

Allelopathic Potential of Some Crop Residues on the Germination and Growth of Soybean (*Glycine max* L.)

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Abstract: Allelopathic potentials of aqueous water extracts from residues of sorghum stem, maize inflorescence and rice husks on the germination of soybeans (*Glycine max*. L.) were investigated. The result showed that the extracts brought about a considerable inhibition in the germination of soybean seeds, reductions in the radicle and plumule lengths of soybean seedlings. Whereas, the extracts of maize inflorescence and rice husk had more inhibitory effects on the growth of soybean radicle, all the three extracts demonstrated pronounced inhibitory effects on the growth of the plumule. The retardation of soybean germination, radicle and plumule growths were concentration dependents as the degree of retardations increases with increase in the concentration of the extracts. Statistical analysis (ANOVA, $P = 0.05$) revealed that there were no significant differences in the germination, radicle and plumule growths at 24 and 48 h experimental time when compared to the control. However, statistical differences abound in the growth parameters at 72 and 144 h experimental time.

Key words: Allelopathic, allelochemicals, crop residues, *Glycine max*.

1. Introduction

The presence of allelochemicals compounds in various plants and crops is now widely realized [1-4]. They may be present in any part of the plant roots, leaves, flowers, fruits or stem from where they are released to the soil by processes such as volatilization, root exudation, leaching and decomposition [1, 5]. Ogbe et al. [6] and Khalid et al. [7] asserted that these allelochemicals affect plant growth and development of other plants. Such effects, so far identified, included inhibition of seed germination [8, 9], seedling growth retardation [10, 11], poor seedling survival [12], decrease in cell turgor [13] and decrease in photosynthetic rate, transpiration, enzyme activity, metabolic energy for respiration and developmental activity [14].

Recent initiatives are now suggesting that allelochemicals are equally present in significant proportions in some crop residues. Consequent on this, Kayode and Ayeni [15] demonstrated the allelopathic effects of some crop residues on the germination and growth of cowpea (*Vigna unguiculata*), Kayode and Ayeni [16] on maize (*Zea mays*), Ayeni and Kayode [17] on *Sphenostylis sternocarpa* and Ayeni et al. [18] on *Bidens pilosa*.

The study being reported here examined the allelopathic potentials of aqueous extracts from residues of sorghum stem, rice husk and maize inflorescence on soybean, an important leguminous food crop widely cultivated in Nigeria.

2. Materials and Methods

The study was conducted in the laboratory of the Department of Plant Science, University of Ado-Ekiti, Ado-Ekiti, Nigeria. Soybean seeds were obtained from

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the Teaching and Research Farm of the University of Ado-Ekiti, Ado-Ekiti, Nigeria. Mature sorghum plants and maize inflorescences were harvested from the department's experimental farm. The sorghum stems were cut into small pieces to facilitate drying. Fresh rice husk were obtained from Ikere-Ekiti, a town located at about 25 kilometers from the University.

These materials were air dried for three weeks, pounded using pestle and mortar and blended with electric blender. Portions of 5 g, 10 g, 15 g, 20 g, and 25 g were measured out from the rice husk, sorghum and maize inflorescence. Each portion was soaked in 200 mL distilled water in 500 mL conical flask. The mixtures were shaken intermittently and left overnight (for 24 h). The aqueous extracts were filtered using Whatman No. 1 filter paper and the filtrates were used as fresh or kept in refrigerator for further use.

Petri dishes were double laid with Whatman No .1 filter papers. Five soybean seeds were put in each Petri dish and each treatment was replicated ten times. The filter papers were moistened daily with the different extract concentrations. Control experiment, whose Petri dishes were moistened with distilled water, was also set up and replicated 10 times. All the Petri dishes were put in growth chamber at room temperature between 30 and 35 °C. The seeds were considered germinated upon radicle emergence. The radicle and plumule growth elongations were recorded at 24 h interval. The results obtained from the extracts treated seeds were compared to those obtained from the control experiment using one way analysis of variance (ANOVA) with SPSS Version 11 (2009) computer. Duncan Multiple Range Test (DMRT) at 5% probability level was used as a follow up test to separate the means.

