AUTOALLELOPATHY OF SELECTED MULTIPURPOSE TREE SPECIES AND THE EFFECT OF THEIR LEACHATES ON AGRICULTURAL TEST CROP

By

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(2014-17-110)

THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Autoallelopathy of selected multipurpose tree species and the effect of their leachates on agricultural test crop"** is a bonafide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of any other University or Society.

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Introduction

INTRODUCTION

Allelopathy may be defined as the science which studies processes, whereby the secondary metabolites from plants and microorganism affect the growth and development of biological systems (Rice, 1984). These secondary metabolites are broadly named as allelochemicals and are released into the surroundings by volatilization, leaching, exudation and decomposition. The presence of allelochemicals implies a positive or negative effect on the germination and growth of the surrounding plants. The study of allelopathy is very much vital in agroforestry systems, since trees and agricultural crops are grown together; the yield from the crops depends on the nature of tree-crop interaction. Generally allelochemicals are found to reduce the yields of agricultural and silvicultural crops. The allelochemicals also plays a crucial role in the basic metabolism of the plants affecting their physiological and biochemical activities. In order to sustainably manage the system, it is very much essential to identify the tree crop compatibility.

Autoallelopathy is the situation, where the germination and growth of a species is inhibited by the chemicals released by themselves. The autoallelopathic action is noticed in many orchards and in fields where the same vegetables are grown continuously. The long term effect of growing a tree or crop continuously in the same field and the consequent change in growth pattern is essential. Only such a study can predict the possible ameliorating measures that can be adopted in such situation. Monoculture or pure plantations in long run may deteriorate the soil not only by depleting the soil nutrients but also by accumulating the allelochemicals. Eventhough there are a lot of literature pertaining to the allelopathic effect of many weeds and agricultural crops, the autoallelopathic and allelopathic details related to most of the tree species grown under agroforestry systems are unknown.

Multipurpose trees species like *Acacia auriculiformis* (Auriculiformis), *Acacia mangium* (Mangium), *Ailanthus triphysa* (Matti), *Grevillea robusta* (Silver oak) and *Swietenia macrophylla* (Mahogony) have been established as plantations and is incorporated in agroforestry models across the state of Kerala to meet the growing demands. It is not known, on a long run whether there will be any deleterious effects on the soil and consequently on the crops which are grown along with these trees.

In the Kerala context, the relevance of these selected tree species are well known, owing to their fast growth and multiple uses. The multiple uses of *Acacia auriculiformis* has recently generated a greater interest due to its teak–like grain, and has begun to be used in joinery and furniture making as cheap substitute of teak. *Acacia mangium* is another important species used in plantation forestry programs due to its fast growth. *Ailanthus triphysa* is a medium to tall evergreen tree species and the wood is used in matchwood and plywood industry. *Grevillea robusta* is another fast growing evergreen tree, the wood of which is used in the manufacture of body building of heavy vehicles, furniture, cabinetry and fences. *Swietenia macrophylla* is another important tree species that is being extensively planted by the farmers all along the borders of farms and also as managed block plantations.

Though there are well established plantations and also a recent boom in the cultivation of the above mentioned trees in many parts of Kerala, the possible allelopathic effects have not been thoroughly investigated so far. It is also not known whether there will be any deleterious effect on the soil and on the crops particularly in the polyculture production systems involving trees and crops in an intricate mixture. The present study will address the important issue of autoallelopathic effect of the selected tree species on the growth and development of the seedlings of the same species and on the agricultural test crop.

To explore into such an important and current issue of practical relevance, the present investigation was undertaken with the following objectives.

1. To investigate the possible autoallelopathic effects of leachates of selected multipurpose trees (MPTs).
2. To study the effects of leachates of the above MPTs on the germination and growth of selected agricultural test crop.

Review of literature

REVIEW OF LITERATURE

Tree-crop interactions are implicit in agroforestry system as the trees and crops are grown together in intricate mixtures and such interactions can be positive or negative (Basavaraju and Gururaja, 2000). Such stimulatory or inhibitory effect caused as a result of the release of various secondary metabolites is regarded as allelopathy. Allelopathy as defined by Rice (1984) is the science which studies processes, whereby the secondary metabolites from plants and microorganism affects the growth and development of biological systems. In many of the instances the term allelopathy is used to denote the inhibitory effect of the biochemical released by the plants. But, it need not be always inhibitory. According to Narwal (1994) the allelochemicals which inhibit the growth of a particular species at a certain concentration may show a positive effect on the growth of the same or different species at different concentrations. The effect of allelochemicals on the growth of the surrounding plants or crops or on itself can be noticed as it once reaches the target plant. The secondary metabolites from various parts of the trees or plants including shrubs, herbs and grasses called as allelochemicals is released to the surroundings by processes such as volatilization, leaching, root exudation, and decomposition of plant residue (An *et al.,* 2003). The study of allelopathy has immense potential in agroforestry as these physiological and biogeochemical processes are responsible for the development of suitable tree crop combinations in these systems.

The literature pertaining to the objectives of the present investigation are reviewed in this chapter.

2.1 ALLELOPATHY IN AGROFORESTRY

The growing of trees and crops together is an age old practice, were the different green components may compete for various natural resources like, light, water, and nutrients or they may have complementary needs. When the interactions between the trees and crops are managed well under agroforestry systems, traditional or modern, it can outperform sole cropping systems. In most of the cases allelopathic effect are selective and vary with different tree crops (Melkania, 1986). In general the highest concentration of allelochemicals are found in the leaves; however, these toxic secondary metabolites are also present in all other plants parts in varying concentrations. In certain species the allelopathic effect may be very much outstanding, making it difficult to explain with the theory of competition for resources why some species in the plant community regulates through the production and release of chemicals attractants, stimulators or inhibitors (Putnam and Tang, 1986).

Rice (1984) reported the presence of allelochemicals in several crop species, such as maize (*Zea mays*), wheat (*Triticum aestivum.*), oats (*Avena sativa*) and barley (*Hordeum vulgare*). Rafiqul-Hoque *et al.* (2003) have identified the presence of higher concentration of bioactive chemicals in certain trees, suggestive of a large inhibitory potential (Barnes *et al.*,1996). The integrated land use system for production in agroforestry makes the situation very complex. This complexity is attributed due to the difference in the potential of different trees to show different type of stimulatory (positive) or inhibitory (negative) effect on crops. The effect of tree allelochemicals in the growth of annuals and legumes has been estimated through experiments. Mimosine toxicity of *Leucaena leucocephala* was observed on green gram *i.e.* inhibitory effect on germination. The possible allelopathic effect of *Acacia* trees has also been recognized (Rafiqul-Hoque *et al.*, 2003). In certain species there are evidences for the presence of autotoxicity which is responsible for the inhibition of seed germination and or delay of seedling growth and can be seen in some annuals including corn, *Zea mays* (Martin *et al.,* 1990) and wheat, *Triticum aestivum* (Jessop and Stewart, 1983). Allelochemicals in soil and their effect on crop plants may be modified by soil moisture, soil temperature and other soil factors (Patrick and Koch, 1958). The effects of secondary substances released by plants can be long lasting (Patric, 1971) or quite transitory (Kimber, 1973) and can ultimately influence practices like fertility, seeding and crop rotations.

Allelopathy is exhibited by a number of living organisms belonging to different taxonomic groups such as microbes, algae, fungi, ferns, gymnosperms and angiosperms (Rice, 1995). Among these, tree allelopathy assumes greater significance due to their larger size and perennial habit which may serve as a major and continuous source of allelochemicals in soil. According to Rice (1984) tree allelopathy is responsible for many visible effects such as barren forest floor or poor vegetation under canopy of some trees, regeneration problem of propagules of some of the forest tree species, and plodding loss of species diversity. The effect of allelopathy is found under both plantations and natural forests. Trees incorporated in agroecosystems in various ways may also bring about significant effects on the associated crops and result in reduction in crop productivity (Kohli *et al.,* 2006). The role of allelopathy, particularly in the tropical regions is very much prominent In the tropics, agroforestry systems in particular, allelopathy plays an important role in influencing both the negative effects and positive benefits and is a major factor in formative tree–crop–soil interactions (Rao *et al.,* 1998). The potential of different tree parts like the leaves, stem, root, fruits, flowers, litter etc., to act as an allelopathic source has been studied in various tropical species (Rice, 1984, 1995; Lisanework and Michelsen, 1993). Rizvi *et al.* (1999) extensively reviewed the role of allelopathy under various agroforestry systems and identified more than 80 trees having allelopathic sway on the crops grown along with them. But, the major drawback of these researches is that the results are based mainly on the laboratory experiments with entirely different conditions when compared to the natural environment. So, the studies fail to explain the action of these chemicals in the field conditions. The allelopathy of certain tree species like eucalyptus, populus, leucaena, and walnut is well documented under laboratory and field conditions and provides a strong basis for conducting allelopathic research under agroforestry systems.

A number of studies have shown that mulches and prunings of trees may release allelochemicals and thus suppress crop growth. Kamara *et al.* (1999) studied the effect of leaf extracts and mulch from 5 year old multipurpose trees (MPTs) viz. *Gliricidia sepium*, *Leucaena leucocephala*, *Enterolobium cyclocarpum*, *Senna siamea*, *Tetrapleura tetraptera*, *Milletia thoningii*, *Lonchocarpus sireceus*, *Pithecelobium dulce*, *Terminalia superba*, *Gmelina arborea*, *Grewia pubescens*, *Pterocarpus santalinoides*, *Nuclea latifolia* and *Alchornia cordifolia* on cowpea (*Vigna unguiculata*). Leaf extracts and mulch from *Gliricidia sepium*, *S. siamea*, *M. thoningii*, and *Grewia pubescens* significantly reduced germination and early growth of cowpea. Further, mulch from the trees with fast decomposing leaves viz. *Leucaena leucocephala*, *Gliricidia sepium*, and *Grewia pubescens* was found to be more phytotoxic. These workers postulated allelopathy, in addition to nitrogen immobilization, as the possible reason for the observed effect. Kamara *et al.* (2000) tested 14 MPTs for their phytotoxic effects against *Zea mays* (maize). The study reported that trees like *Gliricidia sepium* and *L. leucocephala* with fast decomposing foliage supplied more nitrogen to the soil and thus growth of maize was better in their mulches. However, the growth of maize was stunned when mulch decomposed slowly and released lesser nitrogen. The study concluded that allelopathic effects of leaf extracts of MPTs diminished under field conditions and is thus ecologically irrelevant. Anthofer *et al.* (1998) tested the effect of leaf prunings of nine agroforestry trees viz. *Grevillea robusta*, *Erythrina abyssinica*, *Gliricidia sepium*, *Albizia schimperiana* , *Acacia nilotica* , *A. polyacantha* , *L. leucocephala*, *L. pallida* and *Entada abyssinica* on the growth of wheat (*Triticum aestivum*) under a pot trial experiment. Leaf prunings of *L. leucocephala*, *L. pallida*, *G. sepium*, and *E.*

abyssinica proved good for the growth of wheat, whereas those of *Grevillea robusta, A. polyacantha, A. nilotica,* and *Erythrina abyssinica* adversely affected the growth of wheat. The adverse effect of the leaf prunings of these agroforestry trees was attributed to allelopathy in addition to N immobilization.

King (1979) pointed out the need for investigations of allelopathy in various tree species used in agroforestry where there is a good chance of allelochemicals release by the intercrop trees affecting food and fodder crops. Therefore, it seems essential that the allelopathic compatibility of crops with trees should be checked before introducing in agroforestry system (Gaba, 1987).

2.2 ALLELOPATHY IN SOME IMPORTANT TROPICAL TREE SPECIES

2.2.1 Allelopathy in *Acacia auriculiformis*

Acacia auriculiformis, a leguminous species (Mimosoideae), naturally distributed in Australia, Papua New Guinea and Indonesia (Pinoyopusarerk, 1990), introduced in Bangladesh for afforestation and reforestation of degraded and wasteland areas (Rahman, 1984 and Das, 1985). Although the species is fast growing and can grow in wide ranges of soils (Davidson, 1985) the ground vegetation under its canopy indicated that it has some allelopathic potentials which might have been caused either by fallen leaves (through decomposition of litter) or plant leachates or root exudates. Consequently, the release of allelochemicals (organic substances) into the soil inhibits seed germination and establishment of agricultural crops and vegetation (Rice, 1979). Petmark and Williams (1991) recommended *Acacia auriculiformis*as agroforestry species. Very few researches were done on this aspect in case of *Acacia auriculiformis* (Jadhav and Gaynar, 1992; Rao *et al.,* 1994; Bora *et al.,*1999) in tropics.

2.2.2 Allelopathy in Eucalyptus species

The genus Eucalyptus is indigenous to Australia and has been introduced into many countries, owing to their fast growth and their ever increasing demand in paper and plywood industries (Turnbull, 1999; Cossalter *et al.*, 2003). Considering its fast growth (Cossalter *et al.*, 2003), wider adaptability (Gardner, 2007; Johansson *et al.*, 1996) and high productivity (Singh and Toky, 1995), many Eucalyptus species are grown in agricultural fields in order to bridge the widening gap between the demand and supply of raw materials. However, there is no difference in opinion about the ecological functions of Eucalyptus and that it reduces the diversity of understorey species and the productivity of understory crops (Moradshahi *et al.*, 2003), because its allelochemicals have potential effects on the growth of other plant species (Turnbull, 1999). Many studies have evaluated the allelopathic effects of Eucalyptus species (Sasikumar *et al.*, 2003). It is revealed that certain phenolic acids and volatile oils released from different parts of the tree like leaves, bark and roots of certain Eucalyptus species act as allelopathic agents and are harmful to other plant species growing in its vicinity (Sasikumar *et al.*, 2003). The allelopathic effects have been mostly studied of litter extracts and least of live root extracts (Singh *et al.*, 2005). The extracts of leaf litter and root exudates of *Eucalyptus urophylla, E. citriodora* and *E. camaldulensis* inhibited the germination speed and seedling growth of radish. The root exudates of *E. urophylla* stimulated the seed germination but did not affect the seedling growth. For cucumber, the applications of leaf and root exudates have a positive effect on the germination. Exudates of all Eucalyptus species stimulated the seed germination, while their leaf litter was inhibitory to seedling growth. Thus, it can be said that cucumber can be grown well under three eucalyptus species, if their leaf litter were removed in tree-crop agroforestry systems. The allelopathic effects of leaf litter were found to be stronger than root exudates. Removal of litterfall might be a good management strategy to nullify the allelopathic effects of eucalyptus on understory crop species.

The monoculture plantations are reported to support either very little or almost negligible understorey vegetation (Singh *et al.*, 1993) and the species diversity index are also found to be very low when compared with other native plantations. The possible reason for species depletion is often been identified as allelopathy (Suresh and Rai, 1987; Kohli *et al.*, 1997). In agroforestry, Eucalyptus species are usually planted on the field boundaries as windbreaks, shelterbelts, or simply scattered in the fields. Studies shows that eucalyptus used as shelterbelts are very harmful to the crops growing in the adjoining area (Kohli, 2006). Kohli and his associates reported a significant decline in the density, root and shoot length, biomass, and economic yield of crops up to 11 m from the shelterbelts of *Eucalyptus*. Based on the evaluation of bioefficacy of phytotoxins (extracted from the soil collected at different distances from the tree, and at varying depth), the impoverished performance was attributed to the allelopathic property of *Eucalyptus* (Singh and Kohli, 1992). *Eucalyptus* is reported to release a variety of volatile and nonvolatile allelochemicals that affect growth of associated vegetation (Kohli, 1990). Various volatile terpenes like limonene, cineole, citronellal, citronellol, a-pinene, and grandinol, etc., were identified from the crude oil are highly allelopathic and affect the germination and growth of native vegetation (Kohli *et al.*, 1992).

Under natural conditions, volatile oils are released from the leaves through diffusion and being heavier than air, it descents and get adsorbed to the surface of soil particles, and thus affect the vegetation supported by this soil. The content of the oil in leaves varies considerably with species, climatic conditions, soil conditions and also due to seasonal changes. The germination, seedling vigor, and seedling length of the four crops, namely, *Phaseolus aureus*, *Hordeum vulgare,* and *Avena sativa* were significantly reduced when placed in chambers flushed with eucalyptus oil. The

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germination of *P. aureus* placed in petridishes having eucalyptus absorbed soil is found to be very poor (Singh *et al.*, 1992). The volatile allelochemicals have also been found to hinder respiration, reduce the chlorophyll content, and cause wilting (Kohli and Singh, 1992). In addition, the leachates and extracts from the eucalypt leaves, litter, bark and leaf mulch have been reported to decline the germination and initial growth of a number of plant species (Lisanework and Michelson, 1993).

A variety of agricultural crops were tested for their susceptibility or resistance to the aqueous leachates of *Eucalyptus*. The levels of resistance were related to the ratio of thickness of the seed coat and volume of seed (Kohli, 1994). Studies conducted by Kohli (1994) and Singh (1991) demonstrate that in a plantation, both volatile as well as nonvolatile allelochemicals are continuously being added to the soil system. The soil collected from the floor of these plantations was found to be rich in phenolic compounds and their content varied with distance as well as depth. The study conducted by Kholi (1990), identified a number of phenolic acids like gallic acid, gentisic acid, syringic acid, vanillic acid, caffeic acid, *p*-coumaric acid, ferulic acid, and cinnamic acid in the soil as well as in the leaves.

2.2.3 Allelopathy in *Leucaena leucocephala*

Leucaena is a widely recommended tree species for agroforestry owing to its fast growth rate, fodder, fuel and wood value, nitrogen fixing ability, and to enhance the overall productivity of land (Chou and Waller, 1989; Nair, 1989; Lantican and Taylor, 1991). However, the presence of a non-protein amino acid along with some phenolic compounds in its leaves and seeds is a cause of concern to allelopathic researches and ecologists. After working with different species of *Leucaena* for several years has concluded that exclusion of understorey vegetation by *Leucaena* is at least partly mediated by allelopathy (Kuo *et al.*, 1983; Chou and Kuo, 1986; Chou, 1993). According to Suresh and Rai (1987 and 1988) seed germination, root length,

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and dry matter production were reduced in sunflower and sorghum when grown in top soil collected from the field or when the soil is mulched with dry leaves or irrigated with aqueous leaf extracts.

Many other studies also reported the allelopathic effect of aqueous extracts of leaves, litter, soil, leaf leachate, seed exudates, dry leaf mulch, topsoil, and its allelochemicals. *Abelmoschus esculentus, Acacia confusa, A. nilotica, Ageratum conyzoides, Alnus formosana, Bidens pilosa, Brassica chinensis, B. juncea, Cajanus cajan, Casuarina equisetifolia, C. glauca, Cicer arietinum, Helianthus annuus, Lactuca sativa, Liquidambar formosana, Mimosa pudica, Miscanthus floridulus, Phaseolus vulgaris, Pinus taiwanensis, Stachytarpheta jamaicensis, Sorghum bicolor,* and *Vigna radiata* are some of the negatively sensitive species to allelochemicals of *Leucaena* (Narwal, 1996; Sinha, 1996). According to a report of the International Institute for Tropical Agriculture (Anon., 1980), the yield of maize (*Zea mays*) and rice (*Oryza sativa*) was found to increase when grown in association with *Leucaena*. Rachie (1983) found an increase in the production of maize intercropped with *Leucaena*. Studies conducted by Jeyaraman (1991) and Salazar *et al.* (1993) supported a positive influence of *Leucaena* green leaf mulch on several growth and yield contributing parameters of rice, resulting in a higher yield. *Cajanus cajan,Sesamum indicum, Ricinus communis,* and *Sorghum vulgare* are some of the plants that are positively affected by *Leucaena* (Singh, 1983). However,the effect of the same in maize is condradictory. Karim *et al.* (1991) reported a reduction in growth and yield of maize grown in association with *Leucaena* hedges. The presence of a number of phenolic compounds and mimosine attributes to the allelopathic property of *Leucaena.* The differences in concentrations of mimosine have been found to act inhibitorily when applied to different plants. Germination, length of radicle and plumule of *Abelmoschus esculentus, Brassica campestris, Phaseolus aureus, Raphanus sativus, Triticum aestivum,* and *Vigna mungo* have been found to be inhibited by 1 m*M* mimosine. *Phaseolus aureus* and *V. mungo* were affected the most and showed an 83 and 86% inhibition of radicle growth, respectively. Rizvi *et al.* (1992) have found that mimosine inhibits many of the physiological and biochemical parameters in *V. mungo* and *P. aureus.* They observed that mimosine inhibited seedling vigor, food mobilization efficiency, solubilization of starch, breakdown of proteins, and activity of amylase. The decreased amylase activity was at synthetic as well as catalytic level, and it was mediated by gibberellic acid. They further stated that mimosine altered the hormonal balance of the seedlings leading to an inhibition in their growth. When *V. mungo* plants were grown in the soil with *Leucaena* leaves at different amounts of , nitrogenase activity of root nodules was inhibited (Rizvi and Rizvi, 1998). A report by Prasad and Subhashini (1994) confirms the inhibitory effects of mimosine on germination and seedling growth of rice mediated through its effect on nitrate reductase, catalase, IAA-oxidase, peroxidase, and its isozymes.

2.2.4 Allelopathy in *Populus deltoids*

Owing to fast growth, the tree is widely recommended under agroforestry programs and is used as shelterbelts wind breaks or in bund plantations. But, researches carried out to study the allelopathic activity of the species revealed the possible negative impact of the leaf litter on the crops. Singh and his associates (1998) monitored the possible effect of *Populus deltoids* shelterbelts on the productivity of wheat. Their study observed that the density, biomass, and yield were noticeably abridged to about 12 m in the fields with populous shelterbelts than with the unsheltered fields kept as control. The wheat productivity was found to be considerably high after 12 m. Added, the same observations are being marked for the experiment with sheltered field of wheat with populous at 20m. However, after a distance of 20 m, they noticed no significant alteration in the yield making the effect of shelterbelt negligible. In general, the populous sheltered fields are having lesser productivity than the ones which are being kept unsheltered. The possible reason for this reduced vigour and production is explained though the allelopathic behavior of the tree in question. These observations are being proved correct by the findings that the correlation between the concentration of the phenolic compounds is inverse (Singh *et al.*, 1998). Singh *and* his associates (1999) conducted an experiment to evaluate the relative performance of two shelterbelt species- *Populus deltoides* and *Dalbergia sissoo*. The result showed a fovourable result for *Dalbergia sissoo* than for *Populus deltoids*. Analyzing the datas obtained through the study they came to the finding that though trees generally retard the growth of crops below them or nearer to them the effect is sever in those species having allelopathic nature. This implies that in an agroforestry system the species should be grown together only by checking their compatibility. Singh *et al.* (2001) tried to find the comparative efficiency of certain selected seasonal crops such as wheat, lentil, mung bean, oat, clover, rapeseed, and sunflower. The study was conducted in a system whereby the selected crops are grown in alley with *Popolus deltoid* under two conditions first- by retaining the *Populus deltoid* soil in the experimental site and the second- by replacing the soil from an area with no *Populus* trees. The result of the study was in agreement with the allelopathic nature of the tree species observed by the other scientists. The marked reduction in the germination in the first case was identified to be due to the presence of allelochemicals present in the soil. Allelopathic nature of the tree species is proven under laboratory conditions also. Soil analysis from under the tree canopy signed the presence of certain allelochemicals in it like phenolic acids and salicin (Singh, 1996).

2.2.5 Allelopathy in *Gliricidia sepium*

Gliricidia is a multipurpose tree species highly recommended in the tropical agroforestry systems. Tian and Kang (1994) demonstrated the leaf pruning effect of *Gliricidia sepium* on the germination and growth of maize and cowpea under the conditions of laboratory and field. Maize responded to the treatment of application of leaf extracts by showing a retarding growth. The mulch of the tree in the field resulted in the formation of leaf chlorosis in both the agricultural crops. The result showed a comparatively better performance by the cow pea than maize in the treatments. Presence of various phenolic groups have been made by Ramamoorthy and Paliwal (1993) and include allelochemicals such as gallic acid, protocatechuic acid, p-hydroxybenzoic acid, gentisic acid, b-resorcyclic acid, vanillic acid, syringic acid, p-coumaric acid, m-coumaric acid, o-coumaric acid, ferulic acid, sinapic acid, coumarin, and myricetin.

2.2.6 Allelopathy in *Azadirachta indica*

Neem is an indigenous tree to Indian continent has been exploited for medicinal and antimicrobial properties from very ancient time onwards. With the advent of research, besides the conventional uses many more uses of the same has been exploited. The U.S. National Academy of Science acknowledged the tree as a “tree for solving global problems” (Anon, 1992). However, some experimental results indicates the possible allelopathic effect of the tree selected crops. According to the study of Puri and Bangawa (1992) the crop yield in sorghum (*Sorghum bicolor*) varied from 7 to 33% and 3 to 16% in safflower (*Carthamus* sp.). The study also found that the yield of wheat to be unaltered when grown under neem when grown 5 m apart from the main stem.

2.3 AUTOALLELOPATHY

Autoallelopathy occurs when a plant releases toxic chemical substances into the environment that inhibit germination and growth of same plant species (Miller, 1996). Also known as Autotoxicity or Autointoxication, it has been known to occur in a number of weeds and crops in natural and agroecosystems, fruit trees in orchards and in vines, trees, and shrubs in natural forests and plantations. Besides, some lower plants such as ferns are also known to exhibit the phenomenon of autoallelopathy. Various parts of the plant are responsible for autotoxic behavior such as leaves, roots, shoots, fruits, seeds, cotyledons and seed coat, rhizome, inflorescence, leaf litter and plant residues, etc. (Curtis and Cottam, 1950; Tamura *et al.,* 1967; Newman and Rovira, 1975; Miller, 1996). The chemicals responsible for bringing about such effects are known as Allelochemicals or Autochemicals or simply Phytotoxins. Varieties of such chemicals are found in plants and are either secondary metabolites or the waste products of the primary metabolic processes (Swain, 1971). The chemical nature of these compounds can be simply organic acids, straight chain alcohols, aldehydes or ketones, unsaturated lactones, fatty acids, naphthaquinones, complex quinones, simple phenols, phenolic acids, tannins, terpenoids (monoterpenes, sesquiterpene lactones, and diterpene lactones), amino acids, polypeptides, alkaloids, glucosinates, purines, and nucleotides, etc. (Rice, 1995; Seigler, 1996). The release of these chemicals from the plant is facilitated by many processes such as leachation from the living as well as the dead plant parts, root exudation, decomposition, and volatilization (Guenzi and McCalla, 1962; Kumari and Kohli, 1987; Singh and Kohli, 1992; Bradow and Connick Jr., 1990; Einhellig, 1995; Kohli *et al.,* 1997; Inderjit, 1996). Autotoxicity has been observed in both natural as well as in the manipulated ecosystems such as grasslands, wastelands, fields, natural forests, plantations, orchards, etc., where it causes a number of ecological and economic implications such as a decline in crop yield due to soil sickness, regeneration failure of natural forests, replant problem in orchards etc. Species possessing the autotoxic phenomenon are known to regulate their populations over space and time, avoid intra-competition, self-perpetuation, and better geographical distribution although there is no evidence that they are favored by natural selection.

