GROWTH BEHAVIOUR OF *MICHELIA CHAMPACA* L. AND *TOONA CILIATA* M.ROEM ALONG WITH HEDGES OF *CAJANUS CAJAN* L. AND *LEUCAENA LEUCOCEPHALA* (LAM) DE WIT IN AN AGROFORESTRY SYSTEM OF MIZORAM

By

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I certify that the thesis entitled ***"Growth behaviour of Michelia champaca L. and Toona ciliata M.Roem along with hedges of Cajanus cajan L. and Leucaena leucocephala (Lam) De wit in an agroforestry system of Mizoram"*** *submitted by Ms.C.Lalchhandami for the partial fulfilment of Master of Science in Forestry of the North-Eastern Hill University, Shillong embodies the record of original investigation by her under my supervision. She has successfully completed all her papers and the thesis presented is worthy of being considered for the award of the M.Sc.Degree. The work has not been submitted by any other degree of any other University.*

Aizawl,
The 17th December 1999.

(DR.U.K SAHOO)
Supervisor

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(C.LALCHHANDAMI)

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CHAPTER - I

INTRODUCTION

Agroforestry is the practice of combining trees with crops on the same unit of land. Although the scientific principles of Agroforestry are now only being understood, the practice has been existed since very early times. In fact, from time immemorial, the farmers have been cultivating crops in the tree based water shed without knowing the proper tree crop combination and their beneficial effects. But these practices were side-stepped by many researchers and experts and not much importance was given. However, in the recent years, this practice have come into the limelight due to the ever increasing population, over-exploitation of the forests for food, fodder, fuel, timber and other wood products. Possibly, no single sole cropping system exist today to meet the challenge of food crisis by the gigantic population pressure coupled with the reduced acreage of available land. As a result, efforts are now being made to find appropriate ways to increase production from the land by integrating trees and other woody species with agricultural crops and / or livestock on the same piece of land.

In North Eastern India 'jhum' (local name of shifting cultivation is the predominant form of agriculture practised extensively by the tribals. In the past, the jhum cycle used to be 20-25 years which allowed sufficient growth of vegetation during those years releasing enormous nutrients to be utilised for the new jhum cycle. As a result, there was hardly any nutrient or soil loss. However, with the increase in population pressure and reduced acreage of available land, now the jhum cycle has been reduced to a mere 2-3 years resulting in a huge soil and nutrient loss, loss in biotic agents, soil moisture content resulting in decreasing crop productivity. Due to the various ill effects of jhumming on the soil in general and crop productivity in particular, the Central Government has suggested several measures to tackle the problem

of jhumming in various states. To cite for ICAR complex for NEH region at Barapani has adopted three tier system in which cultivation of trees are made at the hill top, cultivation of horticulture trees in the middle portion of the hill slopes and terraces are formed at the lower portion of the hill slopes in which cultivation of field crops is done. Similarly, a permanent system of farming for sustainable agriculture development called the "New Contour Farming System" has been introduced in various other states as an alternative means of shifting cultivation. This farming system is aimed at permanent cultivation on the hill slopes by conserving soil and water and recycling the lost top soil. Although the suggested models proved to be very promising, it is not free from limitations. It is difficult to construct terraces, contour trenches on the hilly slope which are very cost effective and moreover, require skilled or man power.

Though, Mizoram was once reported as one of the best fortress of ecological diversity, it has been drastically degraded in recent years due to various anthropogenic activities such as traditional method of shifting cultivation (locally called jhum), illicit fellings, encroachment, soil erosion etc. of which the practice of jhum is reported to have a major cause in land degradation. About 80% of the entire population living in the rural areas and mainly the small scale farmer are engaged in shifting cultivation. The State Govt. realizing all the odd effects of jhum cultivation has launched an innovative policy namely 'New Land Use Policy' (NLUP) with effect from 1990 to wean away the farmers from the age old practice of jhum. In this programme, the beneficiaries were selected from different developmental Blocks. The trade included in the scheme were Agriculture and allied sectors, Industries and A.H.Vety and the scheme also included some special packages to help the

poor farmers. Inspite of these benefits, the policy could not make much impact an the farmers by large. Therefore, the quantum of success fell far below the expectations of the Govt. Many factors which can be attributed to the failure of the innovated Govt. policy are (i) Poor extension approach on the policy, (ii) lack of evaluation and monitoring of the system due to frequent transfer of officers associated with the implementation (iii) unproper utilization of the subsidy received by the beneficiaries. Moreover, the scheme was somewhat of imposed nature resulting in its failures to convince the people of its importance in the context of sustainable agroforestry. Thus, the farmers finally had to come back to the same practice of shifting cultivation or the traditional method of tree planting on the home orchard called homestead forestry. With the passage of time, the farmers are becoming more and more aware of agroforestry practice and they have introduced various multipurpose trees in their farms along with agricultural/ horticultural crops. The intercropping of paddy (*Oryza sativa*) and teak (*Tectona grandis*) was and still is the most common and successful practice in Mizoram. The farmers carried out all the works i.e. felling of trees, shrubs, burning, removing of the debris, etc. in a private or alloted land. Arrangements is made in such a way that the harvest (crops) is shared both by the farmers and the landowners whereas the teak plants goes to the landlords. Nowadays, the farmers have started introducing terrace system, pit system in their farmlands.

Michelia champaca L. and *Toona ciliata* M.Roem are two of the most important multipurpose trees of Mizoram (Lalramnghinglova, 1998). They are cultivated for their timber, and firewood values and moreover, they have great medicinal values. *Michelia champaca* is one of the commercially important genera of the family Magnoliacae which attains a height of about

20-25mt. with straight trunk, young shoots silky, bark grey-greyish brown, crown lax, oval or spreading. Its woods finds a variety of uses such as posts, boards, veneers, decorative fittings, manufacture of plywood and miscellaneous purposes (Lalramnghinglova, 1998, Chauhan, 1992). The timber is widely used for house building furniture and several other purposes. Besides, the bark is used to facilitate micturation, diurertic and diaphoretic. Decoction of leaves is applied to eye troubles. The flowers are expectorant and are useful in cough and rheumatism. The dried root and root bark are considered purgative. The seeds and fruits are reportedly useful for healing cracks in the feet. (Lalramnghinglova, 1997). *Toona ciliata* on the other hand, belongs to the family Meliaceae. It usually attains 15-20 mt. height and 1.8-3.0 m. girth. The species has a tremendous potential for reclamation of degraded lands and have been included under Social forestry and wastelands afforestation programmes in many parts of the country (Gurdev Chand and Bhardwaj, 1996). Its timber is used for furniture, doors, windows, construction purposes. The bark is astringent and antiperiodic and used for chronic infatile dysentery and as external application for ulcers.

A large number of trees of these two species have been illicitly felled in the past few years for the extraction of timber, collection of fuelwood, foliages, fodder etc. causing their slow disappearance from the forests. Besides with the increase in population and the need for bringing in more and greater areas under cultivation, these tree species have been deforested which results in the disappearance of these species. It has been estimated that approximately 4000 hectare of forest land have been deforested in a year for shifting cultivation. Moreover, due to their medicinal values, a large number of trees have been felled for the extraction of roots, root barks, leaves for their use as medicines.

The potential of *Michelia Champaca* and *Toona ciliata* in meeting the various requirements has been well documented. (Chauhan and Dayal, 1992) Further foliages of these trees have added advantages as they are used as mulch/green manure in agroforestry system in decreasing the velocity of run-off and in releasing nutrients to the soil.

Cajanus cajan and *Leucaena leucocephala* are known for their conservational ability and potential for increasing soil nutrient status of the agroecosystems (Jha, 1993; Anon, 1985; Pathak and Gupta, 1987). The cultivation of *Cajanus cajan* increases total phosphorus availability of the soil (Mirzapur *et al*, 1990).

Agroforestry system in general are more complicated than any agroecosystems, because of the complex interactions between the components involved in the former. Due to the differential ability of nutrient uptake of trees and crops in the system, it is difficult to attribute any single component to the productivity of the soil until and unless a detail study is being carried out on nutrient dynamics of agroforestry system. The crop production in the system will depend on the compatibility of tree-crop. *Cajanus cajan* and *Leucaena leucocephala* both being nitrogen fixing are expected to add nutrients to the system. Besides, these species have other advantages to the system. There are few research works on *Leucaena* species and Pigeon pea in the State (Lalmuanpuia, Unpublished) namely studies on soil erosion, nutrient loss etc, however no treatment is given to these species with regard to their growth attributes, yield etc. Further, no work is seen on *Michelia champaca* and *Toona ciliata*. Therefore, the present study have been made to cover the growth attributes of the species, crop yield in relation to nutrient input.

CHAPTER - II

DESCRIPTION OF STUDY SITE, CLIMATE AND METHODOLOGY

Mizoram, 'The Land of the Highlanders' spread over an area of about 21,087 square km. The State of Mizoram roughly lies between 21°56' and 24°31' North latitudes and 92°16' 93°26' East longitude and about 1000 m.asl altitude in the North-Eastern corner of the Indian Union. (Fig 1). It is bounded by Cachar District of Assam and the State of Manipur in the North, Chin Hills of Myanmar in the East and South, and the Chittagong Hill Tracts of Bangladesh and the State of Tripura in the West. The study is carried out at Lawibual, a small valley of about 1 km East of Aizawl, the capital city of Mizoram. The area of the study site is approximately 4000 sq.ft. and is moderately sloped.

The soil of the experimental site is medium textured, lateritic, clay loam and sand - 67.36%, silt - 21% and clay - 11.64% and reddish brown in colour. The soil is strongly acidic with pH 5.88. The soil has a medium available phosphorus content (17.6 kg/ha), medium available potassium content (152.4 kg/ha) and with 0.97 organic carbon percent.

The vegetation of the experimental site is richly dominated/infested by several kinds of weeds. *Imperata cylindrica* forms the vegetation of the site and often cause great hazards on the growth of the tree species by competing with them for light, moisture and food.

The climate of the area is tropical and moonsonic. The climate is cool in summer and moderate in the winter. The summer temperature generally varies from 21°C to 30°C whereas the winter temperature have a range of 11°C to 23°C. The area receives heavy rainfall in late summer. More than 65 percent of the rainfall taken place between May and September (Fig 2).

