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Allelopathic Effect of Topsoil Extract From *Tectona grandis L.* Plantation on the Germination of *Lycopersicum esculentum*

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Abstract

The use of topsoil extracts transferred from *Tectona grandis L.* plantation to explore similar effects and use of the leaf, bark and root extracts on germination and growth of *Lycopersicum esculentum* is presented. The study was designed to determine the effect of variation of masses of topsoil extracts from teak plantation on the germination and growth response of tomato seeds planted on another soil whose physico - chemical analysis indicate that it can support plant growth. The topsoil extracts were collected in 5kg, 5.5kg, 6kg and 6.5kg packs and respectively spread on 4 mini - plots each with 3 replications and containing 50 planted tomato seeds. The control was the mini - plot without any topsoil extracts. The results showed that the topsoil extracts were able to suppress the germination of the tomato seeds and the effect increased with the mass used. There was a significantly progressive decrease in the mean tall lengths of the seedlings with mass of topsoil indicating a growth inhibition. However, the effect was not very much pronounced in the comparison of the mean values of the short lengths of the seedlings.

Key words: Allelopathy, topsoil extracts, germination

1.0 Introduction

Allelopathy is a natural phenomenon whereby one plant releases a substance which has inhibitory and stimulatory effects on other plants and micro organisms sharing the same habitat (Rice, 1984; Reigosa *et al.*, 2006). A large number of plants have been identified as being allelopathic, and one of which is *Tectona grandis Linn* (Teak). Teak is an agro forestry tree which is largely cultivated in the tropical regions of India and other south Asian countries for its good valuable timber (Leela & Arumugam, 2014) and medicinal use (Khera & Bhargava, 2013). The surface soil and subsoil supporting the growth of teak have been found to contain maximum levels of exchangeable calcium and potassium (Kolay, 2007; Singh *et al.*, 1985) the absence of which can result in restricted growth of roots, stems, leaves and other parts of the plant (Troeh & Thompson, 2005) Allelopathic chemicals found in teak can be present in any part of the plant as well as in the surrounding soil. In more recent times, the allelopathic effect of the leaf extracts on some crops has been reported (Krishna *et al.*, 2003; Macias *et al.*, 2000; Sahoo *et al.*, 2007). The bark and seed extracts have also been used as antifeedant, larvicidal and growth inhibitors (Sree *et al.,* 2008 ; Sahayaraj, 2014). Extensive research has also revealed that the evidence of allelopathy is generally exhibited through; symptoms of plant damage such as reduced germination, growth or development; presence of substances or organisms (plants or microbes) which contain or are capable of producing phytotoxic chemicals in the vicinity of affected plants; the presence of phytotoxic chemicals in the extracts of plants or soils in the vicinity of affected plants (Rizvi & Rizvi, 1992). The source of allelopathic compounds particularly in soils has been traced to leaching, root exudation, microbial decomposition and enzymatic degradation of allelopathic plant material (Rice, 1984). Most allelochemicals are classified as secondary metabolites of the plant (Kruse *et al.*, 2000) and once they are released into the soil, they enter the complex plant - soil system in which diverse factors affect their accumulation, availability and consequently their effective influence on target plants. It is to investigate further the transferability of concentration dependent stimulatory and inhibitory effect (Bhowmik and Inderjiit, 2003) of allelochemical - laden topsoil extract from teak plantation that this research was conducted. The objective is to determine the effect of variation of masses of topsoil extracts from teak plantation on the germination and growth response of tomato seeds planted on another soil to explore similar effect and use as exists in the leaf, bark and root extracts. In order to ensure that the possibility of the observed effect is related to the phytotoxic chemicals only, the physical properties of the soil receiving the topsoil extract as well as its pH was measured. The soil pH can affect the ionisation state of the allelochemical and in turn, its mobility (Rizvi & Rizvi, 1992) while the physical properties altogether give an indication of the quality of the soil.

2.0 Materials and methods

2.1 Location of the experiment: The experiment was carried out at the Crops and Soil Science Department farm, College of Agriculture Education, University of Education, Winneba, Mampong - Ashanti (Longitude 0.05° and 1.30° W and Latitude 6.55° and 7.30° N), in August, 2014. The soil at the farm was largely sandy loam.

2.2 Land and sample preparation: A plot of land measuring 9.5m x 6.5m was prepared and divided into five mini - plots each with three sections for the study. Four of the mini - plots were used for the treatments and the remaining was the control and respectively labelled as A, B, C, D and E. Topsoil extracts were collected from a teak plantation, crushed into fine powder and weighed into 5kg, 5.5kg, 6.0kg and 6.5kg packs. Seeds of a local variety of tomato (Power Rano) were obtained from a certified seed supplier.

