PRODUCTION POTENTIALITY OF MARIGOLD (*Tagetes erecta*) IN DIVERSE PRODUCTION SYSTEMS

A THESIS

By

SHUVO SAHA

Student ID: 1701338

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MASTER OF SCIENCE

IN

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DEPARTMENT OF AGROFORESTRY AND ENVIRONMENT

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

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TO

MY BELOVED PARENTS

CERTIFICATE OF DECLARATION

*I affirm that the research work, presented in this thesis entitled "**PRODUCTION POTENTIALITY OF MARIGOLD (Tagetes erecta) IN DIVERSE PRODUCTION SYSTEMS**" is solely my own work and has not been submitted for any previous academic degree. Any direct quotations used in this thesis have been appropriately cited with quotation marks, and all sources of information have been duly acknowledged through references to the respective authors.*

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PRODUCTION POTENTIALITY OF MARIGOLD (*Tagetes erecta*) IN DIVERSE PRODUCTION SYSTEMS

ABSTRACT

Marigold cultivation is now a profitable enterprise for farmers, but the socioeconomic data and information on this flower are very scarce in Bangladesh. Beyond their aesthetic appeal, these humble flowers carry a profound cultural significance in various societies. Therefore, the study was conducted to identify agronomic practices and analyze relative profitability and input-output at the experimental area of the Department of Agroforestry and Environment, Hajee Mohammad Danesh Science and Technology University, from 2023-24. The experiment was laid out in a single factor Randomized Completely Block Design (RCBD) having three treatments with three Replicationons viz. T_1 multistoried agroforestry (Litchi+Marigold+Bottle Gourd), T_2 intercropping system (Marigold+Bottle Gourd) and T_3 (Sole cropping of Marigold). The growth parameters (plant height, leaf number, number of bud) and yield parameters (flower number, flower size and total yield) of marigold were collected throughout the study period at different harvesting intervals. Moreover, data on litchi and bottle gourd production were also recorded. The results of this study revealed the most favorable growth characteristics and yield outcomes are obtained when cultivating marigold in intercropping with bottle gourd (T_2) and marigold sole cropping (T_3). The yield of marigold flower number was highest (12,00,000 ha^{-1}) in marigold sole cropping followed by in intercropping with bottle gourd (10,40,000 ha^{-1}). The yield reduction in marigold intercropping and agroforestry system was 13% and 26% respectively. The Benefit-Cost Ratio (BCR) was maximum in bottle gourd sole cropping (2.96); almost similar to marigold intercropping (2.21) and in multistoried agroforestry systems (2.17). The LER values of 2.64 for Litchi+Bottle Gourd+Marigold and 1.69 for Bottle Gourd+Marigold highlight their respective efficiencies in utilizing resources, yielding 2.64 and 1.69 times more per unit area than monocropped counterparts. These findings underscore the economic and ecological benefits of practicing multistoried agroforestry system for farmers, demonstrating its potential to optimize land use, increase productivity, and enhance agricultural sustainability.

Keywords: Marigold, Multistoried Agroforestry, Intercropping, BCR, LER, Economic feasibility

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ABBREVIATIONS

AEZ	: Agro-Ecological Zone
AGF	: Agroforestry
BARI	: Bangladesh Agricultural Research Institute
BBS	: Bangladesh Bureau of Statistics
BCR	: Benefit Cost Ratio
BG	: Bottle Gourd
cm	: Centimeter
DAT	: Days After Transplanting
Fert.	: Fertilizer
g	: Gram
GR	: Gross Return
IBL	: Interest on Bank Loan 8% of TIC
IPC	: Initial Planting Cost
IR	: Irrigation
IVL	: Interest on Value of Land 8% of TIC
K	: Potassium
Kg	: Kilogram
LER	: Land Equivalent Ratio
m	: Meter
MC	: Maintenance Cost
Misc. Cost	: Miscellaneous Cost
MoP	: Muriate of Potash
N	: Nitrogen
NMIC	: Non Input Material Cost
NR	: Net Return
OC	: Overhead Cost 5% of TIP
P	: Phosphorus
Pest	: Pesticide
R.BG	: Bottle Gourd Return
RCBD	: Randomized Complete Block Design
TCP	: Total Cost of Production
tha	: Ton Per Hector

TIC	: Total Input Cost
Tk/tk	: Taka
TMIC	: Total Material Input Cost
TNMIC	: Total Non-Input Material Cost
TSP	: Triple Super Phosphate

CHAPTER I

INTRODUCTION

The predicted growth in world population from 7.4 billion (in 2017) to 9.7 billion in 2050 (UN, 2019) has drawn a lot of attention as a factor influencing global food demand (Fukase & Martin, 2020). Between 2010 and 2050, worldwide food demand is predicted to rise by 35% to 56%, while the number of people in danger of hunger is expected to rise. Weather fluctuations, including temperature, extreme water dearth and flood-inducing precipitation in the next couple of years, have been predicted to continue to impact Bangladesh's agriculture (Shahid et al., 2016; Rahman et al., 2023). Therefore, the perception regarding monocropping systems to provide high production the food shortage problem under the changing climate scenario has been dramatically changed. The development of agroforestry as a viable use of land has been especially emphasized in developing countries like Bangladesh because of its numerous positive contributions (Das et al., 2020; Das et al., 2022). Moreover, agroforestry would be a feasible choice in this regard because it provides several benefits like food supply, employment and income generation, investment incentives and ecosystem services (Lasco et al., 2014). Agroforestry is an advanced farming method that vastly improves production per unit area per unit time through maximizing the usage of natural resources (FAO, 2008; Smith, 2010). It is a practical and inexpensive way of incorporating multiple forms of coordinating land usage through combining trees and crops in the same area, particularly for small-scale farmers. It is found to be one of the appropriate means of achieving sustainable production without causing any environmental destruction (Wilson and Lovell, 2016). It brings prosperity for millions of farmers contributing to extra profits, employment, improved food, and nutrition security (Beedy et al., 2013; Estruch et al., 2013; Waldron et al., 2017). However, farmers understand that the initial stage of fruit orchards does not carry economic gains until the tree starts to produce fruit. The barren field of the orchard (up to five to six years) may be extensively utilized for planting seasonal crops (Gill and Bisaria, 1995; Lojka et al., 2021). In this system, trees and agricultural crops are combined and they compete for growth resources, including light, water and nutrients (Swieter et al., 2022).

Mango (*Mangifera indica*), guava (*Psidium guajava*), jujube (*Ziziphus jujuba*), litchi (*Litchi chinensis*), orange (*Citrus sinensis*) etc. are some of the fast-growing fruit trees that are well adapted for cultivation in farmers' fields due to tremendous nutritious benefits, improved demand in the market and affordable price (Rahman, 2021; Zaman and Marma, 2022; Abbas, 2023; Roy, 2023). The aforementioned fruit trees are profoundly grown throughout Bangladesh. The fruit species are predominantly planted in order to provide sufficient space within trees for growing short duration crops during the initial years. The vacant space between trees could be judiciously used for growing leguminous crops and vegetables. Even after the later stage of fruit tree growth (six to ten years), partial shade-loving vegetables and spices can also be grown.

Crop combination systems are, understandably, more demanding than the monoculture in terms of labour and capital and technical and managerial skills. Care and management of many crops where one or two grew before involve considerable amounts of technical knowledge and competence. Processing the various products and their marketing can also pose serious problems. The lack of possibilities for mechanization of various farm operations is another issue that is often cited as a disincentive to crop combination schemes, so the feasibility of such practices is seen as confined to small-scale farmers who usually undertake most of their farm operations manually.

The agricultural component of the agroforestry system has already revealed its great potential to meet the various needs of farmers and farm-based industries. Besides pulses, grains, medicinal and aromatic plants, floriculture is poised to play a significant role in the socioeconomic transformation of marginal lands into more productive agrarian economies.
Flower cultivation in agroforestry has opened up new research and development opportunities. Marigold is sold in the market as loose flowers or after making into garlands for floral decorations and floral arrangements. Other than cut flowers, marigold especially is used for beautification as a pot plant and also used in landscape plans due to its variable height and colour of flowers. It is highly suitable as a bedding plant, in a herbaceous border and is also ideal for newly planted shrubberies to provide colour and fill the spaces. Both leaves and flowers are equally important from medicinal point of view. Flower extract is considered as blood purifier, a cure for bleeding piles and is also a good remedy for eye diseases and ulcers.

Vegetables provide all the nutrient components like carbohydrates, protein, fat, vitamins, minerals, dietary fiber, and water and dietary fiber, which are essential constituents of a balanced diet. The supply of nutrient components through a balanced diet is more effective than supplementation through synthetic vitamins and mineral tablets. Agroforestry is the integration of woody plants with herbaceous plants to derive both economic and ecological benefits. Furthermore, intercropping of annuals in timber trees compared with sole tree woodlots may offer the advantages of reduced tree establishment costs, income generation during the unproductive phase of the trees and efficient use of natural and input resources. In this context, mixing of both the components (vegetables and trees) is essential, profitable and additional income generation up to the productive phase of the tree. This kind of promotion of agroforestry will help in meeting the basic needs of the farmers on a sustainable basis besides halting environmental degradation (Thapa et al., 1989).

Furthermore, because of their edaphic-climatic ability to adapt, litchis are a more popular fruit in the northern part of Bangladesh, especially in the Dinajpur region. Consequently, we ought to develop scientific studies and procedures to benefit cultivators. Considering this, we intend to investigate multistoried agroforestry systems based on litchi to identify the most suitable crop for the various levels and the system's economic feasibility. Hence, using appropriate local techniques, initiatives were made to encourage the growth of litchi trees with marigold flowers and bottle gourds.

Therefore, the present investigation was carried out with the following

i. to quantify the production potentiality of marigold flower and bottle gourd under multistoried agroforestry system
ii. to identify the profitability of various production systems
iii. to calculate the land-use efficiency of different production systems

CHAPTER II

REVIEW OF LITERATURE

Commercial floriculture in Bangladesh is a new dimension in farming culture. Evidences from all civilizations reveal that mankind has historical interest in gardening and culturing flowers to satisfy aesthetic need. Bottle gourd (*Lagenaria siceraria*) is a popular winter vegetable in Bangladesh. It belongs to the family Cucurbitaceae. The climatic condition of winter in Bangladesh favors better growth and yield of bottle gourd as hot and humid summer coupled with summer rainy season gives considerable yield. The research work conducted so far in Bangladesh and abroad pertaining to present research study entitled "**PRODUCTION POTENTIALITY OF MARIGOLD (*Tagetes erecta)* IN DIVERSE PRODUCTION SYSTEM**" has been reviewed in this chapter under following heading:

2.1 Concept of Agroforestry

2.2 Fruit Tree-Based Agroforestry System in Bangladesh

2.3 Fruit Tree-Based Agroforestry System in World

2.4 Litchi tree-based agroforestry

2.5 Timber tree-based agroforestry

2.6 Economic Importance of fruit tree-based agroforestry System

2.7 Economic Importance of Marigold

2.1 Concept of Agroforestry

Agroforestry is a broad term that has been defined differently by various authors. From a perspective of bioeconomics, Agroforestry is a mixed agricultural and tree crop or tree farming system that helps farmers utilize their land more efficiently and generate a higher net economic return over time (Harou, 1983). "Agroforestry is a collective name for all land-use systems and practices where woody perennials are deliberately grown on the same land management unit with agricultural crops or animals in some form of spatial arrangement or temporal sequence" is A commonly used definition provided by the International Centre for Research in Agroforestry (Nair, 1984). Trees in agroforestry systems enhance soil fertility, raise atmospheric humidity, and preserve soil moisture (Shankarnaryan, 1984). In addition to the benefits derived from using trees for fuel and lumber, proper agroforestry makes use of the spaces between tree rows for crops, as noted by Saxena (1984). According to Lagemann

(1987), Bangladesh's cropland agroforestry system is crucial to the country's economy. This helps to generate additional revenue for farmers. It also does not negatively impact the growth and development of the trees. Agroforestry systems preserve and increase soil fertility. The integration of trees with annual crops is thought to enhance the chemical properties of the soil, which is a hypothesis in the agroforestry system (VonMaydell, 1987).

