GROWTH BEHAVIOUR AND YIELD OF MAIZE (*Zea mays*.L) AS AFFECTED BY DISTANCE FROM TUNG(*Aleurites fordii*.Hemsl.) IN AN AGROFORESTRY TRIAL IN MIZORAM

THESIS
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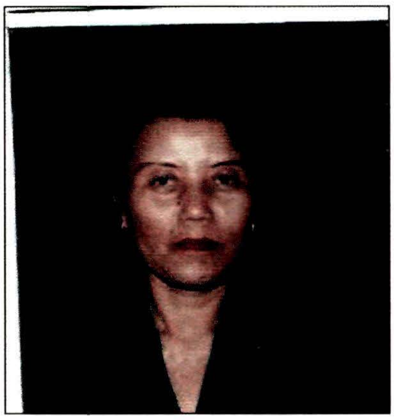
DEDICATION



Mrs. R. Vanlalsangi

Dedicated to my mother who showered me with love and unflagging support.

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I certify that the thesis entitled " ***Growth behavior and yield of Maize as affected by distance from Tung in an agroforestry trial in Mizoram"*** *submitted by Miss Julie Zodinpuii in partial fulfillment for the degree of Master of Science in Forestry (Agroforestry) to the North Eastern Hill University embodies the record of original investigation carried out by her under my supervision. Further, this work has not been submitted for any degree of any University in part or full.*

I wish Miss Julie Zodinpuii all success in life

Supervisor

Aizawl

The 17th December 2001

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INTRODUCTION

1.1 Agroforestry – A Historical Perspective:

The practice of growing trees and crops together existed in different traditional forms of agriculture since antiquity. During the Han Dynasty (206 BC-AD 220), administrators recommended the development of forests together with the raising of livestock and crops (Zhu *et al.*, 1993). The integration between forestry and agriculture had been adopted in Egypt long before the term "Agroforestry was coined (Lakany, 1987). In India, Chanakya had conceived this dual system of production on a small scale during the period 321 -300 B.C. The system of raising trees along with crops has been in vogue in forest department for over 100 years (*taungya* cultivation), in which, forest lands are leased out to the cultivators for raising cereal crops. The cultivators in turn are expected to protect the tree seedlings and saplings. The word *Taungya* (Burmese meaning *taung*-hill, *ya*-cultivation originated in Burma (Myanmar) and spread to several tropical countries like Java, Indonesia, Nigeria, Bangladesh and India. The taungya system is perhaps one of the oldest and most widely practised land use system of simultaneous production of trees and crops in the early stages of plantation establishment (Nair, 1983).

1.2. Scope and definitions of Agroforestry :

The term, agroforestry was coined almost at the time of establishing the International Council for Research in Agroforestry (ICRAF) during 1977. It is a new word used in place of shifting cultivation or agri silviculture or the taungya system (Steward, 1981).

Several investigators across the world have defined agroforestry in various ways. According to annual report (1999-2000) of Indian Agricultural Statistic Research Institute (ICAR), agroforestry is defined as the science of designing and developing integrated self sustainable land management system, which involves introduction / retention of woody components including trees, shrubs, bamboos, canes, palms, alongwith agricultural crops including pastures / animals simultaneously or sequential on the same unit of land, and at the same time meets the ecological as well as socio - economic needs of the people. Baumer, (1991) defines agroforestry as the integration of woody perennials with arable crops as an alternate land use system in the tropical world.

In practice, agroforestry refers to "land use systems and technologies in which woody perennials (trees, shrubs, palms, bamboos etc.) are deliberately combined on the same land management unit with herbaceous crops and /or animals either in some form of spatial arrangement or temporal sequence". In agroforestry systems, there are both ecological and economic interactions among the different components (ICRAF, 1986). According to Rao and Mac Dicken (1991) agroforestry is "a land use that involves deliberate retention, introduction or mixture of trees or other woody perennials in crop/animal production field to benefit from the resultant ecological and economic interaction" Agroforestry is an integrated land use planning system following the principle of generating multiple resources from the some unit of land (Sinha, 1985).

1.3 Importance of agroforestry :

In an agroforestry system, agricultural crops are grown along with the forest plants. In this system, silvicultural practices are combined with practices to grow crops, fodder, energy plants and also animals are sometimes reared in the same piece of land. Such a system is essentially developed to extract the maximum potential from a unit of land to support the people dependent on the system, and also to maintain the sustainability of the system through ecologically sound practices. Appropriate agroforestry systems have the potential to control erosion, maintain soil organic matter and physical properties, augment nitrogen fixation and promote efficient nutrient cycling (Young, 1989). When agroforestry is scientifically implemented, it generates several positive environmental impacts and enhances crop productivity (Jha, 2000).

In any agroforestry system the priority considerations are conservation of soil and water, maintenance of ecological balance, maintenance and/or improvement of soil fertility and crop productivity, scope for production of food, fuel, fodder, medicine, timber and other economic plants for the sustainability of the local population and also to generate additional year-round employment opportunities to the people for their self reliance (Mokhopadhyay, 2000). Agroforestry systems can be sources or sink of green house gases depending on the components of the system and the methods through which these are established (Solanki and Bisaria, 2000). In the present situation, considering the goods an agroforestry system can provide, this system of agriculture holds the potential in sustaining productivity levels and ensuring positive ecological interactions for the benefit of both the end users (human populations), and the provider (the land).

1.4 Agroforestry and its relevance to Mizoram :

Agriculture is the mainstay of the people in Mizoram. The traditional system of farming, commonly known as shifting cultivation or ***Jhuming*** is practiced by a majority of the farmers. In this system of farming, large forest areas are clear felled and burned for cultivation of different crops like paddy, maize, ginger, etc. and other vegetables. This type of farming system adversely effect the ecology by exposing the soils of predominantly steep terrain to the onslaught of heavy monsoons, thus increasing the potential of soil erosion which is accompanied by the loss of various soil nutrients. Further, the process of burning also adversely affects the soil organic matter and physical characteristics.

In the past, the rotation for jhum was long with fallow periods of 20-30 years between two consecutive cropping on the same plot of land, thus making allowances for the reclamation of soil fertility during the fallow period. But recently, due to increasing population pressures, this cycle has been reduced to about 4 - 5 years. The system has thus evidenced serious soil losses due to erosion, and decline in soil fertility status and productivity. In the hilly terrain shorter jhum cycle or continuous cropping without soil and water conservation measures has deteriorated the nutrients status of the soil. Narayana (1990) estimated soil losses in different regions of north India, and concluded that the loss was the highest in the north eastern states and hilly terrain. This is mainly due to practice of shifting cultivation or permanent cropping systems without any effort to prevent soil erosion and water loss.

In the jhum system, while burning the slash, carbon, nitrogen and sulphur are lost due to volatilization (Solanki and Bisaria, 2000). After the burn and before the onset of the first rains, a sizeable quantity of nutrients are lost through blown-off ash due to strong winds during the dry period. The sediment loss during cropping period was reported to be 30 t/ha./year in a jhum cycle of 5 years and with the shortening of the cycle the losses tend to be higher. Jungle cutting, burning, clearing and dibbling of seeds can be discernible from the fact that it counts for nearly 3.7 t/ha. of soil material to slide / roll down to foot hills annually (Singh, 1978).

It is thus evident that this form of agriculture , in its present form, cannot sustain the increasing population table , nor can it ensure the conservation of the soil fertility and physical characteristics for long term productivity. The logical solution to the problem thus lies in developing and/or identifying other forms of ecologically sound and sustainable forms of agriculture which can ensure the well being of the people.

To wean away the farmers from the ecologically detrimental shifting cultivation practices, several alternative models have been suggested. The ICAR has suggested 3 tier system i.e. cultivation of trees at the hill top, cultivation of horticultural crops in the middle portion of the hill slopes and forming terraces at the lower portion of the hill slopes for cultivation of field crops (Jha, 2000). SALT (Sloping Agriculture Land Technology) system has also been suggested as an alternative to jhuming. SALT is a way of farming that can turn a parcel of sloping land into a highly productive upland farm (Mokhopadhyay, 2000). In Philippines SALT is claimed to have certain advantages over both the traditional techniques of shifting cultivation and conventional terrace farming by enabling the farmers of highlands of the Philippines to stabilize and enrich the soil and to grow food crops economically. Among other alternative to shifting cultivation or improvement of jhuming, agro-forestry based systems may be one of the viable options in this region.

As a science of designing and developing integrated self sustainable land management systems with introduction/retention of woody components including trees, shrubs, bamboos, canes, palms etc. along with agricultural crops , in the North-Eastern region, traditional forms of agroforestry had been practiced by farmers in some form or other since ancient times. Such agroforestry practices are (1) Shifting cultivation with retention of trees (2) Taungya cultivation, (3). Intercropping with plantation crops, and (4) Home gardens or homesteads.

Some of the common tree crop combinations practiced in traditional agroforestry systems in the state are:-
1. Intercropping of paddy (*Oryza sativa*) and teak (*Tectona grandis*). This practice is very successful during the initial growth stage of teak.
2. Cultivation of Paddy or vegetables along with tung (*Aleurites fordii.*) is another combination. Some of the common multipurpose tree species present in the state are *Albizzia* spp, *Artocarpus heterophylus, Cassia* spp, *Gmelina arborea, Schima wallichii, Leucaena leucocephala, Erythrina indica, Bischoffia javanica,* etc.

1.5. Identification of the problem :

Mizoram has the highest proportion of land under shifting cultivation. This is for the basic reason that compared to all other states, Mizoram has the least percentage of flat land. The topography of the whole state is undulating, characterized by steep hills interspersed with deep gorges where cultivation is extremely difficult (Mahajan, 1990). It is therefore not surprising that the losses of topsoil from such steep terrain due to practice of jhuming, compounded by the characteristic heavy monsoons is colossal, rendering the uncovered (deforested) jhum plots unproductive within a few years. Different forms of agroforestry is increasingly advocated as alternatives to arrest and even reverse the problem of deterioration of the fragile topsoil , and to make the agricultural systems more sustainable. Besides, such systems are envisaged to increase the returns to the marginal farmers by including the tree component which can also act as an insurance in instances of agricultural crop failure.

Additionally, the successful establishment of agroforestry models would also help in protecting the remaining forest cover from the ravages of jhum related deforestation. In fact, in the North East, this is a primary reason for the depletion of virgin forest stands. Tung (*Aleurites fordii.* Helms.) is cultivated for its seeds, the endosperm of which is used to produce a superior, quick drying oil used in a variety of industries like the manufacture of lacquers, varnishes and paints, leather goods, greases, brake linings, and as coatings of containers used for medicines and food products , and as insulation of wires and metallic surfaces. Maize (*Zea mays*) is the second most important crop of the state, being next only to paddy. The present study aims at investigating the growth behaviour and yield of maize as affected by distance from tung.

1.6 Objectives :

The present experiment was attempted to develop a viable agroforestry model combining Tung and maize as the tree and crop components respectively, which would be socially acceptable, ecologically sound and with enhanced economic return. The following aspects were investigated in course of the study:-

(1) The growth behaviour and yield of maize as affected by distance from tung (*Aleurites fordii.)*

(2) The physico and chemo- edaphic factors (soil moisture ,pH, soil conductance, soil nitrogen).

CHAPTER - II
REVIEW OF LITERATURE

REVIEW OF LITERATURE :

2.1 Agroforestry :

Agroforestry which had been an old practice in the tropics though the term was coined recently, has been advocated as an efficient land use practice to fulfil the basic needs of fuel, fodder and packaging material apart from conservation of soil, water and nutrient particularly on the marginal lands (Khosla and Toky, 1986). Agroforestry can be defined as the deliberate combination of trees with crop plantation or pastures, or both, in an effort to optimize the use of accessible resources to satisfy the objectives of the producer in a sustainable way (Torres, 1983). Agroforestry also defined as a land use 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).

