"GROWTH BEHAVIOUR OF *LEUCAENA LEUCOCEPHALA* (LAM.) DE WIT ALONG WITH *ZEA MAYS* L. AS AFFECTED BY N.P.K FERTILIZERS IN AN AGROFORESTRY SYSTEM OF MIZORAM."

THESIS

SUBMITTED TO THE NORTH EASTERN HILL UNIVERSITY IN PARTIAL FULFILMENT OF THE DEGREE OF MASTER OF SCIENCE IN FORESTRY.

BY

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SUPERVISOR'S CERTIFICATE.

I certify that the thesis entitled "Growth behaviour of *Leucaena leucocephala* (Lam.) de wit along with *Zea mays* L. as affected by NPK fertilizers in an agroforestry system of Mizoram" submitted by Mr. B. Laldikpuia for the partial fulfillment of Master of Science in Forestry of the North-Eastern Hill University, Shillong embodies the record of original investigation by him under my supervision. He has successfully completed all his papers and the thesis presented is worthy of being considered for the award of the M.Sc. Degree. The work has not been submitted by any other degree of any other university.

Dated Aizawl,
The 27th November, 2000.

(Dr. U.K. SAHOO)
Supervisor.

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The 27th November 2000

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INTRODUCTION

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1.1: AGROFORESTRY- A HISTORICAL PERSPECTIVE :

The history of agroforestry is as old as the origin of agriculture. The system of agroforestry has been in practice in India much before the scientific approach to this system has been realised (Singh, 1984). Infact, formal agroforestry practices initially originated in India when the forest department tried to control shifting cultivation by implementing taungya system in Burma which was then part of British India (Sharma, 1992).

The farmers and land owners in different parts of the country integrate a variety of woody perennials in their crop and livestock production fields depending upon the agro-climatic conditions and local need. Growing of field crops like pearl millet, legumes and oilseeds in a field predominated by Khejri (*Prosopis cineraria*) and Bordi (*Zizyphus numularia*) is an example of traditional agroforestry followed by the farmers of Rajasthan, Punjab, Haryana and Gujarat since time immemorial. Similarly, the cultivation of Cardamom (*Amomum subulatum*) in combination with *Alnus nepalensis* in the Central Himalaya. Various tree crop combinations in jhum areas of north eastern hill region are being practiced since long. Growing of forest tree species on the border of fields for meeting local demand of timber, fodder, fuel etc. is a common practice throughout the country. However, despite the long history and wide practice, no systematic approach was made earlier to identify the systems and to improve them for higher productivity, higher economic returns and energy requirements. The recent surge of International interest came about as a response to concern about environmental degradation and rural poverty.

I.2 : DEFINING AGROFORESTRY

Agroforestry is neither an invention nor a new concept. The practice of combining tree species with crops had been practiced in some form or the other in most of the countries. However, agroforestry as an applied science is of recent origin. The term agroforestry was coined almost at the time of establishing the International Council for Research in Agroforestry (ICRAF) during 1977.

Agroforestry involves land management techniques implying the combination of forest trees with crops or with domestic animals or with both. It aims to optimise production per unit area, while at the same time respecting the principle of sustained yield. It has been defined in many ways depending upon its objective and requirement. (King, 1987, Nair, 1987 and Sinclare, 1988). Any standard definition remained elusive for nearly a decade.

In the broadest sense the term "Agroforestry" encompasses any and all land techniques that attempt to establish or maintain both forest tree and agricultural crop on the same piece of land. According to the more strictly scientific definition of agroforestry, all forms of agroforestry are charactarised by :-

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

There must be a significant interaction (positive/negative) between the woody and non-woody components of the system, either ecological and/or economical.

According to the definition made by the International Council for Research in Agroforestry (ICRAF), "Agroforestry is a collective name for all land use systems and practices where woody perennials are deliberately grown on the same land management unit as crops and/or animals either in spatial mixture or in time sequence. To qualify as agroforestry there must be both ecological and economic

interaction between the woody and the non- woody components". This definition given by ICRAF is the most widely accepted one (Lundgren, 1983).

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

Keeping all the different perspective in focus, agroforestry can be defined as a sustainable land use system that forms a symbiotic relationship of trees with agriculture and/or livestock, increases the yield and productivity of the same unit of land under management practice 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 maximised. It seek to achieve a more productive sustainable and diversified output from the land than is possible with conventional mono-cropping systems.

I. 3 : SHIFTING CULTIVATION AND ITS IMPACT :

Shifting cultivation is the most primitive form of agriculture which is still practiced is most parts of the world. It may be defined as an agriculture system which is characterised by a rotation of fields rather than of crops by short period of cropping (one to three years) alternating with long fallow periods and by clearing by means of slash and burn. (Pelzer, 1958).

It is estimated that an area of about 36 million sq.km or about 30 percent of the world's exploitable soils are at present under shifting cultivation. In India about 3 million hectares (Mukherjee, 1974).

Shifting cultivation which is known as jhumming is the principal method of cultivation in Mizoram and its neighbouring hilly states. About 40,000 hectares of land which accounts approximately 63% of the total cropped area of the state was put under jhum cultivation during 1984-85 (Rintluanga, 1994). The percentage of population dependent on jhum cultivation according to a project report on NLUP by Rural Development. Govt. of Mizoram, in 1992, was 85%.

In the past the impact of shifting cultivation on the environment was not noticeable as the Jhumming cycle was sufficiently long. With the increase in demographic pressure, the cycle has now come down considerably. The land now does not have sufficient time to recover its original fertility and bamboo reeds and other coarse grasses have taken the place of evergreen forests. The region/state, despite having almost 85% of the geographical area under forests as reported in the Forest Survey of India's report there is acute shortage of timber and firewood. The green cover consisted almost entirely of bamboo which can hardly be used as firewood and timber. Thus the firewood and timber have to be brought to the consumption centres from long distances at considerable costs.

Repeated jhumming or shortening of jhum does not allow the soil fertility to build up. In recent decades, continous cropping have accelerated soil erosion and condition of the soil is progressively deteriorating. In addition surface run-off, ground water have dried up, with the result that springs have diminished and there is greater fluctuation in their flow now. This is responsible for acute shortage of water everywhere in the region. People now have to travel long distance for collecting drinking water.

As discussed, fertility of the soil has declined considerably because of repeated jhumming resulting in reduction in productivity of land. Goel-*et-al*., (1968) reported that the loss of nutrient increased corresponding with the increase in the degree of slope. Cleaning and burning operation brings changes in both physical and chemical properties of soil. The practice results in a substantial reduction in the content of organic matter, cation exchange capacity and other plant nutrients. (Awasthi, 1976). This inturn induces people to bring still larger areas of land under jhumming year by year to make up the loss due to reduction in crop production.

According to NEC social science research the jhum cycle in Mizoram has come down to 9.74 years (1990). Once the cultivation cycle falls below 10-12 years, it seems that it is no longer economic form of agriculture compared to possible types of settled agriculture (Lianzela, 1998). At present, the state is deficient in production of both foodgrains and non-foodgrains and this deficiency is met up only through import from other surplus regions of the country. To tackle these problems appropriate agroforestry system is the need of the hour in the state. Therefore it is necessary to search for alternative, suitable, sustainable, economically viable and socially acceptable agroforestry models which can tackle the ongoing biophysical problems of the state.

I. 4 : AGROFORESTRY - ALTERNATIVE TO SHIFTING CULTIVATION :

The practice of shifting cultivation is so much a part of socio-economic and cultural life of the tribal people that it needs no detailed studies to understand the intricate relations between soil, fallow and harvest. The people involvement in the fragile ecosystem of jhumming is so conspicious that it leads to a lot of devastating effect on both soil flora and fauna, nutrients, soil moisture, plant and animal biodiversity and in imbalance of an ecosystem. The government of Mizoram launched several ambitious programmes to wean way shifting cultivators from the age old practice of jhumming but the success was only nominal. The main reasons for this was due to non-availability of suitable, sustainable, economically viable and socially acceptable alternative technologies even though the farmer themselves have realised that shifting cultivation has lost its regenerative potential. Young (1989) suggested that agroforestry satisfied many conditions of judicious land management as it combines soil conservation with productive function useful for hill slopes.

Agroforestry approach to land development brings about the potential role of trees/shrubs to alleviate some of the major physical and economical constraints facing marginal and sub-marginal farmers in tribal areas. On these lands deliberate use of woody perennials, when properly integrated in the land use system, restore enhances both productivity and sustainability of land. This benefit is particularly essential to tribals for whom availability of capital and inputs is low and restricted. Agroforestry systems have built in mechanism to enhance production of organic matter in order to maintain and enhance soil fertility, reduce soil erosion, maintain water balance, ultimately creating a favourable microclimate. In the tribal areas, agroforestry systems are more relevant in view of lack of communications and market inputs and cash. This will enable the tribal to produce most of the basic needs such as food, fodder, fuel and small timbers for shelter from a limited land area. Tribals are traditionally bound with forestry which they adore and worship. Therefore, this technology is not alien to their cultural milieu. Even the Scientists are increasingly realising that the only feasible long term approach for sustainable land use pattern is introduction of tree based land use system which the agroforestry aims at.

Jha (1995) opined that any alternative model (agroforestry) can be successful only if it adopted by the local people, suitable to local environment and need of the farmer. Considering the above view points and looking into the various biophysical problems coupled with topographical structure, it is essential that a system must be developed which can be sustainable so far optimum production is concerned. The present study was therefore undertaken to study the potentiality of *Leucaena Leucocephala* var. K-28 along with *Zea Mays* in an agroforestry system of Mizoram, by investigating the effect of application of N, P and K fertilizers on their growth, yield and biomass production besides the changes in some soil physical and chemical characteristics due to agroforestry practice.

CHAPTER - II

REVIEW OF LITERATURE

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REVIEW OF LITERATURE

Leucaena leucocephala (Lam.) de wit belongs to the family *Leguminoceae* (*Mimosoideae*). *Leucaena leucocephala* is a native of Southern Mexico and spread throughout the tropical and sub-tropical regions (Brewbacker and Hutton, 1987). Its most universal common name is "Leucaena". It is also known under various common names such as "Keahaole" in Hawaii, "Bavani" and "Ipil-Ipil" in Phillipines or "Lamtoro" in Indonesia. In India it is commonly known as "Kubabul" but keeping in view its multiple use its name has been changed from Ku (bad)-babul to Su (good)-babul (Relwani, 1981).

