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Growth Response of Three Leafy Vegetables to the Allelopathic Effect of *Vitellaria paradoxa*

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Abstract

This study was conducted to evaluate the growth response of three leafy vegetables (*Celosia argentea*, *Amaranthus cruentus* and *Amaranthus hypochodriacus*) to the leaf extract of *Vitellaria paradoxa.* Forty-five (45) experimental plastic containers were filled with 5 kg of loamy soil each and randomly allocated to the following regimes: control, 20 g, 40 g, 60 g and 80 g of powdered leaves of *V. paradoxa*, in three (3) replicates for each test crop respectively. It was observed that the response of the three leafy vegetables, grown within different composition of *V. paradoxa* leaves, are concentration dependent with respect to the studied growth parameters (plant height, leaf number, leaf area, stem girth). This indicated that *V. paradoxa* has allelopathic potential on the studied vegetables and therefore it could be used for natural weed control.

Keywords: allelopathy, *Amaranthus cruentus, Amaranthus hypochodriacu, Celosia argentea,* growth parameters, *Vitellaria paradoxa,* weed control

Introduction

Allelopathy is an interference mechanism that inhibits or stimulates the associated plant growth due to a release of chemical substances from live or lifeless plant materials (Harper, 1977; May and Ash, 1990). Allelopathy may also play an eminent role in intraspecific and interspecific competition and may determine the type of interspecific association. The inhibition of one plant by another through the release of allelochemicals is well documented (Alagesaboopathi, 2011). The detrimental effects of allelochemicals on recipient plants are considered to be biotic stress, called "allelochemical stress" (Cruz-Ortega, 2002).

Effects of leachates from plants, plant extracts and decomposing plant residues have been the focus of several investigators concerned with the role of allelopathy in agriculture. Plant residues often contain a variety of toxins that are known inhibitors of seed germination or seedling growth. Leachates from plants have been proved to suppress seed germination and vegetative propagules, as well as early seedling growth (Dhwan and Gupta, 1996; Babu and Kandasanmy, 1997) and decrease radical growth.

Vitellaria is a light demanding, slow growing tree, with a thick and fissured bark. Shea nut "butter" has many uses and may or may not be refined. Shea butter is mostly used for cosmetics. Throughout Africa, it is used extensively for food and medicinal purposes and is a major source of dietary fat (Maranz *et. al.*, 2004).

The need to reduce harmful environmental effects from the overuse of herbicides has encouraged the development of weed management systems which are dependent on ecological manipulations rather than agrochemicals (Liebman and Ohno, 1997; Zoheir *et al.*, 2008; Ashrafi *et al.*, 2009). However, few studies were conducted on the leaf extract of *Vitellaria paradoxa*.

The aim of this study was to investigate the allelopathic effect of *Vitellaria paradoxa* leafs on the growth of *Celosia argentea*, *Amaranthus cruentus* and *Amaranthus hypochodriacus*.

Materials and Methods

This study was conducted in screen house conditions, within the Department of Plant Biology, University of Ilorin, (N 08° 28' 53.3", E 04° 40' 28.9"), in the Southern Guinea Savanna belt of Nigeria. The annual rainfall in the area is about 1,200 mm and temperature varies between 33 °C and 34 °C during the year, with a distinct dry season from December to March.

Leaves of *Vitellaria paradoxa* Linn. were collected from matured tree stands in the University campus, while viable seeds of the three test crops (*Celosia argentea*, *Amaranthus cruentus* and *Amaranthus hypochodriacus*) were obtained from the State

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Ministry of Agriculture, Ilorin, North-central Nigeria.

