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The effects of *Triplochiton scleroxylon* aqueous extracts on initial growth of some vegetable crops in Ghana

Abugre, S.,[1]*, Apetorgbor, M. M[2], Abebrese, I. K.[1], Apetorgbor, A. K, [3], Amoako, P. K. [1]

Abstract
The effect of *Triplochiton scleroxylon* (wawa) aqueousextracts were tested on the seeds of tomato (*Lycopersicumesculentum*), pepper (*Capsicum annuum*) and garden egg (*Solanummelongena*) in the pathology laboratory of the Forestry Research Institute of Ghana (FORIG). Aqueous extracts of *T. scleroxylon* leaves (L) and roots (R) were prepared at different concentrations of 2%, 4%, 6%, and 8% and applied to the seeds. The effects of these treatments were assessed in a Completely Randomized Design (CRD) with 4 replications. The findings showed that all the vegetable crops were affected by the different concentrations of the leaf and roots aqueous extracts ($P<0.05$). Tukey-Kramer multiple comparison indicated that the inhibitory effect was positively correlated with concentration of the extracts. The higher extract concentrations (6%-8%) had stronger inhibitory effect whereas; in some cases the lower concentration (2%-4%) showed stimulatory effect during germination. The radicles were more susceptible to the effect of the extracts than the plumules. The germination of *L.esculentum* was highly inhibited in growth by 51.4% in both the leaf and root extracts. Similarly, *C.annuum* recorded the highest inhibitory effect on radicle length by 72.5% in the leaf extract whilst, the highest inhibitory effects in plumule was 44%. The overall results point to an allelopathic inhibitory effect of *T. scleroxylon* on the three vegetable crops.

Keywords
allelopathy — aqueous extract — germination — plumule — radical — *T. scleroxylon*

[1] *School of Natural Resources, UENR, P. O. Box 214, Sunyani, Ghana*
[2] *Forestry Research Institute of Ghana, P. O. Box 63, KNUST, Kumasi, Ghana*
[2] *Department of Theoretical and Applied Biology, KNUST, Kumasi, Ghana*
***Corresponding author**: simabu2001@yahoo.com

Contents

Introduction

Wawa (*Triplochiton scleroxylon*) is a tropical tree of Africa and is widely distributed in the West and Central African forest zone from Guinea in the east to the Central African Republic and south to Gabon and Democratic Republic of Congo [1]. The plant has been tested for cultivation in plantations because it is fast growing, self-pruning and well established in the timber market [2]. In response to native woody species diversity destruction, several methods are being used to foster natural regeneration in degraded forests [3]. The establishment of plantations through the *"taunyga"* system is among these methods. The *taungya* agroforestry system has been the backbone of successful plantation forestry [4]. The system helps produce food for people and at the same time retains the forest cover. The suitability of this system in establishing and managing young forest plantations have been demonstrated [5].However, farmers have raised concern about the harmful effects of trees on cultivated lands and standing crops in *taungya* plantation [6].

The promotion of the establishment of *T. scleroxylon* , and its use in a *taungya* system could be useful as it can be established in combination with food crops. However complains from farmers indicate that, the combination of *T. scleroxy-*

lon and some vegetable crops in *taungya* system suppressed the growth and yield of the crops. The suspicion is that *T. scleroxylon* exhibited allelopathic effect on these crops.

The phenomenon of allelopathy is derived from Greek-words meaning the injurious effect of one upon the other [7]. It involves the mechanism by which chemicals from one plant are released into the environment that affects other plants biological processes [8]. In sensitive species, allelochemicals may inhibit seed germination, shoot/root growth, disturb nutrient uptake or alter naturally occurring symbiotic relationship[8]. Little information on the allelopathic behaviour of *T. scleroxylon* is known. This preliminary study was sought to establish if the reported reduction of yield and growth of the vegetable crops could be due to allelopathic properties exhibited by *T. scleroxylon* . This study therefore evaluated the effect of the leaf and root extracts of *T. scleroxylon* on the germination of the seeds of the three vegetable crops namely; *Lycopersium Esculentum*, mill., *Capsicum annuum* and *Solanum melongena* in the pathology laboratory of the Forestry Research Institute of Ghana.

1. Materials and Methods

1.1 Study Area

The research was conducted in the Pathology laboratory of the Forestry Research Institute of Ghana (FORIG) at Fumesua near Kumasi. The temperature and relative humidity in the laboratory during the period of the experiment was 25 ^{o}C and 77%, respectively.

