"SOIL NUTRIENT BUDGETS AND YIELD OF INTERCROP *Zea mays* (Maize) AFFECTED BY *Leucaena leucocephala* (Kubabul) IN AN AGROFORESTRY TRIAL IN MIZORAM"

THESIS

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I certify that the thesis entitled "Soil nutrient budget and yield of intercrop *Zea mays* (Maize) affected by *Leucaena leucocephala* (Kubabul) in an Agroforestry trial in Mizoram" submitted by Mr. Markordor Khonglah 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 him under my supervision. Further, this work has not been submitted for any degree of any other University nor has it been published in part or full.

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INTRODUCTION

1.1.The science of Agroforestry :

As an applied science, agroforestry is of recent origin. An efficient agroforestry system should aim at systematically developing integrated land use models and practices wherein the positive interactions between trees and crops are encouraged and maximized.

The current concept of agroforestry implies integration of forestry with agriculture and vice-versa. Historically the practice existed in the tropical and sub-tropical countries since long. The '*Taungya*' system has been in existence in Myanmar since ages. This practice was adopted into the Indian context since the advent of scientific forestry (Jha,1992).

As a concept, agroforestry is the synthesis of much of the practical experience and scientific knowledge acquired in the past from the disciplines of agriculture, forestry, ecology, soil science and rural socio- economics (Sharma,1996). Lundgren, (1987) discussed that "the concept of optimization of production of various goods and services, with minimum risk, from a unit of land, as opposed to maximization of a single commodity in monocultural production systems is perhaps new in agroforestry as we know it, and is capable of meeting the present challenge of shortages of fuelwood, fodder, timber, unemployment, environmental degradation, protection and improvement of wastelands and agricultural land." Agroforestry systems with their elements of intercropping are in essence ecological models similar to natural systems,and have, therefore, an element of sustainability associated with them. These systems have lasting production as they help in recycling of organic residues, ensure biological nitrogen fixation and mineral fertilization.This happens all the time in an intercropping system involving nitrogen fixing trees.

1.2. Dwindling forests and the relevance of Agroforestry :

Forest resources have been rapidly declining since the last century and today it has reached an alarming stage around the world (Postel,1984). In the tropics, 80 % (in India it is 87% according to F.A.O, 1983) of the annually harvested wood is used as firewood (Earl,1975) and 90% of the population rely on it for their domestic needs (Eckholm,1973). By the close of the 20th century, it is predicted that in the developing and underdeveloped countries, if no efforts are made to increase the firewood production, food may be scarce.(Smith,1981; World Bank Report,1978), as most of the humid tropical forests will be transformed into unproductive land, and the deterioration of the savanna into desert will continue at an ever increasing speed. (Bene *et al.*, 1977). Although research to sustain larger food yields in the tropical agricultural lands have been exceptionally rewarding, there has not been a matching effort in the tropical forest sector. Total dependence on forest for day to day firewood requirements is not a sound proposition. These can be met partly through agroforestry (Nadagoudar, 1984 ; Lundgren, 1985).

Besides the fuelwood problem, there are other reasons why agroforestry, a traditional indegenous form of land use has re-emerged, *albeit* in new forms, as appropriate alternative forms of land use in recent years. One of them is the highly adverse land-man ratio which is progressively deteriorating in most countries of the region. Asia and the pacific region contains 69 per cent of the world's agricultural lands. In absolute terms, the agricultural land in the region is estimated to be around 453 million hectares. Of these, as much as 93 per cent is already under cultivation.

As population pressure intensifies, in their search for land for agriculture, people in the flood plains migrate to nearby uplands and practice rainfed cropping . Consequentely, 2 million hectares of forests are lost annually in the region. About 75 per cent of this deforested area is encroached for agriculture, resulting in most cases in the development of spontaneous, unplanned settlements. With the destruction of forests and depletion of the thin mantle of fertile top soil through the forces of rainfall and erosion, these lands occuring as somewhat fragile ecosystems are quickly rendered unproductive. The high ecological costs of land degrodation have therefore, become a major concern of several governments. It is the cummulative effect of these factors that have resulted in a renewed focus on more sustainable land use patterns based on systems such as agroforestry (Rao, 1990).

1.3. Defining Agroforestry :

The term agroforestry was coined almost at the time of establishing the International Council for Research in Agroforestry (ICRAF) during 1977. Agroforestry has been an age old practice. It is neither an invention nor a new concept. It is a new word used in place of shifting cultivation, agri-silviculture or the *'taungya'* system (Stewart, 1981). These traditional forms of cultivation are still practised in most of the tropical counties under different socio-economic and environmental conditions in Africa, Central and South America, Oceania, South-east Asia, etc. In India, it is commonly practiced by the hill dwellers of Assam, Arunachal Pradesh , Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Bihar, Karnataka, Madhya Pradesh, and Orissa. The traditonal systems which have evolved by trial and error method are to be preserved and can be improved by scientific modelling and by introducing superior genetic tools, in these polycultural systems.

In a broad sense, the term agroforestry encompasses any and all techniques that attempt to establish or maintain both forest / tree and agricultural crop on the same piece of land. In scientific trems, all forms of agroforestry are characterised by :

• the deliberate growing of woody perennials, agricultural crops, and animals on the same unit of land, either in some form of spatial mixture or temporal sequence;

• there must be a signifant interaction, preferably positive, between the woody and non-woody components of the system, either ecological and / or economical.

Probably because of its wide scope, agroforestry has been variously defined by severel people across the world (Editors, 1982), and any standard definition remained elusive for nearly a decade.

According to the definition given by ICRAF, (1983) - "Agroforestry is a collective word for all land use systems and practices in which woody perennials are deliberately grown on the same land management unit as crops and / or animals. This can be either in some form of spatial arrangement or in sequence." This definition given by ICRAF is more logical and is widely accepted by the community concerned with agriculture, horticulture, silviculture, livestock, fishery, sericulture etc. Besides, this definition is very comprehensive and covers all aspects of forestry on farm lands (farm forestry) also.

According to Bene *et al.*, (1977) and King and Chandler (1978) - Agroforestry is defined as "a sustainable land management system, which increases the yield of the land, combines production of crops (including tree crop) and forest plants and / or animals simultaneously or sequentially, on the same unit of land, and applies management practices that are compatible with cultural practices of the local population." This definition lacks a clear demarcation between 'tree crops' and 'forest plants'.

Another definition given by Nair (1984), states - "Agroforestry is 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 intersections." This last definition can be considered more appropriate as it includes all the aspect of scientific agroforestry, incorporates the concept of the age old systems of retention of trees, and also covers the economic viewpoint.

Keeping all the different perspectives in focus, agroforestry can be defined as - "a sustainable land use system that forms a symbiotic relationship of trees with agriculture and livestock, increases the yield and productivity of the same unit of land under management practices to give economic returns that are complementary and beneficial to each other".

The science and practice of agroforestry aims at systematically developing land use systems and practices where the positive interactions between trees and crops are maximized. It seeks to achieve a more productive, sustainable and diversified output from the land than is possible with conventional mono-cropping systems.

The success of Agroforestry can be judged by its acceptance and popularity in rural areas. The agro-climatic conditions, location of the site and expectations of the farmers should be taken into consideration before developing agroforestry models for a given field. The important concerns of the farmer, while adopting agroforestry, will be to make sure that the trees grown in the field do not affect the agricultural operations in any way.

The agroforestry systems prevalent in the state of Mizoram include various forms of combination of trees and food crops. Additionally, some improvements to jhum cultivation are also being tried in several places under a centrally sponsored jhum control project 1987 (Jha and Lalramnghinglova, 1996). The most common and successful practice is intercropping of *Oryza sativa* (Paddy) along with *Tectona grandis* (Teak). Other prominent agroforestry farming systems in Mizoram are the combination of agricultural crops and trees, for example *Zea mays* and *Albizia procera* at spacing of 2 x 3 m by triangular planting method employed in slopy areas.

1.4. The Shifting Cultivation problem:

It is estimated that an area of about 36 million sq.km or about 30 per cent of the world's exploitable soils are at present under shifting cultivation, producing the bulk food of more than 250 million people or 8 per cent of the world population. In India about 3 million people are engaged over an area of 7,769,800 hectares in various states.

Shifting cultivation is known by different names in different parts of the country. It is called *'Jhum'* in Assam, Meghalaya, Tripural and Mizoram, *'Podu'* in Arunachal Pradesh, *'Dhai'* in Orissa and *'Penda'* in Madhya Pradesh. In FAO terminology it is called *'Slash and Burn'* agriculture.In India, shifting cultivation is practiced by the hill dwellers of North Eastern Region, Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh and Orissa States.

The North Eastern Region of India is predominantly hilly. Shifting cultivation is prevalent in the region, resulting in deforestation. Growing agricultural crops on slopy terrain causes loss of topsoil through heavy rain, and there is decline in soil fertility. Sustainable, socially acceptable and economically viable land use systems following the land capability, are needed to ensure sustainability and conservation of natural resources.It is estimated that the area affected by shifting cultivation in the North Eastern Hill Region is 62,854 sq.kms (State Forest Report, 1989). The annual soil of loss of Carbon, Nitrogen, Phosphorus and Potassium from the N.E. states due to shifting cultivation is 88.346, 10.669, 0.772 and 6.051 thousand tonnes respectively (Sharma and Prasad, 1994). Sharma (1993), indicated the high agricultural potential of the region if suitable land used systems are followed and soil health is maintained. According to Chauhan (1990), the annual loss of soil and crop yield in the North Eastern Region, due to shifting cultivation was estimated to be 15.5 million tonnes and 52.23 thousand tonnes respectively.

The practice of shifting cultivation is so much a part of socio-economic and cultural life of the people of tropical world and needs detailed studies to understand the intricate relations between soil, fallow and harvest. The government launched ambitious programmes to wean away shifting cultivators from this age old practice but the success was only nominal. The main reasons for this was non-availability of suitable, sustainable, economically viable and socially acceptable alternatives, even though the farmers themselves have realised that shifting cultivation has lost its regenerative potential. Young (1989), suggested that agroforestry satisfies many conditions of judicious land management as it combines soil conservation with production function useful for hill slopes.

As outlined above, shifting cultivation, the prevalent agricultural practice is also the chief contributor to the decline in forests. It has been realized beyond doubt that the sustainability of such form agriculture is poor, especially in hilly terrain with heavy monsoonic rainfall. These two factors are responsible for speedy erosion of top soil, thereby depleting the fertility status and productive potential.