2.4 AUTOALLELOPATHY ASSOCIATED REGENERATION PROBLEM

Regeneration of trees is affected by a number of factors both climatic and biological, such as organic matter accumulation, acidification of soil, nutrient cycling, and allelopathy. Allelopathic effects of associated species also adversely affect the natural regeneration of the trees, for example, ericaceous members in the coniferous forests (Mallik, 1995) and *Vaccinium myrtillus* in the spruce forests (Gallet, 1994). Often the trees release allelochemicals after leachation and degradation of litter, root/mycorrhizal exudates, and bark, which interferes with the germination, growth, and establishment of young seedlings. Examples of autotoxicity are numerous in coniferous forests, for example, *Abies balsamea* (Thibault *et al.,* 1982), *Araucaria cunninghamia* (Bevege, 1968), *Cunninghamia lanceolata* (Zhang, 1993), *Picea abies* (Gallet, 1994; Pellissier, 1994), *Picea mariana* (Thomas, Jr., 1974; Mallik and Newton, 1988), and *Pinus radiata* (Chu-chou, 1978). In the forest ecosystems litter that falls extensively on the ground remains the principal reason for the regeneration problem as it is known to release allelochemicals, particularly the phenolics after degradation and leachation (Blashke, 1979; Kuiters, 1990; Appel, 1993). In the case of *Picea abies* litter and root extracts and soil solutions show toxicity toward its own seedlings (Weissen and van Praag, 1991) and *p*-hydroxyacetophenone — the main allelochemical besides many other phenolic acids and tannins has been isolated from water extracts of litter and organic layer (Gallet, 1994).

2.5 PHYSIOCHEMICAL PROPERTIES OF LEACHATES FROM PLANT PARTS

The allelopathic activities of leachates of plant parts can be related to its physicochemical properties. The concentration of total carbohydrate was found to be greater than that of free sugar in the leaf and inflorescent leachate of *Leucas aspera, L. lavandulifolia, L. stricta and L. cephalotes* (Kamat and Singh,1994). Tripathi *et al.*

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(1998) in a study quantified the soluble protein, carbohydrate, proline and the total phenol content in the leaf extract of *Tectona grandis*, *Albizia procera* and *Acacia nilotica*. The result showed a higher concentration of protein in *Albizia procera* followed by *Acacia nilotica* and *Tectona grandis* and phenol content in the order *Acacia nilotica* > *Tectona grandis* > *Albizia procera*.The influence of fruit leachate of *Terminalia pallida* on the biochemical composition of *Vigna radiata* seedlings was studied and the results showed that 15 out of 25 amino acids were reduced to undetectable levels, decreased the level of gibberellins like substances and increased the production of several phenolic compounds particularly caffeic, ferulic and gentisic acids in the seedlings at higher leachate concentration (100 per cent) (Lakshmipathichetty and Rao, 1994).

Sivagurunathan (1997) estimated the physiochemical properties of different plant parts of three *Eucalyptus* species, viz., *Eucalyptus citriodora, E. globulus and E. tereticornis*by collecting the leachates at 6 hours interval from 0 to 36 hrs and recorded significant increase in electrical conductivity, total solids, reducing sugars, total sugars, total protein, total phenols and decline in pH with an increase in soaking period. Naidu *et al*. (2000) estimated the polyphenol oxidase and peroxidase enzyme activities in different seed parts of *Sapindus trifoliatus* and inferred that the polyphenol oxidase activity was found to be maximum in mesocarp. Singh and Ranjana Singh (2003) found that the leaf leachate of *Eucalyptus citriodora* significantly increased the sugar and organic acid content in *Vigna radiata, Vigna mungo* and *Arachis hypogea*, however a reduction in aminoacids was observed over the control.

Hemaiswarya *et al*. (2008) found that the bark leachates of *Thespesia populnea* significantly decreased the chlorophyll content over the control, indicating the inhibitory role of allelochemicals on photosynthesis and the total protein content of Amaranthus shoots decreased with increasing concentrations of bark leachates.

Kavitha *et al.* (2012) reported that the fresh and dry weights, Chlorophyll, aminoacid and protein contents of green gram *(Vigna radiata)*, Black gram *(Vigna mungo)*, groundnut *(Arachis hypogaea)*,pearlmillet *(Pennisetum typhoides)* and fingermillet*(Eleusine coracana)* seedlings were decreasing with increasing concentration of leaf extracts.

2.6 EFFECT OF LEACHATES OF TREE PARTS ON SEEDLING GROWTH

The primary effects of allelopathy on crop production would seem to be a result of toxin release from plants into the soil (Borner, 1960; Patrick, 1971). The secondary compounds are present in varying concentrations in plant parts. The residues remaining after harvest may release allelopathic compounds following a rainfall or through litter degradation by microorganisms (Patrick *et al.*, 1963: Kimbler, 1973). The effect of these secondary substances may be long lasting (Patrick, 1971) or quite transitory (Kimbler, 1973) thus ultimately affecting the overall agronomic practices including fertilization, seeding and crop rotations (Rice, 1979).

Swaminathan *et al.* (1990) reported that composite leaves, stems and flower extracts of *Parthenium hysterophorus* had greater inhibition effect on germination of some multipurpose tree species such as *Acacia leucophloea, Casuarina equisetifolia, Eucalyptus tereticornis* and *Leucaena leucocephala* and also on some agricultural crops such as cowpea, sorghum and sunflower.The allelopathic activity of the leaf leachate of commonly grown agroforestry tree species viz., *Dalbergia sissoo, Bauhinia variegata, Ficus bengalensis, Morus alba, Populus deltoides, Salix babylonica* and *Leucaena leucocephala* on seed germination and early growth of rice under *in vitro* condition where in significant reduction in germination and seedling growth was observed (Koul *et al.*, 1991). The allelopathic effect of aqueous extract of

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mature leaves of seven agroforestry tree species viz., *Azadirachta indica, Terminalia arjuna, Dalbergia sissoo, Albizia lebbeck, Sesbania grandiflora, Acacia auriculiformis* and *Leucaena leucocephala* on *Triticum aestivum,Oryza sativa* and *Cicer arietinum* under *invitro* condition had been done by Rao *et al.(*1994) and observed maximum inhibition in germination of test crops caused by *Sesbania grandiflora* followed by *Acacia auriculiformis.* They inferred that decrease in germination was directly proportional to the increase in the concentration of the leaf extract. Balasubramanian and Ravichandran (1996) tested the allelopathic influence of leaf extract from matured leaves of six agroforestry tree species viz., *Eucalyptus tereticornis, Leucaena leucocephala, Ailanthus excelsa, Gliricidia sepium, Acacia nilotica* and *Tectona grandis*, on germination of *Casuarina equisetifolia* and concluded that the inhibitory effect on *Casuarina* was increased when the concentration of the extract increased. Leaf litter of *Eucalyptus tereticornis, Ailanthus triphysa, Bombax malabaricum, Myristica fragrans, Artocarpus hirsuta, Thespesia populnea* and *Anacardium occidentale* inhibited both the germination and seedling growth of rice and cowpea (Jacob John and Nair, 1996) .The experiment undertaken by Joshi *et al*. (1996) found that the aqueous extract from the dried leaves of *Fraxinus micrantha* inhibited the germination and the growth of *Raphanus sativus, Eleusine coracana, Triticum aestivum* and *Brassica campestris* while Swaminathan (1996) revealed that the bark extract of three tree species viz., *Acacia nilotica, Ailanthus excelsa* and *Casuarina equisetifolia* significantly inhibited the germination of sesame, pigeon pea and maize. Germination of blackgram and sorghum was decreased significantly by adverse allelopathic effect of *Prosopis juliflora* leaf litter whereas sunflower was found to be resistant (Chellamuthu *et al.,* 1997). Dharmaraj (1998) studied the allelopathic potential of *Leucaena leucocephala* on blackgram, soybean, cotton and some agroforestry tree species and observed that the phytotoxicity of *Leucaena* leaf leachate depends on the level of mimosine content in the leaves and reported that *Acacia nilotica* was more tolerant and the rest of the crops were susceptible to the phytotoxic effect of *Leucaena* leaf leachate.

Suman (1999) reported that the secondary chemicals viz., tannin and mimosine from S*yzygium cumini* and *Leucaena leucocephala* were found to stimulate the germination, radicle and plumule elongation of test crop at lower concentration. The aqueous extract from fully matured leaves and roots of *Tectona grandis* showed reduction in shoot length, root length and leaf area of peanut and maize in a study by Selvam *et al.* (1998). Sadhna Tripathi *et al.* (1998) observed that there was a stimulatory effect on germination, shoot length, root length and nodulation of soybean under soil, leaf and rhizome extracts at 10 and 20 per cent concentrations of *Dendrocalamus strictus.* Tripathi *et al.* (1998) studied the allelopathic effect of leaf leachate of *Tectona grandis, Albizia procera* and *Acacia nilotica* and observed the stimulatory effect on germination and seedling growth of soybean in the order of *Tectona grandis, Acacia nilotica* and *Albizia procera.* Banwari and Lal (1999) reported higher concentration of *Mangifera indica* litter extract (5 and 7.5 per cent) significantly inhibit germination while lower concentration (2.5 per cent) of litter increased the germination by 6 per cent each in rice and soybean, 5 per cent each in maize and *Sesbania sesban* and 3 per cent each in *Desmanthus virgatus*, *Stylosanthes hamata, Atylosia scarabaeoides* and *Clitoria ternatea*. The leaf extract of *Acacia auriculiformis* was found to inhibit germination, radicle length and plumule length of rice, mustard and grass also observed the plumule elongation was significantly reduced than radicle length and the degree of inhibition was directly proportional to the concentration of the leachate (Bora *et al*., 1999).

John and Nair (1999) studied the allelopathic influence of leaf litter of certain multipurpose trees viz., *Acacia auriculiformis, Casuarina equisetifolia, Albizia lebbeck, Leucaena leucocephala, Artocarpus heterophyllus, Mangifera indica* and *Tamarindus indica* on rice and cowpea and the leaf litter of all the trees inhibited the germination and growth of rice and radicle growth of cowpea, however germination of cowpea was not inhibited by *Artocarpus heterophyllus* and *Mangifera indica.*

Tripathi (1999) revealed that the soil and root extracts of *Tectona grandis* stimulated the germination, shoot length, root length, chlorophyll-a, chlorophyll-b, protein and amino acids in soybean. The bark leachate of both *Casuarina* and *Eucalyptus* inhibited the germination and growth of cowpea, cluster bean, sword bean, bitter gourd and moringa and observed that Eucalyptus was more inhibitory than Casuarina (Swaminathan *et al.,* 1999). Studies conducted by Channal *et al.* (2000) revealed the allelopathic effect of leaf leachates from *Azadirachta indica, Acacia nilotica, Eucalyptus tereticornis, Tamarindus indica, Tectona grandis, Albizia saman* and *Syzygium cumini* on germination and seedling growth of rice and sorghum and the leaf leachates of all trees promoted the germination of sorghum by 15-32 per cent over the control, while *Azadirachta indica* and *Acacia nilotica* increased germination in rice by 3.5 to 3.8 per cent over the control. The seedling length of sorghum and rice was markedly increased under leaf leachates of *Acacia nilotica* and *Azadirachta indica.*

Choudhary *et al.* (2000) found that the aqueous extracts of *Azadirachta indica* had inhibitory effect on rice and wheat under laboratory conditions. Padhy *et al.* (2000) reported that all the concentrations such as 5,10, 15 and 20 per cent of leachate from the *Eucalyptus globulus* considerably inhibited the germination of finger millet and inferred that when longer the duration of presoaking of seeds in leachates was greater the inhibition in germination. In a study, Tripathi *et al.* (2000) inferred that the leaf and root extracts of *Dalbergia sissoo* stimulated the germination, shoot length and nodulation of *Vigna radiata.* Chowdhary *et al.* (2002) studied the allelopathic effect of aqueous leaf extract of *Pinus roxburghii, Quercus leucotrichophora* and *Zea mays* on germination and seedling growth of rice, pea and capsicum indicated that the longer duration of soaking exhibited more inhibitory effect on germination, shoot length and root length. Djanaguiraman *et al.* (2002) studied the influence of *Eucalyptus globulus* aqueous extract on green gram, blackgram and cowpea and inferred that the higher concentrations of the leachate (25 per cent) decreased the germination by 45.3 per cent, shoot length by 23.1 per cent, root length by 31.3 per cent and drymatter by 65.7 per cent over control. Reports of the study by Masilamani *et al.* (2002) showed that the water soluble germination inhibitors present in the mesocarp of *Tectona grandis* significantly inhibited the germination of black gram, cowpea and soyabean by 90 per cent, 64 per cent and 16 per cent respectively.

Khare and Bisaria (2002) studied the allelopathic influence of *Leucaena leucocephala* on seed germination and seedling growth of *Triticum aestivum* under laboratory condition and found that the aqueous extract of fresh leaf, leaf litter, flower and pod extracts stimulated the seed germination and seedling growth at lower concentration and inhibited significantly at higher concentration. Parvez *et al.* (2002) reported that the leaf leachate of *Tamarindus indica* caused significant inhibitory growth in root and shoot of lettuce. Patil *et al.* (2002) studied the effect of *Casuarina* needle aqueous leachate on germination and growth of wheat, sorghum, groundnut and greengram and observed the significant reduction in germination, shoot and root length at higher leachates concentration. Investigation was carried out by Saroj *et al.* (2002) to determine the allelopathic influence of ber (*Zizyphus mauritiana*) leaf aqueous extracts on four test crops viz., groundnut, cluster bean, wheat and mustard under laboratory condition. The results revealed that the seed germination of mustard was significantly inhibited by ber leaf extracts and the reduction was 60 per cent to 77 per cent over control, due to the presence of water soluble allelochemicals in ber leaf extracts. Ber exhibited maximum inhibitory effects on mustard and minimum on cluster bean with respect to germination and seedling parameters.

Studies by Bhattacharjee *et al.* (2003) reported that the leaf leachates of *Casuarina equisetifolia* and *Ipomea pescaprae* reduced the germination per centage of green gram. Devaranavadgi *et al.* (2003) investigated the allelopathic activity of commonly grown farm trees, viz., *Acacia nilotica, Albizia lebbeck, Azadirachta indica, Cassia siamea, Dalbergia sissoo, Hardwickia binata* and *Leucaena* sp on winter

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sorghum. The results indicated that among the tree species studied, *Hardwickia binata* had the minimum allelopathic effect on winter sorghum. The allelopathic influence of *Leucaena leucocephala* on seed germination and seedling growth of *Triticum aestivum* were studied under laboratory condition and observed that aqueous extract of fresh leaf, leaf litter, flower and pod stimulated the seed germination and the seedling growth of *Tritium aestivum* at lower concentration and inhibited significantly at higher concentration (John and Narwal, 2003). Kaushal *et al.* (2003) carried out studies on the allelopathic effect of leaf leachate from *Grewia optiva* and *Populus deltoides* on beans, chickpea, maize, sorghum and wheat. The reduction in germination of test crops was observed when compared to control and the reduction was more at higher concentration. Aqueous leaf leachates of *Eucalyptus citriodora* significantly inhibited the germination and the seedling growth of *Arachis hypogea* (100 per cent) >*Vignamungo* (50 per cent) and *Vigna radiata (*42.3 per cent) over the control (Singh and Ranjana Singh, 2003). Chen *et al.* (2004) reported that the leachates of eucalyptus inhibited the germination and seedling growth of *Phaseolus radiate*, *Glycine max*, *Stylostanthes guianensis* and *Macroptilium atropurpureum.*

Raj (2004) reported that the leaf litter, fresh leaf, bark and root leachates of *Simarouba glauca* effected the shoot length, root length and shoot dry weight, root dry weight and total dry weight of the blackgram, cowpea, greengram, redgram. Jeronimo *et al.* (2005) reported that the aqueous extracts of *Solanum iycocarpum* leaves at 1% significantly reduced root growth and inhibited root hair and lateral root differentiation in *Sesamum indicum*. Nandal *et al.* (2005) reported that the aqueous extracts of Populus deltoides leaves adversely affected the germination and seedling growth of some wheat varieties at high extract concentration. Bhatt *et al.* (2009) observed the inhibitory effects were more on germination, total dry matter yield and pigment contents of rice, maize, rice bean, green gram, rapeseed than on root and shoot length. All the test crops were found sensitive to allelopathic influences of tree species particularly, *Terminalia myriocarpa* and *Michelia oblonga*. The allelopathic influences were species specific. Rapeseed and legume test crops were highly susceptible to toxicity of trees than cereal test crops. Bhatt *et al.* (2010) reported that the pulp extracts of *Syzygium cumini* significantly suppressed the germination, growth and biomass yield of *Oryza sativa*, *Vigna radiate* and *Zea mays* in pot culture. Hanwenwu *et al.* (2011) reported that the distillation of *Eucalyptus dundasii* leaves yielded essential oil fraction and the aqueous fraction is inhibited the germination and seedling growth of *Lolium rigidum* and *Hordeum glaucum*.

Parvin *et al.* (2011) reported that the aqueous leaf extracts and roots of Albizia *lebbeck* had highest allelopathic effects on germination, shoot length, root length, shoot dry weight, root dry weight, total dry matter of mungbean and soybean. In a pot culture experiment, the maximum inhibition of seed germination and seedling vigour of bhendi was exerted by the elements of *Tamarindus indica*, followed by *Citrus indica*, *Mangifera indica*, *Artocarpus heterophyllus* and *Acacia catechu* on *Capsicum annum*, *Glycine max*, *Zea mays*, *Oryza sativa* and *Abelmoschus esculentus.* (Sahoo, 2011).

Materials and methods

MATERIALS AND METHODS

The study entitled "Autoallelopathy of selected multipurpose tree species and the effect of their leachates on agricultural test crop" was carried out with the objective of understanding the possible effects of leachates of these MPTs on germination, seedling growth and dry matter production of seedlings of the same tree species and the agricultural test crop. The materials used and the methods followed in the study are furnished hereunder.

3.1 LOCATION

The study was carried out in a nursery polyhouse, in the College of Forestry, Vellanikkara, Thrissur, Kerala. The soil for the pot culture experiment is collected from different well established plantations of the selected MPTs. Soil for raising *Acacia mangium and Acacia auriculiformis* seedlings were brought from 20 year old plantation established during 1996 at the arboretum of College of Forestry, Vellanikkara, Thrissur, Kerala (between 10°32' North latitude and 76°16 East longitude), *Grevillea robusta* from 22 year old stand in the experimental site attached to College of Forestry, Vellanikkara, Thrissur, Kerala (between 10°33' North latitude and 76°18' East longitude) and *Swietenia macrophylla* from permanent preservation plot at Panayamkode in Nilambur Forest Division.

3.2 EXPERIMENTAL MATERIAL

The experimental material used for the present study includes the the seedlings raised in the polyhouse of five MPTs viz., *Acacia auriculiformis, Acacia mangium, Ailanthus triphysa, Grevillea robusta, Swietenia macrophylla* and an agricultural test crop Anaswara variety of cowpea.

Plate 1. Permanent preservation plot of *Swietenia macrophylla*, Panayamkode, Nilambur

3.4 BRIEF DESCRIPTION ABOUT THE SELECTED MPTS

Multipurpose tree species are getting extensively cultivated in plantations and agroforestry programs throughout the world. Fast growing species grown as plantations in the tropics act as a valuable source of firewood, timber and pulp for meeting the demands of increasing population.

3.4.1 *Acacia auriculiformis*

A medium sized tree reaching about 30 m in height and 90 cm in diameter. It is an exotic from Papua New Guinea and Australia. The species has become naturalized in many parts of India including Kerala. *A. auriculiformis* grows successfully in all types of soil and climate. Wood is mainly used for furniture and construction purposes.

3.4.2 *Acacia mangium*

Acacia mangium is a leguminous tree species indigenous to Australia and was unknown as an exotic until 1966 when it was first introduced into Sabah, Malaysia by D.I. Nicholson, an Australian forester. *Acacia mangium* has a fragmented natural distribution which stretches from Indonesia to Irian Java, the western province of Papua New Guinea and North East Queensland in Australia. The wood is mainly used for furniture, construction purpose and in paper and pulp manufacture. Because of its density and calorific value (4800- 499000 kcal/kg), the wood is also useful as an excellent fuelwood.

3.4.3 *Ailanthus triphysa*

Fast growing evergreen tree attaining a height of 30 m and dbh of 95 cm, *Ailanthus triphysa* occurs in the Western Ghats, from Konkan , Southwards to Kerala up to 1500 m. This is a very important tree of interest in agroforestry system and is grown widely in Kerala for varying purposes.

3.4.4 *Grevillea robusta*

Native to Australia, *Grevillea robusta* is a fast growing, medium sized evergreen tree attaining a height of 30 to 35 m and dbh of 50 to 60 cm. it is a very popular tree in tropical and sub tropical climate and is grown as shade tree in tea and coffee plantation in Kerala.

3.4.5 *Swietenia macrophylla*

A moderately fast growing, very large deciduous tree, attaining a height of 40 m and DBH of 127 cm with stout branches. The tree is a native to Mexico and South America and it was introduced in India. It is also grown in most tropical countries for the showy appearance and hard wood of good quality.

3.5 POT CULTURE EXPERIMENT

3.5.1 Soil collection

The soil for pot culture experiment is collected from well established plantations. The sites with well decomposed litter are identified which are plain, away from drainage channels and are within the crown canopy of the plantation. The

Plate 2. Collection of surface soil for conducting pot culture experiment in tree nursery, College of Forestry, Vellanikkara

undecomposed litter is scrapped away with spade and topsoil is collected to a depth of 10-15 cm.

3.5.2 Collection of samples

Fresh leaves, bark and root samples were collected from the trees of *Acacia auriculiformis, Acacia mangium, Ailanthus triphysa, Grevillea robusta* and *Swietenia macrophylla* from within the plantations and nearby Kerala Agricultural University, Vellanikkara, Thrissur.

3.6 PHYSICO-CHEMICAL PROPERTIES OF LEACHATES

3.6.1 Preparation of leachates for Physico-chemical analysis

Hundred grams of samples viz., fresh leaves, bark and root of these samples from the selected MPTs were soaked in 1000 ml of water (1: 10 ratio of w/v basis). The leachates were collected for a total duration of 36 hours at an interval of six hours. A few drops of toluene were added and the leachates were stored at 4^0C for physico-chemicals analysis.

Different physiochemical properties viz., pH, electrical conductivity, total solids, total carbohydrate, total protein and total phenol were estimated as mentioned here under.

3.6.1 Ph

The pH of the leachates was estimated by using pH meter. (ELICO, LI 120 pH meter, India)

3.6.2 Electrical Conductivity

The electrical conductivity of the leachates was estimated by using conductivity meter (ELICO, CM 180 conductivity, India) and is expressed in dS m^{-1}.

3.6.3 Total Solids

Total solids were estimated by weighing known quantity of the leachates taken in a pre-dried, pre-weighed weighing bottle after drying at $103^0 - 105^0$ C for 8 hours (American Public Health Association, APHA 1989) and it is expressed as g l^{-1}.

3.6.4 Total Phenol

The total phenols were estimated with Folin-ciocalteau reagent by following the method of Malik and Singh (1980) Pyrocatechol (AR grade) standard was used to quantify the phenols present in the samples by using UV- Visible Spectrophotometer and is expressed in mg l^{-1}.

3.6.5. Total carbohydrate

Total carbohydrate of the leachates was estimated by following the Anthrone method with the use of UV-Visible Spectrophotometer (Hedge *et al.*, 1962) and is expressed in mg l^{-1}.

3.7 COLLECTION OF LEACHATES AND ASSESSMENT OF ALLELOPATHIC EFFECTS.

3.7.1 Preparation of leachates

Samples of fresh leaves, bark and root were collected from the selected MPTs were soaked in water in the ratio of 1:10 (w/v basis) and the leachates were collected at 24 hours and then used for pot culture experiment.

Pot culture experiment was conducted in a factorial completely randomised block design to assess the allelopathic effect of leachates on test crops. The test crops were sown in pots containing soil media in the ratio of 1:1 of soil and sand. Immediately after sowing test crops, sowing irrigation was given with water uniformly for the agricultural crop and tree species for its germination. Every day the leachates of about 250 ml were added to each pot and water (250 ml) served as control. Subsequently instead of giving life irrigation with water on 3rd day after sowing, the leachate of various sources from different tree species were given to the test crops as per the treatment schedule and it was extended up to 60 days after sowing (DAS). The pot culture experiment was replicated four times in FCRD and recorded the observation on the parameters viz., germination at 7 DAS, shoot length, root length, shoot dry weight and root dry weight at 30 and 60 days after sowing.

3.7.2 Germination

Germinated seeds of the test crops were counted at 7 DAS and the per cent germination was calculated (ISTA, 1986) as under.

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

3.7.3 Shoot length

Shoot length of the test crop and tree seedlings are recorded at 30 DAS and 60 DAS and expressed in cm (ISTA, 1985).

3.7.4 Root length

The root length of the test crop and tree seedlings are measured at 30 DAS and 60 DAS and expressed in cm. (ISTA, 1985).

3.7.5 Total Seedling length

The total seedling length of the test crop and tree seedlings are workedout by adding the values of shoot and root length taken on 30 DAS and 60 DAS and expressed in cm.

3.7.6 Shoot dry weight

Shoot of seedlings used for measuring shoot length was air dried under shade for 12 hours and then transferred to a hot air oven maintained at 85°C for 12 hours. After drying, the shoots were cooled in the desiccators containing calcium chloride for 30 minutes and weighed in a top pan electronic balance and expressed in g.

3.7.7 Root dry weight

Roots of seedlings used for measuring root length were air dried under shade for12 hours and then transferred to a hot air oven maintained at 85^0C for 12 hours. After drying the roots were cooled and weighed in a top pan electronic balance and expressed in g.

3.8 PHYTOCHEMICAL ANALYSIS OF PLANT SAMPLES

In order to estimate the nutrient accumulation in the aboveground and belowground biomass, triplicate samples of different tissue types (bark, leaf and coarse root) were analysed for N, P and K. Three samples each were drawn from the composite sample for phytochemical analysis. The collected samples were oven dried for a constant weight at 72°C and the samples were powdered for doing the analysis.

3.8.1 Total nitrogen

Total nitrogen content in plant samples was determined by using continuous flow analyzer (SKALAR).

