

**EFFECT OF VARIOUS SPACINGS ON THE GROWTH BEHAVIOUR
OF TUNG (*Aleurites fordii*. Hemsl.) AND THE YIELD OF SOYBEAN
(*Glycine max* L. merr) UNDER AGRO - FORESTRY SYSTEM OF
MIZORAM.**

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**THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE
DEGREE OF MASTER OF SCIENCE IN FORESTRY
(SPECIALIZATION IN AGROFORESTRY)**



**DEPARTMENT OF FORESTRY
SCHOOL OF LIFE SCIENCES
NORTH EASTERN HILL UNIVERSITY
MIZORAM CAMPUS, AIZAWL, INDIA
2001.**

*Dedicated with love and affection
to my Father, J.P. Lalchhuanga (L)*

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CERTIFICATE

I certify that the Thesis entitled " Effect of various spacings on the growth behaviour of Tung(Aleurites fordii. Hemsl.) and the yield of Soybean (Glycine max L. merr.) under agroforestry system of Mizoram ". Submitted by Mr. Israel Lalremruata in partial fulfilment for the Degree of Master of Science in forestry (Specialization course in Agroforestry) to the North Eastern Hill University, Shillong embodies the record of original investigation carried out by him under my supervision. He has been duly registered and has successfully completed all his papers. The Thesis presented is worthy of being considered for the award of the M.Sc. Degree. Further, this work has not been submitted for any degree of any other University nor has it been published in part or full.

I wish Mr. Israel Lalremruata all success in life.

Aizawl
The ...19/12/01.....


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ACKNOWLEDGEMENT

I take this opportunity to express my most sincerest and wholehearted sense of gratitude to my Adviser, Dr. Rakesh Mohan, Reader, Department of Forestry, North Eastern Hill University (NEHU) for his constant guidance during the entire course of this investigation and preparation of the thesis.

I am also highly grateful to Prof. L.K. Jha (Head of Department), Dr. U.K. Sahoo and Dr. D. Paul for their valuable advice and untiring services rendered.

My profound thanks are due to my sister, Mrs. Zothanmawii Pachuau and CITECH, for typing this manuscript neatly.

I express my deep sense of appreciation to Pradeep Chhetri, who helped me in the preparation of map and graphs.

Words fail to express my deep sense of indebtedness to my colleagues, Mr. Charseng Ch. Marak, Miss Julie Zodinpuui, Miss Zohmingliani, Miss Rebecca Lalmuanpuui and Miss Phindarilin Kharmujai for their help and co-operation during the entire course of this investigation.

I am highly obliged to the members of my family, for their good wishes and wholehearted support during the period of my study.

Above all, I thanked the ALMIGHTY GOD for giving me health and opportunity in completing the Course.

Aizawl
The ...!9th Dec. 2001


19/12/07
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CHAPTER - I

INTRODUCTION

1. INTRODUCTION

Agroforestry is an ancient land use practice of growing trees in association with crop for meeting some of the household needs. Growing of the shade and food trees near settlements were recognized by the presence of tree-grooves. Forest and Agriculture have always been conceived as diagonally opposite propositions but rapid decrease in first cover coupled with increasing food, fuel and fodder demands of growing population has necessitated bringing these two identities nearer. Agroforestry promises to help farmers in increasing profitability, productivity and sustainability of production on their land.

According to Rao (1989) Agroforestry can be defined as, “The deliberate introduction of woody perennial, on the same unit of land as agricultural crops and or animal, either in some form of spatial mixture or temporal sequence and there must be a significant interaction (positive and or negative) between the woody and non-woody components of the system, either ecological and or economical.”

Lundgreen and Raintree (1983) defined Agroforestry as “A collective name for land use systems and technology where woody perennials (trees, shrubs, bamboo, palms, etc) are deliberately used on the same land management unit as agriculture crops and /or animal, either on the same form of spatial arrangement or on ecological sequences”

Recently, ICAR (Annual report 1999-2000) has mentioned that, “Agroforestry is the science of designing and developing integrated self-sustainable land management system including introduction or

retention of woody components including trees, shrubs, bamboos, canes, palms, along with agriculture crops including pastures/animals simultaneously or consequential on the same unit of land and at the same time to meet the ecological as well as socio-economic needs of the people”

Forest constitutes the basic life support system and plays an important role in the socio-economic development of the society. In India, particularly the North-Eastern State forest resources have been destroyed through the age old practice of shifting cultivation locally known as Jhum by the tribals. Shifting cultivation is one of the most ancient system of farming believed to have originated in the Neolithic period around 7000 B.C (Borthakur, 1992). It is also alternatively called as the slash and burn method of cultivation. The system is regarded as the first step in transition from food gathering and hunting to food production. Yet this most primitive system of farming is still in vogue in the North East India. In the days when this system of food production emerged, it looked well and there was a balance between population and soil fertility as a result of larger fallow cycle of 20 to 30 years. The cycle at present reduced to 3 to 6 years due to population pressure and reduced acreage of available land (Borthakur *et al.*, 1983)

According to Task Force Report on Shifting Cultivation in India, Ministry of Agriculture, 1983, the area affected due to shifting cultivation is 4.37 million ha. However, the National Remote sensing Agency has estimated an area of 4.24 million ha. under shifting cultivation including forest blanks (Anonymous, 1986). The system at present has become not only unproductive but hazardous to the

environment. The deleterious effect of the system which involves forest cutting, burning, clearing and dibbling of seeds can be discernible from the fact that it accounts for nearly 3.7 tonnes/ha. of soil material to slide/roll down to foot hills annually (Singh, 1978). Estimates reveal that nearly 181 million tonnes of soil is lost annually as a result of shifting cultivation in North Eastern Hill region (Prasad *et al.*, 1981). Soil erosion from hill slopes (60-70%) under first year, second year and third year (abandoned jhum / shifting) was reported to be 146.6, 170.2 and 30.2 tonnes /ha/year, respectively (Singh and Singh, 1978). Exposure of rocks due to soil erosion, heavy silt load of riverbeds and drying of perennial water resources from the areas of shifting cultivation are other evil effects as reported by Goswami (1968)

In Mizoram, 7,889 sq.km of the total geographical area is under reserve forest. The practice of jhuming which is still in vogue is quite common in Mizoram but is becoming less sustainable as cultivation cycles are shortened due to population pressures. A reduction in the length of jhum cycles has a number of adverse environmental consequences. About 71.15% of the working population are involved in shifting cultivation (Statistical Abstract, Department of Agriculture and Minor Irrigation, Mizoram 1997 – 1998). As shifting cultivation is the major mode of farming of the majority of the population, the land could hardly sustained productivity causing enormous social cost in the form of loss of soil nutrients and forest level coupled with reduction in jhum cycle. Thus, the jhum system of farming on hill slopes without any soil and water conservation measures fails to meet the minimum food requirement of the people of the state (Singh and Prasad, 1980).

In the year 1990, Government of Mizoram has initiated an innovative policy known as “New Land Use Policy” (NLUP) for the control of shifting cultivation in the state. Under the programme of NLUP, different trades such as agriculture and allied sectors, industries and A.H. and Vety were included. Under agriculture and allied sectors, the people of Mizoram have taken up plantation of different M.P.T.s viz; Teak (*Tectona grandis*), Tung (*Aleurites fordii*) and horticultural crops in a massive scale. Intercropping of paddy (*Oryza sativa*) and Teak (*Tectona grandis*) is one of the most common practice of agroforestry system in the state (Lalramnghinglova and Jha, 1996). However, these systems which lack scientific approach need to be improved through research. This would help create awareness specially to the farmers living in remote areas so as to achieve full potential of different agroforestry system.

1.1 TUNG (*Aleurites fordii*), Family – *Euphorbiaceae*

Tung tree is also known as ‘Tung nut’, ‘Tung oil’ or ‘China wood oil tree’ (Fair child 1913). The word ‘Tung’ is Chinese for ‘Heart’, the general shape of the leaf (Potter and Crane, 1957). It is native central and Western China, where seedlings have been planted for thousand of years. It is also planted in southern United States from Florida to Eastern Texas.

In Mizoram, Tung was introduced right from chieftanship in Mizo villages. The first matured trees of Tung were available during 1940’s at North Chaltlang. Intercropping of paddy (*Oryza sativa*) and Teak (*Tectona grandis*) is the usual practice. Recently, few processing units have come up in Mizoram, where people could market the seeds at

Rs. 7/- to 10/- per Kg. (clean seed). Due to this marketing facilities, the villages has taken up Tung plantation in a larger scale. During 1998, the Tung grower's association crushed 16 MT of oil (Anonymous,1997)

Aleurites fordii, Hemsl, (Tung oil tree) is one of the most important species that yields Tung oil commonly known as 'China wood oil of commerce. It is a soft wooded, smooth-barked deciduous tree that may grow to 30 feet. Tung tree is not a tall tree, height of the tree ranges from 15 to 30 feet or may be less with more or less equal distribution of the crown. However in China, they may even be smaller. They may grow upto 20 to 25 feet in height usually about 10 inches in diameter at breast height. In some areas or localities, the trees may grow taller as much as 50 to 60 feet with a crown of 60 feet in diameter (Jordan, 1930). Generally, Tung tree have low branching habit and has a much branched spread of the crown. Leaves of Tung tree are dark green, up to 15 cm wide, heart shaped, sometimes lobed, appearing usually just after or sometimes before flowering.

First blooms appear from late February to April before the leaves appear. In bloom, the tree is highly attractive because of its mass of pink blossoms similar to flower of (*catalpa spp*) followed by the dense foliage of 3 to 5 inch heart-shaped dark green leaves. The attractive and colourful blossoms, which are borne on the ends of the growing shoots to the previous season, vary in type. They may be all staminate, all pistillate, or predominantly one or the other (Dickey and Reuther, 1940, Mc Cann, 1942) The percentage of pistillate flowers may depend on the vigour of the tree, with more such flowers produced on trees making more vigorous growth (Abbott 1929). The reddish white flowers occur in

panicled cymes or clusters with usually about 60 staminate and one pistillate flower each, with rarely a perfect flower (Newell, 1924). Each flower may be an inch or more in length, and the tree is covered with the canopy of blossoms. The pistillate flowers have a 3 to 5 –celled ovary that, when pollinated, produces a top-shaped fruit 2 to 3 inches in diameter, usually bearing five seeds. Flowers are usually in cluster, whitish, rosethroated, produced in early spring from terminal buds of shoots of the previous season; monoecious, male and female flowers surrounded by several staminate flowers. The blossoms flower secrete some nectar, and the staminate flowers produce a copious amount of pollen (Pering, 1937) and the blossoms are freely visited by bees.

The fruits of Tung tree are spherical, pear shaped or top shaped, green to purple at maturity, with 4-5 carpets each with one seed; seeds usually 4-5, but may vary from 1 to 15, 2-3.2 cm long, 1.3-2.5 cm wide, consisting of a hard outer shell and a kernel from which the oil is obtained. Flowering starts from February-March and fruiting starts from late September to early November. It contains 14-20% Kernel 53-60% nut, 30-40% oil. It also contains 75-80% elaeo stearic, 15% oleic, Ca 4% palmitic, and Ca 1% stearic acids. Tannins phytosterols, and a poisonous saponin are also reported (List and Horhammer , 1969-1979).

Tung tree is best suited to a temperature ranging from sub-tropical dry to moist through tropical very dry to dry forest life zones, and is reported to tolerate annual precipitation of 6.4-17.3 cm and temperature of 18.7-26.2°C with a pH of 5.4-7.1 (Duke, 1978,1979). Tung trees requires a concentrated climate and soil requirements. They require long hot summers with abundant moisture, with usually of at least 112cm of

rainfall which is evenly distributed throughout the year. Trees require 350-400 hours in winter with temperatures 7.2°C or lower; without this cold requirement, trees tend to produce suckers from the main branches. Trees are susceptible of cold injury when in active growth. Production of Tung is best where day and night temperatures are uniformly warm. Much variation reduces tree growth and fruit size. Trees grow best if planted on hill tops or slopes, as good air- drainage reduces losses from spring frosts. Contour planting on rolling land escapes frost damage and makes its growth best on virgin land.

Tung tree requires well-drained, deep aerated soils with high moisture holding capacity to be easily penetrated by the roots. Green manure crops and fertilizer may be needed. Dolomitic lime may be used to correct excessive acidity. Soil having a pH of 6.0-6.5 is best for Tung tree and also liming is beneficial to most soils in the Tung belt where more acid soils requiring greater amounts of lime.

