EFFECT OF *TECTONA GRANDIS* LEAF EXTRACT, MULCH AND WOODLOT SOIL ON GERMINATION AND GROWTH OF MAIZE

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DECLARATION

I declare that except references to other people's research which have been duly cited, this thesis submitted to school of Postgraduate Studies, Kwarne Nkrumah University of Science and Technology, Kumasi for the degree of Master of Science in Agroforestry is my own investigation.

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ABSTRACT

The Allelopathic effects of *Tectona grandis* leaves were tested on maize seedlings in the laboratory, on field soil mulched with *Tectona* prunings and on top soil, sub-soil from garden soil and *Tectona* woodlot. The laboratory experiment was conducted in sterilized Petri dishes. The effects of the different concentrations of aqueous extracts 25%, 50%, 75%, and 100% were compared to distill water (control). The aqueous extracts caused significant inhibitory effects on germination, shoot and root elongation, root and shoot dry weight upon increasing the concentration of the extracts of 10 day old maize seedling. Bioassay indicated that the inhibitory effect was proportional to the concentration of the extracts and higher concentrations 75%-100% had the stronger inhibitory effect whereas, in some cases the lower concentration 25%-50% showed stimulatory effect. The study also revealed that inhibitory effect was much pronounced in root rather than shoot growth. The field studies tested *Tectona grandis* mulch on weed control. The results indicated that different rates of *Tectona* mulch rate had significant effects on weeds. In the field, the height, diameter, shoot dry weight, root dry weight and yield of maize not significantly ($P \geq 0.05$) affected because the addition of mulch had a beneficial effect by providing nutrients during decomposition. Comparison of soils under *Tectona* woodlot and garden soil indicated that there is no significant ($P \geq 0.05$) between the means. All the parameters studied, that is height, diameter,

shoot and root dry weight were similar. Finally, it was hypothesed that, there is no allelopathic effect of soils under Tectona grandis woodlot on maize growth. Generally, within 0.15cm soil depth, shoot dry weight, root dry weight, height and diameter showed no significant (P≥0.05) differences between mean. Therefore, the hypothesis was accepted since, the means were similar. Also, within 15 – 30cm soil depth, shoot dry weight, root dry weight, height and diameter showed no significant (P≥0.05) differences between mean. Therefore, the hypothesis was accepted because, the means were similar and allelochemicals in soils are rapidly lost near soil surface and soil organisms are capable of detoxifying allelochemicals in soil. Based on the overall finds of this research, these conclusions were drawn. Firstly, allelopathy is a concentration – dependent phenomenon. The allelochemicals present in Tectona grandis can have an allelopathic inhibitory effect on different crops associated with Tectona plantation and also different agroforestry systems in field conditions. Secondly, addition of Tectona grandis mulch in the field had a beneficial effect on maize since; the allelochemicals in the mulch are transient. It is known that Tectona grandis mulch have the ability to control weeds. Finally soil under Tectona grandis woodlot has no effect on crops.

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1.0 CHAPTER ONE

1.1 INTRODUCTION AND BACKGROUND

Agroforestry intentionally combines woody perennial with agricultural crops or pasture plants in a variety of spatial or temporal arrangements. Thus the choice of species combinations can dramatically influence the productivity and ultimate success of agroforestry systems. The challenge in plant interaction is identifying the various factors that influence the productivity of plant associations as in agroforestry systems. Allelochemicals originating from foliage leachings, root products, or mulches of crops or woody plants can result in reduced growth or death of companion plants. For example, black walnut *(Juglans nigra)* is widely known for its allelopathic root exudation on field crops and conifers (Rietveld, 1982).

Literature reveals that some tree crops release some phytotoxins into the soil, which adversely affect the germination and yield of crops (Bhatt and Todaria, 1990). There are two types of allelopathy; true and functional allelopathy. True allelopathy is the release into the environment of compounds that are toxic in the form they are produced by the plant. Functional allelopathy is the release into the environment of substances that become toxic as a result of transformation by microorganisms (Aldrich, 1984). Therefore, allelopathy is defined as the release by trees of substances that inhibits the germination or growth of associated crops (Akobundu, 1987). This type of tree-crop interactions was named phytochemical ecology by Harborne (1977).

Chemicals that originate from plants or microorganism impact many organisms in the ecosystem, but the term allelopathy has most often referred to the activity of these chemicals on other plants or microorganisms (Enhellig, 2002). Many of the phototoxic substances suspected of causing germination and growth inhibition have been identified from plant tissues and soil. A wide array of these compounds is released into the environment in appropriate quantities through root exudates and as leachates during litter decomposition. Most of these are phenolic compounds and are implicated in allelopathy, a process which includes the direct or indirect detrimental effect of one plant on the germination, growth and development of another plant (Zaprometov, 1992).

Plants produce a large variety of secondary metabolites like phenols, tannins, terpenoids, alkaloids, polyacetylenes, fatty acids and steroids, which have an allelopathic effect on the growth and development of the some plant or neighbouring plants. Considerable knowledge has been obtained concerning the chemicals involved in allelopathy (Rice, 1984; Narwal and Tauro, 1994). Several researches have documented the existence of allelochemicals in higher plants and microorganisms (Salisbury and Ross, 1992; Grayer and Horborn, 1994; Rauha et al., 2000). These chemicals are produced in above or below ground plant parts or in both to cause allelopathic effects in a wide range of plant communities. For example, the bark, leaf and leaf litter extracts of *Quercus glauca* and *Q. leucotrichophora* significantly suppressed both the germination, plumule and radicle length and of chlorophyll content of wheat, mustard and lentil (Bhatt et al., 1994).

In general, leaves are the most potent source of allelochemicals. However the toxic metabolites are also distributed in other plant parts in various concentrations. Several allelopathic studies have attempted to test either plant extracts or isolated chemicals on plant growth. For example, phytotoxic effects of *Gliricidia sepium* were tested on maize seedlings in the laboratory and on maize and cowpea seedlings in the field. In the laboratory test, growth of maize seedlings was significantly depressed by addition of leachate of Gliricidia. In the field experiment leaf chlorosis of maize and cowpea occurred with application of Gliricidia pruning mulch but did not reduce yield (Tian and Kang, 1994).

In natural ecosystems allelopathy may help explain some important phenomena such as: the dominance of a single species or group of species over others, successional change and species replacement or the maintenance of a defected stage in the successional process, and reduced ecosystem productivity. One of the most worked out aspects of alle1opathy in manipulated ecosystems is its role in agriculture. In this, the effects of weeds on crops, crop on weeds and crops on crops have been invariably emphasized. In addition, the possibility of allelochemicals as bio-regulators and natural pesticides promoted sustainable agriculture (Pellissier and Souto, 1999). However, allelopathy has received focused attention due to the growing desire to replace synthetic chemical inputs to agroecosystem with naturally produced material. This has spurred a burst in applied research on allelopathy (Gliessman, 1998).

PROBLEM STATEMENT AND JUSTIFICATION

Agroforestry is a relatively new field. Little work has been conducted on species compatibility with crops (Wood, 1988). Some species currently used in agroforestry systems reportedly have allelopathic properties (Watanabe et al., 1988). For example, allelopathic interference from Eucalyptus foliage leaching and volatiles and plant residues (Suresh and Rai, 1987) has been described. Also, residue mulches of *Leucaenca leucocephala* reportedly have allelopathic properties. Reddy, (1984) studied the inhibitory effect of *Eucalyptus*, Bamboo and Teak on germination and seedling growth of certain food crops.

King (1979) pointed out the need for allelopathic research of various tree species used in agroforestry as there is a good chance of allelochemicals produced by the intercrop trees affecting food and fodder crops. In Ghana there are speculations that *Tectona grandis* has allelopathic effects on agricultural crops and ground vegetation. These exudates can be detrimental to other plants and play an appreciable role in the distribution of vegetation, the yield of various crops and weed growth (Putnum and Duke, 1978; Rice, 1984).
Therefore this research attempts to scientifically investigate these speculations.

OBJECTIVES AND HYPOTHESIS

The broad objective of this study was to evaluate the allelopathic effects of teak on maize growth. The specific objectives of this study were:

- Aqueous extracts from teak leaves on germination, weed growth, shoot length, root length and dry weight of shoot and root maize.
- Teak leaf mulch on weed biomass, height, diameter and yield of maize
- Soils from teak woodlot on germination, height, and diameter of maize.

The study hypothesized that,

- Aqueous extracts of teak leaf have no allelopathic effect on germination of maize seedlings.
- Teak mulch has no allelopathic effect on the growth maize seedlings.
- Soils from teak woodlot have no allelopathic effect on the growth of maize.

The research hypotheses were tested in three experiments and are reported in this thesis as follows:

Chapter 3: Effects of aqueous extract of teak leaf on germination and growth of maize.

Chapter 4: Effects of teak leaf mulch on germination and growth of maize.

Chapter 5: Effects of soil from teak woodlot on germination, and growth of maize.

Chapter 6: General conclusion and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews literature on allelopathy and covers *Tectona grandis, Zea mays*, definition and types of allelopathy, sources of allelochemicals and includes methods of toxins release, and experimental evidence on allelopathy.

2.2 DESCRIPTION OF TECTONA GRANDIS

Tectona grandis belongs to the family Verbenaceae and its common name is called teak, which originated from Southeast Asia. The natural range is wet tropical low and forest of Burma, India, Thailand, and on the Indonesian islands and grows in a variety of soils but deep soils with good drainage are necessary for satisfactory growth. Its climatic range is moist and wet tropical and has a large deciduous tree over 30m in high, in a good growing condition. The bole is often buttressed and may be fluted to a considerable height up to 15cm long below the first branches, and up to 1m in diameter at breast height. The crown opens with many small braches and the back is brown on the bole distinctly fibrous and with shallow longitudinal fissures. (Mbuya et al.,1994).

The leaves are four-sided branchlets, bear the very large leaves which are shield for three to four months during the latter half of the dry season. The leaves are shiny above and hairy below with vein network clear about 30 x 20cm but young leaves up to 1m long. The flowers are small about 8mm across with manve-white and are arranged in large flowering heads of about 45cm long. Teaks also have a medicinal value. The bark is bitter tonic and is considered useful in treating fever and also useful in treating headache and stomach problems. It is useful in furniture making, boat, decks and for indoor flooring and is widely used to make doors and house windows. It is resistant to the attack of termites and its wood contains scented oil which is the repellent to insects. The leaves yield the dye which is used to colour clothes. Teak is probably the best protected commercial species in the world (Mbuya et al., 1994).