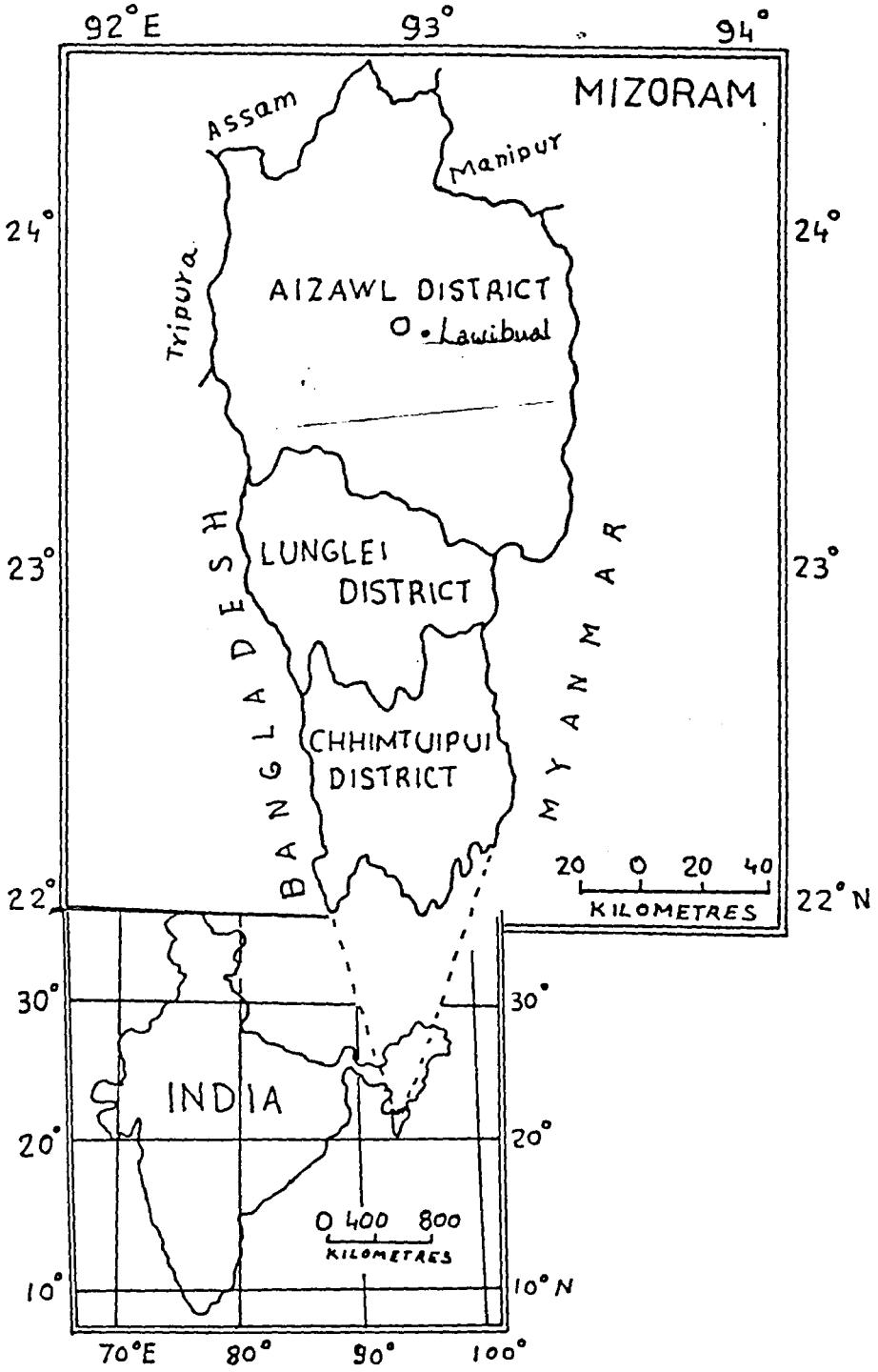

Fig 1 - Map of Mizoram, showing the experiments site at Lawibual, Aizawl.

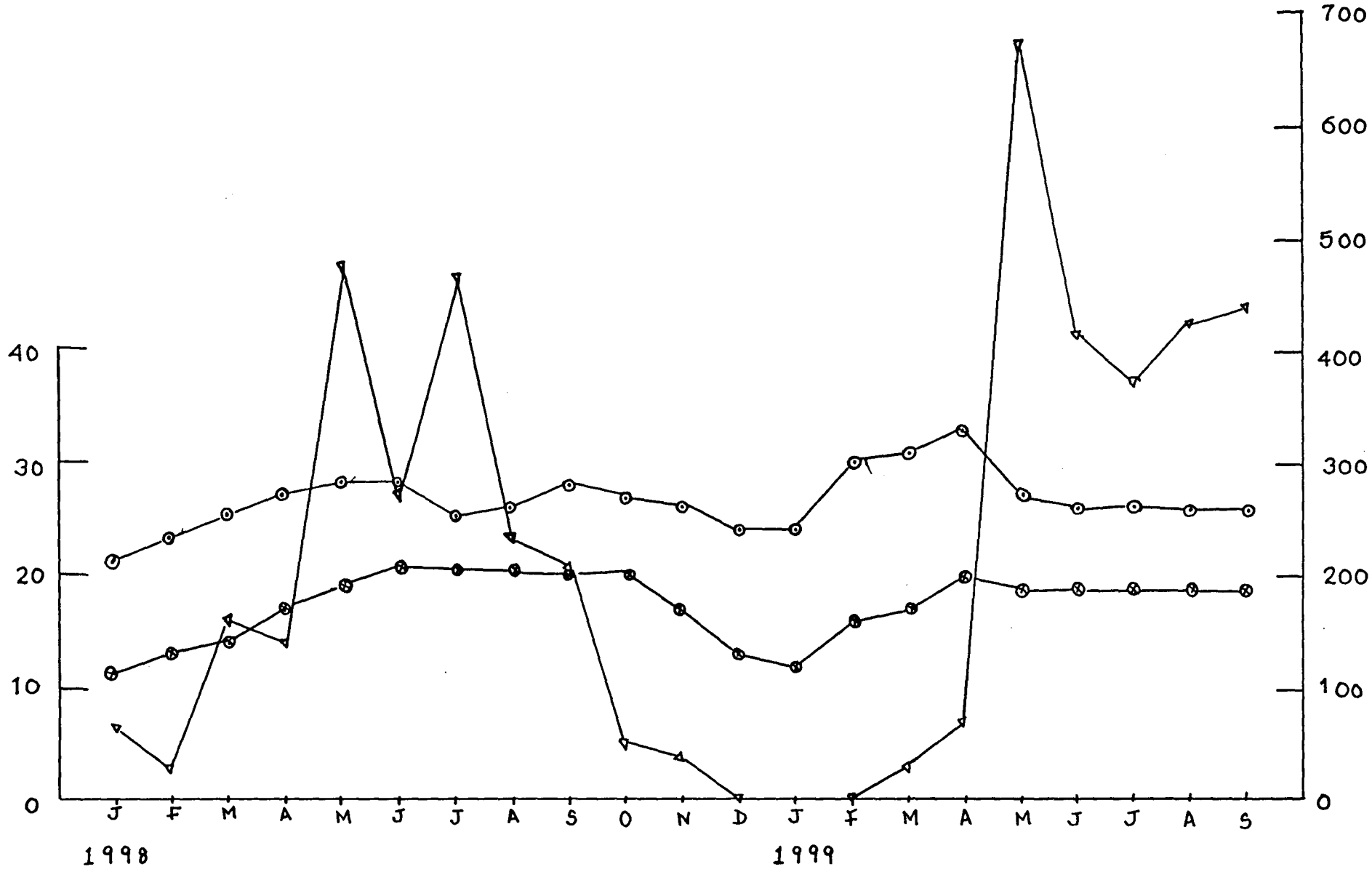

Fig 2 - Monthly variation in mean minimum (⊗—⊗), mean maximum (⊙—⊙) temperature (^{0}C) and rainfall (mm) (△—△) of the study site.

During the study period, (i.e. September 1998 - September 1999), the area receives heavy rainfall in the late summer of 1999 (from May to September '99) and a very low rainfall in the initial period of the experiment. (October '98 - April '99). May, July, August, September are the rainest months with a rainfall that scores up to 342.70 mm whereas December, January and February are the driest months with no or negligible rainfall.

The selection of the experimental site was done at the month of August 1998. After being cleared of all the bushes and other weedy vegetation, the whole field (area 200m x 150m) was divided into two separate plots one for *Toona ciliata* and the other for *Michelia champaca.* The seedlings were procured from Environment and Forest Dept., Aizawl and transplanting of the seedlings to the fields was done at the month of September '98. In the field, the experiment was laid out following Randomized Block Design (RBD) with 5 sub plots each for the tree species. A spacing of 2.5 m plant to plant and 3m row to row was kept for both the species and 3m spacing between the two different species to nullify the boarder effects. Green hedges *Leucaena leucocephala* (subabool) and *Cajanus cajan* (Pigeon pea) were introduced along with the main tree species. i.e. *Michelia champaca* and *Toona ciliata* (Fig.3). These green hedges were raised from poly pots filled with kitchen soil and FYM in the ratio of 2:1. An agricultural crop, *Zea mays* (maize) was also introduced in the interspace between the two rows of the two species at the spacing of 60 x 30cm and 65 cm. away from the tree species.

The study on the growth behaviour of the two species was done from the month of September 1998 till September 1999. The various growth attributes such as collar thickness, height, number of leaves and number of