Leucaena Leucocephala is found in many places throughout the tropical and sub-tropical world. Over 100 varieties of *Leucaena leucocephala* are known which can be grouped into three types namely-Hawaiian type, Salvador type and Peru type. Salvador type and Peru type are tall varieties attaining height upto 15-20 m while Hawaiian type is short bushy variety allowing height upto 5 m. In Salvador type some high yielding cultivars have been developed and are being planted as a sources of timber, fuel etc. The cultivars are K6 (Peru) K8 (Mexico) and K28 (El Salvador). These varieties can grow upto 20m in height and 25 cm in diameter in 5 years (USAID, 1976).

Leucaena leucocephala has the ability to fix nitrogen in the soil by forming a symbiotic relationship with *Rhizobium loti*, the nitrogen fixing bacteria (Halliday and somersegaran, 1983). *Leucaena leucocephala* is capable of coming up under varying conditions and can grow under large rainfall variations. It attains the best development with an annual rainfall of 600-1700 mm. This species can grow under wide variety of soil types varying in texture from rock to heavy clay. It can also grow well on dry, barren hill sides and acts as a protective cover over large areas. Its rugged habit deep root system, abundant seeding and quick growth enable to establish itself even in unfavourable situations.

Leucaena leucocephala is a fast growing multipurpose tree species and is widely used for wood, fuelwood, green manure and forage. In Mizoram, this species has been cultivated for their food value. The tender pods are taken as vegetables. Studies on agroforestry system at the Indian Grassland and Fodder Research Institute, Jhansi have indicated the potential of this species for forage, fuelwood, fallow improvement, complementary to crops, and biomass optimisation besides soil amelioration (Pathak and Patil, 1982 ; Pathak *et al.*, 1986). However, less effort have been done on the potentiality of *Leucaena leucocephala* in the state of Mizoram. The role of *Leucaena leucocephala* as a multipurpose tree species can be reviewed under different heads.

II. 1 : SOIL AMELIORATIVE ROLE OF *LEUCAENA LEUCOCEPHALA* :

Leucaena is a good source of organic fertilizer and is a green manure crop. Researches carried out at Hawaii University reveals that as a green manure crop, the fertilizer equivalent of a year harvested hectare of Hawaiian Giant is estimated to exceed 550 Kg of N, 225 Kg of P20 and 550 Kg of K20. In this way Leucaena improves the fertility of land (USAID, 1976).

Experiment conducted by Dikjman (1950) revealed that Leucaena is suitable and thrive well on steep slopes and rocky slopes due to its nitrogen fixing ability, deep rooting system for pumping and regular supply of organic matter to the soil through shedding of leaves.

Leucaena foliage can be used as organic fertilizer for improving the fertility status of the soil (Brewbaker, 1975). The leaves contain about 20-30 % crude protein which is exceptionally high as compared to other plant species (Manidool, 1982).

Gill *et al.*, (1982) investigated the effect of Leucaena foliage compared to *sesbania* foliage as a source of green manure. The results demonstrated the usefulness of Leucaena foliage as a source of green manure 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 soil properties by increasing aeration, water retention capacity and cation exchange capacity.

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 Phillipines (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.

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 (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, 1989). Moreover, the litter and humic layers on the soil surface act as a cushion against erosion (Nair, 1984).

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

Pathak and Gupta (1987) have reported organic matter addition through leaf litter in 2 - years old Leucaena plantation to be 5.6 ton/ha. annually, which improved tilth, cation exchange capacity, water holding capacity, bulk density, brought down pH from alkaline to normal and improved the yield of successive crops. Pathak and Gupta (1997) showed that crop (oat) production showed a 47% higher response from Leucaena leaf compared to the inorganic nitrogen applied in the same dose. This experiment showed the possibility of using Leucaena leaf as a rich source of nitrogen for crop production specially in remote areas where the availability of inorganic nitrogen is problemsome.

II.2 : EFFECT OF FERTILIZERS ON MPT'S :

Nutritional factors play a significant role in the growth and development of fast growing species (Pokhriyal *et al.*, 1986). As such greater emphasized is now being laid on fertilizer application as a means of increasing production. Rao (1977) emphasized the poor fertility status of majority of forest soils in the country and their effective amelioration by application of fertilizers as is being practiced in many parts of the country. Similarly Bhatnagar (1978) mentioned that regulation of balanced supply of minerals is one of the most important aspect for maximising production in the shortest possible time.

The application of fertilizers on the growth and biomass production have found to be significant as observed by many researchers. According to

Mohan (1992) *Terminalia myriocarpa* greatly responds to fertilizer application (N.P.K). Their seedlings growth was enhanced when treated with Urea, Superphosphate and Muriate of potash.

The application of fertilizer (N and P) also have a great effect on the nutrient uptake and biomass production of *Bauhinia variegata*. Nitrogen application significantly increased biomass in all parts of the plant. The application of phosphorus showed significant effect on leaf and total biomass (Koul *et al.*, 1995). Application of fertilizer (N.P.K) on *Eucalyptus tereticornis* and *E. camaldulensis* seedlings also helped in boosting up their growth (Sundararaju, *et al.*, 1984).

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

The effect of both organic and inorganic fertilizers application on five MPTS seedlings and its impact on survival and its establishment in the field have been studied (Chellamuthu *et al.*, 1995). Application of neem cake extract or cowdung slurry or combined applications of manure, phosphorus and potash together significantly increased the root length, shoot length, basal diameter and dry matter production of seedlings in the nursery. Giangoo *et al.*, (1990) also studied the fertilizer response (N, P and manure) by two species of Poplars (*Populus deltoides* and *P. niagra*) on initial growth in the nursery in Kashmir and found that the fertilizer dose of 1500 Kg/ha of P and 20 Kg/ha of manure was the best dose for obtaining maximum height for both the species.

Mohan (1992) studied the response of N, P, K fertilizers on the growth of *Terminalia myriocarpa*. He concluded that the applications of 336 Kg/ha of

N, 336 Kg/ha. of P and 112 kg/ha. of K was the best dosage for sandy loam soil.

Leguminous species in many cases have responded to nitrogen application (Gigon and Rorison, 1972; Pokhriyal *et al.*, 1988). Urea has been favoured as nitrogen fertilizer because of its high nitrogen content results in low application cost per unit weight of nitrogen (Foster *et al.*, 1985 a). Singh *et al.*, (1991) suggested split application of urea for better growth response. However, excessive nitrogen fertilizer has adverse effect to the plant growth. Kanwar (1976) reported cereal receiving excess nitrogen have been shown to exhibit lodging as a result of the decreased thickness of cell walls or owing to the poor development of mechanical tissues of stem or both. Adverse effect of excess nitrogen on the growth characters in Populas species has also been reported (Deol and Khosla, 1983).

Totey *et al.*, (1988) studied the effect of N and P fertilizers on the growth of *Dendrocalamus strictus* seedlings. The length and girth of rhizome were found to increased with increasing dose of Phosphorus. Phosphorus being an essential constituent of several enzymes and co-enzymes which are involved in basic reactions of photosynthesis, it is assumed that phosphate had a specific action on encouraging root development (Russell, 1975). In case of dry matter production Totey *et al.*, (1988) reported that with increasing dose of N, the yield of leaves, culms roots and rhizomes were found to be decreased. In higher N conditions, carbohydrates are rapidly converted into proteins and smaller proportion is left for cell wall material giving rise to thin wall cells (Russells, 1975). Subba Rao (1977) mention that spray of urea in leguminous crops reduced the rhizobium activity and thereby reduced nodulation.

Leucaena leucocephala, being a leguminous crop, it required little or no nitrogen fertilization. However, mineral balance in the soil is very important timber and firewood. The green cover consisted almost entirely of bamboo which can hardly be used as firewood and timber. Thus the firewood and timber have to be brought to the consumption centres from long distances at considerable costs.

Repeated jhumming or shortening of jhum does not allow the soil fertility to build up. In recent decades, continous cropping have accelerated soil erosion and condition of the soil is progressively deteriorating. In addition surface run-off, ground water have dried up, with the result that springs have diminished and there is greater fluctuation in their flow now. This is responsible for acute shortage of water everywhere in the region. People now have to travel long distance for collecting drinking water.

As discussed, fertility of the soil has declined considerably because of repeated jhumming resulting in reduction in productivity of land. Goel-*et-al.*, (1968) reported that the loss of nutrient increased corresponding with the increase in the degree of slope. Cleaning and burning operation brings changes in both physical and chemical properties of soil. The practice results in a substantial reduction in the content of organic matter, cation exchange capacity and other plant nutrients. (Awasthi, 1976). This inturn induces people to bring still larger areas of land under jhumming year by year to make up the loss due to reduction in crop production.

According to NEC social science research the jhum cycle in Mizoram has come down to 9.74 years (1990). Once the cultivation cycle falls below 10-12 years, it seems that it is no longer economic form of agriculture compared to possible types of settled agriculture (Lianzela, 1998). At present, the state is deficient in production of both foodgrains and non-foodgrains and this deficiency is met up only through import from other surplus regions of the country. To tackle these problems appropriate agroforestry system is the need

Due to negative interactions the components of many agroforestry systems show competition for limiting resource. Singh *et al.*, (1989) report that alley cropping in the semi arid tropics induces competition for moisture between the trees and crops which may severely reduce crop yield. On the other hand shade can be beneficial when it reduces soil temperature during crop germination and establishment in hot climate. The total annual Q (=Photosynthetically active radiation intercepted by its canopy) for tree crop combination is likely to be higher than for sole crops (Ong *et al.*, 1989).

The various advantages of intercropping of trees with crops by way of productivity, additional income from farm, improving soil condition, control over weeds etc. has been worked out by various scientists. (Ong *et al.*, 1989, Aiyer, 1949 ; Rao *et al.*, 1979).

Experiment conducted on the age-old agroforestry system of Khejri and annual crops in semi-arid region of India have demonstrated better growth of the crops due to improved physical soil conditions and higher availability of nutrients and moisture (Singh, 1987). Gill and Patil (1983) reported the total biomass production in a silvipastoral system near Jhansi was invariable higher compared to monocrop systems. This is because in many cases increases soil fertility and moisture, and provide shade or shelter to the undercrops.

