“EFFECTS OF *IN SITU* LITTER BURIAL (TREE) WITH EARTHWORM AMENDMENT ON SOIL CHEMO-EDAPHIC AND NITROGEN BUDGETS, AND CROP PRODUCTIVITY (MAIZE)”

THESIS

SUBMITTED TO THE NORTH EASTERN HILL UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FORESTRY (AGROFORESTRY)

BY

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CERTIFICATE

*I certify that the thesis entitled "**Effects of in situ litter burial (tree) with earthworm amendment on soil chemo-edaphic and nitrogen budgets, and crop productivity (Maize)**" submitted by Mr.R.Vanlalchhuanga 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 University nor has it been published in part or full.*

I wish Mr.R.Vanlalchhuanga all success in life.

Place : *Aizawl*
Date : 27. 11. 2000

Supervisor

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Place : Chaltlang, Aizawl.
Date : 27. 11. 2007

(R.VANLALCHHUANGA)

CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF PLATES

INTRODUCTION

INTRODUCTION

1.1 Agroforestry – A Historical Perspective :

Historically, the practice of combining tree species with crops had existed in some form or the other in most countries. Agroforestry has been practiced in China since ancient times. During the Han Dynasty (206 BC – AD 220), administrators recommended the development of forests together with the raising of livestock and crops according to different site conditions (Zhu *et al.*, 1993). The integration between forestry and agriculture has been adopted in Egypt long before the term "Agroforestry" was coined (EL.Lakany, 1987). It has also been reported by Olufenai (1987) that a form of agroforestry system called 'Taungya' started in 1927 in moist regions of Nigeria. Agroforestry has also been an age-old practice in India. It is reported that the system of raising trees along with agricultural crops has been in vogue in Forest Department for over 100 years (Taungya cultivation) in which forest lands were leased out to the cultivators for raising cereal crops, the cultivators in turn were expected to protect the tree seedlings and saplings.

1.2 The Science of Agroforestry :

As an applied science, agroforestry is of recent origin. Jha (1991) has opined that the setting up of the International Council for Research in Agroforestry by the Food and Agricultural Organisation (FAO) in 1878 is a landmark in the developmental history of agroforestry. In agroforestry, co-existence of farm and forestry is adopted on a scientific basis and consequently the total yield of land is raised significantly. An efficient agroforestry system should aim at systematically developing integrated land use systems and practices where the positive interactions between trees and crops are encouraged and maximized. Pathak (2000) has mentioned that agroforestry is being viewed as a restoration agent, rehabilitation process, bioremediation mechanism and foster mother to high input agriculture on fragile lands. According to the State of Forest Report (1997), India has a total forest cover of 63.34 million hectare. Currently, the area under agroforestry (including farm forestry) covers over 66 million hectares (Pathak,2000).

1.3 **<u>Defining Agroforestry</u>** :

Because of its wide scope, agroforestry has been defined in various ways by several investigators across the world. Westly (1990) has pointed out that researchers define agroforestry practices differently depending on the focus of their work.

In practice, agroforestry refers to "land use system and technologies in which woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately combined on the same land management unit with herbaceous crops and/or animals, either in some form of spatial arrangement or temporal sequence". In agroforestry systems, there are both ecological and economic interactions among the different components (ICRAF, 1986). This definition is widely accepted as it is very comprehensive and covers all aspects of agroforestry.

According to King and Chandler (1978), "agroforestry is a sustainable land management system which increases the overall yield of land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially on the same unit of land, and applies management practices that are compatible with the cultural practices of the local population". This is one of the most common definitions, but fails to make a clear demarcation between 'tree crops' and 'forest plants'.

According to Rao (1989), the term 'agroforestry' in a broad sense encompasses any and all techniques that attempt to establish or maintain both forest tree and agricultural production on the same piece of land. This definition may be applicable in a broad sense, but is not explicit from a strict scientific point of view.

Rao and MacDicken (1991) have given a more precise definition of agroforestry as a land use that involves deliberate retention, introduction or mixture of trees or other woody perennials in crop/animal production fields to benefit from the resultant ecological and economic interactions. This definition may be considered more appropriate as it includes all aspects of scientific agroforestry, incorporates the concept of the age-old systems, and also covers the economic point of view.

The Annual Report (1999-2000) of Indian Agricultural Statistics Research Institute (ICAR) defines Agroforestry as "the science of designing and developing integrated self sustainable land management system, which involves introduction/retention of woody components including trees, shrubs, bamboos, canes, palms, along with agricultural crops including pastures/animals simultaneously or sequential on the same unit of land, and at the same time meets the ecological as well as socio-economic needs of the people".

Considering the different perspectives, agroforestry may be defined `as a sustainable land management system that optimizes land productivity by harnessing positive interactions between trees, crops and/or livestock'.

1.4 **Importance of Agroforestry :**

Agroforestry is designed to meet the growing requirements of mankind by improving the productivity of plants and animals, and is based on the principle of optimum utilization of land. When agroforestry is successfully implemented it can generate several positive environmental impacts. Young (1989) has mentioned that an appropriate agroforestry system has the potential to control erosion, maintain soil organic matter and physical properties, augment nitrogen fixation, and promote efficient nutrient cycling.

The adoption of agroforestry on a scientific basis is found to be important for generating the supply of fuelwood at a convenient distance for the consumers, small timber to meet the requirements of the rural population, fodder for feeding livestock and production of food crops, fruits, vegetables, etc. Agroforestry also helps in raising the income of the rural farmers as it creates employment opportunities. It even helps in obtaining an ecological balance in rural areas.

It may be stated that the agroforestry programmes always fulfil the objective to raise the total yield of land considerably in comparison to the traditional system of land management consisting of a dichotomy between forestry and agriculture, horticulture and animal husbandry.

In Mizoram, traditional forms of agroforestry have been practiced by some farmers in their own way. Cultivation of Paddy (*Oryza sativa*) as an intercrop in the first year or establishment stage of Teak (*Tectona grandis*) plantation is one of the common practices adopted by the farmers. Cultivation of Paddy, Maize (*Zea mays*) or vegetables along with Tung (*Aleurites fordii*) is another common combination in the state. Other prominent agroforestry systems include combination of a variety of trees along with horticultural crops.

1.5 <u>Identification of Problem</u> :

In Mizoram, majority of the farmers are still practising traditional system of farming, commonly known as ' Shifting Cultivation ' or ' *Jhumming*'. Local tall varieties of paddy (*Oriza sativa*) occupies the major portion of jhum land. Vegetables like Pumpkin, Brinjal, Cowpea, Chilli, Bittergourd and Maize are grown as mixed cropping with paddy.

In earlier years the fallow period between two jhums was long enough to permit natural regeneration of vegetation . But on account of population pressure, the fallow period is now extremely reduced and does not permit the desired growth of natural vegetation and replenishment of soil fertility with the result that the land is progressively becoming infertile . This is compounded by heavy soil erosion losses and surface run-off (Sarma and Jha, 1993).

Since large areas of forests are clear-felled and burnt each year for jhum land, the practice of shifting cultivation adversely affects the ecology, enhances soil erosion, increases run-off and loss of soil nutrients. The use of fire in shifting agriculture is also found responsible for huge amount of volatilization losses of Carbon, Nitrogen, Phosphorus, etc.(ITTO Report, 1994).

The State of Forest Report (1997) has mentioned that shifting cultivation remains the single largest factor for the loss of forest cover. Between 1995 and 1997 assessments, 1,875 Sq.Km. of forest area, mainly concentrated in the states of Manipur, Nagaland, Assam and Mizoram was lost because of shifting cultivation, and out of this 292 Sq.Km. of forest area was lost in Mizoram due the same reason.