Sulphuric acid and Selenium powder mixture - One liter of conc.H_2SO_4 was poured carefully and into a two liter beaker. Selenium powder (3.5g) was then dissolved into the H_2SO_4 by heating the beaker for 4 to 5 hours at 300°C. the black colour of the solution changed to deep blue colour and then light yellow. The solution was then cooled.

Digestion mixture – 10.8g salicylic acid was weighed and added into 150ml of H_2SO_4 and Selenium mixture which was already prepared.

For estimation of N, 0.3g of the leaf sample was taken in the digestion mixture was poured into the digestion tube. The tube was then swirled well and allowed to stand for 2 hours or overnight. It was then inserted into the digestion block and heated at 100°C for 2 hours. After cooling, the tubes were removed from the block and 1ml of 30% H_2O_2 was added. After the reaction ceased, they were again placed in the digestion block and heated at 330°C for 2 hours. When the digest turned colourless, the digest was made up to 75ml in a standard flask. The reagents were added and the readings were then read directly from the Continuous flow analyzer.

3.8.2 Total Phosphorous

Total phosphorous content in plant samples was also determined by using continuous flow analyzer. The digestion mixture and the procedure followed for digestion were same as described for nitrogen.

3.8.3 Available potassium

The potassium content was estimated in a known aliquot of diacid extract using flame photometer (Jackson, 1958).

3.9 PHYTOCHEMICAL ANALYSIS OF SOIL

Composite soil samples were collected from each plantation from different location at 10 -15 cm .the soil was air dried and ground to pass through a 2mm sieve. Triplicate samples were drawn from the composite samples and analyzed for total nitrogen, total phosphorus (both by continuous flow analyzer) and the total potassium by flame photometry (Jackson, 1958). Under pot culture experiment the soil analysis for various parameters is carried out at the end of 30 and 60 DAS.

3.9.1 Ph

The pH of the leachates was estimated by using pH meter. (ELICO, LI 120 pH meter, India)

3.9.2 Electrical Conductivity

The electrical conductivity of the leachates was estimated by conductivity meter (ELICO, CM 180 conductivity, India) and is expressed in dS m^{-1}.

3.10 EXPERIMENTAL DESIGN

Factorial completely randomized block design (FCRD) has administered for statistical analysis of data obtained from the laboratory and nursery experiments by using SPSS software.

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Results

RESULTS

The results of the research entitled "Autoallelopathy of selected multipurpose tree species and the effect of their leachate on agricultural test crop" are detailed in this chapter.

4.1 PHYSICOCHEMICAL PROPERTIES OF LEACHATES

The results of the properties such as pH, E.C., total solids, total phenols are discussed as below

4.1.1 pH

The pattern of change in pH in the leachates of different plant parts viz., leaf, bark and root of different multipurpose tree species at six hour intervals upto a duration of 36 hours are presented in Table 1.

4.1.1.1 *Acacia auriculiformis*

The leachates of leaf, bark and root of all the five species showed a decrease in pH with advance in time and shows significant difference. The leaf leachate of *Acacia auriculiformis* showed highest value of pH at 6th hour (7.212) and the value is on par with that of the 12th hour (6.892). The lowest pH for leaf leachate of *A. auriculiformis* was noted at 36th hour (4.938). The bark leachate of the species showed the maximum pH (7.962) at 6th hour and showed significant difference with readings at the other intervals. The 36th hour recorded lowest bark leachates pH (5.967). The root leachate also showed a similar trend with lowest pH recorded at 6th interval and is on par with 3rd and 4th interval.

The leaf, bark and root leachate at 6th hour varied significantly among plant parts. pH recorded at 12th hour of leaf leachate is on par with that of bark leachate, while varied significantly with that of root leachate.

4.1.1.2 *Acacia mangium*

The highest pH is recorded at 6 hour for leachates of leaf (7.502), bark (6.906) and root (6.682). The pH of leaf leachate at 1st and 2nd interval showed significant difference with values obtained at 3rd to 6th interval. The lowest value of bark leachate (5.954) is recorded at 6th interval. For root leachate the lowest pH of 5.851 is noted at the 36th hour and varied significantly from pH values in other intervals.

The leaf, bark and root leachate at 1st, 2nd and 5th interval varied significantly among the plant parts. But, in the 3rd, 4th and 6th interval the leaf leachate significantly varied with bark and root leachates while the root and bark leachate showed no significant difference.

4.1.1.3 *Ailanthus triphysa*

The highest pH value of leachates of leaf (6.933), bark (6.389) and root (7.433) is recorded at the 6th hour and lowest pH of leaf (5.000), bark (5.053) and (5.509) at 36th hour. The pH of leaf leachate of *Ailanthus triphysa* varied significantly between the intervals.

The pH of bark leachate at 1st interval (6.389) varied significantly with that of leaf and bark leachate. The pH of leaf, bark and root leachate at 12th hour is 6.572, 5.645 and 7.108 respectively and varied significantly with each other. However, pH at 6th interval showed no significant difference.

4.1.1.4 *Grevillea robusta*

Leaf leachate of *Grevillia robusta* showed highest value (6.462) for pH at the first interval (ie. 6th hour) and lowest at the 36th hour (3.829).A similar pattern was observed in the bark and root leachate with highest value at 6th hour and the lowest at 36th hour.

The leaf, bark and root leachate of 24th hour marked no significant difference in the pH. The pH of leaf leachate varied significantly with the bark and root leachate at 5th and 6th interval. The pH of root leachate at 12th hour (6.427) was significantly high and the pH was on par with bark leachate.

4.1.1.5 *Swietenia macrophylla*

The leaf leachate of *Swietenia macrophylla* showed highest value of pH at 6th hour (7.979) and the value is on par with that of the 12th (7.733). The lowest pH for the leaf leachate of *S. macrophylla* was noted at the 36th hour (6.772). The bark leachate of the species showed the maximum pH (5.963) at 6th hour. The 36th hour recorded lowest bark leachates pH (4.305). The root leachate also showed a similar trend. The lowest pH recorded at the 6th interval and is on par with 5th interval. The leaf leachate marked the highest pH among the leachate of different plant parts in all the intervals and the bark leachate marked the lowest pH in all the six different durations. The pH of leaf, bark and root showed significant differences at all the six intervals.

Table 1. pH of the leachates from different plant parts of selected trees

Species	Duration (Hours)	pH of Leachates		
		Leaf	**Bark**	**Root**
A. auriculiformis	06	$^{B}7.212^{a}$	$^{A}7.962^{a}$	$^{C}6.314^{a}$
	12	$^{A}6.892^{a}$	$^{A}6.806^{bde}$	$^{B}6.110^{ab}$
	18	$^{B}5.745^{bd}$	$^{A}6.846^{cbde}$	$^{B}5.980^{abd}$
	24	$^{B}5.533^{cbde}$	$^{A}6.597^{bcdef}$	$^{B}5.505^{bcd}$
	30	$^{B}5.167^{cbde}$	$^{A}6.292^{bcdef}$	$^{B}5.332^{cbd}$
	36	$^{B}4.938^{ecd}$	$^{AB}5.967^{def}$	$^{A}5.402^{bcd}$
A. mangium	06	$^{A}7.502^{a}$	$^{B}6.906^{a}$	$^{C}6.682^{a}$
	12	$^{A}7.472^{a}$	$^{B}6.847^{a}$	$^{C}6.622^{a}$
	18	$^{A}6.993^{b}$	$^{B}6.455^{b}$	$^{B}6.379^{bc}$
	24	$^{A}6.745^{c}$	$^{B}6.406^{cb}$	$^{B}6.272^{bcd}$
	30	$^{A}6.568^{dc}$	$^{B}6.323^{bcd}$	$^{C}6.103^{cd}$
	36	$^{A}6.257^{e}$	$^{B}5.954^{e}$	$^{B}5.851^{e}$
A. triphysa	06	$^{A}6.933^{a}$	$^{B}6.389^{a}$	$^{A}7.433^{a}$
	12	$^{B}6.572^{a}$	$^{C}5.645^{a}$	$^{A}7.108^{a}$
	18	$^{B}5.902^{b}$	$^{B}5.444^{bcd}$	$^{A}6.573^{bc}$
	24	$^{B}5.667^{c}$	$^{B}5.332^{bcd}$	$^{A}6.331^{bcd}$
	30	$^{A}5.275^{cd}$	$^{B}5.081^{bcd}$	$^{C}5.732^{cd}$
	36	$^{A}5.000^{e}$	$^{A}5.053^{e}$	$^{A}5.509^{e}$
G. robusta	06	$^{B}6.462^{a}$	$^{BC}6.323^{a}$	$^{A}7.060^{a}$
	12	$^{B}5.811^{b}$	$^{AB}6.183^{ab}$	$^{A}6.427^{b}$
	18	$^{B}5.698^{bc}$	$^{AB}6.028^{abcAB}$	$^{A}6.252^{bc}$
	24	$^{A}5.507^{bcd}$	$^{A}5.789^{b}$	$^{A}5.931^{bcd}$
	30	$^{B}4.613^{e}$	$^{A}5.532^{bcd}$	$^{A}5.526^{de}$
	36	$^{B}3.829^{e}$	$^{A}5.353^{bd}$	$^{A}5.258^{ef}$
S. macrophylla	06	$^{A}7.979^{a}$	$^{C}5.963^{a}$	$^{B}6.874^{a}$
	12	$^{A}7.733^{ab}$	$^{C}5.213^{b}$	$^{B}6.297^{b}$
	18	$^{A}7.522^{b}$	$^{C}4.774^{c}$	$^{B}5.945^{bc}$
	24	$^{A}7.361^{bc}$	$^{C}4.363^{d}$	$^{B}5.705^{cd}$
	30	$^{A}6.639^{d}$	$^{C}4.419^{cde}$	$^{B}5.324^{e}$
	36	$^{A}6.772^{de}$	$^{C}4.305^{def}$	$^{B}5.270^{ef}$

Means having same lowercase letter as superscript is homogeneous for each species within a Column.

Means having same uppercase letter as superscript is homogeneous for each duration within a row.

4.1.2 Total solids

The change in total solid content in leachate of plant parts with time and the change between plant parts at each time interval is shown in the Table 2.

4.1.2.1 *Acacia auriculiformis*

The total solid content of leaf leachate of *A. auriculiformis* showed significant increase with increase in time. The highest concentration of total solid (37.37 g l^{-1}) is recorded at the 36th interval and is on par with the 5th interval. The lowest concentration of total solid recoded at the 6th hour (9.77 g l^{-1}) varied significantly with the rest of the time interval. The total solid content in the bark leachate increased from 16.22 g l^{-1} at 6th hour to 45.59 g l^{-1}at 36th hour. The total solid content in root also followed a similar trend with the lowest total solid (17.72 g l^{-1}) at 6th hour and highest total solid (47.20 g l^{-1}) at 36th hour.

The root leachate marked the highest value for total solid (17.72 g l^{-1}) among the leachates of plant parts at the 1st interval. The leaf leachate had the lowest solid content (9.77 g l^{-1}) at 6th hour and significantly varied with root and bark leachate at the 1st interval. Total solid content in the 36th hour also followed the similar pattern. The 2nd and 3rd interval marked no significant difference in total solid among the leachates of plant parts.

4.1.2.2 *Acacia mangium*

The readings of total solid content in leaf leachate varied significantly with time, recording the highest (32.52 g l^{-1}) at the end of 36th hour and lowest reading (8.14 g l^{-1}) at the 6th hour. The bark and root also followed similar pattern. The highest value is noted at the 6th interval and the lowest at the 1st interval in both the plant parts.

The highest value for total solid content at the end of 36th hour is recorded for the root leachate (47.33 g l^{-1}) and showed significant difference with total solid content of bark (44.87 g l^{-1}) and leaf (32.52 g l^{-1}) leachate.

4.1.2.3 *Ailanthus triphysa*

The highest value of total solid content for leaf (53.81 g l^{-1}), bark (32.65 g l^{-1}) and root (38.05 g l^{-1}) was recorded at the 6th interval. The lowest recoded total solid concentration of leaf leachate (28.36g l^{-1}) at 1st interval and is on par with values obtained at the next interval. The solid content for bark leachate of tree increased from 15.69 g l^{-1} to 32.65 g l^{-1} and root leachate from 15.65 g l^{-1} to 38.05 g l^{-1} from 6th to 36th hour.

In all the intervals except 6th interval, the leaf leachate showed significant difference between the other two plant parts while, the bark and root showed no significant difference. The leaf (58.81 g l^{-1}), bark (32.65 g l^{-1}) and root (47.33 g l^{-1}) leachate showed significant difference at the 36th hour.

4.1.2.4 *Grevillea robusta*

The total solid content of leaf leachate increased from 6th hour to 36th hour continuously from 26.90 g l^{-1} < 29.97 g l^{-1} < 34.38 g l^{-1} < 43.17 g l^{-1} < 47.88 g l^{-1} < 51.19 g l^{-1}respectively. The bark leachate significantly varied from the 1st interval to the 6th interval. The highest total solid content (33.76 g l^{-1}) inroot leachate is recorded at 36th hour and the lowest (20.39 g l^{-1}) content is recorded at 6th hour.

The first four intervals showed a similar trend with leaf leachate showing significant difference with the bark and root leachate in each interval. But, the last two intervals showed significant difference among all the three plant part leachate.

4.1.2.5 *Swietenia macrophylla*

The leaf, bark and root recorded the highest value for total solid content at the end of 36th hour and the values recorded are 31.56 g l^{-1}, 45.87 g l^{-1} and 46.29 g l^{-1} respectively. The lowest value recorded is at the 6th hour and was 11.63 g l^{-1}, 24.44 g l^{-1} and 22.14 g l^{-1}respectively for leaf, bark and root leachate.

The leaf, bark and root leachates at 1st interval recorded the value 11.63 g l^{-1}, 24.44 g $l^{-1}$and 22.14 g l^{-1}respectively. In the 1st interval the leaf leachate varied significantly with bark and root leachate. The values for total solid content for the bark and root leachate was on par. The 36th hour marked highest value for total solid for root leachate and the value is on par with bark leachate. The value for total solid content of leaf leachate at the 6th interval is 31.56 g l^{-1} and showed significant difference with the leachate of the other two plant parts.

Table 2. Total solids of the leachates from different plant parts of selected trees

Species	Duration (Hours)	Total solid of leachates (g l^{-1})		
		Leaf	Bark	Root
A. auriculiformis	06	$^{B}9.775^{e}$	$^{A}16.220^{e}$	$^{A}17.720^{f}$
	12	$^{A}20.445^{dc}$	$^{A}23.040^{d}$	$^{A}24.285^{ed}$
	18	$^{A}25.320^{cb}$	$^{A}29.910^{cb}$	$^{A}28.535^{d}$
	24	$^{A}28.285^{b}$	$^{AB}33.940^{b}$	$^{A}36.490^{cb}$
	30	$^{B}31.575^{ab}$	$^{A}40.740^{a}$	$^{AB}37.560^{b}$
	36	$^{B}37.375^{a}$	$^{A}45.590^{a}$	$^{A}47.200^{a}$
A. mangium	06	$^{B}8.140^{f}$	$^{A}14.305^{f}$	$^{A}14.885^{f}$
	12	$^{C}12.665^{e}$	$^{B}16.010^{e}$	$^{A}21.635^{e}$
	18	$^{B}17.905^{d}$	$^{B}17.760^{d}$	$^{A}26.575^{d}$
	24	$^{C}23.095^{c}$	$^{B}26.420^{c}$	$^{A}34.000^{c}$
	30	$^{C}30.445^{b}$	$^{B}34.505^{b}$	$^{A}39.170^{b}$
	36	$^{C}32.520^{a}$	$^{B}44.870^{a}$	$^{A}47.335^{a}$
A. triphysa	06	$^{A}28.365^{ef}$	$^{B}15.695^{ed}$	$^{B}15.655^{ef}$
	12	$^{A}28.930^{e}$	$^{B}18.995^{d}$	$^{B}18.025^{e}$
	18	$^{A}32.875^{d}$	$^{B}23.940^{bc}$	$^{B}22.165^{cd}$
	24	$^{A}42.170^{c}$	$^{B}26.325^{b}$	$^{B}24.830^{c}$
	30	$^{A}46.550^{b}$	$^{B}29.720^{ab}$	$^{B}30.475^{b}$
	36	$^{A}53.810^{a}$	$^{C}32.655^{a}$	$^{B}38.050^{a}$
G. robusta	06	$^{A}26.900^{f}$	$^{B}18.985^{f}$	$^{B}20.395^{f}$
	12	$^{A}29.970^{e}$	$^{B}22.825^{de}$	$^{B}23.155^{e}$
	18	$^{A}34.380^{d}$	$^{B}24.740^{d}$	$^{B}25.500^{d}$
	24	$^{A}43.175^{c}$	$^{B}29.245^{c}$	$^{B}30.120^{bc}$
	30	$^{A}47.885^{b}$	$^{B}33.415^{b}$	$^{C}30.625^{b}$
	36	$^{A}51.190^{a}$	$^{B}37.450^{a}$	$^{C}33.760^{a}$
S. macrophylla	06	$^{B}11.630^{f}$	$^{A}24.445^{f}$	$^{A}22.145^{e}$
	12	$^{C}17.765^{e}$	$^{A}28.250^{e}$	$^{B}25.445^{d}$
	18	$^{C}20.655^{d}$	$^{B}34.910^{d}$	$^{A}39.240^{bc}$
	24	$^{B}25.320^{bc}$	$^{A}42.285^{bc}$	$^{A}41.030^{b}$
	30	$^{B}26.910^{b}$	$^{A}42.995^{b}$	$^{A}45.160^{a}$
	36	$^{B}31.565^{a}$	$^{A}45.875^{a}$	$^{A}46.290^{a}$

Means having same lowercase letter as superscript is homogeneous for each species within a Column.

Means having same uppercase letter as superscript is homogeneous for each duration within a row.

4.1.3 Electrical conductivity

The electrical conductivity of leaf, bark and root leachate significantly varied among the five species. The variations in electrical conductivity among tree species and the plant parts with increasing soaking time are depicted in the Table 3.

4.1.3.1 *Acacia auriculiformis*

The electrical conductivity of leaf, bark and root increased from the 6th hour to 36th hour. The highest value for leaf leachate (1.74 dSm^{-1}) is recorded at the 36th hour and the lowest (1.14 dSm^{-1}) at 6th hour. The highest value for bark and root leachate recorded is 1.83 $dSm^{-1}$and 1.80 dSm^{-1}respectively. The lowest value for bark leachate (1.35 dSm^{-1}) is recorded at the 6th hour and is on par with the value noted at 2nd interval. For root the lowest value (1.28 dSm^{-1}) noted at 6th hour and varied significantly from values obtained at other intervals.

The bark leachate marked highest electrical conductivity in all the intervals. In the 1st and 2nd interval the leaf leachate showed significant difference with the bark and root leachate and the the values for bark in both the intervals was on par with the root leachate value. In the 3rd, 4th and 5th interval, the leaf, bark and root leachate showed significant differences

4.1.3.2 *Acacia mangium*

The highest value for leaf, bark and root leachate is marked at 36th hour and is 1.905 dSm^{-1}. The highest value recorded at 36th hour is on par with the value marked at 2nd interval (1.82 dSm^{-1}). The lowest value of root leachate (1.21 dSm^{-1}) is marked at 6th hour and shows no significant difference with value marked at the 12th hour.

The electrical conductivity of root leachate at the 6th hour significantly varied with the leaf and bark leachate. The leaf and bark leachate showed no significant difference among them at the 1st interval. The highest electrical conductivity was recorded in leaf leachates. A similar trend is followed in other intervals also.

4.1.3.3 *Ailanthus triphysa*

The electrical conductivity of all the plant part leachate of *Ailanthus triphysa* viz., leaf, bark and root significantly varied with time. The 1st interval showed significant difference in the leaf, bark and root leachate. The highest value for electrical conductivity in the 6th hour is marked for the leaf leachate. From the 2nd to 6th interval, the leaf leachate significantly differed from the bark and root leachate. At the end of 36th hour the leaf, bark and root leachate marked the highest values 2.08 dSm^{-1}, 1.75 dSm^{-1} and 1.76 dSm^{-1}respectively. Generally, the highest electrical conductivity was recorded in leaf leachates.

4.1.3.4 *Grevillea robusta*

The electrical conductivity of leaf leachate of *G.robusta* increased from 1.47 dSm^{-1} to 2.06 dSm^{-1} from 6th to 36th hour. The electrical conductivity of bark leachate increased from 1.22 dSm^{-1} to 1.63 dSm^{-1} and that of root leachate increased from 1.40 dSm^{-1} to 1.89 dSm^{-1} from 6th to 36th hour. The highest electrical conductivity was recorded in leaf leachates.

4.1.3.5 *Swietenia macrophylla*

The electrical conductivity of the leaf, bark and root leachate followed the same trend.as compared to other species. All the plant part marked the highest value of electrical conductivity at the 6th interval and the lowest value at 1st interval. The highest values recorded for leaf, bark and root leachate of the species is 1.54 dSm^{-1}, 1.74 dSm^{-1} and 1.64 dSm^{-1} respectively.

Significant difference among the tree parts were observed as the soaking time increased as at the 24th, 30th and 36th hour. The highest electrical conductivity was recorded in leaf leachates.

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Table 3. Electrical conductivity of the leachates from different plant parts of selected trees

Species	Duration (Hours)	Electrical conductivity of leachates(dSm^{-1})		
		Leaf	**Bark**	**Root**
A. auriculiformis	06	${}^{B}1.140^{ef}$	${}^{A}1.350^{de}$	${}^{A}1.285^{ef}$
	12	${}^{B}1.165^{e}$	${}^{A}1.390^{d}$	${}^{A}1.350^{e}$
	18	${}^{C}1.275^{d}$	${}^{A}1.655^{bc}$	${}^{B}1.475^{d}$
	24	${}^{C}1.365^{c}$	${}^{A}1.710^{b}$	${}^{B}1.600^{bc}$
	30	${}^{C}1.490^{b}$	${}^{A}1.775^{ab}$	${}^{B}1.660^{b}$
	36	${}^{A}1.745^{a}$	${}^{A}1.835^{a}$	${}^{AB}1.805^{a}$
A. mangium	06	${}^{A}1.360^{e}$	${}^{A}1.375^{f}$	${}^{B}1.210^{ef}$
	12	${}^{A}1.470^{d}$	${}^{A}1.465^{e}$	${}^{B}1.265^{e}$
	18	${}^{A}1.610^{bc}$	${}^{A}1.555^{d}$	${}^{B}1.370^{d}$
	24	${}^{A}1.660^{b}$	${}^{A}1.675^{bc}$	${}^{B}1.460^{bc}$
	30	${}^{A}1.825^{a}$	${}^{A}1.755^{b}$	${}^{B}1.495^{b}$
	36	${}^{A}1.905^{a}$	${}^{A}1.855^{a}$	${}^{B}1.640^{a}$
A. triphysa	06	${}^{A}1.450^{f}$	${}^{C}1.220^{f}$	${}^{B}1.300^{ef}$
	12	${}^{A}1.575^{e}$	${}^{B}1.345^{e}$	${}^{B}1.365^{e}$
	18	${}^{A}1.645^{d}$	${}^{B}1.460^{d}$	${}^{B}1.480^{d}$
	24	${}^{A}1.805^{c}$	${}^{B}1.545^{c}$	${}^{B}1.575^{bc}$
	30	${}^{A}1.940^{b}$	${}^{B}1.675^{b}$	${}^{B}1.635^{b}$
	36	${}^{A}2.080^{a}$	${}^{B}1.755^{a}$	${}^{B}1.765^{a}$
G. robusta	06	${}^{A}1.475^{f}$	${}^{C}1.220^{f}$	${}^{B}1.400^{f}$
	12	${}^{A}1.580^{e}$	${}^{B}1.345^{de}$	${}^{A}1.535^{e}$
	18	${}^{A}1.665^{d}$	${}^{B}1.400^{d}$	${}^{A}1.650^{cd}$
	24	${}^{A}1.760^{c}$	${}^{B}1.470^{c}$	${}^{A}1.700^{bc}$
	30	${}^{A}1.885^{b}$	${}^{C}1.540^{b}$	${}^{B}1.745^{b}$
	36	${}^{A}2.065^{a}$	${}^{C}1.635^{a}$	${}^{B}1.890^{a}$
S. macrophylla	06	${}^{B}1.145^{f}$	${}^{AB}1.195^{e}$	${}^{A}1.255^{fe}$
	12	${}^{B}1.225^{de}$	${}^{AB}1.295^{cd}$	${}^{A}1.310^{e}$
	18	${}^{B}1.290^{d}$	${}^{A}1.365^{c}$	${}^{A}1.440^{cd}$
	24	1.390^{bc}	${}^{A}1.610^{b}$	${}^{B}1.485^{bc}$
	30	1.440^{b}	${}^{A}1.705^{a}$	${}^{B}1.550^{b}$
	36	1.545^{a}	${}^{A}1.740^{a}$	${}^{B}1.640^{a}$

Means having same lowercase letter as superscript is homogeneous for each species within a Column.

Means having same uppercase letter as superscript is homogeneous for each duration within a row.

4.1.4 Total phenol

Variation in total phenol content among the leaf, bark and root of the five tree species are presented in Table 4.

4.1.4.1 *Acacia auriculiformis*

The total phenol content of *Acacia auriculiformis* leaf leachate varied significantly from 6th to 36th hour. The maximum phenol content (705.82 mg l^{-1}) in leaf leachate was recorded at the 36th hour. The bark and root leachate also recorded the highest values at 36th hour and is308.63 mgl^{-1} and 384.40 mg l^{-1} respectively. The lowest value recorded for leaf, bark and root is 353.06 mgl^{-1}, 123.51 mg l^{-1} and 164.11 mg l^{-1} respectively.

The leaf, bark and root leachate values for total phenol varied significantly within each interval among the plant part. The highest total phenol value is observed in the leaf leachate and lowest in the bark leachate at all the six intervals.

4.1.4.2 *Acacia mangium*

The total phenol content in *A. mangium* leaf leachate increased from 386.80 mg l^{-1} to 622.45 mg l^{-1} and significantly differed among the intervals. The maximum value for bark leachate is recorded at the 36th hour and is 212.55 mg l^{-1}. The maximum and minimum value for root leachate recorded is 252.07 mg l^{-1} and 177.32 mg l^{-1} at 36th hour and 6th hour respectively.

The leaf, bark and root leachate values for total phenol varied significantly among different interval among the plant part. The highest total phenol value has observed in the leaf leachate and the lowest in the bark leachate in all the six intervals.