To address these problems, government agencies have from time to time prescribed other forms of agriculture such as bench terracing, alley cropping, minimum tillage agriculture etc.The Indian Council of Agricultural Research (ICAR) for the North Eastern Hill Region has suggested a model land use plan as an alternative to shifting cultivation. This provides for the top 1/3rd of the hill slope to be under forest, the middle 1/3rd under horticulture and the bottom 1/3rd of the hills slope to be terraced (Singh, 1981). The three - tier system with trees and silvi-pastoral system for the upper ridges (100% slope), horticultural crops in the middle portion either alone or in combination with leguminous fodder (50 - 100% slope) and agricultural crops in the lower portion of the hill slopes (< 50% slope), with bench terraces or / and contour bunds is envisaged to be an ideal alternative to jhuming by not only reducing the soil and run-off losses but also by ensuring maximum production allowing modern technology to be followed. This will help in providing a subsidiary source of income through animal husbandry as well as providing a permanent and continous interest in the land because of the horticultural crops and trees.Terracing of the entire hill slope is not necessary since trees and horticultural crops can be raised without terrace while only the lower protion of the hill need to be terraced for agricultural crop. Contour bunding is suggested where terracing is not immediately possible. This suggested plan still needs wider demonstration and field trials for testing its adaptability, economic viability and social acceptability.

The proposed trial of agroforestry including *Leucaena leucocephala* (Kubabul) and *Zea mays* (Maize) has been carried out as a possible alternative to jhum. The former, as a multipurpose nitrogen fixing species, can effectively help increase the depleting soil nitrogen budgets, afford a canopy cover and ensure decrease in soil erosion, and also can meet fuelwood and fodder requirements. The latter is the second most important staple food crop of the local people. The development of suitable model using this combination can help in discouraging the use of fire and in developing a suitable agroforestry model which can also supplement the farmers fuelwood and fodder requirements and thus reduce the pressure on natural forests.

1.5. Objectives:

The main objectives of the present study were to evaluate the following:

1. Growth performance of both *Leucaena leucocephala* and *Zea mays*.
2. Yield of maize crop at different spacings of *Leucaena leucocephala.*
3. Seasonal fluctuation of major abiotic factors and soil nutrient budgets (C,N,P&K) of the site.

REVIEW
OF
LITERATURE

REVIEW OF LITERATURE

2.1. Agroforestry in shifting cultivation:

In the past few decades the potential of tree legumes for improving agricultural and silvicultural productivity has been well recognised, especially in the third world countries. The positive role of multi-purpose trees (MPT's) in mixed farming systems that have been infrequently studied may prove to be useful for agroforestry, particularly in traditional shifting cultivation wherein the lands are left fallow for a 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, could also reduce the fallow cycle of traditional shifting agriculture to one-year period, which could mean an increase in arable crop land as well as crop(s) produced (Yadav, 1981).

Investigation on the nitrate -N profile of soil in sole and parallel multi-cropping systems of maize and beans have shown that there was nitrate-N in the deeper horizons, whereas the nitrate-N content beyond 30 cm depth was drastically reduced in intercropping as it was better utilized by the mixture of crops. Environmental resources, both in spatial and temporal terms, and both above and below ground, can usually be better shared between a mixture of species than by a single crop (Huxley, 1980).Agroforestry has therefore been suggested as a substitute for the fallow lands of shifting cultivation in modern sedentary agriculture due to increasing human population.

2.2. Agroforestry in augmentation of nitrogen and moisture:

Scattered examples of the preservation and use of naturally occuring leguminous trees (NFT's) for fertility maintainance in indigenous farming systems (Okigbo and Lal, 1978) and the results of early research on planted fallows and ' alley cropping 'systems for cereal and root crop production between rows of legume trees (Pareira,1978; Benge,1979 and Wilson,1979) have demonstrated the potential of such systems to maintain high soil nitrogen levels(Raintree,1980). Selected species for intercropping must however be easy to establish, fast growing ,deep rooted, have the ability to conserve soil water,withstand frequent prunings and be able to produce heavy and easily degradable foliage (Wilson and Kang, 1981).

The properties of fast growth, moisture retention as well as biological nitrogen fixation (BNF) are possessed by *Leucaena spp.* (Guevarra,1976). The choice of deep rooting leguminous trees such as *Leucaena* species not only lends a measure of the much needed drought resistance to the system, but the canopy developed during the dry season could also control weeds, and the foliage as mulch help in conserving soil moisture (Kang *et al.*,1984).

2.3. Leucaena as multifaceted species:

Leucaena leucocephala is a tropical, leguminous, fast growing, drought resistant tree with fairly deep tap root system. It belongs to the family leguminoseae. It has a range of varieties from tall and slender (upto 20 m. tall) to bushy types (upto 5 m.) with deep roots of upto 2.5 m. (Djikman,1950).

Success in wide range of environments is a hallmark of *Leucaena*. True, it is restricted to the tropics and subtropics, and within that huge region to elevations below about (1,500 ft), but it withstands large differences in rainfall, sunlight, salinity, and land terrain, as well as periodic inundation, fire, windstorm, frost and drought (Parfitt, 1976).

Leucaena, due to its good tolerance to high temperature and extended drought, and remarkable regeneration capacity can be used for afforestation of steep slopes (Anonymous, 1977).

Patil and Pathak, (1979) have reported that *leucaena leucocephala* has been widely planted in some states of India, because of its fast growth rate, fodder, fuel and its role in soil improvement and soil conservation, and also can grow in a variety of soil climatic conditions.

Leucaena spp. is a multipurpose plant with a large number of uses, e.g. fodder (mainly for ruminants), fuelwood (24-1003/ha) and wood for pulp, paper and construction (Anon., 1980 b).

Kulkarni, (1980) investigated that in Ahmednagar district under drought prone conditions, *Leucaena* seedlings raised in polythene bags, attained a height of 0.7 to 1.0 m at the time of planting and withstood drought condition during the planting year.

At Urulikanchan (Mean annual rainfall 350 to 400 mm with shallow, murum lateritic soil), a two year old plantation of K_8 and K_{28} varieties of *L. leucocephala* raised at a spacing of 1m ^{2} under irrigation (one irrigation every 45 days from December to May) exhibited an average height and diameter growth of 9.5 m and 6 m respectively. Another plantation raised at a spacing of 3x1m exhibited an average height and diameter of 9.5 m and 9.54 cm respectively at the end of 3 ½ years. Avenue trees of Leucaena planted at spacing of 4.2 m^2 exhibited an average height of 12.97 m and D.B.H 20.24 cm in about 4 years time (Relwani, 1980).

Ahmed, (1981) reported low girth increment at close spacings (10 x 30 cm^2 or 225 x 15 cm)

Patil, (1981) reported that *Leucaena leucocephala* grows in areas with an annual rainfall as low as 50 mm to 2500 mm or more. Its growth is restricted at low temperatures. It thrives best on well on well drained soil pH 7 to 8.5. It cannot tolerate strongly acidic soils. Nodulation and growth are adversely affected at pH below 5.5. It can grow on rocky and heavy clay soils but cannot tolerate water logged conditions.

Leucaena leucocephala yields gum and four dyes namely black, red, brown and yellow, that can be extracted from bark, leaves and other parts of the tree (Deshpande, 1981).

Leucaena also provides services roles such as soil conservation and fertility improvements through Biological Nitrogen Fixation (BNF) and green leaf manure (GLM). Beside, it helps break impervious sub-soil layer, improve water percolation and prevent surface run - off (Anon, 1980 b).

Salvadorian - type *Leucaena* is a deep rooted plant, with an aggressive tap root that can penetrate deep into the soil and thus enable the plant to withtstand drought. (Jiang 1982).

Once *Leucaena* is established, it has several advantages such as:

(a) Leached plant nutrients are recycled from sub-soil.

(b) Provides biologically fixed nitrogen to the companion crop.

(c) Provided favourable conditions for soil macro and micro-organisms.

(d) Provides prunings which can be applied as mulch, and shade during the fallow period to suppress weeds.

(e) Protects soil against erosion, especially, if planted along contours, and

(f) Provides an inexpensive source of stakes for yam vines, fuelwood and fodder, and its seeds are often used as human food (Ngambeki and Wilson, 1983).

Leucaena coppices well and its coppicing ability allows repeated harvests of firewood, timber and foliage (Brewbaker, 1984).

Grewal *et al*., (1992) investigated the planting of *Leucaena leucocephala* at closer spacing (0.75m x 0.25m), and obtained significantly more fodder and fuelwood yield and returns than at wider spacing of 3.75m x 0.25m. He also reported that the combination of *Leucaena* with maize / blackgram gave significantly higher net returns as compared to pure maize or pure blackgram.

2.4. Effect of Leucaena as organic fertilizer in maize production:

Flores, (1975) and Leviste, (1976) citing the work of Brewbaker reported that maize yield was increased by 133% when fertilized with *Leucaena* green leaf manure (GLM) as compared to the control plots.

Many workers have investigated the use of Leucaena hedgerows / alley cropping with maize as an alternative low nitrogen input system, in which maize yield can be sustained at a relatively low level or without nitrogen inputs (Guevarra, 1976; Kang *et al* 1981; Ngambeki *et al*, 1983). Such experiments in Hawaii and the Philippines have shown that *Leucaena* foliage of 1.0 ton dry weight basis of GLM increased the yield of maize to 1.0 ton, where 4.0 tons of freshly harvested foliage is equivalent to 4% of nitrogen (Guevarra, 1976).

In Morogoro, Tanzania, trials were laid out in 1980-1981 under alley cropping with *Leucaena* (intercropped with maize and beans in separate plots) to evaluate its potential in food and fodder production under various regimes of lopping, and variety of weeding . (Maghembe *et al* 1980). The yield of maize was 1645 Kg/ha and was greater than twice the national average yield of maize in Tanzania, i.e. 670 Kg/ha (Acland, (1981).

Addition of *Leucaena* GLM from full grown hedgerows was to sustain maize grain yield at about 3.8 t/ha for two consecutive years with no N - addition, while with no addition of prunings, maize grain yields declined. Higher maize grain yield were obtained by supplementation with low N - rates of 20-50 Kg/N/ha depending on a variety of soil. The effect of nitrogen contributed by *Leucaena* mulch on maize grain yield was about 100 Kg/ha for every 10 t/ha of fresh prunings. Other studies at IITA showed higher N-yield of 189 - 250 Kg/N/ha from 5,000-8000 Kg/ha dry leaves with 3.2 - 3.5% N - content (Kang *et al.,* 1981).

Evensen, (1982) further showed that *Leucaena* GLM surface mulching to be only 41.2% as efficient in supplying N to maize as in urea. These efficiencies were however higher than Guevarra's (1976) 38% value because Guevarra used chopped whole *Leucaena* foliage including the woody fraction. Woody materials would release N slowly during their decomposition and there fore decrease total available-N.