To replenish the soil physico-chemical and nutrient status, and to harness the nutrients in organic matter (particularly the continuous input of organic matter from the tree component), the present agroforestry experiment is being attempted with *Schima wallichii* Choisy and *Erythrina indica* Lam. as the tree components and *Zea mays* (Maize) as the crop component . The former are indigenous to the region, and are extremely popular with the local farmers. The latter forms the second most important food crop coming only next to paddy.

1.6 **Objectives :**

The present study is being carried out with the following objectives :

(1) To estimate the rates of N-release of the two litter species through the activity of earthworms.

(2) To compare the nitrogen inputs from buried litter of two different tree species, i.e. *Erythrina indica* Lam. and *Schima wallichii* Choisy., both with and without earthworm amendments.

(3) To estimate the yields of Maize *(Zea mays)* and compare such yields among controls and the two types of litter buried.

(4) To analyse the chemo-edaphic factors such as pH, Conductance and Soil moisture.

REVIEW
OF
LITERATURE

REVIEW OF LITERATURE

2.1 <u>The Tree Component</u> :

A number of research works have been carried out on various aspects of agroforestry. Patil *et al.*, (1998) stated that the most important factor in designing agroforestry systems is selection of suitable tree species. Altieri *et al.*, (1987) have also mentioned that micro-site enrichment through improvement in the soil organic matter and mineral nutrient pools is an important attribute of trees and shrubs in agroforestry. The performance and potential role of individual tree species on nutrient cycling affect the suitability of each species for soil rehabilitation and for its combination with agricultural crops. Knowledge of each species' potential, then, is important in influencing tree species choice. Decomposition rates and the release of nutrients from decomposing litter provide valuable information on the capacity of different species to replenish nutrient concentrations in the soil over time (Glover and Beer, 1986; Szott *et al.*, 1991).

If Nitrogen-fixing tree species (NFTs) are planted in the system, soil nitrogen increases considerably. Further, foliage of some NFTs contains considerable nitrogen which when mixed with soil improves the soil nitrogen status (Jha and Sarma, 1993). George and Kumar (1998) also reported that the Nitrogen-fixing tree species (*Leucaena, Casuarina* and *Acacia*) in general were associated with higher concentration of soil N, available P and K. Studies conducted by Montagnini *et al.*, (1991) showed that soil N available was higher under the N-fixing tree (*Stryphnodendron microstachyum*) than under those of non-N fixing species. The result of the studies conducted by Patil *et al.*, (1998) on the nutrient status of soil under different canopies at Prabhunagar clearly indicated that *Eucalyptus* and *Casuarina* improved organic carbon content of the soil, and at higher rates, as compared to other species, contrary to the belief that *Eucalyptus* decreases the fertility status of the soil. An investigation conducted by Peter (1986) in Eastern Ethiopia on farmers field also indicated a statistically significant increase in the crop yield by 56% on an average for the crops under the tree canopies compared to those away from the trees.

2.2 <u>Litterfall and Decomposition</u> :

Although many works on litter dynamics and nutrient turnover in tropical forest ecosystems are available, aspects of decay and the resulting changes in soil nutrient pool are scarce and poorly described in tropical situations (George and Kumar, 1998).

Some workers have reported positive effects of litter fall and litter decomposition on soil. Anon (1978) mentioned that the influence of leaf litter and decomposition of organic matter largely determine the fertility level of the forest soil. Paulsamy *et al.*, (1990) reported that the mineral input of the soil is mainly dependent upon the nature and type of litter and the rate of its decomposition; and that decomposition is influenced by various environmental and biotic factors.

The addition of tree leaves and branches as mulches to soils has been shown to improve site microenvironmental conditions (Buldelman, 1989) and increase the productivity of agricultural crops (Duguma *et al.*, 1988; Gutteridge, 1990; Onim *et al.*, 1990; Tiraa and Asghar, 1990; Yamoha and

Burleigh, 1990). It has also been reported that mulch from leaf litter can protect soils against erosion, decrease weed growth, release nutrients to the soil via decomposition, and moderate soil moisture loss and temperature fluctuations (Buldelman, 1988, 1989; Montagnini *et al.*, 1993)

Das and Ramakrishnan (1985) studied the litter dynamics in Khasi Pine of North East India and stated that litter on the forest floor acts as an input-output system for nutrients. Litterfall and its subsequent decomposition forms the major source of energy and nutrient for the soil and litter organisms of the woodlands (Pande, 1999), and as litter decomposition proceeded, the concentration of N in the residual mass increased (George and Kumar, 1998).

The time taken for complete litter decomposition may differ from species to species. King (1978) reported that litterfall and litter decomposition rates have positive effect on soil and is one of the important characteristics which a tree species intended to be grown in conjunction with crops should have. George and Kumar (1998) have mentioned that *Casuarina* and *Leucaena* litter decomposed completely within 6-7 months.

2.3 *Schima wallichii* and *Erythrina indica* in Agroforestry :

Only very few research findings could be traced out regarding *S. wallichii* and *E. indica*. Brewbaker (1986) listed over 200 species of multipurpose leguminous trees that might be used in agroforestry systems, and genera that have shown promise include *Erythrina* (Pezo *et al.*,1989), and this genus contains several species widely used in agrforestry systems in the tropics

(Thulin,1983; Lazier and Mengistu,1984; Teketay,1990; Muthuchelian,1992). The result of the field survey conducted by Khaleque (1987) indicated that *Erythrina spp.* is one of the most common fuel trees in Bangladesh. Jha and Sarma (1993) mentioned that *Erythrina suberosa* is a promising multipurpose tree for humid and semi-arid western ghats of India.

Alrim (1988) mentioned that *Erythrina spp.* is one of the most common shade trees planted to shade *Theobroma cacao* in Brazil. *Erythrina spp.* is also regarded as an important tree species which can be grown as companion species (Reddy,1993), and is also planted for fencerows, nurse tree in Coffee plantation and also as windbreaks (Brewbaker,1993).

Combe (1982) opined that species belonging to genera *Erythrina* produces valuable fodder. Troup (1975) also mentioned that the lopped leaves of *E. indica* are valuable as green manure and as cattle fodder. Salazar *et al.*,(1993) studied crop-tree interactions in alley cropping systems on alluvial soils of the Upper Amazon Basin and concluded that under conditions favourable for crop production, the use of rapidly decomposing nutrient- rich mulches of *Erythrina spp.* resulted in greater crop production, presumably due to their ability to supply readily available nutrients to the crops.

The farmers of Mizoram believe that *Schima wallichii* decreases the fertility status of soil and always avoid planting of crops near and under the tree. But researchers have reported that this tree is planted and used for some meaningful purposes. Abdurachman (1989) reported that *S. wallichii* has been planted in Sukabum Community Forests (West Java). The tree is also planted to shade Large Cardamom plantation in eastern Himalayas (Kumar and Bhardwaj,1993). Venugopal (1986) also mentioned that *Sechim edule*, a vegetable crop, is raised near *S. wallichii* which offers support and aerial space for the vines of the former to grow and spread over the entire canopy. This puts luxuriant vegetative growth with abundant fruits and is often fed to pigs.

2.4 Maize (*Zea mays*) in Agrofrestry :

Maize (*Zea mays*) occupies an important place among the cereals throughout the world. It is used both for food as well as fodder. It forms the second most important food crop coming only next to paddy in the North Eastern states of the country. Maize is extremely popular as a companion crop in Mizoram. It is grown mixed with Paddy (*Oryza sativa)* in the jhum lands.