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).

The agroforestry potential of *Leucaena leucocephala* was identified for providing complementary effect on the yield of crops (Pathak *et al.*, 1979). In an experiment conducted by Pathak and Gupta (1779) where a crop of oats was grown between rows of Leucaena, it was found that the associative effect of Leucaena gave a crop yield improvement of 40 percent. Gill and Patil (1983) further observed that the beneficial effects of Leucaena intercropping with forage crops, its use to improve crop yield and ameliorate soil properties.

Leucaena is being intensively inter-planted with traditional fodder crops like maize, sorghum, pearlmillet, hybrid napier, oat etc. . (Pathak, 1988). According to Gill *et al.*, (1982) and Relwani and Khandala (1988) the results have been quite encouraging in favour of mixed cropping, particularly with sorghum as an annual crop and hybrid napier as perennial. Gill and Patil (1981) also reported higher yield of *Cenchrus cilliaris* and *C. setigerus* from three cuttings in association with Leucaena as compared to pure stand for grass. Debroy *et al.*, (1980) also did not observe reduction in the yield of grass under Leucaena plantation.

The above review of literature on Leucaena indicates that although a voluminous amount of work has been carried out on this species elsewhere, no work hitherto has been undertaken in Mizoram. These studies are essential to develop strategic prescription for the state while tackling the ongoing biophysical problems. However, as the time frame for such studies require longer duration and continous monitoring of the research, it is not possible to entertain those here. The present study which is intended only for a 1-year period therefore focus, on the growth behaviour of *Leucaena leucocephala* as affected by different dose of NPK fertilizers in a maize based agroforestry system in Mizoram.

CHAPTER - III

DESCRIPTION OF THE STUDY SITE, CLIMATE AND METHODOLOGY.

CHAPTER -III

DESCRIPTION OF THE STUDY SITE, CLIMATE AND METHOLODOGY :

III. 1 : DESCRIPTION OF THE STUDY SITE AND CLIMATE :

The field experiment was carried out at Zemabawk, which lies at the outskirt of Aizawl (latitude 21^0 58'-24^0 35' N, longitude 92^0 15'- 93^0 29' E, with an altitude of 1132 m above m.s.l.). the state capital of Mizoram. (Fig.I). The climate of the area is humid tropical characterised by short and dry winter, long summer with heavy rainfall. The average annual rainfall of the area is 2030 mm. The temperature does not fluctuate very much throughout the year. In summer the temperature is usually between 21^0C to 31^0C while winter temperature normally records between 11^0 C to 23^0 C (Fig.II).

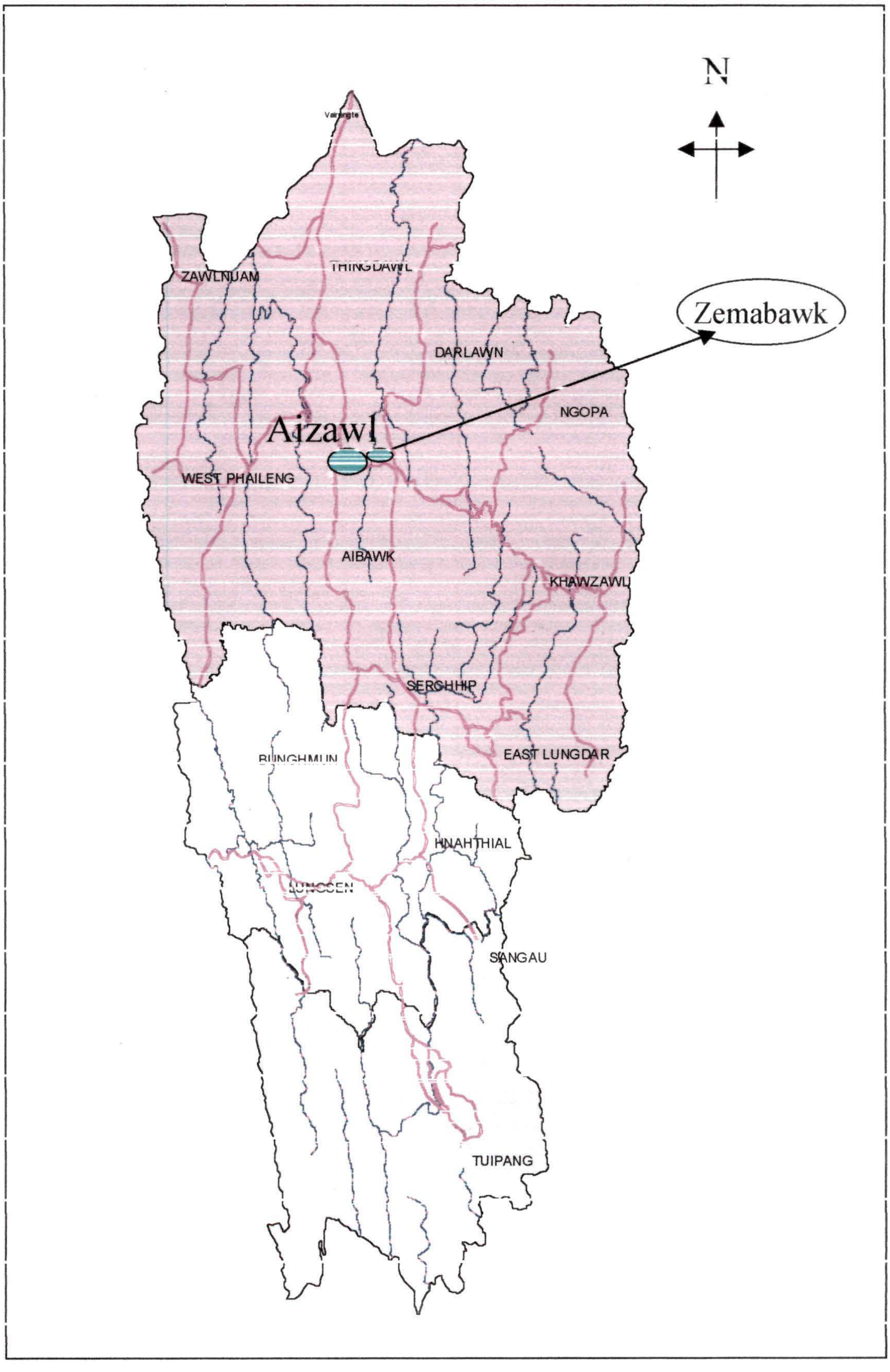
The area of the study site is approximately 1300 sq.m. The site is moderately slope. The texture of the soil in the experimental area before planting was found to be sandy clay having 62.15 % sand, 8.02 silt and 29.83 % clay with an average pH value of 5.4.

The dominant plant species of the study site before clearing land were *Imperata cylindrica*, *Ageratum conizoides* and *Saccharum spp.*

III. 2 : METHODOLOGY - EXPERINMENTAL DESIGN AND TREATMENTS :

The field experiment was laid out following Randomised Block Design (RBD) with three replications. Four treatments were allocated in each replication. As such there were 12 treatments in the experimental field i.e. 12

Fig - I Location Map of Experimental Site.



plots including control. The size of each plot measured 9m x 8m and a space of 1.5 m was kept around each plot (Fig.III).

The system selected for the study was characterised by intercropping *Leucaena leucocephala* (Lam.) de wit Var. K-28 with *Zea mays* L.var. Vijaya composite. One month old polypot raised seedlings of *Leucaena leucocephala* were transplanted from a nursery to the field at a spacing of 3m x 2m in the month of September, 1999. After 7 month of establishment of the seedlings of Leucaena, *Zea mays* (maize) was planted in the interspaces between *Leucaena leucocephala* at a spacing of 60cm x 40cm with 2-3 seeds per hill. Experiment was continued upto September 2000 i.e. for a period of one year.

The effect of fertilizers on growth performance of Leucaena and *Zea mays* was tried in the present investigation. For the purpose, three fertilizer treatments were considered which are as follows :-

Treatment	N (Kg/ha.)	P (Kg/ha.)	P (Kg/ha.)
T_I	100	50	60
T_{II}	125	70	80
T_{III}	150	90	100

N, P and K fertilizers were given in the form of Urea, Superphosphate and Muriate of Potash respectively. Fertilizers were given in two equal split applications. First half of fertilizer dose was applied to the field in the month of September, 1999 after 15 days of transplanting of Leucaena seedlings. The remaining half dose was applied in the next year in the month of May after 30 days of maize germination.

