

**EFFECT OF FERTILIZER AND SOIL AMENDMENT ON
THE PERFORMANCE OF TURMERIC AND GINGER
IN GHORANEEM BASED AGROFORESTRY SYSTEM**



**A Thesis
By**



MD. MAMUN AL AHSAN CHOWDHURY

Student No. 0505003

Session: 2005-06

Thesis Semester: January-June, 2006

**MASTER OF SCIENCE (M.S.)
IN
AGROFORESTRY**

**DEPARTMENT OF AGROFORESTRY
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY
DINAJPUR**

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*Submitted to the Department of Agroforestry, Hajee Mohammad
Danesh Science and Technology University, Dinajpur in partial
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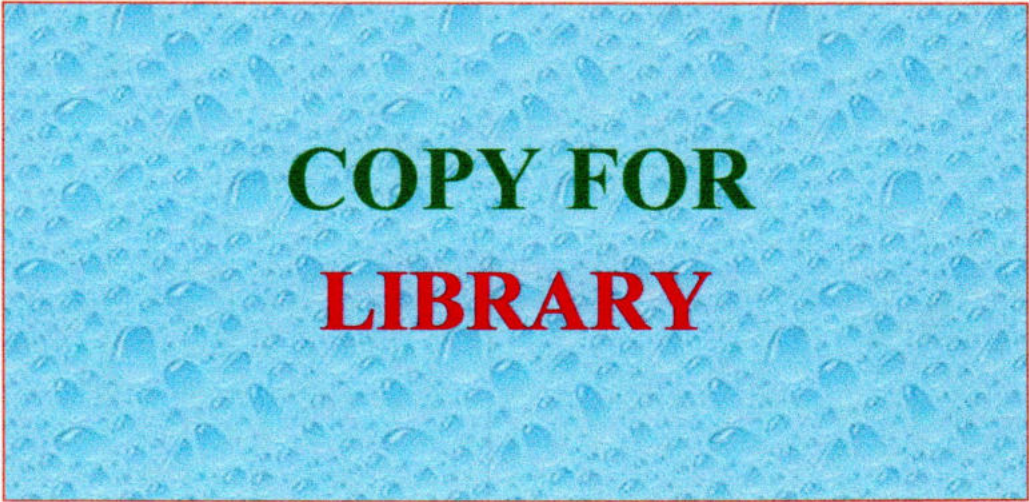
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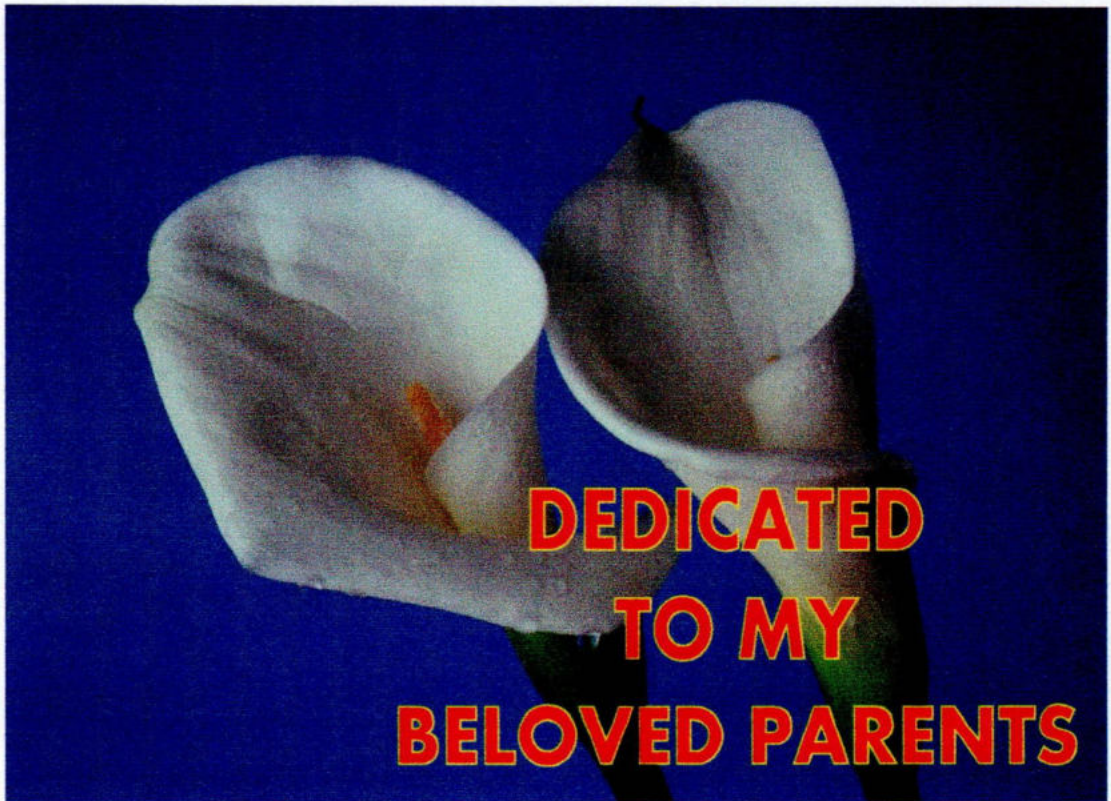
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ABSTRACT

Two experiments were conducted at the farmer's ghoraneem woodlot adjacent to the HSTU Research Farm, Dinajpur during April to December 2005. The theme was to investigate the response of turmeric and ginger to fertilizer and soil amendment in the ghoraneem based agroforestry system.

The first experiment was performed with turmeric (var. Dimla T-027) while the second one with a local variety of ginger. In both the experiments four treatments, i.e. T_1 (no fertilizer), T_2 (Cow dung @ 10 t/ha), T_3 (T_2 +Dolochoon @ 240 kg/ha), T_4 (T_3 + Recommended doses of NPKSZn) were used. Both the experiments were laid out in the Randomized Complete Block Design (RCBD) with 5 replications.

In turmeric, values of all the growth parameters studied (i.e. plant height, number of leaves/plant, number of tillers/plant, length of leaf blade) were the highest in T_4 followed by T_3 . Oppositely, significantly lowest values for all the observed traits were in T_1 . But the values of all the yield contributing attributes (number of fingers/plant, fresh finger weight/plants, dry finger weight/plant, fresh rhizome weight/plant, dry rhizome weight/ plant) were the maximum in T_3 followed by T_4 . Significantly the uppermost yield (42.40t/ha) of turmeric was recorded in T_3 followed by T_4 (40.7t/ha) while the lowest (29.17t/ha) in T_1 .

In ginger, every growth parameter showed similar trend like the experiment with turmeric. But the yield and yield contributing characteristics were found the best in T_4 followed by T_3 . The highest yield of ginger (26.37t/ha) was recorded in T_4 followed by T_3 (26.13t/ha)

ABBREVIATIONS AND ACRONYMS

%	:	Per cent
abst.	:	Abstract
AEZ	:	Agro-Ecological Zone
cm	:	Centimeter
<i>et al.</i>	:	And others
FAO	:	Food and Agriculture Organization
RCBD	:	Randomized Complete Block Design
g	:	Gram
i.e.	:	That is
m	:	Meter
t/ha	:	Ton per hectare
viz.	:	Namely
BBS	:	Bangladesh Bureau of Statistics
BARC	:	Bangladesh Agriculture Research Council
DAP	:	Days after planting
Kg	:	Kilogram
mm	:	Millimeter
Fig	:	Figure
LSD	:	Least significant difference
DC	:	Degree Celsius
*	:	1% level of significance
**	:	5% level of significance
&	:	And

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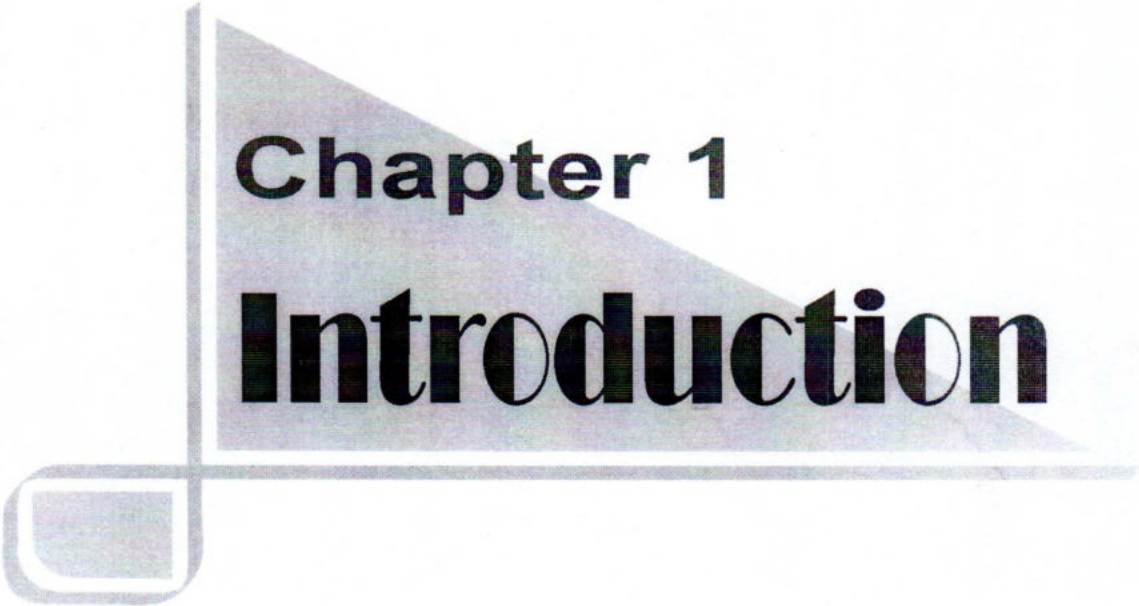
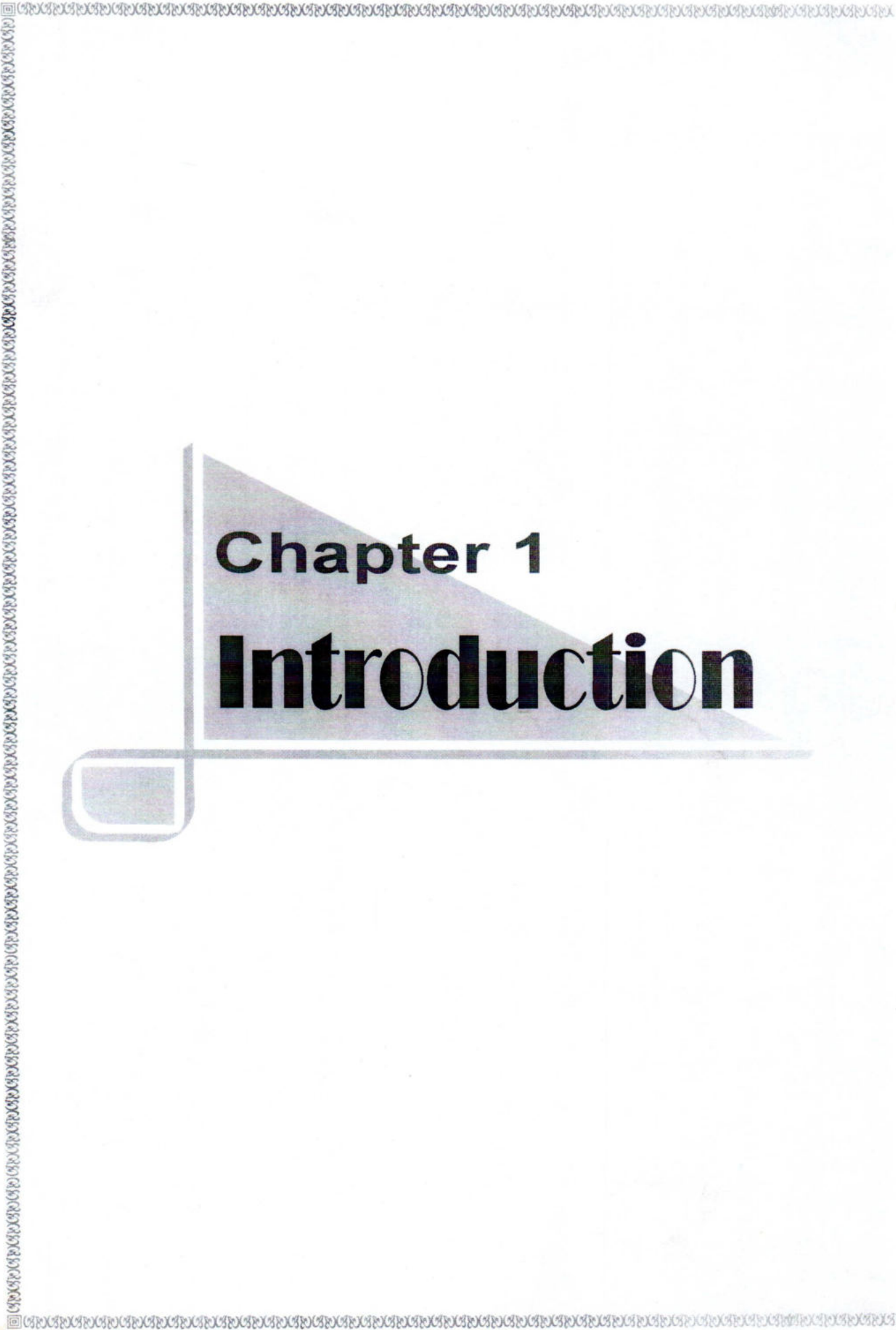
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Chapter 1

Introduction

CHAPTER 1

INTRODUCTION

Bangladesh is an agrarian country enjoying the tropical to sub-tropical climate. Her population is 134.3 millions in an area of 147570sq km with a growth rate of 1.54% (BBS, 2003). The total forest area of the nation covers about 13.36% of the land (BBS, 2001). However, according to the Forest Master Plan and surveys conducted by multinational donor agencies, only 6% or a total of 0.769million hectares land of the territory has actual tree coverage (Anonymous, 1999). But to have benefits of the nature, any state should have at least 25% of her land covered with forests. So, the dominion is suffering from inadequate forest coverage coupled with over population for a limited land. The realm has neither the ability to increase command areas of agricultural crops nor to increase the forest area for ecological demands. Under these fatal situations, various agroforestry systems can address the stress of the day to considerable extents.

According to Lundgren and Raintree (1982), agroforestry is a collective name for land use systems and technologies whereby woody perennials (trees, shrubs, palms, bamboo etc.) are deliberately grown on the same land management unit as agricultural crops and / or animals either in spatial mixture or in temporal sequences.

Common Bangladeshi people traditionally use various spices in curries in their daily life. Among them turmeric (*Curcuma longa*) and ginger (*Zingiber officinalis*) are the most important ones. Besides making curries they are also used for medicine as a carminative and aromatic stimulant to the gastrointestinal tract (Purseglove *et al.*, 1988) and many other purposes. In addition, turmeric and ginger are high valued crops having good local as well as export potentials (Siddique, 1995). But here total production of turmeric is

41.5 thousand metric tons from 16.06 thousand hectares while ginger is 43,000 metric tons from an area of 7,692 hectares (BBS, 2003).

Turmeric requires a hot and humid climate. It is cultivated in most areas of the tropics and subtropics provided that rainfall is adequate or facilities for irrigation are available. So, it is usually grown in regions with a rainfall of 1000-2000mm/annum. However, cultivation has been extended into moist areas with a yearly rainfall above 2000mm (Purseglove *et al.*, 1981). The humus rich virgin soils of hills and forests are also suitable for it.