Fresh samples of *Vitellaria paradoxa* leaves were cut into small pieces, air dried at room temperature and made into powder using an electric blender. Four different regimes (20 g, 40 g, 60 g and 80 g) of the powdered leaves were prepared as treatments. Forty-five (45) experimental plastic containers were filled with 5 kg of loamy soil each and randomly allocated to the following regimes: control, 20 g, 40 g, 60 g and 80 g of powdered leaves, in three replicates for each test crop respectively. The soil in the experimental plastic containers was moisture to saturation with borehole water and left for thorough agglomeration of the powdered leaves with the soil matrices for three days. Few seeds of each test crop of *Celosia argentea* and *Amaranthus* sp. were germinated in a nursery and after two weeks, three young seedlings of the same height and vigour of each test crop were transplanted into the plastic containers.

The experiment was set-up for two months with regular irrigation with borehole water in ambient condition of photo-periodism. Measurements were taken two (2) weeks after transplanting (WAT) and lasted for eight (8) weeks with an interval of two weeks. The morphological parameters scored include: plant height, leaf length and breadth, stem girth and leaf number; the plant height, leaf length and breadth were measured with a standard meter rule, while the stem girth was measured with an Electronic Digital Caliper (Titan 23175 model). The leaf area was calculated according to Pearcy *et al.* (1989) as follows:

Leaf area = $(L \times B) \times K$

where L = length of leaf, B = maximum width and K = 0.72

Statistical analysis

Data generated were analyzed using Statistical Package for Social Science (SPSS) 16.0 for Windows. Duncan Multiple Range Test (DMRT) was used to separate mean differences at $p<0.05$.

Results and Discussion

Generally, the results revealed that the response of the three leafy vegetables (*Celosia argentea*, *Amaranthus hybridus* and *Amanranthus hypochondriacus*) grown within different levels of leaves' composition of *Vitellaria paradoxa* are concentration dependent. Statistically, there were significant differences between treatments. The results revealed that the growth parameters of the vegetables decreased with increasing concentration of *Vitellaria paradoxa* leafs. Consequently, the results indicated that the leaf allelopathy effect of *Vitellaria paradoxa* significantly inhibited the growth of the studied vegetables. This trend is in line with Jadhar and Gayanar report

Table 1. Mean plant height of the studied leafy vegetables to the allelopathic effect of *Vitellaria parodoxa* leafs

Specie	Treatment	2 WAT	4 WAT	6 WAT	8 WAT
	Control	8.47 ± 0.52^{a}	25.53 ± 1.74^{a}	42.00 ± 2.97^{a}	68.18 ± 1.80^{a}
	20 g	7.00 ± 1.49^{b}	18.90 ± 3.40^{b}	30.80 ± 2.57^{b}	48.00 ± 1.94^{b}
Celosia argentea	40 g	6.07 ± 0.79^{b}	11.70 ± 2.00^{c}	17.33 ± 2.30^{c}	25.78 ± 0.76^{c}
	60 g	4.45 ± 1.22^{c}	9.45 ± 1.45^{c}	14.45 ± 1.71^{c}	21.95 ± 2.59^{c}
	80 g	3.72 ± 0.75^{c}	7.32 ± 1.85^{c}	10.92 ± 2.95^{c}	16.32 ± 0.12^{c}
	Control	8.32 ± 0.22^{a}	19.43 ± 1.91^{a}	31.27 ± 2.60^{a}	43.18 ± 2.06^{a}
	20 g	8.18 ± 0.17^{a}	17.75 ± 2.29^{a}	28.28 ± 3.21^{ab}	38.05 ± 1.89^{ab}
Amaranthus cruentus	40 g	7.00 ± 1.01^{b}	14.68 ± 3.31^{b}	23.33 ± 1.18^{bc}	31.80 ± 2.45^{bc}
	60 g	5.83 ± 1.68^{c}	12.03 ± 2.89^{b}	19.46 ± 1.83^{c}	27.18 ± 0.89^{c}
	80 g	3.18 ± 0.74^{d}	6.68 ± 1.21^{c}	10.42 ± 1.69^{d}	14.20 ± 2.42^{d}
	Control	8.50 ± 0.45^{a}	16.97 ± 2.59^{a}	25.30 ± 1.63^{a}	33.80 ± 1.89^{b}
	20 g	8.05 ± 0.56^{a}	18.72 ± 2.59^{a}	29.38 ± 0.21^{a}	40.05 ± 1.85^{a}
Amaranthus hypochondriacus	40 g	6.83 ± 0.68^{b}	15.73 ± 1.42^{a}	25.30 ± 2.33^{a}	34.98 ± 0.48^{b}
	60 g	6.08 ± 0.74^{c}	11.33 ± 0.92^{b}	22.17 ± 1.96^{ab}	29.03 ± 2.89^{c}
	80 g	4.25 ± 0.52^{d}	8.35 ± 1.25^{b}	12.40 ± 2.15^{b}	16.98 ± 1.42^{d}

