

Allelopathic effects of *Amaranthus viridis* L. on some growth characters of Swiss chard plant (*Beta vulgaris* var. *Cicla*)

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Abstract

A pot experiment was conducted at Faculty of Education, Alzaiem Alazhari University, Sudan, during 2019/2020 to evaluate the effect of *Amaranthus viridis* powder on the emergence and growth of Swiss chard (*Beta vulgaris* var. *cicla*). The experiment was set as a completely randomized design (CRD) with four replicates. In the treatments the powder of *Amaranthus viridis* was incorporated into the soil at rate of (0, 0.5, 1.0, 1.5 and 2.0% w/w) representing T₁ (control), T₂, T₃, T₄ and T₅ respectively. Results indicated that *Amaranthus viridis* powder decrease germination, plant height, number of leaves, leaf area, shoot and root fresh and dry weight, chlorophyll content (a, b) and some chemical elements (P, Ca, Mg, Fe) of Swiss chard (*Beta vulgaris* var. *cicla*).

Keywords: *Amaranthus viridis*; Swiss chard; Germination; Allelopathy; Chemical constituent

1. Introduction

Food shortage and deficiency is considered to be one of the most global problems across the world. Weeds leaf uncontrol may cause great losses in crop yield and these losses exceeded that caused by other pests,

Plants growing together compete with each other for sunlight, soil nutrients and water. To reduce competition, plants produce chemicals that affect the germination and growth of neighbouring plants by disruption of various physiological processes [1]. These chemicals are known as allelochemical which released into the environment by plant organs.

Swiss chard (*Beta vulgaris* var. *cicla*) is a vegetable which is consumed by the majority of the Sudanese population. The main constrain of Swiss chard production is the weed infestation. *Amaranthus viridis* is one of the dominant weeds that compete with Swiss chard and other vegetables.

The present study was conducted to evaluate the effect of *Amaranthus viridis* on the germination growth, yield and some chemical constituents of Swiss chard (*Beta vulgaris* var. *cicla*).

2. Material and methods

2.1. Plant material

Amaranthus viridis plants were collected from the farm of the Faculty of Agriculture, University of Khartoum. The plants were uprooted, washed with distilled water than dried at room temperature (25°C for 96 hours. Plant then chopped and ground into fine powder. The Swiss chard seeds were obtained from local market (local cultivar).

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2.2. Pot experiment

Plastic pots (18 × 30 cm) filled with silt soil, were arranged in completely randomized design (CRD) with four replications. Five treatments were used, the first one T₁ representing the control where the soil was from *Amaranthus* residue. The other four treatments were represented by T₂, T₃, T₄ and T₅, where soils were incorporated with *Amaranthus* powder in 10, 20, 30 and 40 g per pot which representing 0.5, 1.0, 1.5 and 2.0% w/w residue (soil) respectively. Five seeds of Swiss chard were sown in each pot and later thinned to two seedlings. Pots were irrigated daily with tap water. During the experiment the germination percentage, plant height, numbers of leaves, leaf area were recorded. At the end of the experiment shoot and root fresh and dry weight, chlorophyll content (a, b) and some elements (P, Ca, Mg, Fe) were variance (ANOVA) according to [2].

3. Results and discussion

The germination percentage of Swiss chard plant decreased as the concentration of *Amaranthus viridis* increased (Table 1). The reduction of germination percentage was from 83.33% at control to 46.65% at treatment T₂ then decreased to 6.60% and 3.33% at treatments T₃ and T₄ respectively. These results were supported by the findings of [3] who reported that *Amaranthus viridis* extract significantly decreases the germination of mung bean (*Vigna radiata* (L.) R. Wilczek). Similar results were reported by [4] they found that the extracts of the whole plant of *Amaranthus* exhibited severe inhibition of seed germination of tomato as well as of weed seeds of *Conyza bonariensis*. Also [5] concluded that leaf leachates of *Amaranthus viridis*, *Parthenium hysteroporus* and *Polygonum plebeinum* significantly inhibited the growth of *Triticum aestivum*. The inhibition in the germination percentage of Swiss chard may be attributed to the presence of phenolic acids. These phenolic acids may inhibit cell division, water and nutrient uptake and consequently germination.

The highest plant height of Swiss chard was observed at control 14.16 cm, then decreased to 10.20, 10.00, 9.50 and 8.80 cm in treatments T₂, T₃, T₄ and T₅ respectively. These results were confirmed by the findings of [6] who reported that extracts of *Amaranthus viridis* decreased shoot growth of rye grass compared to control. Similar results were reported by [7] who found that incorporation of powder residue *Amaranthus viridis* in the soil significantly decreased plant height of common bean (*Phaseolus vulgaris* L.) cow pea (*Vigna sinensis* (L.) Walp), pigeon pea (*Cajanus cajan* (L.) Mill sp) and alfalfa (*Medicago sativa* L.).