3. Results and Discussion

The allelopathic effects of aqueous extracts from the three crop residues on soybeans showed that no germination was recorded until 72 h experiment time. Table 1 show the aqueous extracts from sorghum stem

Table 1 Effects of aqueous extracts from sorghum stem, maize inflorescence and rice husk on the germination of soybean (*Glycine max*) seeds.

Species extract (g/200 mL)	Time (h)					
	24	48	72	96	120	144
A						
Sorghum stem 0	0.00 ^a	2.40 ^a	4.90 ^a	4.90 ^a	4.90 ^a	4.90 ^a
Sorghum stem 5	0.00 ^a	0.00 ^b	3.10 ^b	4.50 ^{ab}	4.50 ^{ab}	4.70 ^{ab}
Sorghum stem 10	0.00 ^a	0.00 ^b	3.00 ^b	4.30 ^{ab}	4.10 ^{ab}	4.50 ^{ab}
Sorghum stem 15	0.00 ^a	0.00 ^b	2.40 ^b	3.70 ^{bc}	4.00 ^{bc}	4.00 ^{bc}
Sorghum stem 20	0.00 ^a	0.00 ^b	2.10 ^b	3.30 ^b	3.50 ^{bc}	3.50 ^{bc}
Sorghum stem 25	0.00 ^a	0.00 ^b	1.90 ^b	2.90 ^b	3.00 ^d	3.00 ^d
B						
Maize inflorescence 0	0.00 ^a	2.30 ^a	4.20 ^a	4.80 ^a	4.80 ^a	4.80 ^a
Maize inflorescence 5	0.00 ^a	0.00 ^a	3.10 ^b	4.70 ^a	4.70 ^a	4.70 ^a
Maize inflorescence 10	0.00 ^a	0.00 ^a	2.80 ^b	3.90 ^b	4.70 ^a	4.70 ^a
Maize inflorescence 15	0.00 ^a	0.00 ^a	2.00 ^b	3.40 ^b	4.20 ^a	4.20 ^a
Maize inflorescence 20	0.00 ^a	0.00 ^a	0.80 ^c	2.10 ^b	2.80 ^b	2.80 ^b
Maize inflorescence 25	0.00 ^a	0.00 ^a	0.00 ^c	1.10 ^c	1.80 ^c	1.80 ^c
C						
Rice husk 0	0.00 ^a	2.80 ^a	4.80 ^a	5.00 ^a	5.00 ^a	5.00 ^a
Rice husk 5	0.00 ^a	0.20 ^b	3.70 ^{ab}	4.80 ^{ab}	4.80 ^a	4.80 ^a
Rice husk 10	0.00 ^a	0.00 ^b	2.80 ^{ab}	3.90 ^{ab}	4.50 ^{ab}	4.50 ^a
Rice husk 15	0.00 ^a	0.00 ^b	2.60 ^{bc}	3.70 ^c	4.20 ^{ab}	4.20 ^a
Rice husk 20	0.00 ^a	0.00 ^b	2.40 ^{bc}	3.40 ^c	3.70 ^b	3.70 ^b
Rice husk 25	0.00 ^a	0.00 ^b	1.50 ^c	2.40 ^d	2.80 ^c	2.50 ^c

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

extracts. The results revealed that the germination of extract treated soybean seeds was inhibited. The degree of inhibition increased with increase in the concentration of the extracts. For example, at 72 h experimental time, 4.90% germination was recorded in the control and 3.10%, 3.00%, 2.40%, 2.10% and 1.90% were recorded at 5, 10, 15, 20 and 25 g/200 mL extracts respectively. Statistical analysis revealed that there were no significant differences in the germination of treated and non-treated seeds at 24 h after planting. However, statistical differences were observed in the germination of soybeans from 48 h to 144 h experimental time when the proportion of germination in the treated seeds and that of the control experiments were compared at 5% level of significance.