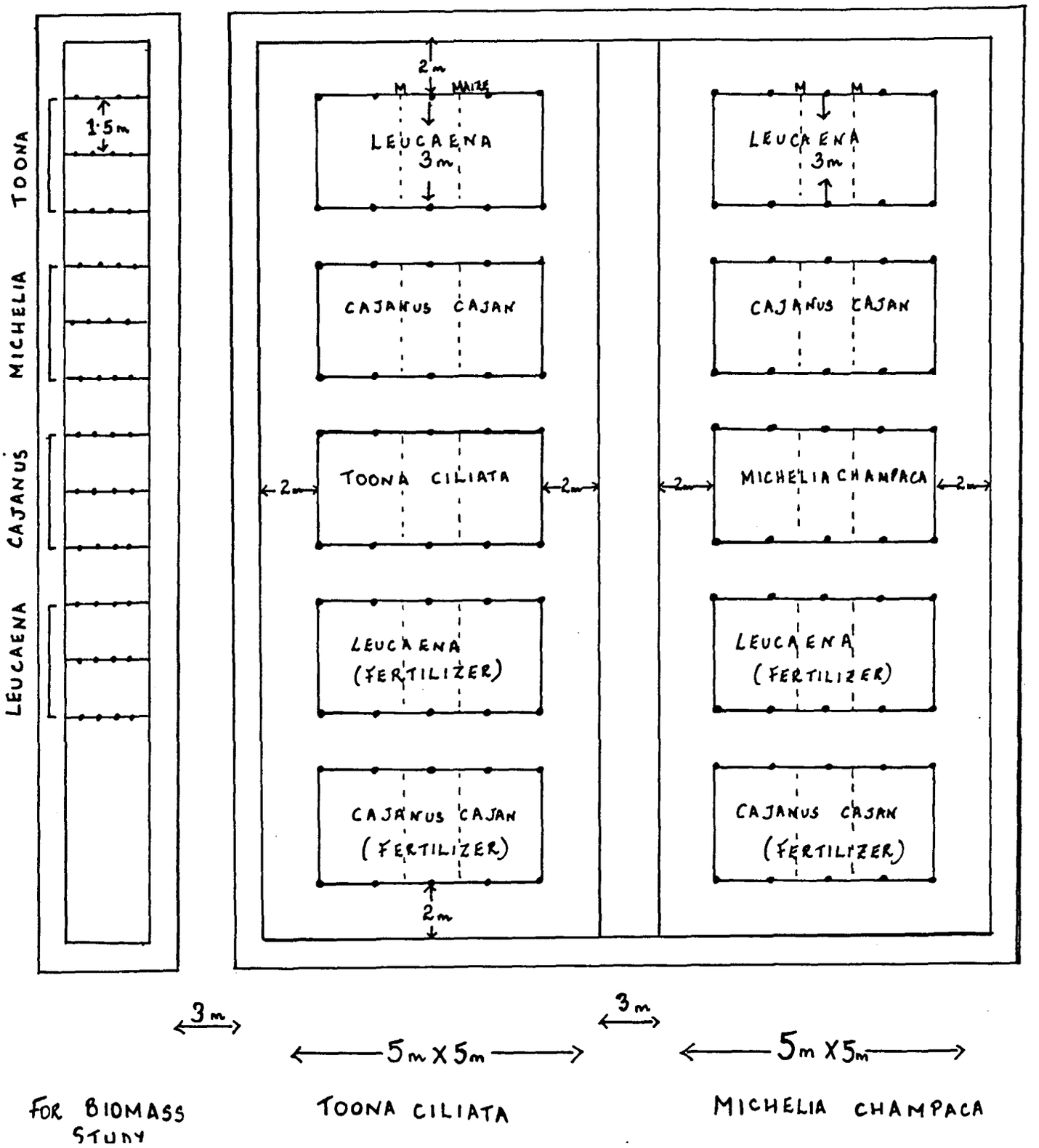

Fig 3 - Experimental Lay out of Toona ciliata and Michelia champaca along with Leucaena leucocephala and Cajanus cajan under maize intercropping.

branches was recorded at a monthly interval. The tree height was measured using standard method. Tree height was determined perpendicularly from the ground level to the tip of the apical meristem. At the same time, the number of branches, number of leaves and the collar diameter were also assessed at a monthly interval. From the harvestable plot, each of the four species was also harvested monthly for determining the biomass (fresh weight and dry weight). These plant samples were washed with tap water and then allowed to dry in hot oven at 105°C to a constant weight in the laboratory. Horizontal root length and vertical spreading of the root was recorded with the help of a measuring tape. Fertilizer (N,P,K) was applied in the month of October 1998 in all the sub plots (for both the species) in the form of urea, super phosphate and muriate of potash at the rate of 0.05 gm/plant of urea, 0.04 gm/plant of muriate of potash and 0.59 gm/plant of super phosphate at the initial stage of the experiment. The growth attributes (height,collar thickness, number of leaves, branches) were also recorded at a monthly interval to see the effect of N,P,K on the growth of the tree species. The mean yield of maize was recorded at the harvest.

A complete analysis of the soil was done in Soil Testing Laboratory under Agriculture Department. The various soil parameters such as soil texture, soil temperature, moisture, pH,C:N ratio, N,P,K content of the soil were carried out in the laboratory. Soil nitrogen was tested by Potassium permanganate method using Kjedahl Digestion and Distillation method, soil phosphorous by calorimeter using Brays P method. Potassium was determined by Flame Photometer using Ammonium acetate method (normal). Soil temperature was measured using a soil thermometer . The moisture content of the soil was determined by Gravimetric method and the soil pH was

electrochemically tested by digital pH meter (1:2.5 soil, water suspension). For determining the C:N ratio, the organic carbon was determined by using Wakley and Black (1967) Rapid Titration Method.

For checking the attack of pests on the plants, pesticide Melathion (0.2%) was lightly sprayed at bi-monthly interval. Glyphosphate was also sprayed for checking the growth of notorious weeds especially *Imperata cylindrica* before the introduction of agriculture crop in the field.

The data obtained were subjected to ANOVA (Analysis of Variance) to see the effect of month on the growth behaviour of various tree species on a particular treatment. Students T-test was made to compare the varieties in growth parameters between the plant species under both fertilized and non-fertilized plots. The data on the maize yield were also subjected to ANOVA to see the effect of fertilizer on the yield of the maize. The biomass (above and below ground) yield and the vertical and horizontal spreading of the four species were correlated to find the relationship between the factors.

CHAPTER - III

REVIEW OF LITERATURE

Great amount of research works have been carried out elsewhere on various aspects of agroforestry which includes agroforestry model as alternative to 'jhum' a shifting cultivation (Jha, 1995), soil management for agroforestry (Dhar and Jha, 1993)), selection of plant species for agroforestry (Santra, 1993), nursery pest management under agroforestry (Thakur, 1993), genetic improvement of agroforestry trees (Surendran and Chardrasekaran, 1993), tree- crop interaction in agroforestry practices (Harsh and Tewari, 1993),alley cropping (Wilson and Kang, 1981), mulch farming (Lal, 1973), biomass and nutrient distribution (Gupta *et al*, 1992) etc. Besides the growth performances of trees in various agroforestry systems have also been carried out by many researchers (Mohan, 1992, Osman *et al*, 1997).

PERFORMANCE OF MPTS

The early performance of some multipurpose tree species in degraded forest area in Western Ghats of Karnataka have been studied. According to Jagadishchandra *et al* (1995), the species like *Acacia, Eucalyptus* gives promising results for converting the degraded and non-productive forest areas into production and protective areas. The growth and biomass production of some species of *Acacia and Eucalyptus* in degenerated Sal forest of Bangladesh are also reported and it was found that certain species of *Acacia and Eucalyptus* performs better than the other species. (Hossain *et al*, 1997). Mohit Gera *et a*l (1992) studied the performance of seventeen(17) different MPTs under semi arid region of Central India in order to screen out the best adoptable species with desirable characters for use in various afforestation, agroforestation and Social forestry programmes. Their results suggested that *Gmelina arborea, Azadirachta indica* and *Leucaena leucocephala* were

among the fastest growing species with maximum MAI (Mean Annual Increment) making them promising candidates for agroforestry and Social forestry plantations. The growth performance of interspecific hybirds of *Eucalyptus* (FRI - 4 and FRI - 5) were compared with widely planted Mysore gum (local control) for their growth performance (Sidhu, 1985). The growth performance and biomass yield of some leguminous taxa has been carried out at Garhwal, Himalaya. (Bhatt *et al*, 1996). Their results showed that *Albizzia lebbek* and *Dalbergia sissoo* showed average highest germination, biomass allocation and better growth performance as compared to other leguminous species and thus can be recommended for mass afforestation of degraded lands in Garhwal hills. Deb Roy (1984) studied the growth and above ground biomass production of *Albizzia lebbek* under Silvipastoral system. After 3 years of study, his results revealed that the growth in height, collar diameter, diameter at breast height (dbh) increase with age reaching maximum in the 3rd year of the study. Osman *et al* studied the growth and nutrient dynamics of young *Pinus caribaea* morelet plantation on a denuded hill soil of Bangladesh.

The growth performance of directly seeded leguminous tree, non-leguminous forbs, grasses and crops evaluated on a 12yr old flat surface coal mine spoil at Jhingruda colliery, Singrauli indicate that the legumes have better growth performance than the non-legumes after one year of seedling growth (Jha and Singh, 1987). Singh and Kumar (1991) studies the growth behaviour in *Moghana macrophylla* (Wild) in the nursery at Indian Lac Institute, Nankum, Ranchi. The growth analysis revealed that the various parameters had more values in the first phase of 60-90 days after sowing (DAS) than the advanced stage of the seedling growth (90 - 105 DAS).

STUDIES ON BIOMASS PRODUCTION AND NUTRIENT STATUS OF SOIL

The nutrient accumulation and the biomass of a *Cryptomeria japonica* plantation increase with the age of the stand but the proportion in aerial components of plants were reversed (greater in young and less in mature stands). These observations were derived from a study made from eight stands of *Cryptomeria japonica* plantation of Darjeeling varying from 7 to 40 years (Bajrang Singh, 1987). From a study conducted on one hundred plants ranging from 3.5 years to 7.5 years, Khan and Pathak (1986) reported that the variation in the biomass/growth had increasing trend upto 6.5years and decline afterward. They also found that the 'dbh' provides the optimum prediction of biomass. The growth, biomass production and plant mortality in seven (7) *Sesbania sesban* and three (3) *Sesbania macrantha* accessions were studied in Tumbi, in Tabora, Tanzania (Karachi *et al,* 1991). Their findings indicates that there was significant difference in height, height incremental rates and root collar diameter, at three (3) and five (5) months after field establishment whereas the rates of increase in collar diameter were similar. The biomass production and mineral cycling of five different aged stands of *Pinus roxburghii* were studied in Himachal Pradesh (Rawat and Tandon, 1993). Their findings revealed that the total biomass of these stands ranges between 25t/ha to 90 t/ha. Patil *et al* (1996) have compared the nutrient status of soil under tree canopies (Teak, *Casuarina, Eucalyptus, Albizzia, Sissoo)* at Prabhunagar and found that the pH was highest in case of teak and lowest in *Sissoo.* Highest potash content was also observed under *Dalbergia sissoo* whereas only a little variation was noticed for available phosphorus content of the soil among the tree species.

STUDIES ON TREE-CROP INTERACTION IN AGROFORESTRY

The growth and field of *Acacia albida* intercropped with maize (*Zea mays*) and beans (*Phaseolus vulgaris*) were studied at Morogoro, Tanzania (Okorio *et al,* 1991). The studies reported that the intercropping did not significantly influence volume and biomass of the tree, nor the yield of the intercrops (maize and beans). Natarajan *et al* (1991) also studied the intercropping of Pigeon pea (*Cajanus cajan*) with maize, sunflower and groundnut in Zimbabwe. According to them Pigeon pea can be intercropped with maize and sunflower without being detrimental to the grain yield of the crops. A study on tree-crop interaction on *Grewia optiva, Morus alba,* and *Eucalyptus* with paddy and wheat were conducted on a silty clay loam soil in Doon Valley (Khybri *et al,* 1988). Their study reported that all the tree species had depressing effect on the crop yield with *Eucalyptus* having the greatest depressing effect on the crop yield.