2.3 DESCRIPTION OF ZEA MAYS

Zea mays Linnaeus, known as maize throughout most of the world, and as corn in the United States, is a large, annual, monoecious grass, that is grown for animal feed, silage, human grain vegetable oil, sugar syrups and other miscellaneous uses. It is the premier cash crop in the United States and its cultivation, genetics, processing, financing and distribution on a national and international scale is pervasive and complex. Corn has been cultivated since the earliest historic times from Peru to Central North America. The region of origin is now presumed to be Mexico (Gould, 1968).

Dispersal to the old world is generally deemed to have occurred in the sixteenth and seventeenth centuries (Cobley and Steele, 1976). However, recent evidence indicates that dispersal to India may have occurred prior to the twelfth and thirteenth centuries by unknown means (Johannessen and Parker, 1989). A *Zea mays* is a genus of the family Gramineae commonly known as the grass family. Maize is a tall, robust, monoecious annual with overlapping sheaths and broad, conspicuously distichously blades, staminate spikelet these numerous spikelet forming large spreading terminal called tassels.

2.4 DEFINITION AND TYPES OF ALLELOPATHY

Allelopathy is described as the beneficial and deleterious biochemical interaction between plants and micro-organisms. Rice, (1974) defines allelopathy as any direct or indirect effect by one plant, including micro-organisms, on another through the production of chemical compounds that escape into the environment and subsequently influence the growth and development of neighboring plants. It includes both inhibitory and stimulative reciprocal biochemical interactions.

2.5 SOURCES OF ALLELOCHEMICALS

Allelopathic compounds are natural products that may be direct metabolites, by products of other metabolic pathways or breakdown products of compounds or biomass. The compounds are often toxic to the plants that produce them if they are not stored in some non toxic from or released before they build up internally to toxic levels. In some cases, even when the toxins are released from the plant, they many build up in the immediate environment and become toxic to the plant that produced them. Allelopathic compounds take many forms, from water soluble to volatile simple to complex and persistent to very short-lived. The most common allelopathic compounds fall into such chemical groups as tannis, phenolic acids, terpenes and alkaloids (Gliessman, 1998).

Allelopathic products are released from the plants in a variety of ways they can be washed off the green leaves, leached out of the dry leaves, volatilized from leaves, exuded from roots, or released from shed plant material during decomposition. Flowers, fruits and seeds can be sources of allelopathic toxins. There are also cases in which products do not become toxic until they have been altered once they are in the environment either by normal chemical degradation or by conversion to toxic compound by micro-organisms (Gliessman, 1998).

2.6 EXPERIMENTAL EVIDENCE OF ALLELOPATHY

2.6.1 Allelopathic evidence on walnut

The first direct evidence of the reasons underlying the fatal consequences of the walnut toxin on herbs was obtained by Massey, (1927) who planted tomato and alfalfa plant in a region up to 27m from the trunk of a walnut true and found that may plants died as a result. The position at which the tomato plants remained unaffected by the allelopathy coincided with the extent of root growth of the tree and Massey assumed at that time that the plants were killed by the exudation of toxin from the roots.

Bode, (1958) indicated that this simple view of root exudation might be incorrect and that the toxic effects were actually due to leaching from the walnut leaves, stems and branches of a bound toxin, which under went hydrolysis and oxidation in the soil with the release of the true toxin which then killed may annual species growing in the vicinity. The area of toxicity was therefore determined by the canopy of the tree and the ability of the leachate to saturate the surrounding soil.

2.6.2 Allelopathic evidence of weeds

The results of the effects of aqueous extracts of leaf, stem, and root of *Chromolaena odorata* on the root growth of *Vigna unguiculata*. The soaking of seeds in *Chromolaena* extracts for 48 hours seems to have given marked inhibition of root growth. The same trend was observed for treatment of seeds with stem extract. However, there was no significant differences between the effects of leaf, stem and root extracts on the mixed and white seed varieties kept under continuous light. Leaf extracts saturated for 48hours inhibited the height of the white more than mixed variety of *Vigna. unguiculata*. In general, the root growth of white and mixed varieties was more affected by leaf, stem and root extracts. Leaf growth under continuous light was inhibited with seeds treated for 36 hours (Eze and Gill, 1992).

Also *Chromolaena odorata* is a trouble some weed of arable fields and plantations (Eze and Gill, 1992). The leaves of *Chromolaena odorata* contain a large amount of allelochemicals

(Ambika and Jayachandra, 1980), which may retard the growth of crop plants. Tijani-Eniola and Fawusi (1989) have reported on the allelopathic activities of crude methanol extract of *Chromolaena odorata,* on seed germination and seedling growth of the tomato. Pandya (1975) recorded similar results on the effect of *Celosia argentia* extract on root and shoot growth of sorghum *vulgare* seedling. Similar results on the effect of *Cyperus rotundus* leaf extracts on seedling growth of both shoots and roots of *wheat* were found.

Seed germination was generally less affected by *Siam* weed extract than was weed seed germination. In the laboratory, maize seed germination was not hindered by *Siam* weed extract. On cowpea and soybean, 14 and 8 percent reduction in seed germination, respectively was recorded when compared with the untreated control. Although, weed seed germination in laboratory was generally low, percent reduction in germination in *Siam* weed treated with the extract was 87%, when compared with the untreated control. Germination of *Tridax* was poor and therefore the effect of the treatment could not be ascertained. The same trend of germination was maintained in the greenhouse except that the weed seed germinated better than in the laboratory. (Adetayo et al., 2000).

Allelopathic chemicals released by weeds can directly influence crop seed germination and emergence, crop growth and development, and the health of associated crop symbionts in the soil. An example is bitter grass *(Paspalum conjugatum),* an aggressive weed in annual cropping systems in Mexico. As the dominance of the grass increases, the stunting of the corn becomes more noticeable, reaching a point where the corn is not even able to establish when the grass is densest. Water extracts made from the dry grass that has not yet been leached by rains showed the ability to affect both germination and early growth of corn seed (Gliessman, 1989).

For germination, as compared to the control (0%), the aqueous extract of Parthenium from leaf and flower parts at 5% and 10% concentration levels exhibited significant inhibition on seed germination. Complete failure of seed germination was recorded as a result of application of 10% aqueous extract from leaf. Aqueous extracts from stem and root had shown no adverse effect on seed germination. Leaf and flower extracts at lowest (1%) concentration had little impact on seed germination. There were significant differences between treatments in influencing seedlings shoot and root length. (Tefera, 2002).

As compared to control, except aqueous extracts from leaves which had a deleterious effect on shoot length, those extracts from stem, flower and root seemed to have a stimulatory effect on shoot length. Stem extract in low concentration (1%) greatly promoted shoot length. Similarly, stem and root extracts at 5 and 10% and flower at 1 and 5% showed a stimulatory effect on shoot length. Aqueous extracts from root at 1% promoted root growth as compared to control. However, as root extract concentration level increased from 5 to 10%. In contrast, extracts from leaf and flower parts exhibited higher root growth inhibition even at low concentration levels (Tefera, 2002).

The different aqueous extracts of *Parthenium* and lantana produced negative and positive allelopathic effects on germination and seedling vigor of rice seeds. At 5 days of sowing, the aqueous extracts of *Parthenium* leaves (5%) produced a significantly higher germination than the rest of the treatment combination except *Parthenium* leaves (10%) and *Parthenium* flower (10%). At 11 days of sowing, the highest germination was noted in the control and *Parthenium* leaves (5%), and the lowest in *Parthenium* leaves (6.7%) resulted in maximum and minimum shoot length, respectively. *Parthenium* leaves (5%) had a shoot length comparable with that of *Parthenium* leaves (20%). *Parthenium* leaves (20%) and *Parthenium* flower (10%) produced the highest and lowest dry root Weight, respectively, whereas *Parthenium* leaves (5%) and *Parthenium* leaves (10%) showed the highest and lowest dry shoot weight, respectively. (Tefera, 2002).

The negative (stimulatory) allelopathic effects of different aqueous extracts of *Parthenium* leaves on field crops have been reported (Oudhia and Tripathi, 1998). Many allelochemicals for example parthenin, P-coumric acid, caffeic acid, coronopllin, and sesquiterpene lactones from the aqueous extracts of *Parthenium* leaves responsible for positive (inhibitory) allelopathic effects have also been reported (Narwal, 1994). In this experiment, the effects of these allelochemicals were significant up to 6.7% concentration. At lower concentration (that is 5%), the phytotoxic effects of these allelochemicals were not observed.

Unamma (1981) demonstrated that exudates of tropical weeds inhibited the growth of yam in a manner similar to yield reductions observed when yams were grown in full competition with weeds. This inhibition occurred when environmental conditions of light, moisture and nutrients were not limiting.

2.6.3 Allelopathic evidence of *Brassica nigra*

Members of *Brassica species* have frequently been cited as allelopathic crops (Bell and Muller, 1973). Some *Brassica species* have harmful effects on crops including reduced seed germination and emergence of subsequent small - grain crops when grown in rotation (Bialy et al., 1990). *Brassica nigra* residues inhibited establishment of grass species and sorghum (Brown et al., 1991).

Also, extracts from fresh black mustard *(Brassica nigra)* plant leaves, flowers, roots and mixture solutions showed inhibitory effects on seed germination. The degree of inhibition increased with the extract concentration (Munir and Tawaha, 2002). Chang and Miller (1995) support these findings. They found that degree of inhibition increased with increased extract concentration. Leaf extract was the most inhibitory at all concentration, while the extract of root was the least inhibitory. The results found in this study are inconsistent with Ballester et al., (1979) who reported that the inhibitory effects of allelopathic plants was produced by flower extracts.