The use of *Leucaena* tops maintained maize yields at a reasonable level, even with no additional nitrogen input on low fertility sandy inceptisoils 40% increase in maize yields from two - year alley cropping with *Leucaena* over control plot of maize alone at IITA which had the same basal fertilizer rate and maize population density has also been reported (Anon, 1982 a).

Alley cropping system could also contribute to reduction of both soil crosion in the uplands (hedges are planted along contour lines) and help to reduce the ever increasing fuelwood requirement (Torres,1983).

Gill and Patil, (1984) observed that maize crop manured with herbage from intercropped *Leucaena* produced as much grain (3.0 t/ha) as pure stand of maize (without *Leucaena*) intercrop fertilized with 60, 30 & 30 N, P & K (Kg/ha) respectively.

Kang *et al.*, (1985) found that alley cropping with *Leucaena* on an Entisol (pH 6) for six years could maintain maize yields at around 2 t/ha with no additional fertilizer.

Leucaena leucocephala increased maize yield by 0.7 t/ha compared to only 0.3 t/ha by the application of fertilizer (Sullivan, 1985) and 1.4 t/ha with or without fertilizer (Watson and Lagnihan, 1985)

Sanginga *et al.*, (1989) reported that *Leucaena* can fix 35% of N biologically and that litter was taken from deeper soil layers. This represents a net input into the system of about 88 Kg/ha/year N. (Kessler and Breman 1991).

Matthew *et al.*, (1991) in the low input traditional systems of Chiteme and Fundikila, investigated that in a limed maize alley cropping trial lasting six years, in the absence of nitrogen fertilizer *Leucaena leucocephala* consistently improved maize yield by upto 95% and also there was some evidence of improvement of soil chemical and physical characteristies in the *Leucaena* treatments of this trial.

Leucaena leucocephala GLM alone at the rate of 15, 10, 15 and 20 t/ha, yielded 2.13, 2.83, 3.11 and 3.68 t/ha of maize grain when combined with 60 Kg N/ha. (Kwesiga *et al.*, 1991)

Matthew *et al.*, (1992) reported that in their experiment, maize yield from the *Leucaena* plots with fertilizer, N were higher (although not significantly) than those from the plots with no trees but with 60 Kg/ha N applied, and in 4 of the years were not significantly different from the yields from the plots with 120 Kg/ha N with no trees.

2.5. Effect of Leucaena on soil fertility:

Leucaena foliage can be used as organic fertilizer for improving the fertility status of the soil (Brewbaker, 1975). In some parts of Asia, *Leucaena leucocephala* and *Sesbania grandiflora* are among legumes recognised as efficient soil fertility restorer (Guevarra, 1976 and Anon, 1977).

Studies in the Philippines (Anon, 1977) have demonstrated that a well grown *Leucaena* plot can yield around 87.3 Kg/ha of Phosphorus and 375 Kg/ha/year of Potassium.

The tap-root system of *Leucaena* makes it unsuitable for binding surface soil, a situation leading to excessive soil erosion especially under dense pure *Leucaena* stands. It has therefore been suggested that intercropping or strip planting of a second species or planting a shade tolerant 'live mulch' grown under *Leucaena* crop could be a solution (Terges *et al.,* 1978 and Pound *et al.*, 1983).

Gill *et al.*, (1982) investigated the effect of *Leucaena* foliage compared to *Sesbania* foliage as source of green manure. The results demonstrated the usefulness of *Leucaena* foliage as a source of green manure (though actual yields were not given by the author) and subsequently an important source of manuring the crops for tropical and sub-tropical climatic conditions. Besides, increasing crop production, *Leucaena* provided organic matter that improved soils properties by increasing aeration, water retention and cation exchange capacity.

Leucaena leucocephala is more than just nitrogen mineral elements such as phosphorus and potassium, absorbed by the roots from deep soil become incorporated into the foliage. This helps

Leucaena grow in soils low in minerals such as phosphorus (Brewbaker, 1984). Foliage incorporated in the soil lead to an increase of nutrients in the soil.

In Hawaii, *Leucaena* foliage harvested from one hectare after one year growth contained 44 Kg of phosphorus and 187 Kg of potassium, as well as calcium and micronutrients (Anon, 1984 d).

The high turnover of foliage and efficient nitrogen fixation (NAS 1984; Lulandala, 1985) can contribute highly to soil conservation and improvement. Planted as a fertilizer crop, one hectare of *Leucaena* can provide an amount of nitrogen equivalent to a ton of ammonium sulphate fertilizer each year, especially when the foliage is incorporated in the soil (NAS, 1984). Moreover, the litter and humic layers on the soil surface act as a cushion against erosion (Nair, 1984).

Hu Taiwei *et al,* (1984) in China reported that soil nutrient reserve (0-30 cm) content under *Leucaena* increased in available nitrogen, phosphorus, potassium, calcium and magnisium at the rate of 5.52, 1.67, 13.94, 676.71 & 125.53 Kg/ha/year on average respectively after 4.5 years of growth.

An annual nitrogen fixation rate of 197 Kg/ha by *Leucaena* has been reported (Lulandala and Hall, 1986).

Pathak and Gupta, (1987) studied organic matter addition through leaf litter in 2 year old *Leucaena* plantation to be 5-6 t/ha annually which improved tilth, cation exchange capacity, water holding capacity, bulk density, brings down soil pH from alkaline to normal and improved the yield of successive crops

In an alley cropping trial with *Leucaena leucocephala,* Hauser (1990), showed higher nutrient (N,K, Ca and Mg) levels in the surface soil than in the subsoil under the hedgerows. He attributed this to nutrient accumulation in the surface soil due to leaf litter fall and nutrient uptake by the tree from the subsoil.

Hauser and Kang, (1992) investigated that following six years of alley cropping with *Leucaena*, the organic carbon level in the surface soil declined to a very low level in the control (no tree) treatment (0.59% c) as compared with alley cropped plot (0.94% C). High soil organic carbon level was, however, maintained under the *Leucaena* hedgerows (1.23% C).

STUDY AREA

STUDY AREA

3.1. Location:

The field experiment was carried out in Mualpui Veng which is 3 Km East of Aizawl, in the state of Mizoram (Fig.1).

Mizoram ia a hilly state and is located in the north east corner of India. The state lies between 21^{0}56'N - 24^0 31'N latitudes and 92^{0}16'E - 93^{0}26'E longitudes. Being sandwitched between Bangladesh and Myanmar, its location is of strategic significance geographically and politically; and shares a total common international boundary of abour 585 Kilometres with these two countries. Mizoram has a total geographical area of 21,087 sq. km.

3.2 Topography:

The entire territory is mostly mountainous and hilly with precipitatous slopes forming deep gorges culminating ito several streams and rivers. The mountain ranges are inclined north to south direction in parallel series. The ranges are separated from one another by narrow deep river valleys. The elevation ranges from 40 metres at Bairabi to 2157 metres at Phawngpui. There are only few small patches of flat lands which are mostly inter-mount plains (Anon, 1990).

The geological formation of Mizoram is young and immature. It shows prominent relief features with steep slopes, and is still undergoing denudation in response to various exogenetic (isostatic gravity) processes (Liangkhaia, 1976).

3.3 Climate:

Owing to its location, physiographic characteristics and the influence of the southwest maritime airmass, Mizoram generally enjoy a typical monsoon type of climate. It is humid and warm in summer and dry and cool in winter. The climate of the state, however, is also influenced by the periodic cyclonic disturbances, local mountain and vally breezes and extensive forest cover.

The salient thermo - characteristics of Mizoram is that temperature does not fluctuate much throughout the year. The highest temperature is observed during May, June and July. The summer temperature generally varies from 21^{0}C to 30^{0}C whereas winter temperature have a range of 11^{0}C to 23^{0}C.

The entire state of Mizoram is under the direct influence of rainfall during the monsoon period. The average rainfall is 250 cms. per annum. Aizawl located at 23^{0}44'N and 92^{0}43'E recieves about 218 cms annual rainfall.

The soils of Mizoram are dominated mainly by loose sedimentary formations. Soils vary from sandy loam, clayey loam to clay, generally mature but leached due to steep gradient and heavy rainfall. The pH is acidic to neutral in reaction, due to excessive leaching. In uneroded soils, the nitrogen content is quite high fostered by accumulation of organic matter.

3.4. Site Characteristics:

The study carried out in Mualpui Veng was located at 23^{0}44'N latitude and 92^{0}43'E longitude of Aizawl. The site was located in south-east at a lower elevation compared to the main Aizawl town. The area was having a moderate slope. Few years back, the land was under jhum cultivation, where upland paddy was the main crop.

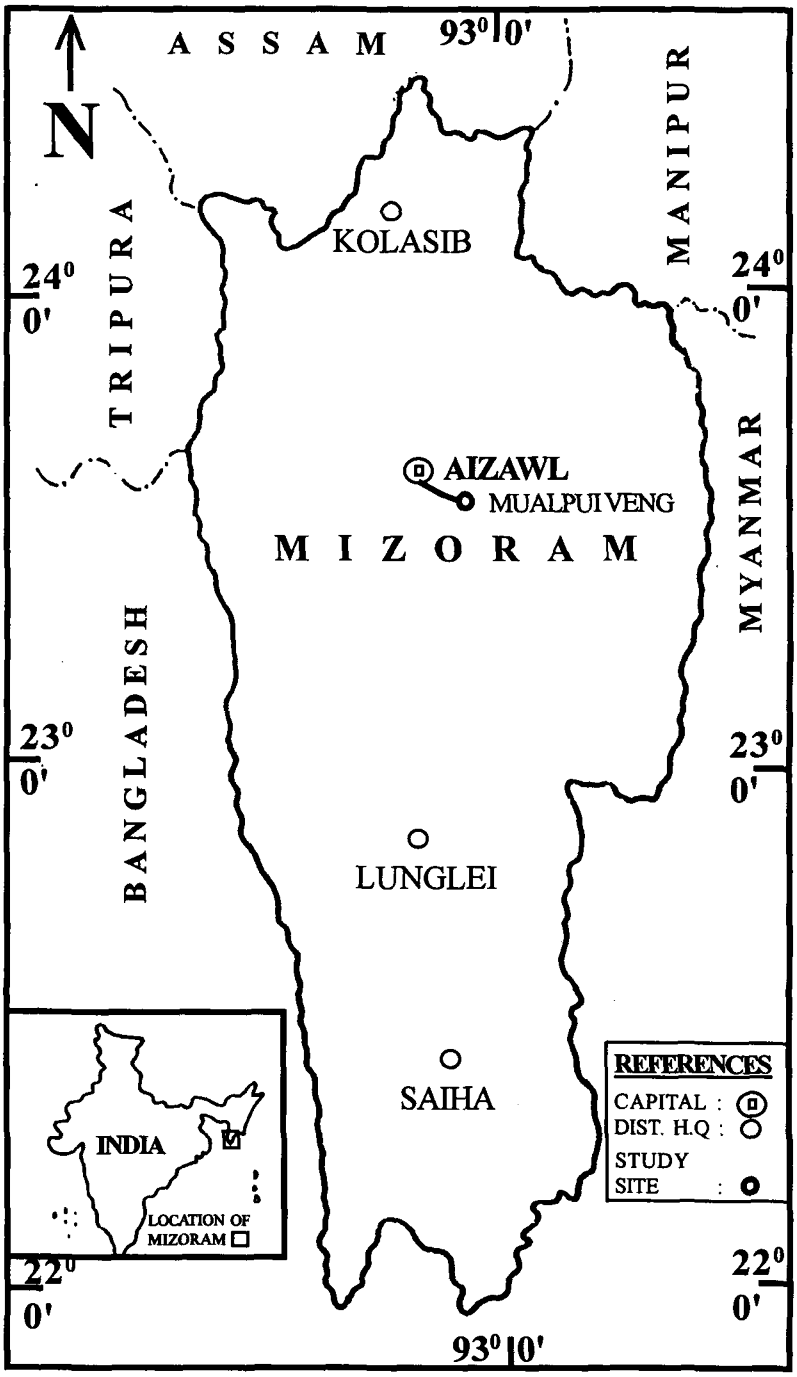


Fig. 1. Map of Mizoram showing location of study site.