Narayana (1986) has stated that agroforestry is a sustainable land management system which increases the overall yield of the land, combines the production of crops and forest plants simultaneously on the same unit of the land. It is therefore, socially, culturally and ecologically acceptable form. A land use that involves deliberate retention, introduction or mixture of trees or other woody perennials in crop/animal production field to benefit from the resultant ecological and economic interaction (Rao & Mac Dicken, 1991).

According to Bentley at. al. (1986) agroforestry has potential advantages for poor rural India. Like modern high yield intercropping systems, agroforestry has several characteristics of interests : (1) Complexity, (2) Productivity, (3) risks and (4) investment. Each characteristic has advantages and disadvantages for the poor which can be manipulated and improved with applied research.

A number of research work has been conducted on various aspect of agroforestry. Agroforestry intercropping system is an adaptation and refinement of the bush fallow system commonly practiced by small scale farmers in Africa (Wilson and Kang, 1981). Encouraging results have been obtained from agroforestry intercropping studies conducted at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (Hartman, 1981, Wilson and Kang, 1981) where the practice originally acquired its name.

The positive role of multipurpose trees (MPTs) in mixed farming systems that have been frequently studied, may prove to be useful for agroforestry, particularly in traditional shifting cultivation where in the lands are left fallow for varying time period (Felker and Bandursky, 1978). Singh *et. al.*, (1978) reported reduced nitrogen leaching under legume intercropping with cereals. The practice of intercropping, particularly with MPT's besides reducing nutrient leaching would also reduce the fallow cycle of traditional shifting cultivation agriculture to one year period, which could mean an increase in arable crop land as well as crop (s) produced (Yadav, 1981). According to Andrews (1972) intercropping of tree species and agriculture crop has the following advantages :-

(1) Better spread production over the growth period.
(2) Higher combined yields
(3) Higher yield stability from season to season.
(4) Improve quality of products
(5) Reduced adverse effects of pests
(6) Higher returns
(7) Better soil protection against erosion.

Sekar *et. al.*, (1993) reported that trees in alleys form reliable fodder source in lean season, conserve the soil and moisture, and improve the soil productivity to provide sustained yield. If Saline- alkaline, so far barren, are brought under agroforestry particularly under plantation species further deterioration of soil and becoming unproductive can be checked. It is estimated that yield as much as 40 tonnes of wet wood per hectares per year can be obtained from such plantation. If proper species are selected and agroforestry practices are followed it is not exaggeration that very high yields can be obtained (Patel, 1988).

Species selected for agroforestry intercropping must be easy to establish, fast growing, deep rooted, coppicious, have the ability to withstand frequent prunings and be able to produce heavy and easily degradable foliage (Wilson and Kang, 1981). There are many tree species which have found to be suitable for intercropping of arable annual/perennial crops (Nair, 1984; young, 1987; Dwivedi; 1992). Among these prominent tree species are *Acacias, Poplars, Eucalyptus, Albizias,* etc.

Pruning helps in minimizing the shade effect on intercrop and maintain the quality of timber, fruits, etc. Duguma *et. al.*, (1988) reported that maize and cowpea yield were higher with the increase in pruning frequency on decrease in the pruning height. The yield of arable crops increased a specially in 7.8 m. alley width in the mulch system. The mulch system supplied Nitrogen to the arable crops and increase the yield (Konwar *et. al.*, 1988). Sheikh and Haq, (1978) conducted a study to find out the effect of shading of individual trees growing in the agricultural fields on the yield of crops. *Acacia nilotica* (Babul) and *Dalbergia sissoo* (Shisham) were tried into localities and found that they have deleterious effect on the crop yield, the maximum loss being within 2 m. radius of the tree and also that the yield were poorer from the portions of the crop falling on the northern side of the tree. Intercropping with nitrogen fixing trees and alley cropping system are highly suitable for subsistence farmers with poor, degraded sites. The leguminous shrubs and trees have great influence in building up soil nitrogen, soil organic matter and also help in improving other soil nutrients with their leaf litters. The influence of the 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).

Reynolds *et. al.*, (1988) reported that leguminous trees planted along the contours limit soil erosion. Muhammed, (1984) has stated that agroforestry open a big scope for not only increasing the production wood (long term) but also provides increased production of cereals, fodder, oilseeds, legumes, vegetables, etc. (short term) and generate steady income for the farmers.

Khattak *et. al.*, (1980) reported the effect of forest trees on the yield of agriculture crops grown as interculture. *Populus delloides, Eucalyptus Citriodora, Dalbergia sissoo* and *Bombax ceiba* were planted at 4.3 x 4.3 m and underneath wheat was sown. It was found that yield under *Dalbergia sissoo* was significantly higher (1916 kg. $ha.^{-1}$) as compared to other species. The yield from control plots was 2,000 kg. ha. on an average.

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). *Leucaena* is claimed to be the most ideal species for agroforestry. Because of number of advantages such as no competition with field crops, fixation of nitrogen, easy decomposition of litter, fast growth and easy established, high yield of wood and fodder (Hegde, 1984).

Shankaran *et. al.*, (1987) reported that Moongbean and tree species (*P. cineraria and A. albida*) had positive interaction and that moongbean productivity was increased under these tree species. Jha *et. al.*, (1989) reported that soyabean gave the highest yield (6.31 g/ha) in combination with tree species.

Sheikh and Haq (1986) have studied the effect of poplar rows on the yield of sugarcane in Peshawar valley. The poplars depressed the sugarcane crop 0 to 10 m away from the trees. The yield was 80 t./ ha elsewhere, while average yield from the study area was 75 t./ha.. Singh (1983) reported a marked increase in productivity of Pigeon pea (*Cajanus cajan),* til (*Sesamum indicum,),* Castor (*Ricinus Communis*) and Jowar (*Soghum vulgare*) under Leucaena.

Ojeniya and Agbede (1980 a, b) and Agbede (1985) reported that Yam (*Dioscorea bulbifera*) and maize can be grown adequately with young *Gmelina arborea* trees. Kang *et. al.*, (1981) and Torries (1983) suggested interplanting of maize with *Leucaena* spp. in nitrogen deficient soils. According to the study conducted by Grewel *et. al.* (1992) combination of *Leucaena* with maize gave significantly higher net return as compared to pure maize. Intercropping of bamboo and tea with *Aleurites spp.* is being done in Vietnam (F.A.O., 1996).

A typical agroforestry system will allow economic and ecological interactions between woody and non-woody components and also increase, sustain and diversify the total land out put (Nair, 1989).

2.2. The tree component :

TUNG :

Latin name	*Aleurites fordii.*
Common name	Chinese wood – oil tree
Family	*Euphorhiaceae*

The Tung tree is native to central and western China, where seedlings have been planted for thousands of years. It was also planted in Southern United States from Florida to Eastern Texas. Tung tree has also been known as Tung-nut, Tung oil or china wood oil tree (Fairchild, 1913). The word 'Tung' is Chinese for 'heart', the general shape of the leaf (Potter and Crane, 1957).

Aleurites fordii. Hemsl., the Tung oil is by far the most important species that yield Tung oil more commonly known as the Chinese wood oil of commerce. The oil which is found in the cell of the seeds, is colourless and neutral in reaction (Gardner *et. al.*, 1941). The best Chinese Tung oil is a darker in colour and contain upto 7% of acid. The dark colour is obtained due to its indigenous methods of handling in China.

Aleurites fordii., Hemsl., belongs to the spurge family Euphorbiaceae, there being five species of this genus known to science (Newell *et al.*, 1935).

In appearance the Tung Oil tree is somewhat similar to the Japanese varnish tree (*Sterculia platanifolia*, L.) commonly used for street planting and as an ornamental shade tree in the south in America (Newell *et. al.*, 1935). It is a very low tree which ranges from 15 to 30 ft. height, or less with an equal spread of the crown i.e.. 15 ft. to 30 ft. in diameter. In China, they generally grow 20 to 25 ft. in height and are small sized, about 10 inches in diameter, at breast height. In some localities, however, the trees attain a height of even 50 ft. to 60 ft. with a crown of 60 ft. maximal spread in diameter. (Jordon, 1930).

It is a deciduous tree with a low branching habit and has a much branched spread of the crown. It is said that the Tung tree has a tap root, this is the case initially, but the condition does not remain for long, as development of the main root does not deep pace with that of the branch roots which soon outgrow it.

The colourful and attractive blossoms, which are borne on the ends of the growing shorts of 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 vigor 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 three to five cell ovary that, when pollinated, produces a top-shaped fruit 2 to 3 inches in diameter, usually bearing five seeds. The blossoms secrets some nectar, and the staminate flowers produce a copious amount of pollen (Pering, 1937)., Bees visit the blossoms freely. The fruit of the Tung is roughly spherical in shape, about 11/2 to 3 inches in diameter, smooth and glabrous narrowed at both ends with a smooth surface, when mature, and in appearance somewhat like a russet apple. There are 3 to 4 seeds in each fruit, each 3/4 to 1 inch long and broad, very slightly ridged and warty on the surface, in as many one-seeded segments, though occasionally there may be 7 seeds in a fruit, when, however, the size of the individual seeds is correspondingly smaller the shell which is comparatively thin opens from the base upwards, on ripening. The chromosome number of *Aleurites fordii.* is 22 (Biwas, 1946). The hard outer shell and a kernel are the portions of the seed from which the oil is obtained (James, 1983).

The natural habitat of , *Aleurites fordii.* is characterized by hot tropical summers and cold winters, with temperature as high as 90^0 F to 110^0 F; cold winter with a fair amount of snow that often lies on, the temperature falling sometimes to 20^0 F. (Empire Marketing Board Bulletin, 1930).

According to Duke (1978 - 1979) *Aleurites fordii.* is found from sub-tropical dry to moist tropical very dry to dry forest life zones. This species is reported to tolerate annual precipitation of 6.4 cm.

to 17.3 cm., temperature of 18.7^0 C to 26.2^0 C pH of 5.4 to 7.1. 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 loses from spring frosts. Contour planting on high rolling land escapes frost damage.

Aleurites fordii. is also able to thrive on rocky hillsides and on poor soils (Troup, 1932). It grows equally well on conglomerate and stone or sandy clay. The soils must be well drained, deep aerated, and have a high moisture holding capacity to be easily penetrated by the roots. Green manure crops and fertilizers may be needed. In India the tree has done well on poor lateritic loams, as well on a variety of other soils, and on impoverished agricultural soils. The soil must be moist and at the same time have good drainage, because the trees cannot withstand water logging, even for short periods.

Tung trees may be propagated by seed or budding. Seedlings which have been self-pollinated for several generations give rather uniform plants. A 'mother' tree proven worthy by progeny testing may be propagated by budding. The budded trees, which are generally identical with the original tree, will provide an adequate supply of seed satisfactory for planting. Seedlings are used for the root system for budded trees. Most successful budding is done in late August, by the simple shield method (James, 1983). Seeds are sown during March/April in a warm green house. When the seedlings are large enough to handle, they are pricked out into individual pots and grow for at least the first winter on a green house. In the early summer, they are planted out in the main field and are protected from the cold for their first winter out doors.