According to Nair's (1987) hypothesis, an agroforestry system can significantly increase soil fertility through the following means: (i) adding more organic matter to the soil through pruning, leaf litter, and other biomass; (ii) effectively recycling nutrients within the system; (iii) biologically fixing nitrogen dioxide (N2 in the case of leguminous shrubs and trees); and (iv) potentially enhancing interactions between related species due to variations in the root systems, canopy structures, and active zones of water and nutrient absorption. Over a long period, a variety of groups of people have practiced agroforestry in various ways under various conditions. These practices include dune fixing, bush following, taungya, alley cropping, green hedge and fences, afforestation blocks, protein banks, use of woody perennials for shelter, conservation of soil and water, homestead agroforestry, cattle under woody perennials, aqua forestry, api-silviculture, and many more (Torquaebian, 1990).

Agroforestry is a very old and traditional idea (Haque et al., 1996). One of the oldest agroforestry systems among them is the taungya (Haque et al., 1996). According to Agriculture and Agri-Food Canada (2006), agroforestry is an integrated system that manages rural land resources by combining trees with crops or livestock. The temporal and spatial scales of agroforestry systems vary from one system to the next. This implies that agroforestry techniques can be used intermittently or continuously throughout the year. It also encompasses the ability to perform a single practice or a combination of practices, which further influences the temporal scale. Since the trees can be planted in zones or mixtures, the arrangement of the trees within the system relates to the spatial scale.

In Ghana, agroforestry is gaining popularity as a resource-efficient and environmentally benign alternative to traditional land use practices (Owusu, 2002). Agroforestry is a system of land use that practically helps to materialize the desired goals in all of these areas. Due to the unparalleled benefits and ramifications of this land use system, agroforestry has recently attracted attention worldwide, including in India. The purpose and components of the agroforestry system determine these various spatial and temporal arrangements (Mosquera-Losada et al., 2009, McAdam et al., 2009). Typically, the production functions of tree components include fruit, nuts, oil, and timber as well as firewood, cork, and fodder for human consumption. The crop components are typically used to produce fodder, vegetables, fruit, grains, and seeds in addition to biomass feedstock (McAdam et al., 2009). Moreover, various objectives and advantages are highlighted because agroforestry is "part of a multifunctional working landscape" (Jose, 2009).

Agroforestry provides longer-term sustainability in addition to consistent productivity. Through its special method of improving the microclimate, it protects against the whims of the climate and reshapes the agroecosystem with greater stability and resilience (Sanjeev et al., 2012 and Nair, 2007).

2.2 Fruit Tree-Based Agroforestry System in Bangladesh

Islam et al., (2008) conducted an experiment to evaluate the performance of winter vegetables under Guava-Coconut based multistate system. The result revealed that significantly vigorous plant growth as well as tallest plants were found under reduced light level whereas maximum yield plot^{1} and yield ha^{1} were recorded under full sunlight condition.

Sayed et al., (2009) showed that highest production of vegetables was recorded in control condition (without tree) which was significantly similar with 3 and 4-feet distance from the tree base and the lowest was observed under one feet distance which was almost similar with 2 feet distance. The growth characteristics of Telsur are significantly influenced by the vegetables Khatun et al., (2009) showed similar results.

Islam et al., (2009) reported that morphological characteristics of winter vegetables, leaf length, leaf diameter, stem girth, fresh and dry weight decreased consistently with the decrease of distance from the tree. The growth characteristics of Hopesodorata was significantly influenced by all the three winter vegetables (red amaranth, stem amaranth & coriander).

Hasan (2014) evaluated the performance of Indian spinach and Okra in association with Lombu tree at different distance from tree base. Different distance from tree base treated as different treatment. The yield of Indian spinach in association with Lombu tree reduced 46.45%, 26.77% and 3.2% in 0.0-2.5 feet, 2.5-5.0 feet and 5.0-7.5 feet distant area, respectively. Similarly, the yield of okra along with Lombu tree reduced 14.20%, 7.15% and 1.73% in 0.0-2.5feet, 2.5-5.0feet and 5.0-7.0 feet distant area, respectively.

Mahmudul (2012) conducted an experiment to find out the performance of chili under different orientation (i.e., North, South, East & West) from akashmoni tree. Among the morphological parameter of chilli, plant height, diameter of plant, no. of leaves plant, standard leaf length, leaf diameter, no. of fruits plant, and yield of chili (t/ha) were decreased as competition increased in association of akashmoni.

Rahman (2013) evaluated the growth performance of two winter crops viz. mustard and sweet gourd grown under 2 years Akashmoni tree saplings of 4 different distances viz. 0 (open field), 2, 4 and 6 feet distant from tree sapling bases. Among the different morphological characteristics of winter crops plant height, length of branch, no. of siliqua per branch, length of siliqua, vine length, fruit length, number of fruits, and fruit diameter increased consistently with the increase of distance from sapling. The growth characteristics of Akashmoni (Acacia auriculiformis) significantly influenced by the interaction of the crops. The shortest tree was found under tree-mustard combination. In the view of tree height, the better tree-crop combination was found from tree-sweet gourd because of the lower competition for nutrient, water and light.

Ahmed et al., (2013) conducted an experiment to evaluate the effect of Akashmoni tree on the growth and yield of Kankong and Jute vegetable. The Kankong and jute yield was gradually increased with increasing distance from Akashmoni tree base. However, the vegetable yield had reduced remarkably at 5 feet distant from tree base. Both Kankong and Jute successfully cultivate along with 2 years old Akashmoni tree without significant yield loss.

A field experiment was conducted by Farhana et al., (2013) for evaluating the growth performance of Spinach grown under 5 years old Lohakat tree saplings of 4 different distances viz. open field, 0-0.5m, 0.5-1.0m and 1.0-1.5m distant from tree sapling bases. Yield as vegetable was highest in open field condition was 2.5, 15.18 and 24.98% lower in 1.0-1.5m, 0.5-1.0m and 0-0.5m distance area from Lohakat tree base, respectively. Seed yields remarkably reduced in the near area of Lohakat tree, and it was 37.06 and 69.30 % lower in 0.5-1.0m and 0-0.5m distance area from Lohakat tree base respectively.

Hasan et al., (2013) conducted an experiment to evaluate the performance of radish and bitter gourd under eucalyptus trees. The morphological characters and yield contributing characters were increased gradually in treatments where distance was more from eucalyptus tree base. Similarly, fresh, and dry yield of bitter gourd was also higher in the control treatment whereas both yields viz. fresh and dry were statistically like that of the 100 cm distance from the tree base. Height and girth of Eucalyptus was also significantly influenced by the interaction with radish and bitter gourd where the highest increment of tree height (32.40 cm) and girth (1.80cm) was recorded under Tree-bitter gourd-based agroforestry system while the lowest increment of tree height (23.80 cm) and girth (1.40 cm) was found in without vegetable condition.

Rakib et al., (2013) studied the performance of radish in association with three fruit tree species during winter season. The result showed that yield of Radish association with Guava, Lemon and Mango as vegetables and seed production was gradually increased with increasing distance from the tree base. Both as vegetable and seed production of Radish in association of these three fruit trees are rank as Mango > Guava > Lemon. Growth of all fruit trees was observed as height and girth increment. Height and girth increment of mango, guava and lemon tree was little bit higher under control (without Radish) condition.

Rahman et al., (2010) According to Tomato performances were conducted at the Bangladesh Agricultural University's Germplasm Center using multi-layered agroforestry systems based on Amloki + Guava, Horitoki + Lemon, and Bohera + Lemmon because tomatoes can be grown in partial shade. The middle layer of the tomato was used to provide some shade and financial support.

Three medicinal plants were put to the test in an experiment at the Bangladesh Agricultural University's Horticulture Farm's multi-strated coconut orchard in Mymensingh. In a multi-stemmed agroforestry system (MSF) built on coconut trees, aloe vera (*Aloe indica*), asparagus (*Asparagus racemosus*), and misridana (*Kaempferia angustifolia*) were planted, along with guava and lemon for additional shade and benefit from March 2005 to March 2007 (Bari, 2012).

Miah et al., (2018). A jackfruit orchard was transformed into a multilayered agroforestry system between 2012 and 2013 to increase output using the effects of shade, with jackfruit trees maintained as the overstory and associated crops like papaya and eggplant grown as middle and lower-story crops, respectively. From March 2018 to December 2019, different crop combinations were used in multistage agroforestry practices in the South Char Kalibari, close to the Bangladesh Agricultural University in Mymensingh.

Ahmed et al., (2019). The lombu (*Khaya anthotheca*) tree, which is ten years old, was used in this study as a silvicultural component at the top layer, along with ginger, panchamukhi kachu, and turmeric as at the bottom layer, root crops were grown, the second layer's papaya plant was placed between the lombu trees, and the third layer's Chui jhal (*Piper chaba*) was grown as a vine crop on the lombu tree.

Riyadh et al., (2020). Multistorey agroforestry systems (MAFS), where different light intensities were observed, were created from Bangladeshi terrace ecosystem jackfruit orchards to evaluate the productivity, economic, and ecological performances of the system. Three spices, including turmeric, ginger, chili, and papaya, were grown as crops in the lower and middle storeys, respectively.

Ferdous et al., (2022). To screen how well different radish varieties perform in multistory agroforestry systems built on the aonla. In an experimental area of the Bangabandhu Sheikh Mujibaur Rahman Agricultural University, Gazipur, radish was grown alongside carambola and lemon as middle-layered crops and anola was already present.

2.3 Fruit Tree-Based Agroforestry System in World

The coconut based mixed species systems in the tropics often aim at improved resource capture through incorporating several trees and field crops. Productivity of palms and the associated tree components in such mixed systems are, however, known to vary in response to the tree characteristics, planting pattern/geometry and shade tolerance of the components. The effects of three fast growing trees (Vateriaindica, Ailanthus triphysa and Gevillearobusta) grown in association with coconut palms following two planting geometries (single row and double row), on the productivity of coconuts and growth of multipurpose trees were studied in Kerala, India, during 1992-96 by Kumar and Nandal (2004).