Ginger requires a warm and humid climate. It is mainly grown in the tropics from sea level up to an elevation of 1500M. But it can be grown under more diverse conditions than other spices. In India, the main ginger producing state is Kerala where annual rainfall is fairly high; about 3000mm distributed over 8 - 10 months during the ginger growing season. The day temperature ranges from 28⁰C to 35⁰C (Paulose, 1973).

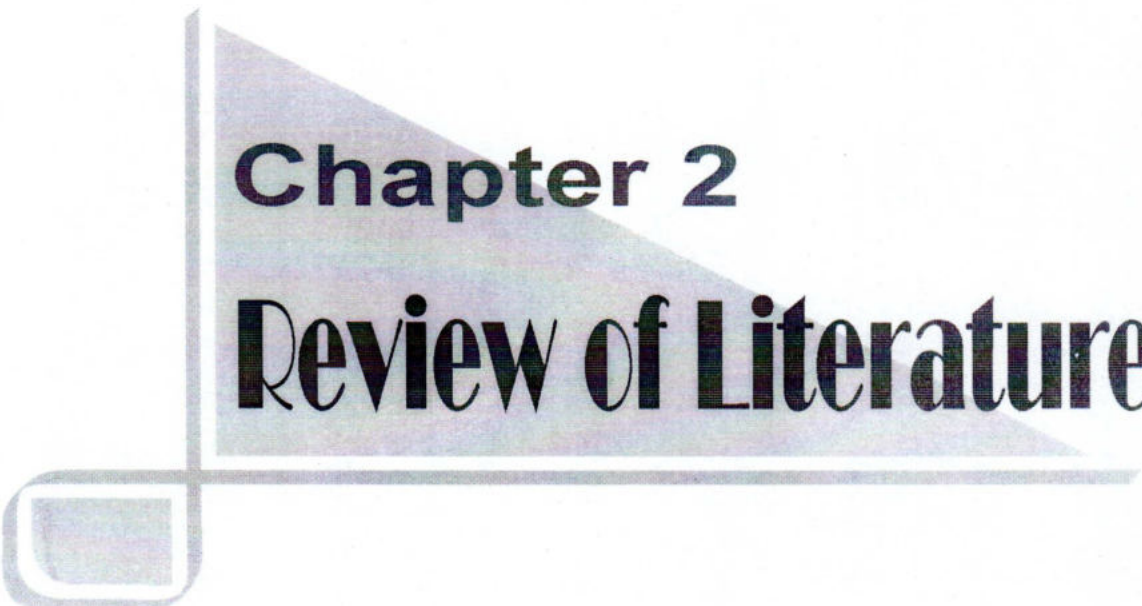
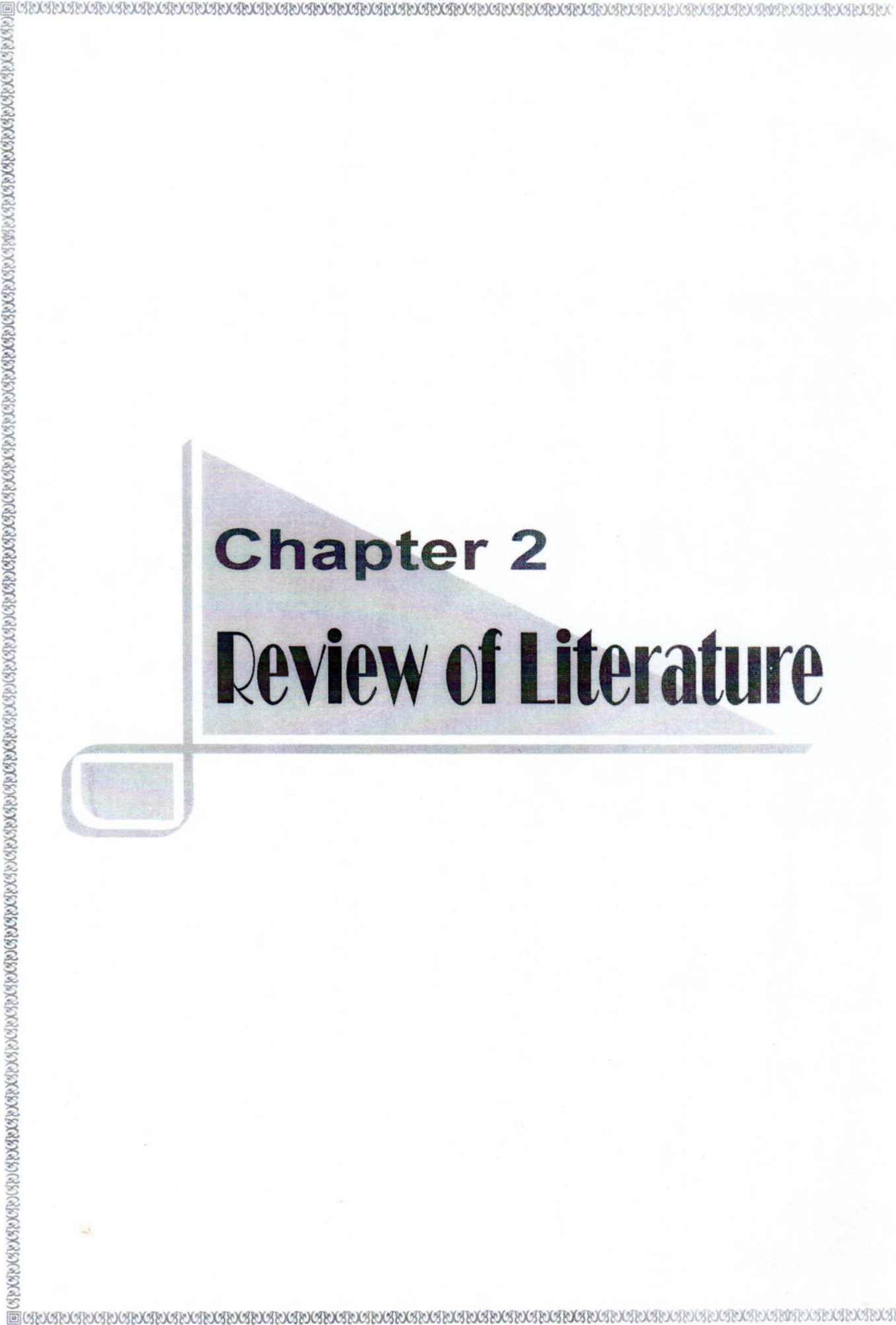
All the above conditions are available in Bangladesh for turmeric and ginger productions. But most of her lands are engaged to produce food crops. So, there is little scope to increase the area of turmeric and ginger without agroforestry. Hence, attempt should be taken to boost-up their culture through appropriate local techniques. Growing these crops in asso-ciation with trees and shrubs in and around homestead/farm land vis-a-vis agroforestry systems may be one of the ways in land constraint situations like Bangladesh. In this case, turmeric and ginger must face shade to some extent depending on the characteristics of the upper-storey tree species. Both the crops are traditionally known as shade loving species and grown under partial shade. But their degrees of shade tolerance and demands of different nutrients have yet not been standardized using scientific protocols.

Use of fertilizers plays a crucial role in the growth and yield of different crops as they supply various nutrients for growth and development of plants. Among the major macro nutrients, NPK are largely used by plants for better physio-morphological and biological developments.

Use of organic manures in the tropic is more vital than the temperate region due to excessive weathering and leaching. So, the tropical soils become seriously impoverished in plant nutrients. Thus proper manuring plays a vital role in crop yield and quality. Cow dung contains all plant nutrients in a relatively small amount. On the contrary, inorganic fertilizers contain large amount of different plant nutrients in readily available forms. Therefore, inorganic fertilizer coupled with cow dung may lead to better performance of turmeric and ginger. Under agroforestry system turmeric and ginger are compatible crops due to their shade loving/tolerant and easy growing natures in all homestead areas. Hence, better uses of natural resources as well as maintenance of natural balance could be ensured.

Although some sporadic studies for turmeric and ginger were done but no systematic information is available on growths and yields of them under agroforestry systems using different doses of fertilizer and lime. So, it is crucial to evaluate the same. With that view, the present investigation was undertaken to meet the following objectives.

- i) To investigate the morphologies of turmeric and ginger crops in the ghoraneem based agroforestry system.
- ii) To assess the yield attributes and yield of those crops under the ghoraneem based agroforestry system using different fertilizers.
- iii) To determine the effect of Dolochoon (Dololime) on the growth and yield of turmeric and ginger under ghoraneem based agroforestry system.



Chapter 2

Review of Literature

CHAPTER 2

REVIEW OF LITERATURE

The available literature related to the present study are thoroughly reviewed and presented in this chapter under different headings.

2.1 Concept of Agroforestry

Agroforestry is an old system although its emergence as an academic discipline is quite new. Agroforestry practices combine agriculture and forestry on the same piece of land. Agroforestry system is defined as the sustainable management system for land that increases overall production, combines agricultural crops, trees and forest plants and/or animals simultaneously or sequentially and applies management practices, which are compatible with the cultural patterns of a local population (Bene *et al.*, 1977).

Saxena (1984) pointed out that agroforestry utilizes the inter space between tree rows for intercropping agricultural crops and that does not impair the growth and development of the trees but enables farmers to derive extra income in addition to benefits accrued from the use of fuel and timber from trees.

Nair (1977) defined agroforestry as a land use system that integrates trees, crops and animals in a way, which is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers.

King (1978) stated that agroforestry might be considered to be practiced whenever trees and agricultural crops are grown in mixture, provided that the combined widths of the rows of agricultural crops do not exceed the heights of the forest trees at maturity and provided further that the

combined widths of rows of forest trees do not exceed the height of the tree crops at maturity or at some selected rotations.

It was hypothesized by Nair (1987) that an agroforestry system can play an important role in improving soil fertility by (i) increasing organic matter content of soil through addition of leaf litter, pruning and other biomass (ii) efficient nutrient recycling within the system, (iii) biological N_2 fixation in case of leguminous shrubs and trees and (iv) possible complementary interactions among associated species due to differences in canopy structures, root systems and active zones of water-nutrient absorptions.

A widely used definition given by the International Council for Research in Agroforestry (ICRAF) is that agroforestry is a collective name for all land use systems and practices where woody perennials are deliberately grown on the same form of spatial mixtures or in temporal sequences. There must be significantly ecological and economic interactions between woody and non woody components (Nair, 1988).

According to Solanki (1998), agroforestry can significantly contribute in increasing demands of fuel wood, fodder and cash flows and infrastructures in many developing countries. He also stated that agroforestry has high potential to simultaneously satisfy 3 important objectives: (i) protecting and stabilizing the ecosystems, (ii) producing a high level of output of economic goods (fuel, fodder, small timber, organic fertilizer etc.) and (iii) producing stable employment, improved income and basic material to rural populations.

Agroforestry does not mean planting trees in the fields or other places; rather it provides farmers with an effective land management system that can ensure more production in a balanced ecological environment (Haque, 1996).

From the bio-economic point of view, Harou (1983) stated that agroforestry combines agriculture and tree crop farming system that enables a farmer or land user to make more effective use of his land which may yield a higher net economic return on a sustainable basis.

A common hypothesis is strongly implied to the agroforestry systems that integration of trees with annual crops improves the chemical properties of the soil (Von Maydell, 1987).

Ong (1988) reported that by incorporating trees with arable crops, biomass production per unit area could be increased substantially when the roots of trees exploit water and nutrients below the shallow roots of crops and when a mixed canopy intercepts more solar energy.

Saka *et al.* (1990) stated that an agroforestry system can provide a sound ecological basis for increased crop and animal productivities, more dependable economic returns and greater diversities in social benefits on a sustained basis.

Bhatia and Singh (1994) observed that agroforestry systems in India plays an important role in increasing biomass production, maintaining soil fertility, conserving and improving soil averting risk.

2.2 Effects of light on plant growth and development

According to Ong *et al.* (1991) shading due to trees is responsible for poor yield of associated crops. Limiting light is obviously the most important factor that causes poor performance of under-storey crops.

The yield of any crop (whether tree crop or field crop) is dependent on intercepted radiation energy. Excessive canopy density as well as excessive exposure to irradiation may depress economic yield (Jackson, 1987).

One of the major constraints of microclimate and growth in agroforestry practices is the solar radiation. Interactions among trees and the solar geometry produce a particular solar climate of a tree/crop system. These interaction effects include interception of radiation by tree stands of various densities, canopy structures, spacing, latitude and time of year on solar paths, shade from single crowns, and spectral quality of sunlight under partial shade (Reifsnyder, 1987).

Zhong and Kato (1988) observed that decreasing in the light intensity also decreases dry weight. Moreover, low light intensity decreases the rate of exudation. Shading decreases starch and soluble sugar contents of root system too.

Singh (1988) reported that low light (25% of normal sunlight) produced by shading significantly decreased tuber yield due to reduction in tuber size apparently caused by uses partitioning (harvest index) of the lower biomass production.

Light not only plays the most vital role in photosynthesis but it carries out important function in various biological processes of plant-life, viz. metabolism, growth and development. Plants grown at high irradiances had higher photosynthetic rate and stomatal conductance while intercellular CO₂ concentrations were lower than in plants grown at low irradiances (Sritharam and Lenz, 1992).

Sarkar and Saha (1997) studied the influence of light intensities on the growth and development of radish in field trial at Baruipur, India and found that reduction of light intensity (to 75 or 50% of full sunlight using muslin cloth supported on bamboo frames) adversely affected the elongation and thickening of radish hypocotyls. Yield of radish was also reduced by reducing light intensity.

Leonardi (1996) reported that shading (60% light reduction) reduced vegetative and fruit growths but increased plant height. It also reduced chlorophyll content, stomatal density, transpiration rate and photosynthetic rate in peppers.

Essentially the underlying processes involved in the partitioning of resources (e.g. light, water and nutrients) are not well understood. A better understanding of resource capture and utilization in agroforestry system is required to facilitate the development of improved systems in terms of species combinations, planting arrangements and overall management systems (Howard *et al.* 1995)

An agroforestry system incorporating a range of tree and crop species offers more scope for useful management of light interception and distribution than monoculture forests and agricultural crops (Miah, 1995).

Wang and Zhang (1998) conducted an experiment under reduced light by 0, 20, 60 and 80% and experienced that stem height was the greatest with 80% shading while the leaf number was the maximum with 60% shading. Stomatal density was also the greatest without shading.

Battistelli *et al.* (1998) stated that at low light levels, plant growth rate, leaf area and specific leaf dry weight were reduced, and the shoot: root ratio was increased compared with plants grown at high light levels. CO₂ assimilation rate was also higher for plants grown under high light levels. Low light affected photosynthetic light driven reactions, the capacity of the Calving cycle, and starch and sucrose synthesis pathways enabling acclimatization to shade conditions and thus promoting survival under shade conditions too.

Contritito *et al.* (1998) studied the effects of shade (0 or 30%) on growth and photosynthetic parameters of capsicum in Italy and noted that shaded plants exhibited better growth and higher yields than control plants. Fruits from shaded treatments were of better class than those of the control treatment.

Light is an essential factor on plant growth and development. The major light factors affecting plant growth are light quality, light intensity, photoperiod and day/night cycle (Toto, 2003)

2.3 Effect of light intensity on spices production

From an investigation on the multistoried agroforestry system at the Bangladesh Agricultural University, Mymensingh, Rahim and Haider (2002) claimed that natural resources could be used properly in this system. When trees of different heights are planted in an agroforestry system, they absorb sunlight from different strata.