4.1.4.3 *Ailanthus triphysa*

The total phenol content in the leaf leachate of *A. triphysa* increased from 371.26 mg l^{-1} to 569.94 mg l^{-1} from 6th hour to 36th hour. The lowest value for bark leachate (94.95 mg l^{-1}) is marked at the 1st interval. The root leachate also followed a similar trend. The values consistently increased with increased from 100.67 mg l^{-1} (1st interval) to 166.74 mg l^{-1} (6th interval).

The leaf leachate marked the highest total phenol content in all the intervals and varied significantly with bark and root leachate. The bark and root leachate marked at all intervals showed a non-significant value among the component parts.

4.1.4.4 *Grevillea robusta*

The readings for leaf, bark and root leachate of *G.robusta* also showed an increasing trend in total phenol content from 6th to 36th hour. The highest reading recorded was 568.41 mg l^{-1}, 297.73 mg l^{-1} and 268.30 mg l^{-1} respectively for leaf, bark and root.

The leaf, bark and root leachate values for total phenol varied significantly within each interval among the plant part. The highest total phenol value is observed in the leaf followed by bark and root leachate in all the six intervals.

4.1.4.5 *Swietenia macrophylla*

The highest readings for the leaf, bark and root leachate of *S. macrophylla* is noted at the 36th hour and the lowest at the 6th hour. With increase in time from 6 hour to 36 hour, the reading for leaf leachate increased from 77.97 mg l^{-1} to 130.66 mg l^{-1}, bark leachate from 108.05 mg l^{-1} to 170.89 mg l^{-1} and that of root leachate from 125.83 mg l^{-1} to 191.25 mg l^{-1}.

The leaf, bark and root leachate values for total phenol varied significantly within each interval among the plant part of *S. macrophylla*. Unlike other species, the highest total phenol content is observed in the root followed by bark and the lowest phenol content in leaf leachate at all the six intervals.

Table 4. Total phenol of the leachates from different plant parts of selected tree species

Species	**Duration (Hours)**	**Total phenol content of leachates (mg / l)**		
		Leaf	**Bark**	**Root**
A. auriculiformis	06	$^{A}353.060^{f}$	$^{C}123.510^{f}$	$^{B}164.115^{f}$
	12	$^{A}416.590^{e}$	$^{C}147.125^{e}$	$^{B}183.630^{e}$
	18	$^{A}442.290^{d}$	$^{C}195.210^{dc}$	$^{B}249.420^{d}$
	24	$^{A}565.475^{c}$	$^{C}203.395^{c}$	$^{B}305.025^{c}$
	30	$^{A}666.735^{b}$	$^{C}260.870^{b}$	$^{B}354.530^{b}$
	36	$^{A}705.825^{a}$	$^{C}308.635^{a}$	$^{B}384.405^{a}$
A. mangium	06	$^{A}386.805^{f}$	$^{C}140.755^{f}$	$^{B}177.320^{ef}$
	12	$^{A}429.775^{e}$	$^{C}154.640^{e}$	$^{B}183.275^{e}$
	18	$^{A}466.860^{d}$	$^{C}165.490^{d}$	$^{B}193.560^{cd}$
	24	$^{A}551.000^{c}$	$^{C}177.385^{c}$	$^{B}199.850^{c}$
	30	$^{A}574.495^{b}$	$^{C}193.340^{b}$	$^{B}236.615^{b}$
	36	$^{A}622.465^{a}$	$^{C}212.555^{a}$	$^{B}252.075^{a}$
A. triphysa	06	$^{A}371.265^{ef}$	$^{B}94.955^{e}$	$^{B}100.675^{f}$
	12	$^{A}380.015^{e}$	$^{C}109.820^{d}$	$^{B}124.050^{de}$
	18	$^{A}409.480^{d}$	$^{B}128.445^{c}$	$^{B}129.040^{d}$
	24	$^{A}471.715^{c}$	$^{B}140.425^{b}$	$^{B}141.600^{c}$
	30	$^{A}511.825^{b}$	$^{B}152.005^{a}$	$^{B}153.505^{b}$
	36	$^{A}569.945^{a}$	$^{B}158.940^{a}$	$^{B}166.740^{a}$
G. robusta	06	$^{A}343.075^{f}$	$^{B}168.265^{f}$	$^{C}187.725^{ef}$
	12	$^{A}366.335^{e}$	$^{B}243.125^{e}$	$^{C}194.285^{e}$
	18	$^{A}390.350^{d}$	$^{B}260.880^{d}$	$^{C}206.355^{d}$
	24	$^{A}464.920^{c}$	$^{B}279.075^{bc}$	$^{C}224.135^{c}$
	30	$^{A}525.915^{b}$	$^{B}287.840^{b}$	$^{C}250.990^{b}$
	36	$^{A}568.410^{a}$	$^{B}297.730^{a}$	$^{C}268.300^{a}$
S. macrophylla	06	$^{C}77.970^{ef}$	$^{B}108.050^{f}$	$^{A}125.835^{f}$
	12	$^{C}80.815^{e}$	$^{B}122.885^{e}$	$^{A}136.585^{e}$
	18	$^{C}88.505^{d}$	$^{B}136.515^{d}$	$^{A}150.265^{d}$
	24	$^{C}107.705^{bc}$	$^{B}150.325^{c}$	$^{A}164.295^{c}$
	30	$^{C}113.060^{b}$	$^{B}158.195^{b}$	$^{A}180.120^{b}$
	36	$^{C}130.660^{a}$	$^{B}170.890^{a}$	$^{A}191.255^{a}$

Means having same lowercase letter as superscript is homogeneous for each species within a Column.

Means having same uppercase letter as superscript is homogeneous for each duration within a row.

4.1.5 Total carbohydrate

The total carbohydrate content showed an increasing trend with increase in time. The variation in the total carbohydrate content in different plant parts of the selected trees is shown in Table 5.

4.1.5.1 *Acacia auriculiformis*

The total carbohydrate content of leaf leachate of *A. auriculiformis* significantly increased with increase in time. The highest concentration of total carbohydrate (947.57 mg l^{-1}) is recorded at the 36th interval. Lowest concentration (246.77 mg l^{-1}) of total carbohydrate recoded at the 6th hour and varied significantly with the rest of the time interval. Total carbohydrate content in the bark leachate increased from 185.59 mg l^{-1} at 6th hour to 760.48 mg l^{-1} at 36th hour. The total carbohydrate content in root also followed a similar trend with the lowest concentration at (194.20 mg l^{-1}) at 6th hour and highest reading (886.18 mg l^{-1}) at 36th hour.

The leaf leachate readings for total carbohydrate recorded highest value among the three plant parts in all the six intervals and varied significantly with the bark and root leachate values.

4.1.5.2 *Acacia mangium*

The highest carbohydrate content in leaf, bark and root leachate is marked at 36th hour and is 781.74 mg l^{-1}, 820.27 mg l^{-1} and 801.24 mg l^{-1} respectively. The values obtained for bark leachate varied significantly at different interval. The lowest value root leachate (181.76 mg l^{-1}) is marked at the 6th hour and showed significant difference with the value recorded at the rest of the intervals.

In *Acacia mangium,* leaf leachate showed the highest value for total carbohydrate in all the intervals observed. A significant difference among the plant part leachate is noticed in the 1st, 2nd and 5th interval. In the 3rd and 4th interval the leaf leachate value for total carbohydrate marked significant difference with bark and root leachate. But, the values of bark and root leachates were on par.

4.1.5.3 *Ailanthus triphysa*

Ailanthus triphysa recorded the highest value of total carbohydrate content for leaf (1009.69 mg l^{-1}), bark (497.00 mg l^{-1}) and root (736.28 mg l^{-1}) at the 36th interval. The lowest recoded total carbohydrate content concentration of leaf leachate (355.83 mg l^{-1}) at 1st interval and is significantly different with the values obtained at consecutive intervals. The bark leachate of the tree increased from 177.53 mg l^{-1} to 497.00 mg l^{-1} and root leachate from 187.93 mg l^{-1} to 736.28 mg l^{-1} from 6th to 36th hour.

The total carbohydrate content at the end of 36th hour is found highest in the leaf leachate (1009.69 mg l^{-1}) followed by root (736.28 mg l^{-1}) and bark (497.00 mg l^{-1}) leachate. The leaf, bark and root leachate varied significantly with each other from 3rd to 6th interval.

4.1.5.4 *Grevillea robusta*

The total carbohydrate content in the leaf leachate of *G. robusta* increased from 280.03 mg l^{-1} to 1024.17 mg l^{-1} from 6th hour to 36th hour. The lowest value for the bark leachate (144.23 mg l^{-1}) is marked at the 1st interval and the reading varied significantly with the readings marked at other intervals. The root leachate also followed a similar trend. The values increased with increase in soaking time 171.57 mg l^{-1}(1st interval) to 2.98 mg l^{-1}(6th interval).

In the first three intervals the leaf leachate value for total carbohydrate content varied significantly with bark and root leachate and the bark and root leachate value were on par. The 5th and 6th interval marked significant difference among the plant part leachate with highest value for leaf leachate followed by root and bark leachate.

4.1.5.5 *Swietenia macrophylla*

The leaf leachate of *Swietenia macrophylla* showed highest value for total carbohydrate at 36th hour (485.53 mg l^{-1}) and significantly differed with the readings marked at other intervals. The lowest total carbohydrate for leaf leachate of *S. macrophylla* was noted at 6th hour (81.53 mg l^{-1}). Bark leachate of the species showed the maximum value (686.64 mg l^{-1}) at 36th hour. The 6th hour recorded lowest reading for bark leachates (116.29 mg l^{-1}). The root leachate also showed a similar trend recording highest value (520.40 mg l^{-1}) at 36th hour and lowest (118.62 mg l^{-1}) at 6th hour.

The leaf leachate varied significantly with the bark and root leachate for total carbohydrate content in the 6th hour. The bark and root leachate value for the same parameter showed no significant difference at 6th hour. However, a significant difference in the total carbohydrate content among the plant parts with highest value for bark leachate followed by root and leaf leachate.

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Table 5. Total carbohydrate of the leachates from different plant parts of selected trees

Species	Duration(Hours)	Total carbohydrate of leachates (mg l^{-1})		
		Leaf	**Bark**	**Root**
A. auriculiformis	06	$^{A}246.775^{f}$	$^{B}185.595^{f}$	$^{B}194.205^{f}$
	12	$^{A}457.050^{e}$	$^{C}255.165^{e}$	$^{B}350.220^{e}$
	18	$^{A}648.380^{dc}$	$^{B}484.000^{d}$	$^{B}469.830^{d}$
	24	$^{A}682.490^{c}$	$^{B}539.745^{c}$	$^{B}511.970^{c}$
	30	$^{A}791.660^{b}$	$^{C}675.230^{b}$	$^{B}724.295^{b}$
	36	$^{A}947.575^{a}$	$^{C}760.480^{a}$	$^{B}886.180^{a}$
A. mangium	06	$^{A}283.750^{f}$	$^{C}143.120^{f}$	$^{B}181.765^{f}$
	12	$^{A}347.880^{e}$	$^{C}257.085^{e}$	$^{B}287.280^{e}$
	18	$^{A}424.120^{d}$	$^{B}377.150^{d}$	$^{AB}399.515^{d}$
	24	$^{A}612.295^{c}$	$^{B}539.670^{c}$	$^{B}555.020^{c}$
	30	$^{A}712.000^{b}$	$^{C}640.855^{b}$	$^{B}667.625^{b}$
	36	$^{B}781.745^{a}$	$^{A}820.270^{a}$	$^{AB}801.245^{a}$
A. triphysa	06	$^{A}355.830^{f}$	$^{B}177.535^{f}$	$^{B}187.935^{f}$
	12	$^{A}472.430^{e}$	$^{B}297.965^{de}$	$^{C}231.925^{e}$
	18	$^{A}637.950^{d}$	$^{C}330.230^{d}$	$^{B}387.610^{d}$
	24	$^{A}755.240^{c}$	$^{C}378.970^{c}$	$^{B}482.520^{bc}$
	30	$^{A}862.400^{b}$	$^{C}437.090^{b}$	$^{B}518.735^{b}$
	36	$^{A}1009.690^{a}$	$^{C}497.005^{a}$	$^{B}736.285^{a}$
G. robusta	06	$^{A}280.035^{f}$	$^{B}144.230^{e}$	$^{B}171.570^{f}$
	12	$^{A}486.900^{de}$	$^{B}278.880^{d}$	$^{B}268.545^{e}$
	18	$^{A}534.160^{d}$	$^{A}477.545^{cA}$	$^{B}399.620^{cd}$
	24	$^{A}774.245^{c}$	$^{A}744.185^{b}$	$^{B}479.830^{c}$
	30	$^{A}920.745^{b}$	$^{C}857.625^{a}$	$^{B}649.440^{b}$
	36	$^{A}1024.175^{a}$	$^{C}934.060^{a}$	$^{B}852.985^{a}$
S. macrophylla	06	$^{B}81.530^{f}$	$^{A}116.290^{f}$	$^{A}118.625^{f}$
	12	$^{C}108.010^{e}$	$^{A}221.355^{e}$	$^{B}174.330^{e}$
	18	$^{C}173.965^{d}$	$^{A}343.670^{d}$	$^{B}290.500^{d}$
	24	$^{C}245.915^{c}$	$^{A}510.135^{c}$	$^{B}383.070^{c}$
	30	$^{C}366.450^{b}$	$^{A}636.530^{b}$	$^{B}437.675^{b}$
	36	$^{C}485.535^{a}$	$^{A}686.640^{a}$	$^{B}520.405^{a}$

Means having same lowercase letter as superscript is homogeneous for each species within a Column.

Means having same uppercase letter as superscript is homogeneous for each duration within a row.

4.2 Autoallelopathic effect of leachates from tree species on its own germination

The results of autoallelopathic effect of leachates of different plant parts of the five selected tree species are presented in Table 6. In all the five selected tree species viz..,*A. auriculiformis*, *A. mangium*, *S. macrophylla*, *A. triphysa*, *G. robusta* the germination is found higher in case of control i.e., the seeds irrigated with tap water. The germination per cent for *A. auriculiformis* showed the lowest germination per cent in case of the pots irrigated with leaf leachate (70%) and varied significantly with other treatments. The germination per cent obtained for both the pots treated with bark leachate and root leachate was 81.11%.

In *A. mangium* highest germination per cent is noted for pots irrigated with tap water (91.11%) followed by bark leachate (85.55%), root leachate (78.88%) and the lowest value was recorded for pots irrigated with leaf leachate (58.88%). All the treatments showed significant difference with each other.

The highest germination per cent for *A. triphysa* is obtained in the control (84.44%) and the lowest germination per cent is marked for the leaf leachate (57.77%). The germination per centage of *A. triphysa* showed no significant difference with the bark leachate, root leachate and the tap water.

The germination per cent in case of *G. robusta* followed the order 52.22%, 60.00%, 62.22% and 76.66% respectively for pots irrigated with leaf leachate, bark leachate, root leachate and the control. The germination per cent irrigated with tap water varied significantly with all other treatments.

The germination per cent for *S. macrophylla* was 91.11%, 87.77%, 86.66% and 94.44% respectively for leaf leachate, bark leachate, root leachate and tap water. The germination per cent obtained with tap water marked the highest value of germination per cent and varied significantly with other treatments.

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Plate 3. Seedlings raised as part of autoallelopathic study of selected tree species in tree nursery, College of Forestry, Vellanikkara

Table.6 Autoallelopathic effect of leachates from tree species on its own germination.

Species	Germination %			
	Leaf	Bark	Root	Control
A. auriculiformis	70.00^{b}	81.11^{a}	81.11^{a}	85.55^{a}
A. mangium	58.88^{d}	85.56^{b}	78.88^{c}	91.11^{a}
A. triphysa	57.77^{b}	81.11^{a}	83.33^{a}	84.44^{a}
G. robusta	52.22^{d}	60.00^{bc}	62.22^{b}	76.66^{a}
S. macrophylla	91.11^{a}	87.77^{bc}	86.66^{b}	94.44^{a}

Means having same lowercase letter as superscript is homogeneous for each duration within a row.

4.3Allelopathic effect of leachates from tree species on germination of agricultural test crop

The result of allelopathic effect of leachates of different plant parts of the selected five trees on germination of the test crop cowpea is presented in Table 7. In cowpea, irrespective of tree species from which the leachates were extracted at different sources such as fresh leaf, bark, root and water served as control have not significantly influenced on the test crops. Interaction between the extract of different tree species and the sources of leachate obtained from various plant parts also found to be non-significant. Except for the leaf leachate all the three plant parts showed hundred per cent germination. In *S. macrophylla* the leaf leachate also showed hundred per cent germination of the test crop.

Plate 4. Two month old *Grevillea robusta* seedlings raised in tree nursery irrigated with a) Tap water b) leaf leachate c) bark leachate d) root leachate

Table.7 Allelopathic effect of leachates on germination of agricultural test Crop

Species	Germination %			
	Leaf	Bark	Root	Control
A. auriculiformis	96.66	100.00	100.00	100.00
A. mangium	93.00	100.00	100.00	100.00
A. triphysa	93.33	100.00	96.66	100.00
G. robusta	96.66	100.00	100.00	100.00
S. macrophylla	100.00	100.00	100.00	100.00

4.4 AUTOALLELOPATHIC EFFECT OF THE SELECTED TREES ON BIOMETRIC OBSERVATIONS

The results on biometric parameters such as shoot length, root length, shoot dry weight and root dry weight at 30 DAS, 60 DAS, 90 DAS and 120 DAS as affected by the application of leachates from different plant parts of the same species are given hereunder.

4.4.1 Shoot length and root length

In the study conducted it is noticed that the seedlings *of A. auriculiformis, A. mangium, A. triphysa* and *G. robusta* irrigated with leaf and root leachate perished by the end of the study period ie., 120 DAS. The shoot length and root length of the tree seedlings in where found highest for the seedlings irrigated with tap water. But in case of *S. macrophylla* the allelopathic effect due to leachate for its own growth and biomatter production was found least when compared with control.

Plate 5. Three month old *Swietenia macrophylla* seedlings raised in tree nursery irrigated with a) tap water b) leaf leachate c) bark leachate d) root leachate

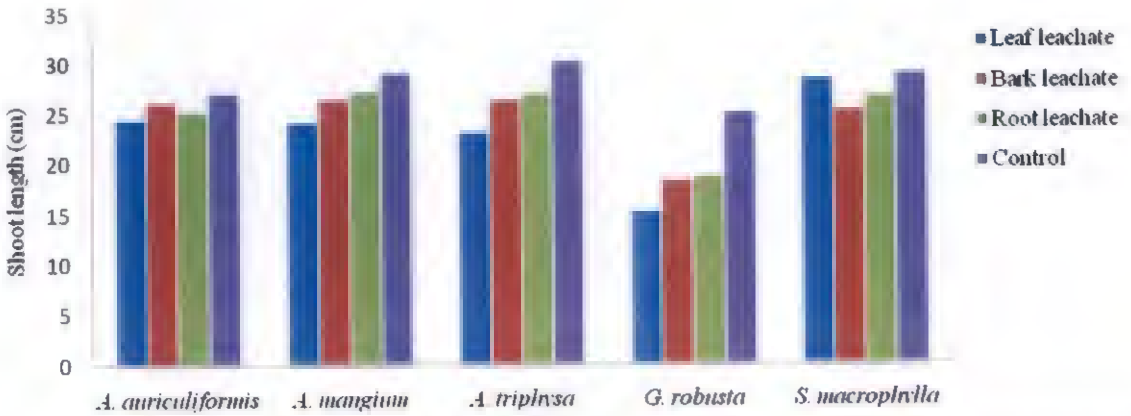

Figure. 1 Shoot length of tree seedlings at 30 DAS as affected by different plant leachates

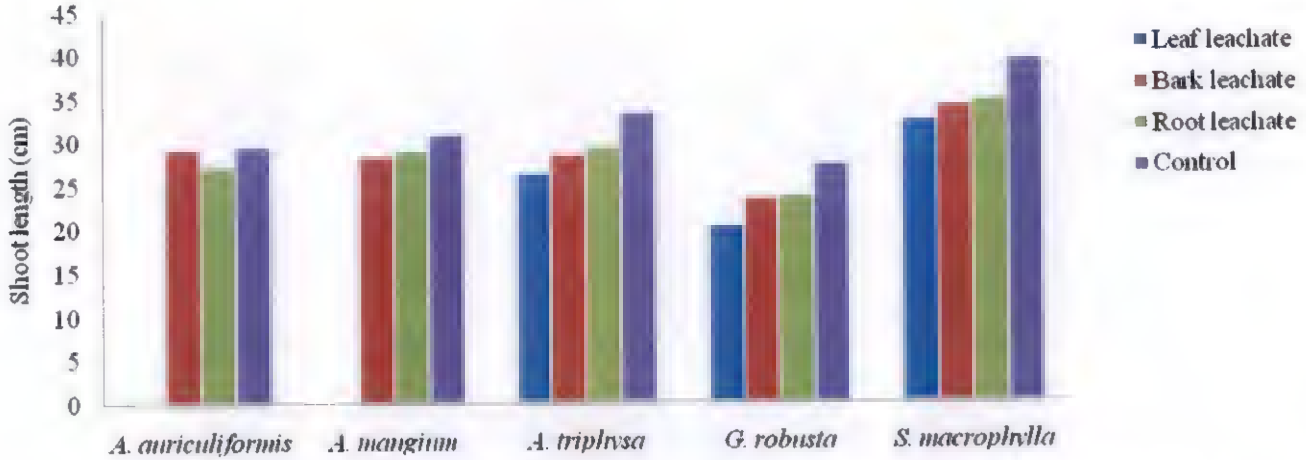

Figure. 2 Shoot length of tree seedlings at 60 DAS as affected by different plant leachates

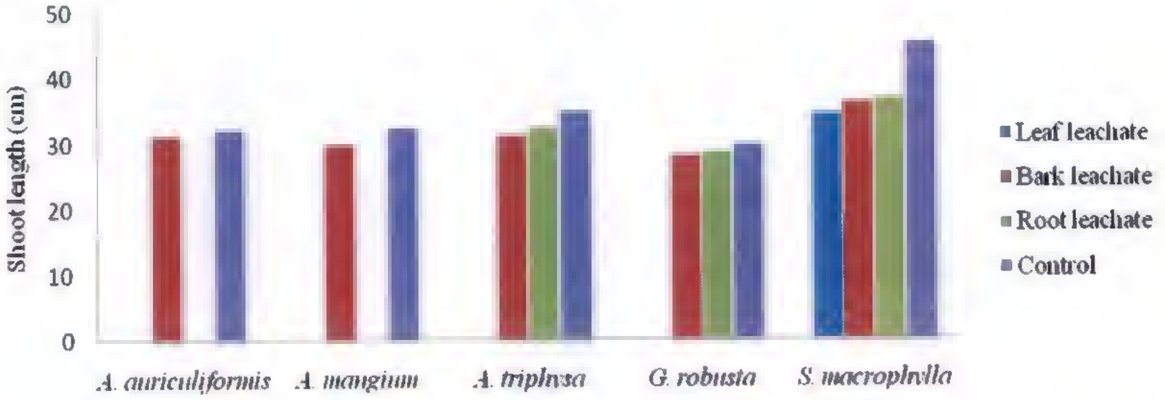

Figure. 3 Shoot length of tree seedlings at 90 DAS as affected by different plant leachates

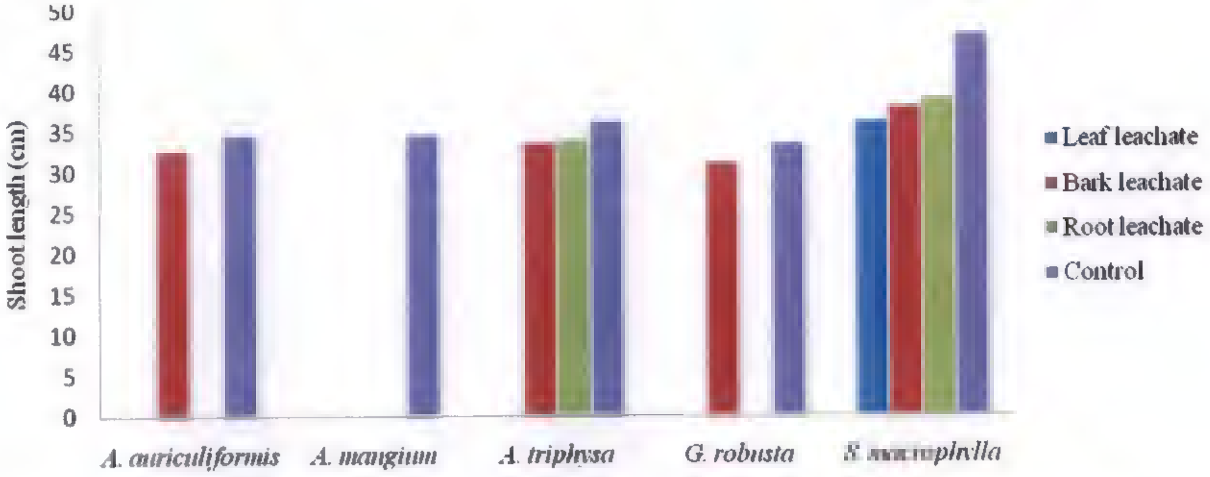

Figure.4 Shoot length of tree seedlings at 120 DAS as affected by different plant leachates

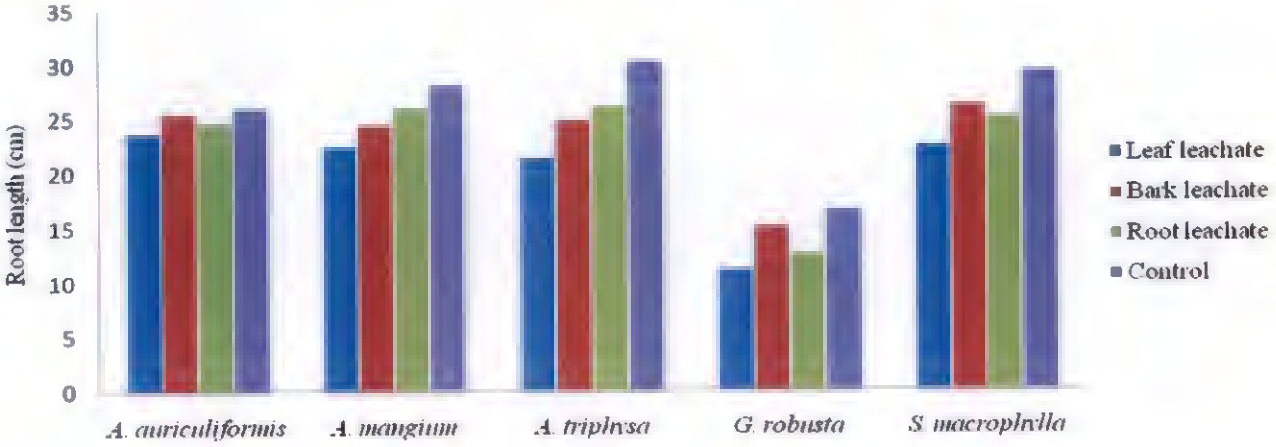

Figure. 5 Root length of tree seedlings at 30 DAS as affected by different plant leachates