STUDIES ON THE EFFECT OF FERTILIZER

Fertilizer play an important role in influencing the growth and biomass production of the tree species and this have been reported by many researchers. According to Mohan (1992), *Terminalia myriocarpa* greatly responds to fertilizer application (N,P,K). Their seedlings growth was enhanced when treated with urea, super phosphate and muriate of potash. The application of fertilizer (N and P) also have a great effect on the nutrient uptake and biomass production of *Bauhinia variegata.* Nitrogen application significantly increased biomass in all parts of the plant. The application of phosphorus showed significant effect on leaf and total biomass. (Koul et al 1995).

Singh *et al* (1998) studied the effect of Nitrogen, phosphorus and mulch on the growth and establishment of *Pinus roxburghii.* After 21 months of the study, they found that the application of fertilizer along with mulching resulted in lower plant mortality and higher plant growth of the species.

Similar responses of N,P,K on *Acacia nilotica* seedlings growth have been reported by Prasad and Rawat (1991). According to them, the application of N and P alone or in combination decreased the growth yield and fertilizer use efficiency in the absence of nitrogen. Application of fertilizer (N,P,K) on *Eucalyptus tereticornis* and *Eucalyptus camaldulensis* seedlings also helped in boosting up the growth and reducing the nursery period of the species by about a months time (Sundararaju *et al*, 1989). The response of *Ailanthus excelsa* to N and P fertilization on an arid sandy soil have been sutdied (Gupta *et al*, 1994). which depicts that fertilization increased the tree height of 2 years old *A.excelsa* by about 48 percent. The effect of both organic and inorganic fertilizers application on five tree species seedlings and its impact on survival and its establishment in the main field have also been studied. (Chellamuthu *et al,* 1995). According to them, the application of neem cake extract or cowdung slurry or combined applications of N,P,K together significantly increased the root length, basal diameter and dry matter production of seedlings in the nursery and ultimately resulted in better survival and establishment of tree seedlings in mainfield plantations.

The effect of nitrogen, *Rhizobium* inoculation and phosphorus on root nodulation, dry matter yield and nutrient uptake in Pigeon pea (*Cajanus cajan*) have been studied. (Rana *el al,* 1995). The study reported that ferti-

lization significantly increased the root length, the number of nodules and the nutrient content in the grain and straw. Similar response of short duration Pigeon pea to nitrogen, *Rhizobium* inoculation and phosphorus have also been reported by Singh *et al* (1995). Fertilization (N and P) also has a great effect on the growth of *Sesbania sesban* (Kanyama Phiri *et al*, 1990). In an experiment carried out al Malawii, it was reported that there was significant increases in canopy height, growth rate, number of primary branches/ plant, stem diameter, leaf and fuelwood dry matter yield attributed to N and P fertilization. Gangoo *et al* (1990) also studied the fertilizer response (N & P and manure) by two species of Poplars (*Populus deltoides* and *P.niagra*) on initial growth in the nursery in Kashmir and found that fertilizer dose of N_{150}, P_{120}, M_{20} was the best dose for both the species. According to Rajbir and Thind (1996), the application of nitrogen (N) at the rate of 100 kg h^{-1} significantly increased the height of *Eucalyptus* after 120 days while the addition of FYM and N failed to affect its collar diameter.

From the above eye's view of the literature, it is depicted that study on various agroforestry practice with different tree species especially the multipurpose ones have been given top priority in the developing countries viz India, Bangladesh, Sri Lanka, Thailand, Phillipines, Mexico, Argentina, Costa Rica, Brazil, Chile, Colombia, Equador etc (Singh and Tewari, 1996). In India, agroforestry research has been on the forefront since last three decades as because it has proven great potential in meeting the challenge of growing food and unemployment problems. The various states where agroforestry are carried out includes West Bengal, Uttar Pradesh, Tamil Nadu, Kerela etc. The North east part of India is one of the twenty 'hot spots' of the world. Unfortunately, 'jhum' (the local name of shifting cultivation) in the past has

been detrimental to the biodiversity of this region and has become a barrier in motivating the tribes towards scientific approaches to agroforestry. Of late, the practice of agroforestry with the judicious land use are becoming popular in this region. In Mizoram, NLUP (New Land Use Policy) was one of the measures undertaken by the Government in 1990 in rehabilitating the jhumming. Under this scheme, the beneficiaries introduced various multipurpose tree species such as *Aleurites fordii, Albizzia lebbek, Morus alba* etc on their land, The other MPTs which have attracted attention of the farmers/ tree growers of the state includes *Tectona grandis, Gmelina arborea, Schima wallichi, Morus alba* etc. Though there have been claims on tree-green hedge crop farming system, terrace brim system (Jha, 1995), not much work have been carried out on various agroforestry aspects in Mizoram. Moreover no work has been undertaken on *Michelia champaca* and *Toona ciliata* which are reported important multipurpose tree species elsewhere (Gurdev Chand and Bhardiwaj, 1996). Therefore the present study has been carried out to cover the growth behaviour of these two MPTs along with two green hedges viz *Cajanus cajan* and *Leucaena leucocephala* in an agroforestry system of Mizoram.

CHAPTER -IV

RESULTS

GROWTH BEHAVIOUR OF *TOONA CILIATA*

The height of *Toona ciliata* under control (without *Leucaena leucocephala/ Cajanus cajan*) plot gradually increased over time. The rate of growth in height was slower in the initial few months (till March) and faster after March. Similar trend was also observed in case of collar thickness, number of leaves and number of branches. All the parameters significantly varied between the months. (Table 1)

The height of *T.ciliata* with *L. leucocephala* also varied significantly (P<O.05). between months and the rate was slower till April after which the rate increased. (Table 2). Other growth parameters *viz* collar thickness, number of leaves and number of branches followed the same trend as with the height.

The height as well as all other growth parameters *viz* collar thickness number of leaves and number of branches followed similar trend across the months and the rate too was similar as with Table I & 2. ((Table 3).

Comparing the growth behaviour of *Toona ciliata* along with different hedges, it was found that the height of *T.ciliata* varied significantly (P<O.O5) with different combination of hedges. The height of the species was higher under *L.leucocephala* hedge (*T. ciliata* + *Cajanus cajan*) and least under control (*T.ciliata*) conditions. (Table I & 3). Similar was the case in all other parameters *viz* collar thickness, number of leaves and number of branches.

RESULTS :

Table 1 : Monthly variation in height (cm) collar thickness (cm) number of leaves and number of branches of *Toona ciliata* under control (without *Leucaena leuccocephala/Cajanus cajan*) plot in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height (cm)	Col. thickness(cm)	No. of leaves	No.of branches
Sep.'98	29.3	1.3	3.6	1.0
Oct.	29.6	1.3	5.0	2.0
Nov.	30.0	1.4	5.0	2.0
Dec.	31.3	1.4	5.6	2.0
Jan.'99	32.1	1.4	6.3	2.6
Feb.	32.6	1.4	6.3	3.3
Mar.	33.7	1.4	6.6	3.3
Apr	36.7	1.6	11.0	3.6
May	42.5	1.8	14.3	6.0
Jun.	44.5	1.9	18.0	6.0
Jul.	47.3	2.1	22.0	7.0
Aug.	49.3	2.1	23.0	7.6
Sep.	53.6	2.3	24.0	7.6
CD at 5%	3.67	0.16	1.95	1.55

Table 2 : Monthly variation in height(cm), collar thickness (cm), number of leaves, number of branches of *Toona ciliata* along with *Leucaena leucocophala* in maize agroforestry system of Mizoram

Month / Year	GROWTH OF PARAMETERS			
	Height (cm)	Col.thickness (cm)	No. of leaves	No.of branches
Sep '98	44.1	1.2	3.6	1.0
Oct	44.6	1.2	4.6	2.0
Nov	45.3	1.3	4.3	2.0
Dec.	45.3	1.4	5.0	2.6
Jan '99	45.8	1.4	5.0	3.0
Feb.	46.16	1.5	7.3	3.3
Mar.	48	1.6	8.3	5.0
Apr.	49.6	1.6	11.0	5.6
May	57.2	1.9	16.0	7.0
Jun.	58.9	2.1	18.3	7.5
Jul.	63.2	2.2	23.3	8.3
Aug.	66.6	2.4	25.6	8.6
Sep.	72	2.8	29.0	8.6
CD at 5%	6.65	0.37	2.49	2.40

Table 3 : Monthly variation in height (cm), collar thickness, (cm), number of leaves, number of branches of *Toona ciliata* along with *Cajanus cajan* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height (cm)	Col. thickness	No. of leaves	No. of branches
Sep.'98	36.0	1.3	4.0	-
Oct.	37.1	1.3	3.3	1.0
Nov.	37.3	1.3	3.6	1.2
Dec.	38.3	1.3	3.0	2.3
Jan '99	38.8	1.4	3.6	2.3
Feb.	38.2	1.4	1.6	2.3
Mar.	41.6	1.6	6.3	2.6
Apr.	43.5	1.6	6.3	3.2
May.	49.5	1.8	15.6	4.0
Jun.	52.6	1.9	20.3	4.0
Jul.	57.1	2.2	23.6	4.3
Aug.	61.7	2.4	25.3	4.3
Sep.	68.0	2.6	28.0	4.6
CD at 5%	8.8	5.08	1.92	0.58

GROWTH BEHAVIOUR OF *MICHELIA CHAMPACA*

The height of *Michelia champaca* under control (without *L.leucocephala/C.cajan*) significantly varied with time (Table 4). The rate of growth was slower in the first few months (till April) but started increasing at a faster rate from May. The other growth parameters *viz* collar thickness, number of leaves and number of branches also followed the same trend as with the height. But the increase rate in the number of branches was quite slow ever after the month of May.

The height as well as the other parameters *viz.* collar thickness, number of leaves and branches of *Michelia champaca* along with *Leucaena leucocephala* significantly varied between the months ($P< 0.05$). The rate of growth however was slower in the initial months (till April) and faster after this month. (Table 5).

All the growth parameters *viz* height, collar thickness, number of leaves and branches of *Michelia champaca* + *Cajanus cajan* also followed the same trend across the months as with Table 4 and 5.