For Maize, a good N supply is important during vegetative growth, but the N requirements are less during flowering and ripening. Reduced shading is also important (Nygren and Jimenez, 1993). Maize growing under alley cropping has been shown to have significantly higher N availability under *Erythrina poeppigiana* than in the sole crop controls due probably to higher N mineralisation and release from the mulch (Haggar, 1991), which is reflected in higher yields.

The result of the mulch experiment conducted by Montagnini *et.al.*,(1993) has shown that tree mulches played a significant role in maize seedling growth. It has also been reported that the addition of mulch of leguminous leaves has a positive influence on Maize growth (Hussain *et al.*, 1990; Kaufusi and Asghar, 1990; Tiraa and Asghar, 1990). According to the study conducted by Grewal *et al.*, (1992), combination of *Leucaena* with Maize gave significantly higher net returns as compared to pure Maize. Wilson and Kang (1981) also reported that in alley cropping system based on *Leucaena*, Maize was promising because *Leucaena* tops maintained Maize grain yield at reasonable level with no additional nitrogen input on a sandy soil. Legume with Maize as an intercrop is also reported to generate yield advantage (Singh *et al.*, 1978).

2.5 Earthworms in Agroforestry :

Earthworms have received the attention of many workers. There are many different genera and species with widely varying habitat requirements, which occur from low-elevation agricultural soils to high-elevation sub-alpine forest soils. Earthworms are responsible for large-scale soil mixing. They transport surface organic matter deep into the mineral soil, promoting good soil structure, and bringing mineral material from lower horizons to the soil surface. Soils with abundant earthworm activity are generally well aerated, well structured and fertile (Kimmins, 1987). The worms convert the organic mater to a condition that is more favourable to microbial decomposition, and this may be the most significant overall effect of earthworm (Satchel, 1967).

Earthworms can be used as an indicator species for evaluating the soil status as well as the vegetation community of different natural and man-managed ecosystems (Daugbjerg *et al.*, 1988; Krivolutzkii and Pokerzhevskii,1991; Fragoso and Rojas,1994; Dennis *et al.*,1994). When natural vegetation is altered, the earthworm communities change proportionately and in some cases, may even be eliminated (Fragoso *et al.*,1997).

Earthworms have been shown to be important in plant residue decomposition by incorporating and mixing surface residues into the soil through their burrowing, feeding and casting activities. Increased earthworm activity can result in increased aggregate stability (Hopp and Hopkins,1946), water-holding capacity (Stockdill,1982), pore size and infiltration rate (Ehlers,1975). In the absence of an active population, however, plant residues have been shown to remain and accumulate near the soil surface (Raw,1962; Edwards and Heath,1963; Barley and Kleining,1964). It has been reported that earthworms generally have their periods of greatest activity in late autumn and again in the spring.

Mackay and Kladivko (1985) conducted an experiment on earthworms and rate of breakdown of Soybean and Maize residues in soil and found that earthworms did not increase Maize shoot and root growth in the greenhouse study. They further mentioned that increases reported in plant growth due to the activity of earthworms (Barley and Jennings, 1959; Mackay *et al.,* 1982) have often been attributed to the effect of earthworms on plant-available soil N and P pools. Some studies have also shown that earthworm castings improved nutrient availability to plant (Krishnamoorthy and Vajranabhaiah, 1986) and contained higher number of microorganism and enzyme activity (Dash *et al.*, 1979; Tiwari *et al.*, 1989).

The importance of earthworms in breaking down organic matter and incorporating it into soil, thereby improving soil structure, aeration and drainage is well established (Darwin, 1881; Edwards and Lofty, 1977; Edwards, 1981). With recent development of minimal tillage and direct drilling of crops into uncultivated soil, after the use of a broad spectrum herbicide, earthworm activity may be even more important in maintaining soil productivity (Edwards and Lofty, 1978, 1980). There is evidence that earthworm populations are influenced greatly by availability of organic matter for food and this may come from plant residues or from animal or human waste applied to the land. Edwards and Lofty (1982) reported that more earthworms occurred with increasing rates of inorganic and organic N and there was a strong positive correlation between earthworm populations and amounts of nitrogen added. A study on 'Nitrogenous fertilizers and earthworm populations in agricultural soils' suggests that the higher concentrations of N influence earthworms by increasing the amount of plant material and when this dies, in turn, the amount of decomposing organic matter increases.

Lee (1982) conducted a study on the influence of earthworms and termites on soil nitrogen cycling and concluded that earthworms have an important role in the transfer of nitrogen from decaying plant tissue into the soil, and its release in chemical forms that can be rapidly taken up and recycled for plant growth. A study on microbial biomass and activity in contrasting soil materials after passage through the gut of the earthworm *Lumbricus rubellus* concluded that the passage of soil through earthworm guts changes its physiochemical properties and the level of microbial activity (Daniel and Anderson, 1992).

From the above reports and findings of some researchers, it can be concluded that selection of suitable tree species plays a very important role in designing good agroforestry systems. Tree species which have positive influence on the physical and chemical properties of soil as well as on productivity of crops have to be chosen. Besides, the sustenance of a healthy decomposer community is also desirable and the multifaceted role of earthworms in modulating soil physical conditions, nutrient budgets and augmenting the microbes (primary decomposers) is evident.

STUDY AREA

STUDY AREA :

3.1 Location :

Mizoram, a hilly state is located in the north-east corner of India. Geographically, the state lies in between 20° 58' - 24° 35' N latitudes and 92° 15' - 93° 29' E longitudes, and having a land area of 21,087 Sq. Km. The state is mostly mountainous and hilly with precipitous slopes. According to the State of Forest Report (1997), Mizoram has a forest cover of 18,75 Sq. Km. Which is 89.03 per cent of the total land area.

The field experiment was carried out in Chaltlang which is situated at the outskirt of Aizawl town in the state of Mizoram.

3.2 Climate :

Mizoram enjoys a moderate climate, and can be summarised as humid tropical, characterised by short winter and long summer. The winter temperature ranges from 11°C to 21°C and the summer temperature ranges from 20°C to 31°C. The average annual rainfall of the state is 2500 mm.

