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Allelopathic Potentialities of *Gliricidia sepium* and *Acacia auriculiformis* on the Germination and Seedling Vigour of Maize (*Zea mays L.*)

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Abstract: Decline in crop yield in cropping and agroforestry system in recent years has been attributed to allelopathic effects. Plants may favourably or adversely affect other plants through allelochemicals, which may be released directly or indirectly from live or dead plants. The objective of this study was to examine and quantify the nature of interference of leaf leachates of *Gliricidia sepium* and *Acacia auriculiformis* on seed germination and seedling vigour of maize and to identify morphological trait for allelopathic interference assessment of maize seedlings. Leaf leachates of both *Gliricidia* and *Acacia* significantly decreased germination percentage and increased mean germination time ($P<0.05$) and ($P<0.01$) of maize seeds particularly at leachate concentrations of 6 and 12% respectively. Similarly, all the seedling growth parameters including seedling vigour index (SVI) decreased significantly ($P<0.05$) and ($P<0.01$) with increasing level of leachate concentration compared with control. It was apparent that *Gliricidia sepium* perform the more inhibitory effect than *Acacia auriculiformis.* Shoot length ($r = 0.792$), root length ($r = 0.920$), shoot fresh weight ($r = 0.873$) and root dry weight ($r = 0.828$) were significantly correlated ($P< 0.01$) with SVI. Seedling root length appeared to be the strongest morphological trait for allelopathic assessment of maize seedling

Key words: Allelopathy, growth parameters, allelochemicals, seedling vigour index, morphological trait, inhibitory effect

INTRODUCTION

Interference may occur when one plant species fails to germinate, grows more slowly, shows symptom of damage, or does not survive in the presence of another plant species. Such interference can result from competition and allelopathy. The interaction of plants through chemical signals has many possible agricultural applications[1]. Decline in crop yields in cropping and agroforestry system in recent years has been attributed to allelopathic effects. It has been reported that *Eucalyptus spp.* and *Acacia spp.* have phytotoxic effects on tree crops and legumes[2]. Also, Menges[3], observed that incorporation of residues of *Palmer amaranth* in the soil inhibited the growth of carrot and onion. Allelopathic associated problems often result to accumulation of phytotoxin and harmful microbes in soil, which give rise to phytotocicity and soil thickness[4]. A large number of weeds and tree possess allelopathic properties, which have growth inhibiting effect on crops. Thus chemicals with allelopathic activity are present in many plants and various organs, including leaves and fruits[5,6] and have potential inhibitory effects on crops[7]. Many allelopathic compounds produced by plants are released to the environment by means of volatilization, leaching, decomposition of residue and root exudation.

Research on allelopathy has had its greatest increase during the period between 1960 and 1970[8] yet much work has failed to separate the possible effects of allelopathy from those of soil water competition[9]. Demonstrating allelopathy requires evidence that interference occurs and that the interference is not due to competition or other indirect influences.

Besides releasing natural products, one plant can influence another in other ways by reducing light intensity or changing its quality; taking up limited waters; changing humidity; absorbing limited nutrients; changing soil reaction and favouring or reducing pathogenic activity. Hence, the study of interference phenomena is difficult and to demonstrate a cause and effect relationship requires the study not only of allelopathy, but also of competition and other influences. Therefore, the first step should be to demonstrate interference between plants and quantify it to the extent possible. The circumstances in which interference occurs should be defined including the stage of plant development affected (seed germination, growth on cotyledonary reserves, growth after the cotyledonary reserve phase). Furthermore, symptoms of interference should be as specific as possible, because they are important for eliminating causes of interference or to bioassay allelochemicals in chromatographic studies. The objectives of the present study include:

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* To examine and quantify the nature of interferences of leachate from *Gliricidia sepium* and *Acacia auriculformis* on seed germination and seedling vigour of maize and
* To identify morphological traits for allelopathic interference assessment of maize seedlings

MATERIALS AND METHODS

Grains of maize (*Zea mays L*) were obtained from the Teaching and research Farm of the Federal University of Technology, Akure, Nigeria. The grains were surface sterilized with 1% Sodium hypochloride for 20 mins, then rinsed with distilled water several times. Fresh samples of leaves of *Gliricidia sepium* and *Acacia auriculiformis* were collected at random at the vegetative stage in early 2002 from the plantation site of the Department of Forestry and Wood Technology. The leaves were sun-dried and then ground using leaf particulator to pass through 2mm mesh sieve. 12% of *Gliricidia* and *Acacia* leachate was obtained by weighing 30g each of the ground materials into 500ml conical flask and 240ml distilled water added. The mixture was shaken intermittently and left for 24 hours. Thereafter, the suspension was filtered using No.1 Whatman filter paper. From the leachates three different concentrations (3, 6 and 12%), were prepared. Three replicates per treatment and 15 maize seeds per replicate were incubated on cotton wool in petri-dishes using the respective leachate concentration and laid in completely randomized design under laboratory condition. The cotton wool was constantly moistened twice daily using the respective leachate concentrations and distilled water as control. The petri-dishes were kept at room temperature under 12 hours of natural light each day and monitored daily. Seeds were considered germinated upon radicle emergence. The first germination was observed after three days while the final germination was obtained before eleven days of sowing.