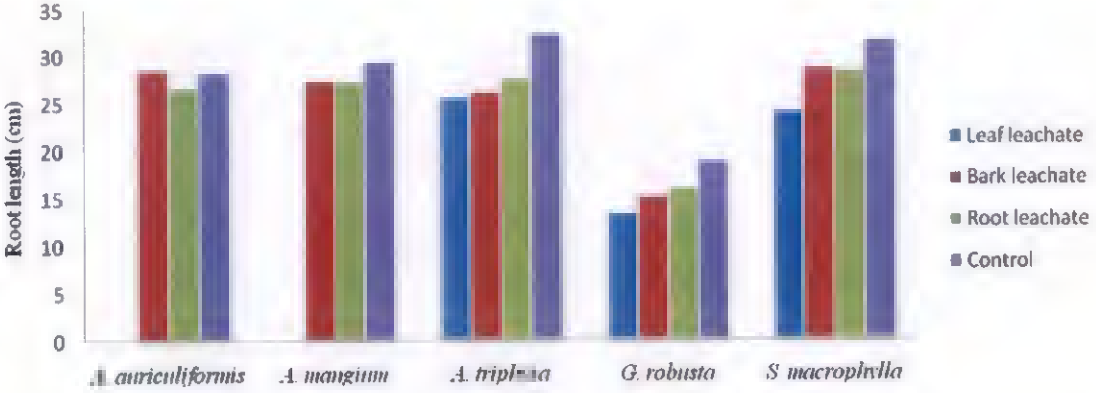

Figure. 6 Root length of tree seedlings at 60 DAS as affected by different plant leachates

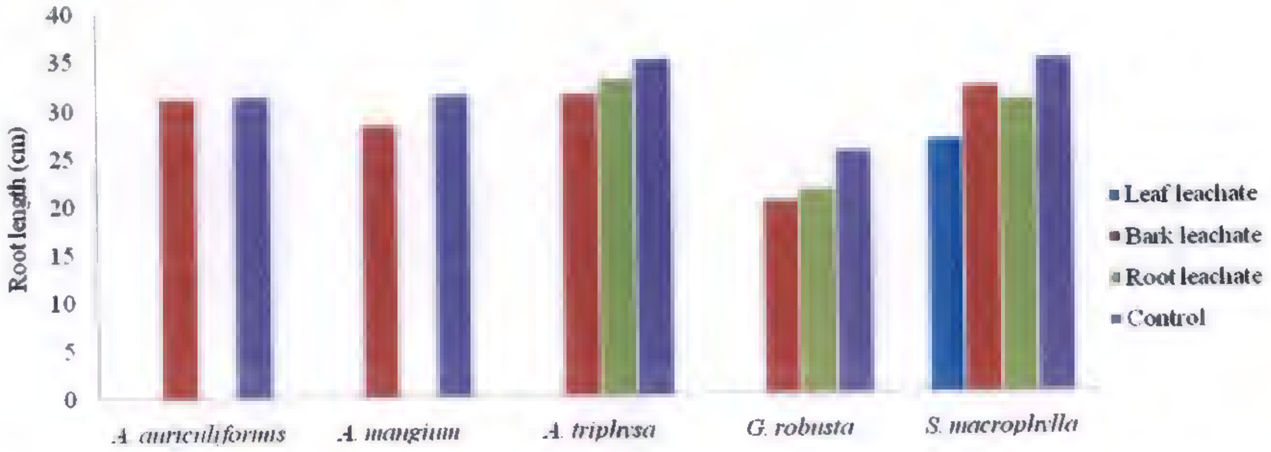

Figure. 7 Root length of tree seedlings at 90DAS as affected by different plant leachates

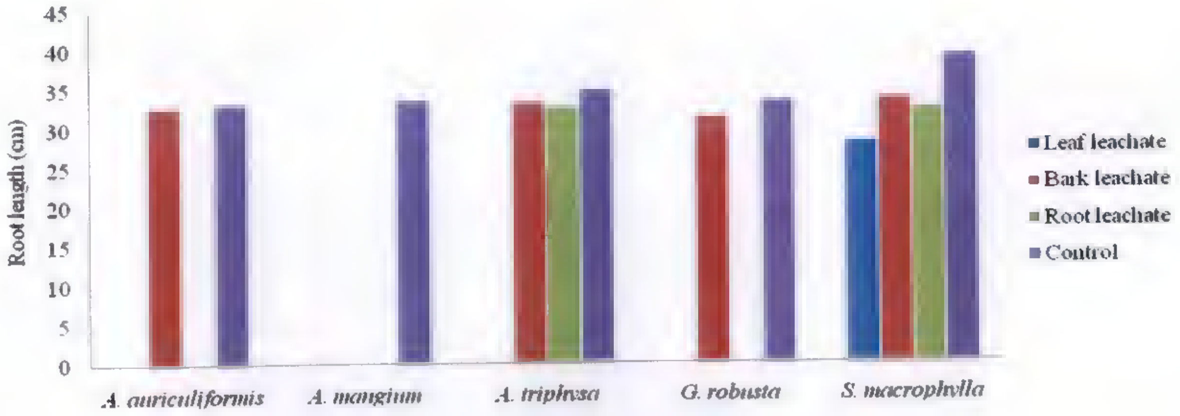

Figure. 8 Root length of tree seedlings at 120 DAS as affected by different plant leachates

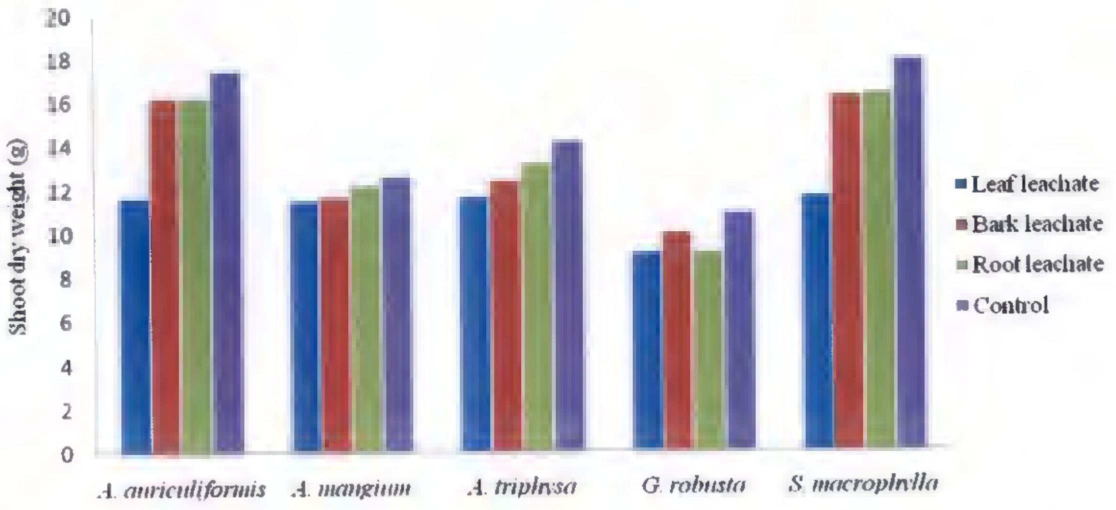

Figure.9 Shoot dry weight tree seedlings at 30 DAS as affected by different plant leachates

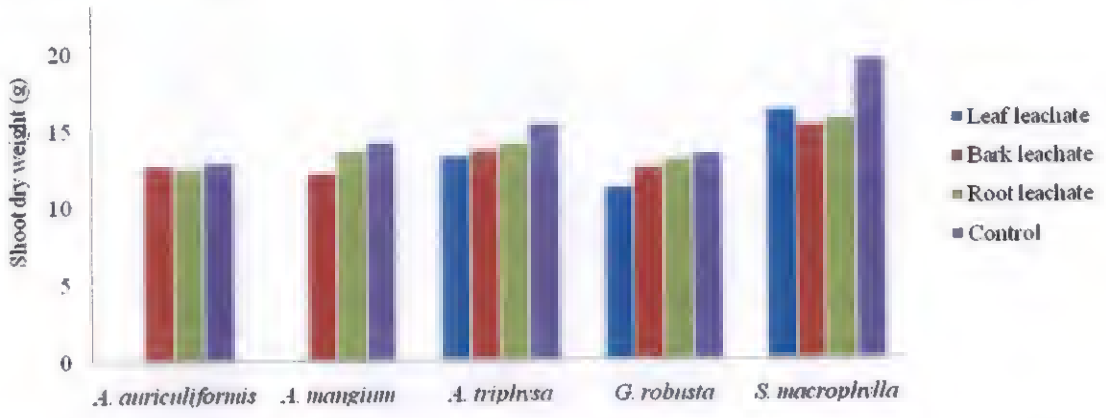

Figure. 10 Shoot dry weight tree seedlings at 60 DAS as affected by different plant leachates

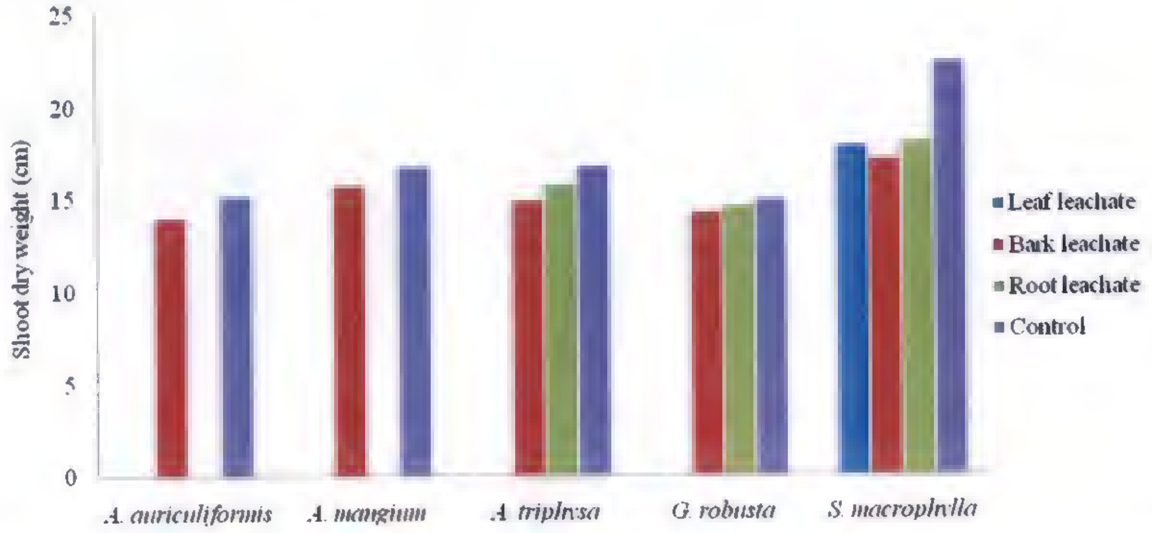

Figure. 11 Shoot dry weight tree seedlings at 90DAS as affected by different plant leachates

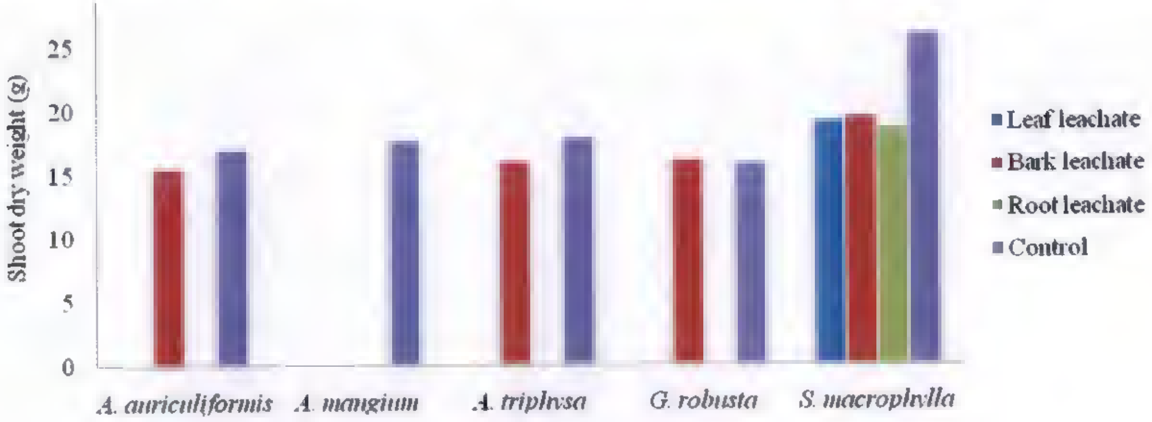

Figure.12 Shoot dry weight tree seedlings at 120 DAS as affected by different plant leachates

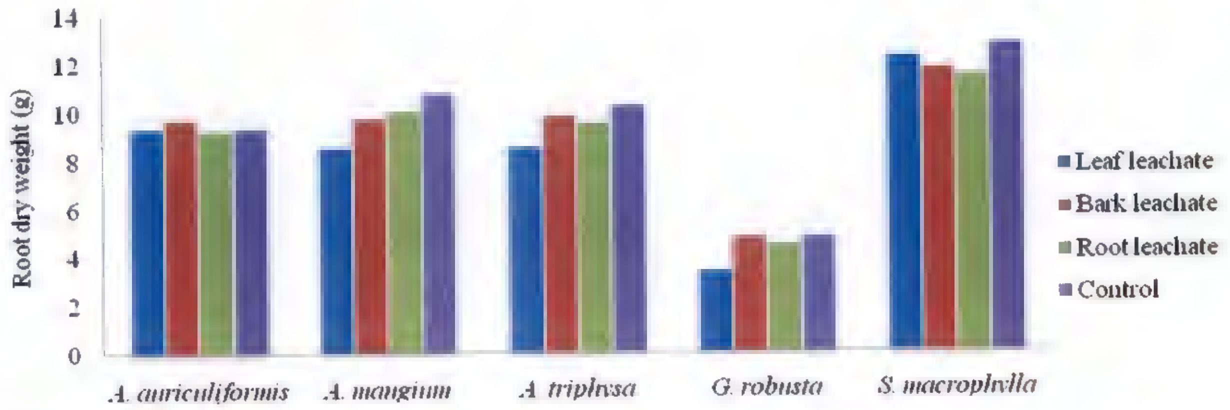

Figure. 13 Root dry weight of seedlings at 30 DAS as affected by different plant leachates

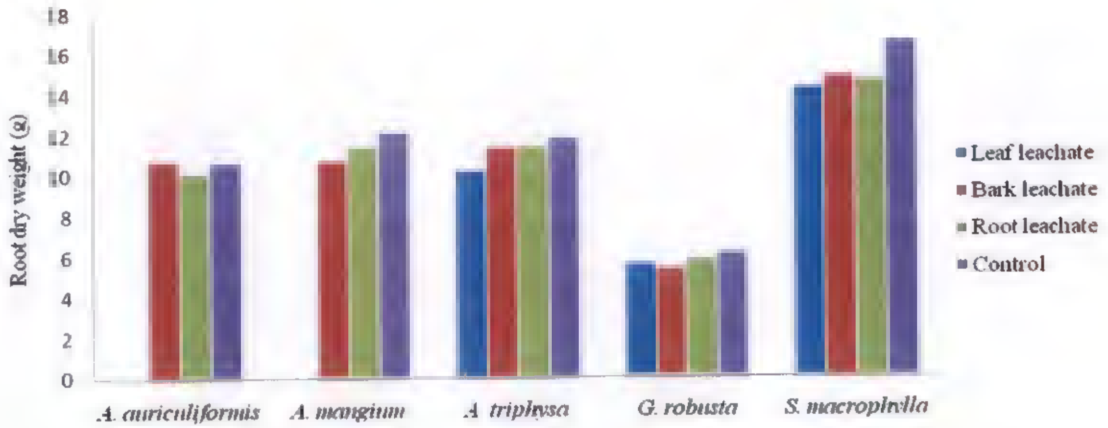

Figure. 14 Root dry weight of seedlings at 60 DAS as affected by different plant leachates

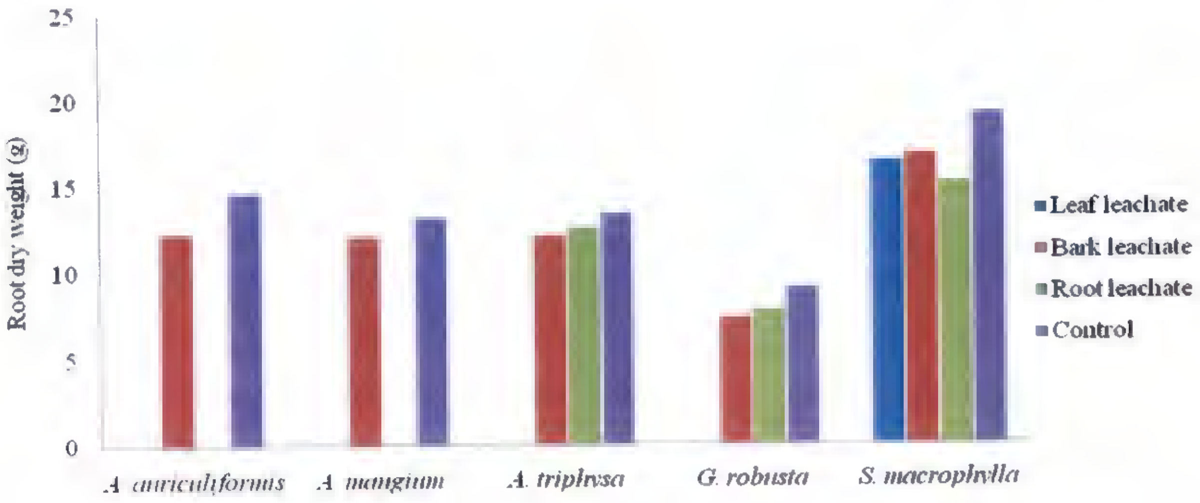

Figure. 15 Root dry weight of tree seedlings at 90DAS as affected by different plant leachates

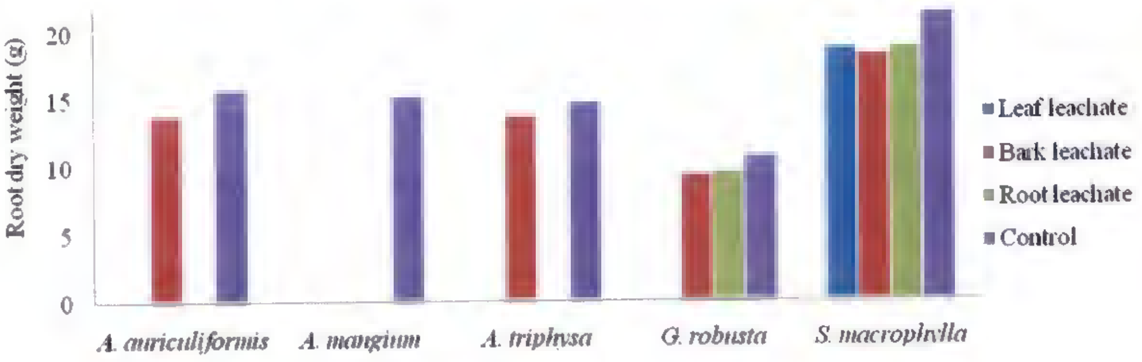

Figure.16 Root dry weight of tree seedlings at 120 DAS as affected by different plant leachates

4.5 ALLELOPATHIC EFFECT OF THE SELECTED TREES ON BIOMETRIC OBSERVATIONS OF TEST CROP

The results on biometric parameters such as shoot length, root length, shoot dry weight and root dry weight at 30 DAS and 60 DAS as affected by the application of leachates from different tree species on the agricultural test crop (cowpea) is given as below.

4.5.1 Shoot length and root length at 30 DAS

The measurement of shoot length taken after 30 DAS is presented in Table.8. For all the treatments the shoot length is found to be greater for *S. macrophylla* than the other four species. In all the cases the leaf leachate marked the lowest shoot length for the test crop and highest shoot length is observed for control. The root length of the test crop is noted to be greater in pots irrigated with the leachates of different plant parts of *S. macrophylla*. The lowest root length of the test crop is marked for the leaf leachate of *G. robusta*. The highest observation for the root length of the test crop is noted for the control and least for the leaf leachate treatment.

Table. 8 Shoot length of test crop at 30 DAS

Species	**30 DAS**				
	A. auriculiformis	*A. mangium*	*A. triphysa*	*G. robusta*	*S. macrophylla*
Leaf leachate	18.64	19.10	18.62	17.71	22.31
Bark leachate	19.52	18.94	18.99	18.64	21.87
Root leachate	19.38	19.34	18.62	18.87	23.78
Control	23.04	21.98	22.78	20.56	26.09

Plate 6. Two month old cow pea seedlings raised in tree nursery irrigated with a) tap water b) leaf leachate c) bark leachate d) root leachate of *Acacia auriculiformis*

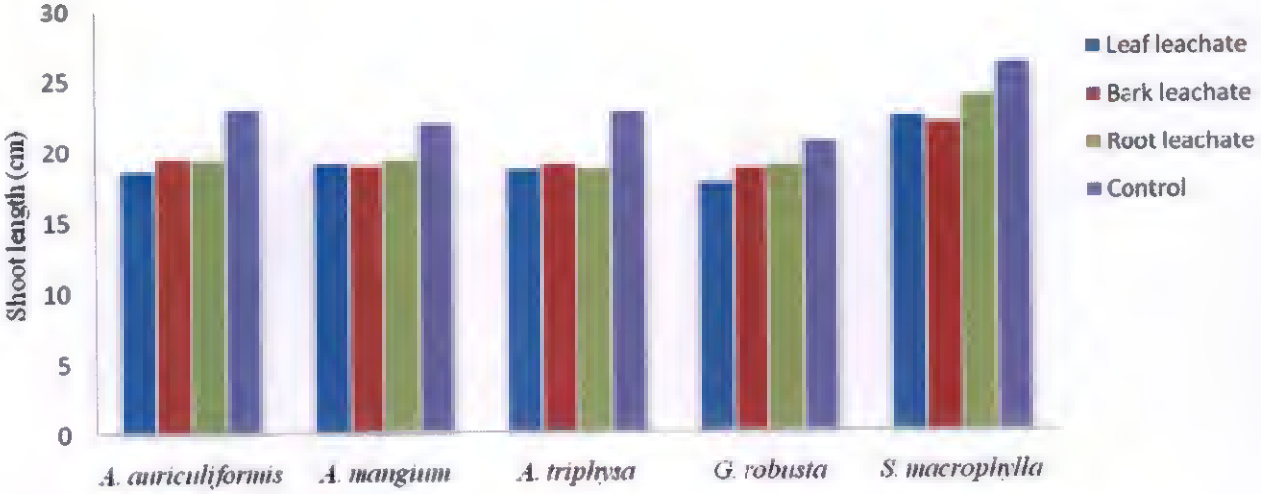

Figure.17 Shoot length of test crop at 30 DAS as affected by different plant leachates

Table.9 Root length of test crop at 30 DAS

Species	**30 DAS**				
	A. auriculiformis	*A. mangium*	*A. triphysa*	*G. robusta*	*S. macrophylla*
Leaf leachate	14.03	15.87	14.01	13.74	17.01
Bark leachate	15.94	15.34	15.67	15.47	16.92
Root leachate	15.99	13.32	15.59	15.93	16.56
Control	16.68	16.26	17.04	16.34	17.65

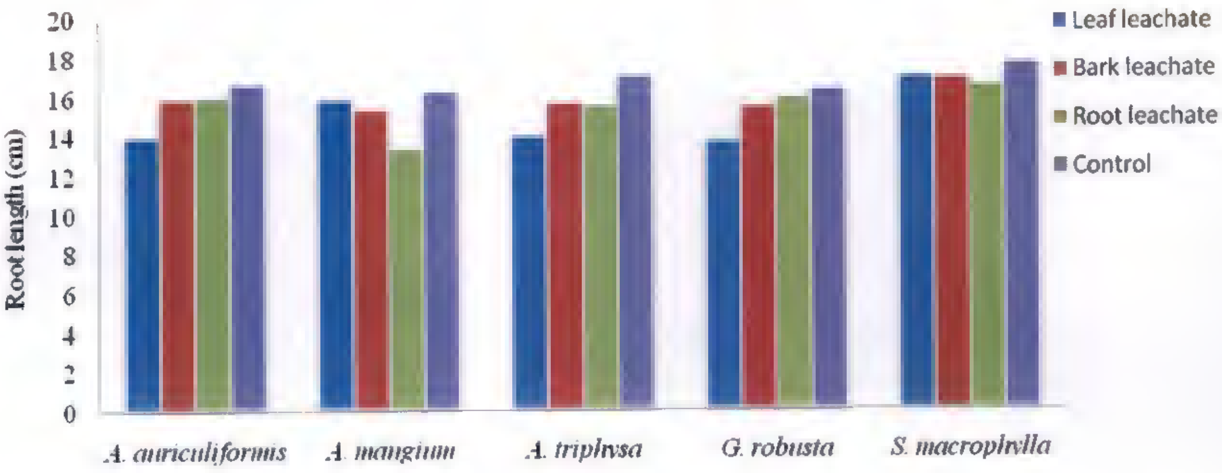

Figure. 18 Root length of test crop at 30 DAS as affected by different plant

4.5.2 Shoot dry weight and root dry weight of test crop at 30 DAS

The shoot and root dry weight of the test crop measured at 30 DAS is presented in Table.10. The observed values shows a higher shoot and root dry weight for the seedlings treated with the plant parts of *S. macrophylla* than the seedlings irrigated with the leachates of other trees. In general the leaf leachate showed the least shoot biomass in all the five species.