3.3 Soil :

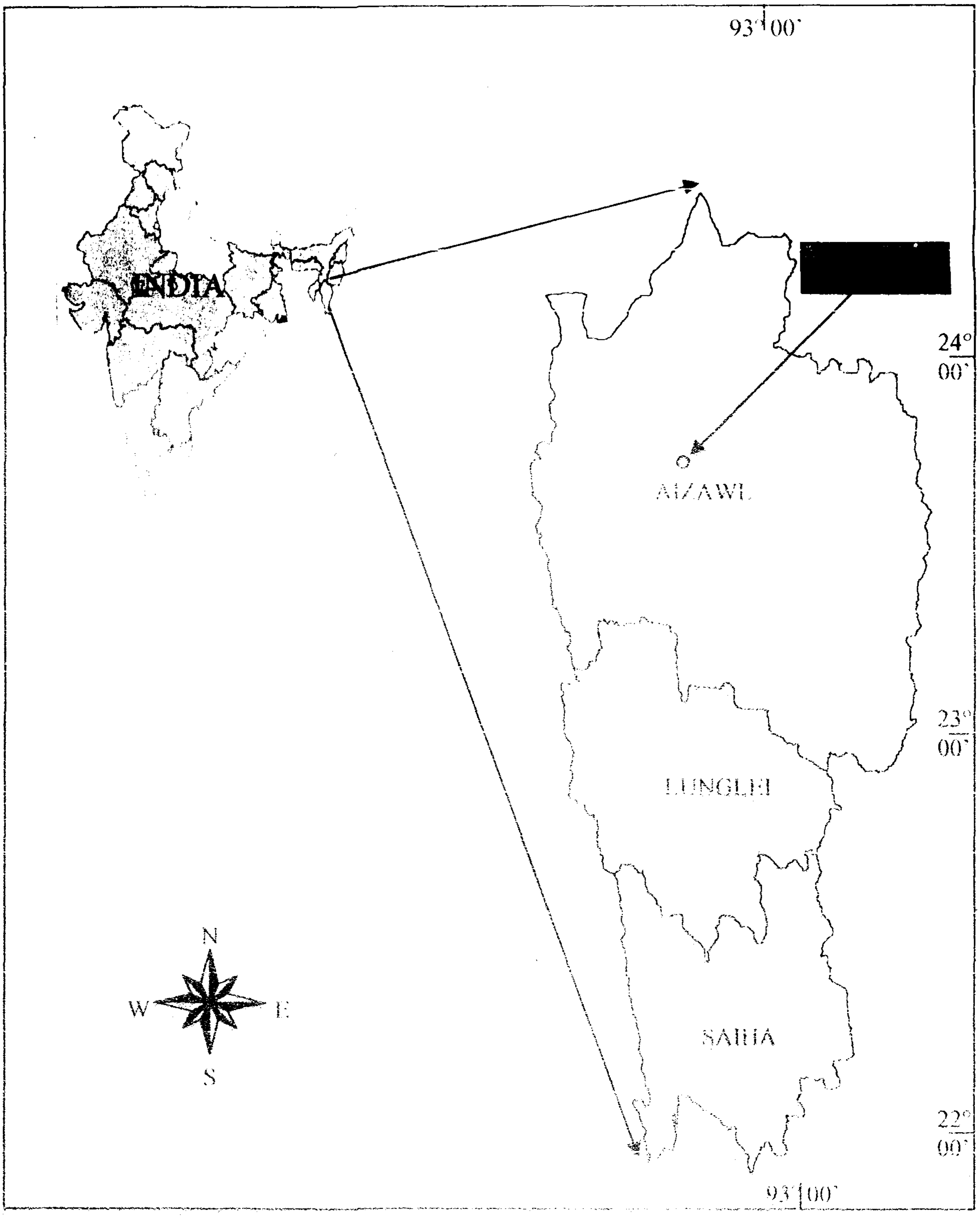
The soils of Mizoram vary from sandy loam, clayey loam to clay. The soils are generally young immature and moderate to highly acidic in nature.

Potash and Phosphorus contents are low but the Nitrogen content is high due to heavy accumulation of organic matters. This is true of forest soils and soils denuded of forest cover for the first jhum cycle. In arable land however, nitrogen pools are considerably reduced.

3.4 Site Characteristics :

The study site, Chaltlang is located at 20° 20' to 24° 27' N latitudes and 90° 20' to 93° 29' E longitudes, and is about 1100 meter from MSL. The soil of the site is lateritic, clay loam, reddish to black in colour and slightly acidic in nature. The average annual rainfall ranges from 1969 mm to 2782 mm during the last five years. The study site is moderately sloped.

FIG.1. LOCATION MAP OF STUDY AREA (CHALTLANG)



MATERIALS

AND

METHODS

MATERIALS AND METHODS

4.1 Design and Layout of Experiment :

The study was carried out following Randomized Block Design (RBD). The experimental block consisted of 6(six) experimental plots, 0.5x0.5 meter in size, and having a spacing of 15 cm between the plots. The basic experimental blocks were replicated thrice. The experiment was initiated by digging up the plots upto a depth of 15 cm. Each plot received 250 gm of litter of the assigned species and 50 gm of earthworms for the assigned treatments. The controls were without any amendments. The soils were returned to the pits and allowed to remain thus. The treatments and controls were as under :

T_1 - Leaf litter of *Erythrina indica* with Earthworm.

T_2 - Leaf litter of *Erythrina indica* without Earthworm.

T_3 - Leaf litter of *Schima wallichii* with Earthworm.

T_4 - Leaf litter of *Schima wallichii* without Earthworm.

T_5 - Only Earthworm without leaf litter.

T_6 - Control (without Earthworm and leaf litter).

The detailed plan and layout of the experiment is given in Figure 2.

Fallen leaves of *E. indica* and *S. wallichii* were collected separately and sun-dried. Earthworms were collected from the nearby areas.

Zea mays (var. Vijaya Composite) was sown in 12th April,2000 in each experimental plot. Four plants were accommodated in each plot leaving a distance of 30 cm between the plants in a plot.

4.2 <u>Sampling Programme</u> :.

4.2.1 <u>Meteorological Data</u> :

Daily records for rainfall and temperature (maximum and minimum) were collected from the Science, Technology and Environment Cell, Planning Department, and Directorate of Agriculture, Government of Mizoram. The monthly means were calculated for the study period, i.e. November,1999 to July,2000.

<u>Soils</u> : Soil samples were taken monthly from each plot by removing 5x5x5 cm soil from just below the litter level. Sampling was continued for 4(four) months to estimate the following parameters.

DESIGN AND LAYOUT OF THE EXPERIMENT

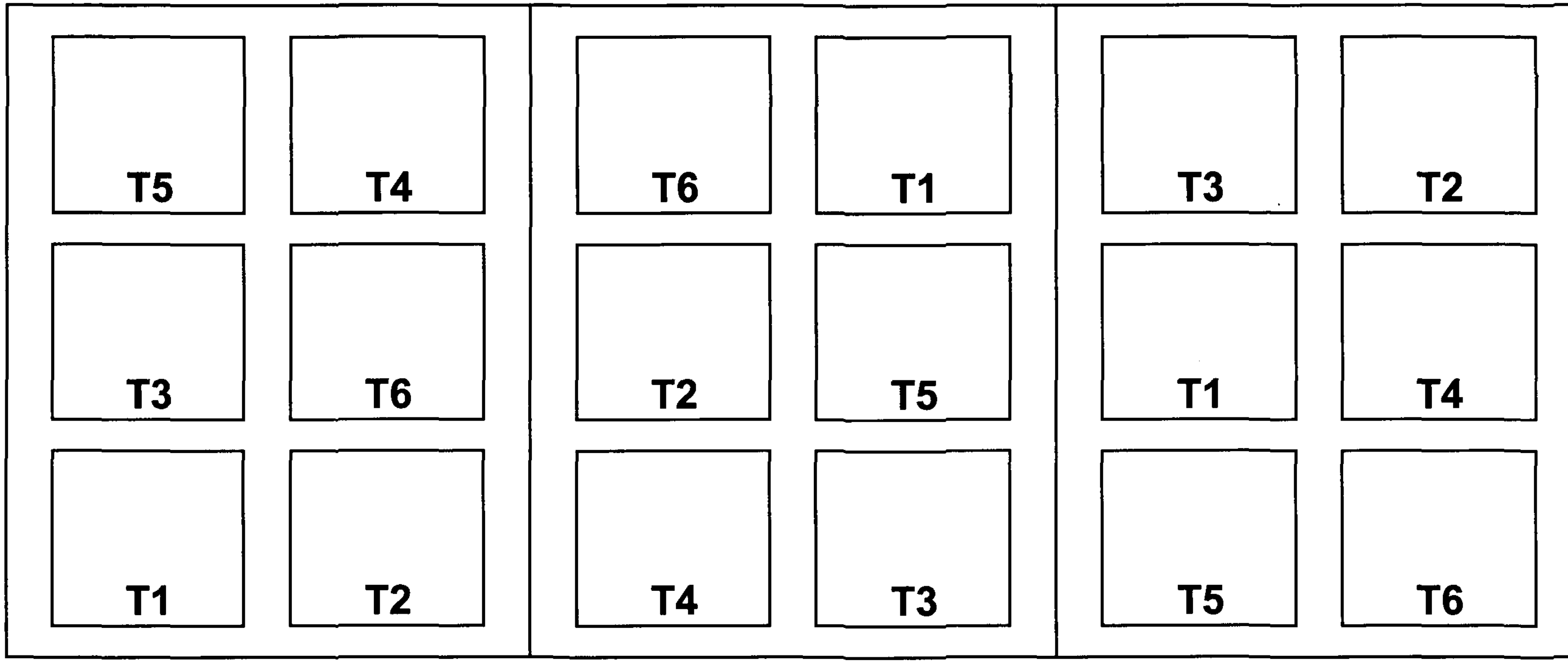


Fig.2 : Randomized Block Design (RBD) Layout for the study site.