Similarly, in the extracts obtained from maize inflorescence, no germination was obtained in the extract treated seeds until 72 h experimental time

(Table 1). 4.20% germination was recorded in the control and 3.10%, 2.80%, 2.00%, 0.80% and 0.00% were recorded at 5, 10, 15, 20 and 25 g/200 mL extracts, respectively. Also statistical analysis revealed that there were no significant differences in the germination obtained from treated and non-treated seeds at 24 and 48 h experimental time. However, in other treatments, significant differences were obtained (Table 1B).

In the rice husk aqueous extracts treated seeds (Table 1C), the pattern of inhibition observed were similar to those observed in other extracts. Also at 72 h experimental time, 4.80% germination was recorded in the control and 3.70%, 2.80%, 2.60%, 2.40% and 1.50% were recorded at 5, 10, 15, 20 and 25 g/200 mL extracts, respectively. Statistical analysis revealed that no significant differences were observed in treated and non-treated seeds at 24 h experimental time. However, in the extract concentrations, statistical differences were observed in the germination of soybean. These results agreed with the earlier report of Bora et al. [19] who observed similar effects from the leaf of *Acacia auriculiformis* on the germination of some agricultural crops whose inhibitory effects were proportional to the concentration of the extracts.

The results of the effects of aqueous extract from three crop residues on the radicle of soybeans were shown in Table 2. It was revealed that in sorghum stem extract treated seeds, no radicle growth was recorded at 24 h experimental time. The results revealed that the extracts retarded the radicle growth of soybeans. Also the degree of retardation increased with the increase in the concentration of the extracts, thus suggesting that the effects on the radicle lengths were concentration dependant.

Statistical analysis revealed that there were no significant differences in the radicle growth of sorghum extracts treated seeds and the control at 24 h experimental time. Statistical differences abound at higher experimental time. Table 2A revealed that at

Table 2 Effects of aqueous extracts from sorghum stem, maize inflorescence and rice husk on the radicle length (cm) of soybean (*Glycine max*) seeds.

Species extract (g/200 mL)	Time (h)					
	24	48	72	96	120	144
A						
Sorghum stem 0	0.00 ^a	0.08 ^a	0.86 ^a	1.85 ^a	3.47 ^a	3.87 ^a
Sorghum stem 5	0.00 ^a	0.02 ^b	0.58 ^b	1.48 ^a	2.45 ^a	3.18 ^{ab}
Sorghum stem 10	0.00 ^a	0.00 ^b	0.44 ^{bc}	0.84 ^b	2.33 ^b	2.57 ^{ab}
Sorghum stem 15	0.00 ^a	0.00 ^b	0.19 ^{cd}	0.84 ^b	1.64 ^{cd}	2.44 ^{bcd}
Sorghum stem 20	0.00 ^a	0.00 ^b	0.16 ^c	0.46 ^b	1.29 ^d	1.87 ^{cd}
Sorghum stem 25	0.00 ^a	0.00 ^b	0.12 ^d	0.37 ^b	1.17 ^d	1.57 ^d
B						
Maize inflorescence 0	0.00 ^a	0.05 ^a	0.61 ^a	2.01 ^a	2.45 ^a	2.98 ^a
Maize inflorescence 5	0.00 ^a	0.00 ^b	0.18 ^b	1.02 ^a	1.52 ^b	1.84 ^b
Maize inflorescence 10	0.00 ^a	0.00 ^b	0.15 ^b	0.15 ^b	1.22 ^b	1.35 ^{bc}
Maize inflorescence 15	0.00 ^a	0.00 ^b	0.15 ^b	0.15 ^b	0.99 ^{cd}	1.22 ^{cd}
Maize inflorescence 20	0.00 ^a	0.00 ^b	0.00 ^b	0.00 ^b	0.89 ^{bc}	0.99 ^{bc}
Maize inflorescence 25	0.00 ^a	0.00 ^b	0.00 ^b	0.00 ^b	0.33 ^d	0.51 ^d
C						
Rice husk 0	0.00 ^a	0.00 ^a	0.98 ^a	2.62 ^a	3.63 ^a	4.23 ^a
Rice husk 5	0.00 ^a	0.00 ^a	0.42 ^b	1.54 ^b	2.77 ^b	3.47 ^a
Rice husk 10	0.00 ^a	0.00 ^a	0.10 ^c	1.09 ^{bc}	1.89 ^c	2.29 ^b
Rice husk 15	0.00 ^a	0.00 ^a	0.08 ^c	1.05 ^{bc}	1.79 ^{cd}	2.12 ^{bc}
Rice husk 20	0.00 ^a	0.00 ^a	0.07 ^c	0.76 ^c	0.15 ^{cd}	1.37 ^{dc}
Rice husk 25	0.00 ^a	0.00 ^a	0.05 ^c	0.70 ^c	0.99 ^e	1.25 ^d