Also, radicle length was relatively more sensitive to allelochemicals than was in hypocotyl (Munir and Tawaha, 2002). Earlier studies showed that water extracts of allelopathic plants had more pronounced effect on radicle growth than on hypocotyl growth (Kimber, 1973). Besides inhibiting radicle elongation, other morphological abnormalities occurred as many of the extracts caused twisted radicle growth. The most severely twisted roots were observed in seedlings treated with leaf and flower extracts. Based on significant radicle length reaction to aqueous extracts, the toxicity may be classified in the following order of decreasing inhibition: leaf, flower, and mixtures of all plant parts, root and stem (Munir and Tawaha, 2002).

2.6.4 Allelopathic evidence of *Gliricidia* species

In agroforestry systems prunings are frequently added as mulch or green manure to improve crop production. In recent years there has been increasing interest in incorporating *Gliricidia* in agroforestry system (Withington et al., 1987). Akobundu (1986) reported that under laboratory conditions the leachate of *Gliricidia* leaves inhibited maize and rice germination. Some degree of leaf chlorosis on maize has been observed in the field when mulching with *Gliricidia* prunings (Tian, 1992). Obando, 1987 reported no allelopathic effect of *Gliricidia* prunings on maize and beans.

However, the phytotoxic effect due to addition of *Gliricidia* pruning was not harmful for maize and cowpea under field condition as the phytotoxic compound can be degraded faster in the field than in the laboratory (Tian, 1992). Addition of the pruning even had a beneficial effect by providing nutrients during decomposition (Tian, 1992), and resulted in a significant increase in maize and in cowpea biomass yield.

However, in the laboratory test the highest maize radicle and shoot fresh weights were observed it the treatment with distilled water. With increasing leachate concentration, fresh weights of both radicle and shoot declined. Addition of leachates reduced the total growth of maize seedling by 37%, 57% and 82% at level 1, 2, and 3 respectively. However, leaf chlorosis of maize and cowpea occurred with application of *Gliricidia* prunings mulch in the field. Increasing mulch rate increased the percentage of chlorotic leaves.

Leaf chlorosis of maize plants was evident in plots that received 0.5 t/ha of dry *Gliricidia* prunings or more. Chlorosis of cowpea occurred at a rate of 2.0 t/ha of prunings. Addition of dry *Gliricidia* prunings resulted in about 90% of leaves of maize plants showing chlorosis that persisted for 2-3 weeks. Addition of *Gliricidia* prunings had however no significant effect on maize biomass yields at 23 days after planting. A significant increase in maize biomass yield with increasing levels of *Gliricidia* prunings was observed at 31 days after planting. (Tian and Kang, 1994).

Furthermore, application of *Gliricidia* pruning at various times before planting markedly reduced incidence of maize leaf chlorosis. Mulching at the time of planting resulted in up to 48%chlorotic leaves, whereas application of mulch a week before planting reduced leaf chlorosis considerably. Maize biomass at 10 days after planting was increased with increasing time interval between mulching of *Gliricidia* and planting of maize. However, only application of *Gliricidia* pruning at one or two weeks before planting resulted in significantly higher maize biomass yields, compared to control at 20 days after planting (Tian and Kang, 1994).

2.6.5 Allelopathic evidence of *Eucalyptus* species

Mousawi and Al Naibi (1975) reported inhibition of seed germination and seedling growth of some herbaceous plants by leaf of *Eucalyptus.* The shoot and root dry weights revealed that the growth of the crops was significantly suppressed by the aqueous extracts of the tree leaves, but with varying degrees of susceptibility. Shoot biomasses were suppressed by all extracts starting from 1 % which was also the case for the root biomasses (Lisanework, and Michelsen, 1993).

The aqueous extracts of leaves of the test tree species, Cupressus *Jusitanica,* Eucalyptus *globules.* Eucalyptus *camaldulensis,* and Eucalyptus *saligna,* significantly reduced both germination and radicle elongation of the majority of the crops mostly starting from concentrations of 1% or 2.5%. Chickpea was affected most strongly, with reduction of germination and radicle elongation by all 1% extracts. Teff germination was inhibited at 5%, where as radicle elongation was affected at 1%. Pea germination was suppressed at 10%, 2.5%, 2.5% and 2.5%, and radicle elongation at 5% for Cupressus *Jusitanica,* Eucalyptus *globules* Eucalyptus *camaldulensis,* and Eucalyptus *saligna* extracts, respectively. Seeds of maize showed no reduction in germination except with the 10%

extracts of Eucalyptus *camaldulensis* and Eucalyptus *saligna* leaves, where as reduction of radicle elongation was seen at extract concentrations of2.5% or 1% for Eucalyptus *camaldulensis* (Lisanework and Michelsen, 1993).

The shoot and root dry weights revealed that the growth of the crop was significantly suppressed by the aqueous extracts of the tree leaves, but with varying degrees of susceptibility. The shoot biomasses were suppressed by all extracts starting from %, which was also the case for the root biomasses in all but a few cases. Among the tested crops teff was the most susceptible. Also, the shoot growth of this crop was further reduced when extract concentration increased. Generally, there was only a slight difference between extract with respect to their effect on shoot and root biomass, although Cupressus. *lusitanica* extracts were less inhibitory than others to pea shoot growth, and 1 % Eucalytus globules extracts did not suppress chicken pea and teff root growth, the leaf extracts of the four tree species can be arranged according to increasing allelopathic potential Cupressus *lusitanica,* Eucalyptus *globules,* Eucalyptus *saligna* and Eucalyptus *camaldulensis* (Lisanework and Michelsen, 1993).

2.6.7 Allelopathic evidence of *Acacia leucopholea*

In the bioassay, leaf aqueous extracts of Acacia *leucoplolea* on bioassay study of Arachis *hypogaea* and Sorghum *vulgare* showed a gradual reduction in all parameters. The seed germination, plumule and radicle length was inhibited in all concentrations. The decrease was concentration dependent. At the highest concentration studied, a maximum of 37% and 44% of reduction in seed germination was observed in leaf extracts on Arachis *hypogaea* and Sorghum *vulgare* respectively. Similar trend was followed in plumule and radicle length. In Arachis *hypogaea* a maximum of 50% and 28% reduction was recorded in plumule and radicle length respectively. But in Sorghum *vulgare* the inhibition in plumule and radicle length brought about by the 20% leaf extract was 37% and 23% respectively (Jayakumar and Manikandan, 1990).

The results of our study showed that the leaf extracts of Acacia *leucopholea* was inhibitory in both Arachis *hypogen* and in Sorghum *vulgare*. Similar results have been reported by Heisey, (1990). He observed that the leaflets of among the various plants parts of *Ailanthus altissima* showed the highest inhibitory effect on seed germination of several weeds and crops. Results similar to our study have been cited by Peters and Zam (1981), who reported significant decreases in germination of red clover seed in leaf extracts of tall fescue plants. The leaf extracts of Acacia *leucopholea* affected the plumular length of the crop plants more than the radicle length. Inhibition of seedling growth by the extracts of many plants has been reported in a few crops and weed species by *Acacia tortilis* in pearl millet, cluster bean and in sesame (Sundramoorthy and Katra, 1991). Allelochemical activity of plant is measured by the sensitivity of radicles in the bioassay (Heisey, 1990).
Hence A. hypogaea crops are very sensitivity than the other crop.

Also, in the pot experiment the leaf aqueous extracts of Acacia *leucopholea* showed inhibitory effect on all growth parameters in Arachis *hypogaea* and Sorghum *vulgare* plants. Decrease in shoot length, root length, leaf area, yield and root nodule was concentration dependent. A maximum of 72% and 45% reduction in shoot length was observed in *Arachis* and sorghum plants respectively at 20% leaf extract concentration. The reduction in the root length was 43% in both the plants at the highest concentrations.
The leaf area was much affected in the *Arachis* plants (50%) than the sorghum plants (37%). The reduction in root nodule number was 56% at 20% leaf extracts of Acacia. The leaf extracts of Acacia *leucopholea* drastically reduced the yield in Sorghum *vulgare* plants (86%) than the Arachis *hypogaea* (80%) (Jayakumar and Manikandan, 1990).

In the pot experiment, the aqueous extracts decreased the growth of the crop plants considerably only at higher concentration. Similar inhibition of shoot length and root length of crop plants by allelopathic extracts have been reported in Oryza sativa, Zea mays by rhizophora apiculata (Rajangam, 1984), in groundnut and corn by eucalyptus (Jayakumar et al., 1990). Reduction in leaf area of the crop plants by aqueous leaf extracts have been reported in few crop species by bamboo in groundnut (Eyini et al., 1989), by eucalyptus globules in groundnut and maize (Jayakumar et al., 1990), by *acacia holosericea* in cowpea, sesame, horse gram (Palani et al., 1998). Sundraoorthy and Katra (1991), reported a reduction in yield of pearl millet, sesame and cluster bean by the aqueous leaf extracts of *Acacia tortilis*. Palani and Dasthagir (1998) observe a significant yield reduction in cowpea, sesame, horse gram and sorghum by aqueous leaf extracts of *Acacia holosericea*.

However, in the post - emergence studies, treatment of A. *leucopholea* leaf aqueous extracts on ground nut and sorghum shoot length root length, and biomass was decreased in all concentrations. No mortality was observed in both the plants in any of the concentrations. In ground nut, at 20% concentration a maximum of 10% reduction in shoot length, 6% reduction in root length, 7% reduction in biomass was observed. But in the case of sorghum the reduction in shoot length root length and biomass was 25%, 11 % and 29% respectively. Inhibition of seed germination, reduction in shoot, root length, leaf area and yield of seedlings of crops species tested showed a linear relationship with increasing concentration of aqueous leaf extracts of Acacia *leucopholea* (Jayakumar and Manikandan, 1990).

2.6.8 Allelopathic evidence of Poplar species

Aqueous leaf extracts of poplar leaves significantly influenced the germination of wheat varieties. Mean germination values of wheat varieties showed that variety UP-2338 recorded the highest and WH-283 the lowest germination under the influence of aqueous extracts. Wheat variety WH-896 recorded the maximum shoot and a root length; however, its root length was at par with wheat varieties WH-533, WH-147 and HD-2329. Germination of wheat varieties decreased significantly at higher concentrations of 10 and 20% over control. Similarly, shoot and root length of wheat varieties was stimulated at lower extract concentration of 5%.