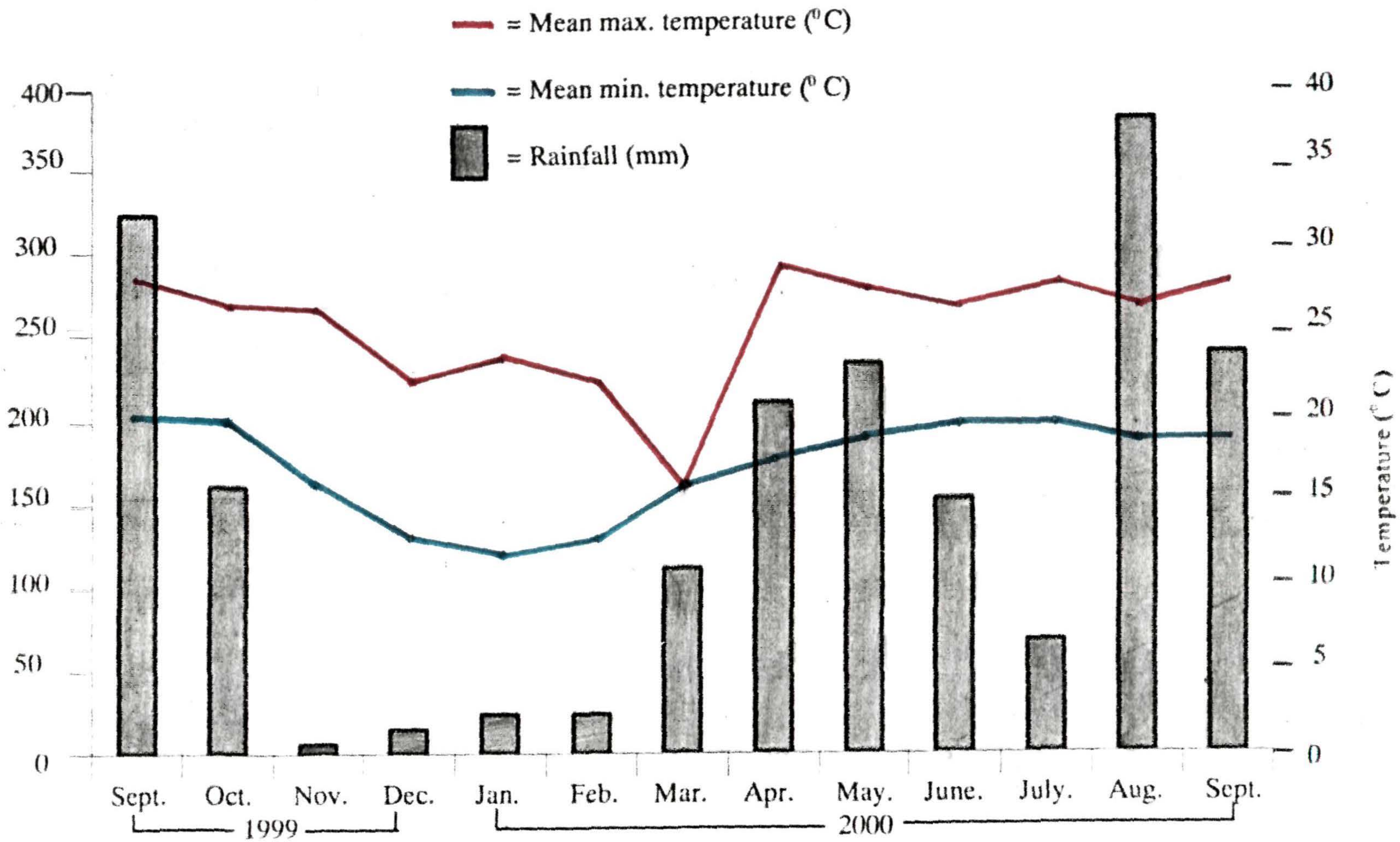


Fig. II : Monthly records of meteorological data during the study period (i.e. September 1999 to September 2000).

III. 3 : FIELD LAYOUT :

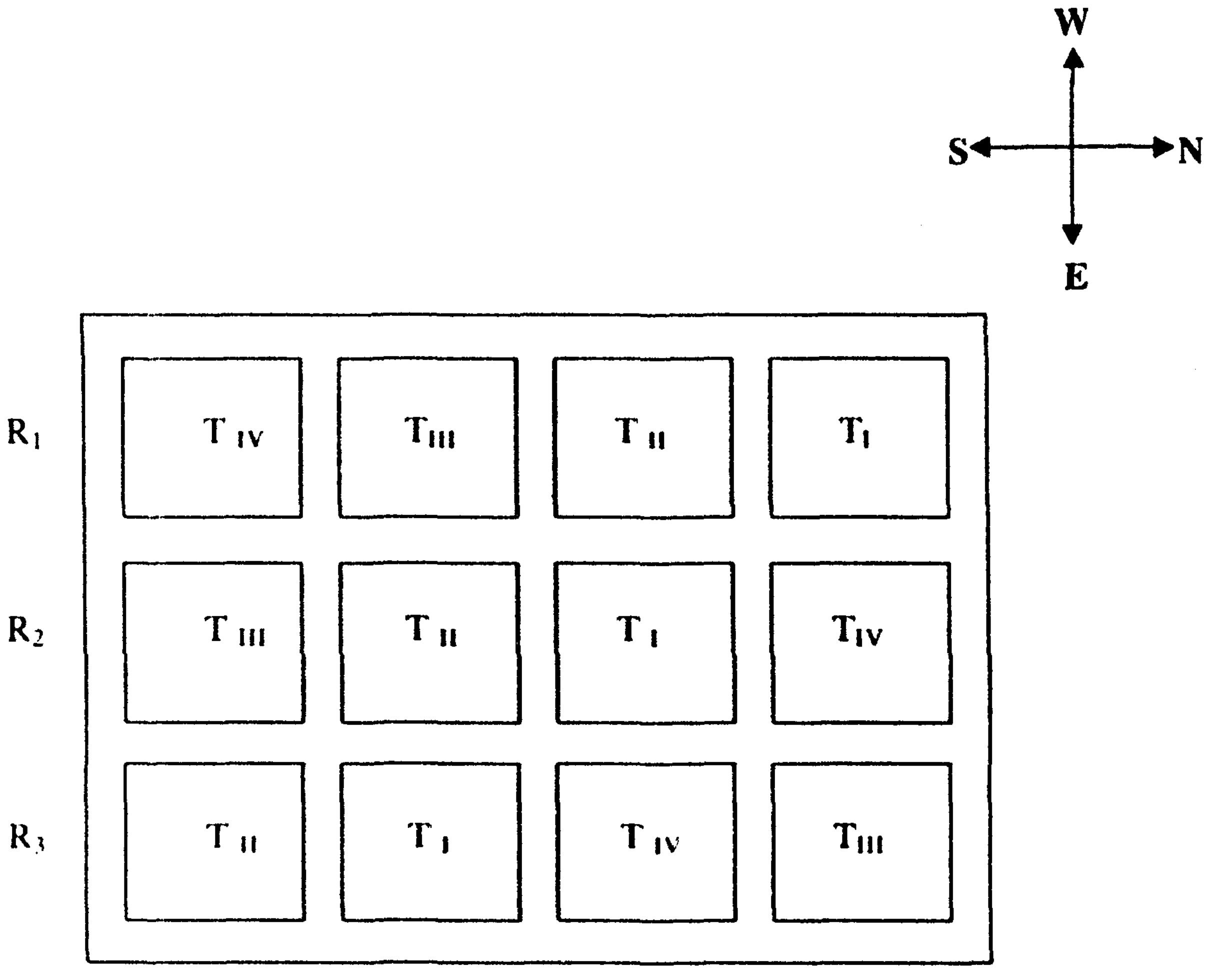


Fig. III. PLAN OF LAYOUT OF THE EXPERIMENT.

DESIGN ... ... Randomised Block Design (RBD).

TOTAL EXPERIMENTAL AREA ... ... 43.5m x 30 m or 1305 sq.m.

PLOT SIZE ... ... 9m x 8 m

SPACING ... ... 3m x 2 m (Leucaena)

... ... 60 cm x 40 cm (Maize)

TREATMENT	N (Kg/ha.)	P (Kg/ha.)	K (Kg/ha.)
T_I	100	50	60
T_{II}	125	70	80
T_{III}	150	90	100
T_{IV}	Control (without fertilizer)		

III. 4 : GROWTH PARAMETERS :

III. 4 . 1 : PARAMETERS MEASURED ON LEUCAENA :

(a) **Height and stem girth measurement :** For measuring seedling height and stem girth 36 trees (3 each from 12 plots) were marked randomly. Plant height was measured using a pole and meter scale and stem girth was measured with the help of a thread which was then measured with a metre scale. The height and girth were recorded at a monthly interval.

(b) **Biomass production :** For determining biomass production, the selected plants from each plot was harvested twice, once after 6 months of transplanting (March' 2000) and the other after one year of transplanting (September' 2000). Fresh weight was first taken and then the plants were allowed to dry in hot oven for determining dry weight.

III. 4.2 : PARAMETERS MEASURED ON *ZEA MAYS* :

(a) Plant height and stem girth were measured at a monthly intervals from one month old seedlings till their harvest.

(b) Number of leaves were recorded at a monthly intervals (after one month of sowing till harvest).

(c) Maize cob weight at harvest.

(d) Number of grains per cob.

(e) Maize grain yield in quintal per hectare.

III. 4.3 : PARAMETERS RECORDED ON SOIL :

Soil sample (0-10cm depth) was collected twice from each plot during the study period, once just before transplanting of Leucaena and just harvesting of maize crop. The various soil parameters studied using specific methods in the present study were :

	PARAMETERS		METHODS
(a)	pH	-	Digital pH meter method (electrochemical).
(b)	Organic carbon	-	Walkey and Black Rapid Titration Method.
(c)	Nitrogen	-	Kjedahl Digestion and Distillation Method.
(d)	Phosphorus	-	Bray's P method using calorimeter
(e)	Potassium	-	Flame Photometer using Ammonium Acetate method

III. 5 : STATISTICAL TESTS :

The data collected on various growth parameters were subjected to Analysis of Variance (Anova - 2 way) to find the variation in these parameters due to fertilizers and time/ month.

CHAPTER – IV
RESULTS

CHAPTER – IV
RESULTS

IV. I : GROWTH BEHAVIOUR OF *LEUCAENA LEUCOCEPHALA* AS EFFECTED BY NPK FERTILIZERS.

The monthly mean records of the growth performance in the plant height, girth and biomass as affected by different levels of NPK fertilizers in Leucaena maize agroforestry system are presented in Table I, II and III respectively.

Plant height :

The plant height in the month of September 1999 i.e., month of transplanting were uniform but at the end of the experiment i.e. September 2000, the plant showed variation in height but not significantly. The plant height during transplanting ranged from 15.2 cm to 15.9 cm. At the end of experiment, the plant height ranged from 95 cm to 122.4 cm.

The plant height due to different levels of NPK fertilizers are given in the Table I a : The growth in height of the plant during the first two months was almost similar in all the treatment. However, beyond two months, there was differential response of the plant with respect to its fertilizers applicability. As can be seen from Table I a. application of NPK fertilizers adversely effected growth character over the control. The plant height was found to be maximum (122.4cm) in the control plot and minimum (95cm) in N_{150} P_{90} K_{100} treatment plot. The results indicated that the height of plant

Plate No. 1. Growth of *Leucaena leucocephala* under *Zea mays* based agroforestry system.

Plate No. 2. *Leucaena leucocephala* grown in the system to check soil erosion and improve soil fertility.

Plate No. 3. Aerial view of some portion of the experimental plot.

Plate No. 4. Harvested maize cobs.

decreases with respect to the fertilizers applications. However, the differences were not significant. (Table I. b).

Stem girth :

The monthly mean records of stem girth are presented in Table II a. It can be seen from the table that the stem girth of *Leucaena leucocephala* at the time of transplanting were uniform between the treatments which ranged from 1.7 cm to 1.8 cm. (Table II a.). The results depicted that application of NPK fertilizers has no discernable influence on the girth growth of the plant. This can be evident from the fact that in the initial few months of the transplanting, the differences in the values in girth between control and other treated plots were almost similarly beyond two months period, fertilizers did not increase the girth of plant, rather had a tendency in checking its growth. The girth values in the control plot during these period were somewhat higher than those recorded in different treatments and the variation observed were also significant. (Table II b.)