The mean germination time was calculated using the relation: $MGT = \sum(fx)/ \sum x$, where x is the number of newly germinated seeds on each day and f is the number of days after seeds were set to germinate[10]. After 21 days, seedling growth was assessed by harvesting three individuals/treatment and different growth parameters including fresh and dry weights were determined. Realizing the importance of dry-matter accumulation in seedling health and low MGT as indication of seed vigour and uniform seedling, seedling vigour index (SVI) was determined as SVI = dry weight per seedling/MGT x 100. Data were subjected to analysis of variance using SPSS software programme. Correlation coefficient was determined by pooling data from all treatments and the relation amongst seedling growth parameters and seedling vigour index was examined.

RESULTS AND DISCUSSION

The allelopathic effect of *Gliricidia sepium* and *Acacia auriculiformis* on the germination of maize is shown in Table 1 and 2 respectively. It is obvious that the leaf leachates of both *Gliricidia* and *Acacia* inhibited the germination of maize. The number of days taken for first seed germination was prolonged by *Gliricidia* leachate and these were significantly higher ($P<0.05$) and (P, 0.01) at 6% and 12% concentration respectively than control (Table 1). Although, *Acacia* leachate also had a slight prolong effect on the number of days for first seed germination, the effect is not significantly different from the control even at 12% concentration (Table 2).

The percentage of seed germination was significantly lower ($P< 0.05$) and ($P< 0.01$) at 6% and 12% leachate concentration respectively than control for both *Gliricidia* and *Acacia* (Table 1 and 2). While the percentage seed germination decreased with increasing concentration of *Gliricidia* and *Acacia* leaf leachates, the mean germination time (MGT) significantly increased compared to control (Table 1 and 2).

The shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and seedling vigour index were all significantly decreased (Table 3 and 4) compared to control with increasing concentration of *Gliricidia* and *Acacia* leaf leachates.

It is however apparent that *Gliricidia sepium* perform the more inhibitory effect than *Acacia auriculiformis*.

The present findings corroborate the earlier report by Bora *et al.*[11] who found that, the inhibitory effect of leaf extracts of *Acacia auriculiformis* on germination of some agricultural crops was proportional to the concentration of the extract. Also, as noted by Jadhar and Gayanar[12] the percentage of germination, plumule and radicle length of rice and cowpea, were decreased with increasing concentration of *Acacia auriculiformis* leaf leachates. In the present study, responses indices revealed that the inhibition of growth parameters of seedlings was more pronounced than that of seed germination.

The inhibitory effect of the test species on seed germination and seedlings of maize may be related to the presence of allelochemicals including tannins, wax, flavonoides and phenolic acids. Furthermore, the toxicity might be due to synergistic effect rather than single one[13]. Phenolic acids have been shown to be toxic to germination and plant growth processes[14].

Rajangam and Arumgam[15] found that, the use of z-aqueous extracts of *Excoecaria agallocha* leaves inhibited seed germination and plumule and radicle elongation of rice. Joes and Gillespie[16] reported that juglone released from black walnut exhibited inhibitory effects on all measured variables including photosynthesis, transpiration, stomatal conductance,

Table 1: Effect of allelopathic potential of *Gliricidia sepium* on the germination parameters of maize *(Zea mays L.)*. Each value is a mean of three replicates

Treatment (leachate concentration) (%)	Number of days taken for fist seed germination	Mean germination (%)	Mean germination time (MGT)
O (Control)	3.0	82.23	7.22
3	3.12^{ns}	44.42^{a}	7.71^{ns}
6	4.41^{a}	31.11^{b}	8.62^{a}
12	5.0^{b}	22.21^{b}	16.0^{b}
LSD			
0.05^{a}	1.30	37.82	1.38
0.01^{b}	1.69	41.62	1.92

ns = not significant.

Table 2: Effect of allelopathic potential of *Acacia auriculiformis* on the germination parameters of maize *(Zea mays L.)*. Each values is a mean of three replicates

Treatment (leachate concentration) (%)	Number of days taken for fist seed germination	Mean germination (%)	Mean germination time (MGT)
O (Control)	3.0	75.5	6.64
3	3.11^{ns}	57.8^{ns}	7.54^{ns}
6	4.12^{ns}	53.3^{a}	8.25^{a}
12	4.20^{ns}	33.3^{b}	10.0^{b}
LSD			
0.05^{a}	1.28	21.9	1.24
0.01^{b}	1.59	23.4	1.72

ns = not significant.

