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Allelopathic effects of sorghum stem and maize inflorescence residues on the germination and growth of okra (*Abelmoschus esculentus* L.)

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Abstract

The allelopathic effects of extracts derived from the residues of sorghum stem and maize inflorescence on the germination and growth of okra (*Abelmoschus esculentus* L.) were determined. Both crop residues (powder) inhibited the growth of okra. The degree of inhibition increased with increase in the concentration of the extracts, thus suggesting that the effects of the extracts from the residues were concentration dependent. Statistical analysis ($p = 0.05$) revealed that in seeds treated with sorghum stem extract, significant differences were observed in the germination percentage of seeds treated with the 50 g extract concentration when compared to the results obtained in the control experiment. In the other treatments no significant differences were observed when compared to the control experiment. Statistical analyses also revealed that there were significant differences in other parameters such as the speed of germination, number of leaves, leaf area, dry root and shoot weights and the relative growth rate of okra seeds treated with extracts from sorghum stem residues when the results were compared to those obtained in the control experiments. Results obtained from seeds treated with extracts from maize inflorescence revealed that there were no significant differences in the number of leaves at harvest, dry root weight and relative growth rate when compared to the results obtained in the control experiments. Statistical differences were in other growth parameters such as germination, speed of germination, leaf area and dry shoot weights of extract-treated seeds when compared to the control experiments. The results showed that the degree of retardation was more pronounced in seeds treated with extracts derived from the residues of maize inflorescence.

Key words: Allelopathy, residues, sorghum stem, maize inflorescence, *Abelmoschus esculentus.*

Introduction

Allelopathy is a biological process by which plants produce one or more biochemicals known as allelochemicals that influence the growth and survival of other plants [21]. These allelochemicals when released to the soil may have beneficial (stimulatory) or detrimental (inhibitory) effects on target organisms [16, 21, 22]. Allelochemicals are present in nearly all plant parts and tissues such as leaves, stems, roots, flowers, seeds, fruits and pollen grains from where they are released into the soil through the process of volatilization, leaching, root exudation and decomposition of plant residues [4, 21].

Allelochemicals had been reported to affect mineral uptake by altering the cellular membrane functions in plant roots [3]. It also leads to the permanent destruction of membrane [8], ion uptake [25], inhibition of electron transport in photosynthesis and respiratory chain, altering of enzyme activities [20, 24]. It also inhibited seed germination by blocking the hydrolysis of nutrient reserve and cell division [10] thus reducing the growth and development of various plants [5].

There is a gross dearth of study on the allelopathic effects of crop residues in Nigeria until recently when the allelopathic effects of some crop residues on some Nigerian agricultural crops were reported [1, 2, 15]. Consequent on this, the study being reported here aimed at examining the effects of extracts derived from sorghum stem and maize inflorescence on okra, an important vegetable crop in Nigeria.

Materials and Methods

The experiment was conducted in the greenhouse of the Department of Plant Science, Ekiti State University, Ado - Ekiti, Nigeria, between July and September 2010. Top soil was evacuated from regenerated vegetation on the University campus to the depth of 10 cm depth. The soil was autoclaved at 100°C for one hour to destroy all unwanted and buried seeds in the soil. Sorghum stems were obtained from the experimental farm of the Department of Plant Science and maize inflorescence residues from a farmland in the Faculty of Agricultural Science of the University. The residues were air- dried for three weeks after which they were chopped into pieces with knife, pounded with pestle and mortar and later blended into powdery form.

Portions of 10, 20, 30, 40 and 50 g each were measured out from the resulting powders of the sorghum stem and maize inflorescence and mixed thoroughly with 500 g of sterilized soil in planting pots. Each treatment was replicated five times and arranged using complete randomized design. Five okra seeds obtained from a local market in Ado - Ekiti, Nigeria, were planted in each of the planting pots after proper seed selection and testing had been made and was moistened daily with equal amount of distilled water at 7.00 GMT.

The seeds were considered germinated upon plumule emergence and they were counted for seven days until no further emergence was observed. The speed of germination known as coefficient of velocity (COV) was calculated according to Kayode [12] as:

$$COV = \frac{A_1 + A_2 + A_3 \ldots\ldots\ldots\ldots A_n T_n}{A_1T_1 + A_2T_2 + A_3T_3 + AnT_n} \times \frac{100}{1}$$

where A = number of seedlings that emerge at a particular number of days, T = number of days involved.

At three weeks after planting, the okra plants were thinned to one plant per pot leaving the most vigorous and healthier plant and the weekly height measurements were recorded for eight weeks. At the end of the eighth week, the parameters such as number of leaves at harvest, length of leaves (length and breadth) were recorded to obtain the leaf area according to Kayode and Otoide [14] as:

$$A = L \times B \times 0.75$$

where A = area of the leaf, L = length of the leaf, B = breath of the leaf and 0.75 = a constant

The plant heights obtained were used to determine the relative growth rate (RGR) according to Kayode and Tedela [13] as:

$$RGR = \frac{\ln H_2 \; \ln H_1}{T_2 - T_1}$$

where H_2 = final height of the plant, H_1 = initial height of the plant, T_2 = final time, T_1 = initial time and ln = natural Log.