Tung trees usually begin bearing fruit the third year after planting, and are usually in commercial production by the forth or fifth year. 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%. Tung trees yield 4.5 to 5 MT/ha. fruits. Fruits may be gathered all through the winter season when other crops do not need care. Because all fruits do not fall at the same time, two or more harvests may be desirable to get the maximum yield. The distribution of oil in different parts of the fruit are- the kernel (14 to 20 %), and the nut (53 to 60%)l. The oil is composed of 75 to 80 % α - 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 trees are cultivated for their seeds, the endosperm of which supply a superior quick - drying oil, utilized in the manufacture of lacquers, varnishes, paints, linoleum, oil cloth, resins, and in cleaning and polishing compounds. Tung oil products are used to coat containers for food, beverages, and medicines, for insulating wires and other metallic surfaces, as in radios, radars, telephone and telegraph instruments (James, 1983).

Tung oil is also used as an ingredient for water proofing masonry. The residue remaining after the extraction of oil from the nuts is burnt to soot and is then mixed with the wood oil to form a paste for caulking the boat. Another caulking mixture is made by mixing the oil with lime and bamboo shavings (Newell *et. al.*, 1935).

As a water resisting varnish it is extensively employed in the treatment of aeroplane fabrics (Bunting, 1931). The water resisting property is due to the presence of elaeo stearic acid, Tung being the only oil of commercial importance containing this particular conjugated unsaturated fatty acid as its principal constituent.

Tung oil forms an important ingredient in leather dressing. It is also used in the manufacture of soap (Newell *et. al.*, 1935). In the existing literature, no examples having tung as the tree component could be found.

2.3 Maize :

Latin name	:	*Zea mays*. L
Family	:	*Gramineae*

The term maize which has been derived from an Arawak - Cexis word, 'Mahiz' is also known as Indian corn. In the United States of America, it is simply known as corn. Maize occupies an important place among the cereals throughout the world and ranks third both in terms of area and production. In India, however, it occupies the fifth position in respect of area and ranks fourth in terms of production.

Maize was believed to be originated in the America. Many theories have been put forward to understand its origin. Anderson (1945) put forth the suggestion that primitive maize (With 20 chromosomes) may have originated from a cross between two species that had 10 chromosomes each, perhaps those of Coix and Sorghum.

Even in India, although there are varieties which may be regarded as 'local', the crop is regarded as only a foreign introduction. It is presumed to have been introduced through the trade links prevalent during the beginning of the 16th Century when Portuguese brought it to the west coast of Africa, India and China.

Maize forms the second most important food crop coming only next to paddy in the north east states of the country. It is consumed in the form of rotis, roasted ears, pop corn and porridge. It is also an important constituent of animal feeds, particularly poultry feed. It is the most widely used material for the manufacture of starch and starch derivatives. Maize oil is being used increasingly for cooking purpose. The cobs are used for making corn pipes and as fuel to make charcoal and in the preparation of industrial solvents. Maize grains contain about 10% protein, 4% oil, 70% carbohydrate, 2.3% crude fibre, 10.4% albuminoids, 1.4% ash. Maize grain has signified quantities of vitamin A, nicotinic acid, riboflavin, and vitamin E. There is no cereal on the earth which has so immense potentiality and that is why it is called 'Queen of Cereals' (Singh, 1983).

Maize is an important cereal and forage crop which is extremely popular as a companion crop in Mizoram. In Mizoram, maize covers an area of 5,277 ha. with an annual production of 9,702 MT in the year 1999 to 2000 (Statistical Abstract, Department of Agriculture and Minor Irrigation, Mizoram, 1999 - 2000).

Maize (*Zea mays* L.) is an annual plant which belongs to family - *Gramineae* and Genus - *Zea*. It is a tall plant which normally grows to a height of 150 to 300 cm. or even more. Being graminaceous plant, maize has a fibrous and deep root system. It consists of seminal roots, crown or coronal roots and brace or aerial roots. The stem is made up of approximately 12 to 18 alternating nodes and internodes and is completely filled with pith. The leaves develop alternately on opposite sides of a stem. The leaf consists of a rigid sheath enveloping the stem, a broad, large and thin blade having a prominent midrib.

Like other cereals, maize bears flowers in spikelets. It is a monoecious plant having two type of inflorescences staminate (tassels) and pistillate (cobs) at two angles on the plants. The male flowers are borne in a cluster (tassel) on top of the end of the stem as a terminal panicle, while the female flowers are borne inside the young cobs which spring from one of the nodes on the stem usually located about midway on the stalk (Singh, 1983).

A grain of corn is the largest of any cereal seed, like any seed, consists of three main parts - the germ, which contain the beginning of the stem, the root and the leaves of a new plant, a white filling called endosperm which nourishes the tiny plant and the hull which protects it. The grain of corn is really a fruit because it consist of a ripened ovary (Jotshi, 1993).

Warm weather favours growth, development and yield of maize, but it is practically grown in extremely divergent climatic conditions viz. temperate to tropical, and upto altitudes of over 2,500 m. Night temperatures below 15.2^0 C and frost at any stage of growth may be fatal to the crop. Stormy weather is extremely harmful as it causes splitting of tender leaves and lodging of plants (Singh, 1991).

Maize was considered to be a kharif season crop but evolution of thermo and photo insensitive varieties have made it possible to grow the crop throughout the year and in almost in every part of the country. Maize requires considerable moisture and warmth from germination to flowering. The most suitable temperature for germination is 21^0 C and for growth 32^0 C. 50 to 75 cm. of well distributed rains is conducive to proper growth (Singh,1983).

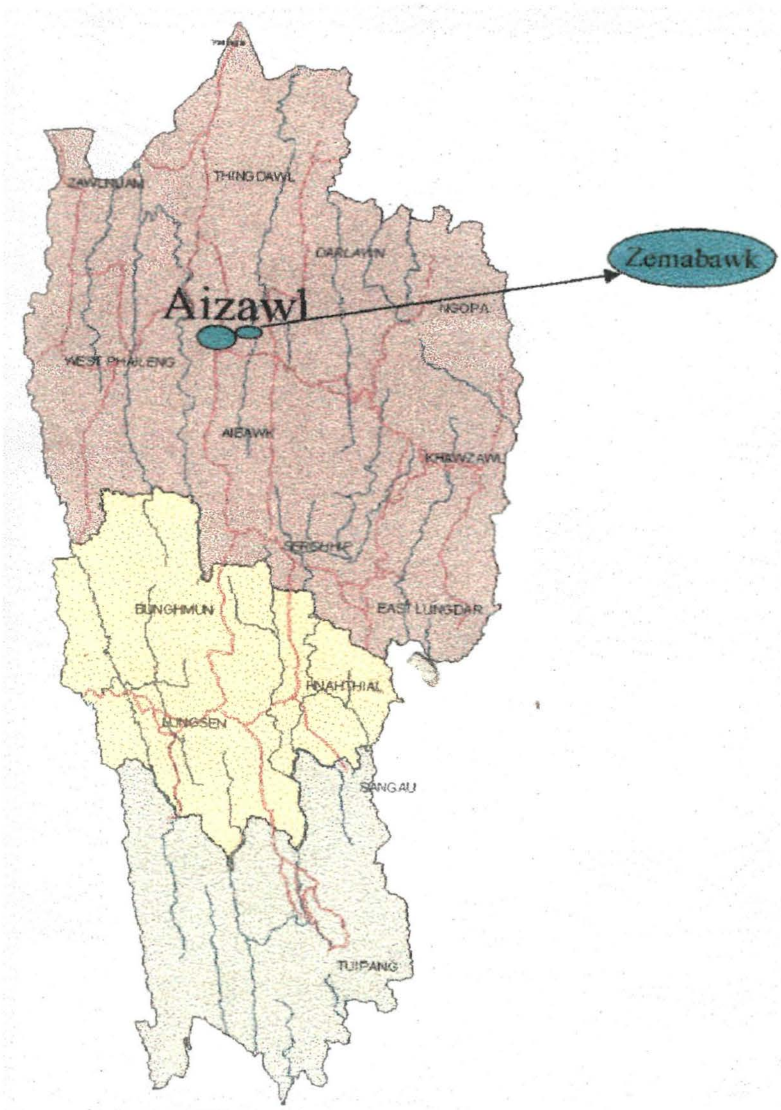
Maize prefers deep and fertile soils which are rich in organic matter content. Light and neutral soils are better for the crop because they offer good drainage and salt free conditions for the crop growth as the maize seedlings are very susceptible to salinity and water logging. Maize can be grown successfully in soils with pH ranging from 5.5 to 7.5.

Maize is one of the world's leading crops cultivated over an area about 120 million ha. with a production of about 394 MT of grain (1979). In India it is grown over an area of 5.7 million ha. with total production of about 6 MT.

CHAPTER - III

STUDY AREA

FIG. I : LOCATION MAP OF EXPERIMENTAL SITE



STUDY AREA :

3.1 Location and physiography :

Geographically Mizoram lies between 21^0 56' - 24^0 31' N latitudes and 92^0 16' - 93^0 26' E longitudes , and having 21,081 sq.km. of land area. The tropic of cancer divides the state into two almost equal parts. The state is bounded on the north by Assam and Manipur, on the east, and south by Chin Hills and Arakan Hills of Myanmar and on the west by Chittagong Hill tracts of Bangladesh and Tripura state, (Patnaik, 2000).

The relief of Mizoram is mountainous and the terrain is of tertiary formation, inclining north to south in parallel series. Structurally they are low plunging anticlines and synclines. The ranges are separated from one another by narrow and deep river valleys, with very small patches of level land.

3.2 Climate and soils :

Mizoram enjoys a moderate climate due to its tropical location. The region falls under the direct influence of monsoon rains, as such it receives adequate amount of rainfall. The climate is hence classified as humid tropical and is characterized by short dry winter and a long summer and heavy precipitation. In Autumn the temperature is usually between 18^0 C - 25^0 C while winter temperature records normally between 11^0 C - 23^0 C. The summer temperature is usually between 21^0 C - 30^0 C.

The average annual rainfall for the whole of Mizoram is 250 cms. Precipitation varies from 170 mm. in the northern and western parts to 2900 mm. in the eastern and southern areas.

The soils vary from sandy loam, clayey loam to clay. In the hilly terrain they are well drained, deep to very deep, moderately rich in organic carbon, low in available phosphate content and medium in available potash content. They are poor in bases, rich in iron and have low pH value.

Soils in the valleys and flat land have heavy texture, poorly permeable water table (with 1 m. depth). They are alluvial and colluvial, most fertile and productive soils. The narrow valleys have light and coarse texture, well-drained, well aerated and young soils, (Thansanga, 2000).

3.3. Site characteristics :

The field experiment was carried out at Zemabawk. The site is about 4 km. east of Aizawl, the capital of Mizoram, and lies between 92^0 15' to 93^o 29' longitudes and 21^0 58' to 24^0 35' N latitude. The altitude of Zemabawk is 1132 m. The topography of the site is slopy. The soil in the experimental plot is sandy loam, black in colour with pH ranges from 5.7 to 6.3. The common weed species found at the site are *Eupatorium* spp., *Imperata Cylindrica, Ageratum Conyzoides,* etc.

CHAPTER - IV

MATERIALS AND METHODS

MATERIALS AND METHODS :

4.1. Experimental design :

The field experiment was carried out in a 40m x 40m area planted with 3 years old Tung (*Aleurites fordii.*). The trees were not planted in any desired spacing rather they are distributed somewhat randomly within the experiment plot. The spacing of trees varied from 3.5-5 m. Seeds of Maize (*Zea mays* var. Vijaya composite) was sown at the onset of the first monsoon rain i.e. at the end of April as an intercrop.

Individual trees formed the foci of sampling. Around each tree, radii of either A- 20 cm, B-40cm, C-60 cm or D-80 cm was demarcated on four sides of the trees. These four points were used for planting the maize (four plants per tree). This unit of sampling was replicated five times. Therefore, for each of the distances five trees formed the total sample, and for the four distances a total of 20 trees. For each treatment (distance) 20 plants were sampled, and for four distances 80 plants.