Tung trees are generally propagated by seed or by budding. Seedlings generally vary considerably from parent plants in growth and fruiting characters. Seedlings having self-pollinated for many generations have rather uniform plants. Budded trees, genetically identical with mother tree will supply adequate amount of seed for planting. The most appropriate time for budding is during the month of late August by simple shield method. Usually seedling trees out grow budded trees, but budded trees produce larger crops and are more uniform in production, oil content and date of fruit maturity. Tung seed are normally short lived and must be planted during the season following harvest. Hulls, retard germination and so seeds should be hulled before planting. Hulled seed may be

planted dry, but soaking in water for 5-7 days hastens germination. Stratification cold treatment or chemical treatment of seeds brings about more rapid and uniform germination. Sowing of seed should be done in the month of February and March. Spacing of seed may be maintained at 15-20 cm. apart, about 5 cm deep and 1.6 metre row to row distance is found beneficial.

Angelo *et al.* (1942) showed that plants caged to exclude bees set no fruit and that wind or shaking the tree was of no value in fruit setting. But when a tree was caged with a colony of honey bees a good set was obtained. Others (Hambleton 1950, Pering 1937) also credit honey bees with setting the crop. The tree is not self sterile. It merely needs the agency to transfer the sticky pollen from the anthers of the staminate flowers to the stigma of the pistillate flower. Brown and Fisher (1941) showed that pollination can occur over several days of the life of the blossom. Webster (1943) concluded that when staminate and pistillate flowers are on separate trees, one staminate tree for 20 pistillate trees was sufficient for satisfactory pollination, provided that some staminate flowers open by the time the pistillate flowers are receptive.

Tung trees usually begin bearing fruit third year after planting, and are usually in commercial production by the fourth or fifth year, attaining maximum production in 10-12 years. Average life of trees in United States is 30 years. Fruits mature and drop to ground in late September to early November. At this time they contain about 60% moisture. Fruits must be dried to 15% moisture before processing. Fruits should be left on ground 3-4 weeks until hulls are dead and dry, and the moisture content has dropped below 30%. Fruits are gathered by hand

and put in baskets or sacks. Fruits do not deteriorate on ground until they germinate in spring.

Tung trees yield about 4.5 - 5 MT/ha fruits. An average picker can gather 60-80 baskets of fruits per day, depending on the condition of the orchard. Fruits may be gathered during winter season when other crops do not need care, since all fruits do not fall at the same time. It is advisable to have 2 or more harvestings in order to get maximum yield. Fruits are usually sacked, placed in crotch of tree and allowed to dry for 2 - 3 weeks before delivery to the mill.

Tung trees are cultivated for their seeds, the endosperm of which supplies a superior quick-drying oil utilized in the manufacture of lacquers, varnishes, paints, linoleum, oil cloth, resins, artificial leather, felt base floor coverings and greases, brake linings and in cleaning and polishing compounds. Tung oil products are also used for coating containers for food, beverages and medicines; for insulating wires and other metallic surfaces, as in Radios, Radar, Telephone and Telegraph instruments (James, 1983).

Tung oil is also used as an ingredient for water-proofing masonry for protective coating, enamels and electrical insulators. It is also extensively used in the treatment of Aeroplane fabrics (Bunting, 1931) and is used as one of the ingredients in leather dressing and in manufacture of soap (Newell *et al.*, 1935).

1.2. SOYBEAN (*Glycine max* L. merril.) Family-Leguminosae

Soybeans are reported to have originated in Eastern Asia or China. The wild form, a slender twining Vine, *Glycine ussuriensis* considered to be the progenitor of *Glycine max* occurs in China, Manchuria and Korea. The first written record of the plant is contained in an ancient Chinese book “Pen Ts’ao Kung Mu (Materia Medica)” which is about 5000 years old. Soybean grain was reported to be one of five sacred grains of China. Soybean has been known to man for over 5000 years.

Although there is no available record as to when Soybean was introduced into India, it has been traditionally grown in the northern hills and several other scattered pockets in the country for many centuries and has become an essential part of the daily diet in these regions.

In Mizoram, eventhough Soybean is an oilseed crop it is cultivated as one of the pulses. It is normally consumed as daily food after fermenting it. On some occasions it is boiled and the gravy is taken as a beverage for tonic. Sometimes it is fed to the poultry birds after crushing into pieces. In the villages the utility of Soybean towards fertilization of soil is less non. Soybean is a promising crop as it grows in every types of soil on the hill slope.

Soybean is an erect, and bushy annual Plants. The plant varies from 0.5 to 2.0 metres in height. The branches may be spreading or ascending, short or elongated depending on cultivar and growing conditions. Being a leguminous crop, soybean was considered to be a

pulse crop but due to high oil content and greater response to applied nitrogen levels it has now been placed in oilseeds category.

The root system of the soybean consists of a tap root, a large number of secondary roots and much branched adventitious roots. The extent of the root system varies considerable under different cultural conditions. However, most of the root system present in the upper 15 centimetres of soil where they remain functional in absorption and support throughout the life of the plant. Nodules are visible about 10 days after sowing and nodules are initiated in the soybean roots by *Rhizobium Japonicum*.

The leaves of soybean are ovate and lanceolate in shape. Flowers are borne on short axillary or terminal racemes and there are annually 8 to 16 flowers in a cluster. Flowers are completely normally self pollinated and completely self fertile. Seeds vary in shape from nearly spherical to somewhat flattened dark brown. The seed coat is marked with a hilum or seed scar that varies in shape from linear to Oval.

Soybean grows well in warm and moist climate. The climatic requirement for soybean are almost the same as for maize. A temperature of 26.5° to 30°c appears to be the optimum for most of the varieties. Soil temperature of 15.5°c or above favour rapid germination and vigorous seedling growth. The minimum temperature for effective growth is about 10°c. A lower temperature tends to delay the flowering. Day length is the key factor in most of the soybean varieties as they are short day plant and are sensitive to photoperiods. Most of the varieties will flower and mature quickly if grown under condition where the day

length is less than 14 hours provided that temperatures are also favourable.

Well drained and fertile loam soil with a pH between 6.0 and 7.5 are most suitable for the cultivation of soybean. Sodic and saline soils inhibit germination of seeds. In acidic soils liming has to be done to raise the pH to about seven. Water logging is injurious to the crop. The seedbed should be well pulverized, free from clods and perennial weeds, well levelled and should have sufficient moisture.

Soybean is mainly a kharif season crop but it may be grown during spring season, thus its sowing is done in June/July as kharif crop, February/March as spring crop on plains and in May/June on hills. The spring planting is common in southern states. The crop is sown either as a pure crop or grown mixed with other crops like red-gram, jowar, bajra, cotton etc. Line sowing should be preferred over broadcasting and a row spacing of 45-60 cm during kharif season, 30-40 cm during spring season and 30-35 cm on hills should be given.

When soybean plants mature they start dropping their leaves. The maturity period ranges from 90 to 140 days depending on the varieties. When the plants reach maturity, the leaves turn yellow and drop and Soybean pods dry out quickly. There is a rapid loss of moisture from the seed. At harvest the moisture content of the seeds should be 15 percent.

Harvesting can be done by hand, breaking the stalkes on the ground level or with sickle. Threshing can be done either with the

mechanical soybean thresher or some conventional methods used in other legumes. Threshing should be done carefully and any kind of severe beating or viability. Soybean can also be threshed by wheat thresher after a little modification. This would involve change off sieve reduction of the cylinder speed and increase in fan speed. A moisture content of 13 to 14 percent is ideal for threshing with thresher. By adopting this improved technology, improved varieties of soybean yield 30-35 qtls. of grain per hectare.

1.3. GENERAL OBJECTIVES :

The general objectives of the field experiment was to find out an appropriate viable alternative to shifting cultivation and also to determine the full potential of Tung based agroforestry system.

1.4. SPECIFIC OBJECTIVES :

The proposed study is designed to meet the following Specific objectives :-

- 1) To investigate the effect of various spacings on the growth behaviour of Tung.
- 2) To investigate the effect of various spacings on the growth and yield of soybean.

CHAPTER - II

SITE DESCRIPTION, EXPERIMENTAL DESIGN, LAYOUT AND PARAMETERS

2.1. MIZORAM :

Mizoram is one of the important states among the North Eastern States lying in the most corner of India. The geographical area of the state is 21,087 Sq.km. It is located between 92⁰15' to 93⁰29'E longitude and 21⁰58' to 24⁰ 35' N latitude. (Statistical Hand Book, Government of Mizoram,1994)

Mizoram is bounded by Chin and Arakan hills of Myanmar (Burma) in the east and south, Bangladesh on the west; on the north west by the state of Tripura and on the north by the district of Cachar (Assam).

Mizoram is mostly mountainous and hilly with precipitous slopes forming deep gorges culminating into several streams and rivers. Almost all the hill ranges traverse in the North-South direction. Blue Mountain is the highest Peak at 2360 m whereas the lowest spot is Bairabi at 40 m above the Mean Sea level. The average hill ranges is 920 metre. The width of the valley broadens to the North and South (Regional Remote Sensing Service Centre, ISRO, Dept. of Space, Govt. of India, Dehradun, 1999).

The temperature ranges from 8⁰C to 34⁰C and the annual rainfall ranges from 2,000 mm to 2,500 mm. The climate is characterized by monsoon rains from May to October, winter from first part of December to the end of February and summer without rainfall, except few showers, from first part of March to the end of April. As a whole, Mizoram climate is pleasant and comfortable without chilling during winter and moderately warm during summer.

The vegetation can broadly be classified as tree forests, bamboo forests and abandoned jhums with shrubs. The trees are mostly evergreen except some few species. The traditional method of cultivation is jhumming which is shifting cultivation. Broadly speaking, there are two methods of cultivation, one is jhum on the hill side and another one is permanent wet rice cultivation in the plain areas at the valley bottom. Recently, a new method of contour trench farming system has been introduced by Department of Agriculture (Anonymous, 1995) which has started gaining popularity amongst the hill farmers. The principal crops cultivated in Mizoram are Paddy (*Oryza sativa*), Maize (*Zea mays*), Pulses like Arhar (*Cajanus cajan*), Cowpea (*Vigna sinensis*), Rice bean (*Vigna spp.*), Oil seeds like Soybean (*Glycine max*), Mustard (*Brassica spp.*), French Mustard (*Brassica spp.*), Groundnut (*Arachis hypogea*), Local mustard (*Brassica spp.*) and Sunflower (*Helianthus annuus*) which are recently introduced having a promising oil seed content.

Mizoram soil is mostly acidic, low in organic carbon, low in available phosphate and medium in potash content. The soil is young without very hard rocks and no limestone deposit is available. The quality of sand is also poor. Soils are well-drained, deep to very deep. They are capable of providing substantial oxygen supply for plant growth and have capability to retain moisture and maintain its supply throughout the growing season of most of the crops.

2.2. EXPERIMENTAL SITE :

The field experiment is being conducted at Zemabawk which is about 4 kms. away from the capital of Mizoram, Aizawl. Zemabawk lies in between 92⁰15' to 93⁰29' E Longitude and 21⁰58' to 24⁰35' N Latitude having an altitude of 432 m (3715 ft.) from the mean sea level. It has an average annual rainfall of 235 cm. summer and winter temperature ranges are recorded as 20⁰C - 30⁰C and 11⁰C - 23⁰C respectively. The soil is sandy loam, pH ranges from 5.4 to 5.6 which is slightly acidic in nature. Weed species such as *Impereta cylindrica*, *Drymaria chordata*, *Cyperus rotundus*, *Ageratum conyzoides* etc. are common in the site.

A complete analysis of soil was done in the Department of Forestry NEHU Mizoram Campus laboratory Aizawl as well as in the Soil Testing Laboratory of the Department of Agriculture, Government of Mizoram, Aizawl. Various soil parameters such as soil moisture, nitrogen, phosphorous and potassium, organic carbon content and pH level of the soil were carried out in the Laboratory.

Soil nitrogen was tested by potassium – permanganate method, using Kjeldahl digestion and distillation method. The soil pH was measured by pH meter (Digital pH meter). Phosphorus content was determined by Bray's No.1 Method. Potassium content was observed by Flame photometer using Ammonium Acetate Method (Normal). Organic carbon content is determined by Walkley and Black (1934) Rapid Titration Method.

2.3. EXPERIMENTAL DESIGN AND TREATMENTS :

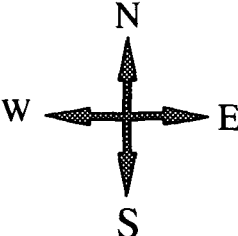
The field experiment was conducted following Randomised Block Design (RBD) with four replications. Tung (*Aleurites fordii*) seedlings having a spacing of 6 m x 6 m, 6 m x 5 m and 5 m x 4 m were planted in the year 1998. the size of each plot measured 12 m x 12 m. The four treatments i.e. A,B,C, and D were allocated in each replications. Altogether, there are 16 numbers of plots as shown in the layout (Fig No.1).

Local variety of Soybean was sown as an intercrop at a spacing of 60 cm x 40 cm over the plantation of Tung trees covering the entire experimental area.