Table 1 Allelopathic effect of *Amaranthus viridis* residue powder on germination, plant height, number of leaves and leaf area of Swiss chard)

Treatments	Germination (%)	Plant height (cm)	Number of leaves	Leaf area (cm ²)
T ₁ (control)	83.33	14.10	4.20	8.44
T ₂ (0.5% w/w)	46.66	10.20	4.00	8.30
T ₃ (1.0% w/w)	6.60	10.00	4.00	8.08
T ₄ (1.5% w/w)	3.33	9.50	4.00	8.00
T ₅ (2.0% w/w)	0.00	8.80	3.60	7.56
LSD	1.40	1.82	0.64	0.23

The number of leaves did not show any significant difference between treatment and control, although some researchers reported a significant decrease in number of leaves of sorghum, millet, maize and wheat. The leaf area of Swiss chard exhibited significant decrease from the control at treatments T₃ (1%, w/w), T₄ (1.5%, w/w) and T₅ (2%, w/w) (Table 1). Similar results were reported by [8] who showed that irrigation of groundnut and maize with water extract of *Eucalyptus globulus* reduced leaf area.

The shoot fresh and dry weight of Swiss chard exhibited a significant decrease in all treatments as compared with control (Table 2). These results were supported by the results of [9] who found that *Amaranthus hybridus* inhibited the dry weight of shoot and root of red clover and root of alfalfa. In connection to this [10] assumed that decrease in fresh and dry weight may be attributed to allelochemicals inhibiting protein and carbohydrate synthesis and hence reducing seedling growth.

The root length, root fresh and dry weight showed a significant decrease from control (Table 2). The root length decrease as the concentration increased.

Table 2 Allelopathic effect of *Amaranthus viridis* residue powder on shoot fresh weight, shoot dry weight, root length, root fresh weight and root dry weight of Swiss chard

Treatments	Shoot fresh weight (g)	Shoot dry weight (g)	Root length (cm)	Root fresh weight (g)	Root dry weight (g)
T ₁ (control)	0.96	0.45	6.90	0.61	0.31
T ₂ (0.5% w/w)	0.70	0.32	4.90	0.52	0.24
T ₃ (1.0% w/w)	0.65	0.30	4.30	0.40	0.20
T ₄ (1.5% w/w)	0.47	0.20	3.60	0.50	0.16
T ₅ (2.0% w/w)	0.30	0.15	3.00	0.22	0.16
LSD	0.14	0.00	0.92	0.00	0.00

Table 3 Allelopathic effect of *Amaranthus viridis* residue powder on chlorophyll content and some chemical elements Swiss chard

treatments	Chlorophyll		P (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Fc (mg/kg)
	a (mg/g)	b (mg/g)				
T ₁ (control)	375.43	152.16	920	2400	2520	1952
T ₂ (0.5% w/w)	353.65	146.65	122	2400	240	1174
T ₃ (1.0% w/w)	242.75	109.30	102	2300	600	1531
T ₄ (1.5% w/w)	318.76	129.13	99	2200	960	1329
T ₅ (2.0% w/w)	350.24	148.24	93	2300	1520	1496
LSD	4.06	3.03	2.69	44.61	51.57	2.69

Root growth is characterized by high metabolic rate and for this reason; roots are highly susceptible to environmental stresses such as allelochemicals in soil [11]. These results were supported by the results of [7] who reported that the incorporated powder of *Amaranthus viridis* into soil decreased root length as well as root fresh and dry weight of sorghum, millet, maize and wheat. The decrease in root fresh and dry weight of Swiss chard may be attributed to the decrease in root and shoot seedling length which induced by allelochemicals found in *Amaranthus* powder.

The chlorophyll content (a, b) decreased significantly as the concentration of *Amaranthus* increased (Table 3). Similar results were reported by [12] and [13] who reported that a reduction was observed in chlorophyll (a) content of the corn treated with *Eucalyptus rostrata* leaf residue. In this respect [14] attributed the decrease in chlorophyll content to the decreases in the relative water content of leaves which initially induce stomatal closure, imposing a decrease in the supply of CO₂ to the mesophyll cells and consequently, photosynthesis could be lowered resulting in the decrease in chlorophyll content.

A significant reduction was observed in content of phosphorus P and calcium Ca, Magnesium, Mg and iron Fe in treatments as compared with control (Table 3). The reduction in P content was also reported by [13] who found that *Eucalyptus* allelochemicals reduced the amount of P and N. On the other hand, the decrease in Ca²⁺, Mg²⁺ and Fe²⁺ was supported by [15] who observed that root exudates of cucumber inhibited the uptake of K⁺, Ca²⁺, Mg²⁺ and Fe²⁺ by cucumber seedlings. The reduction in these elements may be attributed to that, root membranes are primary site of action for allelochemicals and the contact of phenolic acid with the root cell membrane leads to depolarization, an efflux of ions and a reduction of hydrolic conductivity, water uptake and net nutrient uptake [16].

4. Conclusion

The study concluded that *Amaranthus viridis* residue containing phenolic compounds suppress the germination, the growth and yield of Swiss chard. Field studies are needed to evaluate the suppressive efficacy of *Amaranthus viridis* under natural conditions.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no competing interests exist.

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