Table.10 Shoot dry weight of test crop at 30 DAS

Species	30 DAS				
	A. auriculiformis	*A. mangium*	*A. triphysa*	*G. robusta*	*S. macrophylla*
Leaf leachate	0.476	0.448	0.473	0.345	0.523
Bark leachate	0.475	0.422	0.432	0.401	0.527
Root leachate	0.453	0.446	0.402	0.423	0.512
Control	0.496	0.487	0.472	0.444	0.582

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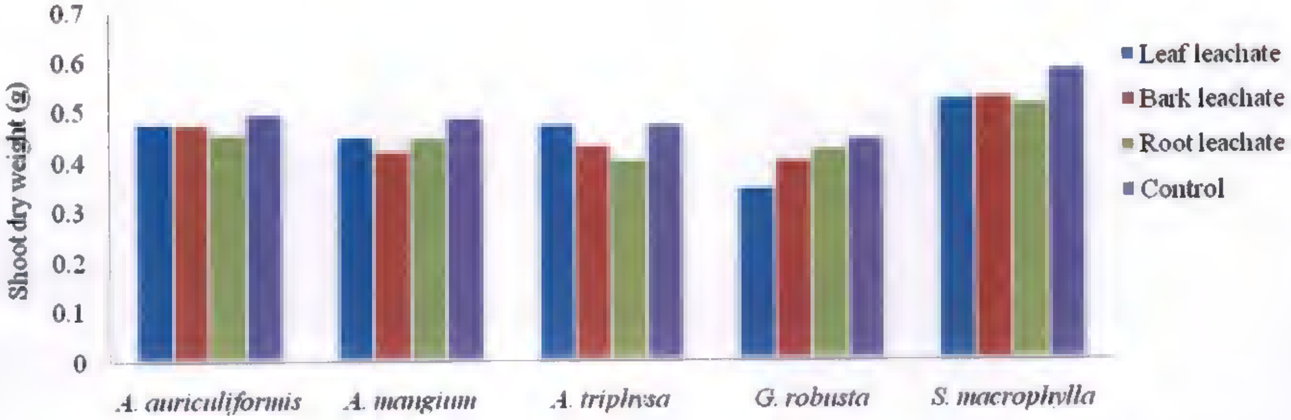

Figure. 19 Shoot dry weight of test crop at 30 DAS as affected by different plant

Table.11 Root dry weight of test crop at 30 DAS

Species	30 DAS				
	A. auriculiformis	*A. mangium*	*A. triphysa*	*G. robusta*	*S. macrophylla*
Leaf leachate	0.086	0.079	0.073	0.071	0.091
Bark leachate	0.090	0.086	0.071	0.069	0.087
Root leachate	0.090	0.092	0.068	0.069	0.085
Control	0.096	0.93	0.077	0.070	0.092

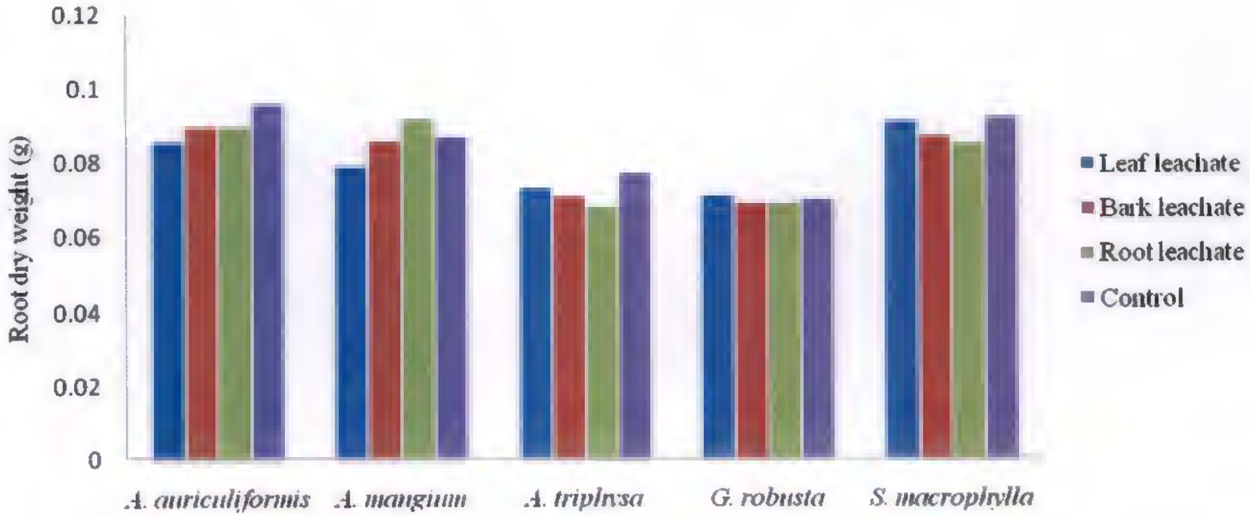

Figure. 20 Root dry weight of test crop at 30 DAS as affected by different plant leachates

4.5.3 Shoot length and root length at 60 DAS

The result of the biometric observations of the test crop made at the 60 DAS is presented in the table. 12 . The observations shows a higher shoot length and root length in the case of plants treated with the *S. macrophylla* plant parts than the plant part leachate of other trees. The shortest shoot length among the treatments is noted for the seedlings treated with the leaf leachate of *G. robusta.* The shortest root length is observed for the seedling treated with the leaf leachate of *G. robusta.*

Table.12 Shoot length of test crop at 60 DAS

Species	60 DAS				
	A. auriculiformis	*A. mangium*	*A. triphysa*	*G. robusta*	*S. macrophylla*
Leaf leachate	28.67	29.62	27.67	25.67	34.26
Bark leachate	28.98	28.34	28.09	27.51	32.03
Root leachate	27.62	28.76	28.95	27.65	33
Control	34.74	30.84	30.64	28.93	37.06

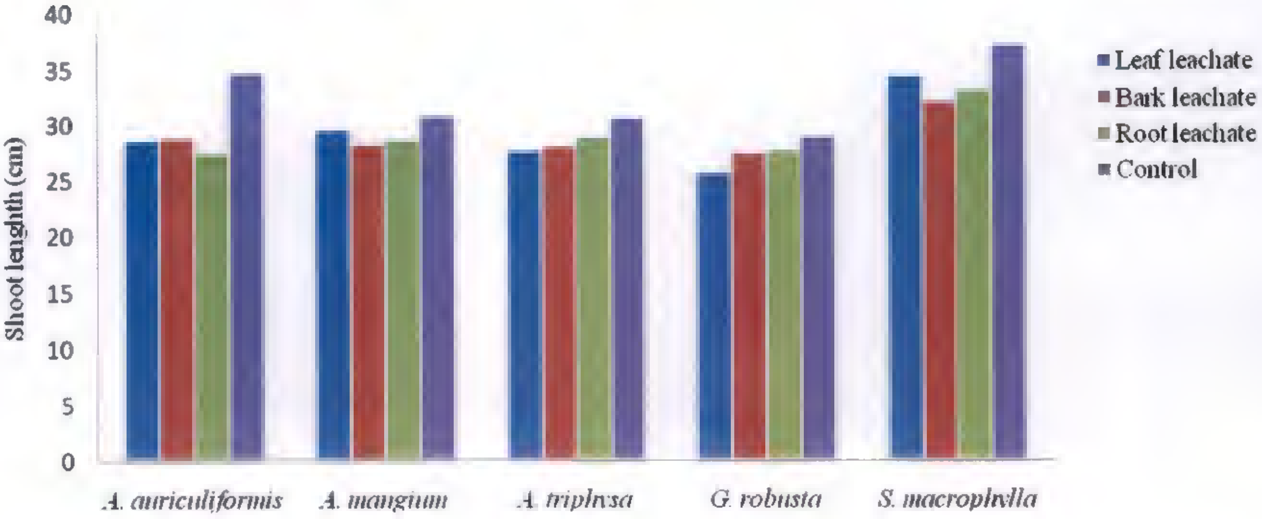

Figure. 21 Shoot length of test crop at 60 DAS as affected by different plant leachates

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Table.13 Root length of test crop at 60 DAS

Species	**60 DAS**				
	A. auriculiformis	*A. mangium*	*A. triphysa*	*G. robusta*	*S. macrophylla*
Leaf leachate	16.78	16.34	15.98	15.59	22.21
Bark leachate	18.54	17.34	17.64	17.98	23.01
Root leachate	18.63	18.93	17.78	17.46	23.04
Control	20.87	20.99	19.89	21.04	26.04

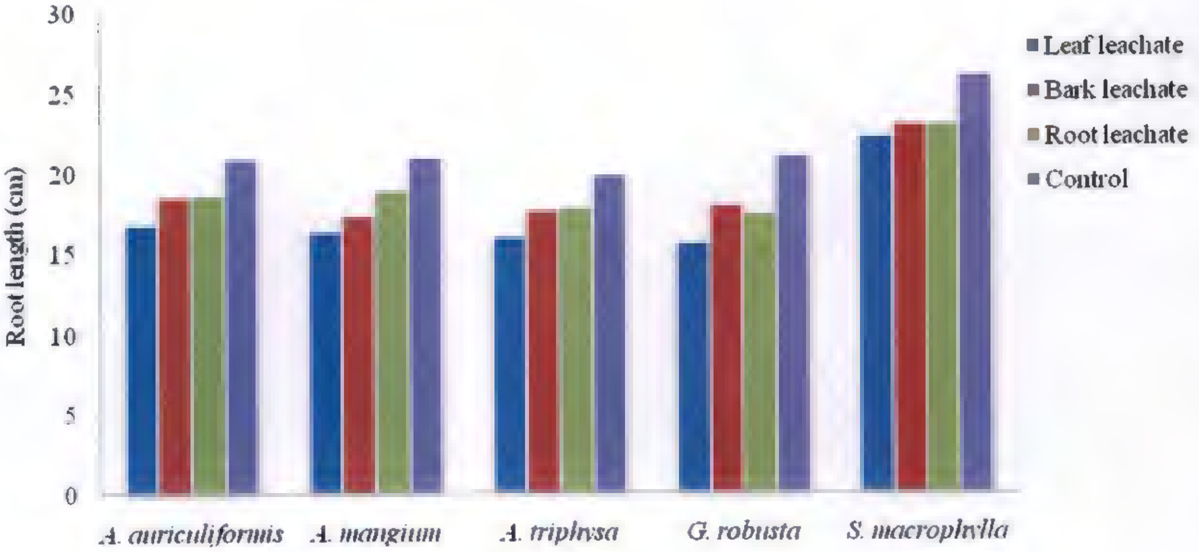

Figure. 22 Root length of test crop at 60 DAS as affected by different plant leachates

4.5.4 Shoot dry weight and root dry weight at 60 DAS

The shoot and root dry weight taken at 60DAS of the test plant is presented in the Table.14. The observed values shows a higher shoot and root dry weight for the seedlings treated with the plant parts of *S. macrophylla* than the seedlings irrigated with the leachates of other trees. In general the leaf leachate showed the least shoot biomass in all the five species.

Table.14 Shoot dry weight at 60 DAS

Species	60 DAS				
	A. auriculiformis	*A. mangium*	*A. triphysa*	*G. robusta*	*S. macrophylla*
Leaf leachate	1.23	1.12	1.09	1.01	2.01
Bark leachate	1.63	1.34	1.19	1.1	1.97
Root leachate	1.67	1.39	1.18	1.29	2.1
Control	1.73	1.79	1.56	1.72	2.46

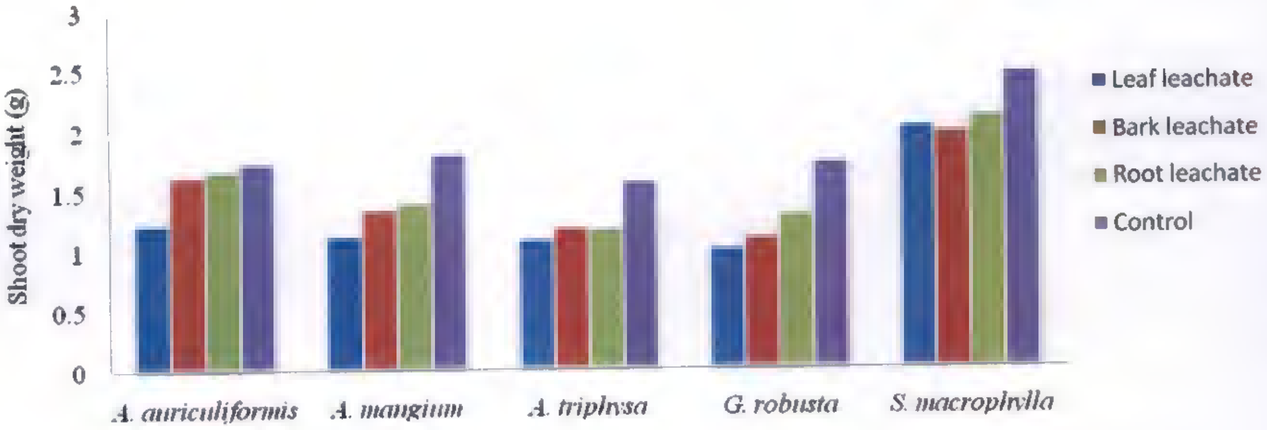

Figure. 23 Shoot dry weight of test crop at 60 DAS as affected by different plant leachates

Table.15 Root dry weight of test crop at 60 DAS

Species	60 DAS				
	A. auriculiformis	*A. mangium*	*A. triphysa*	*G. robusta*	*S. macrophylla*
Leaf leachate	0.1	0.1	0.07	0.07	1.06
Bark leachate	0.15	0.19	0.09	0.08	1.05
Root leachate	0.17	0.18	0.11	0.11	1.06
Control	0.26	0.21	0.18	0.18	1.1

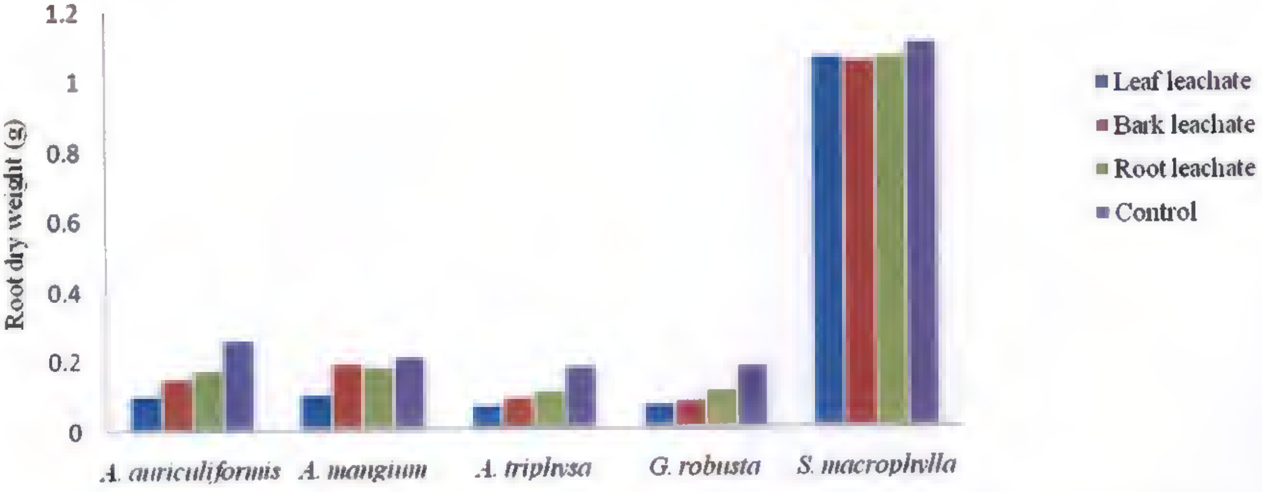

Figure. 24 Root dry weight of test crop at 60 DAS as affected by different plant leachates

The monthly analysis of the soil used for the pot culture experiment has been analysed. The soil nutrient as expected showed a declining trend and the result is presented in Table.16 and Table.17.

4.6.1 Initial soil nutrient

The initial NPK content of the soils (kg ha^{-1}) collected from different plantations used for pot culture experiment is analysed and is presented in the Table.16. The highest initial concentration of nitrogen and potassium is found in the of *S. macrophylla* plantation. The *A. triphysa* plantation marked the second highest concentration of nitrogen and is followed by the *A. auriculiformis* plantation. In case of phosphorous the highest concentration is marked for *A. auriculiformis* plantation and lowest content is found in the *A. mangium* plantation.

Table.16 Initial soil nutrients

Location	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
A. auriculiformis plantation	335.19^{ab}	172.07^{a}	230.6^{b}
A. mangium plantation	272.61^{b}	108.17^{c}	201.76^{c}
A. triphysa plantation	415.17^{a}	107.78^{c}	223.46^{b}
G. robusta plantation	285.17^{b}	110.08^{c}	229.83^{b}
S. macrophylla plantation	365.25^{ab}	152.61^{b}	264.95^{a}

Means having same lowercase letter as superscript is homogeneous within a coloumn.

4.6.2 Nutrient variation in the soil used for Autoallelopathic study

The monthly variation in nutrient content of the soil used for pot culture experiment is analysed and the result is presented in the Table.17 . The total N content in pot culture experiment varied with number of days and also with change in plant part leachate applied. The total phosphorous and total potassium also showed a decreasing trend with increase in duration. This trend is followed for all the five tree species.

Table.17 Changes in the nutrient content (kg ha^{-1}) of the soil in the autoallelopathic pot culture experiment

	Nutrient	N (kg ha^{-1})				P (kg ha^{-1})				K (kg ha^{-1})			
	DAS	30	60	90	120	30	60	90	120	30	60	90	120
A. auriculiformis	Leaf leachate	299.43	-	-	-	153.27	-	-	-	184.16			
	Bark leachate	208.64	172.83	163.15	155.89	156.78	145.87	133.78	126.78	178.12	159.01	143.28	131.56
	Root leachate	272.89	132.22	-	-	153.67	145.63	-	-	167.87	132.33	-	-
	Control	167.78	145.73	127.36	100.45	142.32	123.92	108.43	82.11	208.64	189.02	170.77	145.17
A. mangium	Leaf leachate	232.64	-	-	-	89.45	-	-	-	176.23	-	-	-
	Bark leachate	256.11	230.45	211.34	-	99.45	84.44	77.18	-	163.94	147.83	121.12	-
	Root leachate	243.13	223.81	-	-	98.67	81.89	-	-	178.43	152.98	-	-
	Control	253.87	219.73	187.45	166.99	88.65	72.74	61.79	56.71	176.72	145.64	122.09	109.67
A. triphysa	Leaf leachate	327.69	306.11	-	-	96.76	81.21	-	-	189.56	153.68	-	-
	Bark leachate	292.65	261.55	238.95	216.14	91.22	78.99	59.98	43.52	119.54	98.62	76.14	62.87
	Root leachate	321.78	298.14	267.43	-	90.02	76.66	59.92	-	226.19	119.63	101.22	-
	Control	301.54	282.01	253.98	219.57	92.38	78.63	63.45	55.27	189.81	166.02	141.98	112.82
G. robusta	Leaf leachate	266.11	238.89	-	-	99.33	76.45	-	-	178.43	152.03	-	-
	Bark leachate	271.02	244.78	205.18	188.62	94.81	86.54	73.82	56.13	203.82	191.04	169.65	142.13
	Root leachate	262.14	240.89	201	-	98.32	78.12	60.02	-	205.67	189.65	164.62	-
	Control	261.86	249.12	226.08	201.43	95.78	83.23	68.98	51.65	201.76	193.98	178.23	145.09
S.macrophylla	Leaf leachate	321.89	278.85	251.33	231.09	127.66	103.12	92.83	80.09	241.84	217.08	199.99	168.14
	Bark leachate	341.73	318.88	293.49	-	126.71	108.98	87.89	-	251.02	228.03	188.45	-
	Root leachate	342.18	329.83	301.22	288.6	123.43	109.09	86.38	73.21	251.98	239.14	218	201.23
	Control	344.98	313.52	296.28	262.86	129.03	111.98	92.08	73.21	238.92	212.09	193.65	172.93

4.6.3 Nutrient variation in the soil used for allelopathic study of test crop

The monthly variation in nutrient content of the soil used for pot culture experiment is analysed and the result is presented in the Table 18. The total N content in pot culture experiment varied with number of days and also with different plant part leachate applied. The total phosphorous and total potassium also showed a decreasing trend with increase in duration. This trend is followed for all the five tree species. The total nitrogen content decreased from 296.01 kg ha^{-1} in the first month to 274.36 kg ha^{-1} at the end of second month in the cowpea pots treated with leaf leachate. In all the cases the soil nutrients showed a decreasing trend.

Table.18 Changes in the nutrient content (kg ha^{-1}) of the soil in the allelopathic pot culture experiment

	Nutrients	N(kg ha^{-1})		P(kg ha^{-1})		K(kg ha^{-1})	
	DAS	30	60	30	60	30	60
A. auriculiformis	**Leaf leachate**	270.275	272.690	151.750	130.280	183.160	180.455
	Bark leachate	257.320	191.850	157.040	151.545	172.620	153.450
	Root leachate	277.895	190.670	152.245	136.920	177.125	141.610
	Control	282.060	243.145	148.325	122.655	216.920	190.665
A. mangium	**Leaf leachate**	241.800	220.330	91.155	73.585	175.730	144.650
	Bark leachate	255.225	234.570	97.365	83.280	166.140	137.340
	Root leachate	231.730	222.550	97.505	77.625	177.830	155.930
	Control	262.385	250.495	90.150	75.115	176.210	156.990
A. triphysa	**Leaf leachate**	335.340	292.970	96.040	83.385	193.540	173.110
	Bark leachate	354.400	280.695	94.030	92.115	191.320	183.430
	Root leachate	328.920	283.230	92.650	88.370	193.530	186.345
	Control	339.610	303.800	90.295	82.500	189.695	164.940
G. robusta	**Leaf leachate**	271.965	253.335	108.840	103.270	192.305	165.615
	Bark leachate	261.930	245.505	102.325	96.435	192.880	172.100
	Root leachate	273.485	255.420	100.480	91.285	188.655	166.755
	Control	258.865	245.545	95.385	79.520	183.615	172.140
S .macrophylla	**Leaf leachate**	340.925	213.520	122.905	195.960	240.125	215.100
	Bark leachate	351.145	337.975	134.555	127.500	240.740	226.805
	Root leachate	348.670	280.305	128.645	114.270	234.535	211.810
	Control	342.070	316.305	130.560	115.630	232.390	217.185

Discussion

DISCUSSION

This chapter discusses in detail on the results of the study entitled "Autoallelopathy of selected multipurpose tree species and the effect of their leachate on agricultural test crop."

5.1 PHYSICO CHEMICAL PROPERTIES OF LEACHATES

The physico chemical properties of the leachate viz., pH, total solid, electrical conductivity, total phenol and total carbohydrate up to 36 hours of soaking is discussed hereunder.

5.1.1 pH

The leachate of tree parts viz., leaf, bark and root showed decreasing trend in pH with increase in soaking time (Figure 1). In all the five species viz., *A. auriculiformis, A. mangium, A. triphysa, G. robusta and S. macrophylla* the leaf, bark and root leachate marked the highest pH value at the 6th hour and lowest pH value at 36th hour. The pH decline noticed in leachate as advancement of soaking time may be due to the release of phenolic acid and other soluble acidic components into the water. The study conducted by Murugesan (2003) also observed the decline in leachate pH of four tree species viz., *Acacia nilotica, Azadirachta indica, Gmelina arborea,* and *Tectona grandis* with extended duration of soaking. A study conducted by Silas (2010) with leaf leachate of eleven species it is found that the pH decreased up to the 5th day.

The present study also observed a variation in the pH with different plant parts in each duration. The highest decrease in pH content is noticed in case of leaf leachate. This may be due to the increased leaching of phenolic compounds in leaf. But, in *S. macrophylla* the highest variation in pH is noticed in case of bark leachate. This may be due to the variation in amount of soluble phenolic components within different plant parts of the trees. While, considering the bark and root leachate for their variation in pH, only a very slight variation has been noticed. This may be due to the difference in phenolic component in their solubility and concentration in plant parts.

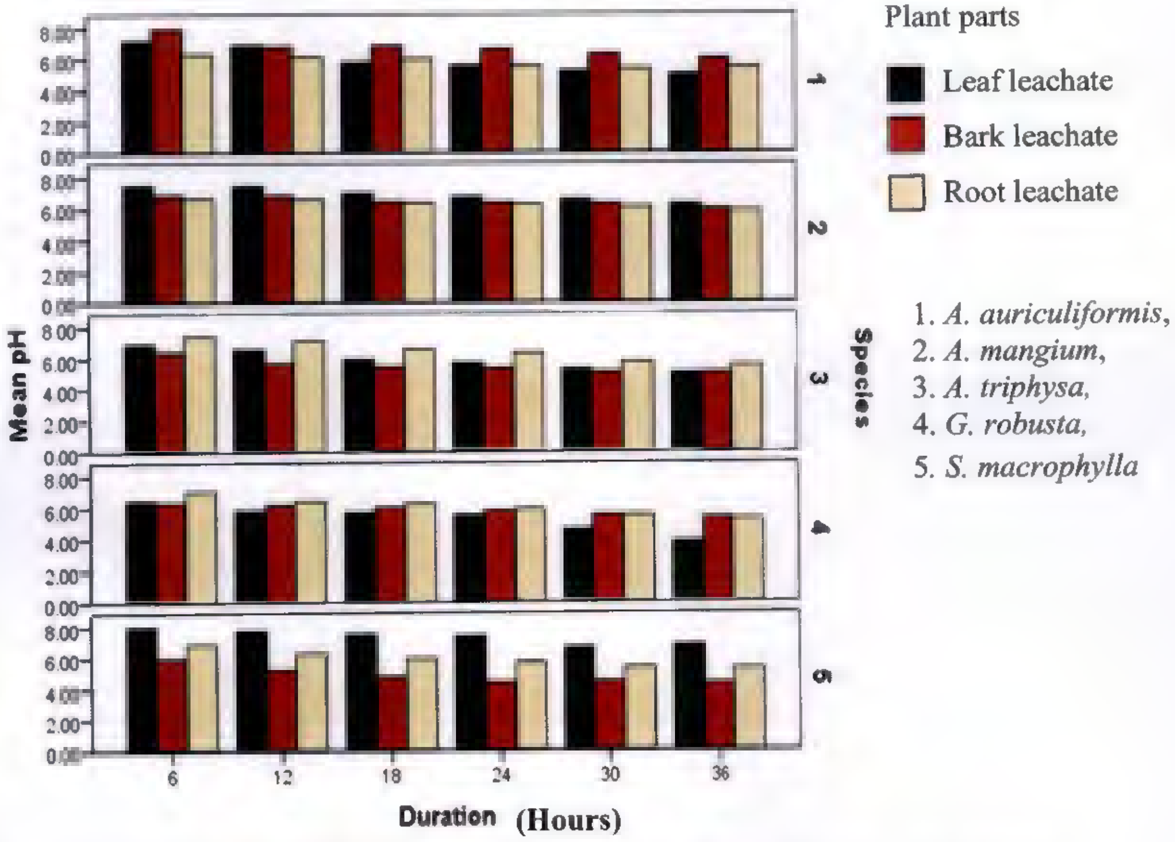

Figure. 25 Variation in pH of leachates in different plant parts of selected tree species

5.1.2 Electrical Conductivity

Results of electrical conductivity showed an increase in salt content with the duration of soaking (Figure.26). Similarly, increase in electrical conductivity with an increase in soaking period was also reported in leachate of *Simarouba glauca* (Raj, 2004) and in four different Eucalyptus species (Sasikumar *et al.*, 2000). Among the different plant part leachate studied for the electrical conductivity, all leaf leachate except *S. macrophylla* showed greater variation in electrical conductivity. The difference for electrical conductivity in case of bark and root leachate is of very narrow range. The possible reason may be the difference in concentration of minerals in various plant components.