The climate was humid tropical characterized by short winter and long summer with heavy rainfall. During summer season, the temperature generally varies from 21^{0}C to 31^{0}C while winter temperature ranges between 4^{0}C to 23^{0}C. The mean annual rainfall during the study period was 215.77 mm.

The soil of site was sandy loam and also compact due to grazing by cattles. The soil pH was acidic in reaction.

MATERIALS AND METHODS

MATERIALS AND METHODS

4.1. Design and layout of experiment:

The study involved intercropping of Salvadorian type *Leucaena leucocephala* (Lam) de Wit at spacings of (2 x 2) m^2, (3 x 3) m^2 and (4 x 4) m^2 (treatments) with maize (*Zea mays*) and a control having only maize. The design adopted for the experiment was Randomized Block Design (R.B.D). The area was divided into equal number of blocks, and each block was again divided into equal number of plots. The size of each plot was 25 sq.m. Each plot was separated from adjacent plots by a distance of 1 m to minimise the border effect. Each treatment was replicated thrice. The detailed plan and layout of the experiment is given in Fig.2.

Leucaena leucocephala seedlings were raised in polythene bags containing a mixture of sandy loam soil and farmyard manure in the proportion of 2:1. Two months old seedlings of 17-19 cm height were planted in the experimental plots on 28.8.98 in 30 cm^3 filled with a mixture of soil and manure. Planting of *Leucaena* was as per the specified spacings.

Zea mays (Var. Ganga-11) was planted in April 1999, in between the interspaces of *L. leucocephala*. The spacing for maize was uniform for all the plots (70 cm x 30 cm) row to row and plant to plant respectively. Thus in every plot 36 number of maize seeds were accomodated in four rows, with 9 plants per row. The control plots had the same number of maize plants (9 x 4 = 36) as in the experimental treatments (Fig.2), but did not have any *Leucaena* plant. No fertilizers were added.

4.2. Sampling program :

A forthnightly triplicate sampling program was originally envisaged, but had to be restricted to monthly sampling due to financial constraints. The different parameters accounted for and the procedures adopted are as follows :

4.2.1. Meteorological data :

Daily records for rainfall and temperature (maximum and minimum) were collected from the Science, Technology and Environment, Planning Cell, Department of Mizoram. The monthly means were calculated represented as such for the study period i.e. September 1998 - August 1999.

4.2.2. Physico-edaphic factors :

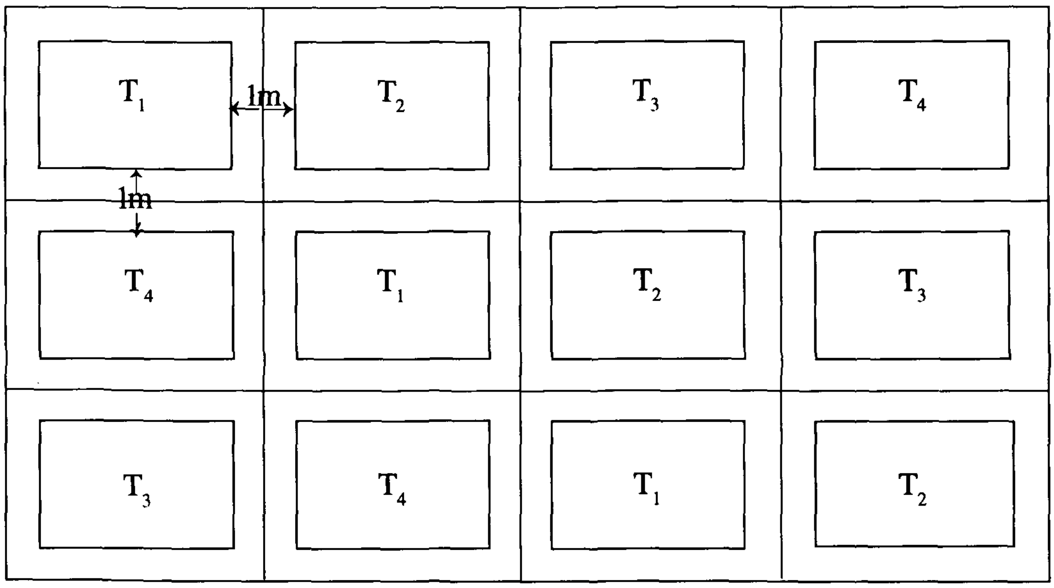
The physico-edaphic factors accounted for the experimental plots were air temperture, soil temperature and soil moisture. Measurements were taken during each sampling occasion.

(i) Air temperature and Soil temperature :

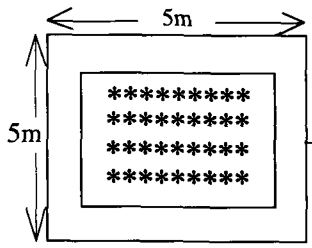
Air temperature was recorded at a height of 1 metre (m) above ground level and soil temperature at a depth of 0-15 cm by using a mercury in glass thermometer.

(ii) Soil Moisture :

Soil samples were collected monthly at a depth of 0-30 cm. The collected samples were carefully labelled and sealed in polythene bags and transported to the lab. Soil moisture loss on drying to constant weight was determined for 100 gms of fresh soil. The soil moisture content was expressed as percent fresh weight and calculated as follows :-



Randomized Block Design (R.B.D.) layout for the study site.



Magnified view of single plot showing spacing of *Zea mays*

Distance between each plot : 1 m.

Size of each sub-plot with border area :	5 x 5 sq.m.
Treatments : (*Leucaena* spacings)	T_1 = 2 x 2 sq.m. T_2 = 3 x 3 sq.m. T_3 = 4 x 4 sq.m. T_4 = Control (without Leucaena)
Maize spacing :	70 x 30 cm.
Number of maize plant / plot.	36 (Nos).
Replications :	3 (Three)

Fig : 2. Showing the details of experimental layout.

$$\text{Moisture}(\%) = \frac{FW - DW}{FW} \times 100$$

where,

M = Moisture.

FW = Fresh weight.

DW = Dry weight.

4.2.2. Chemo-edaphic factors :

(i) Soil pH :

The soil pH was measured in a Systronics double electrode digital pH meter (Model - 331). Soil suspension in distilled water in the ratio of 1:5 were stirred in a magnetic stirrer for 5(five) minutes and allowed to settle before the readings were recorded.

(ii) Soil Nutrients (C,N,P and K) :

For organic Carbon, Nitrogen, Phosphorus and Potassium, the air dried soil samples (after moisture content determination) were ground and sieved. These samples were subsequently used for the estimation of organic Carbon (Walkley-Black method, 1934), Nitrogen (Kjeldahl method in Subbiah and Asija,1956), Phosphorus (Bray and Kurtz method, 1945) and Potassium (Flame photometer method as detailed in Allen (1974). The estimations were done in the soil testing laboratory,department of Agriculture, Government of Mizoram.

4.2.3. Biotic factors :

(i) *Leucaena leucocephala* :

The growth performance of *Luecaena leucocephala* was estimated through measurement of height and stem girth as follows:

Leucaena height was measured with the help of a metre scale from the base of the plants upto the longest tip of the top leaves in each treatment. The height of the plants were recorded for all plants every months during the study period.

Stem girth of *Leucaena* was measured at the base of plants as in the case of height measurements. Measuring tape in centimetre (cm) scale was used for recording the girth of the plants.

(ii) Maize :

The following estimates were recorded for maize:-

Height of maize plant were measured and recorded in all the treatments at every one month interval from May to August 1999. The measurements were done from the base to the longest tip of the top leaves by using a metre (m) scale. The mean height of maize was taken for each replication of the treatment.

Stem girth of maize were also measured monthly. Girth measurement was done at the base of the plant near the ground level with the help of the centimetre (cm) scale.

The number of leaves plant in different plots were counted monthly. The number of leaves were averaged for each plot and recorded.

Mean length (cm) and width (cm) of cobs were measured for each plot yield.

Number of kernels per ear per row were counted and recorded as means.

Number of rows per ear were recorded as means. Mean cob weight Kg per plot (yield / plot) were recorded.

4.2.4. Statistical Analysis :

Correlation coefficient : The statistical formula used for measuring the magnitude and direction of the relation between two or more related estimates is known as correlation coefficient. Correlation coefficient was calculated by the Karl Pearson's formula -

$$r = \frac{\Sigma x . y}{\sqrt{\Sigma x^2 . \Sigma y^2}}$$

where,

r = Correlation coefficient.

x = Independent variable.

y = Dependent variable.

The monthly estimates of the different growth characteristics of *Leucaena leucocephala* and maize (dependent variables) were correlated with meteorological, physico-edaphic and chemo-edaphic factors (independent variable) by using the above formula.

Students t-test : Students t-test is used to test the significance of a single mean or for the comparison of two sample means. It is used in a situation where the sample size is less than 30 and the population variance is known.