Singh *et al.* (2001) observed the effect of three tree species namely eucalyptus (*E. tereticornis*), acacia (*A. nilotica*) and Poplar (*P. deltoides*) on the performance of turmeric in Haryana, India. The mean emergence count of turmeric was the maximum when grown in association with acacia while the minimum in the control i.e. open. The mean height attained by turmeric after 90 days was the highest under eucalyptus and the lowest under poplar. The yield of turmeric was in the order: eucalyptus > control > poplar > acacia.

From studies conducted in Kerala, India, Jayachandra *et al.* (1998) indicated that coconut + ginger system under rainfed conditions gave good returns as ginger performed well under shade where few other crops could do. The yield of ginger were 11-27% higher than open fields. Even the yield was better under 50% artificial shade than under open conditions.

Sathish *et al.* (1998) evaluated the performance of 12 turmeric cultivars in a 20-year old coconut plantation. Plant crop cycle duration, yield and quality were assessed. The cv. Cuddapah produced the tallest plant (57.27 cm) and BSR-1 produced the greatest number of tillers (4.47/clump).

Intercropping of turmeric with *Leucena leucocephala*, *Eucalyptus camaldulensis*, Ghoraneem or *Manilkara* spp. were carried out in Madhya Pradesh, India. The highest yield of turmeric was observed in the *L. leucocephala* treatment. The yield of turmeric decreased with increasing tree age and with increasing density of planting of trees (Mishra and Pandey, 1998)

Nair (1993) stated that multi-species tree gardens characterized by a large variety of multipurpose plants in various vegetation layers provided scopes for effective utilization of environmental factors like water, nutrients and sunlight. He also stated that shade lowered ground surface temperature, which may reduce the rate of loss of soil organic matter by oxidation.

Michon *et al.* (1986) stated that multistoried agroforestry system is characterized by intensive integration of forest species and commercial crops forming a forest like system. Agroforest is a profitable production system and provides a buffer between villages and protected forests.

Michon and Mary (1994) said that multistoried village gardens in the vicinity of Bogor, West Java, Indonesia have long been essential multi-purpose production system for low income households. However, they are being subjected to important conversion processes linked to socioeconomic changes presently found in over crowded semi urban zones.

2.3 Effect of fertilizers

Fertilization has great effects on the growth and yield of ginger. Many research works have been carried out relating to fertilizer application in different countries. But research on the effect of fertilizer, specially nitrogen and potassium on the growth and yield of ginger in Bangladesh is scarce.

Meerabai *et al.* (2000) conducted a two year field study in Kerala, India on turmeric intercropped under partial shade of coconut trees. They noticed that turmeric responded to higher nitrogen (N) and potassium (K) fertilizer than the recommended dose for open field conditions. Application of 120 kg N and 120 kg K₂O/ha gave the maximum economic yield.

Patra (1998) conducted an experiment with turmeric cv. PTS 9 on a sandy loam soil at G. Udayagiri, India. It was planted in a raised bed before the onset of rain and supplied with different rates of N, P and K fertilizers. He cited that rhizome yield and plant growth increased consistently as the application rates of N, P and K were amplified, but all treatments significantly augmented yield and yield components compared to the control treatment. The highest yields were recorded with N: P: K at 90: 60: 90, 120: 60: 90 and 90: 30: 60 kg/ha (25.5, 25.0 and 24.5 t/ha, respectively).

Trafder *et al.* (1998) carried out an experiment with turmeric grown with or without P fertilizer at Dinajpur, Bangladesh. They found that phosphorus increased root growth due to the production of numerous lateral roots, increased water use efficiency and finally, the yield of rhizome.

In the kharif (monsoon) seasons of 1991 and 1992 at Bangalore, India, 2 turmeric cultivars were given 5 rates of NPK fertilizer in addition to 25t/ha FYM. N, P and K. The uptake were similar in the two cultivars in 1992 but N and P uptake were higher in cv. Co-1 than in cv. Bangalore local in 1991. In 1991, N, P and K uptake were the highest following application of 150kg

N+125 kg P + 250kg k/ha but in 1992 they were the topmost followed by the application of the highest NPK rate, i.e. 200kg N + 178 kg P + 300kg K/ha (Venkatesha *et al.*, 1998).

Mehla *et al.* (1997) conducted an experiment at Haryana, India to assess the effect of spacing and fertilizer levels on the growth and yield of colocasia (*Colocasia esculenta* L. schott) during rainy season of 1993-94 and 1994-95 with three spacing (30 x 30cm, 45 x 30cm and 60 x 30cm) and four fertilizer levels consisting of various combinations of N and P. The yield attributes viz., number of leaves, number of corms and weight of corms per plant and corm yield (q/ha) increased significantly with each successive increase in fertilizer up to N₁₀₀ P₅₀ whereas plant height was increased up to the highest dose of fertilizers (N₁₅₀ P₇₅)

With *Calocasia esculenta* cv. Meherchandi, Haroon *et al.* (1997) found in a field study fields in Kushtia, Bangladesh in 1991-93 that yield decreased as the NPK rate was decreased from the usual farmers rate of 185: 190: 80 kg N:P₂O₅:K₂O/ha, but marginal rate of return was increased.

Behura and Swain (1997) carried out a field trial with *Dioscorea alata* at Keonjhar, Orissa, India with 0, 50, 100, 150 kg N and 0, 60, 120, 180kg K₂O/ha. They mentioned that tuber yield increased up to 100kg N and 60kg K₂O per hectare.

Verma *et al.* (1996) carried out an experiment at Kumarganj, India with 16 treatments consisting of combinations of 0, 40, 80 and 120kg/ha of N and K, respectively and cormel yield and nutrient uptake were evaluated. No effect was recorded between N and K levels and days required for emergence of 50% corm. However, the increasing levels of N had positive effects on plant height, suckers per plant and leaves per plant.

Increasing N up to 80kg/ha significantly increased cormel yields. Increasing levels of K had similar effects. There was also a significant interactions between the two nutrients where 80kg N and 120kg K₂O per ha gave the highest yield. On the basis of economics they reported that the application of N @ 80kg/ha in combination with K @ 120kg/ha significantly increased the cormel yield of *Colocasia* spp.

Sheshagiri and Uthaiah (1994) investigated the yield of *Curcuma longa* cv. Co-1 in Karnataka, India in relation to different rates of NPK fertilizer. They reported that growth parameters and rhizome yields were significantly influenced by fertilizer application. The best growth and yield of turmeric were observed at an NPK rate of 120:60:120kg/ha.

Pal *et al.* (1993) conducted an experiment in Kalyani, India on fertilizer application to turmeric grown as an alley crop between *Leucaena leucocephala* trees (spaced 1 m apart in rows 4 m apart) for two years. They pointed out that turmeric responded to N (both as urea and as urea with *L leucocephala* leaves). Average yield over the two years was the greatest (115.54q/ha) when 120kg N (half as urea and half as leaves) + 120kg K₂O were applied and the lowest (90.5q/ha) was in the unfertilized control.

Yamgar and Pawar (1991) conducted an experiment in Maharashtra, India on turmeric with seven fertilizer treatments which were applied with different sources and rates of NPK (kg/ha N: P₂O₅: K₂O) as follows: 60: 40: 40, 45:30:30 and 120:60:60 (recommended dose) as conventional fertilizers, 60: 40: 40 and 45: 30: 30 as suphala, and 60: 40: 40 and 45: 30: 30 as low chloride (17:17:17) complex fertilizer. Highest mean yield (240.28 q/ha) was obtained with 120:60:60 kg NPK/ha. Application of NPK as the conventional fertilizer resulted in higher yields than the low chloride complex fertilizer or suphala.

In a field trial at Thiruvananthapuram, India, Nair and Mohankumar (1991) claimed that increasing levels of N (150kg/ha) and K (150kg/ha) tended to increase the dry matter contents of 5.14 and 6.20g/m²/day, respectively in elephant foot yam.

Mohankumar *et al.* (1990^a) conducted a trial *Colocasia esculenta* in 1984-85 on sandy clay loam soil at vellayani, Kerala, India. The crop received 40-120kg N, 25-75kg P₂O₅ and 50-150kg K₂O/ha. Application of 80kg N, 25kg P₂O₅ and 100kg K₂O/ha was recommended for higher cormel yield. From the study they suggested that under the agro-climatic conditions of humid tropics with medium level of available N, P and K content in the soil of fertilizer dose of 30kg nitrogen, 25kg P₂O₅ and 150kg K₂O/ha with three split applications of N and K would be the optimum economic level of fertilizer for taro.

Mohankumar and Sadanandan (1990^b) studied the effects of three levels of N, P, K and two time of application of N and K on taro (*Colocasia esculenta* L. Schott.) at vellayani, Kerala, India. They found that total uptake of N increased significantly only up to 80kg/ha, but increasing levels of P and K application had significant effects on the uptake of these nutrients at all the levels tried.

Sen and Roychoudhury (1998) conducted a field trial at Kalyani, India to study the effect of application of 40, 80 and 120kg N and 40, 80 and 120kg K/ha on cormel yield of *Colocasia esculenta*. The topmost yield of cormel (17.87t/ha) were obtained when 120kg N was applied. K at 80kg/ha gave significantly higher yield than 40kg/ha but no change was occurred at more K input, significantly higher yields were obtained for 120kg N/ha at all K rates compared with lower N rates.

Anand and Krishnappa (1988) stated that increased application of N and K accelerated the yield of A, B and C grades of potato tubers. Similar results were also found by Castro (1988), Borin and Magrini (1989), Mazur and Viotas (1992), Mollerhagen (1993) and Reust (1995).

Maity *et al.* (1988) conducted an experiment at Kalyani, West Bengal, India to study the efficacy of planting time, size of rhizome as planting material, mulching materials and various levels of N, P and K on the growth and yield of ginger. They reported that the optimum fertilizer rates were N at 120, P_2O_5 at 60 and K_2O at 90kg/ha.

Tayde and Desmukh (1986) set an experiment in Maharashtra, India with five N levels ranged from 0 to 200kg/ha. They reported that the highest yield (30.67t/ha) was obtained with mother rhizome given with 100kg N/ha but secondary rhizomes given with 150 kg N/ha produced a yield of 27.61t/ha.

At the Central Farm, TCRC, Joydebpur, Gazipur a trial was conducted during March to October, 1985 with five doses of N (0, 50, 100, 150 and 200kg/ha), four doses of P_2O_5 (0, 50, 100 and 150kg/ha), four doses of K_2O (0, 50, 100 and 150kg/ha), two doses of sulphur (0 and 20kg/ha) and two doses of zinc (0 and 5kg/ha). The highest yield (25.09t/ha) was obtained from 150kg N, 100kg P_2O_5 , 50 kg K_2O , 20kg S and 5kg Zn (Anon., 1986)

An experiment was carried out at the TCRC, Joydebpur, Gazipur during March 1984 to January 1985 to study the effect of N, P_2O_5 and K_2O on the yield of Mukhi kachu. In the first part, N was applied at the rate of 0, 50, 100, 150, 200 and 250kg/ha keeping the dose of P_2O_5 (90kg/ha) and K_2O (150kg/ha) constant. In the second part, the rates of K_2O application were 0, 50, 100, 200 and 250kg/ha along with 150kg N and 90kg P_2O_5 /ha. The third part involved four doses of P_2O_5 namely, 0, 60, 90 and 120kg/ha along with

150kg N/ha and 150kg K₂O/ha. The entire doses of P₂O₅ and 50% of K₂O were applied at the time of final land preparation. N was top dressed after 20, 60 and 100 days of planting. The remaining 50% of K₂O was given after 60 days of planting as top dressing along with nitrogen. The sources of N, P₂O₅ and K₂O were Urea, TSP and MP, respectively. From the first and second parts, the highest yield of 11.54 and 15.30t/ha were obtained from 250kg N/ha and 150kg K₂O/ha, respectively (Anon., 1985).

Eyubov *et al.* (1984) conducted a trial in Azerbaijan with turmeric. It was grown in 10kg pots, at 2 plants/pot, various fertilizers were applied before planting and at the 2 to 3 leaf stage (10 treatments). The treatments increased yields by 81 to 282% compared to the non-fertilized control. The highest rhizome yield (97.5 g/pot) was obtained from N. P₂O₅: K₂O at 0.2:0.2:0.19 + 75g FYM + 0.2g KOMU (a complex organic-mineral micro-fertilizer) per kg soil.

Ashokan and Nair (1984) conducted field experiments at Vellanikkara, India for two seasons to study the response of taro (*Colocasia esculenta*) to apply N and K. Application of N and K increased the cormel yield. They observed that among the higher levels, effect of N alone was significant. The cormel to corm ratio was improved by N and K applications. The data were found to be in good fit to a quadratic response surface model and the economic optimum doses of N and K₂O worked out from the model were 89 and 79kg/ha, respectively. The height of the plants and number of leaves produced per plant were not significantly influenced by higher levels of N or K. Number of suckers per plant was the maximum and significantly superior (7.4) with 80kg/ha level of K.

Mandal *et al.* (1982) carried out an experiment at Central Tuber Crops Research Institute, Trivandrum in 1971-72 with four levels of N (0, 40, 80

and 120 kg N/ha) and five levels of K (0, 40, 80, 120 and 160kg K₂O/ha). They mentioned that cormel production increased with the increasing levels of both N and K up to 120kg/ha. On the basis of economics, the optimum levels N and K were 100kg N/ha and 144kg K₂O/ha.

Premraj *et al.* (1980) noted that 120kg N and K with 60kg P were found to be optimum for *Colocasia* in Tamil Nadu, India.

De Geus (1973) gave the following recommendations per hectare for Gujarat, India: 100kg N, 35-40kg P₂O₅ and 60kg K₂O, with all the P and K at planting and the N in two split applications, one and three months after planting. It was found beneficial for the rainfed turmeric crop and it gave nearly 100% increased yield over the unmanured crops.

Muralidharan and Balakrishnan (1972) conducted an experiment at Ambalavayal, India with 17 cvs. of turmeric on its fertilizer requirement. They noticed that Tekurpetta was the highest yielding of 17 turmeric cvs. grown for two seasons. They also observed that yields were significantly increased by NPK applications but results were erratic and both the highest (100kg N, 100kg P₂O₅ 200kg K₂O/ha) and the lowest (40:40:80) rates out yielded intermediate treatments.

Samad (1953) reported no significant response to fertilizer application of ginger in Malabar region though there was an increase in yield with 60 kg N/ha. Significant increase in yield was observed by Loknath and Das (1964) with the application of 60kg N, 40kg P₂O₅ and 60kg K₂O per hectare under the agro-climatic conditions of Orissa. Thomas (1965) obtained no significant response with four levels of N (0, 50, 100 and 150kg/ha) and three levels of P₂O₅ (0, 45 and 90kg/ha).

Trial with N, P and K conducted at the Regional Research Station, Kandahat for four years indicated that the combinations of 100kg N, 50kg P_2O_5 and 50kg K_2O /ha was the best results for Kerala conditions, Randhawa and Nandpuri (1965), Nair (1969) and Paulose (1970) recommended an application of 60kg N, 60kg P_2O_5 and 150kg K_2O /ha for the best results.

Aiyadurai (1966) in his review of the Ginger Development Scheme, Himachal Pradesh indicated that N fertilization of the crop with 50 to 100kg N/ha significantly increased yield by 18 to 32% and also improved the dry matter content of rhizome.

Aclan and Quisumbing (1976) observed that the rhizome yields were doubled by applying 30kg N/ha and increased further 75% by 90kg N/ha. Lee *et al.* (1981) obtained 65 t/ha rhizome fresh weight after 251 days of planting with N at 200-300kg/ha.