T1 => Leaf litter of *Erythrina indica* with earthworm
T2 => Leaf litter of *Erythrina indica* without earthworm
T3 => Leaf litter of *Schima wallichii* with earthworm
T4 => Leaf litter of *Schima wallichii* without earthworm
T5 => Only earthworm without leaf litter
T6 => Control (Without leaf litter and earthworm)

METEOROLOGICAL DATA

Parameters	1999		2000						
	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
Temperature (^0C) Minimum	15.5	12.94	11.32	12.11	15.44	17.03	18.01	19.4	19.2
Temperature (^0C) Maximum	26.15	22.95	23.48	22.87	26.14	28.6	26.98	26.8	27.7
Total Rainfall (mm)	13	13	21	16	144	292	543	223	165

Table I : Monthly records of meteorological data during the study period.

Plate No. I
Layout of the experiment
(Pit Digging).

Plate No. II
Filling of pit
with leaf litter

Plate No. III
Dried leaves of *Erythrina indica*
and *Schima wallichii*

4.2.2 Soil Moisture :

The collected soil samples were carefully labeled and packed in polythene bags, and transported to the laboratory. Soil moisture loss on drying to constant weight was determined for 100 gms of fresh soil. The soil moisture content was expressed as

$$\text{Moisture \%} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

4.2.3 Chemo-edaphic Factor :

(i) Soil pH :

The soil pH was measured by using a Systronics double electrode digital pH Meter (Model 331). Soil suspension in distilled water in the ratio of 1:5 was stirred by using magnetic stirrer for 5(five) minutes and allowed to settle before the readings were recorded. Soil pH measurement was done in the Soil Testing Laboratory, Directorate of Agriculture, Government of Mizoram, Aizawl.

(ii) Soil Conductance :

Soil conductance was determined by using Microprocesso conductivity meter (LF 320). The soil suspension in distilled water in the ratio of 1:5 was stirred for 5(five) minutes and allowed to settle before the readings were recorded. Soil conductivity determination was done in the Soil Testing Laboratory, Directorate of Agriculture, Government of Mizoram, Aizawl.

(iii) **Available Nitrogen** :

Estimations of available Nitrogen for each treatment was done for each sampling programme by using Spectrophotometer (Systronics,106). The estimations were done in the laboratory of the Forestry Department, NEHU, Mizoram Campus, Aizawl.

4.2.4 Biotic Factors – Maize :

The following parameters were used to estimate the performance and yield of Maize plant :

(a) **Height** : The height of Maize plants were measured and recorded in all the treatments at every one month interval from May 2000. The measurements were done from the base to the tip of the top leaves by using a Centimeter (cm) scale. The mean height was taken for each replication of the treatment.

(b) **Girth** : Stem girths of Maize were also measured monthly. Girth measurement was done at the base of the plant near the ground level with the help of a Centimeter (cm) scale.

(c). **Number of Leaves** : The number of leaves per plant in different plots were counted monthly. The number of leaves were averaged for each plot and recorded.

(d) **Yield** : Number and weight of Maize cobs, number of grains per cob, weight of grains per cob and the total yield of Maize per plot were calculated and recorded.

4.2.5 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 estimates of the different parameters and growth characteristics of maize were correlated with meteorological, physico-edaphic and chemo-edaphic factors 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 $p = 0.5$, 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

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

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 - Minimum and maximum temperature, and rainfall.

(ii) Physico-edaphic factor - Soil moisture.

(iii) Chemo-edaphic factors -Soil pH, Conductivity and Available Nitrogen (N).

5.1.1 Meteorological factors :

Meteorological data were collected from Science, Technology and Environment Cell, Planning Department, and the Directorate of Agriculture, Government of Mizoram, Aizawl. The daily records of temperature as obtained were averaged for their monthly values. The daily rainfall records were added and calculated the monthly total rainfall. The monthly fluctuations of the meteorological factors are depicted in Table I.

Temperature :

During the experimental period (November 1999 to July 2000), monthly maximum temperature varied from a low of 22.87°C (February,2000) to a high of 26.8°C (April, 2000). Mean monthly minimum temperature recorded was lowest in January, 2000 (11.32°C) and highest in June, 2000 (19.4°C). The temperature started increasing from the month of March (Table 1).

Rainfall :

During the study period minimum monthly rainfall was recorded in the month of November and December, 1999 (13 mm), and the number of rainy days were 3 and 2 respectively. It was observed that there were 15 rainy days with a total rainfall of 543 mm during May, 2000, whereas during June, 2000 there were 18 rainy days with only 223 mm total rainfall. Maximum total monthly rainfall was recorded in May,2000 (Table 1).

5.1.2 Physico-edaphic Factor :

Soil Moisture : The moisture content of the soil taken just below the litter level from each replication showed a general trend of lower moisture during November, 1999 and higher moisture in March, 2000. The moisture content of soil was lowest in November, 1999 under the treatment of *Schima wallichii* without earthworm (9.97%). The highest soil moisture content was observed in March, 2000 under the treatment of *Erythrina indica* with earthworms (22.84%). It was observed that rainfall influenced the moisture content of soil, the more rainfall the higher the soil moisture content. The experiment also depicted that the rate of increase in moisture percentage was highest in the plot treated with *E.indica* and earthworms (Table II).

5.1.3 Chemo-edaphic factors :

The chemo-edaphic factors which were included in the study are Soil pH, Conductivity and Available Nitrogen.

MOISTURE CONTENT OF SOIL (%)

Treatment	1999		2000		
	NOV	DEC	JAN	FEB	MAR
E. indica with earthworm T_1	10.07 (0.036)	12.37 (0.13)	15.43 (0.052)	11.68 (4.057)	22.84 (2.07)
E. indica without earthworm T_2	10.01 (0.043)	12.5 (0.088)	15.03 (0.085)	14.12 (0.15)	21.04 (1.715)
S. wallichii with earthworm T_3	10.05 (0.036)	12.5 (0.065)	15.1 (0.131)	14.02 (0.288)	21.09 (1.69)
S. wallichii without earthworm T_4	9.97 (0.062)	12.29 (0.088)	14.59 (0.168)	13.47 (0.645)	20.2 (0.879)
Earthworm without leaf litter T_5	10.1 (0.072)	12.13 (0.062)	14.83 (0.426)	13.18 (0.918)	18.25 (1.175)
Control T_6	10.15 (0.07)	11.52 (0.079)	14.25 (0.223)	12.29 (0.968)	17.47 (1.574)

Table II : Monthly records of soil moisture content (%) (Standard Deviation in parenthesis).

Soil pH : The mean monthly records of the pH value of the different treatments under study are depicted in Table III. The soil pH at the start of the experiment was found to be 5.4. The highest pH value recorded was 5.8 in February, 2000 under *Erythrina indica* with earthworm treatment (T_1), and the lowest was 5.36 in November, 1999 under *Schima wallichii* without earthworm treatment (T_4). The overall soil reaction was acidic throughout the experiment in all the plots.