Miah, et al., (2001) found that Nicaraguan home gardens had 37% of their total space allocated to fruit producing species, on average; moreover, 85% of the fruits so produced were for home consumption and the remainder for marketing. When farmers in Jamaica were questioned as to the importance of trees, fruit was given as the second most important product following timber When considering competition effects with fruit trees, it is important to consider the multi-year nature of growth cycles and responses. For pear, it was shown 32 that N taken up at or after harvest was preferentially used during the following year for growth and fruiting (MacDicken et al., 1990).

Ding and Su (2010) reported that tree shading reduced the crop yield by 27 and 22% in western and eastern regions, respectively, and also, mean crop yield for western side was 23% lower than eastern side. The direct reason of yield variation was transpiration rate (E) variation at booting stage, that is, maize which had higher daily mean E would obtain higher yield. Moreover, changes of incident photo synthetically active radiation (PAR), air temperature (Ta) and CO_2 concentration (Ca) were the basic reasons of yield variation among different regions. Because higher PAR, higher Ta, and lower Ca, which are caused by the tree shading, would all have led to higher E and finally higher crop yield.

Das (2010) conducted an experiment to observe the growth & yield of tomato, radish, soybean & lettuce grown at different distance of Lohakat tree and under pruned & unpruned condition of the tree. The result of the experiment was that the yield of crops increased gradually with increase of planting distance from the tree. The growth characters of Lohakat tree are not satisfactory in association with tomato and radish but quite better in association with lettuce but found higher in association with soybean.

Fandika et al., (2011) suggested that on agronomic performance, which would support a resurgence of interest in the heritage pumpkin, Kamokamo, relative to exported Buttercup squash in New Zealand. The results indicate that irrigation can modify standard marketable fruit sizes and that Kamokamo has a high yield and water use efficiency potential, compared to Buttercup squash.

Ayala et al., (2011) suggested that in growth and yield performances of trees as well as annual crops grown in combination under tree-crop farming. Plant growth and yield of all component crops were higher when grown under conjugation as compared to their sole cropping.

Singh et al., (2011) suggested that three conservation measures viz. contour furrows (CF) at 6m horizontal interval, raised and sunken beds (RSB) with 6.6m bed width and 15cm elevation difference and conservation bench (CBT) terracing with 2:1 contributing and receiving area were investigated for five growing seasons for their production efficiency.

Wang et al., (2011) suggested that biotic environmental stresses negatively impact crop productivity and are major constraints to global food security.

Krishnaiah et al., (2011) suggested that two-thirds of the world's plant species have medicinal value; in particular, many medicinal plants have great antioxidant potential. Antioxidants reduce the oxidative stress in cells and are therefore useful in the treatment of many human diseases, including cancer, cardiovascular diseases, and inflammatory diseases.

Abnan (2012) an experiment was conducted to study the growth and yield of two winter vegetable i.e., Chilli & Sweet gourd under different spacing from Eucalyptus tree. All parameters i.e., plant height, diameter, leaf length, leaf diameter, no. of fruits per plant, yield etc. increased gradually with increasing distance from Akashmoni tree. It concluded that boundary plantation of Eucalyptus has negative effect on the growth and yield of Chilli & Sweet gourd.

Habib et al., (2012) study the performance of summer vegetable in nagpurindia in association with Xyliadolabriformis tree and to observe interaction effect of Xyliadolabriformis tree on summer vegetables. The growth characters (tree height, number of leaves and stem girth) of Xyliadolabriformis tree are not satisfactory in association with all crops (Indian spinach, Amaranth, Okra, Bottle gourd, sweet gourd and Kangkong) at 9 feet distance from Xyliadolabriformis tree. The yield of the summer vegetables increased gradually with the increase of planting distance of the tree.

Bari et al., (2013) conducted a research on the effect of Guava and Lemon yield of okra produced as agroforestry practice. The result showed that yield of Okra was gradually increased with increasing distance from both of tree base. Yield of Okra was height in open field condition. However, yield of okra in association with Guava reduced by 2.25, 22.26 and 38.89% yield in 5-7.5ft, 2.5-5ft and 0-2.5ft distance respectively. On the other hand, Okra yield reduced 6.8, 26.6 and 43.7% yield in 5-7.5ft, 2.5-5ft and 0-2.5ft distance respectively from Lemon tree base. The Okra yield difference was 5-7% higher in association with Guava.

Michon et al., (1986). The Maninjau agroforestry garden system in West Sumatra is characterized by the intensive integration of commercial crops and forest species, creating a system that closely resembles a forest. Multiple-stage (2-5) agroforestry systems incorporate many different species. Even though multistoried agroforestry systems are simpler than monocultures of trees or annual crops. Due to the vertical structure, it creates shade between layers (Bari, 2009).

2.4 Litchi tree-based agroforestry

Hanif et al. (2010) experimented to assess the performance of the okra plant in an agroforestry system based on litchi, at the Agroforestry Farm, Hajee Mohammad Danesh Science and Technology University, Dinajpur. Randomized Complete Block Design (RCBD) with three Replicationons was used to set up the experiment. Local, hybrid, and BARI-1-okra varieties were used as ground layer crops in the treatments. The result revealed that solely grown hybrid okra variety showed maximum yield and the parameters viz. plant height, leaf number, leaf size, fruit size, and fruit weight that contribute to yield were higher than the other treatments. Okra hybrid variety > BARI-1 okra > Local okra variety may be the possible ranking system for okra variety suitability.

Uddin et al. (2010) experimented to investigate the growth performance of Indian spinach grown alongside pineapple at various litchi tree orientations at the Hajee Mohammad Danesh Science and Technology University's Litchi-Pineapple Agroforestry Farm from April to June 2007. Notably, the open field produced the highest yield of Indian spinach, followed by the south orientation-1), and the east orientation produced the lowest yield. Furthermore, as an agroforestry production concept, the Litchi-Pineapple-based agroforestry system has the potential to produce Indian spinach, according to the results.

2.5 Timber tree-based agroforestry

Ali et al. (2023) conducted an experiment to evaluate the likelihood and yield of producing two vegetables-potato and brinjal in a woodlot between 2019 and 2020. The best method for maximizing land use efficiency, diversification, production, and profitability was the multistoried agroforestry system based on ghoraneem and pineapple for brinjal and potato production, respectively, with the highest BCR (3.09) in both cases.

Akter et al. (2020) conducted an experiment in Bangladesh's Madhupur Sal forest to determine the best agroforestry systems concerning productivity. Five agroforestry practices were chosen at random: Gamar, Ghoraneem, Jackfruit, and Akashmoni trees with Turmeric and Aroid crops; Akashmoni tree with Ginger and Banana crops, Akashmoni tree with Turmeric and Banana crops; and Litchi tree with Pineapple, Ginger, Papaya, and Banana crops. The results showed that NAFS or monocultures are less productive than integrated agroforestry systems. From an economic and ecological standpoint, the Akashmoni-Ginger-Banana-based agroforestry practice was superior to the other methods in Bangladesh's Madhupur Sal forest.

Nadir et al., (2018) investigated crop performance in combinations of Eucalyptus trees and crops, and their potential application in agroforestry systems. The yields of potatoes and beans were significantly impacted by the age of the Eucalyptus plantation ($p<.001$), but not those of nightshades; consequently, the vegetable can be grown in the shade of Eucalyptus trees without experiencing a decrease in yield. Common beans and Irish potatoes are viable crops for agroforestry with Eucalyptus trees, but more research is necessary because of their low yields and specific disease incidences.

Alam et al. 2014 experimented on the Department of Agroforestry, Bangladesh Agricultural University, Mymensingh from October 2013 to March 2014 in Char Kalibari of the Old Brahmaputra River to evaluate the performance of seven distinct winter vegetables about a four- year-old Akashmoni tree for a "Charland"-based farming system. The Akashmoni tree was planted alongside winter vegetables using a two-factor Randomized Complete Block Design (RCBD) with four (four) Replicationons. The yield of sole cropping in monoculture than agroforestry system.

Perveg et al. (2014) experimented between October 2013 and March 2014, at the Char Kalibari, which is next to Bangladesh Agricultural University in Mymensingh by the Brahmaputra River. The experiment's goal was to assess the growth performance of two winter vegetable crops, sweet gourd, and chili, grown beneath four-year-old akashmoni trees at varying distances. Sweet gourd and akashmoni tree growth were found to be the least compatible. The combination of chili produced a higher akashmoni tree growth than the sweet gourd association.

Roshetko et al. (2013) experimented to discuss the contributions of teak systems to the livelihoods of smallholders in Indonesia, where teak has been produced for more than 50 years. In addition to providing food for households, 40% of household income comes from timber and crops in smallholder teak systems. However, the productivity of their teak systems is limited by the lack of labor, resources, and information available to farmers. The government, industry, and support organizations' roles that would benefit all parties involved are described. Policy changes that would encourage smallholders to better manage their teak systems have been identified.

Hasan et al. (2013) carried out an experiment at the Kalibari Char, which is located next to Bangladesh Agricultural University in Mymensingh by the Brahmaputra River from mid-October 2012 to March 2013. The experiment's goal was to assess the growth performance of two winter vegetable crops, namely bitter gourd, and radish, grown under two-year-old Eucalyptus (*Eucalyptus camaldulensis*) trees at varying distances. Consequently, the best distance for increased radish and bitter gourd production in an agroforestry system would be either long distance or control.

Labata et al. (2012) experimented to gather information on the carbon stocks of three particular agroforestry systems in the Province of Bukidnon. The following order is associated with the carbon accumulation of agroforestry systems, according to the results: The mixed multistorey system is superior to the falcata-coffee multistorey system in the taungya agroforestry system. The following order of magnitude for carbon storage was found in the different pools: soil > trees > herbaceous vegetation and litter. These particular agroforestry systems comprise 23-44% of the global carbon stock when compared to natural forests.

Sukla et al. (2000) experimented on twelve-year-old teak (*Tectona grandis* L.f.) plantations grown under three agroforestry systems unmanaged block (Bum), unmanaged line on the farm boundary (Lum), and intensively managed block (Bim) for their growth, wood quality parameters, and productivity estimates. Block plantation harvesting may be postponed for ten to fifteen years to achieve the best economic utilization and mechanical maturity of the wood. This is because tree age is expected to improve growth volume and strength properties.

2.7 Economic Importance of Marigold

D. Mishra et al., (2010) aims at conducting a study on recent developments of floriculture industry in India, according to International Association of Horticultural Producers (AIPH 2010), about 702,383 hectares of area is used for flower cultivation across the globe, out of which 48,705 hectares in are Europe; 21,067 hectares are in North America; 523,828 hectares are in Asia; 4026 hectares are in the Middle East; 7604 hectares are in Africa; and 97,153 hectares are in South America.

Agricultural and Processed Food Products Export Development Authority (APEDA). 2017, experimented the Netherlands is the biggest importer from developing countries, along with major producers of flowers. The US, Germany, the Netherlands, and the UAE are major importing countries for Indian floriculture.