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

72 h experimental time, the radicle growth length in the control was 0.98 cm, those of 5 g, 10 g, 15 g, 20 g, and 25 g extract concentrations were 0.42 cm, 0.10 cm, 0.08 cm, 0.07 cm and 0.05 cm, respectively.

At 144 h experimental time, the radicle length decreased from 4.23 cm in the control to 1.25 cm in 25 g extract concentration. Similarly Table 2B revealed that the maize inflorescence extracts treated seeds showed similar inhibitory effects on the radicle length of soybeans. At 72 h experimental time, radicle length in the control experiment was 0.61 cm which decreased to 0.00 cm in both 20 g and 25 g respectively (Table 2B). At 144 h experimental time, the radicle length decreased from 2.98 cm to 0.51 cm in 25 g extract concentration. Statistical analysis revealed that there were no significant differences in the radicle lengths of soybeans treated with aqueous extracts of maize inflorescence at 24 and 48 h

experimental time compared to control.

The effects of the extracts on the plumule length of soybeans were shown in Table 3. In sorghum stem extract (Table 3A), at 72 h experimental time, the plumule length in the control was 0.16 cm, those of 5 g, 10 g, 15 g, 20 g and 25 g extract concentrations were 0.03 cm, 0.00 cm, 0.00 cm, 0.00 cm and 0.00 cm, respectively. At 144 h experimental time, plumule length in the control experiment was 1.55 cm which was decreased to 0.13 cm in the 25 g extract concentration.

Also in maize inflorescence extract treated seeds (Table 3B), similar results were obtained on the plumule length of soybeans which reduces as the concentration of the extracts increases. For example, at 144 h experimental time, the control experiment has plumule length of 1.31 cm which reduced to 0.13 cm in the 25 g extract concentration. Statistical analysis revealed that there were no significant differences in

Table 3 Effects of aqueous extracts from sorghum stem, maize inflorescence and rice husk on the plumule length (cm) of soybean (*Glycine max*) seeds.