Soil Conductivity : The mean monthly records of the soil conductivity value of the different treatments under study are depicted in Table III. The lowest value of soil conductivity was observed in the month of February, 2000 and highest value in the month of November, 1999, both records were for the Control plot.

Available Nitrogen : The amount of available Nitrogen present in the soil under different treatments were estimated in percentage and are depicted in Table IV. Highest percentage value was observed in the month of March, 2000 in respect of *E. indica* with earthworm treatment, and lowest in March, 2000 in respect of control plot. It was also observed that there was a significant increase in available Nitrogen percentage in all the plots treated with leaf litter. There was also marked differences in the nitrogen contents between the two litter species.

5.1.4 Biotic Factors :

Performance of Maize : The parameters accounted for in the present study to observe the performance of maize plant i.e. height, stem girth and number of leaves in different treatments are depicted in Table V.

SOIL pH AND CONDUCTIVITY (d s/cm)

Treatment	Parameter	1999				2000					
		November		December		January		February		March	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
E. indica with earthworm (T1)	pH	5.4	0	5.7	0	5.6	0.1	5.8	0.057	5.4	0
	Conductivity	0.086	0	0.088	0.0006	0.084	0.0006	0.081	0.0006	0.08	0
E. indica without earthworm (T2)	pH	5.36	0.057	5.7	0	5.7	0.1	5.5	0	5.5	0
	Conductivity	0.08	0	0.072	0.001	0.075	0	0.073	0.001	0.078	0.0006
S. wallichii with earthworm (T3)	pH	5.36	0.057	5.5	0.1	5.4	0	5.6	0	5.7	0.1
	Conductivity	0.089	0.001	0.073	0.001	0.078	0	0.074	0.0006	0.076	0.001
S. wallichii without earthworm (T4)	pH	5.36	0.057	5.6	0	5.46	0.057	5.6	0	5.7	0
	Conductivity	0.08	0.0006	0.078	0.0006	0.074	0	0.071	0.0006	0.079	0.002
Earthworm without leaf litter (T5)	pH	5.36	0.057	5.7	0	5.7	0	5.6	0	5.6	0
	Conductivity	0.086	0.0006	0.088	0	0.081	0.001	0.073	0	0.077	0.001
Control (T6)	pH	5.4	0	5.63	0.057	5.7	0	5.6	0	5.6	0
	Conductivity	0.091	0	0.086	0.001	0.083	0	0.068	0.001	0.076	0

Table III : Monthly records of Soil pH and Soil Conductivity during the study period.
(S.D.= Standard Deviation)

AVAILABLE NITROGEN IN SOIL (%)

Treatment	1999		2000		
	NOV	DEC	JAN	FEB	MAR
E.Indica with earthworm T_1	0.726 (0.061)	0.813 (0.032)	0.883 (0.02)	0.976 (0.025)	1.093 (0.30)
E.indica without earthworm T_2	0.580 (0.03)	0.550 (0.036)	0.680 (0.02)	0.726 (0.041)	0.856 (0.07)
S.wallichii with earthworm T_3	0.733 (0.04)	0.740 (0.036)	0.620 (0.02)	0.656 (0.015)	0.746 (0.023)
S.wallichii without earthworm T_4	0.566 (0.02)	0.563 (0.02)	0.553 (0.02)	0.660 (0.026)	0.683 (0.02)
Earthworm without leaf litter T_5	0.550 (0.01)	0.560 (0.01)	0.540 (0.02)	0.576 (0.015)	0.593 (0.02)
Control T_6	0.546 (0.005)	0.560 (0.01)	0.530 (0.026)	0.526 (0.03)	0.520 (0.026)

Table IV : Monthly records of Available Nitrogen (%) released in the soil.
Standard Deviation (SD) in parenthesis.

Height : It may be seen from the data that the monthly mean increase in plant height ranges from 28 cm to 220 cm in different treatments during April to July. Maximum increase in plant height was observed during May i.e. after one month of planting in *E. indica* leaf litter with earthworm treated plot (T_1). It was also observed that the treated plots showed higher increase in plant height than the control plot. Further, the plots with earthworm amendment showed better increase in plant height than the others. This increase in plant height was found to be significant at 1% level.

Stem Girth : The data depicts that the monthly mean increase in stem girth ranges from 2.6 cm to 5.65 cm in different treatments during the study period. The mean maximum increase in stem girth was recorded in the plot of *E. indica* with earthworm treatment (T_1), and mean minimum increase was recorded in the control plot (T_6). This increase in stem girth was found to be significant at 5 % level. The plants with only earthworm treatment showed lesser increase in stem girth as compared to those with leaf litter treatment.

Number of leaves : The mean number of leaves was found to be 4(four) in all the treatments during April. Variation in number of leaves was observed from the month of May. The mean maximum number of leaves per plant i.e. 12 was observed in the month of July in three plots viz. *E. indica* with earthworm (T_1), *E. indica* without earthworm (T_2) and *S. wallichii* with earthworm (T_3) treatments. The mean minimum number of leaves i.e. 11 at the end of the study period was observed in the control plot (T_6). The increase in the number of leaves was found to be significant at 1 % level.