The girth of the plant increased with increase in time period and the variation in the values between the months were significant (Table II. b.)

Biomass production :

The plant biomass of *Leucaena leucocephala* which are recorded twice during the study period i.e., once after 6 - months of transplanting and the other after a one year period indicated differential response with respect to NPK treatment. (Table III. a) In general, plant biomass both fresh weight as well as dry weight were always higher in control plot than those under fertilized plots. Among fertilized plots, the values in fresh weight and dry weight were higher in low fertilizer dose and least in high fertilizer doses.

This indicate that with increasing in fertilizer dose, the biomass was non - significant between the different fertilized plots. (Table III.b). The variation in months was significant.

Table I. a : Monthly Variation in plant height (cm) of *Leucaena leucocephala* under different treatment condition.

	Treatments			
Month/Year	T_I ($N_{100}P_{50}K_{60}$)	T_{II} ($N_{125}P_{70}K_{80}$)	T_{III} ($N_{150}P_{90}K_{100}$)	T_{IV} (Control)
September'1999	15.9 (0.189)	15.2 (0.119)	15.2 (0.077)	15.6 (0.102)
October	19.0 (0.142)	18.1 (0.2)	17.9 (0.133)	18.2 (0.125)
November	22.5 (0.078)	24.2 (0.178)	22.8 (0.252)	25.8 (0.295)
December	25.1 (0.088)	26.4 (0.191)	25.5 (0.201)	27.2 (0.288)
January '2000	27.9 (0.128)	29.0 (0.273)	27.5 (0.145)	29.8 (0.345)
February	33.5 (0.145)	33.2 (0.268)	29.3 (0.181)	35.4 (0.349)
March	37.4 (0.256)	36.4 (0.335)	34.3 (0.157)	39.2 (0.398)
April	43.4 (0.222)	41.2 (0.166)	39.4 (0.389)	47.2 (0.299)
May	54.6 (0.412)	50.9 (0.242)	45.3 (0.239)	55.7 (0.640)
June	72.6 (0.326)	66.4 (0.493)	60.3 (0.317)	72.8 (0.345)
July	91.0 (0.415)	83.1 (0.605)	74.4 (0.906)	94.3 (0.394)
August	106.5(0.773)	96.7 (0.551)	84.1 (1.801)	16.3 (0.669)
September	115.0(0.684)	108.5 (0.623)	95.0 (1.125)	22.4 (0.510)

Figures in parenthesis indicate standard error (±). n = 3

Table I. b : Analysis of variance of plant height of *Leucaena leucocephala* as affected by variation in month and treatment.

Source of variation	D.F.	S.S.	M.S.S.	F.Value	P<0.05	P<0.01
Month	12	44460.23	3705.01	0.085	N.S.	N.S.
Treatment	3	941.45	313.81	0.0072	N.S.	N.S.
Error	36	1552908.94	43136.36			
Total	51					

N.S. = Non Significant

Table II. a : Monthly Variation in stem girth (cm) of *Leucaena leucocephala* under different treatment condition.

	Treatments			
Month/Year	T_I ($N_{100}P_{50}K_{60}$)	T_{II} ($N_{125}P_{170}K_{80}$)	T_{III} ($N_{150}P_{90}K_{100}$)	T_{IV} (Control)
September'1999	1.8 (0.027)	1.7 (0.008)	1.7 (0.008)	1.8 (0.015)
October	2.0 (0.015)	1.9 (0.008)	2.0 (0.008)	2.0 (0.015)
November	2.3 (0.015)	2.2 (0.015)	2.2 (0.008)	2.2 (0.017)
December	2.6 (0.008)	2.4 (0.008)	2.4 (0.015)	2.6 (0.015)
January '2000	2.9 (0.00)	2.8 (0.017)	2.7 (0.017)	2.9 (0.023)
February	3.4 (0.008)	3.2 (0.032)	3.0 (0.015)	3.5 (0.015)
March	3.9 (0.015)	3.7 (0.031)	3.6 (0.017)	4.0 (0.017)
April	4.6 (0.017)	4.2 (0.032)	4.1 (0.023)	4.6 (0.015)
May	5.3 (0.008)	4.9 (0.015)	4.9 (0.031)	5.3 (0.008)
June	5.8 (0.023)	5.7 (0.017)	5.5 (0.039)	6.1 (0.015)
July	6.9 (0.023)	6.2 (0.045)	6.1 (0.023)	7.0 (0.017)
August	7.7 (0.017)	6.9 (0.05)	6.7 (0.023)	7.9 (0.008)
September	8.3 (0.023)	7.6 (0.065)	7.3 (0.031)	9.0 (0.017)

Figures in parenthesis indicate standard error (±), n = 3

Table II. b : Analysis of variance of stem girth of *Leucaena leucocephala* as affected by variation in month and treatment.

Source of variation	D.F.	S.S.	M.S.S.	F.Value	P<0.05	P<0.01
Month	12	215.45	17.95	332.40	2.60	2.66*
Treatment	3	2.37	0.79	14.62	2.84	4.31*
Error	36	1.96	0.054			
Total	51					

* = Significant at 1% level.

Table III. a : Biomass production of *Leucaena leucocephala* under different treatment condition.

Treatments	After 6 months of transplanting		After 12 months of transplanting	
	resh wt. (gm)	Dry wt. (gm)	Fresh wt. (gm)	Dry wt. (gm)
T_I (N_{100} P_{50} K_{60})	54 (0.174)	26.7 (0.118)	323.1 (1.755)	176.4 (1.039)
T_{II} (N_{125} P_{70} K_{80})	53.2 (0.228)	25.9 (0.18)	297.5 (0.382)	158 (0.577)
T_{III} ($N_{150}P_{90}K_{100}$)	52 (0.205)	24.4 (0.465)	241.3 (0.588)	104.4 (1.495)
T_{IV} (Control)	57.4 (0.324)	30.5 (0.275)	354.2 (1.57)	195 (0.819)

Figure in parenthesis indicate standard error (±). n = 3.

Table III. b : Analysis of variance of Biomass (fresh weight and dry weight) of *Leucaena leucocephala* as affected by variation in month and treatment.

Source of variation	D.F.	S.S.		M.S.S.		F.Value		<0.05	P<0.01
		Fresh wt.	Dry wt.	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.		
Month	1	124874.9	34623.96	24874.97	34623.96	119.454	51.006	10.13	34.12*
Treatment	3	3738.42	2563.53	1246.14	854.51	1.192	1.25	N.S.	N.S.
Error	3	3136.14	2036.43	1045.38					
Total	7								

N.S. = Non Significant.

* = Significant at 1% level.

IV. 2 : GROWTH BEHAVIOUR OF *ZEA MAYS* AS AFFECTED BY NPK FERTILIZERS.

Plant height :

The monthly variation in plant height of maize grown in leucaena - maize agroforestry system is presented in Table IV. a : As the data indicate, the height of the maize was higher under control plot than those under fertilized plots. This was true in the initial few months period. However, afterwards, the plant height was affected and the application of fertilizer influenced the growth significantly. (Table IV. b). The growth in plant height increased with increase in time period and however, the rate of this growth has not been uniform in all the fertilized plots. Under the lower fertilised dose of NPK, the growth in plant height was higher compared to other fertilized plots.

Stem girth :

The monthly mean record of stem girth as effected by different levels of NPK fertilizers are presented in Table V. a. It can be seen from the table that stem girth of maize at harvest ranged from 4.93 cm to 5.4 cm. There was significant variation in stem girth of maize due to different treatments of NPK fertilizers (Table V. b).

It is evident that maximum (5.4cm) stem girth was found in N_{100} P_{50} K_{60} treatment and the least (4.93 cm) in N_{150} P_{90} K_{100} treatment.

Table IV. a : Monthly variation in plant height of maize (cm) under different treatment condition.

Treatments	2000			
	April	May	June	July
T_I ($N_{100}P_{50}K_{60}$)	27.2 (0.163)	85 (0.471)	190.9 (0.311)	195.7 (0.181)
T_{II} ($N_{125}P_{70}K_{80}$)	26.2 (0.113)	76.9 (0.259)	180.8 (0.163)	186.6 (0.508)
T_{III} ($N_{150}P_{90}K_{100}$)	2.7 (0.471)	73.9 (0.433)	169.3 (1.258)	179.9 (0.222)
T_{IV} (Control)	28.9 (0.263)	80.6 (0.594)	186.4 (0.38)	190.6 (0.239)

Figure in parenthesis indicate standard error (±), n = 3.

Table IV. b : Analysis of variance of plant height of maize as affected by variation in month and treatment.

Source of variation	D.F.	S.S.	M.S.S.	F.Value	P<0.05	P<0.01
Month	3	73711.8	24570.6	174.50	3.86	6.99*
Treatment	3	466.4	155.46	11.041	3.86	6.99*
Error	9	211.23	14.08			
Total	15					

* = Significant at 1% level.

Table V. a: Monthly variation in girth of maize (cm) under different treatment condition.

Treatments	2000			
	April	May	June	July
T_I (N_{100} P_{50} K_{60})	1.93 (0.008)	3.1 (0.015)	5.13 (0.032)	5.4 (0.027)
T_{II} (N_{125} P_{70} K_{80})	2.0 (0.015)	2.93 (0.017)	4.9 (0.023)	5.13 (0.023)
T_{III} ($N_{150}P_{90}K_{100}$)	2.1 (0.015)	2.7 (0.008)	4.7 (0.017)	4.93 (0.023)
T_{IV} (Control)	2.03 (0.008)	2.9 (0.015)	5.03 (0.008)	5.23 (0.008)

Figure in parenthesis indicate standard error (±), n = 3.

Table V. b : Analysis of variance of stem girth of maize as affected by variation in month and treatment.

Source of variation	D.F.	S.S.	M.S.S.	F.Value	P<0.05	P<0.01
Month	3	28.62	9.54	596.25	3.86	6.99*
Treatment	3	0.15	0.05	3.125	3.86**	N.S.
Error	9	0.15	0.016			
Total	15					

* = Significant at 1% level.