2.4. LAYOUT

FIG. 1. PLAN OF LAYOUT OF THE EXPERIMENT

R ₁	R ₂	R ₃	R ₄
A	D	C	B
B	C	A	D
C	B	D	A
D	A	B	C



DESIGN : Randomised Block (RBD)

TOTAL EXPERIMENTAL AREA : 48 m x 48 m

PLOT SIZE : 12 m x 12 m

NO. OF TREATMENTS : 4

NO. OF REPLICATION : 4

TOTAL NO. OF PLOTS : 4 x 4 = 16

TREATMENTS :

A = Tung (6 m x 6 m) + Soybean (60 cm x 40 cm)

B = Tung (6 m x 5 m) + Soybean (60 cm x 40 cm)

C = Tung (5 m x 4 m) + Soybean (60 cm x 40 cm)

D = Control (Soybean alone) (60 cm x 40 cm)

2.5. PARAMETER COLLECTED :

As the filed experiment was conducted on a 3 years old established Tung plantation, management of the trees were not necessary. However four weedings were done; 1st weeding was done before sowing of Soybean i.e. during August, 2001. The second weeding was done in the month of September 2001 and the other weedings were carried out consecutively before the harvest of Soybean.

2.5.1. PARAMETERS COLLECTED ON GROWTH COMPONENTS OF TUNG :

- a) Tree height in metre (at 45 Days interval)
- b) Basal diameter in centimetre (at 45 Days interval)

2.5.2. PARAMETERS COLLECTED ON SOYBEAN CROP :

- a) Soybean height in centimetre at regular interval (30, 60 days after sowing and at harvest)
- b) Number of leaves at regular interval (30, 60 days after sowing and at harvest)
- c) No. of Pods at harvest
- d) Grain Yield (Kg/plot) after harvest.

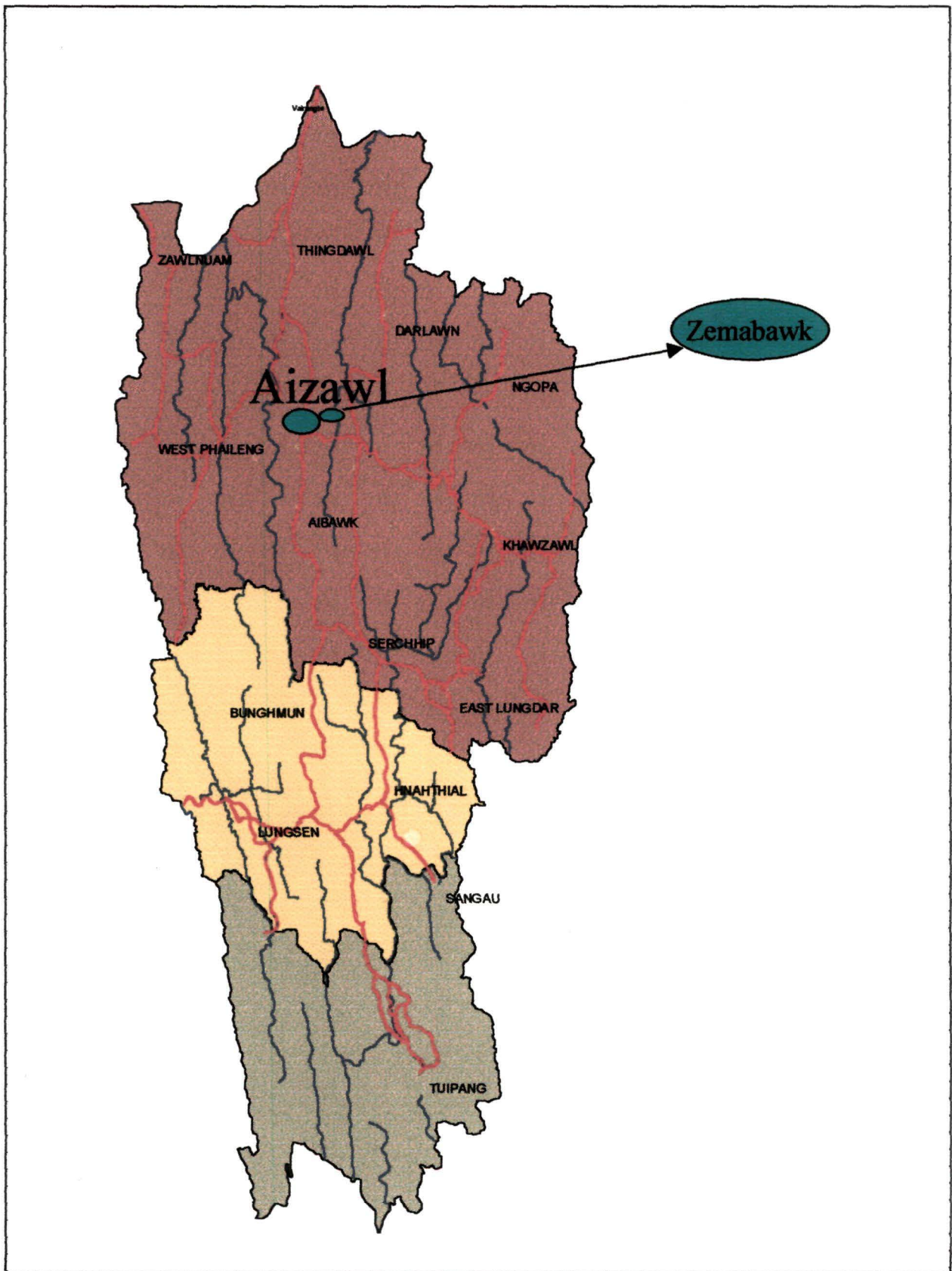
2.5.3. STATISTICAL ANALYSIS :

The different data recorded during the course of study were subjected to ANOVA (Analysis of Variance) to see the effect of month on the growth behaviour of Tung (*Aleurites fordii*) as well as yield of Soybean as effected by various spacings of Tung.

CHAPTER - III

REVIEW OF LITERATURE

Fig. Location Map of Experimental Site.



REVIEW OF LITERATURE

3.1. GENERAL :

Agroforestry is a new name for an old practice, which is now discussed under the head 'Social Forestry' in Indian Forest parlance. Growing trees and crops is not a new invention or concept. This practice in different forms existed in all countries since antiquity. It is gaining adherents among developing countries that are faced with the serious problems of environmental degradation resulting from expansion of intensive crop cultivation into mountain terrain.

Several Workers has defined Agroforestry across the world. An early definition of Agroforestry in seventies considered agroforestry as a sustainable land management system, which increases the yield of the land, combines production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land, and applied management practise that are compatible with cultural practices of the local population (Bene *et al*, 1977 and King and Chandler,1978). Recently, agroforestry is defined as a landuse system that involves deliberate retention, introduction or mixture of trees or other woody perennials in crops/animal production to benefit from the resultant ecological and economic interactions (Nair, 1984).

In other words, Agroforestry is a combination of trees and crops on the same piece of land without effecting each other which would ultimately increase the productivity of the farm. Agroforestry is thus an integrated land use planning system following the principle of generating multiple resources from the same unit of lands (Sinha, 1985).

According to Aiyer (1949), intercultivation of trees species with agricultural crops benefits the farmer in the following ways :-

- a) Additional income
- b) The undercrop and its by-products are extra yield.
- c) Maximum land used.
- d) Greater stability of yield over different seasons.
- e) Better control over weeds, pests and diseases.
- f) Better use of growth resources.
- g) One crop provides physical support to the other crop.
- h) Erosion control through providing continuous leaf cover over the ground surface.
- i) It is the small farmers of limited means who is most likely to be benefitted.

An efficient agroforestry system would aim at systematically developing integrated land use systems and practices where the positive interaction between trees and crops is encouraged and maximized. This seeks to achieve a more productive, sustainable and diversified output from the land than is possible with the conventional mono-cropping system. It is more ecologically more complex than agriculture and forestry practiced separately. This system improves the productivity and maintains the fertility status of soil. Appropriate agroforestry system has the potential to control soil erosion, maintain soil organic matter and physical properties, augment nitrogen fixation and promote efficient nutrient cycling (Young, 1989).

The management of trees and crops in agroforestry system includes all operation that is required to get desired product from the unit

area. The desired product to be produced depends upon the policy and the objective of the management. Decision on policy needs and assessment of available resources, bio-physical causes and need of the factors that influence the growth of the crops along with trees. Knowledge of the above factors enables to choose appropriate Silvicultural and agronomic management techniques to obtain desired produce on a sustainable basis (Jha, 1995).

Agroforestry practices not only conserve the production base of the soil but also tend to improve it. Agroforestry trees, particularly leguminous types, enrich soil through biological nitrogen fixation, addition of organic matter and recycling of nutrients. Agroforestry system help in meeting the requirements of crop plants growing in association with trees, thus reducing need of fertilizer application. Some tree species such as *Leucaena leucocephala* have been reported to fix as much as 400-500 Kg N/ha, which may symbiotically benefit crops growing in its association and improve soil fertility. Primary aim of agroforestry happens to be to provide sufficient fuelwood, thus, diverting 300-400 million tones of cowdung to agricultural uses rather than burning it as fuel. All these factors may lead to the improvement of soil due to adoption of agroforestry systems.

3.2. TUNG AND SOYBEAN IN AGROFORESTRY :

Only few research work have been carried out on Tung based Agroforestry system. Intercropping of Bamboo and tea with *Aleurites* spp. Is being done in Vietnam (FAO, 1996). When Soybean is grown in the inter-space of tree during kharif, it was found out that grain yield was significantly influenced at 1 metre and 5 metre distance from the Tree base. Soybean grain yield at 1 metre distance from Tree base was significantly reduced in all the tree species compared to yield in open area. Shankaran *et al.* (1987) have reported that Soybean and Tree species (*P.cineraria* and *A.albida*) had positive interaction. The loss in yields decreased significantly with the increase in distance from tree line (Dillon, 1993). Intentional tree plantation on cropland or relation of existing trees on cropland in common combination of tree with crops are prevalent world over (Grandstaff *et al.*, 1986). Some examples are : *Acacia nilotica* with rice, *Paulownia* spp. with wheat, Soybean and cotton, *carya illionensis* with Soybean and maize. Jha *et al.* (1989) reported that Soybean gave the highest yield (6.31 g/ha) followed by Sesame (5.67 g/ha) Horsegram (4.57 g/ha) and Niger produced the lowest grain yield (3.02 g/ha) in combination with tree species.

Zea mays and *Glycine max* are cultivated in association with Jackfruit (*Artocarpus heterphyllus*) in Assam, Manipur and Tripura (Singh and Pradhan, 1993).

3.3. RESEARCH WORK CARRIED OUT ON VARIOUS ASPECTS OF AGROFORESTRY :

Great amount of research work have been carried out on various aspects of agroforestry, which include agroforestry models as alternative to jhum or shifting cultivation (Jha, 1995). Soil management for agroforestry (Dhar & Jha). Nursery pest management under Agroforestry (Santra, 1993), Tree-crop interactions in Agroforestry practices (Harsh and Tiwari, 1993), Alley cropping (Wilson & Kang, 1981).

Recently, a *Leucaena leucocephala* variety S-11 has been introduced in Assam, Nagaland and Arunachal Pradesh (Singh, 1999). *Leucaena leucocephala* performed well as a fodder cum-fuel tree. The various advantages of inter-cropping of trees with crops by way of productivity addition of income from the farm, improvement of on soil condition, control over weeds etc., have been worked out by various Scientists (Ong *et al.*, 1989, Aiyer, 1949, Rao *et al.*, 1979).

Intercropping of *Acacia albida* and *Prosopis cineraria* with crop has been reported to increase yield of crop. Raising of forest trees with temporary combination of agricultural crops has been a common practice of reforestation in Burma and India. King (1968) has reviewed about 79 tree species and 42 agricultural crops in 'taungya' cultivation. Arable crops are grown between hedge- rows of shrubs and trees which are pruned to desirable heights to reduce the competition between trees and crops (Kang and Wilson, 1987).

The intercropping of Alder and Cardamom might be highly successful agroforestry system in North East region. Even in shifting cultivation area, laye cardamom – tree plantation is classic example of agroforestry (Borthakur, 1992). Cardamom is highly valued commercial spice crop (Ilyas, 1978). The intercrop is apparently an age-old practice, introduced from Sikkim to other regions. It produces economic return after 3 years and continues to produce upto 30 years or more with peak cardamom production normally from 7 to 18 years (Zomer and Menke, 1993).