The significance of correlation coefficient (r) when it is estimated from a small number of pairs, can be calculated by the following formula -

$$t = \frac{r}{\sqrt{1 - (r)^2}} \times \sqrt{N - 2}$$

where 'r' is the estimated value obtained from 'n' pairs. It has been shown that this ratio is distributed in sampling as 't' with n-2 degrees of freedom (df). the significance of an observed correlation (r) can, therefore, be tested by reference to the 't' table . If the ratio exceeds the 't' value for $p = 0.05$, we have the reason to believe that the sample indicates a real correlation between the two variates.The degrees of freedom for the calculation was N-1 as the number of sample were < 30.

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 mean 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 -

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

where, F = Variance ratio.

MSS = Mean 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 per cent levels. If the calculated ' F ' value is greater than the 'F' table value at 5 % and 1 % then it is said to be significant.

RESULTS

RESULTS

5.1. Abiotic factors :

The results of the abiotic factors accounted for during the present investigation are grouped under three categories :

(i) Meteorological factors : Maximum and minimum temperature, and rainfall.

(ii) Physico-edaphic factors : Air temperature, soil temperature and soil moisture.

(iii) Chemo- edaphic factors : Soil pH, Organic carbon (O.c), Nitrogen (N), Phosphorus (P) and Potassium (K).

5.1.1. Meteorological factors :

Meteorological data were collected from Science, Technology and Environment, Planning Cell, Department of Mizoram. The daily records of the meteorological factors as obtained were averaged for their monthly values. For the rainfall data, the daily records were added and the monthly total calculated. Fig - III depicts the monthly fluctuations of the meteorological factors.

Temperature: During the experimental period (September 1998 - August 1999), monthly maximum temperature varied from a low of 24.52 °C (January) to a high of 33.42° C (Aug gust). Mean monthly minimum temperature recorded was lowest in January (12.4° C) and highest in April (33.42° C). the temperature gradually increased from January to April, and with the onset of monsoon it showed a marginal declined and remained almost constant from June to August (Table - I).

Rainfall : The total annual rainfall recorded during September 1998 to August 1999 was 1942 mm. The total number of rainy days during the study period were 153. During 1999, the onset of rain was from March, peak rainfall recorded was 429 mm in August, and the lowest value was 31 mm in March. However it was observed that there was no rainfall during the month of December upto February (Table - I).

5.1.2. Physico-edaphic factors :

Air temperature : Table-II depicts the seasonal temperature fluctuations of the study site. During the study period, air temperature ranged between 24.8° C to 33.7°C. The highest record was 33.7° C in April and lowest value of mean temperature during January was 24.8° C. Since there was no rainfall during the month from December to February, the air temperature increased during the period of study and reached upto a mean maximum of 33° C in April. However, during the rainy season from March to August, it was observed that air temperature slowly declined and maintained itself almost constant during June to August.

Soil temperature and soil moisture : The monthly variation of mean soil temperature and soil moisture contents of the site during the experimental period are depicted in Table-II. The seasonal fluctuations follwed a general trend of summer peaks and winter minima, as observed for the air temperture.The morning soil temperature recorded at 0-15 cm depth showed the highest peak of 28° C in April and lowest 19.5° C in January. As there was no rain during December to February, the temperatures also gradually increased from December to April. However, with the onset of rainfall, the temperature slowly decreases from April and remained almost constant during May to August.

The moisture content of the soil of site taken at a depth of 0-30 cm from the surface soil, showed a general trend of lower moisture during December to February ranged between 18 % to

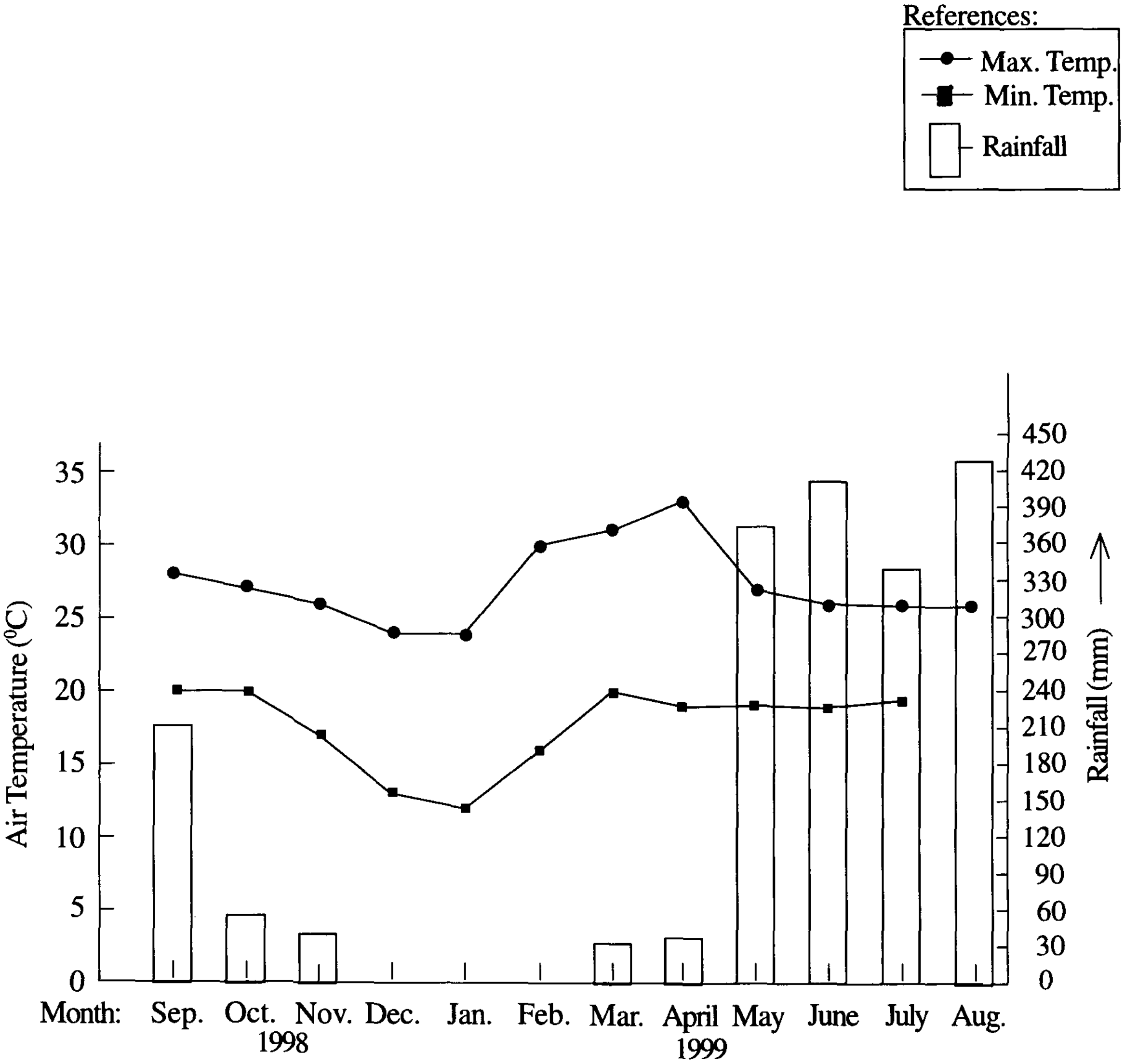


Fig. 3 Seasonal fluctuations of Air temperature and Rainfall.

Parameters		September 1998	October	November	December	January 1999	February	March	April	May	June	July	August
Temperature (0^0 C)	Max.	28.09	27.84	26.87	24.72	24.52	30.35	31.10	33.42	27.84	26.56	26.39	26.28
	Min.	20.25	20.02	17.90	13.32	12.40	16.37	17.43	20.40	19.15	19.76	19.67	19.78
Total Rainfall (mm)		210	58	47	NIL	NIL	NIL	31	37	375	414	341	429

Table - I . Showing monthly records of meteorological data during the study period.

	1998				1999							
Parameters	September	October	November	December	January	February	March	April	May	June	July	August
Average soil moisture (%)	28	26	28	20	19	18	19	20	28	34	32	33
Average soil temperature (0^0 C)	22.4	23.2	21.7	19.8	19.5	25.7	26.8	28.8	22.6	20.8	21.5	21.3
Average air temperature (0^0 C)	28.0	27.9	26.8	24.7	24.8	30.2	31.1	33.7	27.8	26.7	26.6	26.2

Table - II . Monthly records of Physico-edaphic factors for the experimental site during the study period.

28 % respectively. The soil of site showed 34 % moisture content as summer peak during June. The percentage of soil moisture was recorded to be low during the of December to February, probably due to no rainfall during winter season. The lowest soil moisture percentage was recorded in February with only18 %. The percentage of soil moisture gradually increased from March to June and remained steady upto August with the onset of rainfall (Table - II).

5.1.3 Chemo-edaphic factors :

Results of the monthly records of soil characteristics which included soil pH and soil nutrients (O.c, N, P and K) were estimated.

Soil pH : The mean monthly records of the pH value of the site are depicted in Table-III. The soil reaction was acidic with pH varying from 5.71 to 5.85. The highest pH value recorded was 5.83 in November 1998 and lowest 5.71 in June 1999. The soil pH before establishment of *Leucaena leucocephala* was 5.80 during September 1998.

Soil nutrient budgets :

Monthly records of soil nutrient budgets (O.c, N, P and K) recorded from the treatments (i.e. 2 x 2 m^2, 3 x 3 m^2, 4 x 4 m^2 and control) is depicted in Table-III. Resultsof the chemical analysis of the soil samples for nutrients taken from 0-30 cm from the surface soil,before start of the experiments of the present study was found to contain - 0.71 % O.c, 0.060 % N, 16.3 kg/ha P and 120.2 kg/ha K in 2 x 2 m^2; 0.72 % O.c, 0.061 % N, 17.3 kg/ha P and 127.4 kg/ha K in 3 x 3 m^2; 0.75 % O.c, 0.063 % N, 18.9 kg/ha P and 122.8 kg/ha K in 4 x 4 m^2 and 0.76 % O.c, 0.064 % N, 18.0 kg/ha P and 122.6 kg/ha K in control plot. During May, it was recorded that there was decline in soil nutrients. The reason may be due to high uptake of nutrients by maize plant which was planted along with *Leucaena* as an intercrop and also as a sole crop.

The nutrient content of soil was found to be high before planting of *Leucaena* as compared to (monthly variation during) the growth period of both *Leucaena* and maize plants. The reason may be due to burning of dry matter of plants cut during land preparation which has resulted increased in soil nutrients (O.c, N, P and K).

The mean nutrient contents of soil in August after maize was harvested was - 0.69 % O.c, 0.056 % N, 13.7 kg/ha P and 117.8 kg/ha K in 2 x 2 m^2, 0.67 % O.c, 0.056 % N, 12.8 kg/ha P and 116.6 kg/ha K in 3 x 3 m^2, 0.65 % O.c, 0.055 % N, 118.8 kg/ha P and 116.2 kg/ha in 4 x 4 m^2 and 0.65 % O.c, 0.055 % N, 12.2 kg/ha P and 117.5 kg/ha K in control treatments (Table-III).