Panigrahi and Patro (1985) obtained the highest yield of ginger (229.5 q/ha) from cv. P.G.S 35, which received N and K @ of 90kg/ha each under Orissa conditions.

Mohanthy *et al.* (1993) carried out an experiment in Orissa, India with three seed rates (1500, 1800 or 2100kg/ha) and four levels of fertilizer ($N_{75} P_{50} K_{50}$, $N_{100} P_{60} K_{100}$, $N_{125} P_{70} K_{150}$ and 0kg/ha (Control)). They reported that the maximum yield (10.16t/ha) as well as the maximum profit (Rs. 48500) was recorded in the treatment with the highest fertilizer application and a seed rate of 1800kg/ha.

Singh and Neopany (1993) carried out an experiment with some fertilizer combinations and spacing on yield and quality traits of ginger. The experiment was laid in a split plot design with three replications with fertilizer combinations in the main plot while spacing in the sub plot. They

result revealed that for obtaining high yield of ginger, 20 x 20cm spacing with a fertilizer combination of 150 N+80P+60K kg/ha might be used.

Thakur and Sharma (1997) carried out an experiment at Dhaulakuan to study the effect of N and P fertilizer rates on ginger yield and nutrient uptake. N and P rates up to 100kg N and 60kg P₂O₅/ha significantly increased rhizome yield. In general, N P and K uptake by ginger increased with the increase of N and P rates up to 150 and 90kg/ha, respectively.

Gowda and Melanta (1998) conducted a field experiment in Bangalore, India with N P K levels on the yield of ginger cv. Rio-de-Janeiro. They found that the application of 150kg N, 75kg P₂O₅ and 50kg K₂O/ha gave the highest yield.

Singh *et al.* (1998) carried out an experiment in Nagaland, India with three levels of K (0, 40, 80 and 120kg N t/ha). The results showed that application of 80kg of both K and N per/ha on the low hills increased the productivity of turmeric.

Gupta and Sengar (1998) conducted a trial in Madhya Pradesh, India during 1992-95 to study the effects of varying rates of N, P and K on the growth and yield of turmeric. The treatment consisted of 4 rates of N (0, 40, 80 and 120kg/ha) and 3 rates of K (0, 30 and 60kg K₂O/ha). They found that the highest fresh rhizome yield was (17.26t/ha) obtained with the combination of 120kg N and 60kg K₂O/ha.

Kun-Xu *et al.* (1999) studied the effects of various N fertilizers rate on ginger growth and yield. They experienced that N at the rate of 600 kg/ha gave the best growth and the highest yield as well.

The effect of N (20, 45, 60, 75, 100 and 125kg/ha) on rhizome rot of ginger caused by *Pythium aphanidermatum* was investigated in a field

experiment in Bihar, India (Bimla *et al.*, 2000). The minimum disease incidence of 15.00% and maximum yield of 261.25q/ha were recorded at 75 kg N/ha.

Dayanakatti and Sulikeri (2000) conducted a field experiment at Karnataka, India with three levels of plant populations (148148, 111111 and 87719 plants/ha) and four levels of N (50, 75, 100 and 125kg N/ha). Both plant population and N levels had significant effects on fresh and cured rhizome yields, with the highest values being produced under conditions of the highest population and highest level of N (125kg/ha).

Yamgar *et al.* (2001) conducted a field experiment in Maharashtra, India, from 1988-93, to determine the response of turmeric cv Krishna to NPK at 0:0:0:, 120: 60: 60:, 160:80:80:, 200:100: 100 and 240: 120: 120 kg/ha and different levels of N split application: 1 application at 6 weeks after planting (WAP) : 2 splits at 6 and 12 WAP: 3 at 6, 12 and 18 WAP; and 4 at 6, 12, 18 and 24 WAP. The maximum green rhizome yield (0.53g/ plant) was recorded with the combination of N: P: K at 200:100:100kg/ha.

Study on the nutrient requirement of ginger in Wynad, Kerala showed the positive effect of higher dose on the yield. Among the 16 levels of N and K, 3 combinations viz., 150 N, 50 K; 150 N, 100kg K, and 150kg N, 150kg K/ha were found to be significantly superior with respect to yield. The vegetative height was found to be significantly influenced by N. The optimum dose of N and K was a quadratic equation as 144kg and 109kg/ha, respectively (Anon. 2001)

2.5 Performance of crops in agroforestry systems

Rahman (2004) conducted an experiment with ginger on the existing multi-layered Garden at the Germplasm Center (GPC) of Fruit Tree Improvement Project (FTIP), Bangladesh Agricultural University, Mymensingh to determine the growth and development of different vegetables and spices. The highest yield (32.88t/ha) was obtained from the partial shade conditions while the lowest yield was 18.75t/ha of ginger was obtained from the severe shade conditions.

For two years Jaha and Lalnunmawia (2003) investigated the growth performance of three clump-forming edible bamboo species viz. *Dendrocalamus hamiltonii*, *D. longispathus* and *Bambusa tulda* grown along with ginger. The growth of bamboo as well as yield of ginger was significant under fertilizer treatment compared to the control conditions.

Zaman *et al.* (2002) conducted an experiment at the Hill Agricultural Research Station, Khagrachari, Chittagong to determine the proper quantity of manure and to find out the optimum harvesting time for quality ginger production. They found that the combined effects of 2t/ha manure coupled with harvesting after 9 months gave the highest performance (27.17).

Zaman *et al.* (2002) conducted an experiment at the Hill Agricultural Research Station, Khagrachari, Chittagong to investigate the desired plant population and the appropriate depth of seed placement into soil to get the maximum yield of ginger. They found that a plant spacing of 40 x 20cm and rhizome placed at 9cm depth produced the highest yield of 29.81t/ha and 30.58t/ha, respectively. They also found that the treatment combination of 40 x 20cm spacing and rhizome placed at 9cm depth gave the best value (39.00t/ha).

Shanmughaved and Francies (2001) conducted intercropping trials for four crops in bamboo plantations. They intercropped pigeon pea, soybean, turmeric and ginger with *Bambusa bumos* and growth, yield and LER were assessed. Based on the calculated LER, they concluded that the productivity of one hectare under intercropping was equivalent to that of 1.2ha or 1.1ha under monoculture.

Koppad *et al.* (2001) conducted a study in the Varada watershed in Karnataka, India with the alternate land use system (agro-horticulture and agroforestry) in agricultural production. They found that use of the alternate land use system and the improved variety of ginger cv. Alleby gave an average yield of 245 kg/ha. They further stated that alternate land use system such as Teak (*Tectona grandis*) based agroforestry and mango-based agriculture systems were successfully adopted by the farmers.

Pramono *et al.* (2000) worked with conservation technique in ginger plantations at Iumban Julu, North Tapanuli. They reported that due to land tenure considerations, farmer's produces ginger that grows rapidly and the ginger cultivation caused soil erosion. For this reason, soil conservation techniques were required to apply. They tested two treatments, i.e. (i) menkusii as a barrier between ginger plantation and (ii) merkusii + grass as barriers. They found that grass + merkusii brassies reduced soil erosions by up to 70% and surface runoff by up to 62%.

Islam *et al.* (1998) undertook a trial at Ichamati Research Centre, Chittagong in which *Eucalyptus camaldulensis* and *Acacia mangium* (initially 1200 trees each, spaced at 2.27 x 2.75 m) were intercropped with lady's finger, barbate (*Vigna sinensis*), beans (*Dolichos lablab*), ginger, turmeric and arum (*Colocasia esculenta*). The financial benefit cost analysis of both the tree crops and agricultural crops were done separately and in combination.

The combination of tree and crops present a worth of benefit Tk. 12,610 and the present worth of cost Tk. 44,947. So, the net present worth was therefore, Tk. 32,337 with a cost-benefit ratio of 0.28. Based on this they concluded that agroforestry system is profitable.

Gupta and Awasthi (1997) conducted a trial at Jagdalpur in the Kharif season using ginger cv. Suprabha grown with mulches of palas leaves, sal leaves, rice straw, dry grass, leaf or soil. They found that ginger grown with palas leaf mulch produced the highest fresh yield (21.90t/ha) while mulched control produced 16.75t/ha.

Hossain (1995) conducted a trial in Kazir Shimla, Mymensingh with the objective of growing ginger and turmeric in shady place of homesteads. He used varied plot size depending on the availability of spaces or fallow land of farmer. The area per farm under ginger cultivation in the homestead ranged from 3 to 15.75sqm and average was 11.12sqm. The corresponding yields per farm varied from 2 to 5kg with an average of 3.42t/ha, which was significant towards the income of farmers who normally kept the homestead lands fallow.

Zheo and Oosterhuis (1995) observed that when light intensity was reduced to 37% of full sunlight during flowering and fruiting the photosynthetic rate decreased by 47-45% resulting in a significant increase in boll shading with a concomitant decrease in lint yield of 18-52% in cotton.

Angeles and Mendoza (1988) reported that when intercropped with bananas and pineapples at Laguna, pawpaw cv. Smooth Cayenne plants were an average of 71.4cm taller and their average stem diameter was 4.7cm greater than when grown as a pure stand. Leaf production was also greater when intercropped, with longer petioles and greater laminar and petiolar DW being recorded. Intercropping also increased papaya fruit size, number and

yield/tree from 0.9, 7.1 and 6.6 kg/tree, respectively, in pure stand to 1.7, 22.1 and 36.7kg/tree, respectively. This was attributed to each pineapple plant in the intercrop and confirmed by increase in leaf N concentration of papaya when intercropped.

Chapter 3

Materials and Methods



CHAPTER 3

MATERIALS AND METHODS

The materials and methods used in conducting the two experiments are presented here under different headings including brief descriptions of the experimental sites, soils and climates.

3.1. Locations of the experimental plots

The present research works were carried out at a farmers' field (Ghoraneem woodlot) adjacent to the HSTU Research Farm, Dinajpur during April to December 2005 in the upland conditions. The site lies between 25°13 latitude and 88°23 longitudes at the elevation of 40m above the sea level.

3.2. Soil characteristics

The experiments were laid out in a medium high land belonging to the AEZ of old Himalayan piedmont plain area. The soil texture was sandy loam with a pH of 5.0 (very acidic). The structure of the soil was fine and the organic matter, total N, P, K, S, Zn & B contents were 1.20%, 0.06%, 29.35 µg/g soil, 0.21 meq/100g soil, 6.13µg/g soil, 0.73 µg/g soil & 0.27 µg/g soil respectively. The soil characteristics were tested at the Regional Laboratory, SRDI, Dinajpur.

3.3. Status of the Ghoraneem plants

The studies were done under 3 years old Ghoraneem woodlot established in 2002 by the HSTU Research Farm, Dinajpur. Each tree was pruned every year. The characteristics of ghoraneem tree were as follows:

Characteristics	Values
Height	10-12M
Diameter at the breast height	37.5cm

3.4. Climate and Weather

The climate of the study area is characterized by a heavy rainfall during kharif season (April to September) while a scanty rainfall during the rest period, i.e. during the Rabi season (October - March). The mean maximum temperature in the summer (March - September) was 35⁰C and the mean maximum temperature in the winter (November - March) 11.9⁰C. The humidity was 87% in January and 88% in July. The mean annual rainfall was 1822mm most of which occurred in short spells during May-September and light showers occur during the Rabi season (October - March). The average intensity of sunlight under the said Ghoraneem woodlot during the study period was 31259lux (Appendix 1).

3.5 Experimental designs

Both the experiments were laid out in the RCBD. The first experiment was set with turmeric while the second one with ginger. Four different combinations of fertilizers and soil amendment were compared as the four treatments in both the experiments. There were five replications in each study. The size of each plot was 2.5 x 1.2M.

3.6 Treatment combinations of the studies

The four treatment combinations used in both the studies were-

T_1 = No fertilizer and no soil amendment (the control)

T_2 = Well rotten cow dung @ 10 tons /ha.

T_3 = T_2 + Dolochoon (@ 240 kg/ha).

T_4 = T_3 + Recommended doses of NPKSZn (mentioned in the section 3.10.2).

In the studies the soil amendment used was Dolochoon as the pH of the experimental soils were acidic.

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18.1.07

3.7 Land preparation

The land was opened in the first week of April 2005 and then prepared thoroughly by spading and cross spading to obtain a good tilth, which was necessary to get better yield of this crop (Ahmad, 1969). All the weeds, stubbles and crop residues were removed from the field and bigger clods were broken into smaller pieces. Finally, the land was pulverized and leveled uniformly.

3.8 Experimental materials

The varieties used in the experiments were Dimla (T-027) for turmeric and a local one for ginger.

3.9 Manuring and fertilization

Incase of T₄, the recommended dose of fertilizers (NPKSZn) and their method of application as suggested by BARC were followed.

3.10 Crop establishment

The seed-rhizomes/fingers of turmeric were planted maintaining 50 x 25cm spacing between and within the rows at a depth of 8cm. Oppositely, the seed-rhizomes of ginger were planted maintaining a row to row distance of 50cm, a plant to plant distance of 25cm and at a depth of 10cm. Each seed-rhizome of both turmeric and ginger was of 15-20g.

3.10.1 Intercultural operations

Weeding was done as felt necessary. Earthing-up was done thrice; the first one after 60, the second one after 90 and the final one after 110days of planting. Some turmeric plants were infested by *Dichocrocis punctiferalis* insects and that was controlled by spraying Bidrine (10ml/10L). Some turmeric plants were also affected by *Taphrina maculans* at the stage of maturity which was also combated by removal of infested leaves.



Plate-1: Land preparation for planting



Plate-2: Planting turmeric in the prepared

Some ginger plants were affected by leaf spot and rhizome rot diseases, which were controlled by spraying Rovral and Dithane M-45 @ 4.5 g/L at an interval of 15 days, respectively.

3.10.2 Application of manure, fertilizer and Dolochoon

For the T₄ treatment the doses of manures and fertilizers and their methods of application as recommended by BARC except dolochoon (Ideal Trading Limited) are given below:

Recommended fertilizer rates and method of application for turmeric:

Manure / Fertilizers	Dose per hectare
Well decomposed Cowdung (ton)	10
Urea (kg)	235
TSP (kg)	30
MP (kg)	90
Gypsum (kg)	105
Zinc sulphate (kg)	3
Dolochoon (kg)	240

Recommended fertilizer rates and method of application for ginger

Manure / Fertilizers	Dose per hectare
Well decomposed cow dung (ton)	10
Urea (kg)	325
TSP (kg)	45
MP (kg)	125
Gypsum (kg)	105
Zinc sulphate (kg)	3
Dolochoon (kg)	240

Cow dung and Dolochoon were applied 7 days before planting. One half of N and other fertilizers were applied before planting of rhizome. Besides N fertilizer were applied in 3 splits between 2 rows after planting of rhizome at 50, 80 and 110 days of planting.

3.11 Harvesting

Turmeric and ginger were harvested on 27 December 2005 (after 240days of planting) when the leaves turned yellow and started drying up.

3.12 Sampling and data collection

3.12.1 For turmeric

Ten plants were randomly selected from each plot to record data on the following parameters-

- i) **Plant height (cm):** It was measured from the ground level up to the tip of the longest leaf at 120, 180 and 240days after planting (DAP).
- ii) **Number of leaves per plant:** It was counted at the maximum plant growth stage.
- iii) **Number of tillers per plant:** This was recorded at the maximum growth plant.
- iv) **Length of leaf blade (cm):** Three leaves per plant viz., large, medium and small were used for this purpose. Then the mean value was used. In this way in total 30 leaves were used for this datum.
- v) **Breadth of leaf blade (cm):** Three leaves viz., large, medium and small per plant were used for this purpose. Then the mean value was used. In this manner in total 30 leaves were used for this datum.
- vi) **Number of finger per plant:** The number of finger per selected plant was counted at harvest time and their mean was calculated.
- vii) **Finger fresh weight per plant (g):** The weight of fresh finger per selected plant was recorded with the help of a balance at the time of harvest and their average was calculated as weight of individual plant.