Means within the column followed by the same letters are not significantly different at $p<0.05$.

Table 2. Mean leaf number of the studied leafy vegetables to the allelopathic effect of *Vitellaria parodoxa* leafs

Specie	Treatment	2 WAT	4 WAT	6 WAT	8 WAT
	Control	7.00 ± 0.63^{a}	13.00 ± 0.63^{a}	21.00 ± 0.63^{a}	32.5 ± 1.05^{a}
	20 g	6.33 ± 1.10^{ab}	12.33 ± 1.03^{a}	18.67 ± 1.03^{b}	29.67 ± 1.50^{b}
Celosia argentea	40 g	5.83 ± 0.75^{b}	9.83 ± 0.75^{b}	14.83 ± 1.17^{c}	23.00 ± 1.41^{c}
	60 g	4.47 ± 0.82^{c}	7.50 ± 1.76^{c}	11.50 ± 1.16^{d}	19.00 ± 2.10^{d}
	80 g	4.17 ± 0.41^{c}	6.33 ± 0.82^{c}	10.17 ± 0.98^{d}	16.67 ± 1.21^{e}
	Control	5.00 ± 0.00^{a}	10.00 ± 0.00^{a}	16.00 ± 0.63^{a}	21.83 ± 1.47^{a}
	20 g	4.67 ± 0.52^{ab}	10.00 ± 0.89a	16.33 ± 1.21a	21.33 ± 1.21^{a}
Amaranthus cruentus	40 g	4.50 ± 0.55^{b}	9.17 ± 1.17^{a}	13.67 ± 2.16^{b}	18.67 ± 2.73^{b}
	60 g	4.00 ± 0.00^{c}	7.00 ± 1.10^{b}	10.83 ± 2.32^{c}	13.83 ± 1.25^{c}
	80 g	4.00 ± 0.00^{c}	6.00 ± 0.63^{b}	7.83 ± 0.75^{d}	9.83 ± 0.75^{d}
	Control	6.30 ± 0.52^{a}	13.50 ± 0.55^{a}	18.50 ± 0.55^{a}	25.50 ± 0.55^{a}
	20 g	6.00 ± 0.00^{a}	12.00 ± 1.27^{b}	16.83 ± 1.33^{b}	22.83 ± 0.82^{a}
Amaranthu shypochondriacus	40 g	5.50 ± 0.00^{b}	8.67 ± 0.83^{c}	12.67 ± 0.82^{c}	17.67 ± 0.82^{b}
	60 g	5.50 ± 0.55^{b}	7.67 ± 0.52^{d}	11.67 ± 0.52^{d}	15.67 ± 0.52^{c}
	80 g	4.67 ± 0.52^{c}	6.00 ± 0.00^{e}	9.00 ± 0.00^{e}	12.50 ± 0.55^{d}

Means within the column followed by the same letters are not significantly different at $p<0.05$.