1.2 Collection of plant materials

Fresh mature leaves and roots of *T. scleroxylon* (Wawa) were collected from the Bobiri Forest Reserve which is a moist semi-deciduous forest in the Ejisu-Juaben Municipalilty of the Ashanti Region. Seeds of the vegetable crops; *L.esculentum C. annuum* and S.melongenawere purchased from an accredited agricultural shop. The seeds used for the experiment went through a germination test to ascertain their viability.

2. Experimental procedure

The leaves and roots were air dried separately. When well dried, they were ground into powder form. The Leaves (L) and Roots (R) of were weighed to 2, 4, 6 and 8 grams with electronic balance and put into sterilized conical flasks separately. Hundred millilitres (100 ml) of distilled water was added to each of the samples and stirred.

The mixtures were kept for 48 hours at room temperature of $25^{o}C$. The aqueous extract of the leaves and roots were then extracted using pressure pumps. Both the leaves and roots solutions were kept in a dark cupboard. The Petri-dishes were sterilized in an oven for 6 hours. Two layers of Whatman No. 1 filter papers were later used to line the Petri-dishes for the germination. Three milliliters each of the different concentration of the aqueous solutions were saturated in the Petri-dishes using sterilized pipettes. Twelve seeds of each of the vegetable crops; S.melongena, L.esculentum and *C.annuum* were put into the sterilized Petri-dishes. A control treatment of only distilled water was also applied to the seeds in petri-dishes. Each treatment had four replicates. Moisture in the Petri dishes was maintained by adding 0.5 ml of the extracts when the treatments were dry.

The number of seeds of germinated seeds was recorded on the 4^{th} day after the experiment was set up. Record on germination continued till the 10^{th} day. The radicle and plumule lengths were also measured on the 10th day.

3. Data analysis

The data was analyzed using the one-way ANOVA with Tukey-Kramer multiple comparison test ($\propto = 0.05$) in GraphPadInstat version 3.00 for windows.

4. Results

4.1 Effect of leaf extract on germination

The results of the effect of leaf extract of *T. scleroxylon* on germination of the three crops are shown in Fig.1. In general, there was a significant effect of the concentrations of the leaf extract on germination of the crops. The Tukey-Kramer multiple comparison test revealed that, there was a significant difference among germination of *S.melongena* seeds treated with L_2%, L_4%, L_6% and L_8% concentration of extracts compared to the control of distilled water only ($p = 0.0007$). The germination of C.annuum seeds treated with the leaf extract concentration of L_2% did not significantly differ from the control treatment. Significant difference was found between the control and L_4%, L_6% and L_8% ($p = 0.0005$). Also in *L.esculentum*, seed germination was suppressed by the aqueous leaf extract of *T. scleroxylon* compared to the control (p ¡ 0.0001) (Fig.1). The effect of the leaf extract on seed germination was concentration dependent.

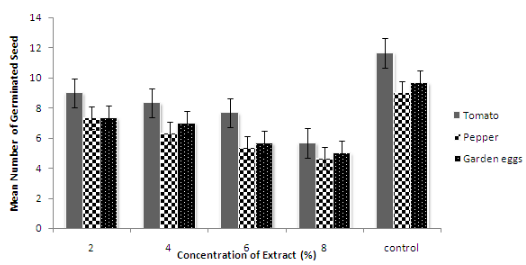

Figure 1. Effect of leaf extract on germination of L. esculentum, *C.annuum* and S. melongena seeds.

4.2 Effect of root extract on germination

The Tukey-Kramer multiple comparison tests showed that, in *S.melongena*, the number of seeds that germinated in R_2%, R_4%, and R_6% and that of the control was not significantly different. However, at 8% concentration of *T. scleroxylon* root extract, the germination of seeds of *S.melongena* was impeded compared to the control (p=0.0007) (Fig.2).The germination of *C.annuum* seeds in R_2% and R_4% compared to the control was not significantly different. Conversely, there was a significant difference between seeds germinated in R_6% and R_8% concentrations and the control (p=0.0004). With regard to *L.esculentum*, all the concentrations of aqueous root extract significantly ($P<0.0001$) suppressed germination compared to the control.The trend of the results showed that *L.esculentum* was highly susceptible to extracts of *T. scleroxylon* .

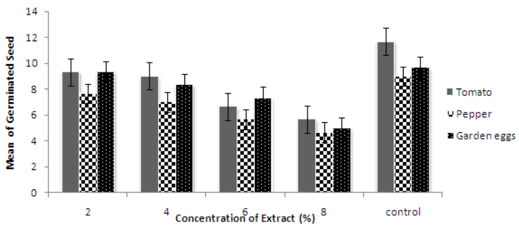

Figure 2. Effect of root extract on germination of L. esculentum, *C.annuum* and *S.melongena* seeds.