The plants were carefully uprooted and washed thoroughly before later separated into roots and shoots. The fresh weights of the roots and shoots were weighed using electronic top loading digital balance (G & G model JJ 300Y, China). They were properly tagged and kept in the herbarium of Plant Science Department, Ekiti State University, for three weeks to obtain the dry weights. The means from the parameters were subjected to one-way analysis of variance (ANOVA, P = 0.05) using a computer software SPSS 2009 version 11.

Results and Discussion

The effects of extracts from residues of sorghum stem and maize inflorescence on the germination percentage of okra are shown in Table 1. The percentage germination of okra seeds decreased with increase in the concentration of the extracts. Results from sorghum stem extracts revealed that the germination percentage was 100% in the control while those of 10, 20, 30, 40 and 50 g extracts concentrations were 100%, 100%, 100%, 84% and 72%, respectively.

Table 1. Effects of extracts derived from sorghum stem and maize inflorescence residues on the germination % of okra seeds.

	Residues	
Treatments	Sorghum stem	Maize inflorescence
0	100.00^{a}	40.00^{a}
10	100.00^{a}	40.00^{a}
20	100.00^{a}	24.00^{ab}
30	100.00^{a}	24.00^{ab}
40	84.00^{ab}	16.00^{b}
50	72.00^{b}	12.00^{b}

Means followed by the same letter within column are not significantly different at p = 0.05.

In maize inflorescence-treated seeds, germination % was 40% in the control experiment and those of 10, 20, 30, 40 and 50 g extract concentrations were 40%, 24%, 24%, 16% and 12%, respectively. Statistical analysis revealed that in sorghum extract-treated seeds significant difference was observed only in the 50 g extract concentration, when the results from the extract-treated seeds were compared to the control. Similarly, in maize inflorescence-treated seeds, results obtained from the 40 and 50 g extract concentrations were significantly different when compared to the control experiment.

The effects of extracts from residues of sorghum stem and maize inflorescence on the speed of germination of okra are shown in Table 2. The speed of germination of okra seeds was reduced with increase in the concentration of both extracts. This showed that the speed of germination was also concentration dependent. Results from okra treated with extract from sorghum stem showed that while the speed of germination in the control was 21.65, those of 10, 20, 30, 40 and 50 g extract concentration were 20.33, 20.09, 19.79, 19.40 and 19.26, respectively. In maize inflorescence-treated seeds, the speed of germination in the control was 20.14 while those of 10, 20, 30, 40 and 50 g extract concentrations were 12.73, 11.94, 11.74, 10.30 and 5.93, respectively.

Table 2. Effects of extracts derived from sorghum stem and maize inflorescence residues on the speed of germination of okra seeds.

	Residues	
Treatments	Sorghum stem	Maize inflorescence
0	21.65^{a}	20.14^{a}
10	20.33^{b}	12.73^{ab}
20	20.09^{bc}	11.94^{ab}
30	19.79^{bc}	11.74^{b}
40	19.40^{bc}	10.30^{b}
50	19.26^{c}	5.93^{b}

Means followed by the same letter within column are not significantly different at p = 0.05.

The effects of the extracts on the number of okra leaves at harvest are shown in Table 3. The results also revealed that the extracts from the two residues decreased the number of leaves in okra at harvest. The number of leaf decreased with increase in the concentration of the extracts. For example, the results from sorghum stem extract-treated seeds showed that the mean leaf number at harvest in the control experiment was 10.60 and those of 10, 20, 30, 40 and 50 g concentrations were 6.00, 6.00, 6.00, 5.80 and 5.00, respectively. Also the number of leaves at harvest of okra treated with maize inflorescence extract was 8.60 in the control, and hose of 10, 20, 30, 40 and 50 g were 8.00, 6.00, 6.00, 5.40 and 4.80, respectively. Statistical analyses revealed that there were significant differences in the number of leaves of okra treated with sorghum stem when compared to the control experiment. No significant differences were recorded in the number of leaves of

Table 3. Effects of extracts derived from sorghum stem and maize inflorescence residues on the on the number of leaves at harvest of okra.

	Residues	
Treatments	Sorghum stem	Maize inflorescence
0	10.60^{a}	9.60^{a}
10	6.00^{b}	8.00^{a}
20	6.00^{b}	6.00^{a}
30	6.00^{b}	6.00^{a}
40	5.80^{b}	5.40^{a}
50	5.80^{b}	4.80^{a}

Means followed by the same letter within column are not significantly different at p = 0.05.

maize inflorescence-treated okra compared to the control experiment.