- viii) **Finger dry weight per plant (g):** After harvest, fingers were dried in an oven for 24 hours at 70⁰C till constant weight. After drying, the dry fingers were weighed.
- ix) **Rhizome fresh weight per plant (g):** The weights of fresh rhizomes were recorded with the help of a balance at the time of harvest.
- x) **Rhizome dry weight per plant (g):** After harvest, rhizomes were weighed and dried in an oven for 24hours at 70⁰C till reaching at a constant weight. After drying the dry rhizome were weighed.
- xi) **Total yield per hectare (ton/ha):** Yield of rhizome per plot was converted into yield per hectare and expressed in tons.

3.12.2 For ginger

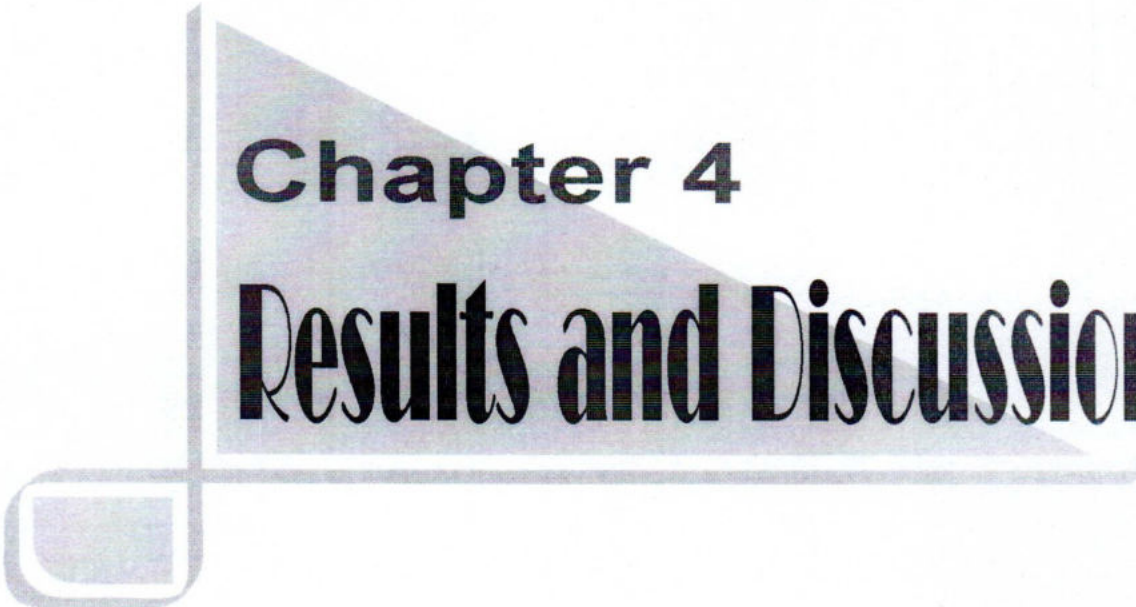
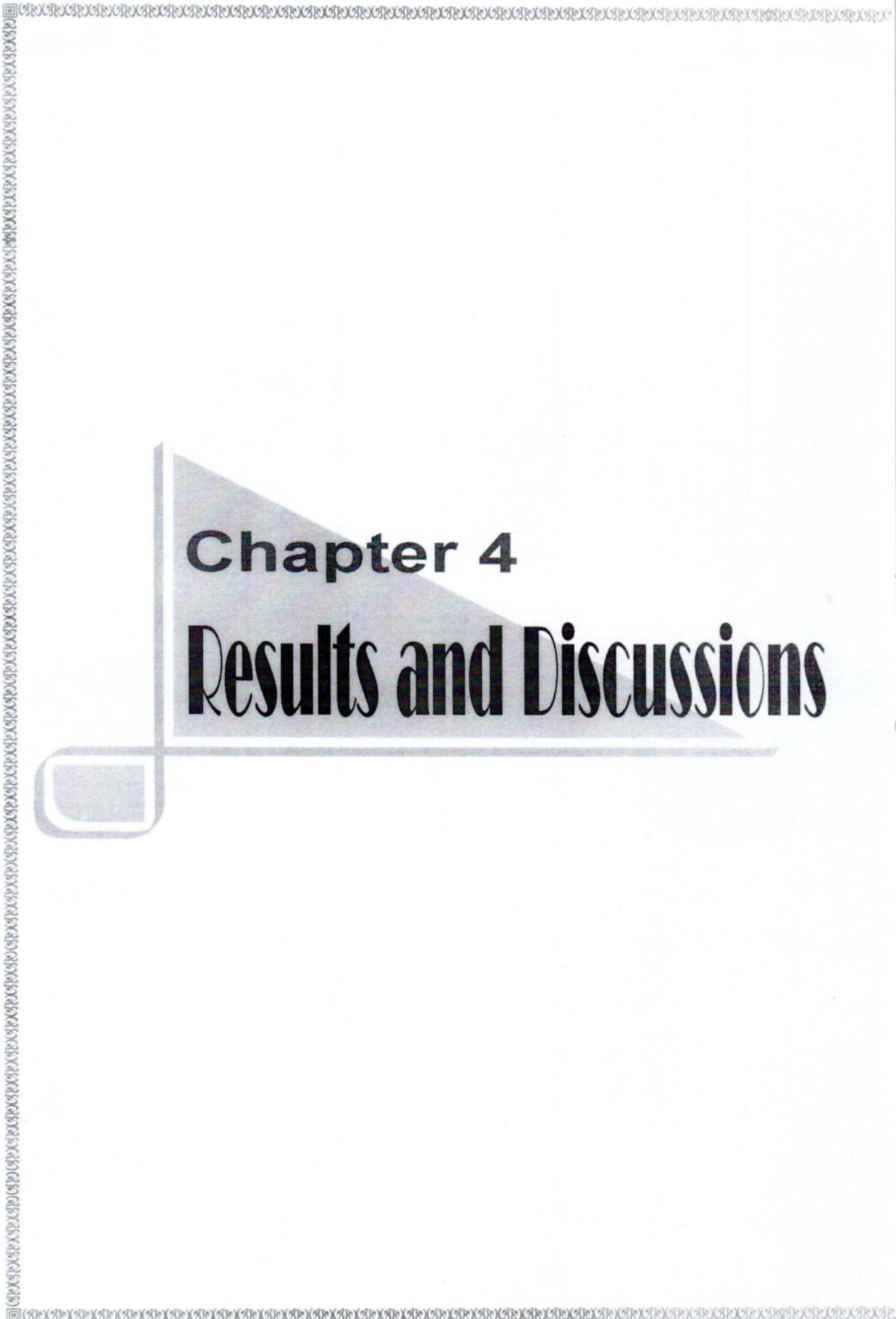
Ten plants were randomly selected from each plot to record data on the following parameters-

- i) **Plant height (cm):** This was measured from the ground level up to the tip of the longest leaf of the sample plants at 120, 180, 240 DAP.
- ii) **Number of leaves per plant:** It was counted at the maximum plant growth stage.
- iii) **Number of tillers per plant:** This was also recorded at the maximum plant growth phase.
- iv) **Number of finger per plant:** It was counted at the time of harvest.
- v) **Finger fresh weight per plant (g):** After harvest, fingers were moped with a handkerchief and then were weighed with a balance.
- vi) **Finger dry weight per plant (g):** After harvest, fingers were dried in an electric oven for 24 hours at 70⁰C till the constant weight was achieved.

- vii) **Rhizome fresh weight per plant (g):** The weight of fresh rhizome per selected plant was recorded with the help of a balance at the time of harvest and their average was calculated as weight of individual plant.
- viii) **Rhizome dry weight per plant (g):** After harvest, rhizome of 10 selected plants were weighed and dried in an oven for 24 hours at 70⁰c till constant weight. After drying the dry rhizome weighed and mean weight was calculated in gram (g).
- ix) **Total yield per hectare (ton/ha):** The yield of rhizome per plot was converted to yield per hectare.

3.13 Data analyses

The data on various growth and yield contributing parameters of turmeric and ginger were statistically analyzed to examine the variations of the results due to the four treatments compared. The analyses of variance for each trait were done by F (variance ratio) test following the RCBD design. The treatment means were compared by the LSD test at both the 1 and 5 percent levels of significances.



Chapter 4

Results and Discussions

CHAPTER 4

RESULTS AND DISCUSSIONS

The results obtained in the two experiments were analysed and presented in this chapter under different headings.

Experiment with turmeric

4.1.1 Plant height

The plant height was significantly influenced by different treatments (Table 1). The tallest plants (115.3 and 161.2cm) were recorded with T₄ at the 120 and 180 DAPs, respectively followed by T₃. The plant height (113.9cm) of T₃ at 120 DAP was statistically similar to T₄. But the plant height (153.6cm) at 180 DAP was not identical. On the other hand, significantly the smallest plants were observed (at 120 and 180 DAPs, i.e. 81.29 and 110.9cm, respectively) in T₁ (control). Moderate plant height was noted under T₂ conditions. Similar result was found by Meerabai *et al.* (2000). The noticed that turmeric responded to higher N and K fertilizer application rates than open field conditions. Mehla *et al.* (1997) found that plant height was increased up to the highest dose of fertilizer (N₁₅₀ P₇₅) in *Colocasia esculenta* but corm yield was increased up to N₁₀₀ P₇₅.

Table 1: Effect of fertilizers on plant height and number of tillers per plant of turmeric at different DAPs.

Treatment	Plant height (cm)		Number of tiller/plant	
	120 DAP	180 DAP	120 DAP	180 DAP
T ₁	81.29 c	110.9 d	1.20 c	2.54 c
T ₂	92.13 b	125.6 c	2.19 b	3.02 b
T ₃	113.9 a	153.6 b	3.13 a	4.37 a
T ₄	115.3 a	161.2 a	3.70 a	4.79 a
LSD (0.05)	1.65	2.09	0.62	0.45

T₁ = No fertilizer (Control) T₃ = T₂ + Dolochoon @ 240 kg/ha

T₂ = Cowdung @ 10 t/ha T₄ = T₃ + Recommended doses of NPKSZn

4.1.2 Number of tiller

It varied significantly due to different treatments. The highest number of tillers per plant (3.70) was obtained from the T_4 treatment at the 120 DAP, which was statistically similar to that of T_3 (3.13). The number of tillers per plant from T_2 was 2.19 and 3.02 at the 120 and 180 DAPs, respectively. Significantly the lowest number of tillers per plant (1.20) was noted from T_1 at 120 DAP. Oppositely, at 180 DAP the highest number of tillers per plant (4.79) was obtained from T_4 , which was statistically similar to that of T_3 (4.37). The minimum number of tillers per plant (3.02) was obtained from T_2 while the lowest (2.54) from T_1 . Patra (1998) reported that growth parameter of turmeric was increased consistently as the application rates of N, P and K was increased.

4.1.3 Number of leave

Significantly the lowest number of leaves per plant was found in T_1 at both the 120 and 180 DAPs (6.16 and 11.37, respectively). But at the 120 DAP all the treatments produced statistically similar number of leaves per plant of which T_3 possessed numerically the highest value (7.53) followed by T_4 (7.48). Oppositely, at 180 DAP only T_3 and T_4 produced statistically similar number of leaves per plant of which T_4 possessed numerically the higher value (24.8)

Table 2: Effect of fertilizers on leaf of turmeric at different DAPs

Treatment	Number of leaf/plant		Length of leaf blade (cm)		Breadth of leaf blade (cm)	
	120 DAP	180 DAP	120 DAP	180 DAP	120 DAP	180 DAP
T_1	6.167 b	11.37 c	57.04 c	59.33 d	15.66 b	15.90 c
T_2	7.367 a	20.30 b	62.26 b	68.10 c	15.86 b	17.33 b
T_3	7.533 a	24.34 a	62.83 b	68.90 b	17.97 a	20.02 a
T_4	7.483 a	24.80 a	65.07 a	73.93 a	18.38 a	20.30 a
LSD (0.05)	0.4143	1.179	0.9929	0.5398	0.9665	0.3343



Plate-3: Vegetative phase of turmeric at 120 DAP (T₂)



Plate-4: Vegetative phase of turmeric at 120 DAP (T₂)



Plate-5: Vegetative phase of turmeric at 120 DAP (T₄)

4.1.4 Length of leaf blade

At 120 DAP, the significantly longest leaf blade (65.7cm) was recorded in T₄ followed by T₃ (62.83). The value of length of leaf blade (62.26 and 68.10cm, respectively) in T₂ was statistically similar to T₃ followed by T₄.

4.1.5 Breadth of leaf blade

It varied significantly by different treatments where the highest breadth of leaf blade (18.38 and 20.30cm) was observed at 120 and 180 DAPs, respectively in T₄ which was statistically identical to T₃ and values were 17.97 and 20.02cm at 120 and 180 DAP, respectively. Significantly the minimum breadth of leaf blade was recorded in T₁ (15.66 and 15.9cm at 120 and 180 DAPs, respectively). According to Schoch (1972), more stimulation of cellular expansion and cell divisions occurred under shaded conditions. The higher values of breadth of leaf blade in T₄ might be the influence of fertilizer elements under shade conditions.

4.1.6 Number of finger

This is an important yield contributing trait. The highest number of fingers per plant was 13.23, 20.60 and 32.15 at the 120, 180 and 240 DAPs, respectively in T₃ followed by T₄ (12.40, 20.25 and 29.24 at 120, 180 and 240 DAPs, respectively). Significantly the lowest number of finger per plant (8.432, 13.22 and 20.47) was recorded at 120, 180 and 240 DAPs, respectively in T₁. Up to 180 DAP, T₃ and T₄ produced statistically similar number of fingers but at 240 DAP, T₃ produced significantly higher than T₄. This might be due to in balanced partitioning of food material at end of the life cycle of turmeric in study place.

4.1.7 Finger fresh weight

It was significantly influenced by different treatments and the influence pattern was quite identical to number of fingers (Table 3). The highest finger fresh weight per plant was 60.12, 70.71 and 361.6g at 120, 180 and 240 DAPs in T₃ followed by T₄ (59.59, 70.13 and 349.8g at 120, 180 and 240 DAP, respectively). Significantly the lowest finger fresh weight per plant was 50.02, 60.08 and 238.4g at 120, 180 and 240 DAPs, respectively in T₁. Lower finger fresh weight in T₄ than T₃ was probably due to the lesion or decay of fingers, which might be the results of reaction of chemical fertilizers in the acid soil used.