Comparing the growth behaviour of *Michelia champaca* along with different hedges, it was also observed that the height varied significantly ($P<0.05$) with different combination of hedges. The height of the species was higher under *Cajanus cajan* hedge (*M.champaca* + *C.cajan*) followed by *Leucaena* hedge (*M.champaca* + *L.leucocephala)* and least under control (*M.champaca)* condition. All other parameters *viz.*collar thickness number of leaves and number of branches also followed similar trend as with height (Table 4-6).

Table 4 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Michelia champaca* under control (without *Leucaena leucocephala /Cajanus cajan*) plot in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height (cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	7.1	1.1	4.3	-
Oct.	8.1	1.1	4.6	1.6
Nov.	9.0	1.2	6.0	1.6
Dec.	9.6	1.2	7.0	2.0
Jan. '99	10.3	1.2	7.6	2.0
Feb.	10.8	1.2	8.6	2.0
Mar.	11.3	1.3	8.6	2.0
Apr.	13.1	1.4	9.3	2.0
May	19.9	1.5	11.6	2.3
Jun.	22.2	1.6	12.6	2.3
Jul.	26.1	1.9	14.0	2.3
Aug.	28.8	2.2	14.3	2.4
Sep.	31.4	2.4	14.6	2.4
CD at 5%	2.7	3.60	1.72	0.50

Table 5 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Michelia champaca* along with *Leucaena leucocephala* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height (cm)	Col.thickness(cm)	No. of leaves.	No. of branches
Sep.'98	10.3	1.0	7.3	-
Oct.	11.9	1.1	9.3	1.0
Nov.	13.0	1.1	9.3	1.0
Dec.	13.6	1.2	7.6	1.0
Jan.'99	13.3	1.3	7.6	1.3
Feb.	15.0	1.3	8.7	1.6
Mar.	19.5	1.4	10.6	3.0
Apr.	23.3	1.4	11.7	2.0
May	31.9	1.8	15.3	2.3
Jun.	36.3	2.2	16.6	2.3
Jul.	43.0	2.5	19.0	2.4
Aug.	50.3	2.7	19.6	2.4
Sep.	54.6	3.2	22.6	2.6
CD at 5%	54.6	0.16	6.67	1.93

Table 6 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Michelia champaca* along with *Cajanus cajan* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	10.8	1.2	6.3	-
Oct.	11.1	1.3	6.3	1.0
Nov.	12.8	1.3	7.0	1.3
Dec.	15.0	1.4	9.3	1.3
Jan.'99	15.0	1.4	9.3	1.6
Feb.	16.2	1.5	8.6	2.0
Mar.	20.8	1.8	10.6	2.0
Apr.	23.6	2.0	12.3	2.0
May	32.8	2.4	14.3	2.3
Jun.	39.6	2.7	16.0	2.3
Jul.	48.6	2.9	18.6	2.3
Aug.	57.6	3.1	19.3	2.6
Sep.	67.6	3.3	23.6	2.8
CD at 5%	7.82	0.19	5.08	0.55

GROWTH BEHAVIOUR OF *LEUCAENA LEUCOCEPHALA*

The height of *Leucaena leucocephala* along with *Toona ciliata* was significantly affected by time. ($P<0.05$). The growth rate was slow in the initial months (till April) and faster after April. (Table 7). Other growth parameters *viz* collar thickness, number of leaves also followed the similar trend as with the height. However, the growth rate in the number of branches was not very fast even after the month of May.

The height as well as the other growth parameters *viz* collar thickness, number of leaves and number of branches of *Leucaena leucocephala* along with *Michelia champaca* also followed the same trend as that of Table 7 (Table 8).

In comparing the growth behaviour of *Leucaena leucocephala* with two (2) different tree species, it was clearly observed that the height as well as the other growth attributes *viz* collar thickness, number of leaves and number of branches of *Leucaena leucocephala* under *Toona ciliata* system (*Leucaena + Toona ciliata)* was higher than that of *L.leucocephala* under *Michelia champaca* system *(Leucaena + Michela champaca)* (Table 7-8).

GROWTH BEHAVIOUR OF *CAJANUS CAJAN*

The growth rate in height, collar thickness, number of leaves and number of branches of *Cajanus cajan* along with *Toona ciliata* also increased significantly ($P<0.05$) with the increase in time. The growth in height as well as other parameters *viz* collar thickness, number of leaves and number of

Table 7 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Leucaena leucocephala* along with *Toona ciliata* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height (cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	18.0	0.6	9.0	-
Oct.	18.6	0.7	7.6	1.0
Nov.	19.6	1.0	7.0	1.0
Dec	20.3	1.2	9.3	1.2
Jan.'99	20.3	1.2	5.6	2.3
Feb.	20.6	1.2	6.0	3.0
Mar.	23.2	1.2	6.0	3.0
Apr.	26.6	1.4	8.3	3.3
May	32.3	1.7	10.0	4.0
Jun	36.3	1.8	9.6	4.2
Jul	40.6	2.0	9.8	4.3
Aug	47.2	2.2	12.6	4.4
Sep	51.3	2.4	15.8	4.6
CD at 5%	3.27	3.91	5.65	0.77

Table 8 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Leucaena leucocephala* along with *Michela champaca* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	16.3	0.6	5.6	-
Oct.	17.6	0.7	6.3	1.3
Nov.	18.9	0.7	6.6	1.6
Dec.	21.2	0.9	5.6	2.0
Jan.'99	23.4	1.2	5.6	2.2
Feb.	24.2	1.3	7.0	2.3
Mar.	25.6	1.3	6.6	2.6
Apr.	25.9	1.4	8.0	2.6
May	27.3	1.5	9.6	3.0
Jun.	29.3	1.7	11.0	3.3
Jul.	31.3	1.7	11.6	3.3
Aug.	33.3	1.8	13.3	3.6
Sep.	36.9	2.1	14.6	3.6
CD at 5%	0.95	9.68	3.80	0.55

branches was lower in the initial months and faster from the month of May (Table 9).

Similar trend as with Table 9 was observed in the growth rate of *Cajanus cajan* along with *Michelia champaca.* All the growth parameters (height, collar thickness, number of leaves and branches) followed the same trend as with Table 9 (Table 10).

In comparing the growth behaviour of *C.cajan* along with two different tree species, it was found that the height of the species was higher in the case of *C.cajan* + *Michelia champaca* and lower in *C.cajan* + *Toona ciliata.* Similar trend was also shared by the other growth parameters *viz* collar thickness, number of leaves and branches (Table 9 & 10).

GROWTH BEHAVIOUR OF *TOONA CILIATA* UNDER FERTILIZED PLOT

The height of *Toona ciliata* under fertilized plot was always higher than under control plot. The values in height was significantly higher under *T.ciliata* + *Leucaena* fertilized plot (Table 11) than the corresponding *T.ciliata* + *Leucaena* control plot (Table 2).

Similar trend was also observed under *T.ciliata* + *Cajanus cajan* fertilized plot (Table 12). The values in height, as well as the other growth parameters *viz* collar thickness, number of leaves and number of branches were higher under *T.ciliata* + *C.cajan* fertilized plot than the corresponding *T.ciliata* + *C.cajan* control plot (Table 3).

Table 9 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Cajanus cajan* along with *Toona ciliata* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	14.8	0.7	4.3	1.0
Oct.	35.6	1.1	6.3	1.6
Nov.	50.3	1.2	14.5	2.0
Dec.	65.3	1.7	17.6	2.0
Jan.'99	68.1	1.7	12.0	2.0
Feb.	68.6	1.9	15.6	2.6
Mar.	71.2	1.9	18.0	2.6
Apr.	73.9	2.0	21.3	2.6
May	88.8	2.1	27.3	2.6
Jun.	101.8	2.3	36.3	3.6
Jul.	123.6	2.4	42.3	4.0
Aug.	130.6	2.5	46.3	4.3
Sep.'99	138.3	3.7	52.0	4.6
CD at 5%	13.43	0.50	2.38	1.1

Table 10 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Cajanus cajan* along with *Michela champaca* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	24.8	0.7	4.3	1.0
Oct.	30.6	1.1	7.3	1.0
Nov.	64.0	1.5	15.6	1.0
Dec.	82.6	1.5	20.0	1.0
Jan.'99	86.3	1.7	20.3	1.6
Feb.	87.6	1.7	18.0	2.3
Mar.	91.6	1.9	25.3	3.0
Apr.	94.8	2.2	28.6	3.0
May	103.3	2.4	37.6	3.6
Jun.	115.3	2.7	53.0	3.6
Jul.	128.3	2.9	61.6	4.3
Aug.	142.3	3.1	69.0	4.6
Sep.	151.3	3.3	76.6	4.6
CD at 5%	9.35	0.01	13.48	0.65

Table 11 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Leucaena leucocephala* along with *Michela champaca* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height (cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	16.3	0.6	5.6	-
Oct.	31.6	1.3	1.0	6.6
Nov.	33.6	1.4	1.3	6.6
Dec.	37.0	1.5	1.6	7.0
Jan.'99	39.3	1.6	2.3	7.0
Feb.	42.3	1.8	3.3	8.3
Mar.	47.0	2.0	5.0	9.0
Apr.	52.0	2.2	7.0	10.6
May	68.0	2.6	14.0	11.3
Jun.	76.0	2.6	20.0	12.3
Jul.	81.3	3.2	26.0	13.3
Aug.	89.0	3.5	30.0	13.6
Sep.	96.0	3.8	33.0	14.2
CD at 5%	4.67	0.41	1.42	2.74

Table 12 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Toona ciliata* along with *Cajanus cajan* in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	36.3	1.2	4.0	1.0
Oct.	37.3	1.3	7.6	1.3
Nov.	42.3	1.4	10.3	2.0
Dec.	46.0	1.5	11.6	3.0
Jan.'99	49.0	1.6	11.6	3.3
Feb.	52.6	1.7	17.3	4.0
Mar.	56.6	1.8	19.6	4.6
Apr.	60.0	2.0	22.3	5.6
May	65.0	2.3	28.3	6.6
Jun.	69.0	2.4	34.0	7.0
Jul.	73.0	2.5	39.3	8.0
Aug.	77.3	2.6	43.0	9.0
Sep.	86.3	2.8	47.6	9.0
CD at 5%	1.55	3.43	5.61	1.40

GROWTH BEHAVIOUR OF *MICHELIA CHAMPACA* UNDER FERTILIZED PLOT

Like *Toona ciliata,* the height of *Michelia champaca* under fertilizer plot was also always higher than under the control plot. The values in height as well as the other parameters (collar thickness, number of leaves and number of branches) of *M.champaca* + *Leucaena* (fertilizer plot) (Table 13) were significantly (P<O.05) higher than the corresponding *M.champaca* + *Leucaena* control plot (Table 5).