5.2.0. Biotic factors :

The biotic factors accounted for i.e. the growth performance of both *Leucaena leucocephla* and *Zea mays*, and crop yields (maize) are listed in Tables - IV, V and VI respectively.

5.2.1. *Leucaena leucocephala* :

The monthly records of the growth performance in height and stem girth of *Leucaena leucocaphala* plant in different treatments is depicted in Table-IV. It may be seen from the data that monthly increase in *Leucaena* height ranged from 0.210 m to 0.976 m and stem girth ranged from 1.16 cm to 3.33 cm in different treatments during September 1998 upto August 1999. The plants showed 100% survival after transplanting (Plate-1). The maximum height increase (0.226 m) was observed in 3 x 3 m^2

Months	1998 September					October					November					December					1999 January					February				
Treatments	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha	K Kg/ha
2x2m	5.80	0.71	0.060	16.3	120.2	5.80	0.76	0.064	19.3	124.5	5.85	0.77	0.065	20.0	120.8	5.82	0.78	0.066	21.6	123.3	5.80	0.79	0.067	25.7	128.1	5.77	0.76	0.064	27.4	130.1
3x3m	5.81	0.72	0.061	17.3	127.4	5.83	0.77	0.065	20.8	123.8	5.81	0.78	0.066	22.4	122.6	5.80	0.79	0.067	23.0	125.6	5.81	0.77	0.065	26.3	129.7	5.76	0.76	0.064	28.8	129.1
4x4m	5.79	0.75	0.063	18.9	122.8	5.84	0.76	0.064	21.2	121.7	5.83	0.77	0.065	21.3	120.9	5.80	0.78	0.066	24.3	127.6	5.80	0.78	0.066	26.2	130.4	5.74	0.75	0.063	21.6	129.3
Control	5.78	0.76	0.064	18.0	122.6	5.82	0.77	0.065	22.2	121.3	5.81	0.77	0.065	22.2	120.8	5.80	0.77	0.065	24.8	125.5	5.79	0.78	0.066	24.6	130.5	5.75	0.78	0.066	22.7	129.7

Months	March					April					May					June					July					August			
Treatments	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha	K Kg/ha	pH	O.c. %	N %	P Kg/ha
2x2m	5.75	0.76	0.064	20.7	127.5	5.75	0.71	0.060	20.2	126.2	5.72	0.68	0.058	17.5	124.4	5.71	0.67	0.056	15.9	121.6	5.78	0.67	0.056	14.5	120.0	5.75	0.69	0.058	13.5
3x3m	5.75	0.77	0.065	20.6	129.8	5.73	0.70	0.059	19.8	125.1	5.71	0.67	0.056	16.5	120.2	5.69	0.66	0.056	14.8	120.2	5.77	0.68	0.057	13.8	119.4	5.74	0.67	0.056	12.8
4x4m	5.76	0.78	0.066	21.2	127.8	5.74	0.69	0.058	18.6	126.4	5.72	0.68	0.058	16.8	122.1	5.73	0.65	0.055	14.6	119.3	5.76	0.69	0.058	12.7	118.8	5.73	0.65	0.055	11.8
Control	5.75	0.78	0.066	20.4	127.0	5.74	0.72	0.061	19.8	127.2	5.71	0.67	0.056	16.7	122.2	5.75	0.66	0.056	15.0	121.4	5.76	0.65	0.055	13.4	119.6	5.73	0.65	0.055	12.2

Table - III . Monthly records of soil pH and nutrient budgets (0-30 cm depth) of the study site in Mualpui Veng, Aizawl during1998-1999.

1998 1999

Months		September			October			November			December			January			February		
Parameters	Spacing	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E
Leucaena leucocephala Height (m)	2 x 2	0.21 ± 0.153			0.266 ± 0.172			0.330 ± 0.191			0.376 ± 0.204			0.423 ± 0.216			0.470 ± 0.228		
	3 x 3	0.226 ± 0.158	2.66	0.007	0.260 ± 0.169	1.47	0.011	0.323 ± 0.189	1.16	0.014	0.363 ± 0.200	0.333	0.02	0.403 ± 0.211	.272	0.027	0.450 ± 0.223	0.214	0.030
	4 x 4	0.21 ± 0.153			0.280 ± 0.176			0.343 ± 0.190			0.376 ± 0.202			0.406 ± 0.212			0.466 ± 0.227		
Leucaena leucocephala Stem girth (cm)	2 x 2	1.16 ± 0.360			1.33 ± 0.384			1.40 ± 0.394			1.50 ± 0.408			1.56 ± 0.417			1.60 ± 0.421		
	3 x 3	1.20 ± 0.365	0.187	0.171	1.46 ± 0.403	0.357	0.167	1.46 ± 0.403	0.851	0.134	1.63 ± 0.426	1.00	1.63	1.63 ± 0.426	0.20	0.182	1.66 ± 0.430	0.20	0.182
	4 x 4	1.26 ± 0.375			1.36 ± 0.389			1.56 ± 0.417			1.66 ± 0.430			1.70 ± 0.434			1.70 ± 0.434		

Months		March			April			May			June			July			August		
Parameters	Spacing	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E	Mean ± SE	F- Ratio	S.E
Leucaena leucocephala Height (m)	2 x 2	0.513 ± 0.238			0.560 ± 0.249			0.623 ± 0.263			0.703 ± 0.279			0.846 ± 0.306			0.976 ± 0.329		
	3 x 3	0.483 ± 0.231	0.727	0.027	0.523 ± 0.241	2.66	0.16	0.590 ± 0.256	2.125	0.023	0.670 ± 0.272	3.25	0.02	0.823 ± 0.302	2.66	0.02	0.960 ± 0.326	4.28	0.021
	4 x 4	0.486 ± 0.232			0.523 ± 0.238			0.576 ± 0.253			0.653 ± 0.269			0.790 ± 0.296			0.913 ± 0.318		
Leucaena leucocephala Stem girth (cm)	2 x 2	1.60 ± 0.421			1.63 ± 0.426			2.03 ± 0.475			2.33 ± 0.509			2.76 ± 0.554			3.23 ± 0.608		
	3 x 3	1.70 ± 0.434	0.288	0.186	1.73 ± 0.438	0.20	0.182	2.03 ± 0.475	0.230	0.208	2.40± 0.516	0.166	0.134	2.90 ± 0.567	1.00	0.163	3.33 ± 0.620	2.04	0.121
	4 x 4	1.73 ± 0.434			1.73 ± 0.438			2.06 ± 0.479			2.40 ± 0.516			2.73 ± 0.551			3.20 ± 0.599		

Table - IV . Monthly records of height and stem girth of *Leucaena leucocephala* during the study period.

Each data is followed by SE value
how the means are compared?

Plate No. 1 Transplanted (one month old) *Leucaena leucocephala* plant.

and the minimum increase (0.210 m) was observed in 2 x 2 m^2 and 4 x 4 m^2 treatments.

The maximum increase in stem girth (1.26 cms) was observed in 4 x 4 m^2 and the minimum (1.16 cm) in 2 x 2 m treatments.

The growth performance of *Leucaena* was probably poor due to no rainfall during December 1998 to February 1999. During this season, the plant was irrigated once in a week. However, it may be seen throughout the growing period that the increase in plant height and stem girth was found to be non-significant in all the treatments,.

5.2.2. *Zea mays* (Maize):

The monthly mean records of the growth performance in height, stem girth and number of leaves of *Zea mays* (Maize) in different treatments and control is depicted in Table -V.

Experimental : (Maize with Leucaena)

It may be seen from the data that the monthly mean increase in plant height, stem girth and number of leaves ranged from 0.633 - 1.87 m; 2.3 - 5.26 cm and 5.3 - 12.33 respectively in different treatments during May to August. In May, after one month of planting, maximum increase in plant height (0.663m) was observed in 2 x 2 m^2 spacing of *Leucaena* and minimum increase (0.633 m) in 3 x 3 m^2 treatment. The mean maximum increase in stem girth (2.5 m) was recorded in 2 x 2 m^2 and minimum (2.3 cm) in 3 x 3 m^2 and 4 x 4 m^2 treatments. This increase in height and stem girth was found to be significant ($P = 0.05$). The mean maximum number of leaves was 6 in number in 3 x 3 m^2 and minimum 5.3 was observed in 4 x 4 m^2 treatment. However, this increase in number of leaves has been found to be non-significant ($P <0.05$), (Table -V).

In August, the mean maximum increase in plant height was recorded to be 1.87 m in 2 x 2 m^2 and the minimum increase was 1.84 m in 4 x 4 m^2 treatment. This increase was found to be significant ($P = 0.05$). The maximum increase in stem girth (5.26 cm) was observed in treatment 3 x 3 m^2 and the minimum (5.0 cm) was observed in 2 x 2 m^2. It was found that this increase in stem girth was significant in all the treatments (Table- V). The maximum number of leaves (12.33) per plant was observed in treatment 3 x 3 m^2 and minimum number was 12 in 2 x 2 m^2 and 4 x 4 m^2 treatment respectively. But this increase in number of leaves under different treatments was found to be non-significant ($P<0.05$).

Control (Maize alone i.e. without Leucaena)

It may be observed from the data that in the month of May, the mean increase in maize height was 0.633 m. This increase in height was similar to treatment 3 x 3 m^2. This increase has been found to be significant ($P = 0.05$). The mean increase in stem girth (2.3 cm) was recorded to be of the same value with treatments 3 x 3 m^2 and 4 x 4 m^2 spacing. The mean number of leaves was 5.3. However, the increase in stem girth and number of leaves was not significant ($P< 0.05$).

In August, the mean increase in maize height and stem girth was 1.85 m and 5.2 cm respectively (Plate-2 &3a). This increase was found to be significant ($P = 0.05$). The increase in number of leaves (12) was found to be non-significant.

5.2.3. Maize yield components:

The yield of maize crop (after harvest) in different treatments are depicted in Table - VI.

Plate No. 2 The Maize crop.