At higher concentration aqueous extracts had no effect on shoot length but significantly retarded the root length of wheat varieties (Nandal et, al., 1999). Melkania, (1984), has also reported an inhibitory effect of P. *deltoides* leaf, soil leachates and rain drip on the seed germination and radicle growth in wheat. The allepolathic potential of poplar leaf litter has been reported due to the presence of catechol and beizoic acid inhibitors in its leaves (Olsen et al., 1971). Allelochemicals may stimulate or inhibit the plant growth depending upon their concentration (Osvald, 1950).

Field studies revealed that mean grain yield of wheat variety WH-896 was significantly higher than all other varieties of wheat. Second best variety, WH-542 also yielded significantly higher grain yield than other varieties of wheat. Wheat variety WH-283 produced minimum grain yield among all the varieties. Mean grain yield of wheat was significantly less under all the spacing of poplar as compared to control wheat. The reduction under poplar might be attributed to competition of poplar with wheat for various growth resources especially sunlight during the early stages of growth. There was 56, 41 and 35 per cent reduction in sunlight under 5 x 4 m, 10 x 2.5 m and 15 x 2.5 m poplar spacing, respectively. Singh *et al.* (2004) have also reported strong relationship between wheat yields in *Ceiba pentandra* based agroforestry system. Grain yield also increased significantly with increasing spacing of poplar due to reduced competition for growth resources.

2.6.9 Allelopathic evidence of Adina cordifolia

Reduction of pigment contents was severe due to Adina *cordifolia,* and mild in Alnus *nepalensis* and Prunus *cerasoides.* The pigment contents were not affected in the presence of Celtis *anstralis* (Bhatt and Todoria, 1990). Kohli et al., (1987) also reported the reduction in the chlorophyll content in *lantana camara* due to the allelopathic effect of Eucalyptus globules. Leaf extracts from Eucalyptus species and C. *insitanica* inhibited the germination, radide elongation and growth of maize, and pea (Lisanework and Michelsen, 1993).

Yield in the control was higher as compared to treatment there by indicating the adverse effect of tree crop components on test crops. All the characteristics of test crop that is shoot length, dry matter production and pigment contents were suppressed except for *Celits australis.* Maximum inhibition of germination and seedlings growth was recorded with *Adina cordifolia.* The effects were less in *Alnus nepalensis* and *Prunus cerasoides.* Inhibition was highest under mulch with dry leaves and aqueous leaf extracts while obstruction in germination of test crops by rhizosphere soil and top soil was less in the same order (Bhatt and Todaria, 1990).

Germination of *Hordeum vulgare* and *Glycine max* was severely suppressed under different germination media. However, gerimination of *Eluesine coracana* was not affected *Celtis australis* and *Alnus nepalensis* did no affect germination of test crops very much except *Glycine max* root length and dry matter production of *Glycine max* was also suppressed to some extent by *Celtis australis* and *Alnus nepalensis.* On the other hand *Adina cordifolia* affected adversely the germination, root or shoot length and dry matter production of

Glycine max and only seed germination and root shoot length in *Hordeum vulgare. Eluesine coracana* remained unaffected and was highly resistant to the tree- crop interactions. *Prunus cerasoides* has also inhibited the seedling attributes of *Glycine max* and *Hordeum vulgare* but less than *Adina cordifolia* (Bhatt and Todaria, 1990).

Studies have been conducted to investigate the effect of plant extracts on protein synthesis. Romero-Romero et al., (2002) showed that aqueous extracts of four native shrubs of the Mexican desert (Sicyos *deppei, Acacia sedillense Sebastiania adenphora* and *Lantana camera)* reduced root growth and induced an overall increase in protein synthesis in root of Zea *mays, Phaseolus vulgaris, Cucurbita pepo* and *Lycopersicon esculentum.*

Allelochemicals produced by leaves of *Callicarpa acuminate* were tested on root growth, protein synthesis and enzyme activity of seedlings of P. *vulgaris,* L. *esculentum* and *Zea mays* (Cruz-ortega et al., 2002). In particular, the synthesis of a protein of a polypeptide was promoted in roots of L. *esculentum* (Cruz-ortega et al., 2002).

2.6.10 Allelopathic evidence of Crop residues

The toxic effects of decaying leaves and other plant debris have often been cited as examples of allelopathy. Hall et al., (1983) reported that the debris from sunflower plants grown under various nutrients stresses inhibited growth of *Amaranthus retroflexus* and called the effect allelopathy, but plant residues from a wide range of sources including com (Bhowmik and Doll, 1982) are known to inhibit seed germination or plant growth.

Also, the use of plant residues in a low input land management system can improve crop production (Kang et al., 1981). This effect is mainly due to decomposition of plant residues and the subsequent nutrient release (Tian, et al., 1992). Decomposition of plant residues can also release phytotoxic compounds that inhibit crop growth (Holapparr and Blum, 1991). Menges (1987) reported that incorporation of residues of *palmer amaranth* in the soil inhibited the growth of carrot and onion. Bhatt and Todaria (1990) reported a reduction in growth of *Glycine max* and *Hordeum vulgare* grown in soil mulched with leaves of *Adina cordifolia* and *prunus cerasoides.*

Large differences have been reported between experiments grown in Petri-dishes and pots and the results obtained when fresh leaves and leaf litter are scattered on the soil in the field (Trenbath, 1991). There is also a large variation in the tolerance of under storey crops to trees. For example, sunflower and cowpea are relatively unaffected by *Eucalyptus tereticornis* compared with sorghum (Suresh and Rai, 1987). *Bhabar* grass has also continued to grow productively under E. tereticornis (Grewal et al., 1992).

2.6.11 Allelopathic evidence of mulch

Allelopathic effects of these compounds are often observed to occur early in the life cycle, causing inhibition of seed germination and or seedling growth. Studies have shown that seeds (Borghetti, Pessoa, 1997), leaves and fruits (Oliveira et al., 2004) of *solanum lycocarpum* have allelopathic properties, inhibiting both seed germination and seedling growth of some target species as *sesamum indicum.* In particular, aqueous leaf extracts were found to inhibit root growth and root hair differentiation and to impair geotropic curvature of sesame seedlings at low concentration.

However, the roots were more affected than the shoots. After five days, the root growth was reduced by about 80% at extract at 1% but the shoot growth was not significantly affected up t0 30% concentration. Despite the effects of the extracts on shoot growth, no abnormality was observed in the shoot morphology of the treated seedlings. The cotyledons expanded, and the hypocotyles greened similarly to the control seedlings (Oliveira et al., 2004).

2.6.12 Allelopathic evidence of Acacia auriculiformis

Leaf extracts of Acacia auriculiformis shows that, the germination percentage revealed that, the inhibitory effect increases with the increase of extract concentration. In all cases that most inhibitory effect was found at is treatment while the lowest was (-1.76%) found in Brassica *juncea* and Phaseolus *mungo* at (50%). The stimulatory effects were mostly observed at (10%). This result support the findings of Rice (1984) who inferred that chemicals that inhibit the growth of some species at certain concentration could stimulate the growth of the same or different species at lower concentrations. Significant inhibition of seed germination was not observed in Phaseolus *Mungo* at (75%) while the minimum (9.61%) was found in C. *arietinum* at (100%) (Rafiqul Hoque et al., 2003).

Also, the shoot lengths of bioassay observed that, in most cases the stimulatory effect was found at (10%) and (25%). The inhibitory effect was much more pronounced at (100%) followed by (75%), (50%) and (25) treatments respectively. The highest inhibitory effect (-41. 46%) was found on *Brassica juncea* at treatment while the lowest (- I. 20%) was in C. *arietinum* at (75%). Maximum elongation of shoot (18.28 cm) was observed in Phaseolus *mungo* followed by (13.94cm) in Vigna *uniguiculata* both at control. Maximum Relative Elongation Ratio of shoot (1930.76%) was observed in Rrphanus *sativus* at (50%) while among the survivors the minimum (58.43%) was in *Brassica juncea* at (100%) (Rafigul Hoque et al., 2003).

Again in the mean root lengths (cm) as well as the percentage of inhibition of root elongation of all the receptor agricultural crops revealed that, in all cases the root length of the crops revealed that, in all cases the root length of the crops were greatly inhibited with the increasing extract concentration except Phaseolus *mungo* (10%) and (25%). Significant inhibitory effect was found at (100%) followed by (50%) and (75%). The highest inhibitory effect (-91.94%) was observed in Brassica *juncea* at (10%). Maximum Relative Elongation Ratio of root (114.58%) was observed in Phaseolus *mungo* at (10%) while the minimum (8.05%) was found in Brassica *juncea* at (100%) (Rafiqul Hoque et al., 2003).

However, there are a number of lateral root developed in different treatments. It was found that in all cases, higher concentration of water extracts had pronounced inhibitory effect on lateral root development. The highest number of lateral root development at control. Maximum (42.73) root developed in Raphanus *sativus* at control while the minimum (2.00) was recorded in Brassica *juncea* at (100%). The most inhibotry effect (85.38%) was found in Raphanus *sativus* at (10%) followed by (-2.96%) Phaseolus *mungo* at the same treatment (Rafigul Hoque. et al. 2003).

The mean shoot lengths (cm) of the seedlings of all he receptor agricultural crops are shown. Stimulatory effect was found in (10%) and (25%) in comparison to control but the inhibitory effect was progressively pronounced with the increase of leaf extract concentrations. In all cases significant inhibitory effect of shoot length was found in (100%) followed by (75%) and (50%) respectively. Among the germinated seedlings, the maximum (-99.40%) inhibitory effect was found on *B. juncea* at (75%) followed by *C. sativus* (-90.23%) at the (100%) and the lowest (-0.75%) inhibitory effect was found on *Vigna unguiculata* at (10%) treatment. Maximum (17.37cm) elongation of shoot was observed in *Vigna unguiculata* followed by *Phaseolus mungo* (17.32cm) in control treatments. Among the survivors, maximum (134.11%) relative elongation ratio (RER) of shoot was observed in *C. sativus* at (10%) while the minimum (59%) was in *Brassica juncea* at (75%) (unddin et al., 2003).

