on tested species was concentration-dependent. The inhibitory effects on all tested species increased as the concentration of both extracts increased from 0% to 100%. The study concluded that aqueous seed and leaf extracts of Jimsonweed have allelopathic effects on leaf chlorophyll content, root and shoot length, fresh and dry weight of grass (C. ciliaris) and legume (N. wightii) species.

Conclusion

- The aqueous extract of Jimsonweed seed significantly reduced seed germination of the leguminous crops; common bean, cowpea, pigeon pea and alfalfa. There was a direct relationship between concentration and reduction in germination.
- Incorporating seed powder of Jimsonweed into the soil at rate of 1, 2, 3, 4 and 5% significantly decreased plant height and root length of crop seedlings as well as plant fresh and dry weight. In addition, the reduction in seedling growth was increased as seed powder increased in the soil.
- Incorporating Jimsonweed seed powder into the soil at rate of 1, 2, 3, 4 and 5% dose not affected the leaf number of seedlings of the leguminous
- Jimsonweed has allelopathic affects on seed germination and seedling growth of the leguminous crops.

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