Table 3: Effect of Allelopathic potential of *Gliricidia sepium* on seedling growth of maize after 21 days of sowing. Each value is a mean of three replicates

Treatment (leachate concentration) (%)	Shoot length (cm)	Root length (cm)	Shoot fresh wt (g)	Root fresh wt (g)	Shoot dry wt (g)	Root dry wt (g)	Seeding vigour index
O (Control)	12.12	6.13	3.97	3.24	0.79	0.64	19.82
3	6.05^{b}	4.50^{b}	1.44^{b}	0.65^{b}	0.28^{a}	0.12^{b}	5.30^{b}
6	4.06^{b}	3.20^{b}	1.13^{b}	0.40^{b}	0.17^{a}	0.10^{b}	3.17^{b}
12	3.10^{b}	1.61^{b}	0.37^{b}	0.27^{b}	0.06^{a}	0.05^{b}	0.66^{b}
LSD							
0.05^{a}	0.76	0.66	1.24	0.63	0.48	0.15	5.53
0.01^{b}	1.40	1.22	2.27	1.16	0.88	0.29	10.16

Table 4: Effect of Allelopathic potential of *Acacia auriculiformis* on seedling growth of maize after 21 days of sowing. Each value is a mean of three replicates

Treatment (leachate concentration) (%)	Shoot length (cm)	Root length (cm)	Shoot fresh wt (g)	Root fresh wt (g)	Shoot dry wt (g)	Root dry wt (g)	Seeding vigour index
O (Control)	9.16	6.16	3.50	3.09	0.70	0.61	19.74
3	7.30^{ns}	4.76^{a}	3.26^{ns}	1.16^{b}	0.64^{ns}	0.23^{b}	11.64^{a}
6	5.66^{a}	3.53^{b}	2.26^{ns}	1.06^{b}	0.46^{a}	0.20^{b}	7.95^{b}
12	1.32^{b}	2.01^{b}	1.66^{a}	0.94^{b}	0.34^{a}	0.18^{b}	5.33^{b}
LSD							
0.05^{a}	2.22	1.05	1.71	1.01	0.22	0.19	5.66
0.01^{b}	4.08	1.92	3.15	1.86	0.40	0.35	10.39

ns = not significant

Table 5: Correlation coefficient (r) associating seedling vigour index (SVI) and seedling growth parameters. *Correlation coefficient determined from pooled data from all the treatments*

Seedling growth parameters	Correlation coefficient (r)
Shoot length (cm)	0.792^{b}
Root length (cm)	0.920^{b}
Shoot fresh weight (g)	0.873^{b}
Root fresh weight (g)	0.650^{a}
Shoot dry weight (g)	0.38^{ns}
Root dry weight (g)	0.828^{b}

$P<0.05^{a}$; $P<0.01^{b}$; ns = not significant.

leaf and root respiration in corn and soyabean. Thus in the present study, the decreased growth variables of seedlings of maize compared to control with increasing concentration of leachates was obviously due to inhibitory effect of the leachates on physiological processes that translate to growth. Although these were not directly assessed, the nature of the inhibitory effect of the leaf leachates to seed germination was likely to be that of inhibities to water absorption which is a procusor to physiological processes that should occur in the seed before germination is trigarred.

Similarly, the nature of the effect of the leaf leachates on seedling growth was likely to be that of inhibition to nutrient uptake by the growing maize thereby reducing growth parameters in proportion that was related to the concentrations of the leachates as observed in the study. This claim is corroborated by the decreased seedling vigour index (SVI) compared to control (Table 3 and 4) with increasing leachate concentration in this present study.

All seedling growth parameters showed positive correlation with seedling vigour index (Table 5). Shoot length (r = 0.792), roto length (r = 0.920), shoot fresh weight (r = 0.873) and root dry weight (r = 0.828) were significantly correlated (P,0.01) with SVI. Seedling root length appeared to be the strongest morphological trait for allelopathic interference assessment of maize seedlings.

CONCLUSION

Acacia auriculiformis and *Gliricidia sepium* leaf leachates inhibited both seed germination and seedling growth of maize; in proportion that was related to the concentration of leachates. The nature of intereference seemed to be that of inhibition to water absorption in germinating seeds and that of nutrient uptake in the growing seedlings of maize.

Shoot and root fresh and dry weights of maize showed positive morphological features for allelopathic interference assessment.

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