2.6.13 Allelopathic evidence of Leocaena leocephala

The results of germination percent of all the five receptor plants are shown. In most cases variation of germination percent due to concentration varied evenly. With the increase of concentraton, the inhibitory effect was progressively increased. In all cases maximum inhibitory effect was found in (100% conc.) except *Vigna unguiculata.* Maximum inhibitory effect (-98.33%) was found on Brassica. *juncea* in (100%) followed by *Raphnus sativus* (-98.0%) in the same treatment and the lowest (-1.67%) relative germination ratio (RGR) was found in *C. sativus* at treatment while the minimum (1.66%) was in *Brassica juncea* at (100%). Among the receptor crops, *C. sativus* was less sensitive to the application of different extracts. However, the species responded differently with the extracts. It was also observed that leaf extracts of *Acacia lebbeck* delayed the germination significantly in all the receptor crops in comparison to the control (unddin et al., 2003).

The mean shoot lengths (cm) of the seedlings of all the receptor agricultural crops are shown. Stimulatory effect was found in (10%) and (25%) in comparison to control but the inhibitory effect was progressively pronounced with the increase of leaf extract concentrations. In all cases significant inhibitory effect of shoot length was found in (100%) followed by (75%) and (50%) respectively. Among the germinated seedlings, the maximum (-99.40%) inhibitory effect was found on *B. juncea* at (75%) followed by *C. sativus* (-90.23%) at the (100%) and the lowest (-0.75%) inhibotury effect was found on *Vigna unguiculata*at (10%) treatment. The highest (+36.92%) stimulating effect on shoot elongation was found on *Raphnus sativus* at (25%) treatment followed by *C. sativus* (+34.11%) at (10%) treatment. Maximum (17.37cm) elongation of shoot was observed in

Vigna unguiculata followed by *Phaseolus mungo* (17.32.cm) in contro treatments. Amognthe survivors, maximum (134.11%) relative elongation ratio (RER) of shoot was observed in *C. sativus* at (10%) while the minimum (59%) was in *Brassica juncea* at (75%) (unddin et al., 2003).

The root length of all the five receptor plant was greatly inhibited with the increase of extract concentration except *C. satvus*, where stimulating effect was observed at (10%). The inhibitory effect was pronounced at (100%) followed by (75%), (50%) and (50%) respectively. Among the survivors, the highest (-99.65%) inhibitory effect was found on *Brassica juncea* at (75%) followed by *C. sativus* (-96.65%) at he (100%). Maximum (19.15cm) root length was observed in *Raphnus sativus* followed by *Vigna unguiculata* (16.21cm) in control treatment. Maximum (117.83%) relative elongation ratio (RER) of root was observed in *C. sativus* at (10%) while the minimum (0.39%) wa sin *Brassica juncea* at (75%) (unddin et al., 2003).

Considering the number of lateral root development, the study revealed that root development significantly decreased with the increased concentrations. In all cases significant effect was found in (100%) (except *C. sativus)* followed by (75%), (50%) and (25%) respectively. In all cases control treatment had the highest mean lateral root number than other treatment except *C. sativus* on which stimulating (+48.66%) effect was found in (10%) treatment. Among the survivors, the highest (-96.34%) inhibition was found on *Raphnus sativus* at (75%) followed by *C. sativus* (-88.46%) in and the lowest (21.72%) in *Phaseolus mungo* at (10%). Maximum (41.87) number of lateral roots was found in *Vigna unguiculata* followed by *Raphlus sativus* (40.13) in control treatments (unddin et al., 2003).

2.6.14 Allelopathic evidence of pines

The red and black pines were observed to have similar and sparse under story growth around the trees, with a denser and more varied growth I areas not strongly populated by the tree species. In several experiments, aqueous extracts of the red pine were taken from fresh leaves, fallen leaves and roots were tested for inhibitory affects using Petri-dishes and pots with soil to test the extracts. These extracts were tested against other red pines and common species within the forest system along with species of plants found outside the forest systems occupied by the pine species. Those species native to the system showed much higher rates of germination than those species normally found outside the system thus providing a plausible explanation for very similar under stories amongst systems containing the pine species. (Nwoboshi, 1968).

This is verified by a second test involving soil germination and growth of interior and exterior plant species in the presence of the aqueous extracts (Rice, 1984). In certain areas within the forest some species whose seeds are known to be present have failed either to germinate or for even when and where there are vacant spaces. Such a situation was found around *Callitris intratropica* in Maningrida forest area of Northern Territory, Australia (Nwobishi, 1968).

2.6.15 Allelopathic evidence of Lactarius hatsudake

The allelopathic effect of aqueous extracts of Lactarius *hatsudake* on seedling growth of barnyardgrass. The data showed that the seedling growth of barnyardgrass was inhibited by aqueous extracts of Lactarius *hatsudake* significantly. Extracts treatments results in the formation of yellow leaves, smaller the root lengths and shoot heights, and some seed mortality. Sox days the treatment with 4.5mg.m, aqueous extracts of Lactarius *hatsudake,* the response index of roots and shoots were -0.91, -0.84. The response index of 2.5mg.ml and 5.5.mgml treatments were significant different from those of the 4.5mgml treatments at an alpha level of 0.05. (Mo et al., 2004).

The inhibitory effect was stronger at higher concentration from 0.50mgml to 5.50mgml on radish. Six days after the treatment with 5.50mgml aqueous extracts of Lactarius *hatsudake,* the shoots of radish did not develop the response index of roots and shoots were -086, -1.00, respectively. The response index of 4.50mg.ml treatment were not significant different from those of 5.50mg.ml treatment at an alpha level of 0.05. The results showed that the growth of rape seedlings was significantly inhibited by the aqueous extracts of Lactarius *hatsudake* and the inhibitory effect was stronger at higher concentrations. Although some seeds germinated, they stopped continuous growth immediately after germination. Six day after the treatment with 5.50mg.mlaqueous extracts of Lactarius *hatsudake*, the response index of roots and shoots were -0.98,-1.00, respectively (Mo et al. 2004).

The allelopathic effects of aqueous extracts of Lactarius *hatsudake* on seedling growth of rice are showed. However, concentration effects were evident for rice. For concentrations >4.50mg.ml, the allelopathic effects on rice root were inhibitory and for concentrations<4.50mgml, the allelopathic effects on rice shoot were stimulation. For concentrations from 0.50 to 5.50mgml, the allelopathic effects on rice shoot were stimulatory. Six days and eight days after the treatment with 5.5mgml aqueous extracts of Lactarius *hatsudake,* the response on the root of rice were -0.26, -3.5mgml aqueous extract of Lactarius *hatsudake,* the response index of rice root and rice shoots were 0.26 and 0.24, respectively (Mo et al. 2004).

CHAPTER 3

3.0 ALLELOPATHIC EFFECT OF TEAK LEAF EXTRACT ON GERMINATION AND GROWTH OF MAIZE SEEDLINGS

3.1 INTRODUCTION

Allelopathy is defined as the direct or indirect harmful or beneficial effects of one plant on another through the production of chemical compounds that escape into the environment (Brown et al., 1991). Many of the phytotoxic substances, suspected of causing germination and growth inhibition have been identified from plant tissues and soils. These substances are termed allelochemicals. Allelochemicals usually are called secondary plant products or waste products of the main metabolic pathways in plants. These may be watersoluble substances that are released into the environment through leaching, root exudation, volatilization and decomposition of plants residues. Most research on allelopathy has focused on the effect of interaction among weed species, weeds and crops and crops species (Hegde and Miller, 1990)

Allelochemicals (inhibitors) are produced by plants as end products, by- products, and metabolites, and are contained in the stem, leaves, roots, flowers, inflorescence, fruits and seeds of the plant. Of these plant parts, leaves seem to be the most consistent producers of these allelochemicals. Teak is a plant grown in Ghana in the humid zones purposely, for short term wood production, by growing it as a woodlot or in association with crops. It was also found in many studies that allelochemicals, which inhibited the growth of some species at certain concentrations, could stimulate the growth of same or different species at lower concentration (Narwal, 1994). The present research was conducted to evaluate the effects of aqueous extract of teak leaf on germination and growth of maize seedlings. The study hypothesizes that, there are no allelopathic effects of teak leaf extracts on germination and growth of maize.

3.2 MATERIALS AND METHODS

3.2.1 Study site

The experiment was conducted at the Faculty of Renewable Natural Resources Laboratory located at the Kwame Nkrumah University of Science and Technology, Kumasi Ghana. From May-August, 2007. Kumasi lies on longitude 06°, 43'W and latitude 01°, and 34'N at an altitude of 278m above sea level.

3.2.2 Preparation of extracts

Fresh leaves from several mature trees of *Tectona grandis* were collected from a woodlot at Awomaso near Kumasi in Ashanti Region. They were air dried, and oven dried to constant weight and ground using a mill. The leachate of *Tectona grandis* was prepared by weighing 50g of ground material into a 500ml beaker and 250ml of distilled water added. The contents of the beaker were transferred into a 500ml polyethylene bottle and shaken for 2 hours. The suspension was filtered using a Whatman number 40 filter paper. Sub samples of the extracts were diluted to obtain the concentrations of 25%, 50%, 75%, and 100% and stored for experiment. Water was used because most allelochemicals are water soluble (Reigosa et al., 1991).

3.2.3 Experimental design

Complete randomized design was used and the following treatments were used;

(T_0) Soak maize seeds in distilled water (Control).

(T_1) Soak maize seeds in leaf extract of 25% concentration.

(T_2) Soak maize seeds in leaf extract of 50% concentration.

(T_3) Soak maize seeds in leaf extract of 75% concentration.

(T_4) Soak maize seeds in leaf extract of 100%concentration

Three replicates of fifteen maize seeds were placed on filter paper. The Petri dishes were randomized and the filter paper was constantly moistened using the respective extracts for a period of 10 days.

3.2.4 Data Collection

Seed germination was recorded 3 days after the onset of germination whiles shoot length and root length were recorded on the l0th day. The percentage of inhibitory effect on the germination and growth parameters to the control was calculated as suggested by Surendra and Pota (1978).

$$I = 100 - \frac{E_2}{E_1} \text{x} 100$$

Where: I - % inhibition.

E_1- control plant.