A similar trend was also observed in *M.champaca* + *Cajanus cajan* fertilized plot (Table 14) when compared with *M.champaca* + *C.cajan* control plot (Table 6).

GROWTH BEHAVIOUR OF *LEUCAENA LEUCOCEPHALA* UNDER FERTILIZED PLOT

The growth rate in height, collar thickness, number of leaves and number of branches of *Leucaena leucocephala* increased significantly (P<0.05) under the fertilized plot. The values in height was higher under *L.leucocephala* + *Toona ciliata* fertilized plot (Table 15) than the corresponding *L.leucocephala* + *T.ciliata* control plot (Table 7). Similarly, all the other parameters (collar thickness, number of leaves and number of branches) also followed the same trend as with the height.

A similar trend was also observed while comparing *L.leucocephala* + *Michelia champaca* fertilized plot (Table 16) with the corresponding control plot (Table 8).

Table 13 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Michela champaca* along with *Leucaena leucocephala* as effected by fertilizer (N,P,K) in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	14.6	1.2	8.9	-
Oct.	16.9	1.2	9.3	1.0
Nov.	18.0	1.3	9.3	1.0
Dec.	21.0	1.3	10.6	2.0
Jan.'99	24.7	1.3	11.6	2.0
Feb.	30.0	1.4	11.6	2.0
Mar.	33.8	1.4	10.3	2.0
Apr.	38.3	1.8	12.4	2.3
May	44.7	2.4	15.3	2.6
Jun.	50.3	2.6	18.6	2.7
Jul.	56.7	2.9	22.4	2.9
Aug.	62.2	3.2	25.7	3.0
Sep.	68.9	3.4	27.8	3.2
CD at 5%	2.46	0.16	6.67	1.93

Table 14 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Michelia champala* along with *Cajanus cajan* as effected by fertilizers (N,P,K) in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	13.6	1.1	7.6	1.0
Oct.	14.6	1.2	9.0	1.0
Nov.	17.3	1.3	10.6	1.0
Dec.	21.6	1.5	12.0	1.6
Jan.'99	25.3	1.7	12.6	2.0
Feb.	26.3	1.9	14.3	2.0
Mar.	31.3	2.0	18.0	2.0
Apr.	37.0	2.2	19.6	2.0
May	48.3	2.5	24.3	2.3
Jun.	58.3	2.8	27.6	2.3
Jul.	63.3	3.1	31.0	2.4
Aug.	73.3	3.4	34.3	2.7
Sep	81	3.7	37.0	2.9
CD at 5%	3.43	10.95	3.31	0.58

Table 15 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Leucaena leucocephala* along with *Toona ciliata* as effected by fertilizers (N,P,K) in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	17.5	0.5	5.3	1.0
Oct	17.6	0.7	6.6	1.0
Nov	20.3	0.8	7.6	1.6
Dec	23.3	1.0	7.0	2.0
Jan'99	26.6	1.1	6.0	2.3
Feb	30.0	1.2	8.3	2.3
Mar	34.3	1.3	9.0	2.6
Apr	39.0	1.4	8.6	3.3
May	48.0	1.6	10.6	4.3
Jun	55.3	1.8	11.6	5.0
Jul	68.0	1.9	12.3	5.0
Aug	78.3	2.2	14.3	5.6
Sep	86.3	2.5	16.6	6
CD at 5%	3.74	0.16	2	0.95

Table 16 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Leucaena leucocephala* along with *Michelia champaca* as effected by fertilizers (N,P,K) in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	0.3	0.7	10.6	-
Oct	21.0	0.8	11.9	1.0
Nov	23.6	1.0	12.6	1.0
Dec	24.0	1.2	12.8	1.2
Jan'99	25.7	1.2	14.2	1.2
Feb	17.3	1.3	14.6	1.6
Mar	30.3	1.3	11.3	2.4
Apr	32.4	1.6	13.9	2.8
May	42.3	2.3	16.6	3.2
Jun	46.0	2.4	19.2	3.6
Jul	53.8	2.6	20.0	4.2
Aug	60.6	2.6	21.0	4.4
Sep	64.3	2.8	22.0	4.8
CD at 5%	1.25	0.16	3.77	0.53

GROWTH BEHAVIOUR OF *CAJANUS CAJAN* UNDER FERTILIZED PLOT

Cajanus cajan significantly (P<O.05) increased all its growth parameters (height, collar thickness, number of leaves and branches) when the plant was subjected to a fertilizer treatment. The values in the number of leaves and branches were significantly (P<0.05) higher under *C.cajan* + *Toona ciliata* fertilized plot (Table 17) than the control *C.cajan* + *T.ciliata* plot (Table 9).

A similar trend was also observed when *Cajanus cajan* + *Michelia champaca* fertilized plot (Table 18) was compared with the corresponding control plot (Table 10). The values in the fertilized plot were significantly (P<0.05) higher than the control plot.

ABOVE GROUND & BELOW GROUND BIOMASS AND VERTICAL & HORIZONTAL ROOT SPREADING

The biomass (both above & below ground) of *Toona ciliata* increased with the time. The Vertical and horizontal spreading of the roots also increased with time. (Table 19).

Similar trend was observed in the biomass and vertical and horizontal root spreading of all other species. (Table 20-22). Out of the four species, *C.cajan* have the highest dry matter production (above and below ground) followed by *T.ciliata, L.leucocephala* and *M.champaca.* In all other species except *C.cajan,* the vertical root length was greater than the horizontal root

Table 17 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Cajanus cajan* along with *T Toona ciliata* as effected by fertilizers (N,P,K) in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	17.2	0.8	4.6	-
Oct.	23.6	1.1	8.0	1.0
Nov.	34.0	1.3	15.0	1.6
Dec.	40.3	1.5	23.6	2.3
Jan.'99	43.3	1.7	31.6	3.3
Feb.	47.3	1.8	37.6	4.3
Mar.	53.6	2.1	42.6	5.3
Apr.	59.3	2.3	59.0	6.6
May	76.3	2.7	67.3	8.0
Jun.	90.3	3.0	75.3	8.6
Jul.	106.3	3.3	84.0	9.0
Aug.	127	3.6	93.3	9.6
Sep.	144	3.9	103.6	10.6
CD at 5%	3.7	3.06	1.97	1.24

Table 18 : Monthly variation in height (cm), collar thickness (cm), number of leaves, number of branches of *Cajanus cajan* along with *Michelia champaca* as effected by fertilizers (N,P,K) in maize agroforestry system of Mizoram.

Month / Year	GROWTH PARAMETERS			
	Height(cm)	Col.thickness(cm)	No. of leaves	No. of branches
Sep.'98	23.8	0.8	4.0	1.0
Oct	29.0	1.1	10.0	1.0
Nov	0.0	1.4	28.0	2.0
Dec	51.3	1.6	35.0	3.0
Jan '99	58.6	1.8	42.3	3.3
Feb	63.3	2.1	52.6	3.6
Mar	67.0	2.3	65.6	4.0
Apr	77.3	2.6	74.3	5.0
May	107.0	3.0	80.6	6.0
Jun	133.0	3.3	89.6	6.0
Jul	152.0	3.7	105.0	7.0
Aug	172.6	3.9	114.3	7.0
Sep	180.0	4.2	121.6	7.0
CD at 5%	8.26	0.16	8.20	1.64

Table 19 : Monthly variation in Above ground & Below ground biomass (gm) and Vertical & Horizontal root spreading (cm) in *Toona ciliata* in maize agroforestry system of Mizoram.

Month / Year	Above ground biomass (gm)	Below ground biomass (gm)	Ratio A\B biomass	Vertical Root spreading (cm)	Horizontal Root spreading (cm)	Ratio V/H
Sep.'98	3.65	2.61	1.39	16.2	14.8	1.09
Oct.	3.76	2.70	1.39	13.0	12	1.09
Nov.	3.89	4.0	0.97	17.8	13.2	1.38
Dec.	4.0	4.10	0.97	18.2	16.3	1.11
Jan.'99	5.20	5.10	1.01	18.6	15.2	1.22
Feb.	5.86	6.21	0.94	20.2	15.6	1.29
Mar.	5.92	7.64	0.77	22.4	16.6	1.34
Apr.	6.02	8.22	0.73	23.4	16.9	1.38
May	14.32	9.46	1.51	24.3	18.2	1.33
Jun.	16.21	9.82	1.65	24.6	18.8	1.30
Jul.	16.86	10.62	1.58	25.8	20.7	1.24
Aug.	20.61	12.42	1.65	25.6	22.8	1.12
Sept.	22.55	13.81	1.63	27.3	24.3	1.12
S.E.	1.88	0.97	-	1.15	0.95	-

n = 13

Table 20 : Monthly variation in Above ground & Below ground biomass (gm) and Vertical & Horizontal root spreading (cm) in *Michelia champaca* in maize agroforestry system of Mizoram.

Month / Year	Above ground biomass (gm)	Below ground biomass (gm)	Ratio A\B biomass	Vertical Root spreading (cm)	Horizontal Root spreading (cm)	Ratio V/H
Sep.'98	0.50	0.12	4.16	19.5	14.0	1.39
Oct.	0.99	0.38	2.60	4.5	5.60	0.80
Nov.	1.20	0.40	3.0	21.5	17.5	1.22
Dec.	1.19	0.83	1.43	17.5	13.5	1.29
Jan '99	1.52	1.96	0.77	18.6	13.8	1.34
Feb.	2.08	1.03	2.01	18.3	13.8	1.32
Mar.	1.38	0.64	2.15	19.3	11.7	1.64
Apr.	2.16	1.12	1.92	20.7	13.3	1.55
May	2.19	1.21	1.80	21.0	14.3	1.46
Jun	3.46	1.62	2.13	24.6	15.3	1.60
Jul.	3.83	1.34	2.85	26.3	19.6	1.34
Aug.	5.41	3.64	1.48	27.4	23.7	1.15
Sep.	6.97	5.29	1.31	28.0	25.3	1.10
S.E	2.19	0.38	-	2.83	2.53	-

n = 13

Table 21 : Monthly variation in Above ground & Below ground biomass (gm) and Vertical & Horizontal root spreading (cm) in *Leucaena leucocephala* in maize agroforestry system of Mizoram.