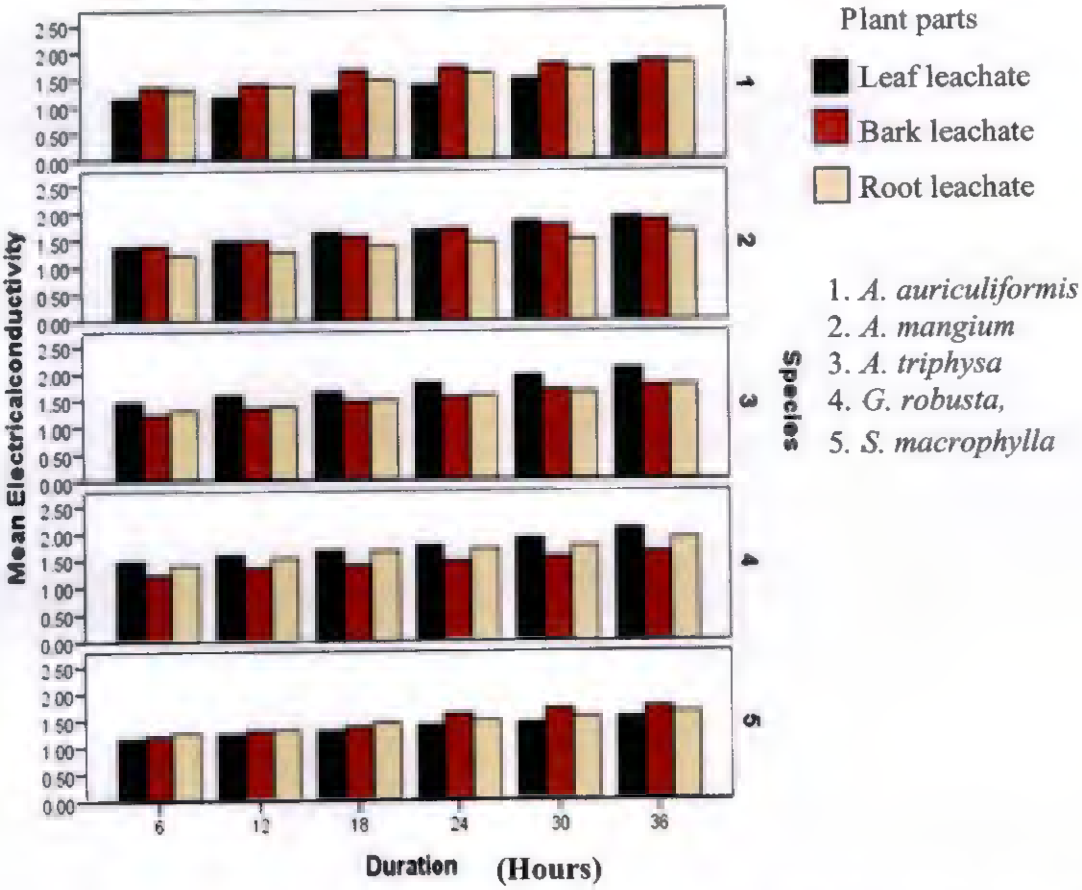

Figure. 26 Variation in electrical conductivity of leachates in different plant parts of selected tree species

5.1.3 Total Solid Content

The total solid content of all the tree species showed an increasing trend with an increase in soaking time (Figure 27). The total solid content accumulation is found more in the root leachate followed by bark and leaf leachate in case of *A.*

auriculiformis, A. mangium and *S. macrophylla.* But, in *A. triphysa* and *G. robusta* the leaves marked the highest total solid content accumulation. This might be due to the accumulation of allelochemicals and other nonvolatile components in the leachates over the soaking period. Similar results were reported in the experiment conducted by Ravi (2005), where he found the increase in total solid content in the leachates of *Ailanthus excelsa.*

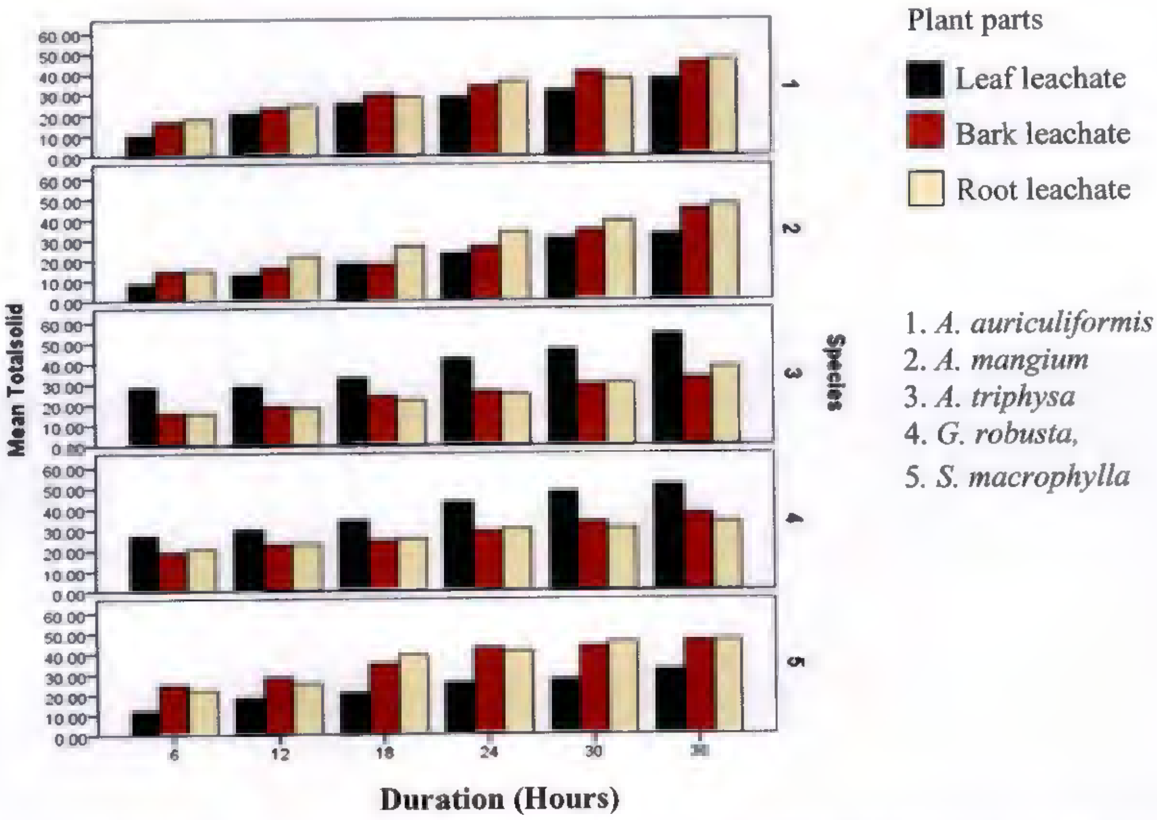

Figure. 27 Variation in total solid of leachates in different plant parts of selected tree species

5.1.4 Total Carbohydrate

Fresh leaves, bark and root leachates showed relatively higher amount of total carbohydrate in all of the tree species (Figure 4). The results confirms the findings of Murugesan (2003) wherein the total carbohydrate showed an increasing trend with an increase in soaking time in *Acacia nilotica, Azadirachta indica, Gmelina arborea,* and *Tectona grandis.* Similarly Ravi (2005) reported that, increasing trend of total carbohydrate is due to extended duration of leachates from various plant parts of *Ailanthus excelsa*. Among the different tree parts except for *S. macrophylla* all the species showed an increased accumulation of total carbohydrate in the leaves. While in case of *S. macrophylla* the total carbohydrate accumulation is found to be more in the bark leachate.

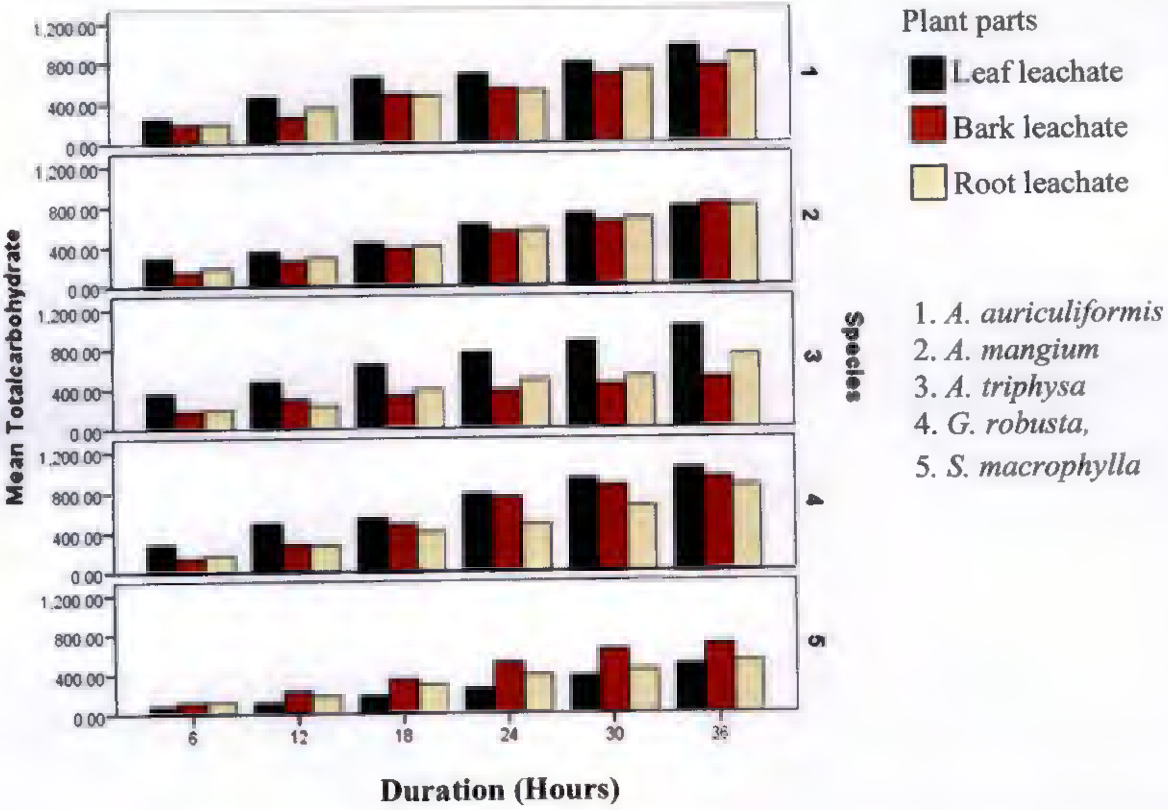

Figure. 28 Variation in total carbohydrate of leachates in different plant parts of selected tree species

5.1.6 Total Phenol

The total phenolic contents of leaf, bark and leaf leachate of all five tree species showed an increasing trend in the content from zero to 36 hours of duration of soaking (Figure 28). Among the plant part leachates, the leaf leachate showed greater accumulation of total phenol in all the species except *S. macrophylla* where the highest accumulation is noted in the root leachate. The higher total phenol content in the leachates in the present study could be due to the release of secondary metabolites during the processes of litter degradation as stated by Siqueira *et al.* (1981). A concentration range of 150 mg l^{-1} and 1000 mg l^{-1} is identified as inhibitory to the plant growth by Guensi and McCalla (1966). The total phenol content of some of the leachate falls in the line with the concentration mentioned as above and hence the higher phenolic concentration in the present study is indicative of the allelopathic nature of tree species on the test crops.

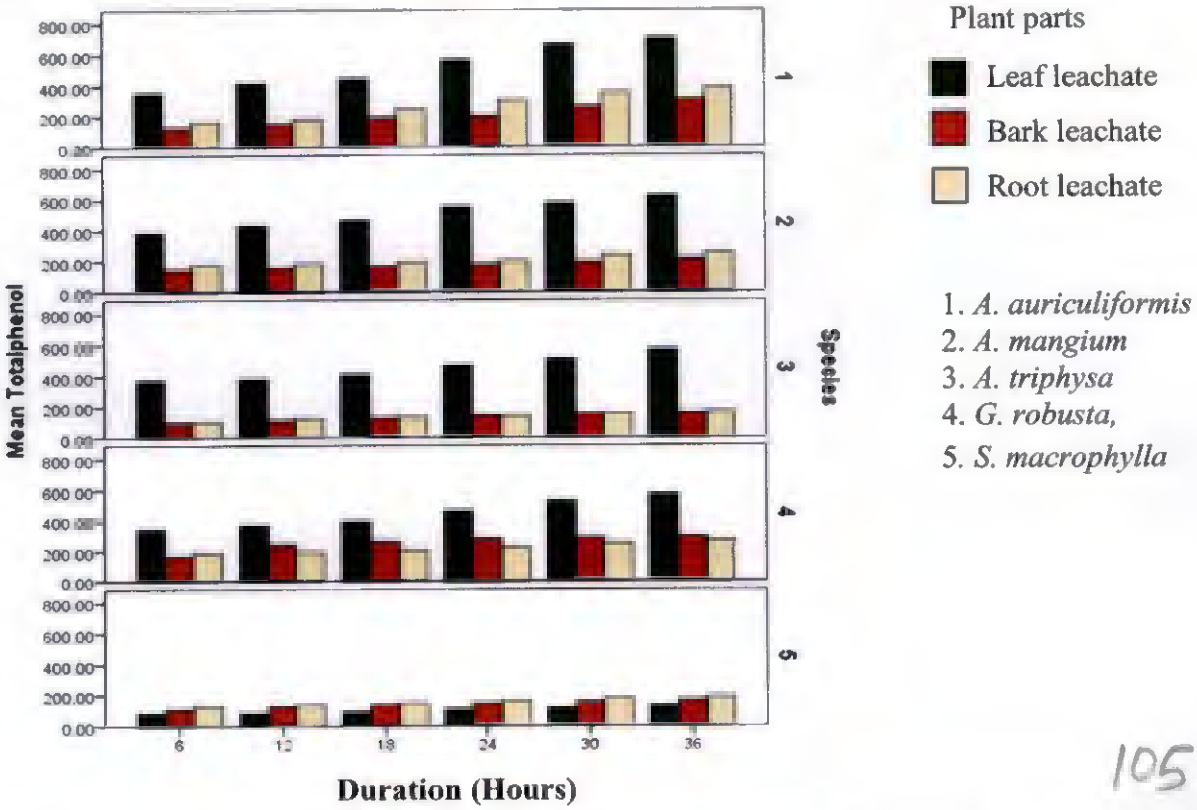

Figure. 29 Variation in total phenol of leachates in different plant parts of selected tree species

5.2 AUTOALLELOPATHIC EFFECT OF LEACHATES ON GERMINATION OF SELECTED TREE CROPS

The result of the study showed a significant difference in germination of the selected trees due to autoallelopathy. In all the tree species, except *S. macrophylla,* significantly lower germination per cent is noted for the pots irrigated with leaf leachates. This may be due to the increased concentration of phenolic compounds in the leaf leachates than the bark and root leachate. But, in case of *S. macrophylla* the germination per cent in leaf leachate is observed to be better than the bark and root leachate. This may be due to the low concentration of phenolic contents.

The result of the present study is in agreement with the study conducted by Warrag *et al.* (1999), where the guava leaf extracts reduced the germination of the guava seeds.

5.3 ALLELOPATHIC EFFECT OF LEACHATES ON GERMINATION OF AGRICULTURAL TEST CROP

The present study also aimed at investigating the possible autoallelopathic effects of five tree species and the effect of their leachate on the growth of agricultural test crop. In the pot culture experiment carried out, it is found that there is no significant difference in germination between the different plant part leachate of the selected five tree species. The germination for all plant parts except leaf leachate marked 100% germination. The leaf leachate of *A. auriculiformis, A. mangium, A. triphysa and G. robusta* showed less germination per cent when compared to leachates of bark and root and tap water. Unlike other tree species studied, the germination per cent age of test crop was not at all affected by the leaf leachates of *Swietenia macrophylla.* The results of the present study is in agreement with the findings of V. R. Nsolomo *et al.* (1995) where the leachate obtained from *Acacia xanthophloea* did not inhibit the germination of *Zea mays* 106 and *Vigna radiata.*The decrease in germination per cent of test crop irrigated with leaf leachate may be due to the presence of greater allelochemicals concentration in the leaves compared to the bark and root. Study conducted by Fisher (1980), reported a greater concentration of allelochemicals in the leaves of many plants. His study also identified the release of these chemicals into the soil ecosystems through root exudates and remains from the foliage.

5.4 AUTOALLELOPATHIC AND ALLELOPATHIC EFFECT PLANT PARTS OF THE SELECTED TREES ON BIOMETRIC OBSERVATIONS

The decrease in the shoot length and root length noticed in both the experiments where the pots were irrigated with leachates of different plant parts as compared to the control. This may be due the presence of allelochemicals in the leachate. The result of the present study is in agreement with the inversely proportional relation of the concentration of leachates and seedling growth as stated by Hamed *et al.* (2015).

5.5 NUTRIENT VARIATION IN THE SOIL USED FOR POT CULTURE EXPERIMENT

The result of the pot culture experiment showed decreasing trend in the nutrient content in the pot culture media as the time advances. This may be due to the absorption of nutrients by the seedlings. The result of the study conducted by John *et al.* (2007) and Hamed *et al.* (2015) also noted a similar reduction in the biometric observation of seedlings treated with leachates in pot culture experiment.

5.6 MANAGERIAL STRATEGIES

The study conducted in the tree nursery of College of Forestry, Vellanikkara leads to the conclusion that the seeds of trees when irrigated with the different plant part leachate inhibit the germination and growth of their own seedlings. This inhibitory effect is predominant for the seedlings irrigated with leaf leachate except in case of *Swietenia macrophylla* of all the five tree species studied via., *Acacia mangium, Acacia auriculiformis, Ailanthus triphysa* and *Grevillea robusta.* The pots irrigated with tap water (control) showed better germination and growth parameters against the pots irrigated with leachates. The test crop showed a decrease in germination percent when treated with leaf leachates except in case of *Swietenia macrophylla* where the leaf leachate had given cent percent germination.

It is evident from the study that except *Swietenia macrophylla* the leaves, bark and root leachate of *Acacia auriculiformis, Acacia mangium, Ailanthus triphysa* and *Grevillea robusta* inhibited the germination and growth of both their own and the agricultural test crop. By keeping in mind the result of the study, some managerial measures can be adopted for avoiding these inhibitory effects in the fields as well as in the nurseries.

In the nurseries the leaves of *Acacia mangium, Acacia auriculiformis, Ailanthus triphysa* and *Grevillea robusta* can be avoided as mulch for the beds sown with their own seeds. Also, mulching of cowpea with the leaves of the above mentioned four species is to be avoided for better growth.

Summary

SUMMARY

A nursery study was carried out with the objective to understand the possible autoallelopathic effects of leachates of selected MPTs and also to monitor the effects of leachates of the above MPTs on the germination and growth of selected agricultural test crop.

The salient findings of the study are summerised as below:

1. 1. pH of all the five species via., *Acacia auriculiformis, Acacia mangium, Ailanthus triphysa, Grevilliea robusta* and *Swietenia macrophylla* showed a decreasing trend with increasing soaking time of all the three tree parts such as leaf, bark and root.
2. An increasing concentration of total solid content is noticed with increasing soaking time in all the tree parts studied of all the five species.
3. The electrical conductivity of leaf, bark and root leachate of all the five species showed an increase in electrical conductivity with increase in soaking time.
4. Total phenol content and total carbohydrate content also showed an increasing trend with increasing soaking time.
5. The autoallelopathic effect of leachates from tree species on its own germination noted the lowest germination for seeds irrigated with leaf leachate of all the five selected tree species and maximum for the seeds irrigated with tap water.
6. The allelopathic effect of leachates from tree species on germination of agricultural test crop showed a decrease in germination per cent with the seeds irrigated with leaf leachate of *A. auriculiformis, A. mangium, A. triphysa* and *G. robusta* against cent per cent germination for control.

7. The germination per cent of *S. macrophylla* seeds irrigated with leaf leachate showed cent per cent germination showing least inhibition of germination by the biochemical present in leaf leachate.
8. The seedlings *of A. auriculiformis, A. mangium, A. triphysa* and *G. robusta* irrigated with leaf and root leachate perished by the end of the study period ie., 120 DAS.
9. The shoot length and root length of the tree seedlings in general were highest for the seedlings irrigated with tap water.
10. The seedlings of the agricultural test crop irrigated with tap water (control) showed increased shoot length, root length and higher dry matter production compared to the seedlings irrigated with different tree part leachate.

References

Reference:

An, M., Liu, D.L., Johnson, I.R. and Lovett, J.V. 2003. Mathematical modelling of allelopathy: the dynamics of allelochemicals from living plants in the environment.. *Ecological Modelling*.161:53–66.

Anon. 1980.*Research Highlights for 1979*. International Institute of Tropical Agriculture, pp. 5–14. Nigeria.

Anon. 1991.*Report of All India Coordinated Research Projecton Agroforestry* (Pusa center), India.

Anthofer, J., J. Hanson and S.C. Jutzi. 1998. Wheat growth as influenced by application of agroforestry-tree prunings in Ethiopian highlands. *Agroforestry Systems* 40:1–18.

Appel, H. M. 1993. Phenolics in ecological interactions: the importance of oxidation. *J. Chem. Ecol.* 19: 1521– 1552.

Balasubramanian. A. and V.K. Ravichandran. 1996. Allelopathy significance of six agroforestry trees on *Casuarina equisetifolia* and modulation. *Madras Agric. J.*, 83: 84-87.

Banwari Lal and B. Lal. 1999. Effect of *Mangifera indica* litter on field crops. Range Management and Agroforestry, 20(2):194-198.

Barnes, R.D., Filer, D.L. and Milton, S.J. 1996. *Acacia karroo.* In: *Tropical Forestry Papers* No. 32. Oxford Forestry Institute, Oxford University.

Basavaraju, T. B.and Gururaja, R. 2000. Tree-crop interactions in agroforestry systems: A Brief Review, *Indian Forester*,126 (11): 1155-116

Bevege, D. I. 1968. Inhibition of seedling hoop pine (*Araucaria cunninghamii* Ait.) on forest soils by phytotoxic substances from the root zones of *Pinus*, *Araucaria*, and *Flindersia*. *Plant and Soil* 29: 263–273.

Bhatt.B.P, J.K.Singh and Moanaro 2010. Effects of pulp extract of *Syzygium cumini*(L.) skeels fruits on rice, maize and green crops. Allelopathy J. 27(1):143-150.

Bhatt.B.P, S.Hussain and J.K.Singh 2009.Allelopathic effects of agro forestry trees on field crops in Eastern Himalaya, India .Allelopathy J. 24(2):373-388.

Bhattacharjee, A., R.K. Bhakat, U.K. Kanp and R.K. Das. 2003. An investigation on allelopathic action of *Casuarina equisetifolia* and *Ipomoea pescaprae*Environment and Ecology, 21: 283-289.

Blashke, H. 1979. Leaching of water-soluble organic substances from coniferous needle litter. *Soil Biol. Biochem.*11: 581–584.

Bora, I.P., J. Singh, R. Borthakur and E. Bora, 1999. Allelopathic effect of leaf extracts of*Acacia auriculiformis* on seed germination of some agricultural crops. *Ann. For.*, 7: 143-146.

Borner, H. 1960. Liberation of organic substances from higher plants and their role in soil sickness problem. Botanical review, 26:393-424.

Bradow, J. M. and Connick, W. J., Jr. 1990. Volatile seed germination inhibitors from plant residues. *J. Chem.Ecol.* 16: 645–666.

Channal, H.T., M.B. Kurdikeri and P.A. Sarangamath. 2000. Allelopathic effect of tree leaf extracts on germination of Sorghum and rice. Karnataka J. of Agricultural Sciences, 13: 338-342.

114

Chellamuthu, V., T.N. Balasubramanian, A. Rajarajan and S.P. Palaniappan 1997. Allelopathic influence of *Prosopis juliflora* (swartz) DC. on field crops. *Allelopathy J.* 4(2): 291-302.

Chen, Q.B., Wang, Z.H., Bai, C.J., Liung, G.D., Peng, L.X., He, L.M. and Yuan, H.Q. 2004. Allelopathic potentials of eucalyptus 12 ABL on some leguminose and herbaceous plants. Abstr.s, the 1st Chinese Allelopathy Conference, May 18-20, 2004, Shenyang, China. Allelopathy J. 15(1): 176.

Chou, C. H. 1993. The role of allelopathy in the diversity of plant communities in Taiwan.*Bot. Bull. Acad. Sin.* 34:211–221.

Chou, C. H. and Waller, G. R., Eds. 1989.*Phytochemical Ecology: Allelochemicals, Mycotoxins, and Insect Pheromones and Allomones*. Monograph Ser. No. 9, Academia Sinica, ROC.

Chou, C. H.and Waller, G. R., Eds., Monograph Series No. 5, Academia Sinica, ROC.

Choudhary, H., R.D. Singh and P. Kumar. 2000. Phytotoxic effects of aqueous extracts of Neem (*Azadirachta indica*) and Chinnabery (*Melia azedarach*) on crops and weeds. *Indian J. of Weed Science*, 32: 201-203.

Chowdhary, H., R.D. Singh, P. Kumar and N. Jyoti Lakshmi. 2002. Allelopathic effects of aqueous leaf extracts of Pine (*Pinus roxburghii*), Oak (*Quercus leucotrichophora*) and Maize (*Zea mays*) on germination and seedling growth of some major hill crops. *Indian J. For.*, 24 (1): 53-57.

Chu-Chou, M. 1978. Effects of root residues on growth of *Pinus radiata* seedlings and a mycorrhizal fungus. *Annal Appl. Biol.* 90: 407–416.

Cossalter, C. and Pye-Smith, C. (2003).*Fast-wood Forestry: Myths and Realities*.Center for International Forestry Research, Indonesia.9 pp.

Curtis, J. T. and Cottam, G. 1950. Antibiotic and autotoxic effects in prairie sunflower. Bull. Torrey Botan. Club 77: 187–191.

Das, S., 1985. Prothomik Bono Biggan. FAO, Philippines.

Davidson, J., 1985. Species and Sites What to Plant and Where to Plant. FAO, Rome.