Annual Report of ICAI-DFR (2018–19) studied that India, as a spiritual country, has a vast floriculture sector; marigold flowers play an important role loosely, as well as in the form of garlands, for various auspicious functions. A total of 342,000 acres are used for floriculture, which yields 769,000 MT of cut flowers and 1,760,000 MT of loose flowers per year (2017–2018 estimates). To ensure continuous growth, the innovation of novel products is essential for the floriculture sector.

Malik et al., (2021) Seven different microbial and fertilizer treatments were studied for enhancement in the production of a marigold crop. These treatments included azotobacter, azospirillum, purple sulfate bacteria (PSB), city compost, vermicompost, poultry beat on production, characterization of the plants, and flower content. The results showed that poultry beat was the most successful, as the plants were healthier, offering a yield of 272.56 q/ha, which was significantly higher than the other treatments. The other recorded yields were 26.48 (vermicompost), 263.98 (city compost), 241.49 (PSB), 238.98 (FYM), 232.48 (azotobacter), 228.92 (azospirillum), and 201.04 q/ha (control). Poultry beat was the most economical option among all the treatments, and the income generated after covering all the expenses for land rent and cost of cultivation, i.e., net and gross returns, was also significantly higher at the average price per quintal of loose marigold sold on the market for INR 1200.

EFSA Panel on Food Additives and Nutrient Sources added to Food (ANS) experimented the bright yellow petals of Tagetes marigold flowers, which are a major source of the current commercial supply of lutein, are to blame. The European Union approved Tagetes lutein

(E161b) as a food and healthcare product colorant, with a daily intake permissible of 1 mg/kg body weight.

Fuad et al., (2022) carried out an experiment, Due to its medicinal properties, it is highly demanded in the pharmaceutical industry because lutein has been tested for macular aged disorder, as it helps in UV light filtration, and is an excellent ROS scavenger, thus having beneficiary effects for aged individuals, infants, and pregnant women.

CHAPTER III

METHODS AND MATERIALS

The experiment aimed to determine the optimal tree-crop interaction in the agroforestry system and assess the performance of marigold flowers with litchi and bottle gourd plants. This chapter provides a detailed presentation of the materials, procedures, and other pertinent activities that took place during the experimental period. It also includes summaries of the experimental details under the following headings.

3.1 Location and Time of Experiment

The study was conducted in the existing HSTU research farm at the Department of Agroforestry and Environment, Dinajpur from 2nd December 2023 to 23rd April 2024. The location was between 25º 13´ latitude and 88º 23´ longitude 37.5 meters above sea level in a medium-high land that belonged to the old Himalayan Piedmont Plain area (AEZ 1). The drainage system was well-developed, and the land had good drainage.

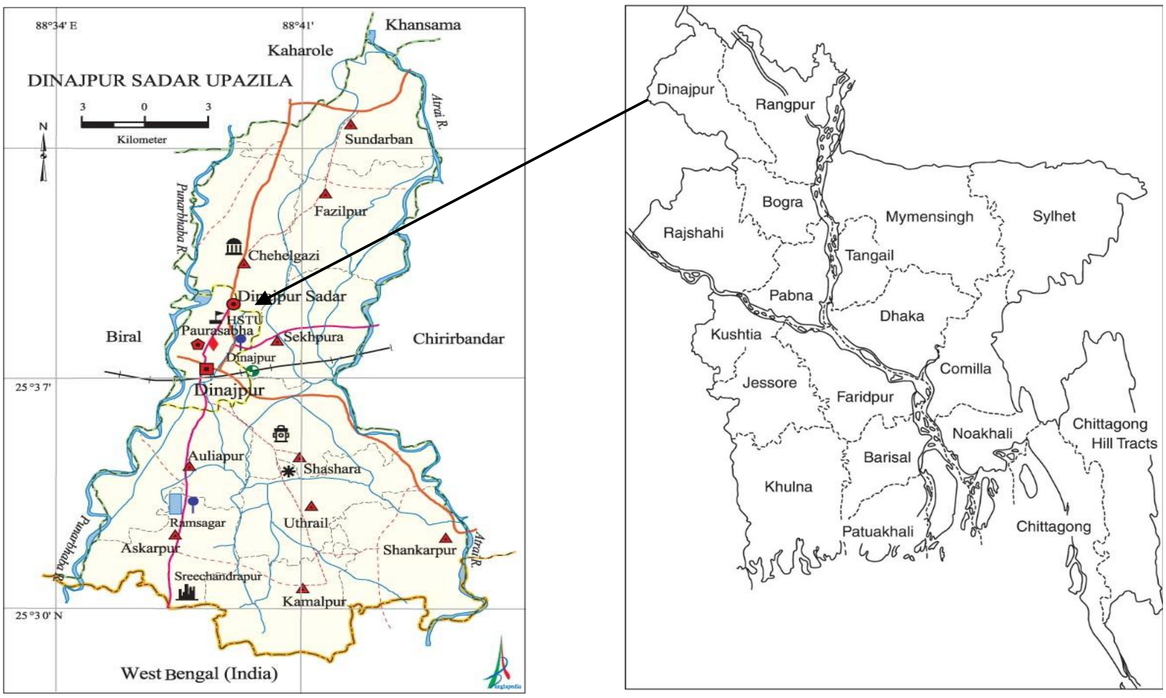

Figure 3.1 Map of the Experimental Site in HSTU, Dinajpur, Bangladesh

3.2 Climate and Weather Condition

The experimental site is in located at an elevation of 40.09 meters (131.53 feet) above sea level, Dinajpur has a Humid subtropical, dry winter climate. The district's yearly temperature is 29.34ºC (84.81ºF) and it is 1.6% higher than Bangladesh's averages. Dinajpur typically receives about 158.53 millimeters (6.24 inches) of precipitation and has 172.24 rainy days (47.19% of the time) annually. The summer season typically begins in June and ends in August. Rainfall patterns show some unique features. Dinajpur undergoes a dramatic transition from the driest months with only 1mm (0.04") of rainfall in January and December to the peak rainy season recording 115mm (4.53") of rainfall in July. Correspondingly, the number of rainfall days increases from about one to two days in winter months to a maximum of 21.5 days in July. Maximum wind speed echoes this pattern, with higher speeds occurring in summer, specifically in July with an average of 10.1km/h (6.3mph). Winter months in Dinajpur, December and January, present a different facet of the city's climate. During these months, the city demonstrates a stark difference from the wet and humid monsoon period. Winters offer cooler temperatures with highs of 26.2°C (79.2°F) and 25.8°C (78.4°F) for December and January, respectively, and lows of 15.5°C (59.9°F) in December and 13.8°C (56.8°F) in January. Rainfall measurements during this period are at their lowest, averaging around 1mm (0.04") to 2mm (0.08"), accompanied by a minimum number of rainy days. The key factors determining climate appear to be rainfall, temperature, and relative humidity. The weather data recorded at Climate and monthly weather forecast Dinajpur, Bangladesh.

3.3 Description of Experimental Materials

3.3.1 Litchi Plants

Litchi (*Litchi chinensis*) is regarded as one of the kings of sub-tropical fruits and famous for its excellent quality such as juiciness, slightly sour-sweet taste, characteristics pleasant flavor and attractive colour. Litchi is a highly priced, popular and major table fruit in Bangladesh. It has a great demand among all classes of people. Litchi is a non-climacteric fruit. The tree reaches up to 12 m or more in height. When grown under congenial climatic conditions, radial diameter of the tree's canopy is also nearly 12 m. The branches are crooked or twisted, low-hanging and spreading, forming a head broader than the height. In some varieties, the branches are fairly straight and more or less upright, forming a compact, rounded head. In some cases, however, the tree assumes fairly wider spreading (horizontal) growth than its height. During initial years of growing, pace of tree’s vegetative growth is highly influenced by growing environment and nutrition (Wills et al., 2004).

In 2006, the China-3 litchi was planted in a spacing 6m x 6m. It is one of the best cultivars of this variety found in the Bengal region in the eastern section of the Indian subcontinent. Intercultural operations are conducted annually by standard protocol. Litchi occupy 17279.99 areas of land in Bangladesh and its production is 87183.80 metric tons (BBS, 2002).

Bangladesh lies in the ‘homegarden zone’ of the global map in Nair and Kumar (2006) and indeed in Bangladesh, practices of agroforestry are well-known to most farming families in rural areas. Before the widespread introduction of rice, wheat and other seasonal cash crops in the 1970s, traditional mixed cropping systems based on perennial tuber, root, and fruit tree crops grown in association with vegetables were practiced throughout Bangladesh (Alim 1993). Moreover, with the decreasing yields of crops planted in seasonal crops, farmers have recognized the need for modifying their farming practices and conserving soil resources. Some alternative farming technologies including multistrata agroforestry systems (e.g., fruit gardening, multipurpose homegardens) have been introduced especially after 1980 in the north as well as in other parts of Bangladesh under various development projects of both government and other organizations such as the Asian Development Bank and the European Union.

3.3.2 Marigold

The planting material for the present experiment comprised of Inca variety of Marigold, collected from different sources in the form of seedling. Nursery was raised for the variety at Rangpur nursery and seedlings were finally transplanted to the field after 25 days. Commercial floriculture in Bangladesh is a new dimension in farming culture. Evidences from all civilizations reveal that mankind has historical interest in gardening and culturing flowers to satisfy aesthetic need. But, in the present world, flower becomes important not only for its aesthetic social values, but also for its economic contribution (Aditya, 1992; Dadlani, 2003). People usually use flowers in all their ceremonies like wedding, birthday, and marriage day greetings, religious offerings and sometimes in social, political, and historical occasions (Haque et al., 2012).

3.3.3 Bottle Gourd

Bottle gourd (*Lagenaria siceraria*) is a popular winter vegetable in Bangladesh. It belongs to the family Cucurbitaceae. The climatic condition of winter in Bangladesh favours better growth and yield of bottle gourd. The average day temperature of 20-27°C with lower night temperature of 18-23°C is optimum for its growth and fruiting. Bottle gourd is widely cultivated throughout the country. Its cultivation and uses are wide in winter season. The national average yield of bottle gourd is only 9.38 tons/hectare (Islam et al.,) which is very low as compared to other bottle gourd producing countries (like India). Several factors are responsible for this low yield; those are lack of high yielding OP and hybrid variety, disease free variety, proper cultural management etc. Data on days to first harvest, fruit number/ plant, fruit number/ plot, average fruit weight (kg), fruit yield (kg/plant), fruit length (cm), fruit yield (t/ha), were recorded from randomly selected plants per plot. Bottle gourd, mainly in Asia, is also used as herbal medicine for a prolonged time (Schlumbaum & Vandorpe, 2012). It contains vitamins C, B, and K, as well as minerals like calcium, magnesium, iron, and zinc. Its juice has helped cure acidity, indigestion, and ulcers. It is also used as a remedy for pain, fever, pectoral cough, asthma, and other bronchial disorders (Deore et al., 2009). This vegetable has been conventionally utilised for medicinal purposes like cardiotonic, cardioprotective, aphrodisiac, diuretic, and antidote to certain poisons (Deshpande et al., 2008). It is also significant to give benefit in nervous diseases, insanity, and epilepsy.