4.2.1 Effect of leaf extract on radicle length

Fig. 3 shows the effect of leaf extracts of *T. scleroxylon* on the radicle length of the three vegetable crops.Generally, the leaf extract of *T. scleroxylon* inhibited the growth of radicle of the crops. The aqueous leaf extracts had a significant effect on radicle length of the three vegetable crops. On S. melongena, all the leaf extract concentrations had significant effects on radicle length when compared to that of the control ($p<0.0001$) . The radicle length of *L.esculentum*, treated with L_2% was not significantly different from the control. However for those treated with L_4%, L_6% and L_8% extract concentrations, radicle length was highly supressed. ($p<0.0001$). With respect to *C.annuum* , there were also significant differences in the radicle length among all the leaf extract concentrations of *T. scleroxylon* compared to the control ($p<0.0001$).

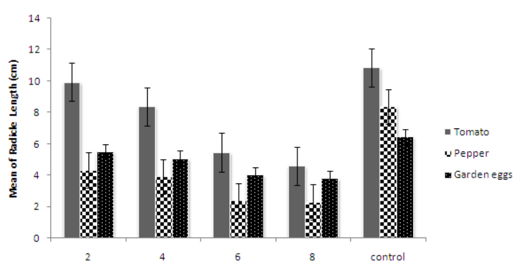

Figure 3. Effect of leaf extract on radicle length of *L. esculentum*, *C.annuum* and *S.melongena*.

4.3 Effect of leaf extract on plumule length

With respect to S.melongena, apart from the L_2%, the rest of the concentrations had significant effects on the plumule length compared to the control ($p<0.0001$) (Fig.4). No significant effect on the plumule lengths of *L.esculentum*, was observed among L_2%, L_4% and L_6% treatments compared to the control. However, seeds treated with the highest leaf extract concentration of L_8% had significant(p=0.0207) effect on the plumule length (Fig.4). Similarly, significant effects occurred on the plumule length of the *C.annuum* grown in L_4%, L_6% and L_8% treatments as compared to the control ($p<0.0001$). Generally, the effect of the leaf extracts were more pronounced on radicle than the plumule.

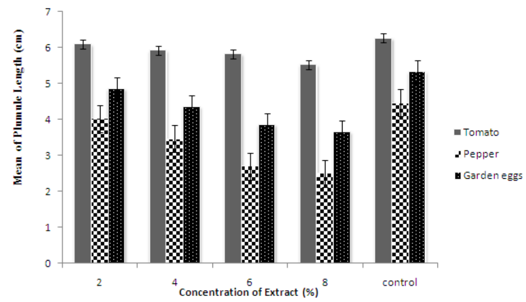

Figure 4. Effect of leaf extract on plumule length of *L. esculentum*, *C.annuum* and *S.melongena*.

4.4 Effect of root extract on radicle length

The results showed that the root extract concentrations of *T. scleroxylon* had negative effect on the radicles of the vegetable crops. In *L. esculentum*, the radicle length decreased in all the extracts compared to that of the control ($p<0.0001$) (Fig.5). The radicle length of *S.melongena* grown in R_4%, R_6% and R_8% were significantly different from the control ($p<0.0001$) (Fig.5). A decrease in radicle length occurred as the concentration of the extracts increased .Similarly, in *C.annuum* , the root extract concentrations negatively affected the growth of the radicle ($p<0.0001$). These results undoubtedly indicate that, the higher the concentration of the root extract, the higher the reduction in radicle length of the test vegetable crops.

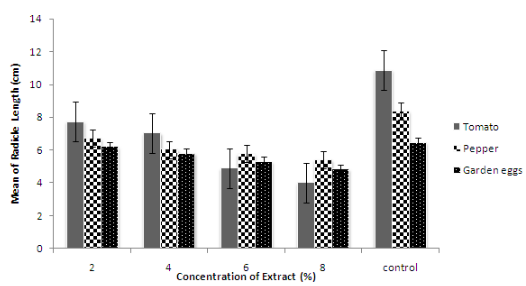

Figure 5. Effect of root extract on radicle length of *L. esculentum*, *C.annuum* and *S. melongena.*

4.5 Effect of root extract on plumule length

Results of root extracts of *T. scleroxylon*on the plumule of the three vegetable crops are presented in Fig. 6. Generally, there was a significant effect of all the concentrations of the root extract on the plumule of the vegetable crops. In all the tested crops apart from R_2%, the rest of the root extract concentrations had significant effect on the plumule length (p<0.0001).