1999

Months		May				June				July				August			
Parameters	Spacing	Mean ± SE	F- Ratio	S.E	C.D	Mean ± SE	F- Ratio	S.E	C.D	Mean ± SE	F- Ratio	S.E	C.D	Mean ± SE	F- Ratio	S.E	C.D
Maize plant Height (m)	2 x 2 m²	0.663 ± 0.271	5.06**	0.009	0.02	1.35 ± 0.387	3.53	0.006	—	1.65 ± 0.428	5.2**	0.005	0.01	1.87 ± 0.456	6.6**	0.007	0.01
	3 x 3 m²	0.633 ± 0.265				1.34 ± 0.385				1.63 ± 0.426				1.85 ± 0.453			
	4 x 4 m²	0.650 ± 0.269				1.33 ± 0.385				1.64 ± 0.427				1.84 ± 0.452			
	Maize alone	0.633 ± 0.265				1.33 ± 0.384				1.63 ± 0.426				1.85 ± 0.453			
Maize stem girth (cm)	2 x 2 m²	2.5 ± 0.527	0.371	0.152	0.37	3.13 ± 0.590	3.33	0.141	0.34	4.06 ± 0.672	9.00**	0.081	0.19	5.0 ± 0.745	8.00**	0.081	0.19
	3 x 3 m²	2.3 ± 0.512				3.16 ± 0.593				4.10 ± 0.674				5.23 ± 0.762			
	4 x 4 m²	2.3 ± 0.512				3.3 ± 0.605				4.3 ± 0.691				5.26 ± 0.764			
	Maize alone	2.3 ± 0.512				2.8 ± 0.564				3.86 ± 0.655				5.2 ± 0.740			
Maize number of leaves	2 x 2 m²	5.6 ± 0.793	1.65	0.37	—	9.33 ± 1.018	0.195	0.35	—	12.00 ± 1.541	1.00	0.23	—	12.00 ± 1.154	1.00	0.23	—
	3 x 3 m²	6.0 ± 0.816				9.00 ± 1.000				12.00 ± 1.154				12.33 ± 1.170			
	4 x 4 m²	5.3 ± 0.769				9.33 ± 1.018				12.00 ± 1.154				12.00 ± 1.154			
	Maize alone	5.3 ± 0.769				9.00 ± 1.000				11.83 ± 1.138				12.00 ± 1.154			

Note: ** Significant at 0.05 per cent level.
C.D. at 0.05 per cent level.

Table - V. Monthly records of height, stem girth and number of leaves of *Zea mays* in the different treatments.

Parameters	Spacing	Mean ± S.E	F - Ratio	S.E	C.D
Ear length (cm)	$2 \times 2\ m^2$ $3 \times 3\ m^2$ $4 \times 4\ m^2$ Control	18.00 ± 1.414 17.06 ± 1.377 16.43 ± 1.351 16.83 ± 1.367	6.52**	0.335	0.30
Ear width (cm)	$2 \times 2\ m^2$ $3 \times 3\ m^2$ $4 \times 4\ m^2$ Control	12.53 ± 1.180 13.10 ± 1.206 12.76 ± 1.191 12.63 ± 1.184	1.28	0.30	—
Number of rows per ear	$2 \times 2\ m^2$ $3 \times 3\ m^2$ $4 \times 4\ m^2$ Control	14.33 ± 1.261 14.00 ± 1.247 13.66 ± 1.232 13.66 ± 1.232	0.63	0.55	—
Number of Kernels per ear per rows	$2 \times 2\ m^2$ $3 \times 3\ m^2$ $4 \times 4\ m^2$ Control	39.60 ± 2.101 39.00 ± 2.081 40.00 ± 2.108 39.60 ± 2.101	1.18	0.54	—
Cob weight (gm)	$2 \times 2\ m^2$ $3 \times 3\ m^2$ $4 \times 4\ m^2$ Control	148 ± 4.04 147 ± 4.06 148 ± 4.05 146 ± 4.03	1.0	1.2	—
Cob yield kg / plot	$2 \times 2\ m^2$ $3 \times 3\ m^2$ $4 \times 4\ m^2$ Control	1.6 ± 0.430 2.1 ± 0.490 1.8 ± 0.451 0.9 ± 0.316	8.8**	0.25	0.62

Note: ** — Significant at 0.05 per cent level.
C.D. at 0.05 per cent level.

Table - VI. Yield of Maize (*Zea mays*) crop under different treatments.

Experimental : (Maize with *Leucaena*):

Ear length (cm) : It may be seen from the data, that the mean maximum ear length was 18.00 cm in 3 x 3 m^2 and the minimum was 16.43 cm in 4 x 4 m^2 treatment (Plate-3b). The results of ear length were significant (P = 0.05) in all the treatments Table VII.

Ear width (cm) : From the data, it is clearly seen that here was no significant trends in mean ear width of maize between any of the treatments. (i.e. in 2 x 2 m^2, 3 x 3 m^2 and 4 x 4 m^2). However, it was recorded that the maximum ear width was 13.10 cm in 3 x 3 m^2 and a minimum of 12.53 cm in 2 x 2 m^2 treatments.

No. of rows per ear : The mean maximum number of rows per ear of 14.33 was recorded in 2 x 2 m^2 and minimum was 13.66 in 4 x 4 m^2 treatments. The number of rows per ear was found to be non -significant.

Number of kernels per ear per row : The mean maximum number of kernels per ear per rows was 40 in 4 x 4 m^2 and minimum 39 in 3 x 3 m^2 and 2 x 2 m^2 treatments. This component was also found to be non-significant.

Cob weight (gm) : Mean maximum cob weight of 148 gm was recorded in 2 x 2 and 4 x 4 m^2 and minimum 147 gm in 3 x 3 m^2 treatments. The cob weight of maize was non-significant ($P<0.05$).

Cob yield (kg per plot) : The mean highest cob yield recorded was 2.1 kg in 3 x 3 m^2 and lowest was 1.6 kg in 2 x 2 m^2 treatments. Maize cob yield showed significant result in all the treatments (P = 0.05).

Control : Maize without *Leucaena*:

Ear length (cm) : The mean maximum ear length was 16.83 cm. in control plots and was found to be significant (P 0.05).

Ear width (cm) : The maximum ear width was 12.63 cm and has been found to non-significant ($P<0.05$)

Number of rows per ear : Maximum of rows per ear was 13.16. This number of rows per has been found to be non-significant.

Number of Kernels per ear per rows : Maximum number of kernels per ear per rows was 39.6. Number of kernels has been found to be non-significant.

Cob weight (gm) : Mean weight of maize was 146 gm. But this cob weight has been found to be non-significant Table VII.

Cob yield (Kg/plot) : The cob yield of maize was 0.9 Kg in the control plot and was significant at P = 0.05.

Plate No. 3 (a) Maize crop before harvest

Plate No. 3 (b) Harvested cobs.

Parameters	Control	Spacing 2 x 2 m^2	Spacing 3 x 3 m^2	Spacing 4 x 4 m^2	F - Ratio	S .E .	C . D . (0.05%)
Plant height (m)	1.85	1.87	1.85	1.84	6.66**	0.007	0.01
Stem circum-ference (cm)	5.2	5.0	5.2	5.2	8.00**	0.081	0.19
Number of leaves	12	12	12.33	12	1.00	0.23	0.19
Ear lenght (cm)	16.83	18.00	17.06	16.43	6.52**	0.335	0.30
Ear width (cm)	12.63	12.53	13.10	12.76	1.28	0.3	—
Number of rows / ear	13.66	14.33	14.00	13.66	0.63	0.55	—
Number of kernels / ear/ row	119	119	117	120	1.18	0.541	—
Cob weight (gm)	146	147	148	148	1	1.2	—
Cob yield (Kg)	0.9	1.6	2.1	1.8	8.8**	0.25	0.62
Cob yield (Kg / ha)	360	666.6	866.6	733.3	13.33***	203.52	498.02

Note: *** — Significant at 0.01 % level
** — Significant at 0.05 % level

Table - VII. Average yield of Maize crop under different spacings of *Leucaena leucocephala.*

Parameters / Spacing	*Leucaena leucocephala*	Rainfall	Air temperature	Soil temperature	Soil moisture	Organic carbon (O.c.)	Nitrogen (N)	Phosphorus (P)	Potassium (K)	pH
2 x 2 m^2	Height	+ 0.714	-0.069	- 0.038	+ 0.501	- 0.663	- 0.738	- 0.517	- 0.607	- 0.673
	Stem girth	+ 0.845	- 0.245	- 0.259	+ 0.637	- 0.666	- 0.761	- 0.584	- 0.451	- 0.569
3 x 3 m^2	Height	+ 0.731	- 0.093	- 0.112	+ 0.632	- 0.733	- 0.763	- 0.660	- 0.718	- 0.651
	Stem girth	+ 0.761	- 0.462	- 0.208	+ 0.613	- 0.685	- 0.723	- 0.722	- 1.908	- 0.525
4 x 4 m^2	Height	+ 0.701	- 0.050	- 0.099	+ 0.516	- 0.812	- 0.883	- 0.807	- 0.547	- 0.453
	Stem girth	+ 0.678	- 0.287	- 0.272	+ 0.614	- 0.802	- 0.793	- 0.801	- 0.501	- 0.332

Table- VIII. Correlation (r) between *Leucaena leucocephala* (height and stem girth) with different abiotic factors.

Parameters / Spacing	*Leucaena leucocephala*	Rainfall	Air temperature	Soil temperature	Soil moisture	Organic carbon (O.c.)	Nitrogen (N)	Phosphorus (P)	Potassium (K)	pH
2 x 2 m²	Height	+ 0.253	-0.967	-0.662	+ 0.797	+ 0.127	-0.720	-0.973	-0.980	+ 0.620
	Stem girth	+ 0.287	-0.814	-0.402	+ 0.570	+ 0.346	-0.666	-1.146	-0.982	+ 0.658
	Leaf	+ 0.822	- 0.958	-0.613	+ 0.752	+ 0.030	-0.738	-0.974	-0.943	+ 0.724
3 x 3 m²	Height	+ 0.258	-0.970	-0.671	+ 0.804	+ 0.222	-0.793	-0.989	-0.965	+ 0.543
	Stem girth	+ 0.321	- 0.836	-0.444	+ 0.608	+ 0.304	-0.641	-0.980	-0.974	+ 0.592
	Leaf	+ 0.095	- 0.928	-0.538	+ 0.691	+ 0.413	-0.746	-0.975	-0.957	+ 0.735
4 x 4 m²	Height	+ 0.240	-0.967	-0.550	+ 0.794	-0.294	-0.641	-0.989	-0.957	+ 0.269
	Stem girth	+ 0.282	-0.867	-0.478	+ 0.640	-0.283	-0.761	-0.986	-0.972	+ 0.816
	Leaf	+ 0.090	-0.880	-0.622	+ 0.765	-0.300	-0.667	-0.978	-0.900	+ 0.847
Control	Height	+ 0.254	-0.968	-0.664	+ 0.799	-0.724	-0.591	-0.974	-0.895	+ 0.582
	Stem girth	+ 0.326	-0.755	-0.335	+ 0.507	-0.647	-0.629	-0.965	-0.100	+ 0.213
	Leaf	+ 0.091	-0.952	-0.596	+ 0.740	-0.739	-0.615	-0.965	-0.871	+ 0.732

Table-IX. Correlation (r) between *Zea mays* growth performance (height, stem girth and no of leaves) with different abiotic factors.