E_2 - treatment plant

3.2.5 Statistical Analysis

Data on seed germination, shoot length, root length, shoot dry weight and root dry weight were analyzed using Analysis of Variance (ANOVA). Where significant results were obtained means will be compared using multiple comparison test at ($\propto$ = 0.05) to separate means.

4.0 RESULTS

The results of ANOVA which tested the hypothesis that, leaf extracts *or Tectona grandis* have no allelopathic effect on germination and growth of maize seeds after 10 days of sowing are presented in (Table 1).

Table 1: Summary of P-values of analysis of variance, testing the effect of Tectona grandis leaf extracts on germination and growth of maize seedlings after 10 days.

Parameter	Sources	d/f	P-values	C.V	n

Germination	Treatment	4	0.000***	7.36	84.87%
Shoot length	Treatment	4	0.004***	15.61	9.36(cm)
Root length	Treatment	4	0.001***	21.66	19.02(cm)
Shoot dry weight	Treatment	4	0.003***	28.69	0.36(g)
Root dry weight	Treatment	4	0.001***	28.98	0.33(g)

Values are means ±95% confidence intervals; ns is not significant, *** is significant at 0.001 probability level.

Table 2: Comparison of treatment means on the effect of *Tectona grandis* leaf extract concentrations on maize germination and seedling growth after 10 days.

	Concentrations					
Parameter	0%	25%	50%	75%	100%	Mean
Germination (%)	100.0a	100.0a (0.00)	95.53a (-4.47)	68.86b (-31.14)	60.00b (-40.00)	84.87%
Shoot length (cm)	10.93a	11.67a (+6.70)	10.50a (-3.93)	7.46b (-31.74)	6.23b (-43.00)	9.36cm

Root length (cm)	19.60a	25.36a (+29.38)	25.33a (+29.23)	18.46a (-5.81)	6.33b (-67.70)	19.02cm
Shoot dry weight (g)	0.43a	0.46b (+6.97)	0.50c (+16.27)	0.33d (-23.25)	0.06e (-86.04)	0.36cm
Root dry weight (g)	0.26a	0.53b (+103.84)	0.46bc (76.92)	0.33ac (+26.92)	0.07d (-76.92)	0.33cm

Values in the parenthesis indicate the inhibitory (-) or stimulatory (+) effects in comparison to control. Values in the rows followed by the same letters are not significantly different ($P \geq 0.05$).

4.1 Effects on germination

Table 2 shows the germination percentages. It was observed that extract concentration of 25% and 50% were similar for germination. However, extract concentrations of 75% and 100% were significantly higher for germination. The study revealed that the inhibitory effect started from 75% extract concentration. The highest inhibitory effect 60% was obtained at 100% extract concentration.

4.2 Effects on shoot elongation

The mean shoot lengths of bioassay are given in Table 2. It was observed that 25%, 50% were similar. However, extract concentrations of 75% and 100% was significantly higher.

The highest inhibitory effect (-43.00) was observed in extract concentration of 100% while the lowest (-31.74) was found in extract concentration of 75%.

Effects on root elongation.

The mean root lengths are shown in Table 2. It was observed that extract concentrations of 25%, 50%, and 75% were similar. However, extract concentration of 100% did differ significantly.

4.3 Effects on shoot dry weight (g)

The mean shoot dry weights are given in Table 2. It was observed that extract concentrations of 25%, 50% were similar. However extract concentrations of 75% and 100% were significantly higher. The highest inhibitory effect of (-86.04) was observed in extract concentration of 100% while the lowest effect was (-23.25%) found in extract concentration 75%.

4.4 Effects on root dry weight (g)

The mean root dry weights are given in Table 2. It was observed that extract concentrations of 25%, 50% and 75% were similar. However, extract concentration of 100% did differ significantly. The inhibitory effect of (76.92) was observed in extract concentration of 100%.

5.0 DISCUSSION

This research hypothesized that the effects of *Tectona grandis* leaf extract have no allelopathic effect on maize germination seedling growth. The hypothesis was rejected because there were significant differences in the parameters studied including germination, shoot elongation, root elongation, shoot dry weight and root dry weight. Considering the foregoing result, it seemed that there was phytotoxic effect of *Tectona grandis* leaf extract based on germination, shoot elongation, root elongation, shoot dry weight and root dry weight. This could be due to chemical substances in the extracts of the leaf, which again would suggest an allelopathic potential of the tree species under field condition (Michelsen and Lisanework, 1993).These results correlated with the findings of Bora et al., (1991) who found the allelopathic effect of leaf extract of *Acacia auriculiformis* on seed germination of some agricultural crops. Michelsen and Lisanework (1993) also reported that, eucalyptus leaf species inhibited germination of root and growth of crops.

The present results demonstrates that shoot and root lengths, shoot dry matter and root dry matter are reduced to a higher extent by increasing the concentration of leaf extract from 75% to 100%. This suggest that, the potential allelopathic effect could be more pronounced in areas where rainfall is low or erratic and thus insufficient to dilute phytotoxic substances by run-off or leaching from top soil (May and Ash, 1990). Also, the results of this study showed that root elongation was much more inhibited than shoot elongation.

These results are also in conformity with the earlier findings of Chou and Waller (1980), Swami - Rao and Reddy (1984), Chou and Kuo (1986), Alam (1990), and Zackrisson and Nilsson (1992). All these studies supported that root growth was more sensitive and responds more strongly to the increasing concentration of the aqueous extract in comparison to shoot.

However, McCalla and Haskins (1964) suggested that effect of root decline was due to its inference with the plants growth processes, reducing cell division or auxin induced growth of roots. Also, the reduction in root length at higher concentration could indicate that cell division was affected as allelopathic chemicals have been found to inhibit gibberellins and indoleacetic acid function (Tomaszewski and Thimann, 1966). Pandya (1975) recorded similar results on the effect of *Celosia argentia* extract on root and shoot growth of sorghum.

Munir and Tawaha, (2002) reported that root length was relatively more sensitive to autotoxic allelochemicals than shoot length. These results are in agreement with this study. Such an outcome might be expected, because it is likely that roots are the first to absorb the allelochemicals or autotoxic- compounds from the environment (Kimber, 1973). Besides inhibiting radicle elongation, other morphological abnormalities occurred on shoot and root development of the crop at the highest concentration (100%).

The dry weights yield indicates that the growth of the crop was significantly suppressed by the aqueous leaf extract of *Tectona grandis*. The shoot dry weights were suppressed by higher extract concentration, as well as the root dry weight. The root dry weights tend to decrease more than the shoot dry weight. This could be attributed to the fact that, the roots elongations were affected by the extracts concentrations that resulted in the reduction in the dry weights.

6.0 SUMMARY AND CONCLUSION

This study tested the hypothesis that leaf extracts of *Tectona grandis* is have no allelopathic effect on germination of maize seedlings after 10 days. The results show that, extract concentrations of 75% and 100% had significant effect on germination, shoot length, root length, shoot and root dry weight. The study also revealed that, the root length as much more inhibited than the shoot length. At lower concentration of 25% and 50%, the extracts showed stimulatory effect whiles at higher concentrations 75% and 100%, the extracts showed inhibitory effects. Based on the above results, it could be concluded that *Tectona grandis* could have inhibitory effect on maize germination and seedling growth agroforestry systems.

CHAPTER 4

4.0 ALLELOPATHIC EFFECT OF TEAK MULCH ON GROWTH OF MAIZE 4.1 INTRODUCTION

Allelopathic interference can results from natural products released from mulch of plant residues. The use of plant residues in a low input land management system can improve crop production. This effect is mainly due to decomposition of plant residues and the subsequent nutrient release. Decomposition of plant residues can also release phytotoxic compounds that inhibit crop growth. Thus soil toxicity may develop during residue decomposition, initially when natural products are leached from surface residues and later during microbial transformation (Dalton et al., 1983).

Menges (1987) reported that incorporation of residues of palmer amaranth in the soil inhibited the growth of *Glycine max* and *Hordeum vulgare* grown in soil mulched with leaves of *Adina cordifolia* and *Prunus cerasoides*. Plant residues mulches commonly used in agroforestry systems to protect soil from erosion, conserve moisture, and supply nutrients such as nitrogen may be the source of allelochemicals that could reduce crop productivity, but an interesting possibility is that, chemicals from the mulch may contribute to the effect of reducing weed growth and thereby increasing crop yield (Ramamoorthy and Paliwali, 1993). The study was conducted to evaluate the effect of Tectona grandis mulch on weed growth, germination and growth of maize. The study hypothesizes that, there are no allelopathic effects of Tectona grandis mulch on maize growth.

4.2 MATERIALS AND METHODS

4.2.1 Study Site

The experiment was conducted at the Faculty of Renewable Natural Resources demonstration farm located at the Kwame Nkrumah University of Science and Technology, Kumasi in the humid zone of Ghana. Kumasi lies on longitude 06°, 43'W and latitude 01°, and 34' N at an altitude of 278m above sea level. The area has a bimodal rainfall with an annual mean ranging between I500mm and 3000mm. The mean temperature ranges between 22°C and 34°C.

4.2.2 Field experiment

Leaves were collected from an eight year woodlot at Awomaso near Kumasi in Ashanti region, and air-dried before they were applied as mulch. Randomized complete block design was used, with three replicates each. The following treatments were applied: (0) as control, 2t/ha, 4t/ha and 6t/ha of dry *Tectona grandis* mulch on the day that maize was planted. The total size of the field for the experiment was 21 m x 16m. The area was demarcated into I2treatment plots with each measuring 4m x 4m with I m borders, between each treatment. Within each plot, a subplot was demarcated measuring 2m x 2m where the treatments were applied. The maize was planted at a spacing of 80cm x 60cm.

There were 3 plants per stand and was thinned to two plants per stand.

4.2.3 Data collection

During the study height and diameter of maize plants were measured twice at fourth and eighth week. The maize was also harvested at 12 week and the grains were oven-dried to a constant weight. Data were collected on weed biomass.

4.2.4 Statistical analysis

Data on weed biomass, maize diameter and maize yields were analyzed using analysis of variance (ANOVA). Where significant results were obtained means were be compared using multiple comparison test at ($\propto = 0.05$) to separate means.