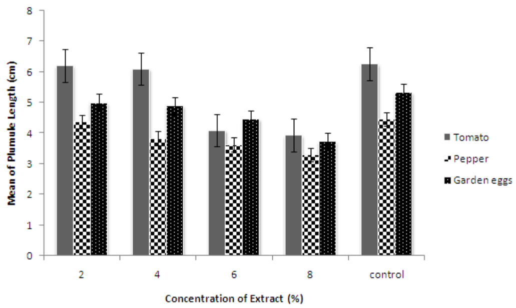

Figure 6. Effect of root extract on plumule length of *L.esculentum*, *C. annuum* and *S. melongena*

5. Discussion

The success of many agrisilvicultural systems would be dependent largely on the compatibility between the tree species and the associated crops. To have a better understanding of the phenomenon, a screening of tree species to select those that are compatible with crops is very important. Screening for tree species with allelopathic properties is vital in taking a decision on the tree-crop association that provides optimum benefits. Allelopathy has been described as both positive and negative beneficial interactions between plants [9]. The results of the present study showed that, the concentrations of the leaf extracts of *T. scleroxylon* suppressed the germination of *L.esculentum*, *S.melongena* and *C.annuum* . However, the lower concentrations of the leaf extracts did not reduce germination of *C. annuum* .This finding is in conformity with that of [10]and[11], who stated that in most cases allelopathic effect are selective and vary with different tree crops. Meanwhile, the results showed that, lower concentrations of the root extracts of *T. scleroxylon* did not suppress the germination of *L.esculentum*, S.melongen aand *C.annuum* . However, higher concentrations did suppress germination. This study has demonstrated that both root and leaf aqueous extract of *T. scleroxylon* exhibits significant inhibitory effect on seed germination of *L.esculentum*,*S.melongena* and *C.annuum* .

Bora et al.[12] 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. There is an indication of the availability of inhibitory chemicals in higher concentrations in the leaf and root extracts of *T. scleroxylon* that reduced the germination of vegetable crop seeds. This result confirms the findings of[13]who noted that aqueous extracts at concentrations of 10, 15 and 20% had inhibitory effect on wheat germination The reduction in seed germination might be due to the presence of allelochemicals that inhibited the process of seed germination. According to [14], extracts from the leaves of *Moringaoleifera* affected germination of *Vigna unguiculata* radicle negatively.

The radicle is the part of the embryo of seed-bearing plants that develops into the main root. It allows the seed to absorb water for the leaves to carry out photosynthesis. Water and salts from the soil are absorbed by the root hairs on the radicle and pass to the rest of the seedling. Later lateral roots develop from the radicle. Once the radicle is firmly anchored in the soil, the hypocotyl starts to grow.

The inhibition of the radicle could therefore have a detrimental effect on the plant's capacity to photosynthesize and grow. An increase in the concentration of the leaf and root extracts led to an increase in inhibitory effects on radicle growth; therefore highest reduction in radicle length was observed in treatment L_8%. [15] found that the inhibitory effect of some plant extract on radicle length of wheat 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. Phenolic acids have been shown to be toxic to germination and plant growth processes [16].

Similarly, [17] confirmed that extracts of many plant species contain allelochemicals which affect enzymes responsible for plant hormone synthesis in addition to inhibition of nutrient and ion absorption by affecting plasma membrane permeability. Studies by [18] revealed that, the use of aqueous extracts of *Excoecariaagallocha* leaves inhibited seed germination, plumule and radicle elongation of rice.

Generally, both leaf and root extracts had significant effect on the plumule length of the three vegetable crops and the effects were concentration dependent. The results of the present study are in conformity with the earlier findings of [19-22] who reported that root growth was more sensitive and responds more strongly to the increasing concentration of the aqueous extract in comparison to the shoot. The reduction in plumule growth of the seeds might be a result of the presence of allelochemicals in the extracts that were able to inhibit the synthesis of growth hormones which in turn prevented cell division and differentiation to increase the length of the plumule. The chemicals might have stimulated the production and synthesis of growth hormones such as auxins. Allelochemicals are not only species specific but organ specific [9].

6. Conclusion

The study evaluated the alleopathic effect of aqueous extracts of *T. scleroxylon* on germination, radicle and plumule length of *L.esculentum*, *C.annuum* and *S.melongena* in the laboratory. It revealed that extracts from the leaf and root both had a significant effect on germination, plumule and radicle length of the vegetable crops. The degree of allelopatheitic effect was concentration dependent, as higher concentrations did suppress germination, radicle and plumule length, It is therefore possible to adopt management practices in the field that could reduce the effect of *T. scleroxylon* on the vegetable crops. Spacing and reduction in density of *T. scleroxylon* could be an option to reduce suppression of the crops.

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