3.4 The Experimental Design and Treatment Combination

The experiment was conducted on the floor of 18-year-old litchi and bottle gourd. The marigold was planted in the alleys while the bottle gourd was planted in the vacant spaces between lines of the tress. The experiment was conducted following single factor Randomized Complete Block Design (RCBD) with three Replicationons.

There were three treatments (When Marigold is the main production)-

T_1 = Litchi + Marigold + Bottle Gourd

T_2 = Marigold + Bottle Gourd

T_3 = Sole cropping of Marigold

3.4.1 Plot size, land preparation and crop establishment

Each plot size for cultivation was 3 × 2 = 6m^2 as determined by measuring tape fitting in about 40 plants with row-to-row and plant-to-plant spacing of 40 × 30 cm, respectively.

3.4.2 Field preparation

Initially the field was ploughed thoroughly with the tractor and the stubble of old crop and weeds were removed and field was leveled and raised beds were prepared. The clods were broken by khurpi and the plots were prepared by using rope and liner.

3.4.3 Planting of seedlings

The healthy, uniform, pest and disease-free seedlings were planted in the field with the help of rope asper the treatments at recommended spacing (40cm × 30 cm), The transplanting was done during evening hours. After transplanting, crop was immediately irrigated. Bottle gourd was planted in the vacant space between tree-to-tree distance, in T_2 (Marigold + Bottle Gourd) and sole cropping of bottle gourd two seedlings were planted in each plot.

3.4.4 Fertilizer application

To attain an appropriate soil condition, the field was first tilled using a tractor and harrowing. In the last stage of soil preparation, the land was fertilized with cow dung, triple super phosphate, K_2O in the form of muriate of potash. Of nitrogenous (N) fertilizer in the form of urea was applied.

3.4.5 Irrigation

When necessary, irrigation was carried out with a flexible hose pipe to guarantee adequate soil moisture.

3.4.6 Weeding and Hoeing

Weed management is an important factor to control weed in order to reduce the competition between the weeds and Marigold plants. After planting, weeding, hoeing was done manually at regular intervals by hand till the crop was ready for harvest.

3.4.7 Gap filling

Marigold seedlings are soft, tender and susceptible to damping off. Hence, certain gaps were observed few weeks after transplanting the seedlings dew to white mould fungus attack.

Mortality after transplanting was immediately replaced with fresh seedlings to ensure 100% plant survival in each plot until one month after transplanting.

3.4.8 Pinching

Pinching was performed once after 30 days of transplanting by removing the apical bud along with two leaves from each plant.

3.5.9 Harvesting

Fully opened flower with maximum size were harvested on alternate days during evening hours. The number of flowers were recorded immediately after harvest.

Table 3.1 Organic and Inorganic Fertilizer Applied for Marigold Production during the Experiment

Fertilizers	Total amount of the dose (kg)	Last Tillage kg/ plot Preparation	After Care		
			1st (g)	2nd (g)	3rd (g)
Rotten Cow Dung	36	36			
Urea	3.24	1.62	0.54	0.54	0.54
MoP	1.20	0.72	0.24	0.24	-
TSP	1.44	0.72	-	-	-
Vermi Compost	25	25			

Rotten cow dung (CD) was applied fifteen days before planting. First, second and third doses of the application were 30, 50 and 80 days of transplanting, respectively.

3.5 Data analysis

3.5.1 Gross return

It was computed using the formula that follows. Gross return (Tk ha^{1}) Trees outcome + crops outcome

3.5.2 Net Return

It was calculated using the formula below:-

Net Return (Tk ha^{1}) = Total cost of production (Tk $ha^{-1)}$/ gross return (Tk ha^{-1})

3.5.3 Benefit-cost ratio

The ratio of gross return to total production costs is known as the benefit-cost ratio, or BCR (Islam et al., 2004). The following formula was used to calculate it (Islam et al., 2004). The profitability of multistoried agroforestry was estimated in the term Benefit-cost ratio by the following formula:

Benefit cost ratio (BCR) = Gross return/Total cost of production

3.5.4 LER

The comparative advantage of land use through agroforestry and traditional farming will be calculated in the term Land Equivalent Ratio (LER) by the following formula:

LER = Xi/Xs + Yi/Ys, Where X and Y are the yields of crop components in agroforestry (i) and sole cropping systems (s).

3.6 Statistical Analysis

The recorded data were statistically analyzed using the "Analysis of Variance" technique with the help of "STATISTIX 10' The means were separated by Tukey HSD (Honestly Significant Difference) test.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Results

The performance of marigold grown under litchi trees and bottle gourd intercropping were covered in this chapter. The study's result was shown and discussed, and various tables and graphs were used to illustrate potential interpretations. The experiment findings are shown and examined under the following headings:

4.1.1. Growth Parameter of Marigold

4.1.1.1. Plant Height

The plant height of marigold at 60, 75 and 90 DAT did not differ significantly, but a significant difference was found in the initial stage of growth i.e. at 30 and 45 DAT (Table 4.1).

Table 4.1. Plant Height (cm) of Marigold at different days after transplanting (DAT) under various production systems

Treatment	Plant Height (cm)				
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT
T_1	8.43 b	12.23 b	14.93	17.40	20.70
T_2	10.00 ab	16.00 ab	18.53	21.87	24.33
T_3	12.20 a	18.20 a	19.93	22.40	24.07
Level of significance	*	*	NS	NS	NS
CV (%)	11.93	10.22	11.53	9.17	6.99

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Marigold

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

At 30 and 45 DAT, the highest plant height was recorded in T_3 (12 cm and 18.20 cm) which was statistically similar with T_2 (10 cm and 16 cm) and the lowest plant height was recorded in T_1 (8 cm and 14.93 cm).

Numerically, the maximum plant height at 60DAT, 75 DAT and 90 DAT were maximum in T_3 (19.93cm, 22.40 and 24.06 cm) followed by T_2 (18.53cm, 21.87 cm and 24.33 cm) and T_1 (14.93 cm, 17.40 cm and 20.71 cm), respectively.

4.1.1.2 Leaf Number

The leaf number of marigold varied significantly at initial (30 DAT) and final data (60 DAT) collection dates, however, leaf number did not varied significantly at 45 DAT (Table 4.2). At 30 and 60 DAT, the highest leaf number was recorded T_2 (25.67 and 75.67) which was statistically similar with T_3 (24.07 and 73.67) (Table 4.2). Numerically, the maximum leaf number of marigold at 45 DAT in T_3 (71.93) and lowest in T_2 (62.87).

Table 4.2. Leaf Number of Marigold at different days after transplanting (DAT) under various production systems

Treatment	Leaf Number		
	30 DAT	45 DAT	60 DAT
T_1	13.33 b	36.00	38.00 b
T_2	25.67 a	62.87	75.67 a
T_3	24.07 a	71.93	73.67 a
Level of significance	*	NS	*
CV (%)	19.65	27.59	19.49

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Marigold

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.1.3 Bud Number

The marigold bud number did not varied significantly at the initial (30 DAT) and final (90 DAT) data collection time but varied significantly in between them i.e. at 45, 60 and 75 DAT (Fig. 4.1). At 30 DAT and 90 DAT, the intercropping T_2 (10, 15.33) and sole cropping T_3 (9, 13.67) of marigold produce more flower buds than marigold raised in agroforestry system. At 45 and 75 DAT, the highest bud number was recorded in T_3 (14 and 10.67) which was similar with T_2 (13 and 10.33) and the lowest plant height was recorded in T_1 (5.67 and 7.33). At 60 DAT recorded the maximum bud number in T_2 (20.68) which was statistically similar with T_3 (20.33) and lowest bud number recorded in T_1 (10).

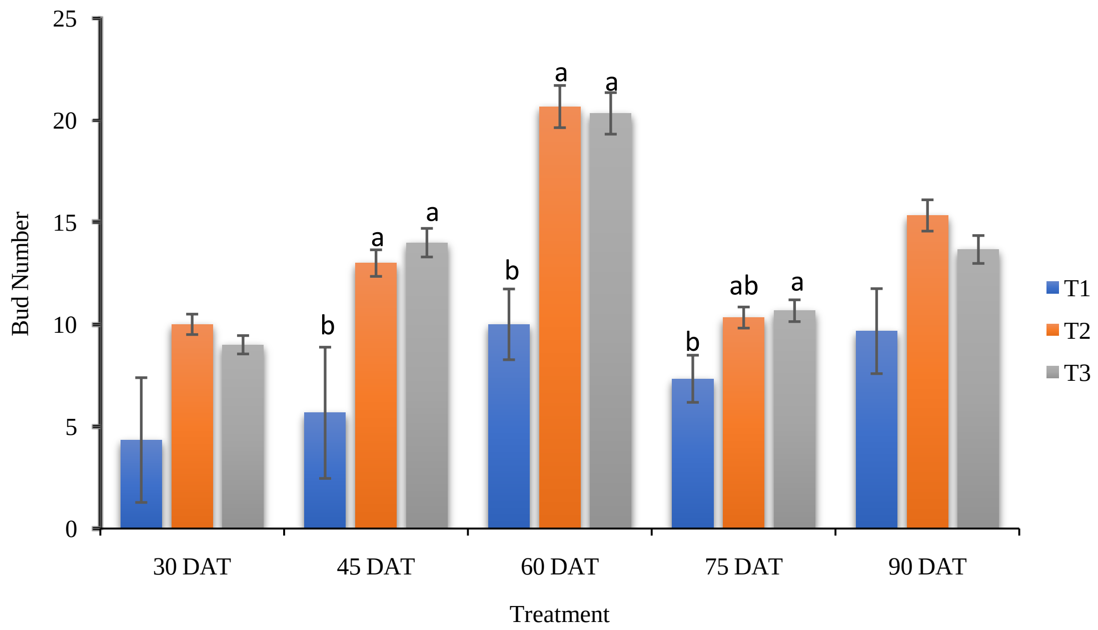

Figure 4.1 Bud Number of Marigold at different days after transplanting (DAT) under various production system

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Marigold

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.1.4 Flower Number

The flower number of marigold at 75 DAT did not differ significantly but a significant difference was found in the final stage of growth i.e. at 90 DAT (Table 4.3). At 75 DAT maximum number of flowers were counted in T_3 (8) and lowest number of buds counted in T_1 and T_2 (6) where both were similar. At 90 DAT the maximum number of buds counted in T_2 (10) which was statistically similar with T_2 (9.33) and the minimum number of the buds were counted in T_1 (6).

Table 4.3 Flower number of Marigold on different days after transplanting (DAT) under agroforestry systems

Treatment	Flower Number	
	75 DAT	90 DAT
T_1	6.0000	5.667 b
T_2	6.3333	9.333 a
T_3	8.0000	10.000 a
Level of significance	NS	**
CV (%)	27.38	12.96

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Marigold

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.1.5 Flower Size (mm)

The flower diameter of the marigold varied significantly among treatments in various production systems (Figure 4.2). When comparing the tree crop association treatments, T_2 (under the bottle gourd) yielded largest flower (66 mm), while T_1 (under the litchi tree) treatment produced smallest flower (45mm).