Table 3: Effect of fertilizers on number of fingers and fingers' weight per plant of turmeric at different DAPs

Treatments	Number of finger/plant			Finger fresh wt./plant (g)			Finger dry wt/plant (g)		
	120 DAP	180 DAP	240 DAP	120 DAP	180 DAP	240 DAP	120 DAP	180 DAP	240 DAP
T ₁	8.432 b	13.22 c	20.47 c	50.02 c	60.08 c	238.4 c	8.653 c	17.12 b	46.51 b
T ₂	9.203 b	14.88 b	27.43 b	50.94 b	64.20 b	352.7 b	10.58 b	17.41 b	68.15 a
T ₃	13.23 a	20.60 a	32.15 a	60.19 a	70.71 a	361.6 a	15.33 a	21.05 a	68.42 a
T ₄	12.40 a	20.25 a	29.24 b	59.59 a	70.13 a	349.8 b	14.30 a	20.58 a	68.09 a
LSD (0.05)	1.078	0.3996	2.566	0.8238	0.7231	7.720	1.156	0.3159	0.7502

4.1.8 Finger dry weight

The highest finger dry weights of per plant were 15.33, 21.05 and 68.42g at 120, 180 and 240 DAPs, respectively in T₃ followed by T₄ (14.30, 20.58 and 68.09g at 120, 180 and 240 DAPs, respectively) (Table 3). Up to 180 DAP, T₃ and T₄ produced statistically similar dry yield but at 240 DAP T₂ also produced statistically similar dry yield to T₃ and T₄. The lowest finger dry weights of per plant (8.653, 17.12 and 46.51g at 120, 180 and 240 DAPs, respectively) were found in T₁.



Plate 6: Sample turmeric of final harvest (T₁)

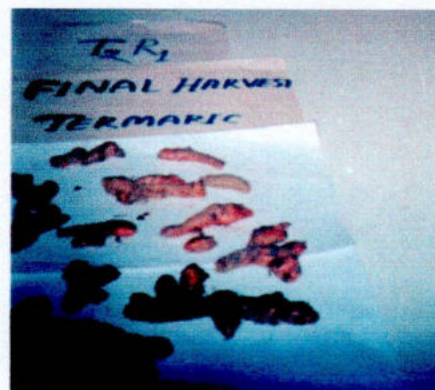


Plate 7: Sample turmeric of final harvest (T₂)



Plate 8: Sample turmeric of final harvest (T₃)



Plate 9: Sample turmeric of final harvest (T₄)

4.1.9 Rhizome fresh weight

It was significantly influenced by the treatments (Table 4). Significantly the highest values of rhizome fresh weight was found in T₃ at each sampling dates (54.61, 76.32 and 109.2g at 120, 180 and 240 DAPs, respectively) followed by T₄ (54.10, 70.27 and 108.1g at 120, 180 and 240 DAPs, respectively). Significantly the lowest rhizome fresh weight per plant was found in T₁ at each sampling date and the values were 47.71, 54.14 and 85.79g at 120, 180 and 240 DAPs, respectively. Patra (1998) found almost similar result reported that rhizome yield and plant growth of turmeric was increased consistently as the application rates of NPK were increased and all treatments significantly increased yield and yield components compared to the control.

Table 4: Effect of fertilizers on weight of rhizome per plant of turmeric at different DAPs

Treatment	Rhizome fresh wt./plant (g)			Rhizome dry wt/plant (g)		
	120 DAP	180 DAP	240 DAP	120 DAP	180 DAP	240 DAP
T ₁	47.71 d	54.14 d	85.79 d	4.683 c	6.493 b	12.17 b
T ₂	50.73 c	67.51 c	105.3 c	5.333 b	9.993 a	12.60 b
T ₃	54.61 a	76.32 a	109.2 a	6.650 a	10.10 a	15.93 a
T ₄	54.10 b	70.27 b	108.1 b	6.377 a	10.05 a	15.50 a
LSD (0.05)	0.4934	0.6978	1.070	0.5133	0.1998	0.6027

4.1.10 Rhizome dry weight

The highest rhizome dry weight per plant was recorded in T₃ (6.65, 10.1 and 15.93g at 120, 180 and 240 DAPs, respectively). T₄ produced statistically similar rhizome dry weight per plant to T₃ at all sampling dates and the values were 6.37, 10.05 and 15.5g at 120, 180 and 240 DAPs, respectively. The lowest dry weights were found in T₁ (4.68, 6.49 and 12.17g at 120, 180 and 240 DAPs, respectively).

4.1.11 Fresh yield

Fresh yield was significantly influenced by the treatments (Appendix IV). Significantly the highest fresh yield was found in T₃ (10.36, 13.32 and 42.40tons at 120, 180 and 240 DAPs, respectively) followed by T₄ (10.13, 13.19 and 40.70tons at 120, 180 and 240 DAPs, respectively). Significantly the lowest fresh yields at different sampling dates were found in T₁ (8.80, 10.28 and 29.17tons, respectively). Mehla *et al* (1997) reported that the yield attributes of *Colocasia esculenta* viz. number of leaves, number of corms, and weight of corms per plant and corn yield (q/ha) were increased significantly with each successive increase in fertilizer up with to N₁₀₀ P₅₀ whereas plant height was increased up to the highest dose of fertilizer (N₁₅₀ P₇₅). Almost similar result was found by patra (1998) in turmeric. He reported that highest yield were recorded with N: P: K at 90: 60:90 (25.5 t/ha) followed by 120: 60: 90 (25.0 t/ha) and 90: 30: 60 kg/ ha (24.5 t/ha). Relatively better yield of turmeric in T₃ might be due to better photosynthetic efficiency and faster translocation of photosynthetes to the storage organ of under partial shade conditions. This might be achieved due to soil amendment. The treatment T₄ failed to result the highest yield; which was a primary assumption. So, extra chemical fertilizers in acid soil under partial shade conditions might not be suitable for maximizing the yield of turmeric.

4.1.12 Dry yield

The highest dry yield was found in T_3 (1.98, 2.80 and 7.59tons at 120, 180 and 240 DAPs, respectively) followed by T_4 . Again T_4 produced statistically similar dry yield to T_3 at 120 and 240 DAPs except the dry yield at 180 DAP. The values were 1.86 and 7.52tons at 240 DAP. T_2 also produced similar yield to T_3 and T_4 . The lowest dry yields of different sampling dates were found in T_1 (1.20, 2.13 and 5.28tons, respectively).



Plate 10 : Sample turmeric for dry Weight



Plate 11 : Sample turmeric for dry Weight

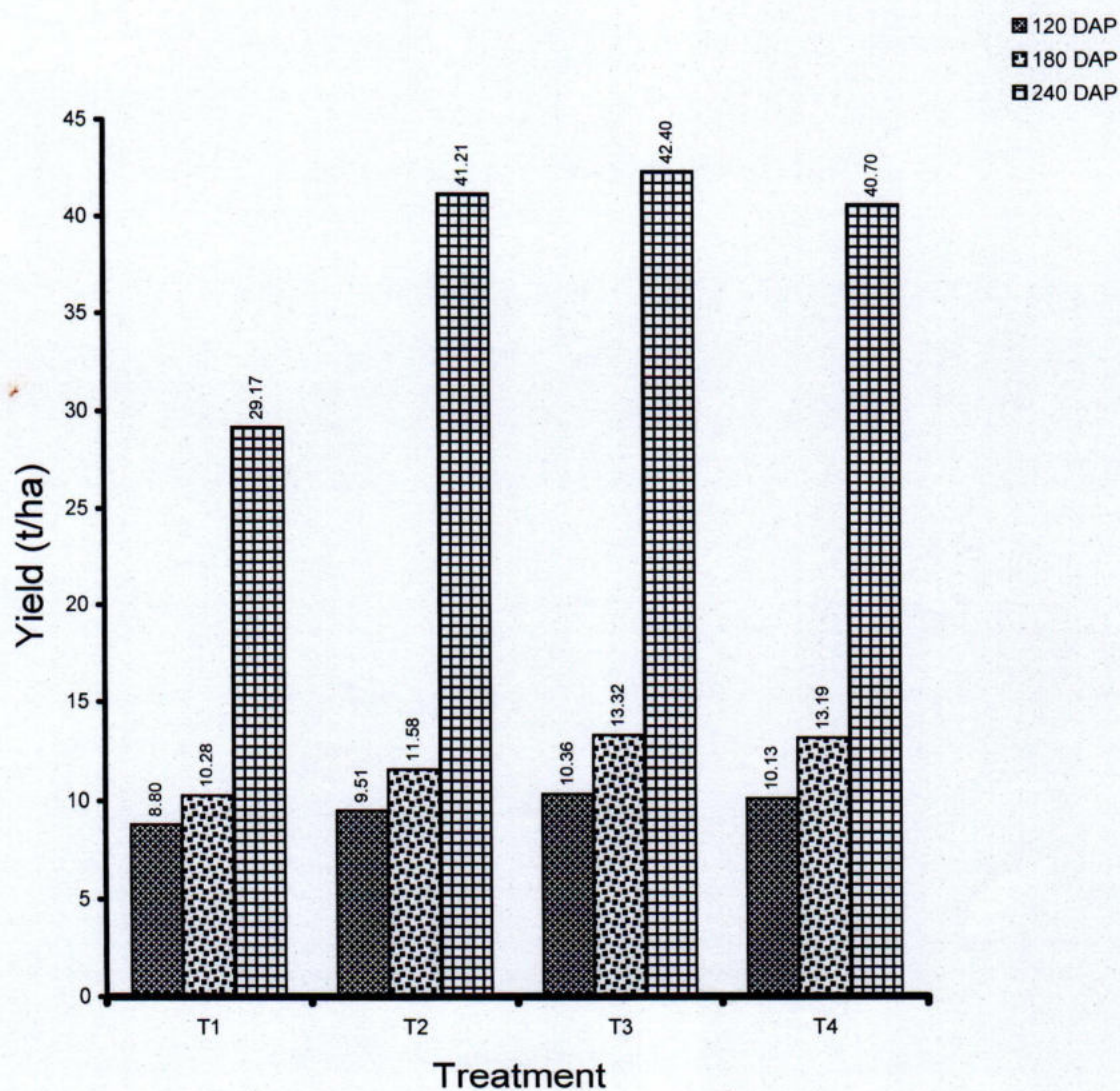


Fig: 1 Effect of fertilizers on fresh yield of turmeric

T₁: No fertilizer

T₂: Cowdung @ 10 t/ha

T₃: T₂ +Dolochoon@ 240 kg/ha

T₄: T₃+ Recommended doses of NPKSZn

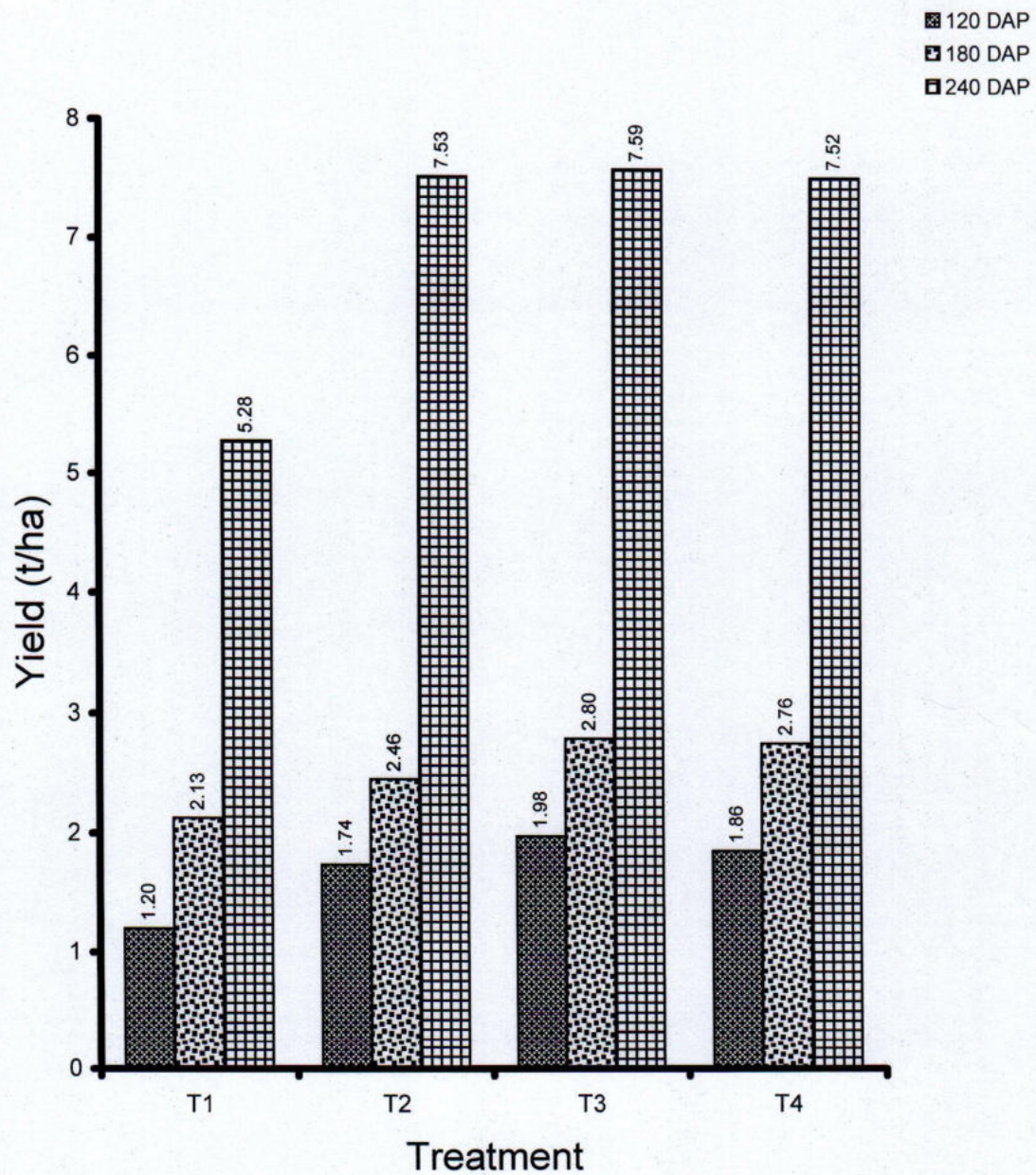


Fig:2 Effect of fertilizers on dry yield of turmeric

T₁: No fertilizer

T₂: Cowdung@ 10 t/ha

T₃: T₂ +Dolochoon @ 240 kg/ha

T₄: T₃+Recommended doses of NPKSZn

EXPERIMENTS WITH GINGER

4.2.1 Plant height

Plant height varied significantly due to the treatments used (Table 5). The tallest plant (61.33 and 87.39cm) was recorded in T_4 at the 120 and 180 DAPs, respectively followed by T_3 (54.95 and 64.19cm). On the contrary, significantly the shortest plants (45.63 and 50.89cm) were observed at the 120 and 180 DAPs, respectively in T_1 . However, moderate plant height was recorded in the treatment T_2 . The vegetative height was also found by the IIRS kerala (2001).

Table 5: Effect of fertilizers on Plant height, number of leaf per plant and number of tiller per plant of ginger at different DAPs

Treatment	Plant height (cm)		Number of leaf/plant		Number of tiller/plant	
	120 DAP	180 DAP	120 DAP	180 DAP	120 DAP	180 DAP
T_1	45.63 d	50.89 d	42.35 d	70.62 d	3.09 d	5.46 d
T_2	51.60 c	57.95 c	61.20 c	112.00 c	5.24 c	8.24 c
T_3	54.94 b	64.19 b	67.12 b	140.00 b	5.69 b	11.02 b
T_4	61.33 a	87.39 a	75.43 a	207.20 a	6.26 a	15.03 a
LSD (0.05)	0.8686	0.6686	4.608	3.507	0.1672	0.5721

4.2.2 Number of leave

Significantly the highest number of leaves per plant was found in T_4 at both the 120 and 180 DAPs (75.43 and 207.20 respectively) followed by T_3 (67.12 and 140.00 respectively). On the other hand, significantly the lowest number of leaves per plant was found in T_1 at both 120 and 180 DAPs (42.35 and 70.62, respectively).