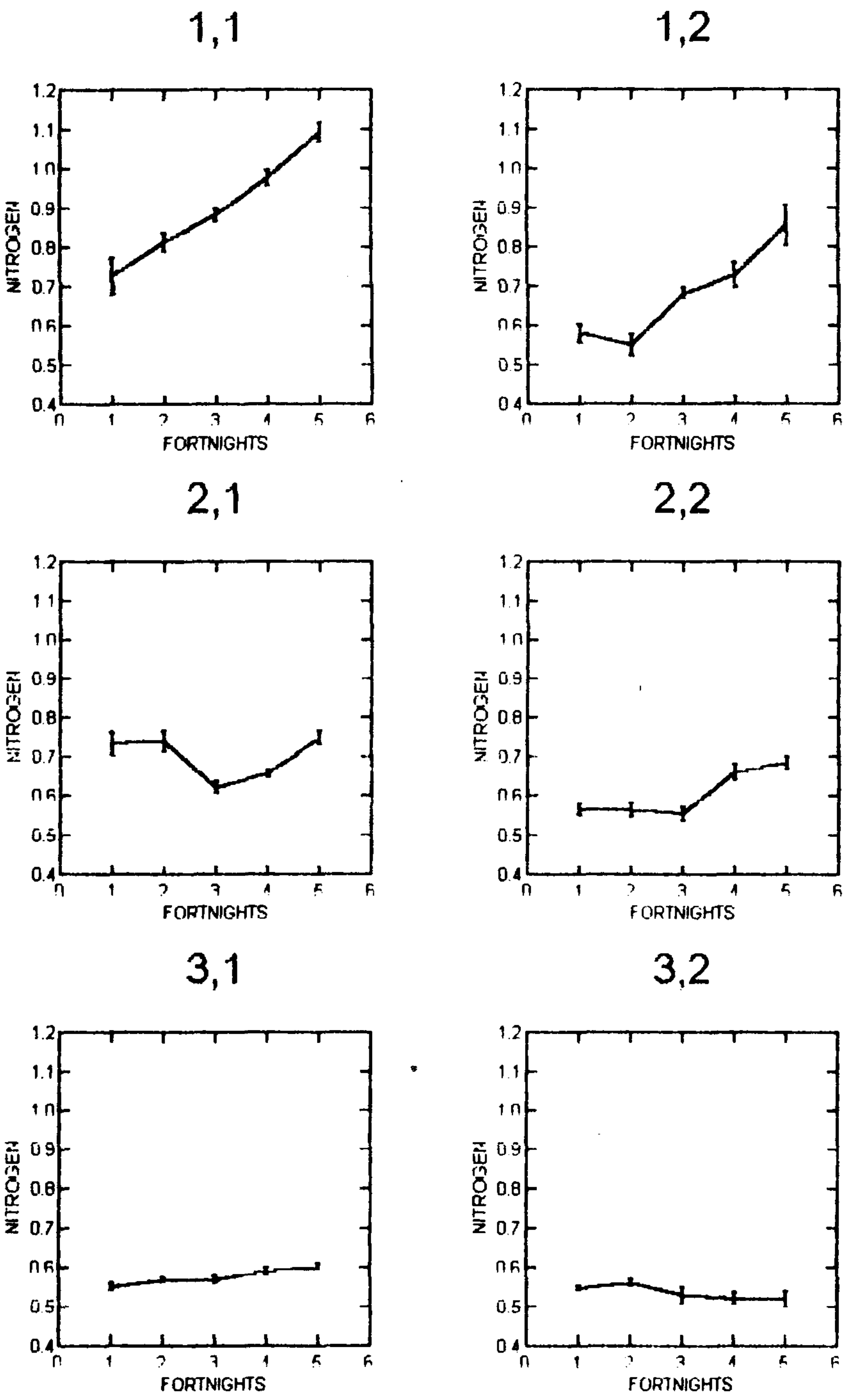


Fig. 3 Available N (%) in soils of the different treatments

1,1 Erythrina + earthworms 1,2 Erythrina - earthworms

2,1 Schima + earthworms 2,2 Schima - earthworms

3,1 Litter - earthworms 3,2 Control (-litter-earthworms)

Yield of Maize : The yield of maize crop after harvest from different treatments are depicted in Table VI.

Number of cobs : It was observed from the study that one plant bore only one cob. There were some plants which failed to bear even a cob. The mean maximum number of cobs was recorded in *E. indica* with earthworm treatment (T_1). However, the number of cobs was found to be non-significant.

Weight of cobs : The mean maximum weight of a cob recorded was 0.117 kg in *E. indica* with earthworm (T_1) treatment followed by 0.099 kg in *E. indica* without earthworm (T_2) treatment. Mean minimum weight of a cob recorded was 0.081 kg in only earthworm without leaf litter treatment (T_5). The weight of cob was found to be significant at 5 % level.

Number of Grains : The mean maximum number of grains was observed in *E. indica* with earthworm treatment (T_1) i.e. 343.32 and the mean minimum number of grains recorded was 234.99 in only earthworm without leaf litter treatment (T_5). However, the number of grains was found to be non-significant.

BIOTIC FACTORS (MAIZE PERFORMANCE)

Treatment	Parameter	APRIL		MAY		JUNE		JULY	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
E. indica with earthworm	Plant Height	31	1	116	11.13	163	8.18	220	22.91
T1	Stem Girth	2.7	0.1	3.25	0.09	5.24	0.144		0.35
	No.of Leaves	4	0	8	0	10	0	12	0
E. indica without earthworm	Plant Height	30	1	110	10	160	10	215	20
T2	Stem Girth	2.65	0.132	3	0.25	5	0.3	5.25	0.492
	No.of Leaves	4	0	8	0	10	0	12	0
S. wallichii with earthworm	Plant Height	30	1	122	12.48	158	12	215	24.06
T3	Stem Girth	2.7	0.1	3.05	0.2	4.8	0.36	5.24	0.691
	No.of Leaves	4	0	8	0	10	0	12	0
S. wallichii without earthworm	Plant Height	28	2	108	10.58	155	12.12	210	22.27
T4	Stem Girth	2.6	0.1	3	0.25	4.6	0.4	5.12	0.72
	No.of Leaves	4	0	7	1	9	1	11.5	0.5
Earthworm without leaf litter	Plant Height	29	1	103	13.74	134	18	202	18.33
T5	Stem Girth	2.6	0.132	3.1	0.2	4.35	0.589	5.08	0.811
	No.of Leaves	4	0	8	0	10	0	11.5	0.5
Control	Plant Height	29	2	101	12.48	125	13.74	198	17.08
T6	Stem Girth	2.6	0.132	3.08	0.17	4.1	0.6	4.8	0.721
	No.of Leaves	4	0	7	1	9	1	11	1

Table V : Monthly records of the biotic factors / Performance of Maize (Plant height and Stem girth in cm.).
(S.D. = Standard Deviation)

YIELD OF MAIZE CROP AFTER HARVEST

Treatment	Number of Cobs	Weight of Cobs	Number of grains
E. indica with earthworm T_1	0.915 (0.17)	0.117 (0.37)	343.32 (127.3)
E. indica without earthworm T_2	0.875 (0.25)	0.099 (0.049)	298.33 (143.79)
S. wallichii with earthworm T_3	0.875 (0.25)	0.096 (0.045)	292.49 (138.28)
S. wallichii without earthworm T_4	0.875 (0.25)	0.087 (0.041)	274.99 (142.34)
Earthworm without leaf litter T_5	0.875 (0.25)	0.081 (0.03)	234.99 (139.78)
Control T_6	0.915 (0.17)	0.087 (0.016)	243.91 (103.52)

Table VI : Yield of Maize Crop under different treatments after harvest.
Standard Deviation (S.D.) in parenthesis.

Plate No. IV
***Erythrina indica* tree**

Plate No. V
***Schima wallichii* tree**

Plate No. VI
Maize plants in the experimental plot

Plate No. VII
Maize plants in the experimental plot

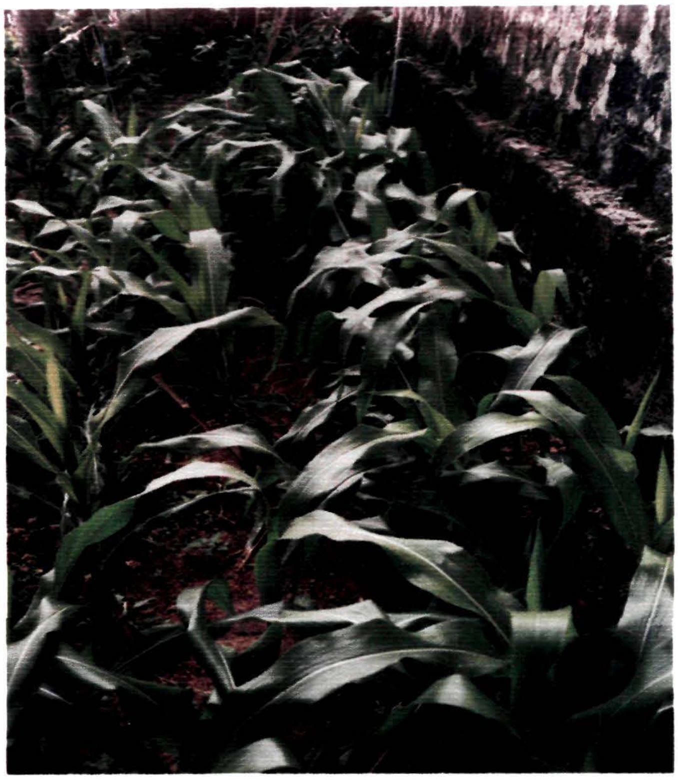


Plate No. VIII
Maize cobs harvested from different treatment

Plate No. IX
Maize cobs harvested from the experimental plots

Treatment	Rainfall	Air Temperature
E. indica with earthworm (T_1)	0.434	0.7269
E. indica without earthworm (T_2)	0.1015	0.7413
S. wallichii with earthworm (T_3)	-0.00004	0.7271
S. wallichii without earthworm (T_4)	-0.00002	0.7358
Earthworm without leaf litter (T_5)	-0.4319	0.7326
Control (T_6)	-0.4215	0.7378

Table VII : Correlation 'r' between Plant Height of Maize and me Meteorological Factors.