4.3 RESULTS

Table 3: Summary of P- values of analysis of variance testing the effects of *Tectona grandis* prunings on maize growth

Parameter	Sources	d/f	P-values	n
Weed biomass	Treatment	3	0.63 ns	12
Maize height (cm)				
• 4 week	Treatment	3	0.17 ns	12
• 8 week	Treatment	3	0.41 ns	12
Maize diameter (cm)				
• 4 week	Treatment	3	0.41 ns	12
• 8 week	Treatment	3	0.30 ns	12
Grain (g/ha)	Treatment	3	0.32 ns	12

Values are means $\pm$ 95% confidence intervals; ns is not significant

Table 4: The effects of *Tectona grandis* prunings on maize growth and yield.

Parameter	Treatments

	Control	2 t/ha	4 t/ha	6 t/ha	Mean
Weed biomass (g)	103.40	69.86	68.53	63.20	76.20
	(34.44)	(31.89)	(30.35)	(29.41)	
Maize height (cm)					
• 4 week	159.30	175.30	141.00	186.00	165.40
	(18.81)	(17.42)	(16.57)	(16.06)	
• 8 week	532.30	556.30	463.30	572.30	531.20
	(66.76)	(61.83)	(58.84)	(57.02)	
Maize diameter (cm)					
• 4 week	15.00	18.60	17.00	19.60	17.55
• 8 week	(2.90)	(2.71)	(2.58)	(2.50)	
	19.60	22.00	20.00	23.30	21.23
Grain (g/ha)	(2.05)	(1.90)	(1.81)	(1.75)	
	384.10	450.00	495.00	647.00	493.80
	(138.21)	(127.99)	(121.81)	(118.04)	

Values in the parenthesis are the standard errors.

4.3.1 Effect on weed biomass after six weeks (g)

It was observed that all the treatments 2t/ha, 4t/ha and 6t/ha were all similar. Treatment 2t/ha had 69.86g, 4t/ha had 68.53g and 6t/ha had 63.20g. Treatment 6t/ha recorded the lowest weed biomass of 63.20g whiles 2t/ha recorded the highest weed biomass of 69.86g.

There were no significant differences among means for weed biomass.

4.3.2 Effect on maize height (cm)

It was observed that all the treatments 2t/ha, 4t/ha, and 6t/ha were all similar. At the fourth week, treatment 2t/ha had 159.30cm, 4t/ha had 175.30cm and 6t/ha had 186.00cm. Treatment 4t/ha recorded the lowest height of 141cm and highest height recorded in 6t/ha which was 186cm. At the eight week treatment 2t/ha had 532.30cm, 4t/ha had 556.30cm and 6t/ha had 572.30cm. The lowest height was recorded in 4t/ha was 464cm whiles the highest height was recorded in 6t/ha was 572cm. There was no significant difference ($P \geq 0.05$) between the means of height increment for both fourth week and eight week.

4.3.3 Effect on maize diameter (cm)

It was observed that all the treatments 2t/ha, 4t/ha, and 6t/ha were all similar. Treatment 2t/ha had 15.00cm, 4t/ha had 18.60cm and 6t/ha had 19.60cm for the fourth week. It was observed that at the fourth week, 4t/ha had the lowest diameter 17.00cm whiles 6t/ha had the highest diameter 19.60cm. It was observed that at the eighth week 2t/ha had 19.60cm, 4t/ha had 22.00cm and 6t/ha had 23.30cm. Treatment 4t/ha had the lowest diameter 20.00cm whiles 6t/ha had the highest diameter 23.30cm.

4.3.4 Effect on maize dry weights grains (g/ha)

It was observed that all the treatments 2t/ha had 450.00g/ha,4t/ha had 495.00g/ha and 6t/ha had 647.00g/ha. All the treatments were all similar. Also it was observed that treatment 2t/ha recorded the lowest maize dry weight grain of 384g/ha, whereas 6t/ha recorded the highest maize dry weight grain of 646g/ha. There were no significant differences (P≥0.05) between the means (Table 4).

5.0 DISCUSSION

5.1 Effect of *Tectona grandis* mulch on weed control.

This research hypothesized that, *Tectona grandis* mulch have no allelopathic effect on weed control. The results validate the hypothesis with respect to the different mulch rates for the various treatments used. The suppression of weeds by the mulch could be attributed to physical factors including lower soil temperature, shading and light. Since these factors stimulate the germination of seeds therefore, the mulch hinders these factors to reduce weed growth. It could also be attributed to the thickness of mulch applied. Partial smothering, using a thin layer of mulch weakness weeds by reducing their photosynthetic capacity and thus aid in their control. Again, using moderately thin layers of mulch controls weeds that germinate near the soil surface but, even thick layers of mulch may be in effective in controlling certain perennial species (Bunsid et al., 1985).

Their study confirms this work showing that mulch cannot control weeds entirely as observed in the study. However, it could also be attributed to chemical factors of mulch as well. That is phytotoxicity depends on the type of residue. Kimber (1973) found that straw harvested while it was still green produced a higher level of phytotoxicity than straw harvested at maturity. This suggest that the mulch used in the study was matured therefore, producing little or no allelopathic effect on weed control. It could also be attributed to type of residue. Since phytotoxicity due to crop residue disappears rather quickly upon decomposition (Burnsid et al., 1985). This is also in agreement with this studies since, the mulch were reduced in size before applying it as a mulch, made it decomposed quickly on the treated areas thereby, alleviating the allelochemicals in the mulch.

5.2 Tectona grandis mulch on growth of maize

Similarly, this research hypothesized that, *Tectona grandis* mulch have no allelopathic effect on maize growth. The results accept this hypothesis and had no significant effects ($P \geq 0.05$) on various parameters studied in the experiment including height, diameter and maize yield. Also, it could be suggest that the allelopathic or phytotoxic compounds are known to be mainly phenolic acids (Glass, 1984). These phenolic compounds are degraded with decomposition of plants residues, resulting in the alleviation of phytotoxicity of the decomposing plant residues (Tian et al., 1992).

The results in this research also confirms observation made by Tian (1992) who reported that, the phytotoxic effect was not harmful for maize and cowpea under field condition as the phytotoxic compounds can be degraded faster in the field than in the laboratory. Again, it could be attributed to the fact, that addition of the mulch even had a beneficial effect by providing nutrients during decomposition (Tian, 1992) and resulted in a significant increase in maize and cowpea yield.

The findings of this study are also similar to that of Obando (1987) who reported no allelopathic effect of *Gliricidia* mulch on maize and beans. Tian (1992) also reported that, the biologically inhibitive role of polyphenols does not persist under humid tropical field conditions, due to leaching and decomposition of polyphenols. Furthermore, the nitrogen supply from decomposing mulch may also contribute to alleviation of phytotoxic effect of *Gliricidia* mulch. This report is consistent with this study because, this research was carried out in a humid tropical condition therefore, the allelochemicals may have leached out from the soil.

6.0 SUMMARY AND CONCLUSION

This study tested two hypotheses; first, that *Tectona grandis* mulch does not control weeds. The hypothesis was accepted. The second hypothesis was that there is no allelopathic effect of *Tectona grandis* mulch on maize growth. Generally, the results revealed that, there is no significant effect on height, diameter and yield of maize. Based on these results, these conclusions can be drawn. The effect of different mulch rates on weed control was similar and mulch rates on maize growth were also similar.

CHAPTER 5

5.0 ALLELOPATHIC EFFECTS OF SOILS FROM TEAK WOODLOT ON THE GROWTH OF MAIZE

5.1 INTRODUCTION

Literature reveals that higher tree crop release some phytotoxins into soil, which adversely affect the germination and yield of crops. This type of tree crop interaction was named phytochemical ecology by Harborne (1977). Soil that develops under natural forest and woodlot is fertile, well structured, good water holding capacity and a store of nutrients bound up in the organic matter. Soil organic matter is higher under the trees. Nitrogen is often also higher and sometimes phosphorus, potassium and other exchangeable cations. In particular, mineralizable nitrogen can be considerably higher under trees, the results of the finely comminuted litter (Rhoades, 1997).

Barber, (1968) observed that growth of plants is influenced by soil nutrients and the uptake is dependent at the root surfaces. The differences in plant growth could therefore be related to the fertility status of the soils used in the study. Evidence of the effects on soil comes from comparing soil beneath tree canopies and within the orbit of their root systems with soil in the surrounding area beyond the influence of trees. In some cases, these soil differences are reflected in higher crop yields under trees. A fact observed in the 1960's before the days of 'scientific' agroforestry (Young, 1976). The objective of this study was to evaluate the soils from woodlot on maize growth. The study hypothesizes that there is no allelopathic effects of soil from *Tectona grandis* woodlot on maize growth.

5.2 MATERIALS AND METHODS

5.2.1 Study Site

The experiment was conducted at the Faculty of Renewable Natural Resources demonstration farm located at the Kwame Nkrumah University of Science and Technology, Kumasi and has been described under section 4.2.1.

5.2.2 Pot experiment

Soils were collected from a woodlot and garden soil at two different depths (0 – 15cm and 15 – 30cm for each soil). Soil sampling was done at random using an auger. All sampled soils for each treatment were mixed and bulked. The soils were air dried and sieved through a 2mm mesh. Soil samples equivalent to 4kg weight of each soil type was used to fill each poly bag of size (60cm x 26cm) with perforation at the base.

5.2.3 Experimental design

Complete randomized design was used. T he following treatments were used: garden soil of depths 0 – 15cm and 15 – 30cm were used as control whiles woodlot soil of depth 0 – 15cm and 15 – 30cm. Maize seed were sown in each poly bag at 3 seeds per pot and was thinned to one plant per pot. The experiment lasted for 6 weeks.

5.2.4 Data collection

The shoots were separated from the roots using knife, after which they were air-dried and oven-dried. Shoot dry weight and root dry weight were recorded.

5.2.5 Statistical analysis

Data on shoot dry weight and root dry weight were analyzed using Analysis of variance (ANOVA). Where significant results were obtained means were compared using multiple comparison tests at ($\propto = 0.05$) to separate means.

5.3 RESULTS

Table 5 P-values of student's T-Test comparing maize growth on *Tectona grandis* soil and garden soils at six weeks on soil depth of 0-15cm.