Results of experiments conducted at Ranchi showed that Maize, ragi and paddy could be grown with Teak and Sissoo in the first year (Mishra *et al.*, 1979). Nair (1980) mentioned that under Vanlakshmi agro-forestry project in Kerala, Pepper was planted successfully under Semal, Teak, Silver oak and Rinj and Coca as well as medicinal plants. Maximum yield of Horsegram was recorded in combination with *Pongamia pinnata* whereas grain yield in combination with *Acacia* and *Eucalyptus* was slightly less. Sesame yield was maximum along with *Shorea robusta*. Maximum yield of horsegram was obtained in combination with *Azadirachta indica*. Alongwith *Shorea robusta* yield was slightly less than above combination but growth performance of *Shorea* was very poor. Maximum yield of Niger was recorded in combination with *Tectona grandis* and *Melia azadirach*. Growth performance of these two species were satisfactory. We can consider *Melia* best combination for Niger because at 2m x 2m spacing it gives slightly less than yield in combination of *Tectona grandis* which is planted at 4m x 4m spacing.

Pathak and Gupta (1987) have reported organic matter addition through leaf litter in 2 years old *Leucaena* plantation to be 5.6 t/ha annually, which improved tilth, cation exchange capacity, water holding capacity, bulk density, brought down soil pH from alkaline to normal and improved the yield of successive crops. Mishra and Prasad (1980) suggested that land available between the rows of *Albizia lucida* and *Maughania macrophylla* can be utilized for sweet potato (*Iopomoea batatas*) and Turmeric (*Curcuma longa*) cultivation as an intercrop without any deleterious effects. Ojeniyi and Agbede (1980 a,b) and Agbede (1985) reported that Yam (*Dioscorea bulbifera*) and Maize can be grown adequately with young *Gmelina arborea* trees for food and forest crops, respectively. The interplanting of wheat with *Dalbergia sissoo*, *Eucalyptus citriodora*, *Populus deltoides* and *Bombax ceiba* has no significant difference after first year of plantation but the yield was significantly higher under *Dalbergia sissoo* in the next year (Khattak and Sheikh 1980, Khattak *et al.*, 1981). Sing (1983) reported a marked increase in productivity of Pignon Pea (*Cajanus cajan*), Til (*Sesamum indicum*), Castor (*Ricinus communis*) and Jowar (*Sorghum vulgare*) under *Leucaena*. In arid and semi-arid regimes, significantly higher forage yield of *Vigna capensis* and Sorghum have been recorded when interplanted with *Acacia tortilis* while the grain yield of *Holoptelea integrifolia* improved only under lopped conditions. Rodin and Nikitin (1985) reported reduction in Weed population and better yield of Potato (*Solanum tuberosum*) and Oat (*Avena sativa*) grown in rows between *Abies* plantations.

Besides increasing productivity, agroforestry systems also improve soil sub-systems (Steninlin, 1978). Charreau (1980) argued that tree-crop rotation improves soil fertility more than in fallow system. Ojeniyi *et al.* (1980) stated increase in N and P contents in soil in which food crops are intercropped with *Gmelina arborea*. Kang *et al.* (1981) and Torries (1983) suggested interplanting of Maize with *Leucaena* spp. in nitrogen deficient soils. A similar result was also obtained by Mishra and Prasad (1980) while interplanting Til and Groundnut (*Arachis hypogae*) with *Dalbergia sissoo* and *Tectona grandis* but the potassium content decreased significantly. Wang *et al.* (1982) recorded less soil and water losses in areas planted with rubber (*Hevea* spp.) and tea (*Camelia chinensis*) or pure rubber trees, compared to the cultivation of agrocrops alone. These studies evidence that the tree species planted under these crop-tree associations have no detrimental impact on their soil sub-system.

According to Reynolds *et al.* (1988), on slopping land, when leguminous trees species are planted along the contours, the trees limit soil erosion. Tree foliage (Pruning) can be used as mulch and fertilizer for food crops and or for animal feed. The leguminous shrubs and trees have great influence in building up soil nitrogen, soil organic matter and some of them also help in improving other soil nutrients through leaf litters. The influence of different trees under silvipastoral system after 10 years plantation as compared to non-tree situation (open) on soil fertility built up and water retention properties showed a favourable trend (Hazra, 1990).

From the above research works, it can be mentioned that not much work has been done regarding the Tung based Agroforestry system

particularly in Mizoram context. The present study therefore aims at establishing Tung as an agroforestry crop. Efforts have been made to evaluate the most appropriate spacing for Tung which can be compatible for tree-crop interaction.

CHAPTER - IV

EXPERIMENTAL FINDINGS

4. EXPERIMENTAL FINDINGS:

In this Chapter, an effort is made to present the various experimental findings observed during the course of investigation. These experimental findings are presented with the help of suitable tables, figures and illustration (Plates) for easy understanding.

4.1. PLANT HEIGHT OF SOYBEAN:

After careful examination of the data on plant height of soybean as affected by various spacing of Tung trees presented in Table 1 and Fig. 3 showed that, after 30 days of sowing, maximum plant height was obtained in treatment D (22.8cm) and minimum plant height was recorded in treatment C (19.52cm). However, different treatments have no significant effect on the plant height of Soybean.

At 60 days after sowing, maximum plant height was recorded in treatment D (63.20cm) and minimum plant height was recorded in treatment C (45.12cm) Treatment D (control) and A (6mx6m) spacing showed a significantly higher plant height as compared to treatment B (6mx5m) and treatment C (5mx4m).

At harvest, different treatment A,B,C, and D showed more or less variation. Therefore, the different treatment did not caused any significant variations on the plant height of Soybean. However, the maximum plant height was obtained in treatment D (165.52cm), and the minimum plant height being recorded in treatment C(155.50cm).

4.2. NUMBER OF LEAVES PER PLANT OF SOYBEAN :

The different data on number of leaves per plant of Soybean were presented in Table II and graphically presented in Figure 4. The data obtained after 30 days of sowing indicated that. Maximum number of leaves was recorded in treatment D (24.25) where minimum number of leaves was recorded in 6mx5m spacing (11.25).

At 60 days after sowing, treatment D (65.75) and treatment A(51.00) were found to be highly significant over treatment C(42.50). Treatment A (51.00) and treatment B (50.25) showed almost same number of leaves.

At harvest, treatment D (11.00) and treatment and A (9.75) were found to be significant over treatment C (8.75) and treatment B (6.5). The data indicate that, treatment C (8.75) was Significant as compare to treatment B (6.5). It was observed that, different treatments did not caused significant effect on the number of leaves.

4.3. NUMBER OF PODS PER PLANT OF SOYBEAN :

On careful examination of the data presented in Table – III and Figure 5, it was found out that treatment D (56.50) and treatment A (48.75) were found to be significant over treatment B (47.00) and C (44.50). The maximum number of pod, was obtained in treatment D (56.50) and the minimum number of pod, was obtained in treatment C (44.50).

4.4. GRAIN YIELD PER PLOT OF SOYBEAN :

The data of grain yield per plot of Soybean were presented in the Table-IV and graphically presented in Figure 6. The grain yield of Soybean ranged from 27kgs. to 32.25kgs. Treatment D (32.25) was highly significant over the rest of the treatments. Treatment A (27) was found to be significant over treatment B (25:75) and treatment C (23.25). The minimum grain yield per plot of Soybean was recorded in treatment C (23.25).

TABLE – I : Plant Height of Soybean (*Glycine max L.Merril*) in cm. as affected by Various Spacings of Tung (*Aleurites fodii*)

TREATMENTS	DAYS AFTER SOWING		
	30	60	At harvest
A (6mx6m)	19.87	58.42	162.2
B (6mx5m)	19.67	52.02	159.97
C (5mx4m)	19.52	45.12	155.97
D (Control)	22.8	63.20	165.52
S.E.M_±	2.73	3.88	3.62
CD at 5%	N.S.	8.77	N.S

N.S. = Non-Significant

Fig. 3 : Plant height of Soybean (*Glycine max* L.Merril) in cm. as affected by various spacings of Tung (*Aleurites fordii*)

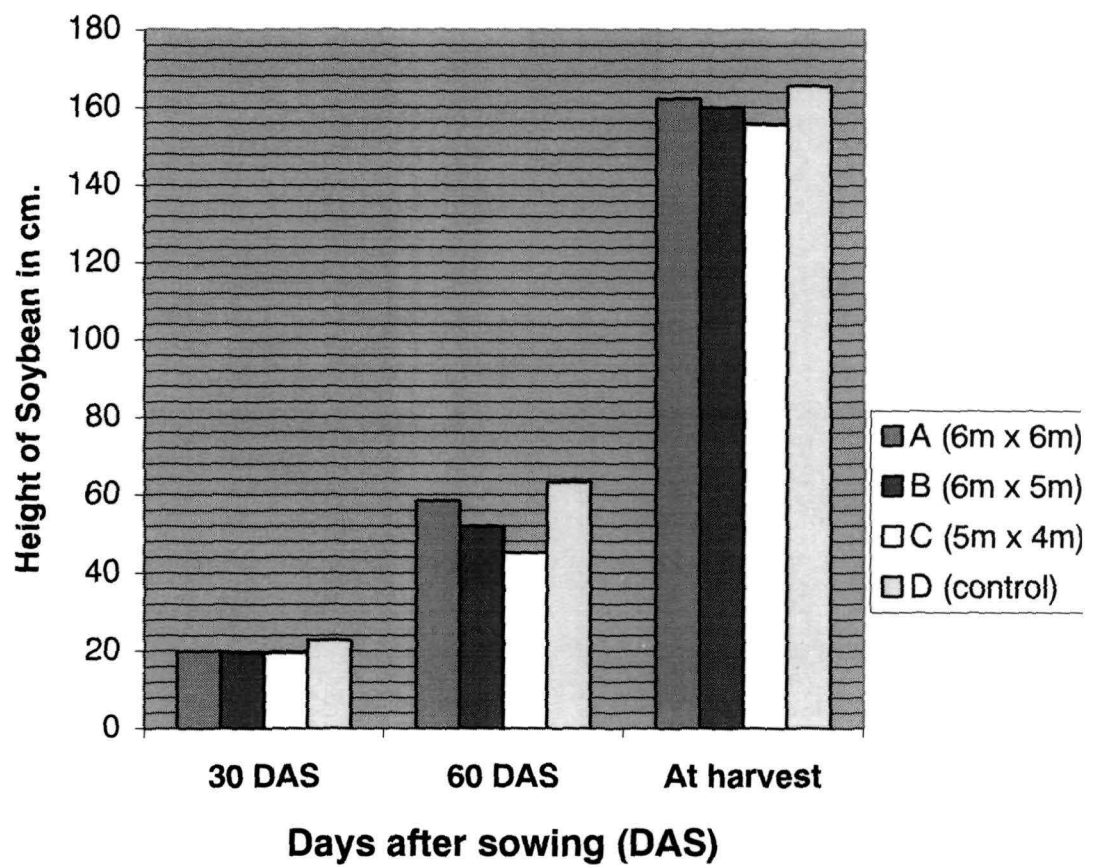


Table – II : Number of leaves per plant of Soybean (*Glycine max L.Merril*) as affected by Various spacings of Tung (*Aleurites fordii*)

TREATMENT	DAYS AFTER SOWING		
	30	60	At harvest
A (6mx6m)	20.25	51.00	9.75
B (6mx5m)	11.25	50.25	6.50
C (5mx4m)	11.75	42.50	8.75
D (Control)	24.25	65.75	11.00
S.E.M _±	2.59	6.11	1.68
CD at 5%	5.88	13.82	N.S

N.S = Non-Significant

Fig. 4 : Number of leaves per plant of Soybean (*Glycine max L.Merril*) as affected by various spacings of Tung (*Aleurites fordii*)