Month / Year	Above ground biomass (gm)	Below ground biomass (gm)	Ratio A\B biomass	Vertical Root spreading (cm)	Horizontal Root spreading (cm)	Ratio V/H
Sep.'98	0.35	0.26	1.34	14.2	8.7	1.63
Oct.	0.68	0.62	1.09	14.3	9.6	1.48
Nov.	0.48	0.35	1.37	14.8	11.1	1.33
Dec.	1.62	0.78	2.07	15.2	11.9	1.27
Jan '99	2.01	0.96	2.09	16.0	13.6	1.17
Feb.	2.50	1.67	1.49	17.6	14.2	1.23
Mar.	2.58	1.69	1.52	19.0	14.3	1.32
Apr.	2.60	1.61	1.61	19.7	14.5	1.35
May	2.86	1.76	1.62	20.2	15.6	1.29
Jun.	5.46	2.28	2.39	20.4	16.0	1.27
Jul.	8.02	3.46	2.31	20.6	18.3	1.12
Aug.	10.42	4.21	2.47	22.7	18.8	1.20
Sep.	12.23	5.38	2.40	23.4	19.2	1.21
S.E	1.03	0.83	-	9.89	0.89	-

n = 13

Table 22 : Monthly variation in Above ground & Below ground biomass (gm) and Vertical & Horizontal root spreading (cm) in *Cajanus cajan* in maize agroforestry system of Mizoram.

Month / Year	Above ground biomass (gm)	Below ground biomass (gm)	Ratio A\B biomass	Vertical Root spreading (cm)	Horizontal Root spreading (cm)	Ratio V/H
Sep.'98	0.55	0.11	5.0	1.6	10.8	0.51
Oct.	0.68	0.23	2.95	6.5	12.0	0.54
Nov.	4.86	1.62	3.0	7.2	14.0	0.51
Dec.	6.19	1.95	3.17	7.5	16.2	0.46
Jan '99	7.87	1.98	3.97	7.8	18.3	0.42
Feb.	12.33	3.61	3.41	8.9	14.3	0.62
Mar.	12.46	6.72	1.85	13.6	15.6	0,87
Apr.	16.22	9.36	1.73	14.4	18.4	0.78
May	29.62	12.42	2.38	15.7	20.3	0.77
Jun.	30.36	14.6	2.09	17.2	20.3	0.84
Jul.	33.61	16.73	2.0	18.2	22.8	0.79
Aug.	38.52	18.24	2.11	20.0	24.6	0.81
Sep.	47.28	25.0	1.89	22.6	25.6	0.88
S.E	4.13	2.15	-	1.53	1.24	-

n = 13

length. In *C.cajan*, the horizontal root length was more than the vertical root length. The vertical spreading of the root was recorded maximum under *T.ciliata* followed by *M.champaca, T.ciliata* and *L.leucocephala.*

There was a positive correlation between above ground and below ground biomass as (r=0.93-*Michelia champaca*, 0.92-*Toona ciliata*, 064-*Leucaena leucocephala* and *Cajanus cajan).* Similarly, lateral spreading and vertical root were also correlated positively. (Table 23).

MEAN YIELD OF MAIZE

The yield of maize (Kg/ha) under *Toona ciliata* fertilized plot differs significantly ($P<0.50$) from the non-fertilized plot. (Table 24) The yield of maize was much higher under the fertilized plots than those under the non-fertilized plots. The highest maize yield was obtained from *T.ciliata*+ *L.leucocephala* fertilized plot, followed by *T.ciliata* + *C.cajan* fertilized plot. The maize yield was lowest under the control plot. (*T.ciliata* control)

The same trend was also followed on the maize yield under *M.champaca* plot. A significant difference ($P<0.05$) in the yield was also observed between the fertilized and the non-fertilized plot. The highest maize yield was observed under *M.chapaca* + *L.leucocephala* fertilized plot, followed by *M.champaca* + *C.cajan* fertilized plot. The control *M.champaca* plot gave the lowest yield, the next being *M.champaca* + *C.cajan* non-fertilized plot.

The maize yield values were always higher under *M.champaca* plots than those under *T.ciliata.* (Table 25).

Table 23 : Correlation coefficient (r) between Below ground - Above ground biomass and Vertical and horizontal spreading of roots of few species in maize agroforestry system of Mizoram.

Factors	*Toona ciliata*	*Michelia champaca*	*Leucaena leucocephala*	*Cajanus cajan*
A/B Biomass	0.92	0.93	0.64	0.98
Vs/Ls	0.79	0.90	0.81	0.65

A/B Biomass - Above / Below ground biomass

Vs/Ls - Vertical spreading / Lateral spreading

Table 24 : Mean yield of maize (Kg/ha) under each treatment combination of *Toona ciliata* in Mizoram.

TREATMENT	MEAN YIELD OF MAIZE (KG/HA)
Without fertilizer treatment :	513
T.*ciliata* + *Leucaena*	343
T.*ciliata* (control)	426
T.*ciliata* + C.*cajan*	
With fertilizer treatment (NPK) :	
T.*ciliata* + *Leucaena*	796
T.*ciliata* + C.*cajan*	696
CD at 5%.	0.30

Table 25 : Mean yield of maize (Kg/ha) under each treatment combination of *Michelia champaca* in Mizoram.

TREATMENT	MEAN YIELD OF MAIZE (KG/HA)
Without fertilizer treatment :	
M.champaca + *Leucaena*	650
M.champaca (control)	353
M.champaca + *C.cajan*	500
With fertilizer treatment (N,P,K) :	
M.champaca + *Leucaena*	993
M.champaca + *C.cajan*	796
CD at 5%	0.90

CHAPTER - V

DISCUSSION

GROWTH BEHAVIOUR OF *TOONA CILIATA*

The climate of the study site played a significant role in the growth of the different parameters (height, collar thickness, number of leaves and branches) of *Toona ciliata* (under control condition). The variation in the growth in height, collar thickness, number of leaves and branches were slower till March and started rising up after March. The temperature was low during November to February (Fig. 2) hindering the growth of the species. However, right from March onward, since there was an increase in temperature the species attained better growth in most of its growth attributes. (Table 1). The rainfall pattern also could have influenced such a trend in the growth attributes. As can be seen from the rainfall pattern (Fig 2), the rainfall was negligible during November to February, whereas in other months, shower was relatively higher. Rainfall increase the soil moisture content and favoured the growth. Further the slower rate of growth of various growth parameters during the first few months could be due to the fact that the species was not able to establish properly in uptaking various natural resources required by it for the growth purposes. However after March/April, the plant was able to utilise the resource due to the higher attainment of these parameters coupled with a favourable temperature and moisture or rainfall of the site.

This assumptions also remain valid for the similar growth pattern of *Toona ciliata* along with *Leucaena leucocephala* (Table 2). and *T.ciliata* with *Cajanus cajan* (Table 3).

The variation in the growth attributes of *Toona ciliata* can be related to species specific compatibility. The higher species growth in height

under *Leucacena* hedge (*Toona + Leucaena)* could be due to the higher release of nitrogenous nutrients by the legume. *Leucaena* has been reported to release / fix N. at the rate of 100 - 500 kg ha^{-1} yr^{-1} where properly established (Kumar *et al*, 1992). The slower growth in the height under control conditions obviously was due to less availability of nutrients to the plants. The other growth attributes (collar diameter, number of leaves and branches) were also higher under *Leucaena(Toona + Leucaena)* than under *Cajanus cajan* (*Toona + C.cajan*) and control condition. This could also be due to the increase rate of release of nutrients by *Leucaena* than *C.cajan.*

Kumar *et al* (1996) also reported that the intercropping of *Leucaena* promoted height and diameter growth of teak and the total nitrogen of the soil increased with increasing proportion of *Leucaena* in the mixture.

GROWTH BEHAVIOUR OF *MICHELIA CHAMPACA*

The prevailing climatic conditions during the study period were important determinants in shaping the growth pattern of *Michelia champaca.* The slower growth rate during the initial few months was due to the unfavourable temperature during these months. As the temperature increased from March, the growth rate in all the parameters also increased indicating that temperature plays a vital role in growth. The rainfall pattern could also have influenced the growth pattern of the species. The rainfall was very low in the first few months (till April) and after which it increased. An increase in rainfall favoured the growth of the species, this indicating its importance for the growth. The slower growth rate in the initial months could also be attributed to its improper establishment. The slower growth rate in the number

of branches in *M.champaca* as compared to *T.ciliata* could be due to the slow growth characteristics of the former than the latter.

The differential growth behaviour of *M.champaca* under differently hedged cropping systems obviously was related to its compatibility. The higher growth in height under *C.cajan* hedge (*M.champaca* + *C.cajan*) than under *Leucaena* (*M.champaca* + *L.leucocephala*) indicated that the species is better compatible with *C.cajan* . The cultivation of *C.cajan* increases total phosphorus availability (Jha *et al*, 1998) and could have positively benefited the growth of *M.champaca. C.cajan* being an actively fixing legume should also supply nitrogen and this could have ameliorative benefits on the chemical properties of the soil. (Singh *et al*, 1987). Obviously, the slower growth in height of this species under control was due to the less availability of nutrient to it from the soil. The higher values in the other growth parameters under *C.cajan (M.champaca* + *C.cajan)* and control condition were related to greater compatibility between the species and the beneficial nutrients released by *C.cajan*. Our assumptions find support from Natarajan *et al* (1991) who have reported that *C.cajan* is the most promising in increasing the grain yield when intercropped with maize and sunflower.

GROWTH BEHAVIOUR OF *LEUCAENA LEUCOCEPHALA*

The trend in the growth pattern of *L.leucocephala* was similar with those of *Toona ciliata* and *Michelia champaca* (Table 7-8). The prevailing climatic conditions (both temperature and rainfall) can be related to it. As has already been discussed, lower rainfall during November - February affected its growth in height as well as the other parameters due to greater

extent. However with the onset of suitable temperature form March / April, better growth in most of its growth attributes was attained. Similarly, rainfall variation on the site was related to the growth of the species. As in *T.ciliata and M.champaca,* the slower growth rate in the initial months could also be attributed to the failure of the species in establishing itself properly. As a result, the plant could not take up the soil nutrients properly which could have benefited its growth.

The variation in the growth behaviour of *Leucaena* with different tree species can also be rightly attributed to the compatibility in the tree-crop combination. The higher growth in height under *Leucaena* + *Toona ciliata* could be due to the greater compatibility of the species than with *Michelia champaca.* The growth of *T.ciliata* along with *Leucaena* could have enhanced the growth of *Leucaena* rather than hampering it. The other growth attributes were also higher under *Leucaena +T.ciliata* than under *Michelia champaca.* This could be due to the greater compatibility between the two species. The tree- crop compatibility has also been reported by Gupta *et al* (1992) in *Populus deltoides* and *Leucaena leucocephala. Populus* when planted alternately with *Leucaena* increases tree growth and wood production in both the species and have been reported to be desirable combination for agroforestry.