Devaranavadgi, S.B., C.S. Hunshal, S.Y. Wali, M.B. Patil and M.A. Bellakki. 2003. Studies on allelopathic effects in Sorghum based agri-silviculture system. *Karnataka J. of Agricultural Science*, 16: 426-429.

Dharmaraj, G. 1998. Allelopathic potential of Leucaena (*Leucaena leucocephala*). In: Abstr. No:129. *Allelopathy J.*, 6(1): 137.

Djanaguiraman, M., P. Ravishankar and U. Bangarusamy. 2002. Effect of *Eucalyptus globulus* on greengram, blackgram and cowpea. *Allelopathy J.*, 10 (2): 157-162.

Einhellig, F. A. 1995. Allelopathy: current status and future goals. In: *Allelopathy: Organisms, Processes and Applications*. pp. 1–24. Inderjit, Dakshini, K. M. M. and Einhellig, F. A., Eds., ACS Symposium Series No. 582, American Chemical Society, Washington, DC.

Fisher, R.F. 1980. Allelopathy- a potential cause of regeneration failure, *J. of forestry*. 78: 346-350.

Gaba, R.K., 1987. Role of Allelopathy in Social Forestry. In: Social Forestry for Rural Development, Khosla, P.K. and R.K. Kohli (Eds.). ISTS, Solan, pp: 228-234.

Gallet, C. 1994. Allelopathic potential in bilberry-spruce forests: influence of phenolic compounds on spruce seedlings. *J. Chem. Ecol.* 20: 1009–1024.

Gardner, R.A.W. (2007). Investigating the environmental adaptability of promising subtropical and coldtoleranteucalyptus species in warm temperate climate zone of KwaZulu-Natal, South Africa.*Southern Hemisphere Forestry Journal* 69:27-38.

Guenzi, W. D. and McCalla, T. M. 1962. Inhibition of germination and seedling development by crop residues. *Soil Sci. Soc. Am. Proc.* 26 :456–458.

Guenzi, W.D. and T.M.Mc Mcalla. 1966. Phytotxic substances extracted from soil. Soil science society *American Proc.*, 30: 214-217.

Hamed M.El-Shora, Abdel-Aal and Faaz F. Ibrahim.2015. Allelopathic potential of *Trichodesma africanum*: Effects on germination, growth, chemical constituents and enzymes of *Portulaca oleracea* . *Int.J.Curr.Microbiol.App.Sci* ., 4(9): 941-951

Hanwen wu, Jinbiao zhang, Rex Stanton 2011. Allelopathic effects of *Eucalyptus dundansii* on germination and growth of rye grass and barley grass. *Allelopathy J.* 28(1):87-94

Hemaiswarya.S and R.Raja 2008. Effects of bark leachate of *Thespesia populnea* on *Amaranthus tricolor*. *Allelopathy J.* 22(1):253-258.

Inderjit. 1996. Plant phenolics in allelopathy. *Botan. Rev.* 62:186–202.

ISTA. 1985. International rules for seed testing. Seed Science & Technology, 13: 356-513.

ISTA. 1986. International rules for seed testing. International Seed Testing Association (ISTA). Seed Science & Technology, 24 (Supplement) Zurich, Switzerland.

Jacob John , Sreekumar, K.M. and Rekha, P. 2007. Allelopathic effects of leaf leachates of multipurpose trees on vegetables. *Allelopathy Journal* 19(1): 507-516

117

Jacob John and A.M. Nair. 1996. Allelopathic effect of leaf litter of multipurpose trees on crops. *Allelopathy J.,* 5 (2): 191-194.

Jacob John and A.M. Nair. 1996. Allelopathic effect of leaf litter of multipurpose trees on crops. *Allelopathy J.*, 5 (2): 191-194.

Jacob John and A.M. Nair. 1999. Allelopathic effect of leaf leachates of multipurpose trees. *Allelopathy J.,* 6 (1): 81-86.

Jacob John and Narwal.S.S.2003. Allelopathic plants. *Leuceana leucocephala.Allelopathy J.* 12(1) : 15-36.

Jadhav, B.B. and D.G. Gayanar, 1992. Allelopathic effects of *Acacia auriculiformis* on germination of rice and cowpea. *Indian J. Plant Phys*., 1: 86-89.

Jeronimo,C.A and F.Borghetti 2005. Allelopathic effects of *Solanum lycocarpum* leaf extract on protein in sesame seedlings. Proc., IV. World Allelopathy Congress.

Jessop, R.S. and Stewart, L.W. 1983. Effect of crop residues, soil type and temperature on emergence and early growth of wheat. *Plant and Soil,* 74: 101-109.

Jeyaraman, S. 1991. Studies on the utility of *Leucaena*as green leaf manure on N economy in rice (IR-20). *MadrasAgric. J.* 78: 313–315.

Johansson, S. and Tuomela, K. (1996). Growth of 16 provenances of *Eucalyptus microtheca* in a regularlyirrigated plantation in eastern Kenya. *Forest Ecology and Management* 82:11-18.

Joshi, R.K., D. Prasad, M.S.M. Rawat and G. Pant. 1996. Allelopathic effect of aqueous extracts of leaves of *Fraxinus micrantha* L. on crops. *Allelopathy J.*, 3(2): 255-260.

Kamara, A.Y., I.O. Akobundu, N. Sanginga and S.C. Jutzi. 1999. Effects of mulch from 14 multipurpose tree species (MTPs) on early growth and nodulation of cowpea (Vigna unguiculata L.). Journal of Agronomy and Crop Science 182:127–133.

Kamara, A.Y., I.O. Akobundu, N. Sanginga and S.C. Jutzi. 2000b. Effect of mulch from selected multipurpose trees (MPTs) on growth, nitrogen nutrition and yield of maize (Zea mays L.). Journal of Agronomy and Crop Science 184:73–80.

Kamat, M. and T.P. Singh 1994. Quantitative analysis of some biochemical constituents in *Leucas* species. *Indian Forester*, 120 (4): 374-375.

Karim, A. B, Savill, P. S., and Rhodes, E. R. 1991. The effect of young *Leucaenaleucocephala*(Lam.) de Wit hedgeson the growth and yield of maize, sweet potato and cowpea in an agroforestry system in Sierra Leone.*Agroforestry Syst.* 16: 203–211.

Kaushal, R., K.S. Varma and K.N. Singh. 2003. Effect of *Grevia optiva* and *Populus deltoides* leachates on field crops. *Allelopathy J.*, 11(1): 229-234.

Kavitha.D., J.Prabhakaran and K.Arumugam 2012.Allelopathic potential of Mangrove species *Exoceccia agallocha* on growth response of some agricultural crops .International J. of Auyrvedic and herbal Medicine 2:1 153:162.

Kimber, R.W.L. 1973. Phytotoxicities form plant residues. I. The influence of rotted wheat straw on seed ling growth. *Aust. J. Agric. Res.*, 18: 361-374.

Kimbler, R.W.L. 1973 Phytotoxicity from plant residue. The relative effect of toxins and nitrogen immobolization on the germination and the growth of wheat. *Plant and soil* 38:543.

King, K.F.S., 1979. Agroforestry and the utilisation of fragile ecosystems. *For. Ecol. Manage.*, 2: 161-168.

Kohli, R. K., Singh, H. P., and Batish, D. R. 1997. Phytotoxic potential of *Populus deltoides* Bartr. ex Marsh. I. Comparative contribution of different parts. *Indian J. Forest.* 20: 300–304.

Kohli, R.K. 1990. Allelopathic Properties of Eucalyptus.MAB DoEn Report. New Delhi, India

Kohli, R.K., D.R. Batish and H.P. Singh. 2006. Allelopathic interactions in agroecosystems. In Allelopathy—A Physiological Process with Ecological Implications, ed. M.J. Reigosa, N. Pedrol and L. Gonzalez,465–493. Netherlands: Springer.

Kohli, R.K., H.P. Singh and D.R. Batish. 1997. Phytotoxic potential of *Populus deltoides* Bartr. ex Marsh. I.Comparative contribution of different parts.*Indian Journal of Forestry* 20:300–304.

Koul, V.K., A. Raina, Y.P. Khanna, M.L. Tickoo and H. Singh, 1991. Evaluation of allelopathic influence of certain farm grown tree species on rice. *Ind. J. For.*, 14: 54-57.

Kuiters, A. T. 1990. Role of phenolic substances from decomposing forest litter in plant-soil interactions. *Acta Botanica Neerlandica* 39: 329–348.

Kumari, A. and Kohli, R. K. 1987. Autotoxicity of ragweed parthenium (Parthenium hysterophorus). *Weed Sci.* 35: 629–632.

Kuo, Y. L., Chou, C. H., and Hu, T. W. 1983.Allelopathic potential of *Leucaenaleucocephala*.In: *Allelochemicalsand Pheromones*. pp. 107–119.

Lakshmipathichetty, M. and K.N. Rao. 1994. Effect of *Terminalia pallida* fruit leachates on the biochemical composition of seedlings in *Vigna radiata*. *Allelopathy J.*, 1(1): 58-65.

Lantican C. B. and Taylor, D. A., Eds. 1991. *Compendium of National Research on Multipurpose Tree Species(1976–1990)*. Winrock International Institute for Agricultural Development, USA.

Lisanework, N. and A. Michelsen. 1993. Allelopathy in agroforestry systems: the effects of leaf extracts of Cupressus lusitanica and three Eucalyptus spp. on four Ethiopian crops. *Agroforestry Systems* 21:63–74.

Mallik, A. U. 1995. Conversion of temperate forests into heaths: role of ecosystem disturbance and regeneration strategies of three ericaceous plants. *Environ. Manage.* 19: 675–684.

Mallik, A. U. and Newton, P. F. 1988. Inhibition of black spruce seedling growth by forest-floor substrates of central Newfoundland. *Forest Ecol. Manage.* 23: 273–283.

Martin, V.L., Mc Coy, E.L. and Dick, W.A. 1990. Allelopathy of crop residues influences corn seed germination and early growth. *Agron J.,* 82: 555-560.

Masilamani, P., C. Dharmalingam and K. Annadurai. 2002. Inhibitory effect of water extracts of epicarp and mesocarp of teak on germination of some field crops. *Indian J. For.*, 25(1): 39-41.

Melkania, N.P. 1983. Influence of certain selected tree species on ground flora, *Ph.D. Thesis,* Kumaun Unviersity, Nainital. 442 p.

Melkania, N.P. 1986. Allelopathy and its significance on production of agroforestry plants association. *Proceeding workshop of Agroforestry for Rural Needs*. Feb.22-26, 1986, New Delhi. ISTS, Solan, pp. 211-224.

Miller, D. A. 1996. Allelopathy in forage crop systems. *Agron. J.* 88(6): 854–859.

Mohan Raj, T. 2004. Studies on compatibility of agricultural crops with *Simarouba* *glauca* DC. M.Sc. Thesis, TNAU, Coimbatore, India.

Moradshahi, A., Ghadiri, H. and Ebrahimikia, F. (2003). Allelopathic effects of crude volatile oil and aqueousextracts of *Eucalyptus camaldulensis* Dehnh. leaves on crops and weeds.*Allelopathy Journal* 12:189-195.

Murugesan, D. 2003. Studies on the allelopathic proclivities of important agroforestry trees on agricultural crops. M.Sc. Thesis, TNAU, Coimbatore, India.

Naidu, C.V., B.V. Prasadareddy and P.S. Rao. 2000. Status of phenolic acids and associated enzymes in different seed parts of *Sapindus trifoliatus* Vahl. *Ann. For.*, 8(2): 262-265.

Nair, P. K. R., Ed. 1989. *Agroforestry Systems in the Tropics*. Kluwer Academic Publishers, Dordrecht, Netherlands.

Nandal,D.P.S and A.Dhillion 2005.Allelopathic effects of Poplal (*Populus deltoids Bartr Ex Marsh*): on wheat varieties Proc., IV. World Allelopathy congress Establishing the scientific Base August 21-26., 2006. Charles Strut University, wagga wagga Pp.234-246.

Narwal, S. S. 1996. Allelopathy related problems in crop production, Agroforestry and horticulture. In: *Allelopathy:Field Observation and Methodology*. pp. 1–40.

Narwal, S.S. 1994.Allelopathy in crop production. Scientific Publishers, JodhpurIndia, pp288.

Neelum Khare and A.K. Bisaria 2002. The allelopathic effect on *Triticum aesticum* of different extracts of *Leucaena leucocephala. Indian J. of Agroforestry*, 4(1): 63-65.

Newman, E. I. and Rovira, A. D. 1975. Allelopathy among some British grassland species. *J. Chem. Ecol*. 63: 727– 737.

Nsolomo, V.R. and J.A. Maghembe 1995. Effect of Acacia xanthophloea leachates on

122

seed germination of some agricultural and multipurpose tree crops. *J. of tropical forest science* 7(3): 398 – 404

Padhy, B., P.K. Patnaik and A.K. Tripathy. 2000. Allelopathic potential of Eucalyptus leaf litter leachates on germination and seedling growth of finger millet. *Allelopathy J.,* 7(1): 69-78.

Panneer Selvam, R., L. Karikalan. and S. Rajan. 1998. Allelopathic effect of *Tectona grandis* leaf and root extracts on *Arachis hypogea* and *Zea mays*. In: Abstr. No. 132, *Allelopathy J.,* 6(1): 137.

Parvez, S.S., M.M. Parvez, H. Gemma and Y. Fuji 2002. Evaluation of allelopathic potential of *Tamarindus indica*. Abstr. No. P-0105 pp:248. In: Abstr.s III World Congress on Allelopathy Challenge for the New Millennium (Eds. Y.Fuji, S.Hiradate and H.Araye), August 26-30, Tsukuba, Japan.

Patil, R.H., C.S. Hunshal and C.J. Itnal 2002. Effect of Casuarina leaf litter leachates on crops. *Allelopathy J.*, 10(2): 141-146.

Patric, A.Z. 1971. Phytotoxic substances associated with the decomposition in soil plant residues. *Soil Sci* ., III : 13-18.

Patrick, Z,A,, T.A.Toussoun and W.C.Sryder. 1963. Phytotxic substances in arable soils associated with the decomposition of plant residues. *Phytopathology*, 53: 152-161.

Patrick, Z.A. and Koch, L.W. 1958. Inhibition of respiration, germination and growth by substances arising during the decomposition of certain plant residues in soil. *Canadian J. Bot.,* 36: 621-647.

Pavin.R, T.L.Shalpa and M.H.A.Amin 2011.Allelopathic effects of *Albizia lebbeck* on Agricultural Crops, *Int.J. Sustain Crop prod.*6 (1):50-57

Pellissier, F. 1994. Effect of phenolic compounds in humus on the natural regeneration of spruce. *Phytochemistry* 36(4): 865– 867.

Petmark, P. and E.R. Williams, 1991. Use of Acacia Species in Agroforestry. In: Advances in Tropical Acacia Research, Turnbull, J.W. (Ed.). ACIAR, Bangkok, Thailand.

Pinoyopusarerk, K., 1990. Acacia Auriculiformis: An Annotated Bibliography. Winrock International Institute of Agricultural Development, Australia, 154.

Prasad, M. N. V. and Subhashini, P. 1994. Mimosine-inhibited seed germination, seedling growth, and enzymes of*Oryza sativa* L. *J. Chem. Ecol.* 20: 1689–1696.

Putnam, A.R. and Tang, C.S. 1986. *The Science of Allelopathy.* Wiley, New York, p. 317.

R.K. Kohli and Singh, D. 1992. Impact of *Eucalyptus tereticornis Sm.* shelterbelts on crops. *AgroforestrySystems* 20:253–266.

Rachie, K. O. 1983. Intercropping tree legumes with annual crops.In: *Plant Research and Agroforestry*. pp. 178–210. Huxley, P. A., Ed., ICRAF, Kenya.

Rafiqul Hoque, A.T.M., R. Ahmed, M.B. Uddin and M.K. Hossain. 2003. Allelopathic effect of different concentration of water extracts of Acacia auriculiformis leaf on some initial growth parameters of five common agricultural crops. *Pak. J. Agron.*, 2: 92-100.

Rahman, M., 1984. Forest Tree Improvement in Bangladesh. FAO., Philippines.

Ramamoorthy, M. and K. Paliwal. 1993. Allelopathic compounds in leaves of *Gliricidia sepium (Jacq.)Kunth.ex Walp.* and its effect on *Sorghum vulgare L. Journal of Chemical Ecology* 19:1691–1701.

Rao, M.R., P.K.R. Nair and C.K. Ong. 1998. Biophysical interactions in tropical agroforestry systems.*Agroforestry Systems* 38:3–50.

124

Rao, O.P., A.K. Saxena and B.P. Singh 1994. Allelopathic effects of certain agroforestry tree species on the germination of wheat, paddy and gram. *Annals of Forestry*, 2(1): 60-64.

Rice, E.L. 1979. Allelopathy-An update. Botanical Review, 45: 15-109.

Rice, E.L. 1984. *Allelopathy/,* 2nd ed., Academic Press, Orlando, FL, pp. 67–68.

Rice, E.L. 1995. Biological Control of Weeds and Plant Diseases—Advances in Applied Allelopathy. Norman, OK: University of Oklahoma Press.

Rizvi, S. J. H. 1996. Role of allelopathy in improving crop productivity. In: *Abstr. 1st World Congress of Allelopathy*,Spain, p. 76.

Rizvi, S. J. H. and Rizvi, V. 1998. Carbohydrate and protein metabolism of *Vigna radiate* as affected by mimosine.In: *Abstr. 3rd Asian Crop Sci. Conf.* p. 6, Taiwan

Rizvi, S.J.H., M. Tahir, V. Rizvi, R.K. Kohli and A. Ansari. 1999. Allelopathic interactions in agroforestry systems. *Critical Reviews of Plant Sciences* 18:773–796.

Sadhna Tripathi., Ashutosh Tripathi, D.C. Kori, S. Tripathi and A. Tripathi. 1998. Allelopathic effect of extracts of *Dendrocalamus strictus* on germination and seedling growth of Soyabean. *Indian J. of Ecology*, 25(2):123-132.

Sahoo.U.K., K.Vanlalhriatpuia and S.Roy 2011.Effects of leaf extracts of common home garden trees on food crops. *Allelopathy J.* 28(1):123-124.

Salazar, A. Szott, L. T., and Palm, C. A. 1993. Crop-tree interaction in alley cropping systems on alluvial soils ofthe upper Amazon basin. *Agroforestry Syst.* 22: 67–82.

Saroj, P.L., B.D. Sharma, R. Burgava and C.K. Purohit. 2002. Allelopathic influence of aqueous leaf extracts of ber (*Zizyphus mauritiana* L.) on germination seedling growth and phytomass of ground storey crops. *Indian J. of Agroforestry*, 4(1): 57-61.

Sasikumar, K., Vijayalakshmi, C. and Parthiban, K.T. (2002). Allelopathic effects of Eucalyptus on blackgram (*Phaseolus mungo* L.).*Allelopathy Journal* 9: 205-214.

Seigler, D. S. 1996. Chemistry and mechanisms of allelopathic interactions. *Agron. J.* 88: 876–885.

Singh, D. and Kohli, R. K. 1992. Impact of *Eucalyptus tereticornis* Sm. shelterbelts on crops. *Agroforestry Sys.*20: 253–266.

Singh, D. and R.K. Kohli. 1992. Impact of *Eucalyptus tereticornis Sm*. shelterbelts on crops. *AgroforestrySystems* 20:253–266

Singh, G. B. 1983. Role of agroforestry in improving the environment.*Indian Farm.*33: 15–19.

Singh, H.P., D.R. Batish and R.K. Kohli. 1999. Impact of *Populus deltoids* and *Dalbergia sissoo* shelter beltson wheat—a comparative study. *International Tree Crops Journal* 10:51–60.

Singh, H.P., D.R. Batish, N. Setia and R.K. Kohli. 2005. Herbicidal activity of volatile oils from*Eucalyptuscitriodora* against *Parthenium hysterophorus*. *Annals of Applied Biology* 146:89–94.

Singh, H.P., R.K. Kohli and D.R. Batish. 1998. Effect of poplar (*Populus deltoides*) shelterbelt on growth andyield of wheat in Punjab, India. *Agroforestry Systems* 40:208–213.

Singh, H.P., R.K. Kohli and D.R. Batish. 1998. Effect of poplar (*Populus deltoides*) shelterbelt on growth andyield of wheat in Punjab, India. *Agroforestry Systems* 40:208–213.

Singh, W.B and Ranjana Singh. 2003. Effect of leaf leachate of Eucalyptus on germination growth and metabolism of greengram, blackgram and peanut.

Allelopathy J., 11(1):43-52.

Sinha, R. C. 1996. Allelopathic Interactions in *Leucaenaleucocephala*-Based Agroforestry System. Ph.D. Thesis.Rajendra Agricultural University, Pusa, India

Siqueira, J.O., M.G.Nair, R.Hammerschmidt and G.R.Safir. 1981. Significance of phenolic compounds in plant-soil- microbial systems. *Critical reviews of plant Sciences.* 10:63-121.

Sivagurunathan,M. 1997. Allelopathic studies in three Eucalyptus species on some field crops. M.Sc.Thesis, Tamilnadu Agricultural University, Coimbatore.

Suman, B.L. 1999. Allelopathic effect of biomass of tree species on range legumes. *Bhartiya Krishi Annusandhan Patrika.*, 14: 1-6.

Suresh, K. K. and Rai, R. S. V. 1987. Studies on the allelopathic effects of some agroforestry tree crops. *Int. Tree Crops J.* 4: 109115.

Swain, T. 1971. Secondary compounds as protective agents. *Annu. Rev. Plant Physiology* 28: 479–501.

Swaminathan, C. 1996. Effect of bark leachates of multipurpose trees on germination and seedling growth of maize, pigeon pea and sesame. *Allelopathy J.*, 3(1): 77-80.

Swaminathan, C., R.S Vinaya Rai and K.K. Suresh. 1990. Allelopathic effect of *Parthenium hysterophonus* on germination and seedlings growth of a few multipurpose trees and arable crops. *The Int. Tree Crops J.*, 6: 143-150.

Swaminathan, C., S. Robin, K. Kannan, D. Malarvizhi and C.V. Dhana Kodi. 1999. Effects of Eucalyptus and Casuarina on the yield of intercrops in agroforestry systems. *Allelopathy J.*, 6(2): 251-260.

Tamura, S., Chang, C., Suzuki, A., and Kumari, S. 1967. Isolation and structure of a novel isoflavone derivative in red clover. *Agric. Biol. Chem.* 31: 1108–1109.

Thibault, J. R., Fortin, J. A., and Smirnoff, W. A. 1982. *In vitro* allelopathic inhibition of nitrification by balsam poplar (*Populus balsamifera*) and balsam fir (*Abies balsamea*). *American Journal of Botany* 28: 478–485.

Thomas, A. S., Jr. 1974. The effect of aqueous extracts of blue spruce leaves on seed germination and seedling growth of several plant species. *Phytopathology* 64: 587.

Tian, G. and B.T. Kang. 1994. Evaluation of *Gliricidia sepium* prunings for phytotoxicity on maize and cowpeaseedlings. *Agroforestry Systems* 26:249–254.

Tripathi, S., Tripathi, A. D.C. Kori and S. Tiwari. 1998. Effect of Teak leaves aqueous extracts on germination and seedling growth of Soybean. *Allelopathy J.*, 5(1): 75-82.

Tripathi.S., A. Tripathi,. D.C. Kori and S. Paroha. 2000. Effect of *Dalbergia sissoo* extracts, rhizobium and nitrogen on germination, growth and yield of *Vigna radiata. Allelopathy J.* 7(2): 255-264.

Tripathi.S., Ashutosh Tripathi and D.C. Kori. 1999. Alleloapthic evaluation of *Tectona grandis* leaf root and soil aqueous extracts on soybean. *Indian J. For.*, 22(4): 366-374.

Turnbull, J.W. (1999). Eucalypt plantations. *New Forest* 17:37-52.

Warrag, M. O. A. 1999. Autotoxicity of mesquite (*Prosopis juliflora*) pericarps on seed germination and seedling growth. *J. Arid Environ.* 27: 79–84

Weissen, F. and van Praag, H. J. 1991. Root growth inhibition effects of holorganic moder humus layer under spruce (*Picea abies* Karst.) and beech (*Fagus sylvatica* L.). *Plant and Soil* 135: 167–174.

Zhang, Q. 1993. Potential role of allelopathy in the soil and the decomposing root of Chinese fir replanted woodland. *Plant and Soil* 151: 205–210.

AUTOALLELOPATHY OF SELECTED MULTIPURPOSE TREE SPECIES AND THE EFFECT OF THEIR LEACHATES ON AGRICULTURAL TEST CROP

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ABSTRACT OF THE THESIS

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ABSTRACT

A study carried out in the tree nursery of College of Forestry, Vellanikkara, Thrissur to assess the autoallelopathic effect of selected multipurpose trees and the effect of their leachate on agricultural test crop. The study on allelopathy is very essential in agroforestry as it effect the yield and performance of the trees and crops grown together and is essential to make judgment on the compatibility of trees and crops. The allelopathic effect of different tree part leachates such as leaf leachate, bark leachate and root leachate of selected trees viz., *Acacia auriculiformis, Acacia mangium, Ailanthus. triphysa, Grevillea robusta* and *Swietenia macrophylla* on the germination and growth of their own seedling and an agricultural test crop cowpea (Var. Anaswara) were studied. The soil for the pot culture experiment was collected from well established plantations of the MPTs and is used as potting mixture with sand in equal proportion. The pots were irrigated with leachates of different tree parts of these trees by soaking the tree part in water for 24 hours in 1:10 w/v concentration. The monthly variation in nutrient status of the soil used for pot culture experiment and the variation in the physicochemical properties of leachates at six intervals is also estimated.

The effect of tree part leachates considerably varied among the germination and biomass production in both allelopathic and autoallelopathic studies. The observations on the germination per cent in allelopathic and autoallelopathic study revealed greater inhibition in the pots treated with leaf leachate in all tree species, except for *S. macrophylla.* With regard to biometric observations and biomass production also, *S. macrophylla* performed as the best compared to other selected species investigated for autoallelopathy. In case of the test crop also, it showed a better growth in pots treated with the leachates from *S. macrophylla*.

The physicochemical analysis of the leachate of tree parts used to irrigate the pots showed increasing trend in total solid, electrical conductivity, total phenol, total carbohydrate and a decreasing trend in pH upto 36 hours. The physicochemical analysis of leachates for total phenol showed a greater concentration in the leaves than the bark and root.

Results converge to the generalisation that among the five selected tree species the effect of auto allelopathy is negligible in case of *S. macrophylla*. The better growth performance of the test crop in *S. macrophylla* tree part leachates shows the compatibility of the test crop with the tree than the other selected tree species.