** = Significant at 5% level.

N.S = Non Significant

Table VI.a : No. of leaves of maize plant under different plant treatment condition.

Treatments	2000			
	April	May	June	July
T_I (N_{100} P_{50} K_{60})	4.7 (0.086)	8 (0.155)	10.3 (0.086)	11 (0.155)
T_{II} (N_{125} P_{70} K_{80})	3.7 (0.086)	7.3 (0.086)	9 (0.155)	10.6 (0.086)
T_{III} (N_{150} P_{80} K_{100})	3.7 (0.086)	7 (0.155)	9 (0.155)	11.6 (0.086)
T_{IV} (Control)	4.0 (0.00)	7.7 (0.086)	9.7 (0.086)	10.6 (0.178)

Figure in parenthesis indicate standard error (±), n = 3

Table VI. b: Analysis of variance of number of leaves of maize as affected by variation in month and treatment.

Source of Variation	D.F	S.S	M.S.S	F value	P < 0.05	P < 0.01
Month	3	96	32	9.49	3.86	6.99*
Treatment	3	1.61	0.53	5.48	N.S	N.S
Error	9	13.49	3.37			
Total	15					

N.S = Non Significant.

* = Significant at 1% level.

Table VII. a : Weight of cobs (maize) under different treatment condition.

Treatments	Cob weight (Kg)
T_I (N_{100} P_{50} K_{60})	0.22 (0.001)
T_{II} (N_{125} P_{70} K_{80})	0.18 (0.0008)
T_{III} (N_{150} P_{80} K_{100})	0.18 (0.00)
T_{IV} (Control)	0.20 (0.002)

Figure in parenthesis indicate standard error (±), n = 3

Table VII. b : Analysis of variance of weight of cobs (maize) as affected by variation in replication and treatment.

Source of variation	D.F	S.S	M.S.S	F value	P < 0.05	P < 0.01
Replication	2	0	0	0	N.S	N.S
Treatment	3	0.002	0.0006	6	4.76**	9.78
Error	6	0.001	0.0001			
Total	11					

N.S = Non Significant.

** = Significant at 5% level.

Number of leaves per plant :

The effect of different levels of NPK fertilizers in stem girth of maize are presented in Table VI. a. It was observed that there was no significant differences in the number of leaves due to different treatments of NPK fertilizers. (Table VI. b.). It is evident from the table that maximum number of leaves (11.6) was found in N_{150} P_{90} K_{100} treatment and the least (10.6) in N_{125} P_{70} K_{80} and control

Weight of maize cobs :

Maize cub weight at harvest was evaluated, and the effect of different levels of NPK fertilizers are presented in Table VII. a. It can be seen from the table that the variation in weight of maize cobs as affected by different levels of NPK fertilizers was found to be significant. (Table VII. b). Maximum cob weight (0.22kg) was found in N_{100} P_{50} K_{60} treatments and the least in N_{125} P_{70} K_{80} and N_{150} P_{90} K_{100} treatments. However, the values in maize cob weight between the two higher fertilizer dose plots were similar.

Number of Maize grains per cob :

The result due to the effect of different levels of NPK fertilizers on number of maize gain per cob at harvest are presented in Table. VIII. a. It was observed that different levels of NPK significantly affected the number of maize gain per cob under different treatments (Table VIII. b.). It can be seen from the table that the mean number of grains per cob at harvest ranged from 297 to 427. Maximum mean number of per cob was recorded in N_{100} P_{90} K_{100} treatment.

Table VIII. a : No. of maize grains per cob at harvest under different treatment condition.

Treatments	No. of grains/cob
T_I (N_{100} P_{50} K_{60})	441.7 (0.739)
T_{II} (N_{125} P_{70} K_{80})	406.7 (1.818)
T_{III} (N_{150} P_{80} K_{100})	392 (0.415)
T_{IV} (Control)	426.7 (0.086)

Figure in parenthesis indicate standard error (±), n = 3

Table VIII. b : Analysis variance of number of grains per cob at harvest as affected by variation in replication and treatment.

Source of variation	D.F	S.S	M.S.S	F value	P < 0.05	P < 0.01
Replication	2	96	48	1.24	N.S	N.S
Treatment	3	4300.24	1433.41	37.07	4.76	9.78*
Error	6	232.01	38.66			
Total	11					

N.S = Non Significant.

* = Significant at 1% level.

Table IX. a : Yield of cobs (Qtls./ha.) under different treatment condition.

Treatments	Yield of cobs (Qtls/ha.)
T_I (N_{100} P_{50} K_{60})	110 (0.785)
T_{II} (N_{125} P_{70} K_{80})	93.3 (0.453)
T_{III} (N_{150} P_{80} K_{100})	90
T_{IV} (Control)	103.5 (1.195)

Figure in parenthesis indicate standard error (±), n = 3

Maize cob yield (Qtls./ha.) :

The yield of maize cob was calculated by taking 1.5 cobs per plant. The effect of different levels of NPK fertilizers on maize cob yield are presented in Table IX. a. The data show that application of different levels of NPK fertilizers have significant effect on maize cob yield. (Table IX. b). The table clearly indicated that maximum cob yield was found in N_{100} P_{50} K_{60} treatment plot and the least in N_{150} T_{90} K_{100} treatment plot.

IV.3: SOIL FERTILITY CHANGES :

Soil samples were collected from each treatments just before transplanting *Leucaena leucocephala* (September 1999) and after harvesting of maize (August 2000). Changes in soil chemical characteristic within the 0-10cm under different treatments were studied and presented in Table X. In all the treatments except control the concentration that were small increases on the level of organic carbon (O.C.) Nitrogen (N), Phosphorus (P) and Potassium(K). However, the differences in these levels were not significant when compared between the treatments.

Table IX. b : Analysis of variance of yield of cobs (Qtls/ha.) of maize as affected by variation in replication and treatment.

Source of variation	D.F	S.S	M.S.S	F value	P < 0.05	P < 0.01
Replication	2	116.67	58.335	5.25	5.14**	N.S
Treatment	3	758.33	252.77	22.75	4.76	9.78*
Error	6	66.67	11.11			
Total	11					

N.S = Non Significant.

* = Significant at 1% level

* * = Significant at 5% level.

Table X : Fertility of soil (0-10cm) under different treatment condition.

Treatments	TIME OF SOIL SAMPLE COLLECTION	pH	O.C%	N%	Kg ha^{-1}	K Kg ha^{-1}
T_I (N_{100} P_{50} K_{60})	Before planting Leucaena (September 1999)	5.5	1.20	0.073	17.05	102.7
	After harvesting of maize (September 2000)	4.9	1.23	0.074	17.09	103.7
T_{II} (N_{125} P_{70} K_{80})	Before planting Leucaena (September 1999)	5.5	1.18	0.072	19.25	111.05
	After harvesting of maize (September 2000)	4.9	1.24	0.074	21.7	112.6
T_{III} (N_{150} P_{80} K_{100})	Before planting Leucaena (September 1999)	5.3	1.18	0.073	19.36	113.4
	After harvesting of maize (September 2000)	4.8	1.23	0.075	22.06	114.7
T_{IV} (Control)	Before planting Leucaena (September 1999)	5.4	1.19	0.073	18.9	101. 3
	After harvesting of maize (September 2000)	5.2	1.05	0.070	18	100.5

CHAPTER - V
DISCUSSION

CHAPTER - V
DISCUSSION

The present study which aimed at evaluating the growth behaviour of *Leucaena leucocephala* alongwith *Zea mays* affected by different doses of fertilizers indicated differential response in the growth attributes of *Leucaena leucocephala* in plant height, girth, biomass production. Similarly, *Zea mays* too was affected by the fertilizer application and showed differential response with respect to its various growth attributes such as maize plant height, girth, number of leaves, weight of maize cob, number of maize grains per cob and maize cob yield. These variation can be attributed to (i)the application of different doses of fertilizers, (ii) the differential uptake behaviour of the plant, (iii) the interaction between the plant components i.e. maize-leucaena compatibility and (iv) to the nutrient requirement of the plant in agroforestry system.

Infact, agroforestry systems are more complicated than any agroecosystem in the sense that this system involve more than two components. The present study being conducted only for one year period was too short to depict anything in concrete. However, an attempt has been made here to attribute various causes which could have affected the results.

V.1 : GROWTH ATTRIBUTES OF *LUECAENA LEUCOCEPHALA* AS AFFECTED BY FERTILIZERS :

Plant height, girth and biomass production of the species increased with time and the rate of change in all these parameters were significantly affected by time. This is related to the characteristic sigmoid growth curve/law of growth universal to all plant species.

During the first two months period, the value in plant height was higher under N_{100} P_{50} K_{60} fertilised plot and least under N_{150} P_{90} K_{100} plot. However, with increase in time, the trend in plant height was changed. With time, a better growth in plant height was observed under control than under all other treatments. Similar was the case in the girth behaviour of the plant. The decrease in plant height and girth (Fig. IV) associated with increase dose of fertilizer in the present study indicate that fertilizer have an adverse effect on the growth of the plant.

Leucaena leucocephala is a leguminous plant which itself can fix atmospheric nitrogen through nodule formation and development and enrich the soil. The nitrogen accumulate by its root nodule is known not only to meet the nitrogen requirement of this plant but also help the neighbouring plants and crops. An additional dose of fertilizer therefore has become limiting for its growth and development. Similar findings have been reported by Subba Rao (1977) who reported adverse effect of fertilizer on the growth of *Leucaena leucocephala*. Szott and Kass, 1993 mentioned that adverse effect of fertilizer on the growth of *Leucaena leucocephala* may be due to negative relationship between nitrogen fixation and quantity of inorganic fertilizer applied.