Plate-12: Vegetative phase of ginger at 120DAP (T_1)



Plate-13: Vegetative phase of ginger at 120DAP (T_2)



Plate-14: Vegetative phase of ginger at 120DAP (T_3)



Plate-15: Vegetative phase of ginger at 120DAP (T_4)



4.2.3 Number of tiller

Number of tiller per plant varied significantly by the treatments (Table 5). Significantly the highest number of tillers per plant i.e. 6.26 and 15.03 was recorded in T₄ at the 120 and 180 DAPs, respectively followed by T₃ (5.69 and 11.02). On the contrary, significantly the lowest number of tillers per plant was recorded in T₁ (3.09 and 5.46 at 120 and 180 DAPs, respectively). Patra (1998) reported that growth parameter in case of turmeric was increased consistently as the application rates of N,P and k was increased.

Table 6: Effect of fertilizers on number of finger and finger weight per plant of ginger at different DAPs

Treatment	Number of finger/plant			Finger fresh wt./plant (g)			Finger dry wt./plant (g)		
	120 DAP	180 DAP	240 DAP	120 DAP	180 DAP	240 DAP	120 DAP	180 DAP	240 DAP
T ₁	6.630 d	8.087 d	10.83 d	51.13 c	66.39 c	133.3 c	3.103 c	3.893 c	7.167 c
T ₂	8.347 c	14.44 c	16.68 c	66.80 b	161.0 b	181.0 b	3.753 b	15.23 b	17.45 b
T ₃	9.947 b	16.92 b	23.84 b	90.90 a	198.2 a	244.6 a	5.520 a	20.48 a	25.88 a
T ₄	10.79 a	29.09 a	40.03 a	91.09 a	198.5 a	246.7 a	5.537 a	21.21 a	26.18 a
LSD (0.05)	0.5471	0.7092	0.7502	0.2963	1.139	2.714	0.3684	0.7941	0.4894

4.2.4 Number of finger

Number of finger per plant is an important yield contributing parameter. There were significant variations due to the effects of fertilizer doses on number of fingers per plant (Table 6). Significantly the highest values of number of fingers were found in T₄ at all sampling dates (10.79, 29.09 and 40.03 at 120, 180 and 240 DAPs, respectively) followed by T₃ (9.94, 16.92 and 23.84 at 120, 180 and 240 DAPs, respectively). Significantly

the lowest number of fingers per plant was found in T_1 at all sampling dates and the values were 6.63, 8.08 and 10.83 at 120, 180 and 240 DAPs, respectively.

4.2.5 Finger fresh weight

The highest finger fresh weight per plant was 91.09, 198.5 and 246.7g at 120, 180 and 240 DAPs, respectively (Table 6) in T_4 followed by T_3 (90.90, 198.2 and 244.6g at 120, 180 and 240 DAPs, respectively). T_3 and T_4 produced statistically similar finger fresh weight at all sampling dates. Significantly lowest finger fresh weight per plant (51.13, 66.39 and 133.3g at 120, 180 and 240 DAPs, respectively) was found in T_1 .

4.2.6 Finger dry weight

Finger dry weight per plant was significantly influenced by different treatments (Table 6). The highest finger dry weight per plant was 5.53, 21.21 and 26.18g at 120, 180 and 240 DAPs in T_4 followed by T_3 (5.52, 20.48 and 25.88g at 120, 180 and 240 DAP, respectively). T_3 and T_4 produced statistically similar finger dry weight at all the sampling dates. Significantly the lowest finger dry weight per plant were 3.10, 3.89 and 7.16g at 120, 180 and 240 DAPs, respectively was found in T_1 .

4.2.7 Rhizome fresh weight

The highest rhizome fresh weight per plant were 23.92, 42.30 and 45.14g at 120, 180 and 240 DAPs in T_4 , was statistically identical and followed by T_3 (23.54, 41.09 and 44.98g at 120, 180 and 240 DAPs, respectively). The lowest rhizome fresh weight per plant was 17.73, 17.44 and 29.94g at 120, 180 and 240 DAPs, respectively in T_1 , which was identical to T_2 (Table 7). Thakur et al. (1997) found almost similar result reported that N and p

fertilizer rates on ginger yield and nutrient uptake N and p rates up to 100 kg N and 60 kg p_2O_5 /ha significantly increased rhizome yield of ginger.

Table 7: Effect of fertilizers on weight of rhizome per plant of ginger at different DAPs

Treatment	Rhizome fresh wt./plant (g)			Rhizome dry wt./plant (g)		
	120 DAP	180 DAP	240 DAP	120 DAP	180 DAP	240 DAP
T ₁	17.73 b	17.44 b	29.94 b	2.293 b	2.713 d	3.103 c
T ₂	18.10 b	18.42 b	30.12 b	2.413 b	3.320 c	3.753 b
T ₃	23.54 a	41.09 a	44.98 a	4.893 a	7.320 b	5.520 a
T ₄	23.92 a	42.30 a	45.14 a	5.030 a	7.790 a	5.537 a
LSD (0.05)	0.4045	1.236	0.2825	0.3222	0.4045	0.3684

4.2.8 Rhizome dry weight

The highest rhizome dry weight per plant was 5.03, 7.79 and 5.53g at 120, 180 and 240 DAPs, respectively in T₄ followed by T₃ (4.89, 7.32 and 5.52 gm at 120, 180 and 240 DAPs, respectively). Except the value of 180 DAP other two sampling dates produced statistically similar dry rhizome. The lowest rhizome dry weight per plant (2.29, 2.71 and 3.10g at 120, 180 and 240 DAPs, respectively) was found in T₁. Except the value of 120 DAP, other two sampling dates produced significantly different rhizome dry weight per plant with T₂. Aiyadurai (1966) reported that N fertilization of the crop with 50 to 100 kg N/ha significantly increased yield by 18 to 32 percent and improved the dry matter content of rhizome.

4.2.9 Fresh yield

Yield recorded as per plant was also expressed to ton/ha. Fresh yield was significantly influenced by treatments (Appendix V). The highest fresh yield was found in T₄ (10.57, 21.72 and 26.37 ton at 120, 180 and 240 DAPs, respectively) followed by T₃ (10.18, 21.54 and 26.15 tons at 120, 180 and 240 DAPs, respectively). Significantly the lowest fresh yield of different sampling dates was found in T₁ (6.01, 7.54 and 13.60 tons, respectively). T₃ and T₄ produced statistically similar fresh yield at all the sampling dates. T₂ produced 7.63, 17.64 and 20.05 tons/ha at 120, 180 and 240 DAPs, respectively which was significantly different from T₁ and T₃. IISR studied on nutrient requirement of ginger in Wynaad, Kerala. They found the positive effect of higher dose of nutrient on the yield of ginger. Among the 16 levels of N and K, three combinations viz, 150 kg N, 50 kg K, 150 kg N, 100 kg K and 150 kg N, 150 kg K/ha were found to be significantly superior with respect to yield. The optimum dose of N and K was quadratic equation as 144 kg and 109 kg/ha, respectively (Anon.2001).

4.2.10 Dry yield

It was also influenced by the treatments and the influence pattern was quite identical to fresh yield of rhizome (Appendix V). The highest dry yield was found in T₄ (0.95, 2.61 and 3.19 ton at 120, 180 and 240 DAPs, respectively) followed by T₃ (0.94, 2.50 and 3.13 ton at 120, 180 and 240 DAPs, respectively). Significantly the lowest dry yields of rhizome at different sampling dates were found in T₁ (0.49, 0.59 and 0.92 tons, respectively).

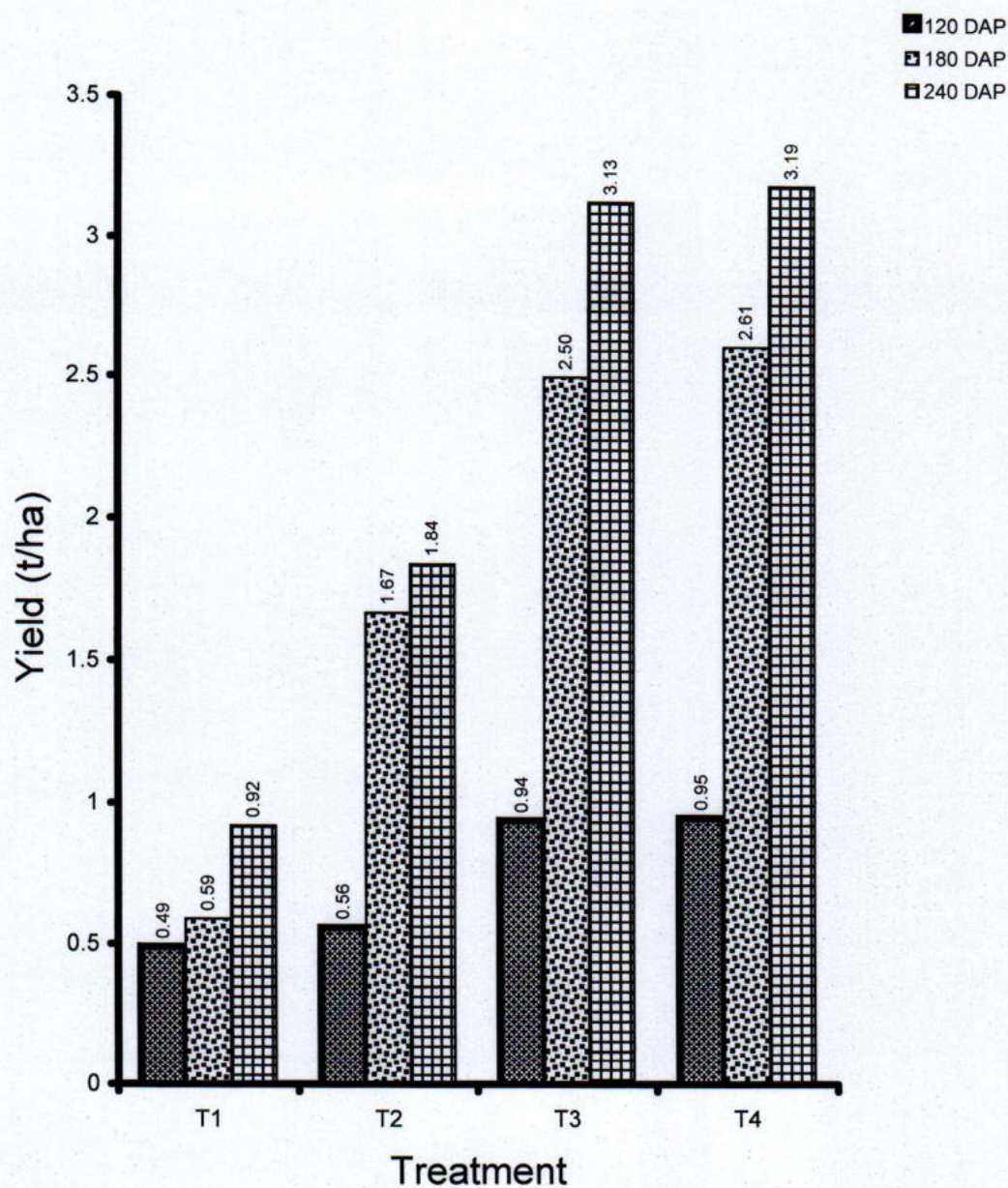
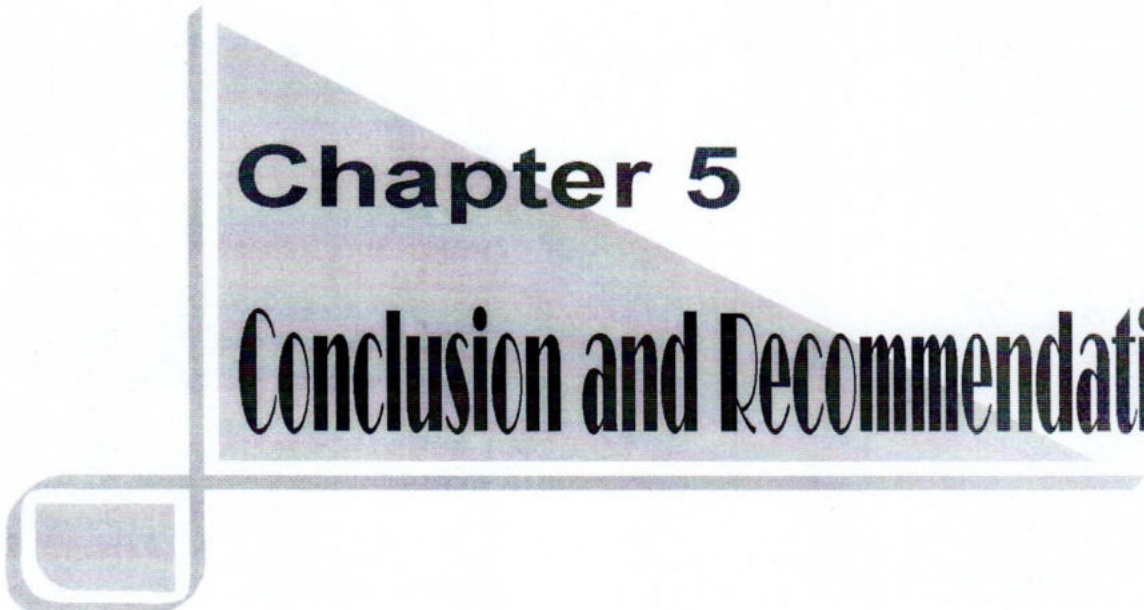
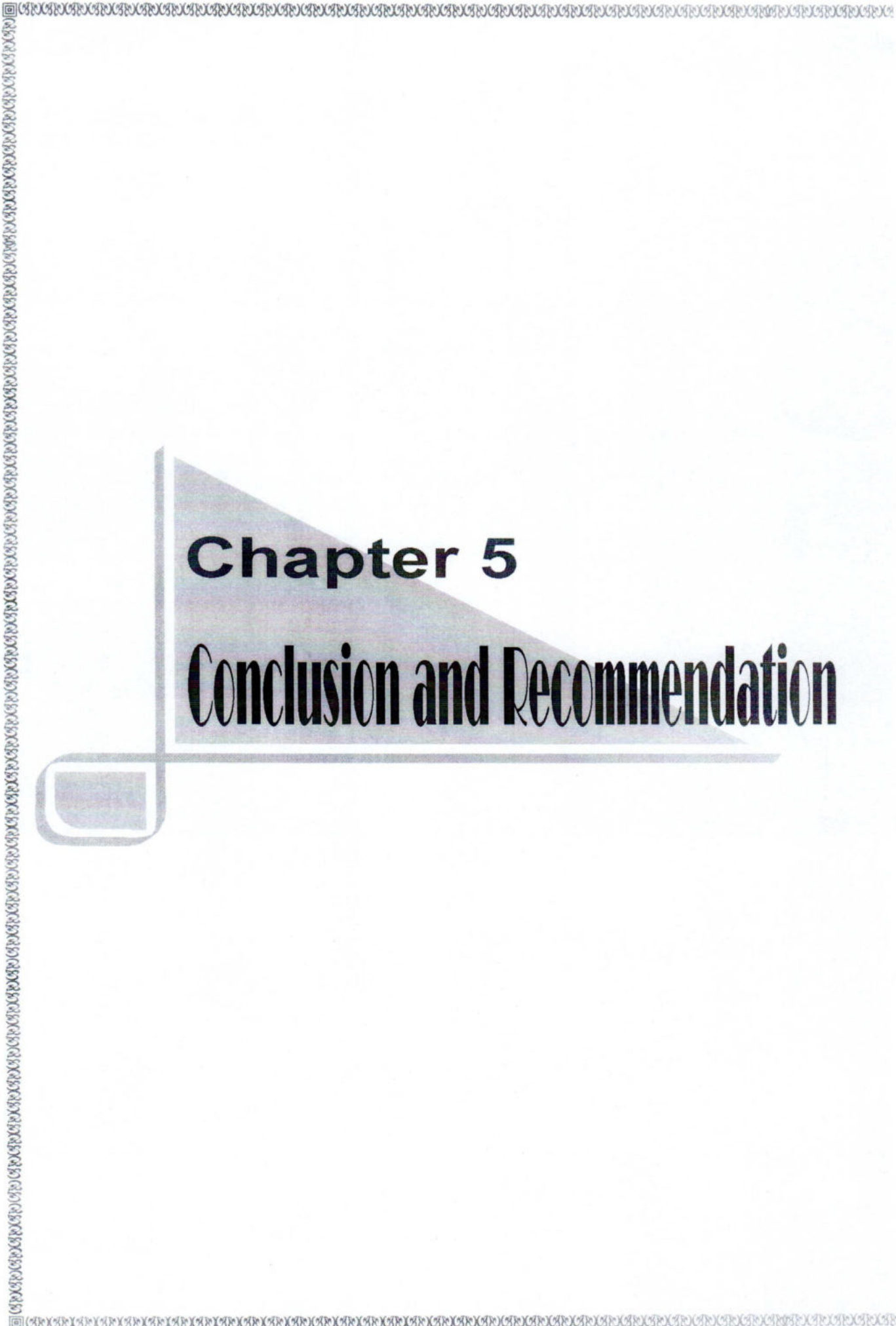