In the study area, 100 trees were selected and marked using the table of random numbers. From among these selected trees, another 20 trees (five for each of the four treatments) were similarly demarcated using the table of random numbers. A monthly sampling programme for the period of sowing to harvest i.e. from May – August was carried out and the required data were collected and analysed.

4.2 Parameters analysed :

The different parameters recorded and analysed for the study are as here under :

1. Physicio - edaphic factor :
   a) Soil moisture
2. Chemo - edaphic factor :
   a) Soil pH
   b) Soil conductance
   c) Available nitrogen content.
3. Biolic factor :
   a) Height of maize in centimetre at 30,60,90 DAS (days after sowing) and at harvest
   b) Number of leaves per maize plant at 30,60,90 DAS
   c) Yield -
   i) No. of cobs per plant
   ii) No. of grains per cob
   iii) Weight of grains per cob
   iv) Total weight of grain yield per plant.

4.3. Sampling programme and soil analyses :

A monthly sampling program was undertaken during the period May 2001 to August 2001 to record and estimate various abiotic and biotic factors as detailed below. Each sample was replicated five times during each sampling occasion.

Soil samples were taken with the help of soil auger at 10-15cm depth. The following parameters were analysed :-

(1) Physico-edapic factor :

Soil moisture :

The soil moisture loss on drying to constant weight was determined for 100gm of fresh soil. Soil moisture content was expressed as

$$\text{Moisture \%} = \frac{\text{fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100.$$

(2) Chemo – edaphic factor :

Soil pH :

The pH of the soil was measured by using a Systronics double electrode digital pH meter. Soil suspensions in distilled water in the ratio of 1:5 were stirred for 5 (five) minutes and allowed to settle before the readings were recorded.

Soil Conductivity :

Soil conductivity was determined by using digital conductivity Meter (Systronics). The soil suspension in distilled water in the ratio of 1:5 was stirred for 5 minutes and allowed to settle before the reading were recorded.

Available Nitrogen :

The air dried soil samples derived from the soil moisture estimations were used for estimation of available Nitrogen (nitrates) colorimetrically by measuring the yellow colour developed during the reaction of nitrates with phenol-disulphonic acid in the presence of an alkali.

(3) Biotic Factor- Maize (*Zea mays.*).

The following parameters were used to estimate the growth performance and yield of maize plants.

Height :-

The height of maize plants were measured and recorded in all the treatments at every one month interval from May 2001. The measurements were done from the base to the tip of the top leaves by using a Centimeter (cm) scale.

Number of leaves :-

The number of leaves per plant in different treatments were counted monthly. The number of leaves were averaged for each treatment and recorded.

Yield :-

Number of maize cobs, number of grains per cob, and weight of grains were calculated and recorded.

4.4 Statistical Analysis :

F – test : F – test is used to test the significance of differences between the treatment means. The comparison is done by finding the ratio of the sum square concerned to the error mean square. This ratio is known as 'variance ratio' and is denoted by the symbol 'F'. It is calculated by the formula.

$$F = \frac{\Sigma MSS}{\Sigma EMS}$$

Where, F = Variance ratio.

MSS = Means sum of square of treatments.

EMS = Error mean square of treatments.

The calculated 'F' ratio from the analysis of variance (ANOVA) is compared with the 'F' table values for significance at different levels of probability and for different degrees of freedom for the numerator and denominator of the ratio. The table of 'F' gives the values for the level of significance commonly used, namely 5 and 1 percent levels. If the calculated 'F' value is greater than the 'F' table value at 5% and 1% then it is said to be significant.

CHAPTER - V

RESULTS

RESULTS

5.1. Abiotic factors :

The Abiotic factors, accounted for were the following :-

(1) Physico - edaphic factor - Soil Moisture
(2) Chemo - edaphic factor - Soil pH,
Conductivity and available nitrogen (N) content.

The data obtained for the different parameters were tabulated, analysed statistically and significance was tested by calculating the critical different (CD) at 5% level, wherever 'F' test was found significant. The data recorded during the field investigations were presented in the form of table and figure for easy interpretation.

5.1.1. Physico - edaphic factors :-

Soil Moisture :

The mean monthly record of soil moisture content in percentage during the entire study period are depicted in Table – I, Figure II. The moisture content was highest (41.55 %) during August 2001 under Treatment A (Maize plants at 20 cm distance from Tung). The lowest moisture content (36.07 %) during the study period was observed from Treatment D (maize plants at 80 cm distance from Tung) during the month of May. The observed moisture content was higher during the study period as compared to other months as because it was the monsoon period. The mean moisture percentage during the study period ranged between 36.07 and 41.55 %. The variation in moisture content of soil under different treatments was non-significant.

5.1.2. Chemo - edaphic factors :

The Chemo - edaphic factors investigated during the study period were :-

(1) Soil pH

(2) Soil Conductivity

(3) Available nitrogen content

5.1.3 Soil pH :-

The mean monthly records of the soil pH values for the different months during the study period under different treatments are presented in Table II, Figure III. The mean monthly records of soil pH was highest in the month of May (5.44) and the lowest in the month of July (5.22) , both values being recorded for the Treatment D (Maize plants at 80 cm distance from Tung). The present study site had an overall soil pH value in the acidic range, with no major differences among the different treatments. This is further revealed by the F test which confirmed the non significance of the variances (Table II).

5.1.4 Soil Conductivity :-

The mean monthly records of the soil conductivity value (mhos/cm^2) are depicted in Table III, Figure IV. The soil conductivity value recorded was highest in May (10.40) and lowest in August (9.27). Both the records were obtained under Treatment D (Maize plants at 80 cm distance). From the data, it was observed that - Treatment D showed highest variation in the soil conductivity value as compared to other treatments. Moreover, it was seen from the table that the variation in the soil conductivity under different treatments during the study period was non-significant.

5.1.5 Available Nitrogen Content :

The mean monthly record of available nitrogen content of the soil throughout the study period under different treatments are depicted in Table IV, Figure V. The analysed data presented in Table IV showed that the highest percentage of available N (1.07) was recorded in August under Treatment D (Maize plants at 80 cm distance from Tung). From the experiment it was seen that the nitrogen content of soil under different treatments did not exhibit major variations resulting in non significant F values Table (IV).

5.2 Biotic Factors :-

The Biotic factors investigated during the study period are :-

1. Growth behavior of maize - Height of maize plant and number of leaves per plant.
2. Yield of maize - No. of cobs per plant, no. of grains per cob, weight. of grains (g) per 1000 grains and weight of grain yield per plant.

The parameters estimated to analyse the growth behaviour of maize under different treatments are the height of maize (cm) and number of leaves per plant.

5.2.1. Height of Maize :-

The mean monthly records of plant height (cm) under the different treatments throughout the study period are shown in Table V, Figure VI. During May (30 days after sowing) maximum plant height (74.58 cm) was observed under treatment D (Maize plants at 80 cm distance from Tung) and the minimum plant height was (71.05 cm) obtained from Treatment A . The data reveals a progressive increase in the height from the minimum of 71.05 cm (treatment A) to the maximum of 74.58 cm (treatment D). This trend was seen throughout the study period and the growth of treatment D was always recorded as the highest.

Similarly, treatment A had the lowest values. The F test revealed significant variation at the 5% levels of significance (Table V). The plant height recorded at harvest showed minimum rate of increase is compared to the previous months. The maximum plant height (179.75) was obtained under Treatment D and minimum plant height (175.43) was obtained under Treatment A.

From the experiment it can be observed that there was a significant difference in plant height between each of the treatment during the entire study period. Treatment D was found to have shown the best result throughout the study period while Treatment A was found to have shown the lowest rate of growth.

5.2.2. Number of leaves per plant :

The mean monthly records of number of leaves per plant under different treatments are depicted in Table – VI, Figure VII. In the month of May the mean number of leaves per plant ranges from 4.5 - 5.6 in which the maximum record was for Treatment D and minimum record was obtained under Treatment A.

The mean maximum number of leaves (8.4) per plant during June was obtained from Treatment D while the mean minimum number of leaves (6.8) was recorded under Treatment A. It was shown from the table that the variation in the number of leaves per plant under different treatment during May and June was significant at 5 % level.

The maximum number of leaves per plant during the study period was recorded in the month of July. The mean number of leaves per plant ranges from 8.4 - 9, the height (9) being recorded under Treatment D and lowest under Treatment A (8.4). The number of leaves per plant showed a slight decrease at harvest (August). The mean number of leaves per plant ranges from 7.4 - 7.6. Treatment A and B showed equal number of leaves 7.6 and Treatment D and C also showed equal number of leaves 7.4. The variation in the number of leaves per plant under different treatment during July and August was found to be non-significant. From the study, Treatment D was observed to have shown the best result in respect of number of leaves per plant.

Yield of Maize :

The number of cobs per plant, number of grains per cob, weight of grains (gms.) per 1000 grains and weight of grain yield per plant were the parameters recorded to estimate the yield of Maize. The yield of maize crop at harvest under different treatment are presented in Table – VII, Figures VIII, IX, X and FigureXI.

5.2.3. Number of Cobs per plant of Maize:

The mean number of cobs per plant at harvest ranged between 0.8 and 2.2. The mean minimum number of cobs per plant (0.8) was observed under Treatment A where one plant had only one cob. Some plants under Treatment A were found to have failed to bear even one cob. The mean maximum number of cobs per plant (2.2) was recorded under Treatment D where some plants even bore 3 cobs. It was observed from the table that the number of cobs per plant did not show significant variation.

5.2.4. Number of Grains per Cob :

The mean maximum number of grains per cob (111.4) at harvest was recorded under Treatment D. The mean number of cobs per plant under the different treatment varied between 74.4 and 111.4 , the mean minimum number of grains (74.4) being recorded under Treatment A. The analysis of F test on the data of Table VII revealed that the number of grains per cobs under different treatments was non-significant.

5.2.4. Weight of Grains (g) per 1000 Grains :-

The mean maximum weight of grains (gm) per 1000 grains was recorded in Treatment D (74.13) and the mean minimum weight of grains per 1000 grains was obtained from Treatment A (57.84). F test on the weight of grains revealed that the different treatments did not have significant effect on the weight of grains.

5.2.5. Weight of Grain Yield per plant (g) :-

The mean maximum weight of grain yield per plant (8.26 g) was recorded under Treatment D and the mean manimum weight of grain yield per plant (5.37 g) was obtained from Treatment A. However, F test on weight of grian yield per plant revealed that the different treatment did not have significant effect.