A gradual decrease in plant biomass (both fresh as well as dry weight) of *Leucaena leucocephala* with increase in fertilizer dose (Fig. V) can also be

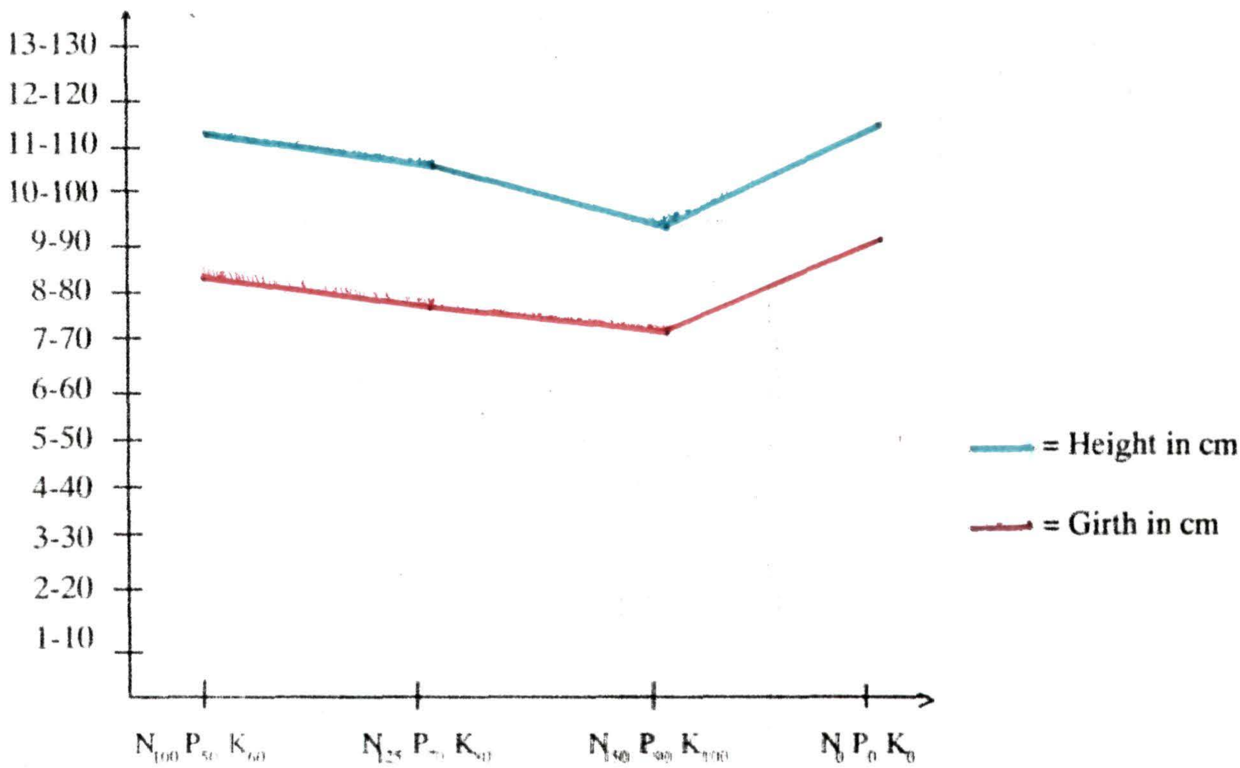


Fig. IV : Response of NPK fertilizers on height and girth of *Leucaena leucocephala* after 1 year in maize agroforestry system.

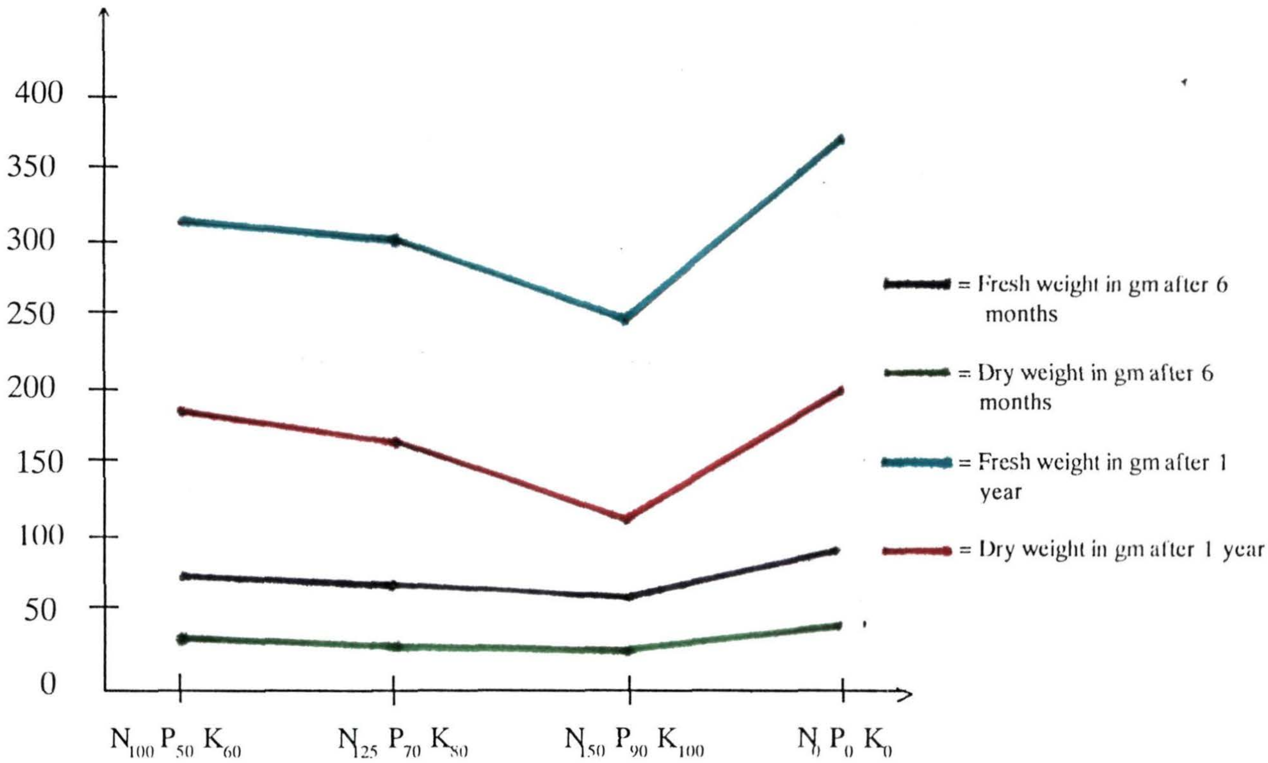


Fig. V: Response of NPK fertilizers on biomass (fresh weight and dry weight) of *Leucaena leucocephala* after 6 months and after 1 year in maize agroforestry system.

related to the above causes. As the plant height and girth were affected adversely due to increase application of fertilizer, obviously the biomass decreased in highly dose/fertilised plot. Conversely, since there was no application on fertilizer in the control plot, the plant under this treatment could grow well and there were no inhibition. For every species, there is a critical nutritional requirement, beyond which the nutrient applied can have inhibitory effect, which has been seen in the present case. Present findings are in line with those of Mohan (1992) and Totey *et al.*, (1988) who reported excess NPK fertilizers have adverse effect on the growth of ***Terminal myriocarpa*** and *Dendrocalamus strictus*.

V. 2 : GROWTH BEHAVIOUR OF *ZEA MAYS* AFFECTED BY FERTILIZERS :

The plant height, girth and number of leaves varied with fertilizer doses in the present study. Among these growth attributes, leaves were affected most (Fig. VI). There were hardly any difference in the number of leaves when compared between the control and a low fertilizer dose plot, however, when the respective values of medium and high fertilized plots were compared either with the control and/or low fertilized plot, significant variation was noticed. This indicated that fertilizer dose consisting of N_{100} P_{50} K_{60} is ideal for the growth of *Zea mays*. Beyond this dose had adverse effect on its growth. As far as the plant height as well as girth are concerned, although there were some tendering towards their inhibition with the increase in fertilizer dose, but these were not very much remarkable (Fig VI).

The yield of maize cob, cob weight and number of maize cob were related to the growth performance of the species in general, which inturn were linked to their nutritional requirement. As has been found that higher dose of

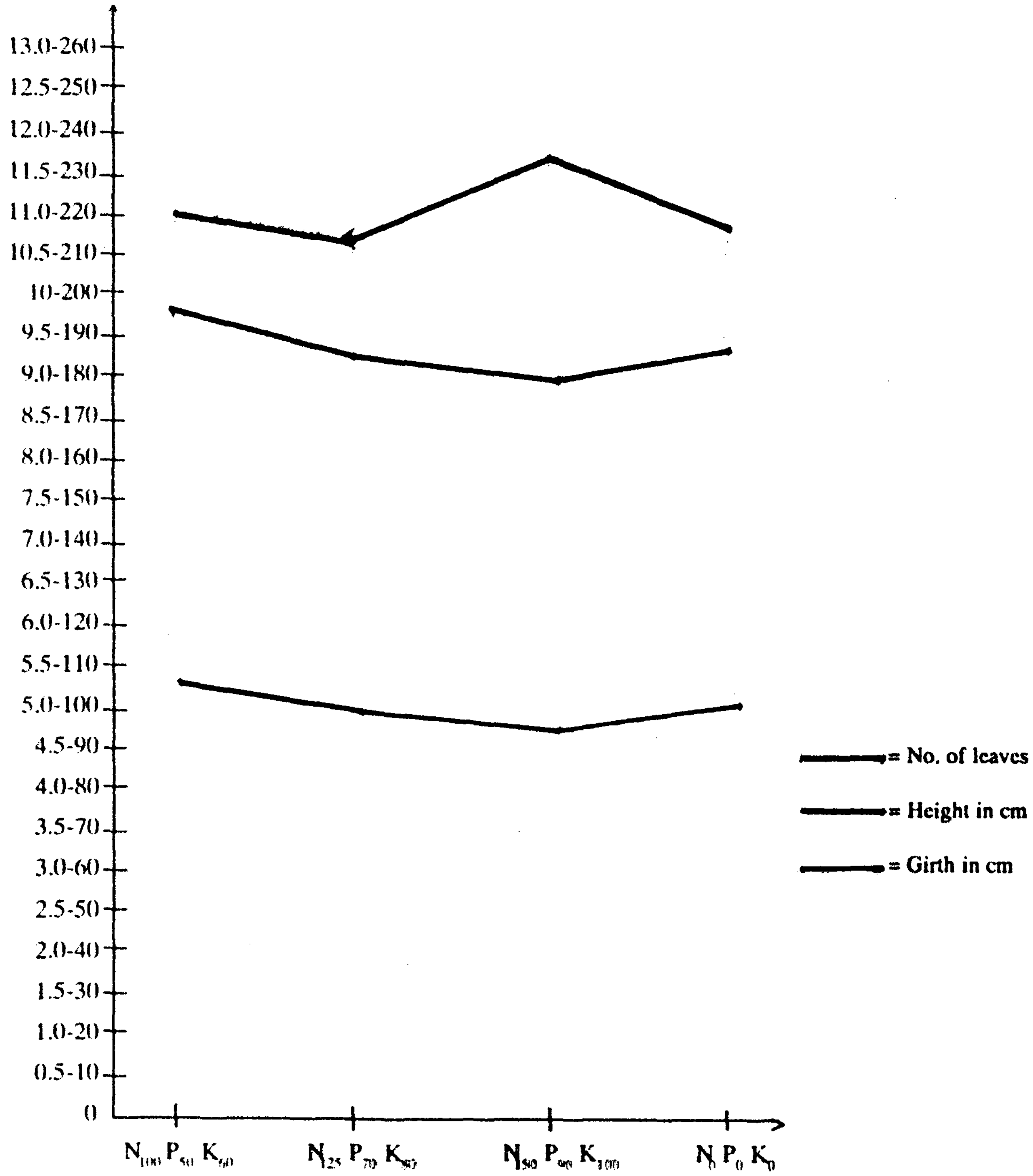


Fig. VI : Response of NPK fertilizers on height, girth and number of leaves of maize at harvest.