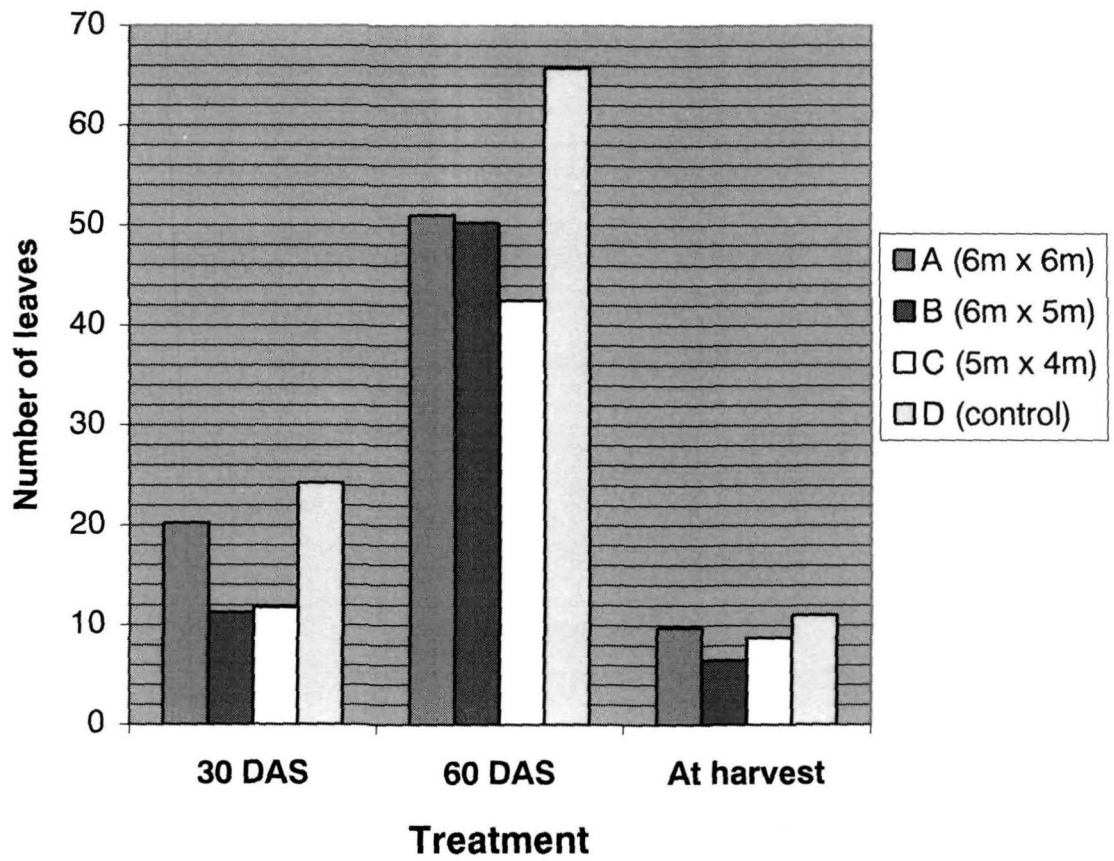


TABLE – III : Number of Pods per Plant of Soybean (*Glycine max L.Merril*) as affected by Various Spacings of Tung (*Aleurites fordii*)

TREATMENTS	No. of Pods/Plant
A (6mx6m)	48.75
B (6mx5m)	47.00
C (5mx4m)	44.50
D (Control)	56.50
S.E.M_±	2.99
CD at 5%	6.76

Fig. 5 : Number of pods per plant of Soybean (*Glycine max L.Merril*) as affected by various spacings of Tung (*Aleurites fordii*)

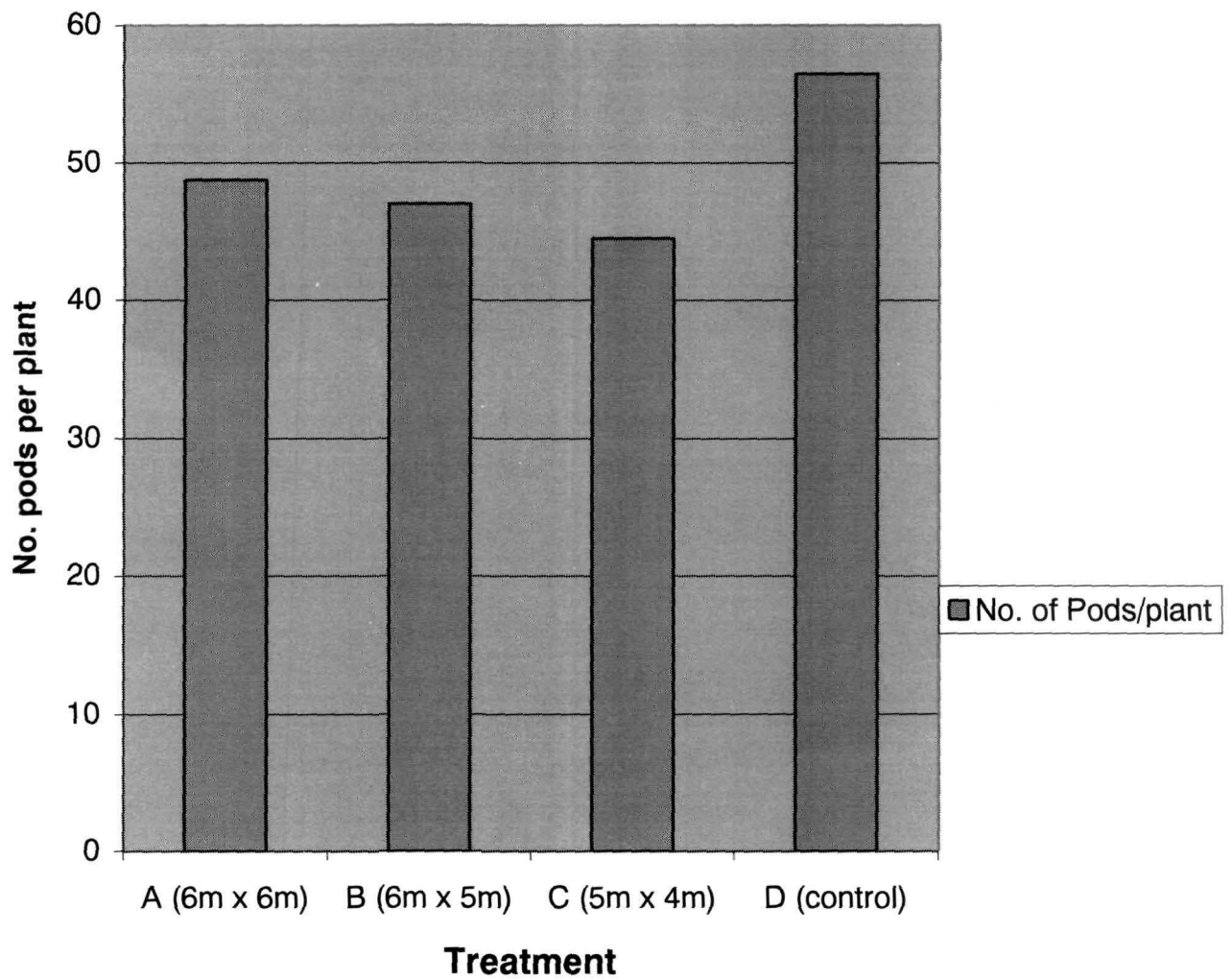
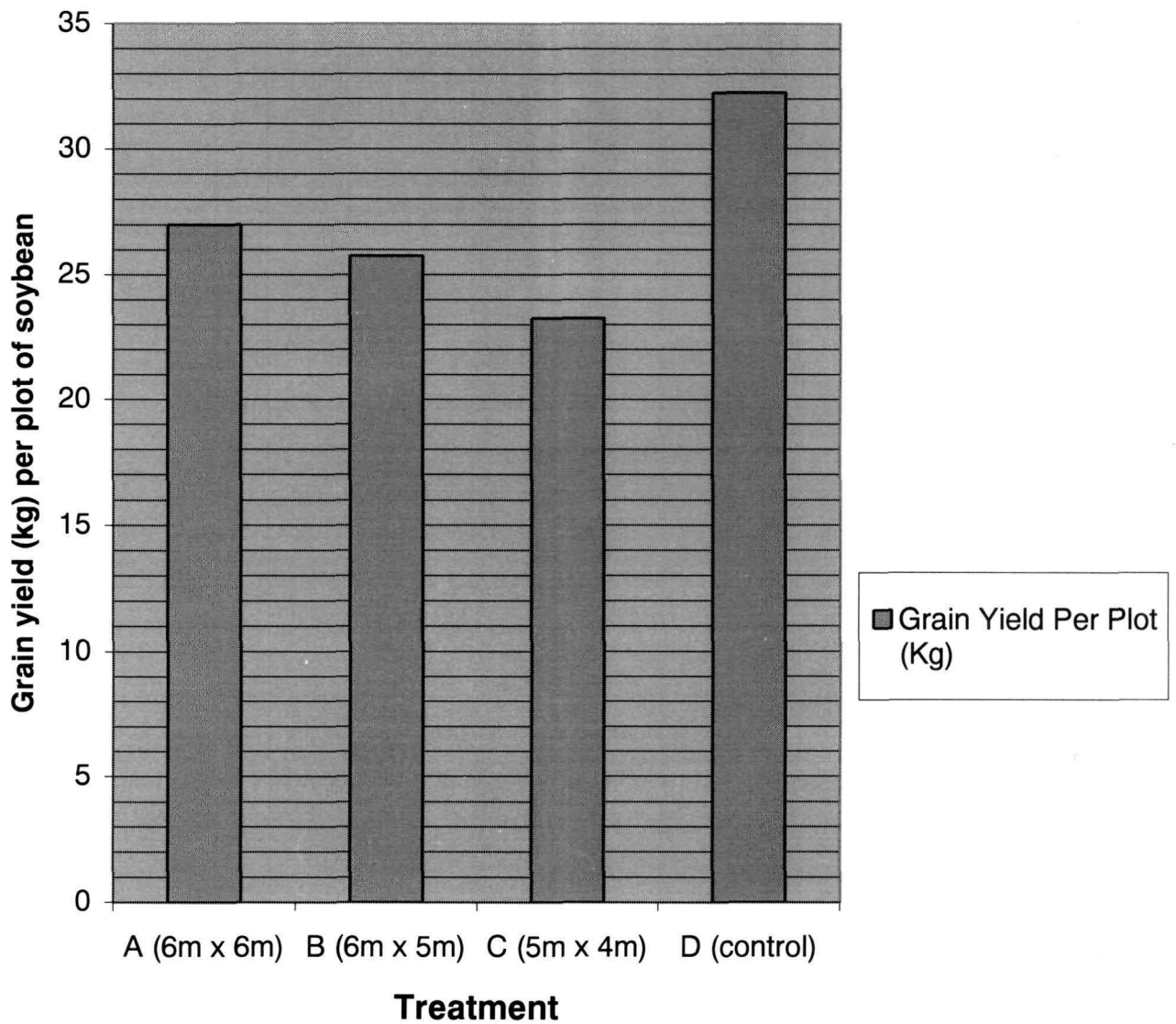


TABLE – IV : Grain Yield (kg) per Plot of Soybean (*Glycine max L.Merril*) as affected by Various spacings of Tung (*Aleurites fordii*).

TREATMENTS	Grain yield/plot (Kg)
A (6mx6m)	27.00
B (6mx5m)	25.75
C (5mx4m)	23.25
D (Control)	32.25
S.E.M_±	1.83
CD at 5%	4.13

Fig. 6 : Grain yield (Kg) per plot of Soybean (*Glycine max L.Merril*) as affected by various spacings of Tung (*Aleurites fordii*)



4.5 HEIGHT OF TUNG TREES:

From the observation of data presented in table -V and figure-7 on the height of Tung trees as affected by different treatments generally present a non-significant effect over the height of Tung.

In the 1st observation, Tung plant height ranged from 2.74m to 3.39m, which showed difference as affected by different spacings. The maximum plant height being found in treatment A (6mx6m) followed by treatment B (6mx5m) and least being C (5mx4m). It can be reported that all the treatments (A, B, C) have a significant effect on the height of Tung trees.

The plant height in 25th January 2001 ranged from 2.81m to 4.09m. The height of the plant as recorded in 6mx6m spacing (4.09m) was significantly higher which was followed by 6mx5m (3.23m), and the minimum plant height was observed in 5mX4m spacing (2.81m). It can also be mentioned that, different treatments have a significant effect over the height of Tung trees.

Similar trends were found in 8th March 2001. The height of the plant ranged from 2.96m to 4.25m. Maximum plant height was obtained in 6mx6m spacing (4.25m), which was followed; by 6mx5m spacing (3.24m) and the minimum plant height was found in 5mx4m spacing (2.96m). It can be reported that, height of the plant in 6mx6m spacing (4.09m) was significantly higher as compared to the other treatments. Treatment A (6mx6m) and B (6mx5m) have a significant effect over the height of Tung.

In the 4th observation i.e., 22nd April 2001, plant height was again recorded highest in 6mx6m spacing (4.36m) and the minimum height was recorded in 5mx4m spacing (3.10m). The height of the plant ranged from 3.10m to 4.36m, which indicate difference as effected by different spacing.

In the 5th observation, the height of the plant ranged from 3.25m to 4.47m. Here, similar trends were obtained as in the 4th observation. Spacing 6mx6m and 6mx5m have a significant effect on the height of Tung plant, while spacing 5mx4m have no significant effect on the height of Tung tree. The maximum height being recorded in 6mx6m spacing (4.47m) followed by 6mx5m spacing (3.49m) and the least recorded in 5mx4m spacing (3.25m).

On critical examination of the observations from 6th to 8th , it can be mentioned that, 6mx6m spacing was found highly significant over the other spacing. The height of the plant ranged from 3.38m to 4.81m. The maximum height being found in 6mx6m spacing followed by 6mx5m spacing and the least being recorded in 5mx4m spacing.

4.6. BASAL DIAMETER OF TUNG TREES:

A critical analysis of the data presented in table –VI graphically presented in figure 8, on the basal thickness (cm) of Tung trees as affected by different spacing indicated the following observations:

In the 1st observation, basal thickness of Tung tree ranged from 3.84cm to 5.41cm, which indicated difference as affected by different spacing. The maximum basal thickness of Tung tree was recorded in 6m x 6m spacing (5.41cm) followed by 6m x 5m spacing (4.72cm) and the least being 5mx4m spacing (3.84cm). It can be reported that, all the different treatments have a significant effect on the basal thickness of Tung tree.