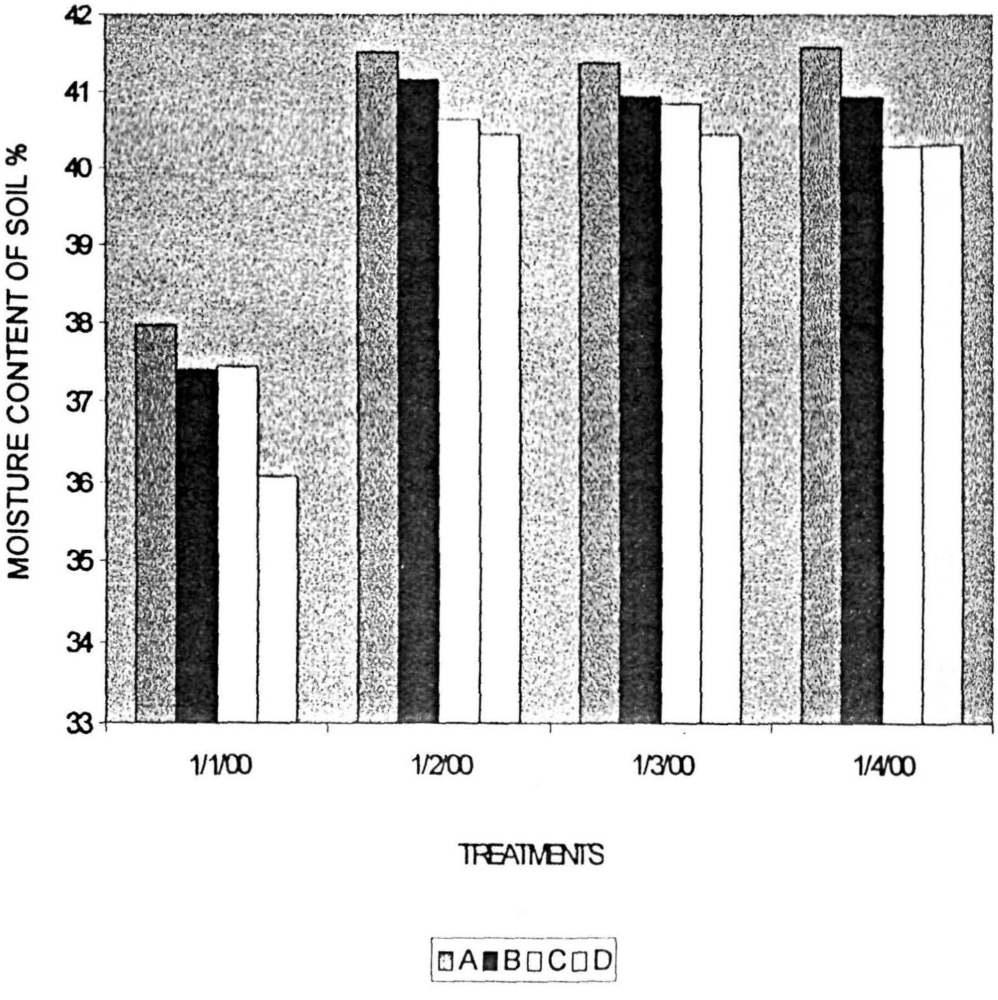
MOISTURE CONTENT OF SOIL (%)

Table I : Monthly Records of Soil Moisture Content (%).

2 0 0 1				
TREATMENTS	MAY	JUNE	JULY	AUGUST
A (20 cm distance from Tung)	37.96	41.50	41.36	41.55
B (40 cm distance from Tung)	37.40	41.15	40.94	40.94
C (60 cm distance from Tung)	37.43	40.64	40.85	40.26
D (80 cm distance from Tung)	36.07	40.42	40.42	40.29
S.E. m $\pm$	0.79	0.38	0.54	0.61
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.

N.S. = Non - Significant

FIG II : MONTHLY RECORDS OF SOIL MOISTURE CONTENT (%)



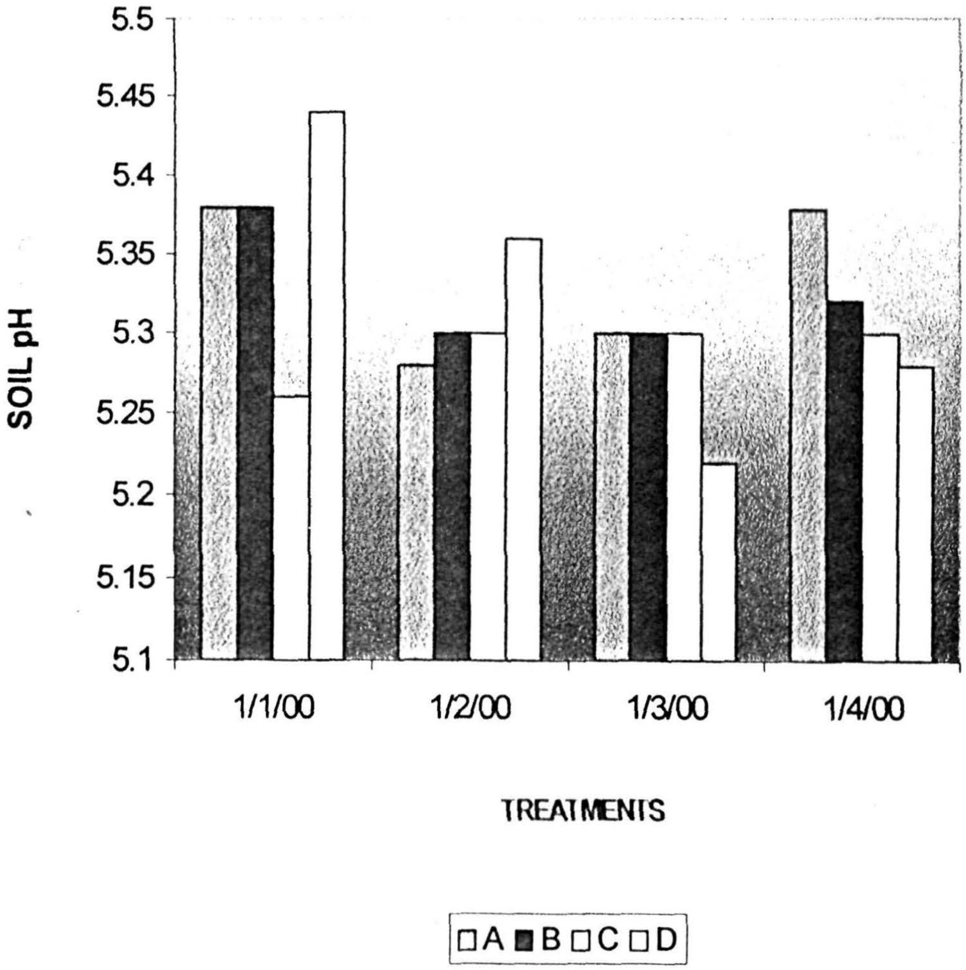
SOIL pH

Table II : Monthly Records of Soil pH.

	2001			
TREATMENTS	MAY	JUNE	JULY	AUGUST
A (20 cm distance from Tung)	5.38	5.28	5.3	5.38
B (40 cm distance from Tung)	5.38	5.3	5.3	5.32
C (60 cm distance from Tung)	5.26	5.3	5.3	5.3
D (80 cm distance from Tung)	5.44	5.36	5.22	5.28
S.E. m $\pm$	0.15	0.18	0.15	0.14
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.

N.S. = Non - Significant

FIG. III : MONTHLY RECORDS OF SOIL pH



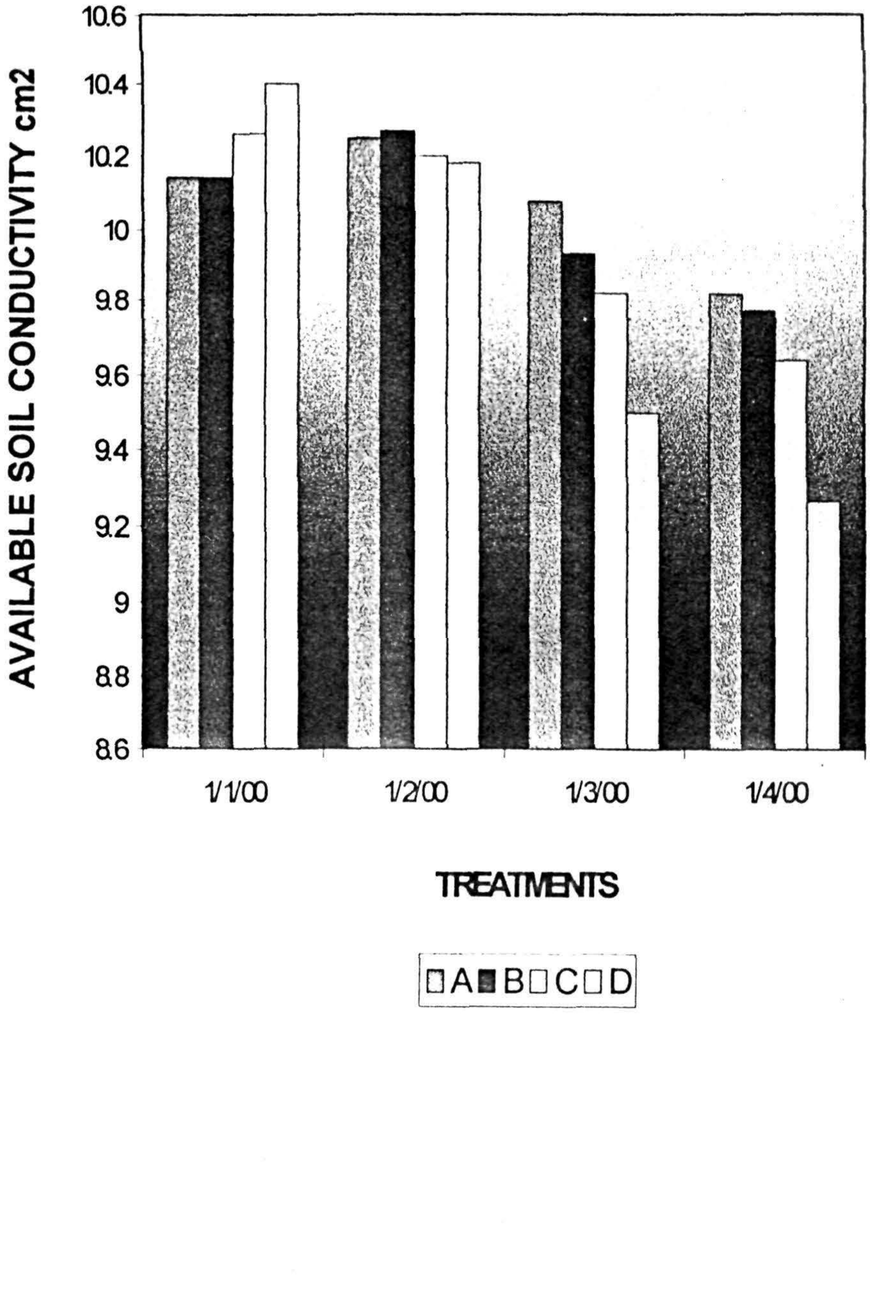
SOIL CONDUCTIVITY

Table III : Monthly Records of Soil Conductivity (Mhos/ cm^2)

	2001			
TREATMENTS	MAY	JUNE	JULY	AUGUST
A (20 cm distance from Tung)	10.14	10.25	10.08	9.82
B (40 cm distance from Tung)	10.14	10.27	9.93	9.77
C (60 cm distance from Tung)	10.26	10.20	9.82	9.64
D (80 cm distance from Tung)	10.40	10.18	9.50	9.27
S.E. m $\pm$	0.497	0.109	0.09	0.28
C.D. at 5 %	N.S.	N.S.	0.196	N.S.