nutrient in fertilizer has stunted growth, it too affected the yield attribute of the species by reducing the quality and quantity of the maize cob. In no way, the fertilizer helped the plant in improving its reproductive ability (Fig VII). Kas *et al.*. (1989) and Kanwar (1976) have also reported that high fertilizer dose effect the quality and quantity of maize cob yield adversely. Present finding are in line with those of Kanwar (1976) who reported cereals receiving excess nitrogen have been shown to exhibit poor growth performance thereby reducing the yield.

As far as the agroforestry system are concerned, it hardly had any discernable influence on the soil parameters. The soil pH was slightly higher before introduction of the crop while it reduced at the end of the study period. Conversely, other soil nutrients were higher after the end of the study period. This may presumably, due to the addition of fertilizer to the system and their less utility by the plant. As the nutrient applied to the system become surplus which can be indicated by vegetative growth of the plants, the nutrient could not be uptake by the plants properly, thus there was hardly any loss of nutrients through the plant. But there might have been loss through run-off, leaching, percolation etc., which unfortunately could not be measured in the present study. Although it was not possible to know exactly how these nutrients were utilized/uptake by plants in the agroforestry system, but there are certain indications that these hardly had any significant influence on the growth of the maize as well as *Leucaena leucocephala.*

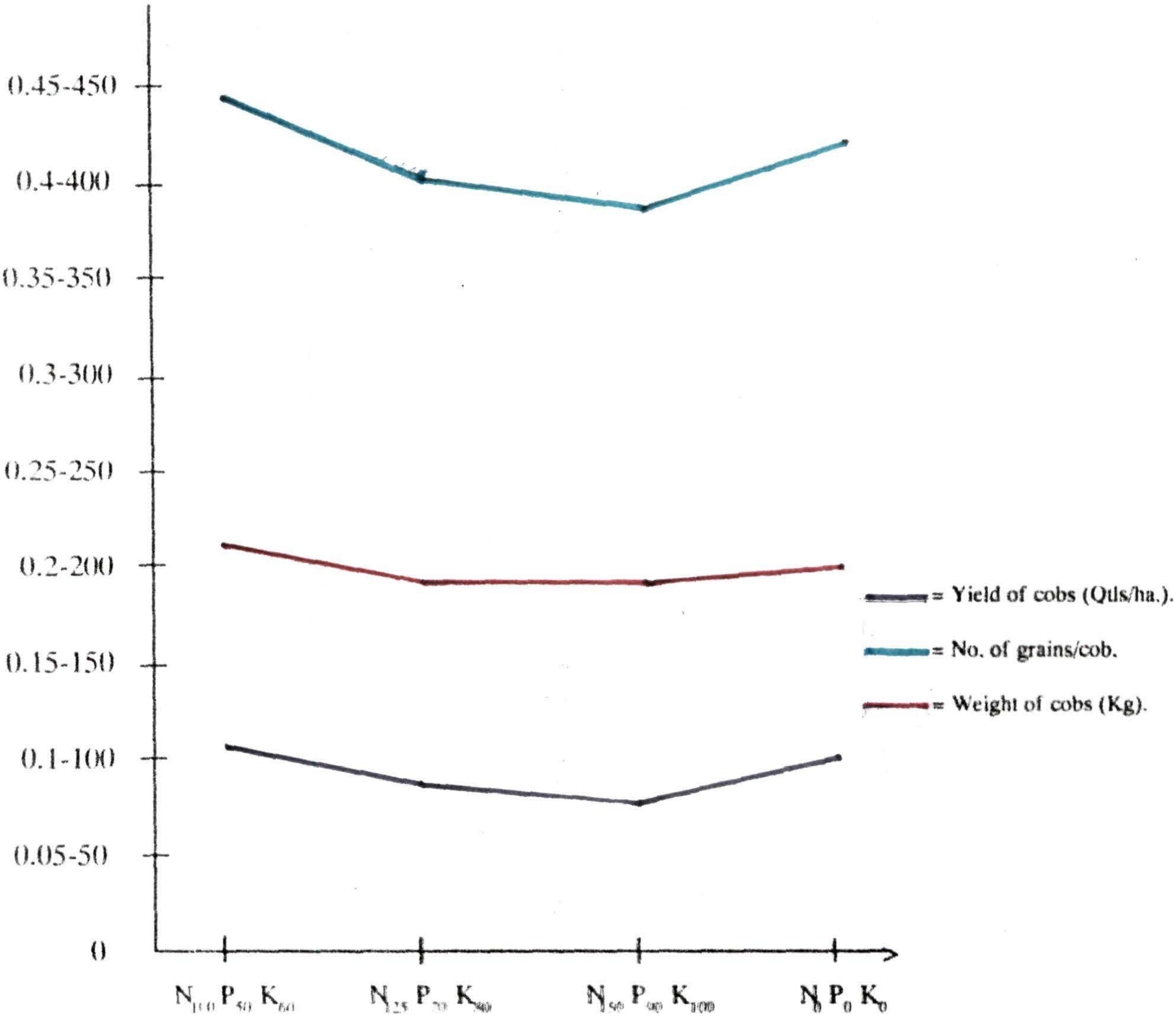


Fig. VII : Response of NPK fertilizers on weight of cobs, number of grains per cob and yield of cobs of maize at harvest.

CONCLUSION

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From the foregoing results and discussion, it was found that the higher level of N,P,K had an adverse effect on the growth behaviour of *both Leucaena leucocephala* as well as *Zea mays*. *Leucaena leucocephala* being a legume, was obviously had a surplus of nutrients as the plant itself synthesize nitrogen to supplement its own requirement, as a matter of fact, the species, suffered on its growth parameters even at the lowest level of NPK application. On the contrary, at low level of NPK application, *Zea mays* showed good performance on its growth behaviour. However, both medium and high NPK levels became critical for this species, thereby the species was not able to utilize the fertilizer resources available to it and showed stunted growth. This was the reason for lower reproductive yield of the species at medium and high fertilized NPK plots.

The performance *Leucaena leucocephala* with respect to height, stem girth and biomass production was best in control. In case of *Zea mays* control plot produced better performance with respect to height, stem girth, number of leaves and yield of cobs.

Considering the performance of *Leucaena leucocephala* and *Zea mays* under control condition and negative impact of chemical fertilizers on plant growth while keeping in mind the cost of chemical fertilizers. It may be suggested to use *Leucaena leucocephala* as an alternative to chemical fertilizers in agroforestry systems of Mizoram.

Since our study was only for a very short period, it may be premature to draw concrete conclusion. Further studies are needed on this species to draw suitable conclusion.

SUMMARY

SUMMARY

An experiment was conducted following Randomised Block Design (RBD) with three replications to study the effect of different levels of NPK fertilizers on the growth of *Leucaena leucocephala* (Lam.) de wit along with *Zea mays* L. The study was conducted from September 1999 to September 2000. The study was carried out at Zemabawk about 5 kms east of Aizawl, the capital city of Mizoram in N.E. India. The various growth attributes such as plant height, stem girth, number of leaves were recorded at a monthly interval, however, plant biomass was estimated at a 6 months interval. The mean yield of maize, number of grains per cob were also recorded at the time of harvest. The data obtained were subjected to analysis of variance (ANOVA - 2 ways) to find the significance of variation in these parameters due to fertilizers.

The major findings of the study were as follows :

(i) The growth performance with respect to height and stem girth under different treatments significantly varied with time.

(ii) The growth in height and stem girth of *Leucaena leucocephala* during the first two months was almost similar in all the treatments. However, beyond two months period, there was differential response of the plant with respect to its fertilizer application.

(iii) Application of fertilizers (NPK) @ 100:50:60, 125:70:80 and 150:90:100 (N:P:K) had an adverse effect on the growth and biomass production of *Leucaena leucocephala*. The growth and biomass production of the species decreased with the increase level of fertilizer.

(iv) *Leucaena leucocephala* under control treatment showed the best result with respect to its growth characteristics (height and stem girth) and also the biomass (fresh and dry weight).

(v) The growth performance of *Zea mays* was higher in fertilized plots than control. However, the rate of its growth has not been uniform in all the plots. Under lower dose of NPK fertilizers, the growth performance was higher compared to other fertilized plots.

(vi) Maximum growth performance of *Zea mays* and yield of maize cob was found in N_{100} P_{50} K_{60} treatment. Next to it in descending order of growth performance and yield were N_0 P_0 K_0 (control), N_{125} P_{70} K_{80} and N_{150} P_{90} K_{100} treatments.

From the present investigation, it can be depicted that application of different levels (100:50:60, 125: 70:80 and 150:90:100 (N:P:K)) of fertilizers decreased all growth parameters and biomass production of *Leucaena leucocephala*. On the other hand, application of N, P and K fertilizers @ 100, 50 and 60 respectively increased all growth parameters and yield of *Zea mays*. This dosage was found to be the optimal dose for *Zea mays* in the experimental soil types. However, since the present study involved only three levels of NPK fertilizers it may be early to draw concrete conclusion on the effect of NPK fertilizers. Further studies are needed to study the effect of other levels of NPK fertilizers.

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