The plant height in 25th January 2001 ranged from 4.49cm to 6.03cm. Basal thickness of the plant was significantly higher in 6mx6m spacing as compared to the other two treatments. The minimum basal thickness was recorded in 5mx4m spacing (4.49cm).

Similar trends were also observed during 3rd observation, i.e., 8th March 2001. The maximum basal thickness of the plant was recorded in 6mx6m spacing (6.45cm) followed by 6mx5m (5.84cm) and the least being found in 5mx4m (4.73cm).

In the 4th observation, i.e., 22nd March 2001, basal thickness of the plant range from 5.11cm to 7.11cm that showed difference as affected by different spacing. Treatment A (6m x 6m) was highly

significant over the other treatments B (6mx5m) and C (5mx4m). The minimum basal thickness was recorded in 5mx4m spacing (5.11cm).

In the 5th observation, the basal thickness of the plant ranged from 5.54cm to 7.50cm. Spacing 6mx6m (7.50cm) was found significant over the spacing of 6mx5m (6.84cm) spacing. The least basal thickness was recorded in 5mx4m (5.54cm) spacing. It can also be reported that there was significant variations among the treatments.

In the 6th, 7th and 8th observations, the basal thickness of the Tung tree ranged from 5.54cm to 9.15cm. In the 6th observation maximum basal thickness was observed in 6mx6m (8.10cm) and the minimum basal thickness was recorded in 5mx4m (6.11cm) spacing. Similar trends were also found in 7th and 8th observations. In 7th and 8th observations, it was found out that, the different treatments have a significant effect over the basal thickness of the plant. Whereas in the 6th observation, spacing 6mx6m (8.10cm) and 6mx5m (7.20cm) showed a difference as affected by different spacing. Spacing 5mx4m (6.11cm) did not show any significant effect on the basal thickness of Tung trees.

TABLE – V : Height (m) of Tung (*Aleurites fordii*) as affected by Various Spacings.

TREATMENTS	INTERVAL OF DAYS							
	0	45	90	135	180	225	170	315
	11.12.2000	25.01.2001	08.03.2001	22.04.2001	06.06.2001	27.07.2001	04.09.2001	19.10.2001
A (6mx6m)	3.39	4.09	4.25	4.36	4.47	4.58	4.69	4.81
B (6mx5m)	3.11	3.23	3.24	3.37	3.49	3.60	3.72	3.84
C (5mx4m)	2.74	2.81	2.96	3.10	3.25	3.38	3.51	3.64
S.E.m±	0.26	0.14	0.06	0.22	0.17	0.12	0.24	0.17
CD at 5%	0.63	0.34	0.14	0.53	0.41	0.29	0.58	0.41

Fig. 7 : Height (m) of Tung (*Aleurites fordii*) as affected by various spacings.

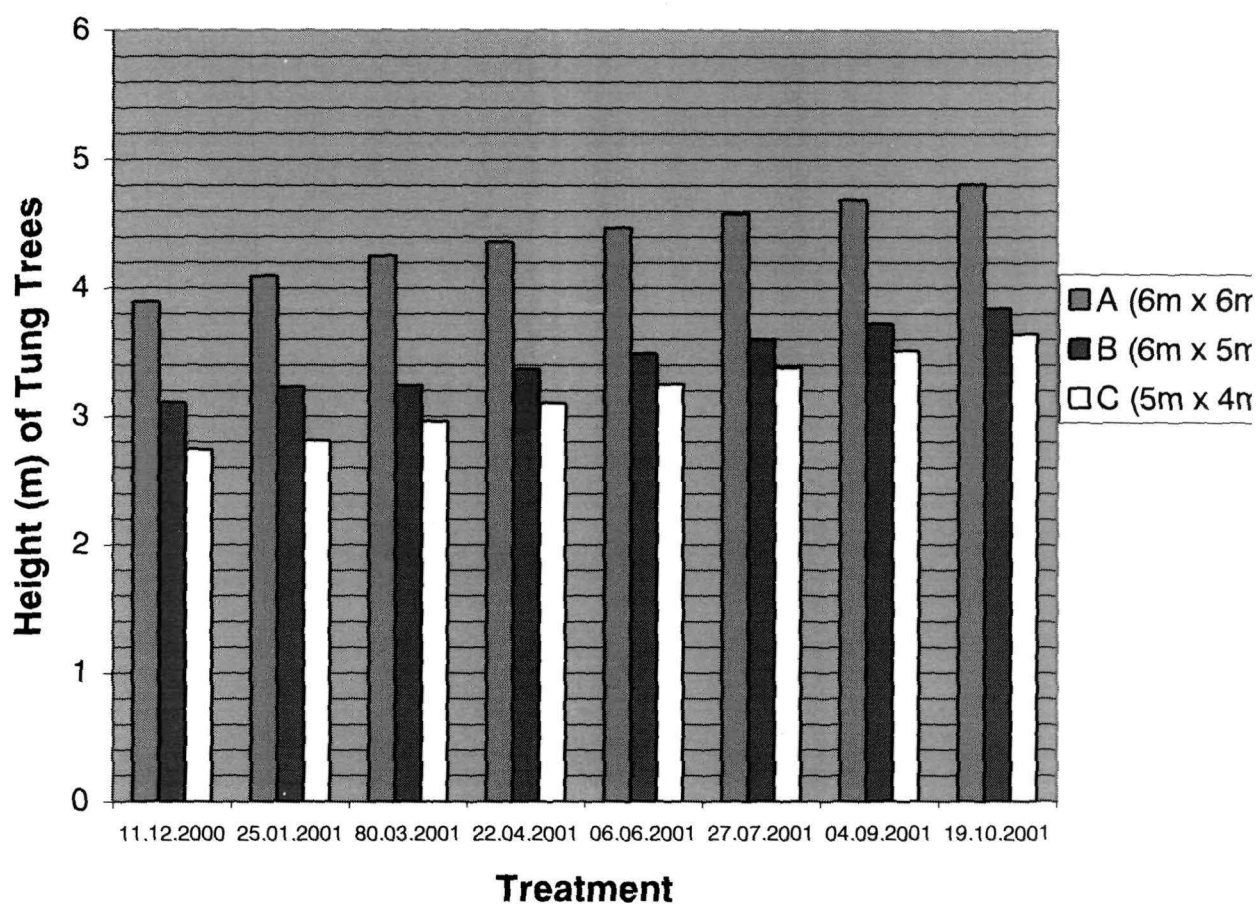
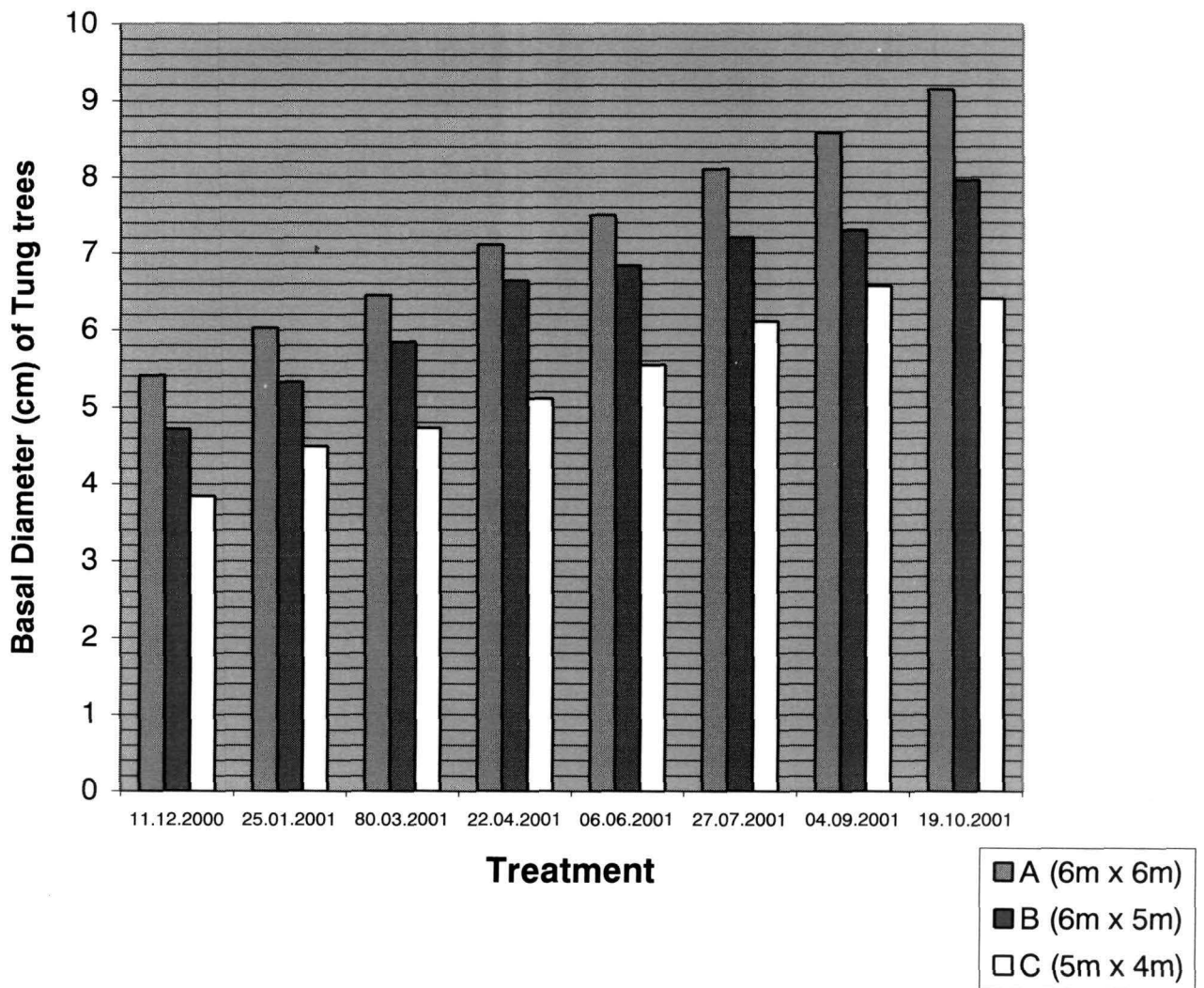


TABLE – VI : Basal Diameter (cm.) of Tung trees (*Aleurites fordii*) as affected by Various Spacings.

TREATMENTS	INTERVAL OF DAYS							
	0	45	90	135	180	225	170	315
	11.12.2000	25.01.2001	08.03.2001	22.04.2001	06.06.2001	27.07.2001	04.09.2001	19.10.2001
A (6mx6m)	5.41	6.03	6.45	7.11	7.50	8.10	8.58	9.15
B (6mx5m)	4.72	5.32	5.84	6.64	6.84	7.20	7.30	7.96
C (5mx4m)	3.84	4.49	4.73	5.11	5.54	6.11	6.57	6.40
S.E.m _±	0.13	0.07	0.17	0.07	0.05	0.5	0.06	0.1
CD at 5%	0.31	0.18	0.41	0.17	0.12	1.22	0.14	0.24

Fig. 8 : Basal Diameter (cm) of Tung Trees (*Aleurites fordii*) as affected by various spacings.



CHAPTER - V

DISCUSSION

5. DISCUSSION:

The present investigation entitled “Effect of various spacings on the growth behaviour of Tung (*Aleurites fordii*.Hemsl.) and the yield of Soybean (*Glycine max* L.Merril)” was carried out with the following two specific objectives :-

- 1) To investigate the effect of various spacings on the growth behaviour of Tung (*Aleurites fordii*).
- 2) To investigate the effect of various spacings of Tung on the growth and yield of Soybean (*Glycine max* L.Merril).