Parameters / Spacing	*Leucaena leucocephala*	Rainfall	Air temperature	Soil temperature	Soil moisture	Organic carbon (O.c)	Nitrogen (N)	Phosphorus (P)	Potassium (K)	pH
2×2 m^2	Height	+ 3.229***	- 0.220	- 0.121	+ 1.829	- 2.804**	- 3.468***	- 1.911	- 2.418**	- 3.054**
	Stem girth	+5.011***	- 0.798	- 0.849	+ 2.612**	- 2.825**	- 3.713***	- 2.360**	- 1.600	- 2.188
3×3 m^2	Height	+ 3.388***	- 0.296	- 0.365	+ 0.102	- 3.414***	- 3.733***	- 2.782**	- 3.265***	- 2.710**
	Stem girth	+ 3.716***	- 0.803	- 0.673	+ 2.495**	- 2.977**	- 3.317***	- 3.817***	- 3.709***	- 1.951
4×4 m^2	Height	+3.107***	- 0.255	+ 0.317	+ 1.907	- 4.402***	- 4.755***	- 4.320***	- 2.070	- 1.685
	Stem girth	+ 2.915**	- 0.945	+ 0.894	+ 2.464**	- 4.250***	- 4.119***	- 4.237***	- 1.837	- 1.113

Note: *** — Signifiant at 0.01 per cent level.
** — Signifiant at 0.05 per cent level.

Table - X. Correlation (t) between *Leucaena leucocephala* (height and stem girth) with different abiotic factors.

Parameters / Spacing	*Leucaena leucocephala*	Rainfall	Air temperature	Soil temperature	Soil moisture	Organic carbon (O.c.)	Nitrogen (N)	Phosphorus (P)	Potassium (K)	pH
2 x 2 m^2	Height	+ 0.371	-5.368**	-1.249	+ 1.866	+ 0.222	-3.286**	-6.069***	-7.046***	+ 1.370
	Stem girth	+ 0.424	-1.986	-0.622	+ 0.983	+ 0.640	-2.790	-1.931	-7.512***	+ 1.517
	Leaf	+ 0.116	-4.771**	-1.098	+ 1.617	+ 0.053	-3.460**	-6.065***	-4.027**	+ 1.819
3 x 3 m^2	Height	+ 0.378	-5.648**	-1.282	+ 1.917	+ 0.396	-4.123**	-9.713***	-5.241**	+ 1.120
	Stem girth	+ 0.479	-2.154	-0.702	+ 1.085	+ 0.554	-2.641	-7.115***	-6.092***	+ 1.274
	Leaf	+ 0.135	-3.527**	-0.902	+ 1.354	+ 0.786	-3.548**	-6.294***	-4.683**	+ 1.878
4 x 4 m^2	Height	+ 0.351	-5.403**	-0.931	+ 1.850	-0.534	-2.641	-9.656***	-4.704**	+ 0.484
	Stem girth	+ 0.416	-2.471	-0.771	+ 0.834	-0.512	-3.712**	-8.469***	-5.916***	+ 2.449
	Leaf	+ 0.128	-2.263	-1.123	+ 1.681	-0.544	-2.837	-6.742***	-2.920	+ 2.759
Control	Height	+ 0.372	-5.485**	-0.889	+ 1.880	-1.818	-2.320	-6.153***	-2.844	+ 1.241
	Stem girth	+ 0.488	-1.629	-0.503	+ 0.832	-1.470	-2.563	-5.260**	-0.142	+ 0.379
	Leaf	+ 0.130	-4.437**	-1.051	+ 1.556	-1.962	-2.467	-5.473**	-2.512	+ 1.863

Note: *** —Significant at 0.01 % level.

** —Significant at 0.05 % level.

Table - XI. Correlation (t) between *Zea mays* growth performance (height, stem girth and no.of leaves) with different abiotic factors.

DISCUSSION

DISCUSSION

The Present investigation primarily aims at a comparison of the yield of *Zea mays* between controls (without *Leucaena leucocephala*) and treatments (with *Leucaena leucocephala* planted at spacings of 2 x 2m, 3 x 3m and 4 x 4m). The experiment also attempts to determine the most suitable spacing of *Leucaena leucocephala* for optimum growth and yield both *Leucaena leucocephala* and maize. Further,it is also desired to detect and quantify changes in the soil nutrient budgets (C,N,P and K) as affected by *Leucaena leucocephala.*

The climate of Mizoram in general and the study site in particular is of monsoonic type with warm humid summers and cool dry winter (Agarwal,1991). Such a climatic regime offers optimal conditions for plant growth (Anon,1990). The records of the meteorological and abiotic factors for the present study (Tables I and II) are pointers to this general concept. The importance of moisture is especially highlighted by the positive correlation of both rainfall and soil moisture with plant growth parameters.

Soil nutrient budgets as recorded before the experiment indicate a deficient nutrients status (Table III), when compared to the work of Dadhwal and Singh (1998) who reported 1.1%, 0.12%, 20kg/ha and 155.0kg/ha C,N,Pand K respectively. As with the present study, this work also evidenced marginal decrease in the nutrient budgets after the experiment. Comparison with other work from the region such as Borthakur (1978), Ramakrishnan *et al* (1978), Ramakrishnan and Toky (1981), and Toky and Ramakrishnan (1981a) are also indicative of the overall impoverised nature of the soils of the present study. The negative correction (r and t) of the plant growth parameters with soil nutrients (Table VIII-XI) are further pointers to the contention. The marginal decrease in soil nutrient budgest after the experiment cannot however be attributed to a absence of positive interaction. The physico-chemical and profile development of the edaphos in a long term process and the present experiment of one annual cycle is not enough to draw concrete conclusions. Nevertheless, the increased yields of maize in the treatments as compared to the controls are definitely indicative of the immediate benefits of the nitrogen fixing *Leucaena leucocephala* on the performance of the primary crop.

When growth performance of *Leucaena leucocephala* was considered for comparison with similar studies elsewhere, it was seen that the annual increments (height and d.b.h) records of the present study fall for short of other investigation (Palit, 1981; Gandotra,1981; Prasad,1981; Kaul and Sharma,1981). One comparable study was that of Reddy and Kushalappa (1980) who reported annual increments of 1-1.2m (ht) and 1-3cm (d.b.h). However, most of the studies had fertilizer ammendments and this probably effected a better performance in contrast to the present study with no fertilizer ammendments.

Between treatments comparison of the *Leucaena* growth failed to detect any significant differences (Table IV). This probably reflects the lack of competition for resources, particularly those of the soil at such an early stage of root development. The effect of such competition would probably become apparent at longer time periods when root ramification and enlargement would usher in more stringent competition for the soil bound resources and the growth of the plants in the different treatments would exhibit substancial differences.

The growth performance of maize in all the treatments were better than the control and showed significant differences (Table V). Such results are in accordance to the work of Kang (1981), Flores (1985), Leviste (1976) and Ssekabembe (1984). The latter and other worker like de la Rosa (1988) reported higher yeilds of maize under high density of *Leuceana* planting. Similar findings have also been reported by Rachie (1983) who obtained highest maize under *Leuceana* population of 1000-2000 plants/ha.

Between treatment comparison of cob weight and maize yeilds indicate that the highest yield was obtained in the 3 x 3m treatment (Table VII). Although no directly comparable works are available, the general observation of other workers indicate that individual plants (Maize) planted closer to the *Leucaena* trees showed better growth performance and higher yields. (Singh *et al.*, 1978 ; Jama, 1988). It is logical to presume that the benefits of underground Nitrogen fixation by the *Leucaena* plants are better utilized at close proximmity to the resource.

Considering the limitation of time and financial constraints, the present investigation is a feeble attempt. However, it is evident form the results obtained that there is a close indication of the impoverished nature of the soils, which are unable to sustain the demands of increased yields, move so under the present agricultural practices. The agroforestry option thus becomes more relevant primarily because of its multifaceted benefits occuring directly to the farmer.

The increased yields of the primary crop component (maize) in the treatments are indicative of the immediate benefits of Nitrogen fixation, by the component.

Although it is premature to draw concrete conclusions, such studies merit more inputs by way of time and finance so that suitable models can be developed as packages for the rural community.

SUMMARY

SUMMARY

On the strength of the observations and results obtained, the present investigation is summarised as follows :-

The records of meteorological and abiotic factors are indicative of a monsoonic climatic regime offering optimal growth conditions for suitable plant life forms. However, the impoverished nature of soils due to a history of shifting cultivation are today unable to sustain higher yields.

The growth performance of *Leucaena leucocephala* in different treatments did not exhibit any significant differences as root competition for resources had not set in at such as early age of the plants.

The growth performance of maize however showed significant differences among the treatments, and were also significantly higher than the controls indicating the immediate benefits of *Leucaena* accruing to the maize crop. This was further reflected in higher cob weight and yields in the treatments, the 3 x 3 m spacing had the highest yields of maize and can be considered to be the optimal spacing option.

CONCLUDING REMARKS

CONCLUDING REMARKS

Agroforestry as a scientific discourse has evidenced a vigourous re-emergence form the past when it was a part and parcel of traditional agricultural systems. Such a renewed interest is dictated on the one hand by the pressures on arable land to produce more food and on the other by the increasing threat to the dwindling forest cover for needs of timber, fuelwood, fodder and traditional use.

The scope of Agroforestry is wide as locality conditions and local needs dictate the permutations and combinations of the components which could be tried out for specific situations. This perspective has further widened with the developments of Plant breeding, Biotechnology and Propagation techniques, making it possible for the inclusion of superior genetic pools into such systems.

In North East India where shifting agriculture is till today the mainstay of the population, the lands are progressively registering lower yields due to shortening of the fallow period which in turn restricts the growth of secondary forest cover and development of the soil profile. Such conditions are conducive for the operation of erosive forces of the characteristically heavy monsoonic rain on the poorly covered soils of the hilly terrain, removing immense quantities of the fertile topsoil. Thus the pressure on pristine forests go on increasing and are instrumental in reducing such forest cover. Sustainable agriculture is the most urgent need of the hour especially for the North East, and the benefits of Agroforestry in providing a canopy cover for the vulnerable soils, helping in moisture conservation and amelioration of soil physico-chemical conditions, providing additional benefits of fuelwood and fodder and traditional use etc. are obvious. It is therefore necessary to make more efforts in this promising field to alleviate the productivity constraints and economic hardships of the predominantly farming population of the region.

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