Table 3. Mean leaf area of the studied leafy vegetables to the allelopathic effect of *Vitellaria parodoxa* leafs

Specie	Treatment	2 WAT	4 WAT	6 WAT	8 WAT
Celosia argentea	Control	1.18 ± 0.21^{a}	4.59 ± 0.34^{a}	8.26 ± 0.22^{a}	16.97 ± 0.55^{a}
	20 g	0.67 ± 0.17^{b}	2.64 ± 0.36^{b}	5.89 ± 0.53^{b}	10.01 ± 0.76^{b}
	40 g	0.52 ± 0.10^{bc}	1.68 ± 1.30^{c}	3.68 ± 0.10^{c}	5.78 ± 0.34^{c}
	60 g	0.43 ± 0.07^{c}	1.08 ± 0.71^{d}	1.50 ± 0.50^{d}	2.84 ± 0.23^{d}
	80 g	0.25 ± 0.06^{d}	0.70 ± 0.10^{d}	0.98 ± 0.02^{e}	2.20 ± 0.24^{e}
Amaranthus cruentus	Control	0.64 ± 0.34^{a}	3.30 ± 0.74^{a}	9.77 ± 1.91^{a}	15.30 ± 2.40^{a}
	20 g	0.75 ± 0.44^{a}	4.19 ± 1.71^{a}	12.76 ± 2.51^{a}	19.83 ± 2.00^{a}
	40 g	0.43 ± 0.13^{ab}	3.18 ± 1.31^{a}	9.78 ± 2.01^{a}	15.09 ± 0.41^{a}
	60 g	0.42 ± 0.18^{ab}	2.88 ± 1.75^{a}	8.97 ± 1.64^{a}	14.02 ± 0.63^{a}
	80 g	0.10 ± 0.06b	0.52 ± 0.23a	1.63 ± 0.66b	2.99 ± 1.35^{b}
Amaranthus hypochondriacus	Control	2.59 ± 0.62^{a}	7.41 ± 2.29^{a}	14.42 ± 3.17^{a}	27.70 ± 1.23^{a}
	20 g	5.57 ± 0.88^{a}	6.22 ± 1.19^{a}	11.83 ± 1.30^{b}	20.96 ± 0.49^{a}
	40 g	0.84 ± 0.54^{b}	3.20 ± 0.90^{b}	6.14 ± 1.23^{c}	10.33 ± 1.89^{a}
	60 g	0.50 ± 0.09^{b}	2.01 ± 0.34^{b}	5.24 ± 0.34^{cd}	8.37 ± 0.54^{a}
	80 g	0.32 ± 0.08^{b}	1.68 ± 0.45^{b}	3.87 ± 0.77^{d}	5.53 ± 0.83^{b}

Means within the column followed by the same letters are not significantly different at $p<0.05$.

Table 4. Mean stem girth of the studied leafy vegetables to the allelopathic effect of *Vitellaria parodoxa* leafs