The various experimental findings in accordance with the above listed objectives are discussed as under: -

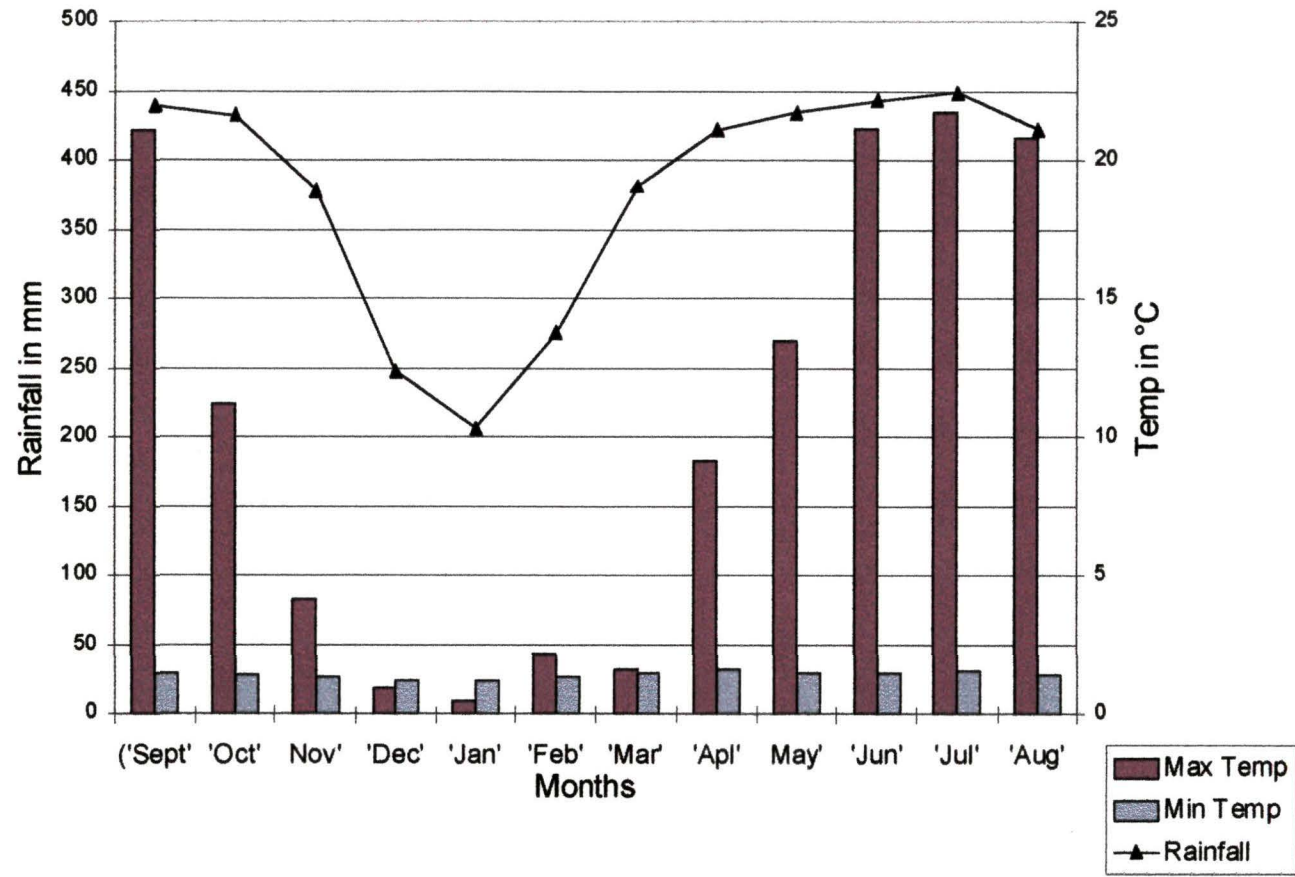
5.1. GROWTH BEHAVIOUR OF TUNG TREES:

Height growth (m) and basal diameter (cm) were recorded at a regular interval of 45 days for a period of approximately one year, starting from 11th December 2000 till 19th October 2001. The data recorded on height (m) and basal diameter (cm) of Tung trees was presented in Table V and VI Fig. 7 and 8. The growths of trees were found to be comparatively lower during December 2000 till February 2001. Growth of tree was faster during the month of April, 2000 up to September, 2001. Thus climatic factor (Temperature & Rainfall) seems to play an important role in the growth of the trees. James (1993) also stated that Tung tree requires long, hot summer with abundant moisture, where day and night temperatures are uniformly warm. Much variation reduces the growth and fruit size.

Tree growth in various treatments shows a significant variation. The growth performance has been found to be better at 6mx6m spacing. Thus the maximum height of 4.81m was recorded at 6mx6m spacing and the least at 5mx4m spacing (2.74m). Similar trend in basal growth was observed. The maximum basal diameter of 9.15cm was recorded at 6mx6m spacing, and the minimum basal thickness was obtained in 5m x 4m spacing (3.84cm). Thus larger spacing seems to exert less pressure on the growth of the tree. This may be due to lower competition for nutrients and sunlight.

However, precise conclusion was not possible as to what factors affect the growth of the Tung trees. Weedy species also seems to affect the growth of the trees. Competition between weedy species and trees seems to be maximum during dry season as there is a scarcity of moisture and consequently affecting nutrient absorption. As a result, lower rate of growth was observed during dry season for all the treatments.

Fig. Monthly records of meteorological data during the study period



5.2. GROWTH ATTRIBUTE OF SOYBEAN:

For self reliance and sustainable yield introduction of Soybean crop, intercropping with Tung trees was studied with different spacing viz. 6 m x 6 m, 6 m x 5 m, 5 m x 4 m.

As Soybean is nitrogen fixing crop, it is an ideal component suited for intercropping. It reduces the requirement of fertilizers to a great extent. The growth rate in terms of height (cm) and number of leaves per plant of Soybean crop was observed to be significant under different treatments at 60 days after sowing (Table I and II, Fig. 3 and 4). Maximum height and number of leaves per plant of Soybean was recorded from treatment D (control). This may be due to the non-hindrance of shade effect over the intercrop. Behera *et. al*, (1998) also obtained taller plants in sole maize than that of intercropping. However, when intercropped with Tung trees, maximum growths were recorded in treatment A (6 m x 6 m) which may be due to the less effect of shade over the intercrop.

Numbers of leaves per plant of Soybean were recorded at 30, 60 days after sowing and at harvest. Maximum number of leaves per plant was recorded at 60 days after sowing where minimum number of leaves was recorded at the harvest of the crop.

5.3. YIELD AND YIELD ATTRIBUTE OF SOYBEAN:

Number of pods per plant and grain yield per plot of Soybean, were also recorded at the harvest of the crop and were presented

in Table III and IV, Fig. 5 and 6 respectively. Maximum number of pods per plant was observed in treatment D (control) followed by treatment A (6 m x 6 m), treatment B (6 m x 6 m) and treatment C (5mx4m). Treatment C (5mx4m) recorded minimum number of pods. There was a significant variation between treatment D (Control) and the other three treatments (A, B, C). It can be mentioned that, intercrop having minimum competition for space, moisture, nutrient and light have maximum number of pods and grain yield per plant. This result confirmed the findings of Dillon, (1993) who reported that, loss in yields decreased significantly with the increase in distance from tree line.

When Soybean was intercropped with Tung trees, maximum grain yield (32.25 Kg/plot) was obtained in treatment D(control) followed by treatment a (6 m x 6 m) i.e., 27 Kg/plot. This may be due to minimal effect of Tung trees on the intercrops. Jha *et al.* (1989) reported that Soybean gave the highest yield (6.31 Qtls./ha.) followed by Sesame (5.67 Qtls/ha.), Horsegram (4.75 Qtls/ha.) and Niger produced the lowest grain yield (3.02 Qtls/ha.) in combination with tree species.

From the above, we can understand that, spacing of tree component in an agroforestry system play a significant role in the height, number of leaves, number pods and grain yield of both the components. It is therefore, a must for an agroforestry to know appropriate spacing of both components in carrying out a successful agroforestry system.

**Plate No.1 Three years old Tung before sowing
of inter crop Soybean (6m x 6m)**



Plate No. 2. : Soybean crop (Control)



Plate No. 3. : Tung (6m x 5m)



Plate No. 4. : Tung (5m x 4m)



CHAPTER - VI

SUMMARY AND CONCLUSION

6. SUMMARY :

The study on effect of various spacings on the growth behaviour of Tung (*Aleurites fordii*) and the yield of Soybean (*Glycine max* L.Merril) under agroforestry system of Mizoram was carried out at Zemabawk. The site of the field experiment is located at about 4 km away from the capital of Mizoram, Aizawl. Zemabawk lies in between 92°15` to 93°29` E Longitude and 21°58` to 24°35` N Latitude having an altitude of 1132 m (3175 ft) from the mean sea level with an average rainfall of 235 cm. The temperature varies from 21°C to 30°C during summer and 11°C to 23°C during winter. Analysis of soil in the experimental site was done in the Department of Forestry NEHU, Mizoram Campus Laboratory Aizawl as well as in the Soil Testing Laboratory of the Department of Agriculture, Government of Mizoram, Aizawl. It was found out that the soil is sandy loam, pH ranges from 5.4 to 5.6, which is slightly acidic in nature.

The area of the experimental field was approximately 2,304 Sq.m. The experiment was conducted on a well established plantation of 3 years old Tung trees which were planted at the spacings of 6 m x 6 m, 6m x 5 m, and 5 m x 4 m in July, 1998. Local variety of Soybean was sown at a spacing of 60 cm x 40 cm in the interspaced of Tung trees covering the entire experimental area during the last week of August 2001. The size of each plot measured 12 m x 12 m. As the trees were already established, management of the trees were not necessary. The experimental site is fully covered with a noxious weeds of *Impereta cylindrica* and so, frequent weeding is necessary to keep away the weeds in the site. Four weedings were done; one before sowing of Soybean i.e.

during 1st week of August 2001. Second weeding was done in the month of September, 2001 and the other weedings were done consecutively before the harvest of Soybean.

The experiment was carried out following randomized block design (RBD) with four replications and four treatments, viz. A (6m x 6m), B (6m x 5m), C (5m x 4m) and control. These treatments were allocated in each replications. Thus, there were 16 numbers of plots.

The various growth attribute of Soybean such as plant height in cm and number of leaves per plant were recorded at a regular interval of 30, 60 days after sowing and at harvest. Numbers of Pods per plant of Soybean and grain yield (Kg/plot) were recorded after the harvest. In case of growth attribute of Tung, tree height (m) and basal diameter (cm) were recorded at a regular interval of 45 days, starting from 11th December, 2000 upto 19th October, 2001. The different data recorded during the course of study were subjected to ANOVA (Analysis of Variance) to see the effect of various spacings on the growth of Tung and the yield of Soybean. The significance was tested by calculating the critical difference (CD) at 5% level, wherever 'F' test was found significant.

Several findings were recorded during the course of investigation, which can be summarized as follows :-

6.1. GROWTH BEHAVIOUR OF TUNG TREES :

Growth behaviour of Tung trees with respect to height and basal diameter which is observed for a period of one year starting from 11th December, 2000 to 19th October, 2001 indicated that the performance of treatment A (6 m x 6 m) was found to be the best. In case of treatment B (6mx5m) and treatment C (5mx4m), not much difference with regard to the height and basal diameter of the trees were obtained. It can be mentioned that treatment C (5 m x 4 m) has the minimum plant height and basal thickness.

6.2. GROWTH PERFORMANCE OF SOYBEAN :

Height and number of leaves of Soybean were recorded at an interval of 30 days. It is found that treatment D (control) has maximum height and maximum number of leaves, which is followed by treatment A (6 m x 6 m). The minimum height and minimum number of leaves was recorded in treatment C (5mx4m) followed by treatment B (6mx5m). It can be mentioned that, there is no much difference in height and number of leaves of Soybean between C (5mx4m) and B (6mx5m) treatments.

Similarly maximum number of Pods and grain yield per plot was maximum in treatment D (control) that is followed by treatment A (6m x 6 m).

CONCLUSION:

From the above investigation, it can be mentioned that, the intercropping of Soybean with trees are feasible in Mizoram context, and the following conclusions can be summarized as below: -

- 1) Treatment A (6 m x 6 m) was found to be the best spacing with respect to the growth behaviour of Tung trees.
- 2) Treatment D (Control) showed maximum growth attributes and grain yield of Soybean. However, when intercrop with Tung trees, Treatment A (6 m x 6 m) was considered as the best treatment.

The above-mentioned findings are based on only one-year observation and so it may be difficult to make a clear-cut conclusion. However as far as, our investigation is concerned, performance of Tung trees having a spacing of (6 m x 6 m) was found to be the best spacing and may be recommended in the Agro forestry system of Mizoram.

Cultivation of Tung oil trees has been introduced in some part of Mizoram for the last few years, which has been giving promising results (Thapa *et al.*, 2000). In this context, intercropping of Tung trees with Soybean can give diverse products from a unit land for self-reliance and eco-sustainability.

Growing trees under the agro forestry practice will provide life support system to the tribal living below poverty line for which agro forestry will be a boon and ensure regular income. Besides meeting the subsistence needs of tribal agro forestry will enable the jhumias to wean

away from the age old unscientific practice which is so prevalent in the state of Mizoram as well as in all the North-Eastern states but show way to permanent settled cropping practice.

BIBLIOGRAPHY

Abbott, C.E., (1929). Fruit Bud Development in the Tung Oil tree, *Journal, Agriculture, Research* 38:679-696.

Agbede 00. 1985. Improving agroforestry in Nigeria. Effect of plant density and interaction on crop production. *Forest Ecol. And Management* 11:231-239.

Aiyer, A.K.Y.N (1949). Mixed cropping in *India*. *Indian Journal agric. Sc.* 19, pp. 439-443.