2.3 Procedure and Measurements

2.3.1 Soil physical properties: Soil samples from each section of the mini - plots were randomly taken. Starting from the first mini - plot and using the method described by Thien and Graveel (2003), a cylindrical metal core of known volume was hammered into the soil, by means of a wooden mallet, until it got completely buried. It was then excavated and any excess soil at both ends trimmed off in such a way that the retained soil aligned with the both rims of the cylindrical metal core. The soil was then extracted from the metal core into a bag and labeled. The procedure was repeated for the remaining fourteen sections.

After recording their wet weights, all the labeled soil samples were then oven dried at 105°C for 24 hours after which their dry weights were also subsequently recorded. The formulae used for calculating bulk density, porosity, solid space and mass wetness are as outlined in Thien and Graveel (2003) while that for void ratio is as stated in Hillel (1982).

(a) Bulk density (g/cm^3)

$$\frac{Sample\ dried\ weight}{Sample\ volume}$$

(b) Porosity (%)

$$100 - \left(\frac{Bulk\ density}{Particle\ density} \times 100 \right)$$

Where the particle density = 2.65g/cm^3

(c) Solid space (%)

$$\left(\frac{Bulk\ density}{Particle\ density} \times 100 \right)$$

(d) Mass wetness (%)

$$\frac{Wet\ weight - Oven\ dry\ weight}{Oven\ dry\ weight} \times 100$$

(e) Void ratio

$$\frac{\textit{Volume of solids and pores} - \dfrac{\textit{Oven dry weight}}{\textit{Particle density}}}{\dfrac{\textit{Oven dry weight}}{\textit{Particle density}}}$$

2.3.2 Soil pH **:** Using the procedure as described in Thien and Graveel (2003), 10g each of the soil samples from each section of the mini - plot were poured into 6 Petri dishes and 10ml of distilled water added to each. The mixtures were then stirred continuously for 10 minutes and left to stand for a further 30 minutes without agitation to allow the salts in the soil to dissolve in the distilled water after which the pH was measured using the Eutech pH meter which measures pH by the electrometric method.

2.3.3 Treatment with the topsoil extract

Starting with the mini - plot labelled A, fifty (50) tomato seeds were sown on each of the three sections after which 5 kg of the topsoil extract was spread fully, by broadcasting, on each section. The procedure was repeated for the remaining mini - plots B - D using respectively 5.5kg, 6 kg and 6.5 kg of the topsoil extract. Fifty (50) seeds were also sown on each of the sections of mini - plot E to serve as the control. The setup was then irrigated twice daily with water until the tomatoes fully germinated within 9 days.

2.4 Measurements and data analysis

The number of seedlings on each section of each mini - plot was counted and recorded. Additionally, both the tall and short lengths of each seedling were also measured and recorded. All data collected were subjected to GenStat version 11.1 analysis of variance (ANOVA) to compare mean values between treatment conditions at 5% significance level.

2.5 Results

2.5.1 Physico - chemical analysis of soil from experimental site

The results in Table 1 show the physico - chemical analysis of the soil samples from the mini - plots used for the field experiment. The mean values of each property for each portion of soil sampled were generally within the range acceptable for the support of plant germination and growth.

Table 1: Physico - chemical analysis of soil used for the field experiment

Mini - plot	Mean Bulk density (g/cm^3)	Mean Porosity (%)	Mean Solid space (%)	Mean Mass wetness (%)	Mean Void ratio	Mean pH
A	1.10	61	39	17	1.58	5.60
B	1.00	61	39	16	1.55	5.58
C	1.00	61	38	18	1.60	5.60
D	1.10	60	40	16	1.54	5.60
E	1.10	60	40	17	1.50	5.60

2.5.2 Effect of variation of masses of topsoil extract on germination

Generally, the addition of the extracts of topsoil from the teak plantation affected the germination rate of the tomato seeds and this, from the results, largely depended on the mass of topsoil used for the treatment. There was a significant difference between mean number of seeds germinated for each treatment and the control (Table 2). When 5kg of topsoil was used, 35.34% of a total of 50 seeds germinated while only 4% germinated when 6.5kg was used. The control obtained 99.34% germination. Therefore as the mass of the topsoil increased, the percentage rate of germination of the tomato seeds decreased (Fig.1) and therefore the allelopathic effect was strongest at the heaviest mass.