N.S. = Non - Significant

FIG. IV : MONTHLY RECORDS OF AVAILABLE SOIL CONDUCTIVITY cm2



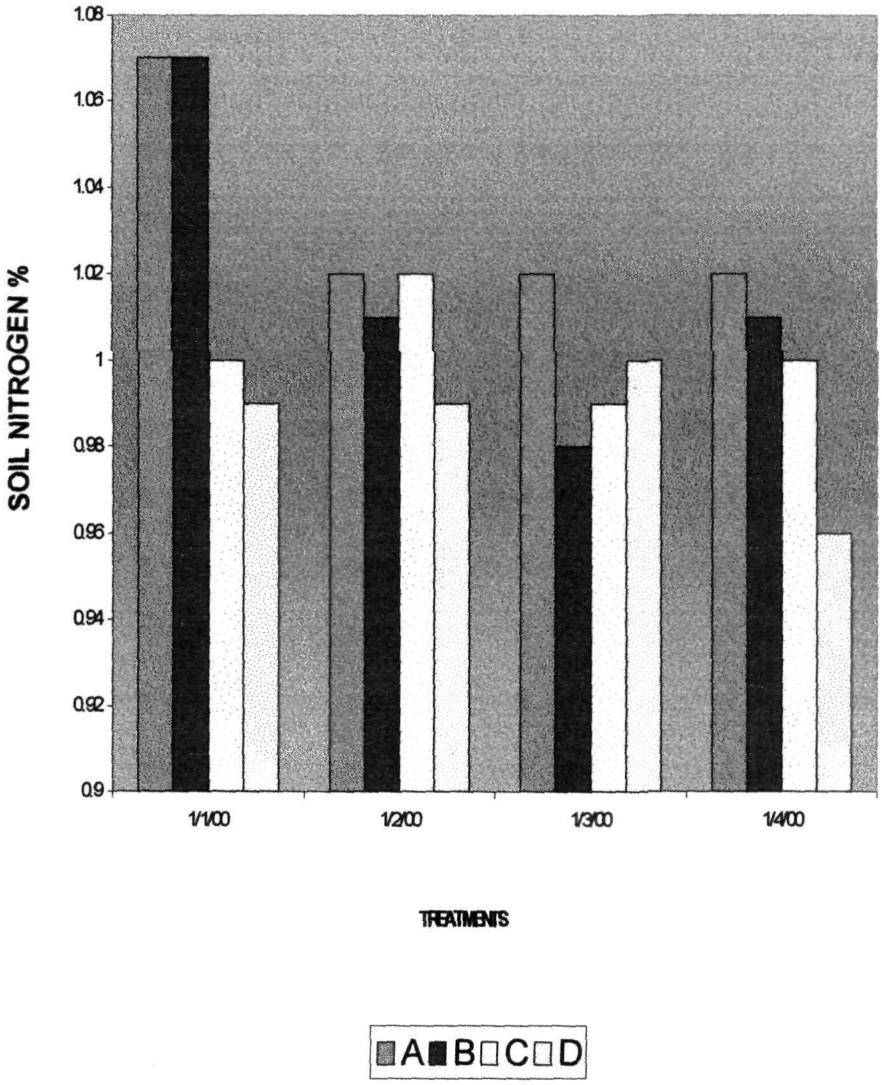
SOIL NITROGEN CONTENT

Table IV : Monthly Records of Soil Nitrogen Content (%)

	2001			
TREATMENTS	MAY	JUNE	JULY	AUGUST
A (20 cm distance from Tung)	1.07	1.02	1.02	1.02
B (40 cm distance from Tung)	1.07	1.01	0.98	1.01
C (60 cm distance from Tung)	1.00	1.02	0.99	1.00
D (80 cm distance from Tung)	0.99	0.99	1.00	0.96
S.E. m ±	0.15	0.11	0.09	0.09
C.D. at 5 %	N.S.	N.S.	N.S.	N.S.

N.S. = Non - Significant

FIG. V : MONTHLY RECORDS OF SOIL NITROGEN (%)

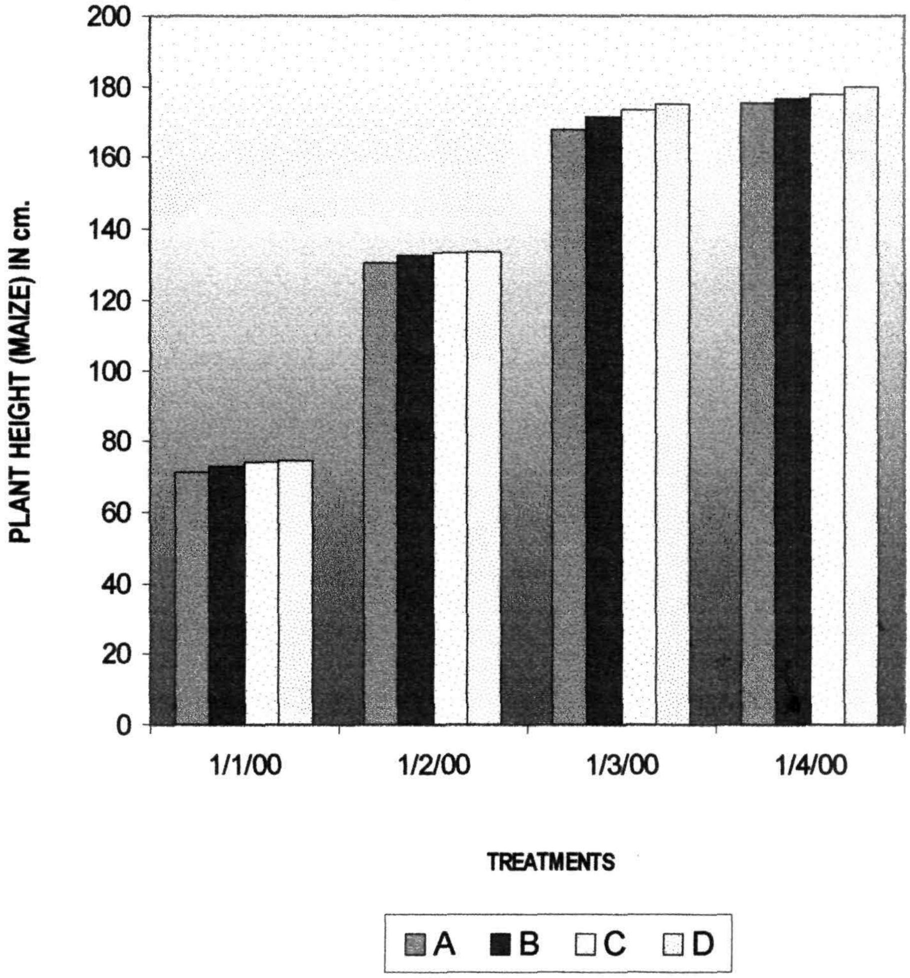


HEIGHT OF MAIZE

Table V : Monthly Records of the Plant Height (Maize) in cm.

	2001			
TREATMENTS	MAY	JUNE	JULY	AUGUST
A (20 cm distance from Tung)	71.05	130.43	167.99	175.43
B (40 cm distance from Tung)	72.65	132.41	171.47	176.85
C (60 cm distance from Tung)	74.08	133.22	173.55	177.98
D (80 cm distance from Tung)	74.58	133.66	175.00	179.75
S.E. m ±	0.31	0.27	0.43	0.17
C.D. at 5 %	0.67	0.59	0.94	0.37

FIG. VI : MONTHLY RECORDS OF THE PLANT HEIGHT (MAIZE) IN cm.



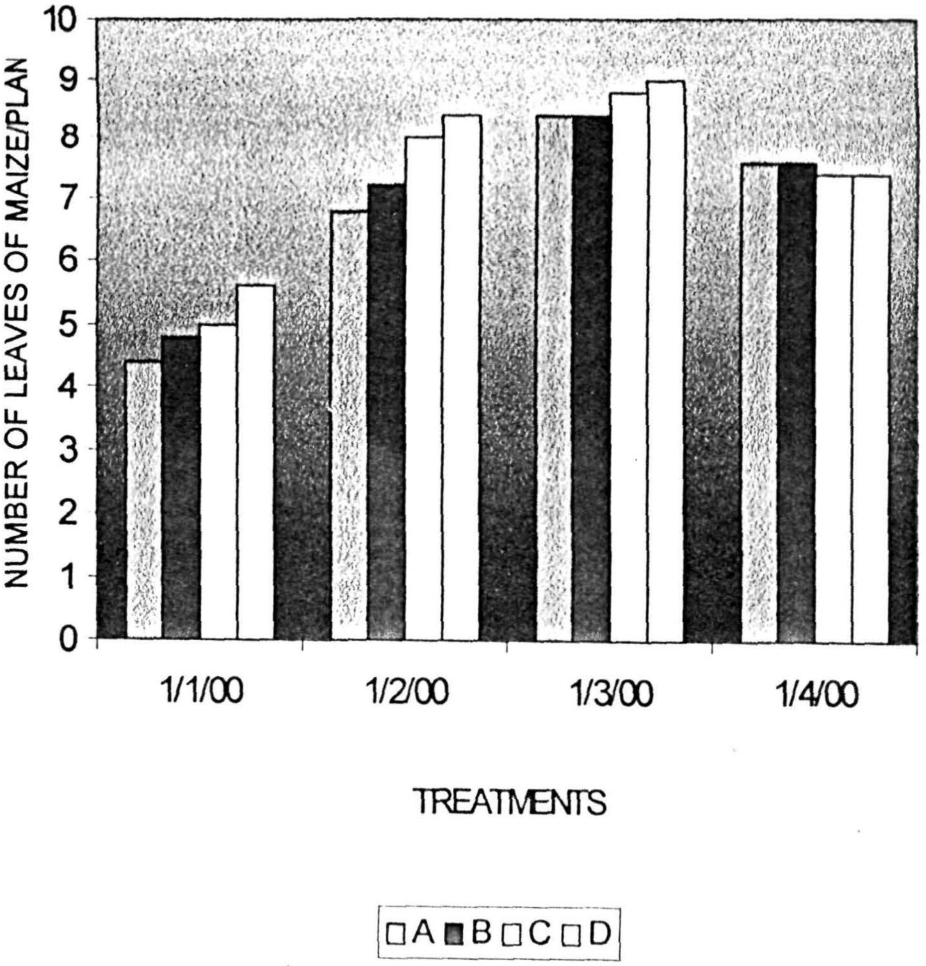
NUMBER OF LEAVES PER PLANT OF MAIZE

Table VI : Monthly Records of Number of Leaves of Maize/plant.

	2 0 0 1			
TREATMENTS	MAY	JUNE	JULY	AUGUST
A (20 cm distance from Tung)	4.4	6.8	8.4	7.6
B (40 cm distance from Tung)	4.8	7.2	8.4	7.6
C (60 cm distance from Tung)	5.0	8.0	8.8	7.4
D (80 cm distance from Tung)	5.6	8.4	9.0	7.4
S.E. m $\pm$	0.28	0.53	0.47	0.46
C.D. at 5 %	0.6	1.15	N.S.	N.S.

N.S. = Non - Significant

FIG. VII : MONTHLY RECORDS OF NUMBER OF LEAVES OF MAIZE/PLANT



YIELD OF MAIZE

Table VII : Yield of Maize Crop under different Treatments after Harvest.

	2001			
TREATMENTS	No of Cobs/Plant	No of Grains/Cob	Wt. of Grains/1000 Grains (g.)	Wt. of Grain yield / plant (g)
A (20 cm distance from Tung)	0.8	74.4	57.84	5.37
B (40 cm distance from Tung)	1.0	80.4	58.5	5.88
C (60 cm distance from Tung)	1.6	107.4	73.34	7.9
D (80 cm distance from Tung)	2.2	111.4	74.13	8.26
S.E. m ±	0.43	20.78	15.14	1.48
C.D. at 5 %	0.94	N.S.	N.S.	N.S.