Species extract (g/200 mL)	Time (h)					
	24	48	72	96	120	144
A						
Sorghum stem 0	0.00 ^a	0.02 ^a	0.16 ^a	0.52 ^a	1.02 ^a	1.55 ^a
Sorghum stem 5	0.00 ^a	0.00 ^a	0.03 ^b	0.21 ^b	0.84 ^a	1.02 ^b
Sorghum stem 10	0.00 ^a	0.00 ^a	0.00 ^b	0.15 ^b	0.36 ^b	0.57 ^c
Sorghum stem 15	0.00 ^a	0.00 ^a	0.00 ^b	0.12 ^b	0.19 ^{cd}	0.26 ^{cd}
Sorghum stem 20	0.00 ^a	0.00 ^a	0.00 ^b	0.08 ^b	0.19 ^d	0.26 ^{cd}
Sorghum stem 25	0.00 ^a	0.00 ^a	0.00 ^b	0.06 ^b	0.12 ^d	0.13 ^d
B						
Maize inflorescence 0	0.00 ^a	0.00 ^a	0.11 ^a	0.71 ^a	1.10 ^a	1.31 ^a
Maize inflorescence 5	0.00 ^a	0.00 ^a	0.01 ^a	0.20 ^b	0.37 ^a	0.71 ^b
Maize inflorescence 10	0.00 ^a	0.00 ^a	0.00 ^a	0.16 ^{bc}	0.34 ^b	0.60 ^b
Maize inflorescence 15	0.00 ^a	0.00 ^a	0.00 ^a	0.10 ^{bc}	0.34 ^b	0.53 ^b
Maize inflorescence 20	0.00 ^a	0.00 ^a	0.00 ^a	0.09 ^b	0.27 ^{bc}	0.43 ^b
Maize inflorescence 25	0.00 ^a	0.00 ^a	0.00 ^a	0.00 ^c	0.03 ^c	0.07 ^c
C						
Rice husk 0	0.00 ^a	0.01 ^a	0.11 ^a	0.94 ^a	1.62 ^a	2.09 ^c
Rice husk 5	0.00 ^a	0.00 ^a	0.01 ^b	0.85 ^b	0.73 ^b	1.24 ^b
Rice husk 10	0.00 ^a	0.00 ^a	0.00 ^b	0.31 ^b	0.21 ^c	0.75 ^b
Rice husk 15	0.00 ^a	0.00 ^a	0.00 ^b	0.04 ^c	0.12 ^c	0.62 ^{bc}
Rice husk 20	0.00 ^a	0.00 ^a	0.00 ^b	0.00 ^c	0.10 ^c	0.31 ^d
Rice husk 25	0.00 ^a	0.00 ^a	0.00 ^b	0.00 ^c	0.05 ^c	0.19 ^d

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

the plumule length of soybean treated seeds between 24 and 72 h experimental time compared to control experiment. However, statistical differences were observed in the plumule length at 96 h to 144 h experimental time.

Similar results were also observed in the rice husk extract treated seeds (Table 3C). For example, results obtained at 72 h experimental time revealed that the control experiment has plumule length of 0.11 cm which reduced to 0.00 cm in the 25 g extract concentration. Statistical analysis revealed that there were no significant differences in the plumule length of the treated seeds when compared to the control at 24 and 48 h experimental time but such differences abound at 96 h to 144 h experimental time.

The results obtained from this study agreed with the previous findings of Jadhar and Goyanar [20] who observed that the percentage germination, plumule and radicle lengths of rice and cowpea were decreased with increasing concentration of the extracts from leaf leachates of *Acacia auriculiformis*. Yarnia et al. [21] observed that the allelopathic effects of sorghum extracts on *Amaranthus retroflexus* seed germination and growth decreased with increase in sorghum extract concentration and also Qudhia [22] who asserted that extract from *C. gigantean* inhibited the growth of radicle and plumule of *Lathyrus sativa*. Similarly Chou and Lin [23] as well as Irshad and Cheema [24] reported that aqueous extracts from rice residues inhibited root growth of lettuce, rice seedlings and Barnyard grass, respectively. Previous studies revealed that the inhibitory compounds occurring in these crop residues are mostly phenols [25]. The phenols in sorghum plants are benzoic acid, *p*-hydrobenzoic acid, vanillic acid, *m*-comedic acid, *p*-coumaric acid, gallic acid, ferulic acid and chlorogenic acid [26]. The rice husk, according to Chuo and Lin [27] contained *p*-hydroxyl benzoic acid, yanillic, ferullic, *p*-coumeric and *o*-hydroxylphenyl acetic acids. Chou et al. [26] had also reported the presence of syringic acid in rice husk.

4. Conclusions

In Nigeria, crop residues are often left uncared for on farms where they decomposed. Residues that possessed allelochemicals released them into the soil. Further studies on the release and effects of these allelochemicals are being advocated in the continued efforts to boost food production in the country.

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