Specie	Treatment	2 WAT	4 WAT	6 WAT	8 WAT
Celosia argentea	Control	0.84 ± 0.07^{a}	1.54 ± 0.70^{a}	2.14 ± 0.07^{a}	2.74 ± 0.07^{a}
	20 g	0.63 ± 0.07^{b}	1.12 ± 0.08^{b}	1.52 ± 0.08^{b}	1.92 ± 0.08^{b}
	40 g	0.56 ± 0.05^{b}	0.84 ± 0.60^{c}	1.04 ± 0.06^{c}	1.64 ± 0.06^{c}
	60 g	0.38 ± 0.10^{c}	0.48 ± 0.10^{d}	0.88 ± 0.10^{d}	1.28 ± 0.10^{d}
	80 g	0.84 ± 0.07^{a}	0.19 ± 0.59^{e}	0.38 ± 0.05^{e}	0.78 ± 0.05^{e}
Amaranthus cruentus	Control	0.53 ± 0.08^{a}	1.08 ± 0.10^{a}	1.98 ± 0.21^{a}	2.48 ± 0.28^{a}
	20 g	0.40 ± 0.16^{ab}	0.87 ± 0.25^{ab}	1.53 ± 0.48^{a}	2.13 ± 0.58^{a}
	40 g	0.40 ± 0.10^{ab}	0.90 ± 0.22^{ab}	1.63 ± 0.39^{a}	2.17 ± 0.47^{a}
	60 g	0.38 ± 1.50^{b}	0.82 ± 0.29^{b}	1.55 ± 0.52^{a}	2.07 ± 0.63^{a}
	80 g	0.25 ± 0.03^{b}	0.52 ± 0.08^{c}	0.88 ± 0.01^{b}	1.23 ± 0.25^{b}
Amaranthush ypochondriacus	Control	1.20 ± 0.09^{a}	1.68 ± 0.16^{a}	2.15 ± 0.19^{a}	2.65 ± 0.19^{a}
	20 g	1.10 ± 0.15^{a}	1.45 ± 0.14^{b}	1.73 ± 0.14^{b}	2.13 ± 0.58^{a}
	40 g	0.59 ± 0.22^{b}	0.93 ± 0.20^{c}	1.13 ± 0.19^{c}	1.42 ± 0.20^{b}
	60 g	0.36 ± 0.04^{c}	0.45 ± 0.05^{d}	0.61 ± 0.05^{d}	0.71 ± 0.08^{c}
	80 g	0.26 ± 0.04^{c}	0.41 ± 0.09^{d}	0.56 ± 0.09^{d}	1.23 ± 0.09^{b}

Means within the column followed by the same letters are not significantly different at $p<0.05$.

(1992) who found that the percentage of germination, plumule and radicle length of rice and cowpea decreased with increasing concentration of *Acacia auriculiformis* leaf leachates. Several reports addressed the importance of allelopathic effect of various trees *E. camaldulensis*, *Prosopis julifera* and *Acacia nilotica* which significantly affected seed germination and seed seedling growth of specific crops and weed species (Khan *et al.*, 2004).

For *Celosia argentea*, control treatments were significantly higher than other treatments, for all the growth parameters studied, at different intervals under experiment, except for treatment 40 g at 4 WAT (Tables 1-4). Gulzar and Siddiqui (2014) reported that the allelopathic effect from aqueous extracts of *E. alba* showed an inhibitory effect on seed germination and seedling growth of weed (*Cassia tora* L., *Cassia sophera* L.) and crop plants (*P. aureus* L., *Oryza sativa* L). *Amaranthus cruentus* response was similar to that of *Celosia argentea* except for 20 g and 40 g treatments, which were not different than control treatments with respect to leaf number and plant height at $p<0.05$ (Tables 1 and 2). With respect to stem girth and leaf area, *Amaranthus cruentus* response was not significantly different than the control at $p<0.05$ (Tables 3 and 4).

Foliar leachates have been regarded to be most phytotoxic in nature (Ferguson *et al.*, 2013; Xuan *et al.*, 2004). This is applicable also to *V. paradoxa* leafs, which may have contributed to the inhibitory effect on the studied vegetables. From similar experiments, researchers concluded that allelopathy and stress interact under natural condition. Romeo and Weidenhamer (1998) reported that under laboratory condition, which is less typically and therefore less stressful than field condition, the allelopathic effect might be reduced. Nevertheless, for the hereby study, biotic stress might be partially responsible for the increase of the allelopathic effect of *V. paradoxa* extract, since the experiment was carried out on the field.

Phenolic acids have been shown to be toxic to germination and plant growth processes (Einhelling, 1995). *V. paradoxa* contains palmitic, oleic, linoleic, arachidic, stearic and phenolics. From its composition, phenolic compounds present might be responsible for the inhibitory effect on the studied vegetables.

Conclusions

The results obtained from the current study showed that *Vitellaria paradoxa* has allelopathic impact on the studied vegetables, therefore *V. paradoxa* could be used as weed control. Hence, further research should be effected on the allelopathic potential of *V. paradoxa* for the natural control of weeds considering sustainable agriculture and achieving the aim of environmental welfare.

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