The effects of the extracts on the leaf area of okra are shown in Table 4. The results revealed that both residues (extracts) had inhibitory effects on the leaf area of okra. The leaf area of the treated okra decreased with increase in the concentration of the extracts. This tends to suggest the effects were concentration dependent. The results from sorghum stem extracts revealed that while the leaf area of okra in the control was 397.79 cm^2, those of 10, 20, 30, 40 and 50 g were 292.73, 277.47, 193.37, 105.88 and 99.89 cm^2, respectively. Similarly in maize inflorescence treated-okra, the leaf area in the control was 534.23 cm^2, and those of 10, 20, 30, 40 and 50 g were 456.67, 385.84, 330.20 , 230.70 and 76.07 cm^2.

Table 4. Effects of extracts derived from sorghum stem and maize inflorescence residues on the leaf area of okra.

	Residues	
Treatments	Sorghum stem (cm^2)	Maize inflorescence(cm^2)
0	397.79^a	534.23^a
10	292.73^{ab}	456.67^{ab}
20	277.47^{ab}	385.84^{ab}
30	193.37^{ab}	330.20^{ab}
40	105.88^b	230.70^c
50	99.89b	76.07^c

Means followed by the same letter within column are not significantly different at p = 0.05.

The effects of the extracts from residues of sorghum stem and maize inflorescence on okra biomass are shown in Table 5. The results obtained in dry root and shoot weights in both residue treatments were similar. Both extracts resulted in decreased weights in the treated okra. The rate of decrease increased with increase in the concentration of the extracts. For example, the dry root weight of okra treated with extracts from sorghum stem was 1.44 g in the control, and those of 10, 20, 30, 40 and 50 g concentrations were 0.76, 0.68, 0.30, 0.24 and 0.20 g, respectively. Similarly, the dry shoot weight was 5.44 g in the control while those of 10, 20, 30, 40 and 50 g were 3.56, 2.64, 2.30, 1.08 and 0.88 g, respectively. In maize inflorescence extract treatment, the dry root weight in the control was 1.38 g which decreased to 1.04 g in 50 g extract concentration. Likewise, the dry shoot weight of the control experiment of okra treated with extracts from maize inflorescence was 10.92 g which decreased to 5.74 g in the 50 g extract concentration.

Table 5. Effects of extracts derived from sorghum stem and maize inflorescence residues on the dry root and shoot weights of okra.

	Residues			
Treatments	Sorghum stem (g)		Maize inflorescence (g)	
	R	S	R	S
0	1.44^a	5.44^a	1.38^a	10.92^a
10	0.76^b	3.56^b	1.32^a	9.24^{ab}
20	0.68^{bc}	2.64^b	1.28^a	8.58^{ab}
30	0.30^{bc}	2.30^c	1.26^a	7.14^{ab}
40	0.24^c	1.08^d	1.12^a	7.02^{ab}
50	0.20^c	0.88^d	1.04^a	5.74^a

Means followed by the same letter within column are not significantly different at p = 0.05.

The effects of sorghum stem and maize inflorescence residues on the relative growth rate of okra are shown in Table 6. The results were similar to those obtained in the earlier parameters studied. The relative growth rate of okra decreased with increase in the extract concentrations. Results from okra treated with extracts from sorghum stem residues, showed that the control experiment was 0.35 cm which decreased to 0.26 cm in 50 g extract concentration. Likewise, in maize inflorescence extract treatment, the relative growth rate was 0.40 cm in the control which decreased to 0.23 cm in 50 g extract concentration.

Table 6. Effects of extracts derived from sorghum stem and maize inflorescence residues on the relative growth rate of okra.

	Residues	
Treatments	Sorghum stem	Maize inflorescence
0	0.35^a	0.40^a
10	0.31^{ab}	0.36^a
20	0.29^b	0.35^a
30	0.27^b	0.31^a
40	0.26^b	0.27^a
50	0.26^b	0.23^a

Means followed by the same letter within column are not significantly different at p = 0.05.

It was, however, apparent that the maize inflorescence residues appeared to have more inhibitory effects on the growth parameters examined on okra than sorghum stem residues. This tends to suggest that okra yields might be reduced greatly when it is planted in plantation of maize or in fields where residues of maize plant are left uncared for. The present findings corroborated Hassan *et al.* [9] that the dry leaf of *Calosotropis procera* retarded the daily and total germination percentage of the seed and grains of selected crops such as barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), cucumber (*Cucumis sativus*) and fenugreek (*Trigonella foenum -graecum*). Similarly Oyun [19] reported that both *Glicidia sepium* and *Acacia auriculiformis* caused a prolonged delay in maize. Also, Melkania [17] noted that extracts from *Celtis australia* and *Juglans regia* caused decrease in the germination of certain crops.

Conclusions

Previous assertions [11, 18] revealed that sorghum contained sorgoleone, an allelopathic compound hydroxyguinine exuded from growing sorghum roots. Allelochemicals in mature sorghum included benzoic, p-hydoxybenzoic, vanillic, p-coumaric, gallic, caffeic, ferulic and chlorogenic acids [6]. Sorghum shoot produce higher amount of cynogenic glucoside whose phenolic products inhibit plant growth [7]. Maize inflorescence allelopathy could be attributed to hydroxamic acid [23]. All these allelopathic compounds (allelochemicals) are responsible for the inhibition exhibited on the growth of okra in this study.

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