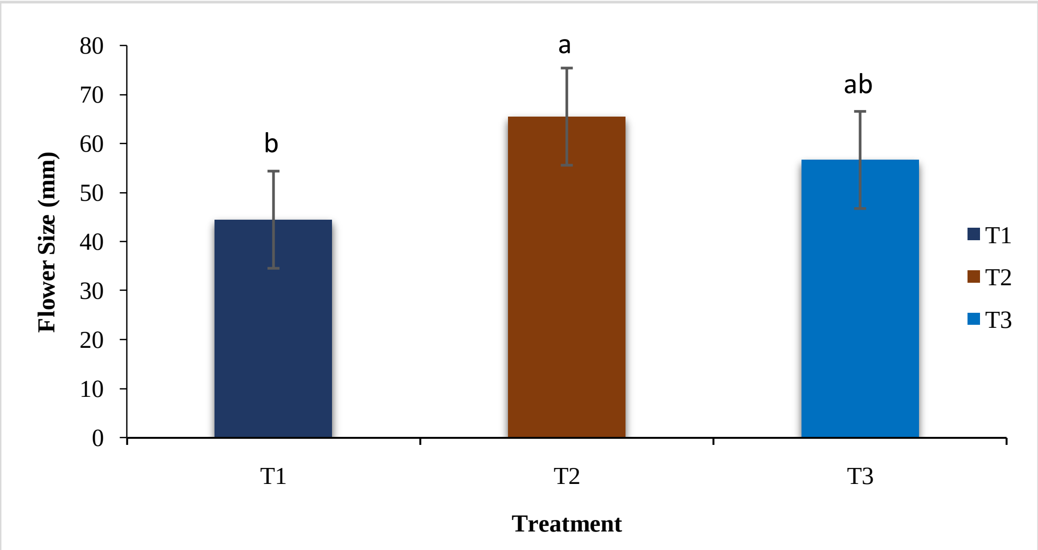

Figure 4.2 Bud Number of Marigold under various production systems

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Marigold

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.1.6 Flower number/plant

The flower number/plant of marigold varied significantly among treatments in various production systems (Figure 4.3). The T_3 (sole cropping of marigold) produced the highest yield per plant (18), while the T_1 (litchi trees + bottle gourd + marigold) produced the lowest yield per plot (13).

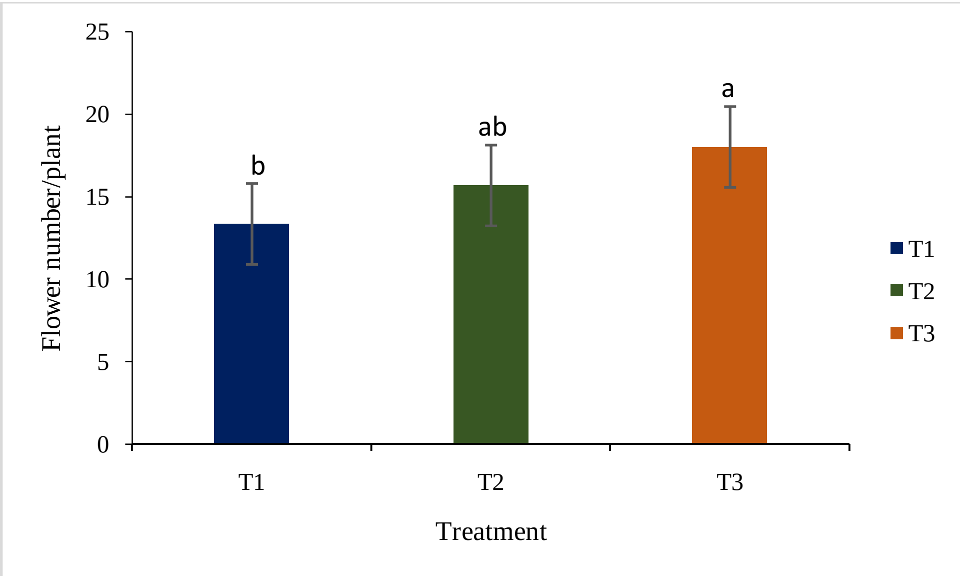

Figure 4.3 Flower number/plant of Marigold under various production systems

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Marigold

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.1.7 Yield (Flower Number/ha)

The outcome demonstrate that the yield/ha of marigold varied significantly between open and agroforestry system (Figure 4.4). The T_3 (sole cropping of marigold) produced the highest yield per ha (1200000), while the T_1 (litchi trees + bottle gourd + marigold) produced the lowest yield per plot (888889) and in T_2 (intercropping of bottle gourd and marigold) yielded moderately (1040000)

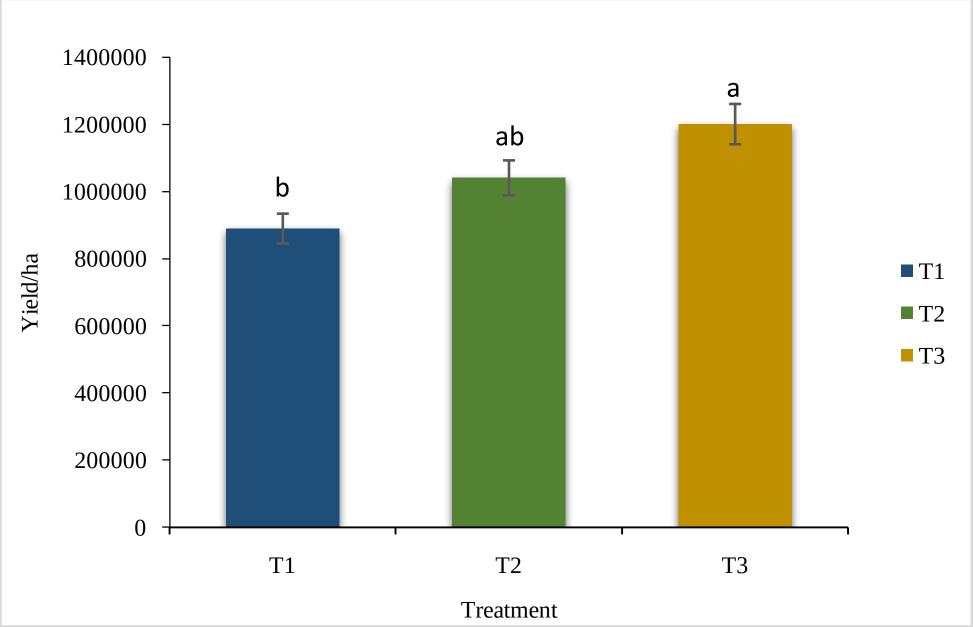

Figure 4.4 Flower number/ha of Marigold under various production systems

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Marigold

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.2 Growth Parameters of Bottle Gourd

4.1.2.1 Plant height (inch)

The plant height of bottle gourd at 45 DAT did not differ significantly, but a significant difference was found in the 60 DAT (Figure 4.5). The plant height of marigold initially i.e. at 60 days after transplanting (DAT) was highest in T_2 (108 inch) followed by T_2 (71.33) and the lowest plant height was recorded in T1 (63 inch). At 45 DAT highest plant height was recorded in T_2 (93 inch) followed by T_3 (92.5) and lowest plant height was recoded in T_1 (63 inch).

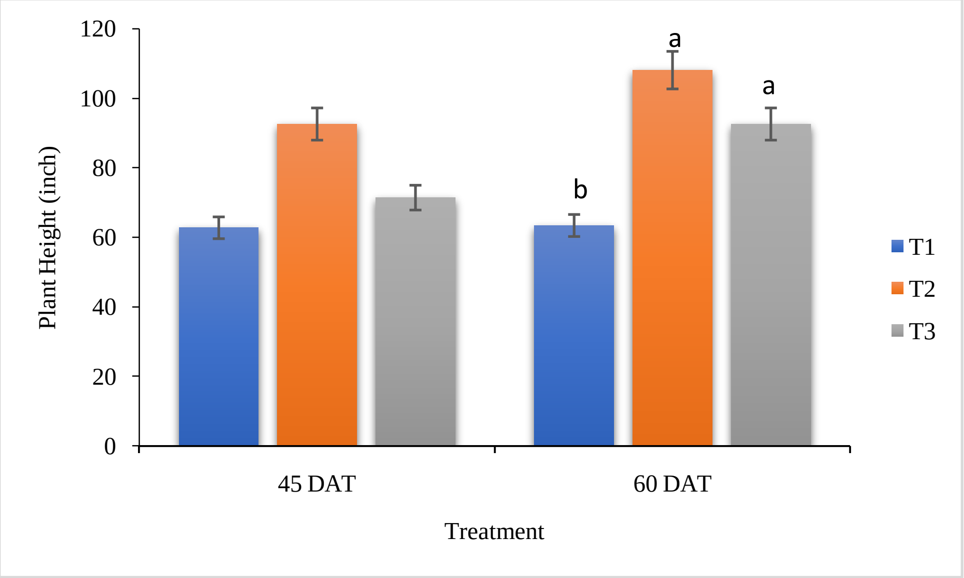

Figure 4.5 Plant Height (inch) of Bottle gourd at different days after transplanting (DAT) under various production systems

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Bottle gourd

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.2.2 Leaf length (cm)

The leaf length of bottle gourd at 30 and 45 DAT did not differ significantly, but a significant difference was found in the final stage of growth i.e. at 60 DAT (Table 4.4). The leaf length of bottle gourd at 30 and 60 days after transplanting (DAT) was highest in T_3 (11.13 cm and 13.39 cm) and lowest leaf length measured at T_1 (8.33 cm and 9.59 cm). At 60 DAT highest leaf length was measured in T_2 (15.78 cm) and lowest leaf length was measured in T_1 (11.01 cm) and T_3 (12.11 cm) which were statistically similar.

Table.4.4 Leaf length (cm) of Bottle gourd on different days after transplanting (DAT) under agroforestry system

Treatment	Leaf length (cm) of Bottle gourd		
	30 DAT	45 DAT	60 DAT
T_1	8.330	9.587	11.013 b
T_2	10.230	13.897	15.777 a
T_3	11.127	13.390	12.110 b
Level of significance	NS	NS	**
CV (%)	12.75	16.51	8.76

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Bottle gourd

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 1% level of probability.

4.1.2.3 Leaf breadth (cm)

The leaf breadth of bottle gourd at 30 and 60 DAT did not differ significantly, but a significant difference was found in the initial stage of growth i.e. at 45 DAT (Table 4.5). Numerically, the leaf breadth of bottle gourd at 30 and 60 days after transplanting (DAT) was highest in T_2 (18 cm and 17 cm) followed by T_1 (10.55cm and 13.80 cm) and T_3 (10.86 cm and 17.03).

Table 4.5 Leaf breadth (cm) of Bottle gourd on different days after transplanting (DAT) under agroforestry system

Treatment	**Leaf breadth (cm) of Bottle gourd**		
	30 DAT	45 DAT	60 DAT
T_1	10.553	11.393 b	13.80
T_2	11.870	17.867 a	17.22
T_3	10.860	17.867 a	17.03
Level of significance	NS	*	NS
CV (%)	21.86	14.19	14.29

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Bottle gourd

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

At 60 DAT the highest leaf breadth was recorded statistically and numerically similar in T_2 (17.87 cm) and T_3 (17.87) and the lowest leaf breadth was measured in T_1 (13 cm).