Parameter/period	*Tectona grandis* soil	Garden soil	P-value
Shoot dry weight (g)			
• 6 week	40.17 ± 90.56	45.83 ± 22.34	0.78 ns
Root dry weight (g)			
• 6 week	12.76 ± 1.98	15.50 ± 6.07	0.61 ns
Maize height (cm)			
• 3 week	25.33 ± 4.61	26.67 ± 3.05	0.78 ns
• 6 week	86.00 ± 16.00	88.33 ± 25.79	0.89 ns
Maize stem diameter(cm)			
• 3 week	2.80 ± 0.36	3.00 ± 0.86	0.57 ns
• 6 week	5.90 ± 0.65	6.33 ± 1.52	0.63 ns

Values are means ± 95% confidence intervals; ns are not significant.

Table 6 P-values of student's T-Test comparing maize growth on *Tectona grandis* soil and garden soil at six weeks on soil depth of 15 – 30cm.

Parameter/period	*Tectona grandis* soil	Garden soil	P-value
Shoot dry weight (g)	35.90 ± 18.99	34.37 ± 17.44	0.56 ns
• 6 week			
Root dry weight (g)	13.60 ± 5.86	14.10 ± 5.14	0.62 ns
• 6 week			
Maize height (cm)			
• 3 week	25.00 ± 5.00	22.67 ± 3.21	0.33 ns
• 3 week	76.33 ± 33.50	70.00 ± 18.52	0.56 ns
Maize stem diameter(cm)			
• 3 week	2.93 ± 0.51	3.80 ± 1.92	0.40 ns
• 6 week	5.57 ± 2.60	6.00 ± 2.00	0.34 ns

Values are means ±95% confidence intervals; ns is not significant

5.3.1 Effect of woodlot soil and garden soil on shoot and root dry weight of maize. Shoot dry weight at 6 weeks on garden soil depth 0-15cm had 45.83g whiles woodlot soil had 40.17g. Root dry weight at 6 weeks on garden soil depth 0-15cm had 15.50 whiles woodlot soil had 12.76g. Shoot dry weight at 6weeks on garden soil depth 15-30cm had 34.37g whiles shoot woodlot soil had 35.90g. Root dry weight at 6weeks on garden soil depth 15-30cm had 14.10g whiles woodlot soil had 13.60g. Within 0 – 15cm soil depth, shoot dry weight and root dry weight (biomass) between soils under woodlot and garden soil were similar ($P \geq 0.05$) for six weeks (Table 5). However, within 15 – 30cm soil depth, shoot dry weight and root dry weight also did not differ significantly ($P \geq 0.05$) between soils under woodlot and garden soils for six weeks.

5.3.2 Effect of height on woodlot and garden soil after third and sixth week

Height at 3 weeks on woodlot soil depth 0-15cm had 25.33cm whiles garden soil had 26.67cm. Height at 6 weeks on woodlot soil depth 0-15cm had 86.00cm whiles garden soil had 88.33cm. Height at 3weeks on woodlot soil depth 15-30cm had 25.00cm whiles garden soil had 22.67cm. Height at 6 weeks on woodlot soil depth 15-30cm had 76.33cm whiles garden soil had 70.00cm. Height of maize was not significantly different ($P \geq 0.05$) on soil depth of 0 – 15cm for three weeks and six weeks (Table 5). However, height on soil depth of 15 – 30cm did not differ significantly ($P > 0.05$) on both woodlot and garden soil for third weeks and sixth weeks (Table 6).

5.3.3 Effect of diameters on woodlot and garden soils after third and sixth weeks

Diameter at 3weeks on woodlot soil depth 0-15cm had 2.80cm whiles garden soil had

3.00cm and height at 6weeks on woodlot soil depth had 5.90cm whiles garden soil had 6.33cm. Diameter at 3weeks on woodlot soil depth 15-30cm had 2.93cm whiles garden soil had 3.80cm and height at 6weeks on woodlot soil depth had 5.57cm whiles garden soil had 6.00cm. Diameters of maize did not differ significantly (P>0.05) on soil depth of 0 – 15cm for three weeks and six weeks (Table 5). However, soil depth of 15 – 30cm also showed no significant difference (P>0.05) in diameter between woodlot and garden soils for third and sixth weeks (Table 6).

5.4 Discussion

This research hypothesized that, *Tectona grandis* woodlot soil have no allelopathic effect on maize growth. The results of this study showed that there is no significant differences between woodlot soil and the garden soil (P≥0.05) for the soil depth of 0-15cm and 1530cm for all the parameters studied including shoot dry weight, root dry weight, height and diameter (Table 5and 6).

The lack of differences could be attributed to there was on allelochemicals in woodlot soils and also the fertility status was the same for the soils used. This observation is also similar to Rhoades, (1977) who reported that, soil that develops under natural forest and woodlot is fertile and a store of nutrients bound up in the organic matter. Also, nitrogen is often higher and sometimes phosphorus, potassium and other exchangeable cations.

Therefore woodlot soil did not have any adverse effect on the maize plants.

Again, it could be attributed to the fact that, highest concentrations of allelochemicals are near the soil surfaces and are more rapidly lost in the soil through volatilization (Chen et al., 1991). However, the no significant differences observed in this study could probably be attributed to the fact that, the woodlot soils were air - dried before being used in the study which may have contributed to the alleviation of phytotoxicity content in the soil since the allelochemicals in the soils are volatile. Moreover, the allelochemicals may also be easily leached out by heavy rainfall (Tian, 1992).

However, it could suggest that decomposition of the leaves and roots under the woodlot had a beneficial effect on the maize plant by providing them with nutrient. Similar results were made by Kang et al., (1981) who reported that nitrogen supply from decomposing mulch may also contribute to alleviation of phytotoxic effect of *Gliricidia* mulch.

Chen et al., (1991) also reported that highest concentration of allelochemicals are near the soil surface are rapidly lost in the soil. Furthermore, Chen et al., (1991) conducted a study to determine the allelopathic effect of rye compound on several plant species. They found that larger seeded and deeper seeds were less sensitive to the allelochemicals. This was likely due to the highest concentration of allelochemicals being near the soil surface where small seeded species typically germinate. Therefore selectivity can be achieved, based on size and seed placement. This study indicates that, no adverse effect was observed because, maize seeds were larger that is why there were no significant difference. However, during this study, an observation made under the *Tectona grandis* woodlot shows that there was little vegetation under the woodlot which indicates that weed seeds are smaller and normally germinates on the surfaces of the soil.

The work in this study are inconsistent with the findings of Todaria and Bhatt, (1990) who reported that the difference in yield of crops treated was considerably high and statistically significant for all crops. Yield in the control was higher as compared to treatment thereby indicating the adverse effects of crops. All the characteristics of the test crop including shoot length, root length, dry matter production were all suppressed. Again, Todaria and Bhatt (1990) reported that inhibition was highest under mulch with dry leaves.

5.6 SUMMARY AND CONCLUSION

This study tested the hypothesis that soils under *Tectona grandis* woodlot have no allelopathic effect on maize growth. Generally, within 0 – 15cm soil depth, shoot dry weight, root dry weight, height and diameter showed no significant ($P>0.05$) differences between means. Also, within 15 – 30cm soil depth, shoot dry weight, root dry weight, height and diameter showed no significant ($P>0.05$) differences between means. Based on these results it can be concluded that soil under *Tectona grandis* woodlot had no allelopathic effect on maize growth but rather had a beneficial effect on maize. Also the no significant difference could be attributed to the fact that woodlot soil had no allelochemicals that affected maize growth. Again woodlot soil had allelochemicals that did not have effect on maize growth.

CHAPTER 6

6.0 GENERAL SUMMARY AND CONCLUSIONS

This research tested four hypotheses and the following conclusions could be drawn. The first hypothesis was that, leaf extracts of *Tectona grandis* have no allelopathic effect on maize seedlings. The results shows that, shoot length, root length, shoot and root dry weight were significantly (P>0.05) higher. Therefore, the hypothesis was rejected. The study also revealed that, the root length was much more inhibited than the shoot length. Lower concentration 25% and 50% allelochemicals showed stimulatory effect whereas higher 75% and 100% extract concentration showed inhibitory effects.

Secondly, it was hypothesized that, there is no allelopathic effect of *Tectona grandis* mulch on maize growth. Generally the results revealed that, there is no significant (P>0.05) effect on height, diameter and yield of maize. Therefore, the hypothesis was accepted. Thirdly, it was hypothesed that, *Tectona grandis* mulch has no allelopathic effect on weed growth. The hypothesis was accepted since there was no significant (P > 0.05) difference in the mulch rates.

Finally, it was hypothesed that, there is no allelopathic effect of soils under *Tectona grandis* woodlot. Generally, within 0.15cm soil depth, shoot dry weight, root dry weight, height and diameter showed no significant (P>0.05) differences between mean. Therefore, the hypothesis was accepted since, the means were similar. Also, within 15 – 30cm soil depth, shoot dry weight, root dry weight, height and diameter showed no significant (P>0.05) differences between means. Therefore, the hypothesis was accepted because, the means were similar. Also, within 15 – 30cm soil depth, shoot dry weight, root dry weight, height and diameter showed no significant (P>0.05) differences between mean. Therefore, the hypothesis was accepted because, the means were similar and allelochemicals in soils are rapidly lost near soil surface and soil organisms are capable of detoxifying allelochemicals in soil.

Based on the overall finds of this research, these conclusions were drawn. Firstly, allelopathy is a concentration – dependent phenomenon. The allelochemicals present in *Tectona grandis* can have an allelopathic inhibitory effect on different crops associated with *Tectona grandis* plantation and also different agroforestry systems in field conditions. Secondly, addition of *Tectona grandis* mulch in the field had a beneficial effect on maize since; the allelochemicals in the mulch are transient. It is known that *Tectona grandis* mulch have the ability to control weeds. Finally soil under *Tectona grandis* woodlot has no effect on crops.

6.1RECOMMENDATIONS

1. Further work should be carried out on the field by planting maize in association with *Tectona grandis* and maize following woodlot after harvesting.
2. Further work should be conducted on chemical composition of *Tectona grandis* leaf extract.
3. Further work should be carried out using *Tectona grandis* parts that is bark and roots.

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