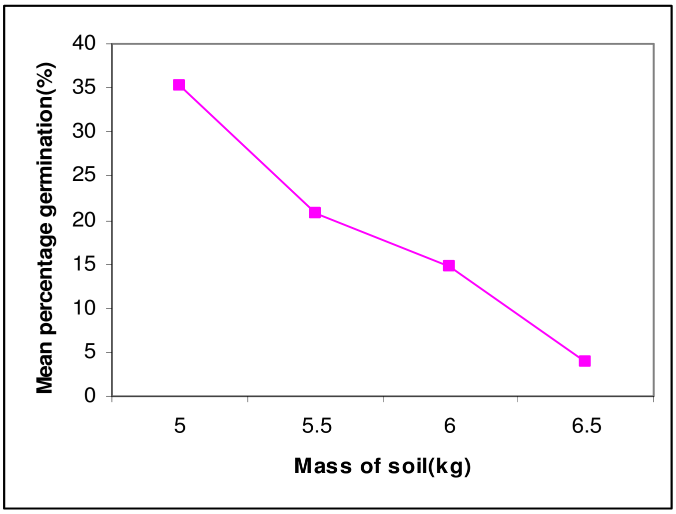

Fig. 1: Variation of mean percentage germination with mass of topsoil extract

Table 2: Mean number of tomato seeds germinated and the germination percentage for various of treatments of topsoil extracts from teak plantation

Treatments	Mean number of germinated seeds per section	Mean percentage germination per section
T_1 = 5kg of soil	17.67^a	35.34
T_2 = 5.5kg of soil	10.33^b	20.66
T_3 = 6.0kg of soil	7.33^c	14.66
T_4 = 6.5kg of soil	2.00^d	4.00
Control	49.67^e	99.34
	LSD = 1.375	

Means within column having the same letter are not significantly different at 5% significance level

2.5.3 Effect of variation of masses of topsoil extract on growth of tomato seedlings

The topsoil extracts also affected the tall lengths and short lengths of the seedlings as shown in Table 3. The mean tall lengths were significantly different from each other and also decreased as the mass of topsoil extract increased. The mean tall length of seedlings using 5kg of topsoil was 5.80cm while 2.70 was recorded for 6.5kg. There was however no significant difference between the mean tall lengths of the lightest topsoil extract and the control. In the case of the short lengths of the seedlings, the effect of the topsoil extract gained significant prominence when the masses got heavier as compared with the control. The lower masses did not show any significant difference of the effect of the topsoil extracts.

Table 3: The mean tall and short lengths of germinated tomato seedlings for various treatments of topsoil extracts from teak plantation

Treatments	Mean tall length of germinated seedling per section(cm)	Mean short length of germinated seedling per section(cm)
T_1 = 5kg of soil	5.80^{a}	1.95^{ac}
T_2 = 5.5kg of soil	5.10^{b}	1.87^{a}
T_3 = 6.0kg of soil	4.47^{c}	1.17^{b}
T_4 = 6.5kg of soil	2.70^{d}	1.68^{a}
Control	6.00^{a}	2.40^{c}
	LSD = 0.345	LSD = 0.479

Means within column having the same letter(s) are not significantly different at 5% significance level

2.6 Discussion

The results have shown that the use of extracts of topsoil from teak plantation has similar effects which the leaf, bark and root extracts have on some crops. The analysis of the physical properties indicated that the soil used for the field experiment was loose or less compacted and therefore porous with sufficient water content to support plant growth. The pH values obtained also showed that the level of acidity of the soil was insufficient to affect the ionization state of the allelochemical and in turn, its mobility. Therefore the marked significant differences in the germination rates of the tomato seeds between the treatment conditions and the control were as a result of the effect of the extracts of the topsoil from the teak plantation. The effect increased with the mass of topsoil extract used as only 4% of the seeds germinated when the largest mass of 6.5kg was used. This is consistent with Evangeline *et* al., (2012) who reported that soil from the root zone of teak had suppressive effects on germination of *Zea mays* L. Similarly, the aqueous leaf extract of teak adversely reduced the germination percentage of green gram and chilli (Leela & Arumugam, 2014). The effect also extended to the growth of the seedlings in respect of their tall and short lengths. There was a significantly progressive decrease in the mean tall lengths of the seedlings with mass of topsoil as the 6.5kg produced the shortest in that category. This also indicated a growth inhibition. When susceptible plants are exposed to allelochemicals, germination, growth and development may be affected (Xuan et al., 2004). Lalmuanpuii & Sahoo (2011) noted that under high concentration of *T. grandis* extract, the growth of shoot of *Z. mays* was drastically decreased. However, the effect was not very much pronounced in the comparison of the mean values of the short lengths of the seedlings.

2.7 Conclusion

This study has demonstrated the allelopathic effects present in transferred topsoil extracts of *T. grandis* on *lycopersicum esculentum* seed germination and seedling growth. The allelopathic effect increased with increasing mass of topsoil extract used.

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