4.1.2.4. Fruit length (inch)

The outcome demonstrates that the fruit length varied significantly between in various production systems (Figure 4.6).

The T_3 (sole cropping of bottle gourd) produced the highest fruit length (13 inch), while the T_1 (litchi trees + bottle gourd + marigold) produced the lowest yield per plot (10 inch).

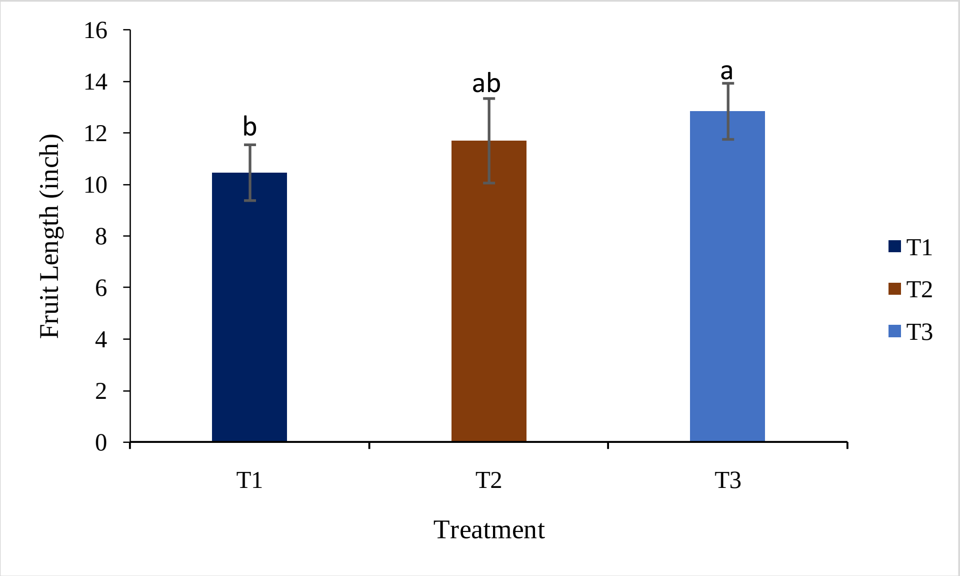

Figure.4.6 Fruit length (inch) of bottle gourd under various production systems

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Bottle gourd

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.2.5. Number of fruit/plot

The number of fruit/plot of the bottle gourd varied significantly among treatments in agroforestry systems (Figure 4.7). The maximum yield (12.33) of bottle gourd recorded in T_3 i.e bottle gourd sole, statistically similar with T_2 (9.67) and the lowest yield observed in T_1 (1)

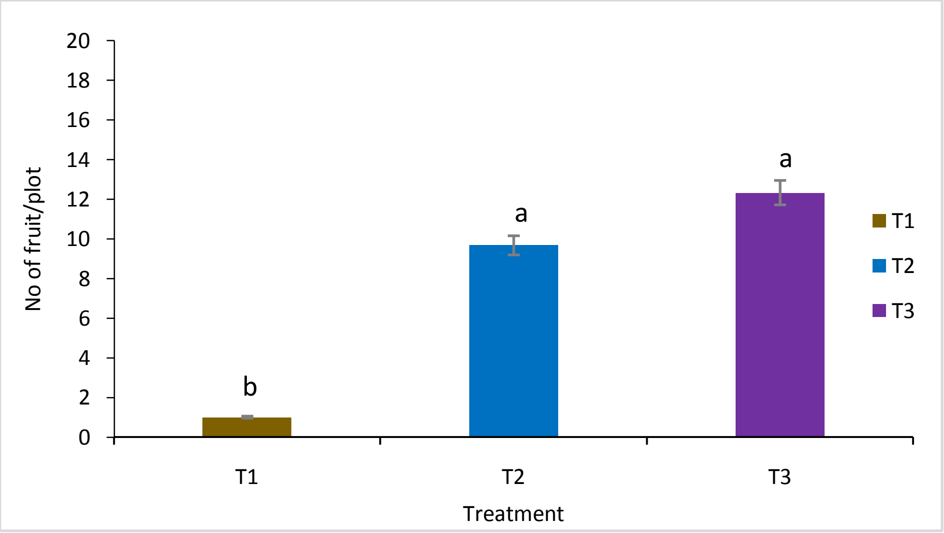

Figure.4.7. No of fruit/plot of bottle gourd under agroforestry system

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Bottle gourd

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.2.6. Yield/plot (kg)

The outcome demonstrate that the yield/ha of bottle gourd varied significantly between under various production systems (Table 4.6). In T_3 produced the highest yield per plot (15.72 kg) compared to the T_2 (12.97), while the T_1 (litchi trees + bottle gourd + marigold) produced the lowest yield per plot (1 kg).

Table 4.6. Yield/plot (kg) of Bottle Gourd under agroforestry system

Treatment	Yield/plot (kg)
T_1	0.802 b
T_2	12.969 ab
T_3	15.719 a
Level of significance	*
CV (%)	47.59

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Bottle gourd

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.2.7. Yield/ha (ton/ha)

The yield of the bottle gourd varied significantly among treatments in various production systems (Figure 4.8). In T_3 produced the highest yield per plot (26198 ton/ha) compared to the T_2 (21614 ton/ha), while the T_1 (litchi trees + bottle gourd + marigold) produced the lowest yield 1337 ton/ha.

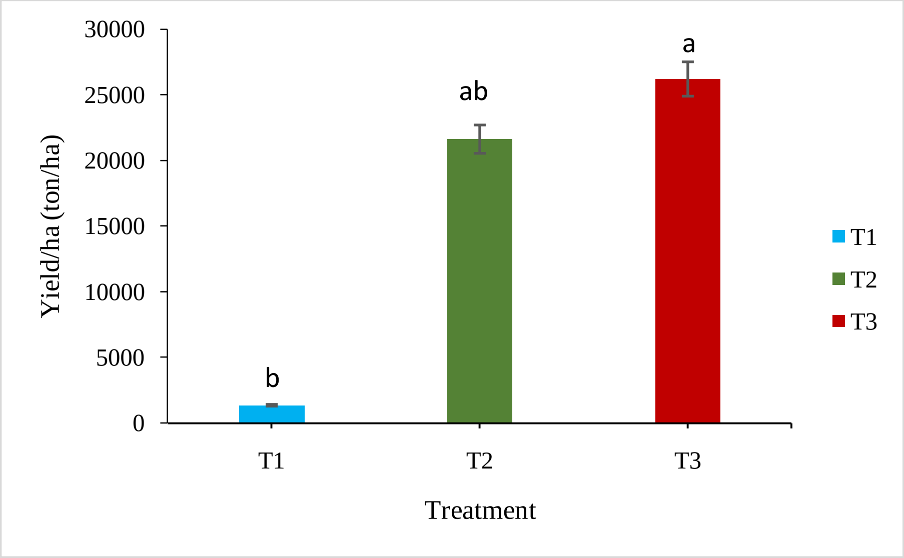

Figure.4.8. Yield/ha (ton/ha) of bottle gourd under agroforestry system

T_1= Litchi trees + Bottle Gourd + Marigold, T_2 = Bottle Gourd + Marigold,

T_3 = Sole Cropping of Bottle gourd

Similar letter (s) found in a figure means they do not differ significantly. On the contrary, having letter (s) in a figure signifies differences at a 5% level of probability.

4.1.3. Economic Analysis of Marigold Production under Different Production System

Table 4.7. Economic Analysis of Marigold Production under Different Production System

Production System	Returns of product			Gross Return of production systems tk ha^{-1}	Total Cost of Production tk ha^{-1}	Net Return tk ha^{-1}
	Litchi	Marigold	Bottle gourd			
Litchi+MG+BG	444800	444444	41666	930910	428635	502275
MG+BG	0	522222	416666	938888	423550	515338
MG	0	600000	0	600000	363660	236340
BG	0	0	500000	500000	168735	331265

NB: Market value of Marigold were calculated at 500tk per thousand flowers

Market value of Bottle gourd were calculated at 25000 tk per ton (25 tk per kg)

4.1.3.1 Marigold Return (tk ha^{-1})

The Marigold Return exhibited variations across different production systems, as indicated in Table 4.6. Among these systems, T_3, representing the sole cropping of marigold, demonstrated the highest return (600000 tk ha^{-1}), followed by T_2 (intercropping system). On the other hand, the lowest value (444444 tk ha^{-1}) was observed in multistoried agroforestry system.

4.1.3.2 GR (Gross Returns) tk ha^{-1}

The gross returns displayed variability across various production systems, as presented in (Table 4.6) T_2, which corresponds to the intercropping system approach with partial shade, exhibited the highest (938888 tk ha^{1}) gross return, followed by the sole cropping of marigold and bottle gourd. Conversely, the lowest (236340 tk ha^{1}) value was observed in T_3, corresponding to marigold sole cropping.

4.1.3.3 NR (tk ha^{-1})

Net returns revealed differences among different production systems influenced by shade levels (Table 4.6). T_2, Marigold + Bottle gourd intercropping system found as the maximum (515338 tk ha^{-1}) followed by T_1. Minimum (236340 tk ha^{-1}) value found at T_3 marigold sole cropping.

4.1.3.4 BCR

The Benefit-Cost Ratio exhibited fluctuations among different production systems, as illustrated in (Figure 4.6). The sole cropping of bottle gourd, recorded the highest (2.96), followed by Litchi + MG + BG (2.17) agroforestry system. On the contrary, the lowest BCR (1.64) was recorded in sole cropping of marigold.

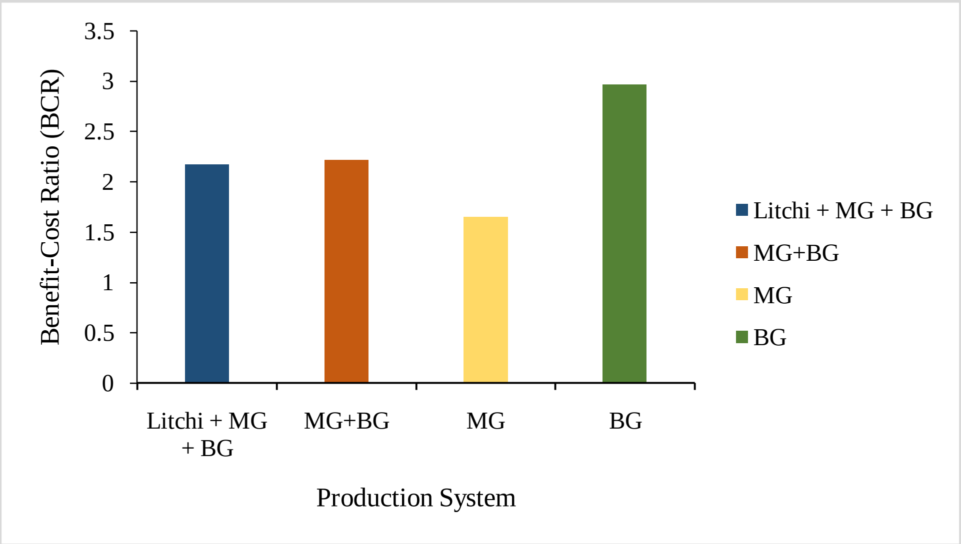

Figure.4.9. Benefit-Cost Ratio (BCR) of marigold production under different production systems

4.1.3.5 Land Equivalent Ratio

According to results, the Litchi+BG + MG- based agroforestry system had the highest LER (2.64), while the MG + BG- based intercropping system had the lowest value (1.79) , These high LER values highlight the significant yield benefits and resource efficiency of these intercropping systems.