Treatment	Rainfall	Air Temperature
E. indica with earthworm (T_1)	-0.68 NS	1.4973 NS
E. indica without earthworm (T_2)	0.144 NS	1.5621 NS
S. wallichii with earthworm (T_3)	-0.00004 NS	1.4968 NS
S. wallichii without earthworm (T_4)	-0.000006 NS	1.5367 NS
Earthworm without leaf litter (T_5)	-0.6772 NS	1.5222 NS
Control (T_6)	-0.6574 NS	1.5481 NS

Table VIII : Correlation 't' between plant he height of Maize and Meteorological Factors.
(NS = Non Significant)

CORRELATION (r&t) BETWEEN HEIGHT OF MAIZE AND ABIOTIC FACTORS (t in parenthesis)

Treatment	Soil pH	Soil Conductivity	Moisture Content	Nitrogen Concentration
T_1	0.891* (1.963)	0.1497 (0.1514)	0.9661** (3.741)	0.0997 (0.101)
T_2	0.9733** (4.2409)	0.0 (-)	0.9007** (2.0729)	0.858* (1.286)
T_3	0.8483* (1.6070)	-0.8214* (-1.44)	-0.9619** (-3.5182)	-0.0562 (-0.0562)
T_4	0.127 (0.128)	-0.7722 (-1.2152)	-0.9856*** (-5.8285)	0.7444 (1.1144)
T_5	0.891* (1.9625)	0.0 (-)	-0.9984*** (-17.6707)	0.872* (3.638)
T_6	0.6621 (0.8835)	0.0 (-)	-0.9914*** (-7.5621)	0.9802*** (4.95)

Table IX : Correlation (r and t) between Height of Maize and Abiotic Factors (t in parenthesis).

*** Significant at 1.0% level

** Significant at 5.0% level

* Significant at 10.0% level.

DISCUSSION

DISCUSSION

Agroforestry systems through the incorporations of tree species ensures a continuous input of litter. Under the conventional jhum system of agriculture as practiced in the North East, such litter along with other forms of slash is heaped up in rows and burnt, resulting in release of nutrients in the form of ash. The burning in itself has been found to be detrimental to the soil, as the physical characteristics such as cohesion of soil particulate matter is reduced, due to destruction of the humus component. This itself increases the potential for erosion during the subsequent monsoon. Additionally, the process of burning induces volatalization of a large fraction of the nutrients held up in the litter. This component is therefore lost from the system (ITTO Report,1994). Besides, soil biota (microflora and fauna) are also reduced to a large extent resulting in sharp fall in total soil metabolism.

The present investigation is an alternative attempt to harness the nutrients in the litter component without allowing for the negative interactions to operate. Although the contribution of soil fauna to total soil respiratory metabolism is low in comparison to soil microflora (Reichle,1997; Persson *et al.,*1980; Visser,1985) groups like earthworms are important as they ensure passage of a large amount of soil and litter through their guts, wherein, size modification and resource quality are altered, often to the benefit of decomposer microflora ensuring faster colonisation and mineralisation of such ingested resources (Wallwork,1970; Crossley,1977; Swift *et al.*,1979). It is , therefore envisaged that the incorporation of earthworms would catalyse the rates of N release in the soil, thus affording a continuous Nitrogen pool for agricultural output on a sustained basis.

Analysis of the available Nitrogen output in the different treatments reveal that for both the species of leaf litter, the output is more in treatments inoculated with earthworms when compared to those without earthworms and the controls. Thus it is evident that inoculation with earthworms enhanced the rates of N release and the amount going to the soil pool is also considerably more in the earthworm inoculated treatments as compared to the others. This is in consonance with earlier works which reported enhanced N mineralisation from litter inoculated with earthworms (Anderson *et al.*, 1985; Anderson and Ineson, 1984; Anderson *et al.*,1983).

Between the species of litter, it was seen that *Erytrhina* which is a N-fixing species evidenced a greater amount of N release than *Schima* litter, the latter a non-N fixing species. This lends strength to the contention that the N-fixing species litter is more palatable to earthworms. Further, as most of the Nitrogen ingested in the form of litter is voided as cast in the soil, often in amounts greater than that incorporated into the metabolism (Lee,1982) as their assimilation efficiency is very low (8-10%), therefore this has far reaching implications on the release and availability of Nitrogen and other nutrients from the faeces, which forms an indispensable resource for plant growth. Besides it is also reported that litter of N-fixing species exhibits faster decomposition rates and enhanced release of nutrients (Sharma *et al.*,1997; George and Kumar,1998).

The correlation of different abiotic factors with height of maize crop which is an indicator of growth potential also exhibited significant values (both r and t) as shown in Table IX.

Comparison of the growth (height of maize) reveals that the treatment of *Erythrina* with earthworms which had the largest output of available N also exhibited the best growth of maize (Table.V). Similarly, the yield of maize was also consistently higher for this treatment as compared to all other treatments.

A test of ANOVA however did not reveal any significant differences among the different treatments with respect to available Nitrogen budgets in the soil. Due to some unavoidable constraints the replication had to be kept to a minimum and this probably resulted in insignificant F values of the ANOVA. Moreover the inoculation experiment as outlined elsewhere was undertaken with the onset of winter between November and March, and this could have resulted in reduced metabolic activity of the earthworm and other associated decomposer microflora which could have also contributed to insignificant F values. Nevertheless, the N release patterns from the two different species of litter and the two different treatments clearly show marked differences. Further, the positive effects of earthworm amendments are also clearly indicated, and could have logically contributed to increased yields.

SUMMARY

SUMMARY

A Randomized Block Design (RBD) experiment to analyse the effect of earthworm amendment to buried leaf litter and consequent release of Nitrogen from two different species (one N-fixing and the other Non-N fixing), both indigenous agroforestry tree component species popular with the farmers of Mizoram, was undertaken. After a period of five months of such inoculation, the different treatment plots were used for growing Maize (var. Vijaya Composite), and the growth patterns of the crop in the different treatments, and yield of maize were recorded along with a host of abiotic and meteorological factors. Results reveal a significant correlation of most of the edaphic factors with crop growth. The N release showed a distinct pattern of increased output in treatments with earthworm amendment for both the species of litter as compared to the controls. Between the two species *Erythrina* exhibited considerably higher output than the non-N fixing counterpart. The insignificant results of ANOVA could have been due to lesser number of replications and timing of the experiment which coincided with the oncoming winter, probably resulting in reduced metabolic activity of the earthworms and other decomposer microflora.

CONCLUDING REMARKS

CONCLUDING REMARKS

Agroforestry as a scientific discipline is increasingly gaining popularity as a means of increasing the potential of a unit of land to produce a variety of products. It is also felt that various models of Agroforestry can reduce the gap between supply and demand in the present situation of an increasing population burden.

In the context of the North East where subsistence level sifting agriculture is predominant, it is often felt that this mode of agriculture is detrimental to the overall ecology of the region. Further more it is also insufficient to provide for an increasing population. Here too, Agroforestry seems to hold promise in alleviating the problem. The present study is a feeble attempt to provide an alternative to the use of fire practiced in jhum for harnessing the nutrients in litter and other forms of slash. The results of the investigation are indicative of the positive interactions triggered by the inoculation experiments. A more detailed long term experiment to develop this idea into working efficiency of the model with possibilities of specific inclusions of the tree component to ameliorate specific soil deficiencies, and additionally also to attempt at synchronisation of nutrient release from the litter component with the growing period of the crop to extract maximum benefit by way of agricultural produce.

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