GROWTH BEHAVIOUR OF *CAJANUS CAJAN*

The trend in the growth behaviour of *Cajanus cajan* (Table 9-10) was similar with that of *Leucaena.* The climatic condition (temperature and rainfall) played significant role in influencing the growth pattern of the species.

The compatibility between the species was another prominent factor in the growth variation of *C.cajan* along with different tree species. The higher growth in height as well as in other attributes (collar thickness, number of leaves and branches) under *C.cajan* + *Michelia champaca* than under *C.cajan* + *T.ciliata* could have been due to its greater compatibility with *M.champaca* than with *T.ciliata.*

GROWTH BEHAVIOUR OF *TOONA CILIATA* UNDER FERTILIZED PLOT

The higher values in height as well as other growth parameters of *T.ciliata* under fertilized plot (Table 11 & 12) than their corresponding unfertilized plot could have been due to the supplementation of fertilizers (NPK) in the former than the latter. Kanyama *et al* (1990) have found that the growth performance in canopy height, number of primary branches / plant, stem diameter, leaf and fuelwood dry matter yield of *Sesbania sesban* were significantly ($P<0.05$) enhanced by the application of N and P fertilizers. Koul *et al* (1995) also supported this view. Besides, Gangoo *et al* (1990) also found that the initial growth behaviour of Poplars (*P.deltoides* & *P.niagra*) was greatly influenced by the fertilization of N,P and manure. The addition of fertilizer increased the height and diameter of both the Poplars species without affecting their root-shoot ratio.

GROWTH BEHAVIOUR OF *MICHELIA CHAMPACA* UNDER FERTILIZED PLOT

The higher values in height as well as other parameters of *M.champaca* under fertilized plot than the corresponding control plot could

be related to the supplementation of fertilizers in the former. Prasad *et al* (1991) reported the response of N,P and K by *Acacia nilotica* seedlings. According to them, the combined application of N,P,K increased the growth, yield and fertilizer use efficiency of the seedling Singh *et al* (1994) also found that the application of N,P,K and mulch were helpful in boosting the plant growth and lowering the mortality in *Pinus roxburghii* transplant.

GROWTH BEHAVIOUR OF *LEUCAENA LEUCOCEPHALA* UNDER FERTILIZED PLOT

The higher increase in the height and other growth parameters such as collar thickness, number of leaves and branches in *Leucaena* under fertilized plots than their corresponding control plot could have been due to the supplementation of fertilizers (N,P,K) in the plot. The effect of fertilizer (N,P,K) on the growth behaviour of *Eucalyptus tereticornis* and *E.camaldusensis* have also been found at by Sundararaju *et al* (1989). According to them, N,P,K helped the species in boosting the growth and reducing the nursery period by about a months **time.**

GROWTH BEHAVIOUR OF *CAJANUS CAJAN* UNDER FERTILIZED PLOT

Supplementation of N,P,K fertilizers was responsible for the higher values in height and other parameters of *C.cajan* under fertilized plot than their corresponding control plot. Rana et al (1995) reported the effect of nitrogen, *Rhizobium,* and phosphorus on root nodulation, dry matter productions and N and P uptake in *Cajanus cajan.* Their findings revealed that N and P fertilization significantly increased the root length and number of nodules. Our results were in accordance with the above investigators.

The response of short duration Pigeon pea (*Cajanus cajan*) to N,P and *Rhizobium* inoculation was also found out Singh et al (1996) who revealed the importance of N and P in increasing both grain and protein yield. Besides, they have depicted the importance of *Rhizobium* inoculation in the dry matter accumulation and nodule count.

SUMMARY

The study on the growth behaviour of *Michelia champaca* and *Toona ciliata* along with green hedges of *Cajanus cajan* and *Leucaena leucocephala* was carried out at Lawibual, a small valley about 1 km, East of Aizawl, the capital city of Mizoram. The study was conducted from September '98 to September '99. The area of the study site was approximately 4000sq.ft. and was moderately sloped. The experiment was laid out following Randomized Block Design (RBD) with five (5) sub plots each for the tree species. A spacing of 2.5 metre plant to plant and 3 metre row to row was kept for both the species and 3metre spacing between the two different species to nullify the boarder effects. Green hedges *Leucaena leucocephala* (Subabool) and *Cajanus cajan* (Pigeon pea) were introduced along with the main tree species i.e. *M.champaca* and *T.ciliata*. An agricultural crop *Zea mays* (maize) was also introduced in the interspace between the rows of the tree species. at the spacing of 60 x 30cm and 65 cm away from the tree species. The various growth attributed such as collar thickness, height, number of branches leaves and number of branches were recorded at a monthly interval. From the harvestable plot, each of the four species was also harvested monthly for determining the biomass (fresh weight and dry weight). The mean yield of maize was recorded at the harvest. The data obtained were subjected to ANOVA (Analysis of variance) to see the effect of the month on the growth behaviour of various tree species on a particular treatment. Students T-test was made to compare the variation in growth parameters between the plant species under both fertilized and non-fertilized plots. The data on the maize yield were also subjected to ANOVA to see the effect of fertilizer on the yield of the maize. The biomass (above & below ground) yield and the vertical and horizontal spreading of the four species were correlated to find the relationship between the factors.

The major findings of the present investigation were as follows :

(1) The growth behaviour of the four studied species significantly varied ($P<0.05$) over a month.

(2) The growth behaviour of the different four species greatly differs with one another with *C.cajan* reaching as high as 151cm and *M.champaca* as low as 31.4cm.

(3) The growth rate of the species tree species viz *Michelia champaca* and *Toona ciliata* behaves differently under the different combinations of hedges viz. *Leucaena leucocephala* and *Cajanus cajan.*

(4) The values in height as well as other attributes of *T.ciliata* were higher under *L.leucocephala (T.ciliata + L.leucocephala)* than under *C.cajan (T.ciliata +C.cajan).* But the growth values of *M.champaca* were higher under *C.cajan (M.champaca + C.cajan)* than under *L.leucocephala (M.champaca + L.leucocephala).*

(5) Fertilizer (N,P,K) have a great influence on the growth of the species. The growth in height, collar diameter, number of leaves and branches of all the four species were significantly ($P<0.05$) higher under the fertilized plot than the non-fertilized plot.

(6) The biomass (above and below ground) yield and the vertical and horizontal root spreading of all the four species viz, *M.champaca, T.ciliata, L.leucocephala* and *C.cajan* increased with the increase in time.

(7) There was a positive correlation between the above and below ground biomass, and vertical and lateral spreading of roots in all the four species.

(8) The mean yield of maize (kg/ha) grown in the interspace of the species significantly ($P<0.05$) differs under each treatment combination of *T.ciliata* and *M.champaca*.

(9) The maize yield were significantly ($P<0.05$) higher under the fertilized plot than the non-fertilized plot in both the tree species .

(10) The mean yield of maize (kg/ha) were higher under *M.champaca* plots than those under *T.ciliata* plots.

From the present investigation, it is depicted that *L.leucocephala* is a better hedge than *C.cajan* Similarly, *M.champaca* was found that better than *T.ciliata* from agroforestry view point. However, since the study period was only for a very short duration it is premature to draw such conclusions on the species investigated. Further studies are necessary to find out best tree hedge-field crop combination which in turn would enable the system to produce a sustainable agronomic yield.

CONCLUSION

From our present investigation it has been found out that the compatibility of species plays an influential role in regulating the growth of the species. The rate of growth in the two tree species viz *Michelia champaca* and *Toona ciliata* were greatly affected by the presence of green hedges viz *Leucaena leucocephala* and *Cajanus cajan.* The values were much higher under the green hedges than under the control plot. (without hedges). The growth rate of *Michelia champaca* was higher under ***C.cajan*** hedge *(M.champaca + C.cajan)* than under *Leucaena* hedge *(M.champaca + L.leucocephala)* and the control plots. The growth rate of *Toona ciliata* was also significantly affected by *Leucaena* hedge. The growth rate in height, collar thickness, number of leaves and branches were higher under *Leucaena* hedge *(T.ciliata + L.leucocephala)* than under *C.cajan (T.ciliata + C.cajan).* Similar trend were also observed in the growth behaviour of the green hedges. The growth in height as well as all the other parameters of *L.leucocephala* were higher when grown along with *T.ciliata* than with *M.champaca.* The growth rate of *C.cajan* was also higher along with *M.champaca* than with *T.ciliata.* This could mean that the compatibility of the species significantly affect the growth behaviour of the species. The findings revealed that *M.champaca* forms a desirable combination just as *T.ciliata* thrives well with *L.leucocephala* in terms of growth in height as well as other attributes. However, the yield of maize (Kg/ha) was significantly higher under *M.champaca + L.leucocephala* plot than under *T.ciliata.* This could be due to the superficial root character of the species which cause detrimental effect on the yield of the maize. Therefore *M.champaca + L.leucocephala* forms a desirable combination in terms of crop production in an agroforestry system of Mizoram.

The application of fertilizers (N,P,K) have a significant effect on the growth of the species. The values in height as well as the other parameters

were significantly higher under the fertilized plot than under the control plot. Supplementation of fertilizers also greatly affect the yield of the maize. The yield of the maize was significantly higher ($P<0.05$) under the fertilized plots than those under the non-fertilized plots.

Toona ciliata and *Michelia champaca* are two of the most important multipurpose trees of Mizoram. (Lalramnghinglova, 1998). They have a great potential in meeting various requirements. But due to the illicitly felling of these trees in large numbers in the past few years for the extraction of timber, fuelwood, foliages etc, they are now slowly disappearing from our forests. Besides a large tract of these trees have been deforested as a result of shifting cultivation. Besides meeting various important requirements, these MPTs, are also of great potential in the reclamation of degraded lands and also have a high medicinal values (Gurdev Chand and Bhardwaj, 1996). Therefore in order to fulfill all these requirements it is recommended to introduce these two MPTs in an agroforestry system of Mizoram and under Social forestry programmes. This will solve the problem of reclamation of degraded lands besides fulfilling the requirement of timber, foliages, fuelwood, medicines and other various purposes. The introduction of hedges *(L.leucocephala* and *C.cajan)* greatly influence the growth of the species and therefore, hedging with these tree species is highly recommended.

The importance of these two MPTs in the present study is highly felt. In view of the limited studies on these species Mizoram as well as other places and their beneficial effects in increasing crop productivity in our study, a greater emphasis is necessary on these species as integrated agroforestry component. Since our present investigation was time bound, it could not throw

enough light on the various important aspects of these species. Therefore further studies are required in a greater details not only on the growth behaviour of these species but also a various other aspects such as the nutrient requirements, crop management etc. to draw suitable conclusion and for recommending these species for sustainable crop yield in the agroforestry system of Mizoram.

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