Angelo, E.Brown, R.T. and Ammen, H.J.,(1942). Pollination Studies with Tung trees. *America.Soc. Horticulture Science proceedings* 41:176-180.

Anonymous (1995) "*New Contour Farming System*". Directorate of Agriculture, Aizawl, Government of Mizoram.

Anonymous (1986) *Assam Tribune*, Guwahati, Aug 22.

Anonymous, (1997). Rainfed Agriculture in watershed areas in Mizoram. *Lecture notes; off-campus training course on Rainfed Agriculture in watershed areas in Mizoram.* Conducted by NERIWALM in collaboration with Directorate of Agriculture and Minor Irrigation, Govt. of Mizoram, Nov. 18-21, 1997 1-2 pp.

- Bene, J.G., Beal, L.H.W. and Cote, A., (1977).** *Trees, Food and People Management on the tropics.* In International Development Research Centre, Ottawa, Canada. 52 pp.
- Brown, R.T. and Fisher, E, (1941).** Period of Stigma Receptivity in Flowers of Tung Trees. *America Soc. Horticulture Science Proceedings.* 39:164-166.
- Borthakur, D.N., Singh, A, Awasthi, R.P., Ghosh, S.P., Prasad, R.N., Rai, R.N., Singh, M.D., Sahu, S.D., Varma, A., Sachan, J.N., Dhar, V., Datta, H.H., Sharma, B.S., and Samanta, R.K. 1983.** *Shifting Cultivation in North East India – Review.* ICAR Research complex for NEH Region, Shillong.
- Borthakur, D.N. 1992.** *Agriculture of the North Eastern Region.* Beecee Prakashan, Guwahati, pp. 137-151.
- Borthakur, D.N. (1992).** *Agriculture of the North Eastern Region with special reference to Hill Agriculture.* Saraghat offset Press, Guwahati.
- Behera, B., Singh, G.S., Pradhan, P.C. and Senpati, P.C., (1998).** Effect of Intercropping and Residue Incorporation on Maize – Cowpea Cropping system in Eastern Ghats. *Indian Jour. Soil Cons.* 26 (2) : 133 – 134 pp.

- Dhar, B.L. and Jha, M.W.**(1993). Soil Management for Agroforestry In: *Agroforestry for rural needs Vol.II* (Eds. Khurana D.K. and Khosla, P.K.) Indian Society of Tree Scientists Solan H.P., pp.530-534.
- Dillon, M.S.** (1993). Quantification and Mitigation of yield losses in wheat due to boundary plantation of Eucalyptus. *Unpublished Ph.D. Thesis, Punjab Agricultural University, Ludhiana.*
- Dickey, R.D. and Reuther, W.,** (1940). Flowering, Fruiting, Yield and growth habits of Tung trees. *Fla. Agriculture, Experiment Station, Bulletin.* 343, 28 pp.
- Duke, J.A.,** (1978). The Guest for Tolerant Germplasm. In : *ASA Special Symposium 32, Crop Tolerance to Sub optimal Land Conditions.* Am. Soc. Agron. Madison, WI. 1-61 pp.
- Duke, F.A.,** (1979). Ecosystematic Data on Economic Plants. *Quarterly Journal crude Drug Research* 17 (3-4); 91-110.
- Fairchild, D.,** (1913). *The Chinese wood oil tree.* U.S. Dept. Agri. Burl Plant Indus. BPI Cir. 108, 7 pp.
- FAO** (1996). *Asia Pacific Agroforestry Profiles : Second Eds.* RAP Pub. 1996/20 FAO, Bangkok, Thailand, 343.

Goswami, P.C. 1968. *Shifting Cultivation and its control in the Garo Hills*, Soil Conservation Department, Assam.

Grand staff, S.W., Grandstaff, T.B., Rathakette, P., Thomas, D.E. and Thomas, J.K. (1986). Trees in Paddy fields in North-East Thailand, In : Martin, G.G.(Editor), *Traditional Agriculture in South-East Asia : A Human Ecology Perspective*, West View Press, Boulder, Colo.

Hambleton, J.I., (1950). *Are Honey Bees Needed for the Pollination of Tung trees ?* Gleamings Bee Cult. 78 : 227.

Harsh L.W. and Tewari, J.C.(1993). Tree-crop interaction for Agroforestry practices. *Agroforestry for Rural needs*. Vol.II (Eds Khurana, D.K. and Khosla, P.K.) Indian society of Tree Scientists, Solan, H.P. pp. 535-541.

Hazra, C.R.(1990). Soil and Climatological Studies in relation to agroforestry research, *1st NARP. Training programme*, organized by IGFRI, Jhanshi.

Ilyas, M. (1978). The spices of India – 11. *Economic Botany*, 32(3): 238 – 263.

Jordan, L.A. (1930). *Tung Oil extract* published in the Tropical Agriculturist, LXXV.

- James, A.Duke**, (1983). *Handbook of energy crops*. Unpublished.
- Jha, L.K. & SEN, P.P.** (1989). *Introduction to Social Forestry*. Himalayan Publication, Bombay, pp. 1-199.
- Jha, L.K.** (1995). *Advances in Agroforestry*, APH Publishing Corporation, New Delhi, pp. 1-669.
- Jha, L.K.** (1995). Silviculture of MPTS Suitable for Agroforestry System. *Advances in Agroforestry*. APH publishing Corporation pp. 476 – 541.
- Kang, B.T., Wilson, G.F. and Sipkens, L.** (1981). *Alley cropping maize (Zea mays L.) and Leucaena (Leucaena leucocephala Lam.) in Southern Nigeria plant and Soil 63 : 165-179.*
- Kang, B.T. and Wilson. G.F.** (1987). *The development of alley cropping as agroforestry : A decade of development*. ICRAF, Nairobi, Kenya.
- King, K.E.S.** (1968). *Agri-silviculture (the taungya system)*. Department of Forestry, Bulletin No.1. Ibadan, Nigeria.
- King, K.F.S. and Chandler, M.T.** (1978). *The wastelands*, KRAF, Nairobi, Kenya.

- Lalramnghinglova, J.H. and Jha, L.K.**(1996). Prominent agroforestry systems and important multipurpose trees in farming systems of Mizoram. *The Ind. For*, 122(7) : 604 – 609.
- List, P.H. and Horhammer, L.**, (1969) – (1979). *Hager's handbuch der pharmazeutischen praxis*. Vols 2-6. Springer – Ve.
- Lungdrear, B. and Raintree, J.B.** (1983). *Sustained agroforestry, Agril. Research for development potential and challenges in Asia*, The Hague, ISNAR; pp. 1-25 (cross ref.)
- Mc Cann, L.P.**, (1942). Development of Pistillate Flower and Structure of the fruit of Tung (*Aleurites fordii*). *Journal. Agriculture Research* 65 : 361 – 378.
- Mishra, J. and Prasad, A.** (1979), Maize, ragi, and paddy could be successfully, grown with teak in Bihar, *Indian Forester*, 105 (9) pp. 638-643.
- Nair, K.** (1980). Vanlakshmi agro-forestry project in Kerala, *Indian Forester*, 106(12), pp. 829-836.
- Nair, P.K.R.**, (1984). *Soil productivity Aspects of Agroforestry*, ICRAF, Nairobi, Kenya : 85 pp.
- Newell, W.**, (1924). Preliminary Report on Experiments with the Tung-oil Tree in Florida. *Fla. Agriculture, Experiment, Station, Bulletin* 171, 193-234 pp.

Ong, C.K., Corlett, J.E., Singh, R.P. and Black, C.R. (1989). Above and below ground interactions in Agroforestry systems. *Paper presented to Inst. Conf. On Agroforestry Principles and Practices, Edinburg, 23 – 28 July.*

Ojeniyi SO and Agbede OO 1980 a Effect of interplanting *Gmelina arborea* with food crops on soil conditions. *Turrialba* 30 : 268-271.

Ojeniyi SO and Agbede OO 1980 b Agronomic assessment of interplanting *Gmelina arborea* with food crops. *Turrialba* 30: 290 – 293.

Ojeniyi SO Agbede OO and Fagbergtro JA 1980 Increasing food production in Nigeria, I. Effect of Agri-silviculture on soil chemical properties. *Soil Sci.* 130 : 76 – 82.

Pathak, P.S. and Gupta, S.K. (1987). Soil amelioration role of *Leucaena* in the Agroforestry System, *Proc. Int. Workshop on Agroforestry for rural needs*, New Delhi.

Pering A.H., (1937). Tung Oil Production and the Beekeeper, *America Bee, Journal.* 77 : 526 – 527.

Potter, G.F. and Crane, H.L., (1957). Tung Production. *U.S. Dept. agri. Farmer's Bul.* 2031. 35 pp.

Prasad, R.N. Pati Ram, Baroah, R.C. and Munna Ram (1981). *Soil fertility management in North Eastern Hill region. Res. Bull.* 9, ICAR Res. Complex for NEH region, Shillong.

Rao, N.G.P., Rana, B.S. and Tarhalkar, P.P. (1979). Stability, Productivity, Profitability of some intercropping system in Dryland Agriculture, *Proceed. Intern. Workshop on intercropping Hyderabad.* Pp. 297 – 298.

Rao, Y.S. and Mac Dicken, K.G. (1991). Foreward, In : *Agroforestry in Asia and the pacific*, Mellick, W., Rao, Y.S. and MacDiken, K.G. (EDS), RAPA Publication, pp. 1-2.

Regional Remote Sensing Service Centre., (1999). ISRO, Dept. of Space, Govt. of India, Dehradun and Govt. of Mizoram, Dte. Of Agriculture & Minor Irrigation, Aizawl. *Natural Resources Database Generation of Mizoram State and Landslide Hazard Zonation of Aizawl District.* 1- 9 pp.

Reynolds, L, Atta – Krah, A.N. and Francis, P.A. (1998) *alley farming with Livestock Guidelines, Humid zone Research Site, International livestock centre for Africa, Nigeria,* pp. 1-30.

Rodin AR and Nikitin FA 1985 Integrated Utilization of plantation area. *Lesnoe Khozyaistov* 5 : 45 – 47.

- Santra, S.C.** (1993). Selection for plant species for Agroforestry an evaluation of the choice of basic criteria. *Indian Society of Tree Scientist Solan H.P.*, pp. 772 – 777.
- Shankaran, K.A., Harsh. L.N. and Katjus** (1987). Agroforestry in Arid region of India. *Agroforestry system*, 5 : 59 – 68.
- Sing, A.** 1978. Shifting cultivation and soil erosion problems in North Eastern Hill region, *paper presented at XVI Annual Convention of ISAE, IIT, Kharagpur.*
- Sing, A. and Singh, M.D.** 1978. Effect of various stages of shifting cultivation on soil erosion from steep hill slopes. *Indian forester*, 106 (2) : 115-21.
- Singh, A. and Prasad, R.N.,** (1980). *Soil and water conservation technology for Jhumland.* ICAR Research Complex, Shillong.
- Singh, Chhidda,** (1983). *Modern Techniques of raising field crops* (19); 245 – 259.
- Singh, GB** 1983 Role of Agroforestry in improving the environment. *Indian Fmg.* 33:15-19.
- Singh, K.A. and Pradhan, I.P.** (1993). An appraisal of Semi-indigenous farming system with special reference to agroforestry in

Sikkim (Eastern Himalayas) *Indian J. Hill farming* 6 : 113 – 124.

Singh, K.A. (1999). Resource management and productivity enhancement through agroforestry in eastern hilly agro-ecosystem of India. *Indian J. Agroforestry* 1(1) 63-72.

Sinha, B.N. (1985). Role of Agroforestry in soil and water conservation, *Proceedings, social Forestry workshop*, BAU., pp. 90-99.

Steninlin H 1978 Increased food production through agri-silvicultural land use system in humid tropics. *Allgenmeine Forest – und Jagzeitung* 149 : 157-164.

Torries F 1983 Potential contribution of *Leucaena* hedgerows intercropped with maize to the production of organic nitrogen and fuelwood in lowland tropics *Agroforestry systems* 1: 323 – 333.

Thapa, H.S., Sahoo, U.K. and Jha, L.K. (2000). Non wood forest products in Mizoram: An overview. *Proc. International Workshop on Agroforestry and Forest Products* 29th – 30th, Nov., 2000, Department of Forestry NEHU, Aizawl, Mizoram: 349 – 358 pp.

Wang HH, Ma WJ, Deng CZ and Li DH 1982. The exploitation of tropical rain forest in relation to soil and water conservation in Southern Yunnan. *Scientia Sinica* 18 : 245 – 257.

Webster, C.C., (1943). A note on Pollination in Budded Plantations of Tung Trees. *Nyasaland Agriculture Quarterly Journal III* (3) : 17 – 19.

Young A. (1990) Agroforestry, environment and sustainability, *outlook on Agriculture*, Vol. 19, pp. 155-160.