Fig:4 Effect of fertilizers on dry yield of ginger

T₁: No fertilizer
T₂: Cowdung @ 10 t/ha
T₃: T₂+Dolochoon @ 240 kg/ha
T₄: T₃+Recommended doses of NPKSZn



Chapter 5

Conclusion and Recommendation

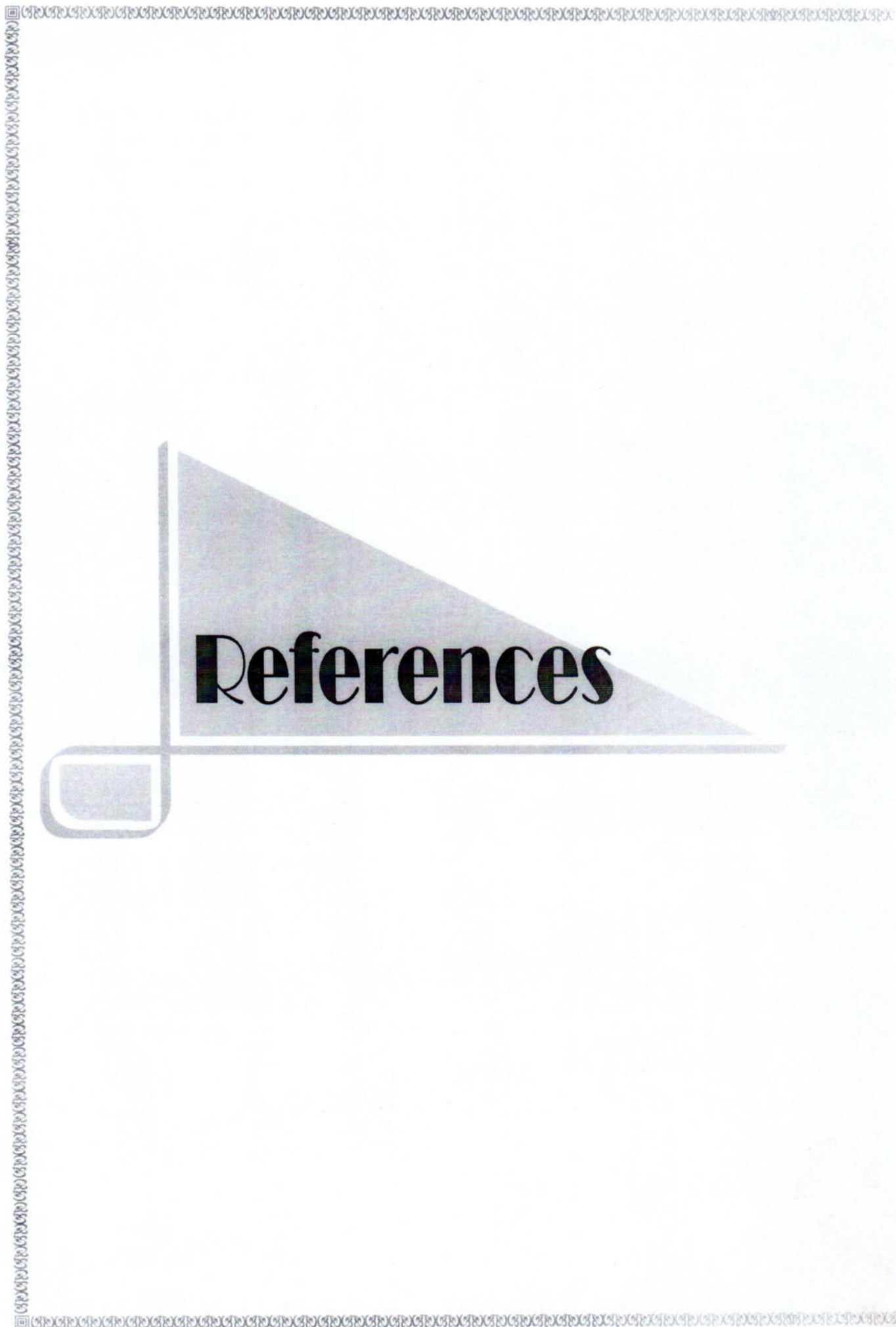
CHAPTER 5

CONCLUSION AND RECOMMENDATION

Almost all the vegetative parameters of turmeric and ginger gradually increased with the increase in fertilizer elements at all the sampling dates. In case of yield contributing characters and yield of turmeric was found highest from the treatment of cow dung and dolochoon (T_3). In case of ginger all the yield contributing characters and yield gradually increased with the increased of fertilizer element all though treatment T_3 (cow dung + Dolochoon) produced statistically similar yield to that of T_4 (recommended fertilizers + cow dung + Dolochoon).

The study revealed that for maximum yield of turmeric from such an agroforestry system, Dolochoon could be applied with cow dung. But application of chemical fertilizer might be harmful. On the other hand, chemical fertilizer with Dolochoon and cow dung may be the cause of higher yield of ginger though cow dung and Dolochoon produced statistically similar yield.

However, the study should be standardized through trials and errors under similar conditions at different orchards and at different places before using it on commercial basis.



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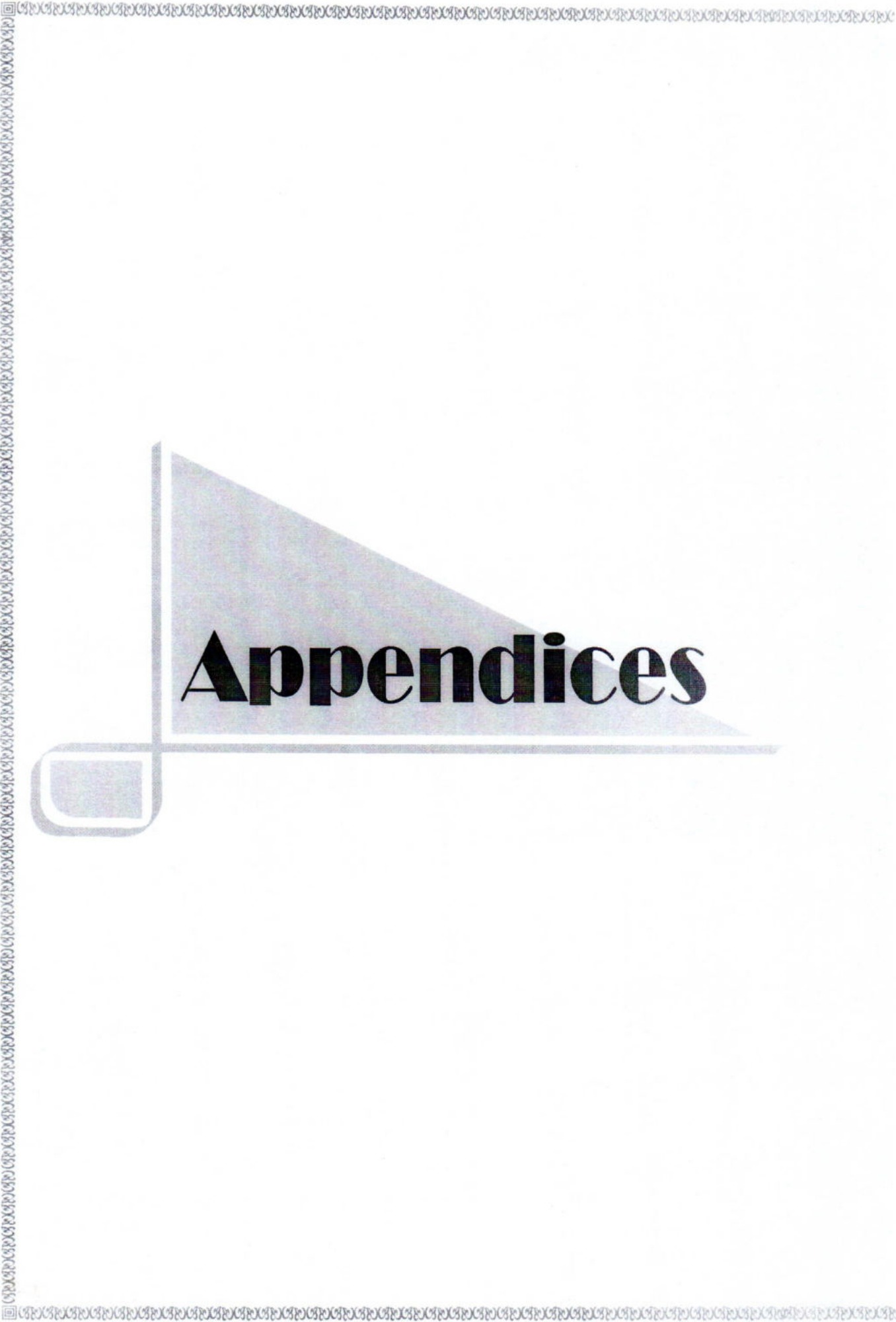
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Appendices

APPENDIX

Appendix I. Monthly average light intensity during May to December 2005

Month	Date	Light intensity at different time of the day (LUX)			Total light intensity (LUX)	Average light intensity (LUX)	Monthly mean light intensity (LUX)
		10.00 AM	12.00 AM	4.00 PM			
May	8.5.05	32200	38300	33100	103600	34533	34499
	15.5.05	30600	33500	30000	94100	31366	
	22.5.05	38200	42300	37600	118100	39366	
	29.5.05	31200	33700	33300	98200	32733	
June	6.6.05	36200	37600	35700	109500	36500	28891
	13.6.50	29700	37200	32400	99300	33100	
	20.6.05	22000	23200	22600	67800	22600	
	27.6.05	23800	24700	21600	70100	23366	
July	4.7.05	30200	33300	22800	86300	28766	40191
	11.7.05	42200	47300	41600	131100	43700	
	18.7.05	38800	47700	40100	126600	42200	
	25.7.05	40700	56200	41400	138300	46100	
August	01.8.05	41100	50800	42200	134100	44700	44624
	8.8.05	40700	48100	43300	132100	44033	
	15.8.05	41000	50200	40900	132100	44033	
	29.8.05	42200	52000	43000	137200	45733	
September	5.9.05	41400	49900	43200	134500	44833	41291
	12.9.05	40500	47600	39700	127800	42600	
	19.9.05	39200	45100	38500	122800	40933	
	26.9.05	36400	42200	36600	115200	38400	
October	03.10.05	35900	41100	36000	113000	37666	36383
	17.10.05	35200	40000	33600	108800	36266	
	24.10.05	34900	39600	33800	108300	36100	
	31.10.05	34700	38600	33200	106500	35500	
November	7.11.05	34100	37500	35900	107500	35833	34116
	14.11.05	33600	36300	34000	103900	34633	
	21.11.05	33100	35500	31400	100000	33333	
	28.11.05	32500	34700	30800	98000	32666	
December	5.12.05	39300	31700	28200	99200	33066	30266
	12.12.05	37200	30500	28000	95700	31900	
	20.12.05	28600	30300	27600	86500	28833	
	29.12.05	27500	28200	26100	81800	27266	

Source: Department of Agroforestry, records of light intensity observation, HSTU

Appendix II: Distribution of monthly average temperature, relative humidity, total rainfall of the experiment site during the period from April to December 2005

Month	Air temperature ($^{\circ}\text{C}$)		Relative humidity (%)	Total rainfall (mm)
	Max.	Min.		
April	32.8	21.1	83	54
May	13.9	21.5	77	213
June	33.2	23.2	82	333
July	32.0	25.8	85	369
August	32.4	26.2	84	466
September	32.0	25.0	89	97
October	31.6	21.0	90	0
November	27.5	15.5	72	0
December	26.6	11.9	85	0

Source: Weather Yard, Wheat Research Center, Dinajpur.

**Appendix III: Analytical results of the soils of the experimental plot
before cropping with turmeric and ginger**

A) Physical parameters

Constituents	Results (%)
Sand	62
Silt	25
Clay	13
Texture	Sandy loam

B) Chemical properties

Soil properties	Analytical level
pH	5.0
Organic matter content (%)	1.00
Total N (%)	0.06
Available P ($\mu\text{g/gm}$ soil)	29.35
Available K (meq/100gm soil)	0.21
Sulphur ($\mu\text{g/gm}$ soil)	6.13
Boron ($\mu\text{g/gm}$ soil)	0.27
Zinc ($\mu\text{g/gm}$ soil)	0.73

Source: Regional Laboratory, Soil Resource Development Institute (SRDI),
Dinajpur

Appendix IV: Effect of fertilizers on yield of turmeric at different DAP

Treatment	Fresh yield (t/ha)			Dry yield (t/ha)		
	120 DAP	180 DAP	240 DAP	120 DAP	180 DAP	240 DAP
T ₁	8.80 d	10.28 d	29.17 c	1.20 c	2.13 d	5.28 b
T ₂	9.51 c	11.58 c	41.21 b	1.47 b	2.46 c	7.53 a
T ₃	10.36 a	13.32 a	42.40 a	1.98 a	2.80 a	7.59 a
T ₄	10.13 b	13.19 b	40.70 b	1.86 a	2.76 b	7.52 a
LSD (0.05)	0.1413	0.06318	0.6834	0.1264	0.0199	0.4512

Appendix V: Effect of fertilizers on yield of ginger at different DAP

Treatment	Fresh yield (t/ha)			Dry yield (t/ha)		
	120 DAP	180 DAP	240 DAP	120 DAP	180 DAP	240 DAP
T ₁	6.013 c	7.543 c	13.60 c	0.49 c	0.59 c	0.92 c
T ₂	7.637 b	17.64 b	20.05 b	0.56 b	1.67 b	1.84 b
T ₃	10.18 a	21.54 a	26.15 a	0.94 a	2.50 a	3.13 a
T ₄	10.57 a	21.72 a	26.37 a	0.95 a	2.61 a	3.19 a
LSD (0.05)	0.4728	0.2278	0.7368	0.0199	0.1094	0.0631