N.S. = Non - Significant

FIG. VIII : MAIZE YIELD AFTER HARVEST

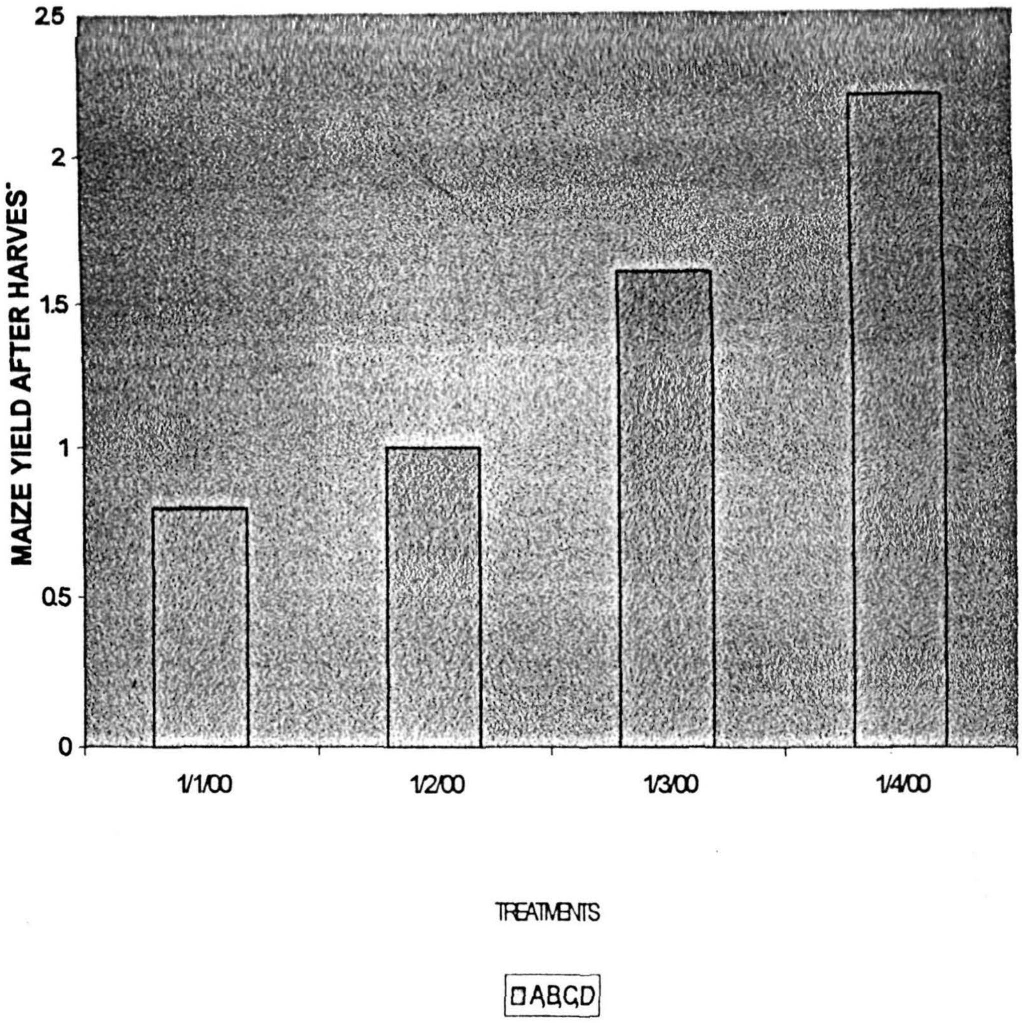


FIG IX : MAIZE YIELD AFTER HARVEST

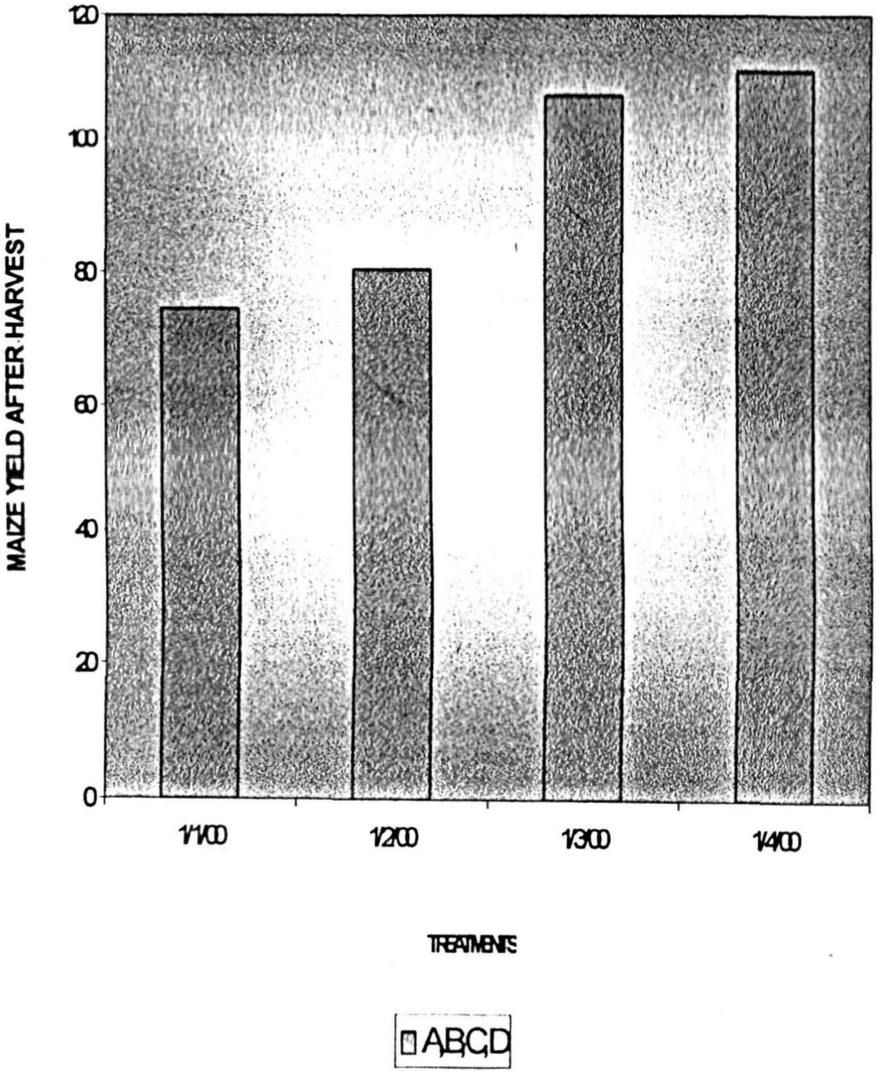


FIG X : MAIZE YIELD AFTER HARVEST

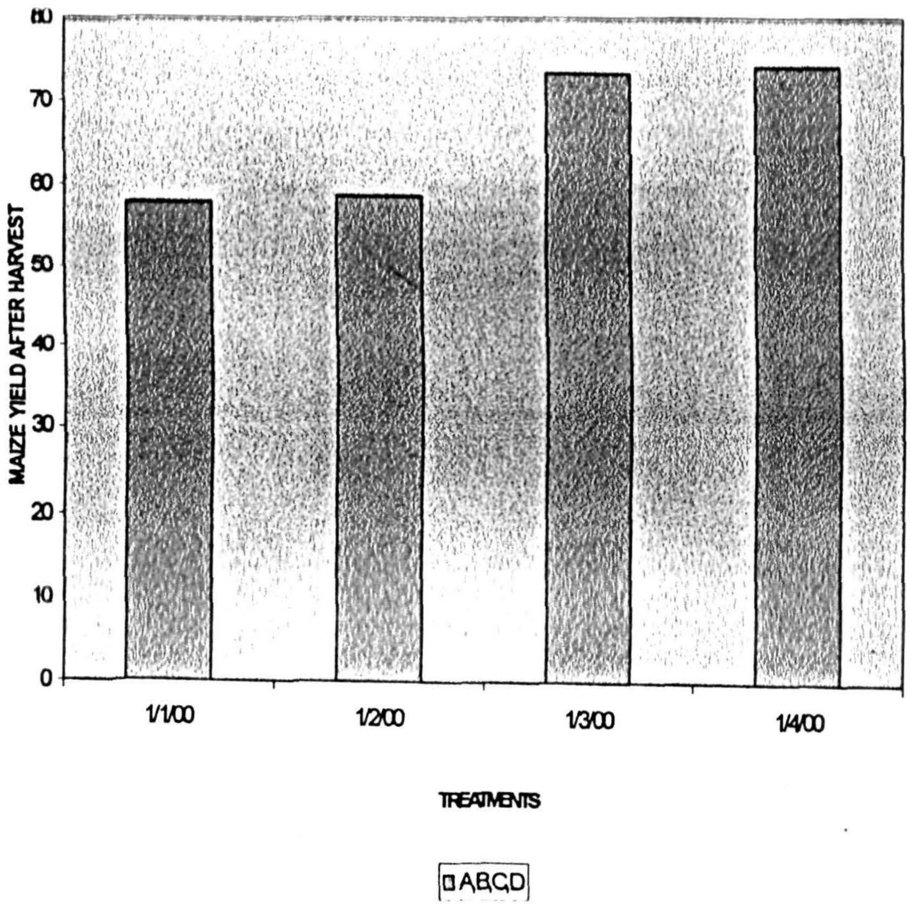
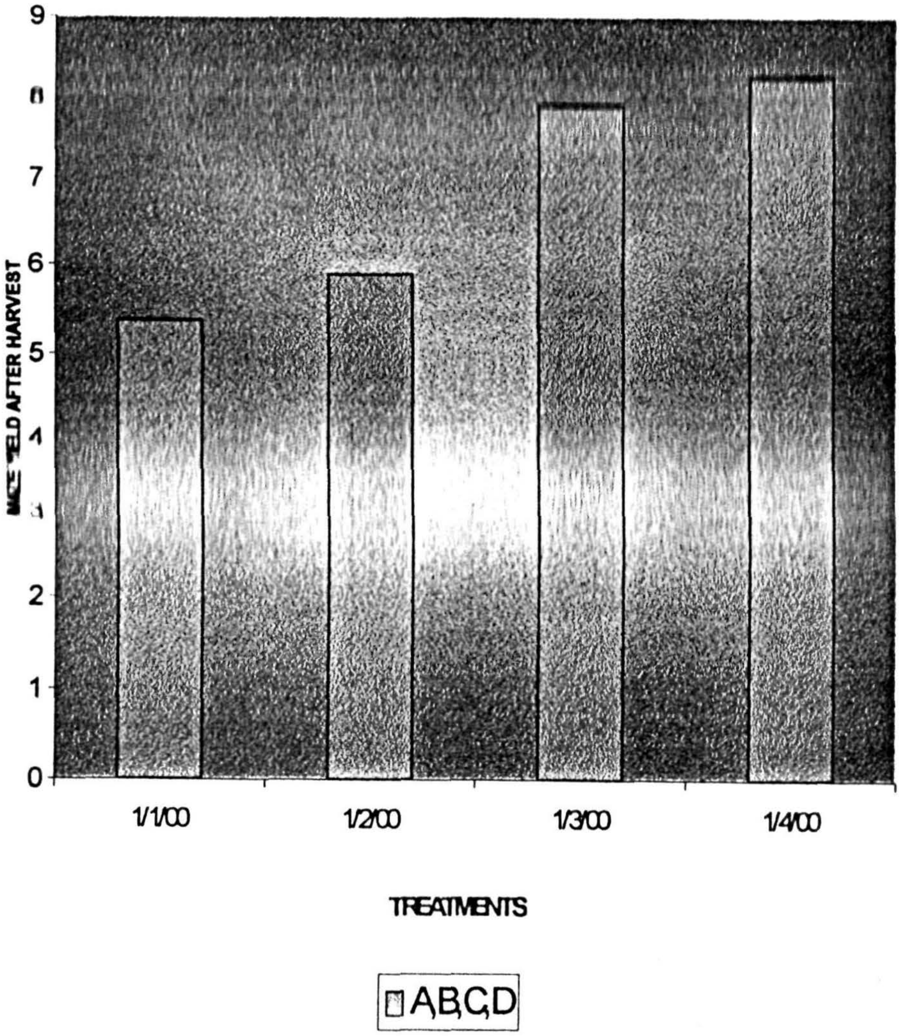


FIG. XI : MAIZE YIELD AFTER HARVEST



CHAPTER - VI

DISCUSSION

DISCUSSION :

The traditional forms of agriculture like shifting cultivation which is still the mainstay of most of the North Eastern states, including Mizoram is increasingly untenable under the present population pressures and an ever dwindling forest cover.

The philosophy behind shifting cultivation probably lies in the harnessing of soil fertility accruing over a long period of time due to the presence of forest cover which assists in the development of a healthy soil profile with high fertility status. Under such circumstances, it is possible to have a good harvest on a continuous basis provided that a long fallow cycle is maintained to make allowances for the development of soil fertility and physical characteristics after the harvest.

The present pressure on a unit of land to produce more and more negates the possibility of the above prerequisites, and this has resulted in an ever declining fertility status of the soil. The situation is further aggravated by the heavy monsoons coupled with steep terrain which results in massive soil erosion and this leads to loss of soil nutrients, causes silting of reservoirs and streams, and disrupts ecosystems. The declining productivity in shifting cultivation with time and its negative impact on the environment is becoming a global concern (Nair, 1984 : Ramakrishnan, 1985). This age old practice needs to be modernized and/ or altered with other forms of agriculture which are less destructive and ecofriendly. Agroforestry has been popularized among decision makers as a conservation farming solution to sustain productivity of the fragile hill agroecosystems (Garrity, 1995). To develop a suitable agroforestry model, it is essential to know the suitable tree crop combination with the desired spacing.

The present investigation " Growth behaviour and yield of Maize (*Zea mays* L.) as affected by distance from Tung (*Aleurites fordii*. Hemsl.) in an agroforestry trial in Mizoram " was carried to find out the ideal distance between the tree (Tung) and intercrop (Maize) The present study was also aim to find out the influence of Tung based agroforestry system on the soil physico and chemo-edaphic conditions.

The viability of the tree-herb association are largely governed by physical factors, viz., shade, moisture, nutrients and chemical interaction (allelopathy) in an interactive manner (Melkania, 1983). Analysis of the soil moisture content under the different treatments revealed that maximum soil moisture was obtained under Maize plant at a distance of 20 cm from Tung . This is probably indicative of the effect of the tree crown to trap the raindrops as throughfall. Besides, the restriction of evapotranspirational losses from under the canopy is also a possibility. Another pointer to these assumptions is the continuously decreasing trend of soil moisture , away from the tree (treatments B, C and D).

The data recorded on soil pH and soil nitrogen content revealed the different treatments did not show significant affect on the soil pH and nitrogen content. Since observations were taken for short period of time i.e. the cropping period of Maize (4 months) this may be the reason that there was no significant variation in the soil reaction and soil nitrogen content under the different treatments. The overall soil reaction throughout the entire study period was found to be acidic with a pH range from 5.22 to 5.4 and the percentage of available nitrogen content ranges from 0.96 to 1.07.The low pH of soil is attributable to leaching of bases under influence of high rainfall in the hills (Solanki and Bisaria, 2000). It was observed from the study the rate of decrease in the soil pH value was maximum under Treatment D and minimum under Treatment A.

Results from the analysed data presented in Table - III revealed that maximum variation in the soil conductivity was found in Treatment D and minimum variation was recorded under Treatment A. It was also observed from the table that the mean maximum soil conductivity value was obtained during May and the mean minimum soil conductivity value was recorded in August i.e. at Harvest. Treatment A showed significant difference over Treatment C and D during July. However, the overall variation in the soil conductivity during the entire study period for different treatments is non-significant.

The growth rate in terms of height (cm) was observed to be significant under different treatments. Maximum rate of growth during the entire study period was recorded in Treatment D while the minimum rate of growth was obtained under Treatment A. The effect on growth of Maize plants under the different treatments may be due to shading effects from the tree components as the three years old Tung had already established with a spreading crown. Density stress has been reported to have either positive or negative effect on height (Cannel, 1983). It has been reported by Dillon (1993) that the loss in yield of the intercrop decreased significantly with the increase in distance from tree line.

The maximum height and number of leaves per plant of Maize were observed from Treatment D. This may be due to the shading effect and intercrop competition. It was reported by Behera *et. al.*, (1998) that taller Maize plant can be obtained under monocropping of maize than that of intercropping.

Number of leaves recorded during May and June showed significant difference between the different treatments while records during July and August are non-significant. The mean maximum number of leaves was recorded in July under Treatment D. The increase in the mean number of leaves per plants under Treatment D may be due to the wider distance of the Maize plants from the tree components (Tung) which facilitate for maximum competition for space, moisture, nutrients and light.

It was observed from the result that there was significant difference in the number of cobs per plant of Maize under different treatment. The maximum number of cobs per plant was obtained in Treatment D. Results from the analysed data on the number of grains per cob and weight of grains per 1000 grains for the different treatment was non-significant. Khattak *et. al.*, (1981) recorded no significant variation in yield in Wheat with increasing distance from *Eucalyptus* tree belt. However, the maximum yield of Maize in terms of number of cobs, number of grains per cob weight of grains per 1000 grains, and weight of grain yield per plant was found under treatment D. This may be due to the effect of distance from Tung that facilitated for minimum shade effect, minimum competition for moisture, space, nutrients, etc. Dhilon *el al.*, (1982) has stated reduction in crop (Wheat) yield beneath *Eucalyptus* probably because of shade.

The yield of maize with respect to grain yield per plant (g) was highest under Treatment D and lowest under Treatment A. The lower grain yield of maize at nearer distance to the tree component (Tung) may be due to competition between maize and tung and also due to the shading effect.

PLATE I : THREE (3) YEARS OLD TUNG BEFORE SOWING OF INTERCROP (MAIZE)

PLATE II : MAIZE CROP AT 90 DAYS AFTER SOWING

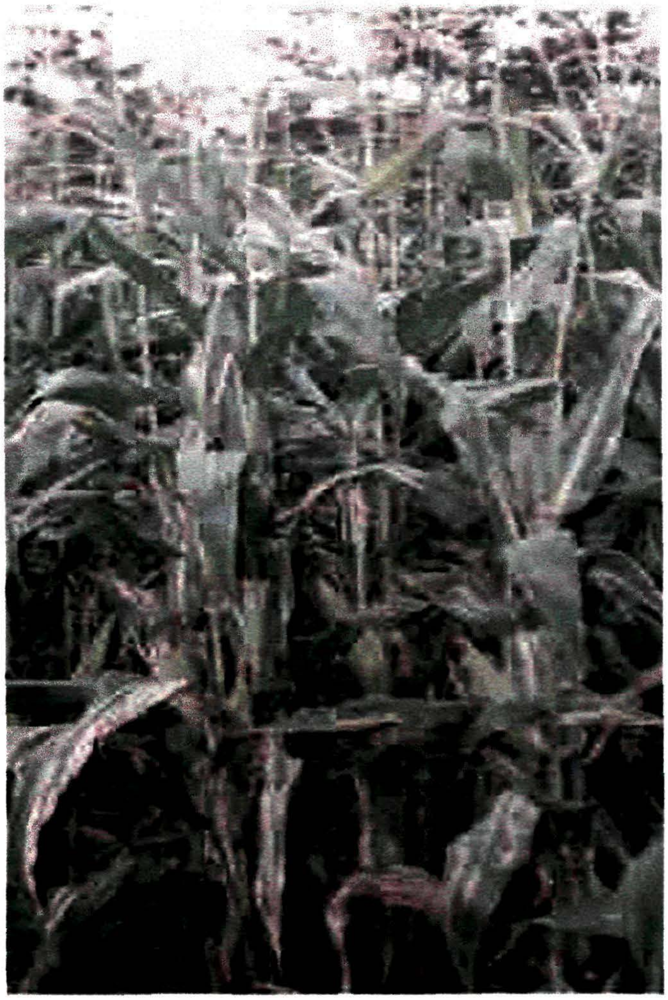


PLATE III : HARVESTED MAIZE COBS

CHAPTER - VII

SUMMARY

SUMMARY :

The study on the growth behaviour and yield of Maize (Zea mays. L) as affected by distance from Tung in an agroforestry trial in Mizoram was carried out at Zemabawk. , about 4 km east of Aizawl, the capital of Mizoram. The altitude of the site is 1132 m. and the topography is slopy. The soils of the experimental plot is sandy loam, black in colour with a average pH of 5.3.

The experiment was carried out in a 40 m x 40 m area planted with (Aleurites fordii.). The trees were 3 years old at the start of the experiment. Maize (Zea mays, var Vijaya composite) was sown at the distance of 20 cm, 40 cm, 60 cm, 80 cm from the Tung tree at the onset of the monsoon i.e. during last week of April.

The experiment was laid out following random sampling method with four treatment viz - Treatment A (Maize plants at 20 cm distance from Tung), Treatment B (Maize plants at 40 cm distance from Tung), Treatment C (Maize plants at 60 cm distance from Tung) and Treatment D (Maize plants at 80 cm distance from Tung) and these treatments are replicated five times.

A monthly sampling programmes for the various parameters on Abiotic and Biotic factors during the entire cropping period was carried out. Among the Abiotic factors the physico and

chemo edaphic factors were investigated. The parameters collected on physico edaphic factor was soil moisture, and chemo edaphic factors such as soil pH, soil conductivity and soil nitrogen content were estimated. The data obtained were subjected to ANOVA to see the effect of the different biotic and abiotic factors on the treatments. Significance was tested by calculating the critical difference (C.D.) at 5 % level, wherever 'F' test was found significant. The experimental finding revealed that the different treatments did not have significant effect on the soil moisture, soil pH, soil conductivity and available soil nitrogen content.

However, the results have shown that the growth behaviour in respect of height and number of leaves per plant during the entire study period was best under treatment D (maize plants at 80 cm distance from tung). The result obtained on the growth behaviour of maize in respect of height (cm) and number of leaves per plant, have shown that treatment D (maize plants at 80 cm distance from tung) had performed best throughout the entire study period followed by treatment C, B and A (maize plants at the distance of 60 cm, 40cm and 20 cm from tung respectively). The treatment A (maize plants at 20 cm distance from tung) had shown the poorest performance as compared to the other. The performance of maize in respect of height under the different treatments showed significance at 5 % level.

The yield of Maize recorded had shown that maximum number of cobs per plant, maximum number of grains per cob and maximum grain weight (g) per 1000 grains, and maximum weight of grain yield per plant were recorded under Treatment D (Maize plants at a distance of 80 cm from Tung) and the minimum yield of Maize was obtained from Treatment A (Maize plant at a distance of 20 cm from Tung). The difference in the number of cobs per plants under the different treatment was found significant at 5 % level while the difference in the number of grains per cob and weight of grains (g) was non-significant.

The overall results of growth and yield of maize suggests that the treatment D (80 cm. Distance from tree) is the best distance as adequate growth and yield occurred under this treatment as compared to the others.

CHAPTER - VIII

CONCLUSION

CONCLUSION :

On the basis of results, the following conclusions were made :-

1. The different treatments (A, B, C and D) did not have significant influence on the physico - edaphic and chemo - edaphic factors.
2. Treatment D i.e. Maize planted at 80 cm distance from Tung showed the best result in respect of growth and yield as compared to the other Treatments A, B, and C.

From the present investigation we can suggest the planting of Maize at 80 cm distance from Tung as it gave best result. However, the present findings are based on observation from one cropping period only, a more detailed long term experiment may be required to corroborate the present findings. From the present investigation, it was observed that Treatment D (Maize plant at 80 cm distance from Tung) showed best result in terms of growth behaviour and yield.

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