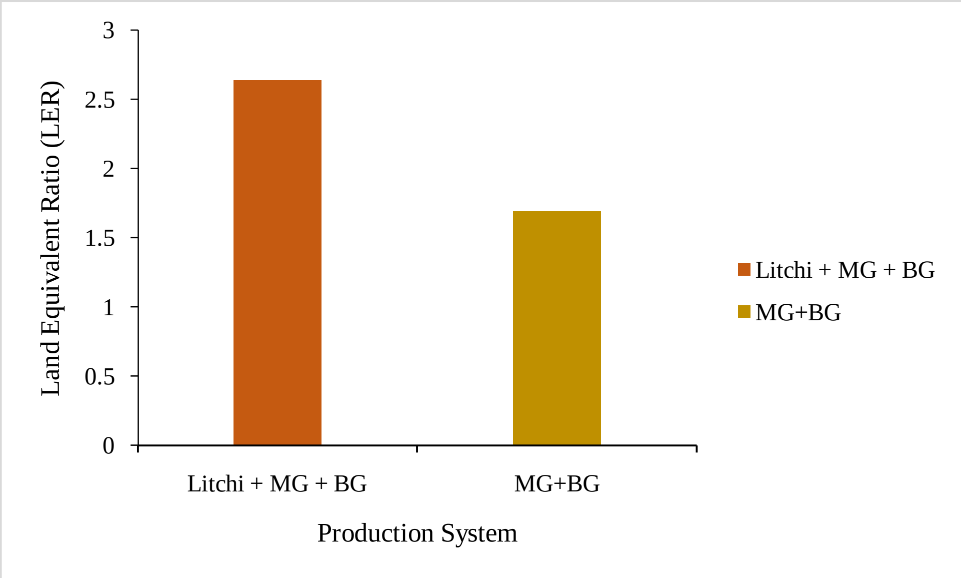

Figure.4.10. Land Equivalent Ratio (LER of marigold production under different production systems

4.2. Discussions

This study found the growth, development and yield of marigold was inhibited in Litchi based agroforestry systems compared to its intercropping and sole cropping. The possible reason could be low light interception from the tree compared to the open. But in the T_2 (bottle gourd + marigold) condition the marigold plant height, number of leaves per plant, number of bud per plant, number of flower per plant, flower size, flower yield per plant, flower yield per plot comparatively similar as the sole cropping of the marigold might be due to partial light penetration.

Trees integration in agroforestry systems might results in either positive and negative effect on the components (Basavaraju and Gururaja, 2000). The impact of trees on under multistorey crops is complicated depending on the local environmental conditions; the tree canopy can have a positive, negative, or neutral effect on plant production (Schade et al., 2003).

The study revealed that the maximum marigold yield found at the T_3 (sole cropping of marigold) condition the number of flower per plant, flower size, flower number yield per plot, flower number yield per hectare was significantly higher might be due to higher rate of photosynthesis and light. The findings of this study are similar to the findings of Kamal and Yousuf, (2012) and Bhuiyan et. al., (2012), Ali et al., (2018) and Kona et al., (2020).

In terms of marigold returns, gross returns, net returns, Benefit-Cost Ratio and Land Equivalent Ratio in intercropping system for marigold production found maximum. This might be total yield of marigold production is higher. Total outputs from multistoried agroforestry are multiple than the sole cropping, total cost of production is higher as it requires more materials, cost, and maintenance than the sole cropping.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The study investigated the growth and yield characteristics of marigold and bottle gourd under different production systems influenced by varying shade levels. Leaf number, leaf length, leaf breadth, and plant height were the four growth contributing factors evaluated. Further study was done on yield-contributing characteristics like bottle gourd length, bottle gourd weight and marigold flower size.

The marigold and bottle gourd production also went through an economic analysis that took the benefit-cost ratio, gross return, and total cost of production into account. The results showed that bottle gourd grown in full sunlight and marigold in partial shade produced promising results at different stages of growth, including higher plant height. Regarding leaf number, multistoried agroforestry under partial shade also showed noteworthy results.

The study's findings showed that growing marigold as a sole crop (T_3) or in intercropping with bottle gourds (T_2) produced the best growth traits and production results. The largest marigold flower number output came from marigold solitary planting, which was followed by bottle gourd intercropping. However, growing marigold in direct sunlight increased the height of the plant. Concerning yield parameters, agroforestry involving litchi-marigold-bottle gourd under substantial shade produced lower yields of marigold flower than marigold grown in direct sunlight.

After conducting an economic analysis, the T_2 system was found to be the most feasible in terms of gross return and net return. However, the benefit-cost ratio is higher in T_2 intercropping systems because of the outcome of bottle gourd returns on the other hand productivity of marigold is comparatively lower than sole and intercropping with bottle gourd. This experiment showed that the associated intercropping (T_2) system of marigold yielded a satisfactory economic benefit than the sole cropping system (T_3).

5.2 Conclusion

The research's conclusions highlight the significance of production methods in influencing marigold and bottle gourd cultivation's growth, yield, and viability from an economic standpoint. The study's results indicate that the various production systems did not significantly hinder marigold growth. In conditions of shade, the growth parameters were at an acceptable level. It might be concluded that agroforestry and intercropping of marigold would be promising option for ensuring higher productivity.

In the agroforestry system integrating Litchi, Bottle Gourd, and Marigold, the Benefit Cost Ratio (BCR) reflects favorable economic returns, while the Land Equivalent Ratio (LER) indicates enhanced productivity through efficient resource utilization. Comparatively, intercropping Marigold with Bottle Gourd also shows strong economic viability with slightly lower productivity gains, highlighting the potential of diversified agroforestry strategies to optimize both economic and agricultural outcomes.

The study aims to quantify the production potential of marigold flowers and bottle gourd within a multistoried agroforestry system, demonstrating the system's viability for diverse crop cultivation. It also evaluates the profitability of various production systems, providing insights into economic benefits. Lastly, the research calculates land-use efficiency, highlighting the optimal utilization of land resources for sustainable and productive agricultural practices.

5.3 Recommendations

- ❖ This type of research should be repeated in various agroecological zone for better yield.
- ❖ Intercropping, particularly marigold and bottle gourd, appears beneficial for marigold production, as it next to multistoried agroforestry in terms of both productivity and Benefit-Cost Ratio (BCR). This approach should be further promoted.
- ❖ Weather condition, photosynthetic active radiation etc. should be considered.
- ❖ Management practices should be more precise.
- ❖ Though marigold grown in full sunlight but intercropping with bottle gourd it performed well, so future research and farming practices should explore and optimize.

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APPENDICES

Appendix I. Production cost analysis of Marigold in various production systems

Production System	NMIC				MIC						TMIC	TIC = TNMIC+TMIC	OC			TCP = TIC + OC
	Litchi	BG	MG	TNMIC	Seed	Fert.	Pest.	IR.	IPC	MC			IBL 8% TIC	IVL 8% TIC	MISC 5% TIC	
Litchi + MG + BG	10000	10000	20000	40000	172000	40000	35000	15000	20000	5000	287000	327000	26160	35000	16350	404510
MG+BG	0	18000	20000	38000	172000	40000	35000	15000	18000	4500	284500	322500	25800	35000	16125	399425
MG	0	0	20000	20000	160000	40000	35000	10000	18000	4500	267500	287500	23000	35000	14375	359875
BG	0	18000	0	18000	12000	35000	30000	10000	18000	4500	109500	127500	10200	35000	6375	179075

Appendix II. Production cost analysis of Marigold in various production systems (contd.)

Production System	RETURN OF PRODUCTS			GROSS RETURNS OF THE PRODUCT	TOTAL COST OF PRODUCTION	NET RETURN	BCR	LER
	LITCHI	MG	BG					
Litchi + MG + BG	444800	444444.4	41666	930910.4	428635	502275.4	2.171802	2.64
MG+BG	0	522222.2	416666	938888.2	423550	515338.2	2.216712	1.69
MG	0	600000	0	600000	363660	236340	1.649893	_
BG	0	0	500000	500000	168735	331265	2.963226	_

NB: Market value of Marigold were calculated at 500tk per thousand flowers
Market value of Bottle gourd were calculated at 25000 tk per ton (25 tk per kg)

Appendix III. Analysis of Variance (ANOVA) of Plant Height of Marigold at Different DATs

Randomized Complete Block AOV Table for Plant Height 30 DAT

Source	DF	SS	MS	F	P
Replication	2	3.7489	1.8744		
Treatment	2	21.4822	10.7411	7.24	0.0469
Error	4	5.9378	1.4844		
Total	8	31.1689			

Grand Mean 10.211

CV 11.93

Randomized Complete Block AOV Table for Plant height 45 DAT

Source	DF	SS	MS	F	P
Replication	2	2.3489	1.1744		
Treatment	2	54.6289	27.3144	10.91	0.0240
Error	4	10.0178	2.5044		
Total	8	66.9956			

Grand Mean 15.478

CV 10.22

Randomized Complete Block AOV Table for Plant height 60 DAT

Source	DF	SS	MS	F	P
Replicationon	2	2.5867	1.2933		
Treatment	2	39.9200	19.9600	4.74	0.0881
Error	4	16.8533	4.2133		
Total	8	59.3600			

Grand Mean 17.800

CV 11.53

Randomized Complete Block AOV Table for Plant height 75 DAT

Source	DF	SS	MS	F	P
Replication	2	0.2222	0.1111		
Treatment	2	45.2356	22.6178	6.37	0.0571
Error	4	14.2044	3.5511		
Total	8	59.6622			

Grand Mean 20.556

CV 9.17

Randomized Complete Block AOV Table for Plant height 90 DAT

Source	DF	SS	MS	F	P
Replication	2	4.5800	2.2900		
Treatment	2	24.6067	12.3033	4.74	0.0879
Error	4	10.3733	2.5933		
Total	8	39.5600			

Grand Mean 23.033

CV 6.99

Appendix IV. Analysis of Variance (ANOVA) of Leaf Number of Marigold at Different DATs.

Randomized Complete Block AOV Table for Leaf Number at 30 DAT

Source	DF	SS	MS	F	P
Replication	2	45.769	22.884		
Treatment	2	269.876	134.938	7.91	0.0407
Error	4	68.231	17.058		
Total	8	383.876			

Grand Mean 21.022

CV 19.65

Randomized Complete Block AOV Table for Leaf Number at 45 DAT

Source	DF	SS	MS	F	P
Replication	2	135.15	67.57		
Treatment	2	2095.23	1047.61	4.25	0.1025
Error	4	986.99	246.75		
Total	8	3217.36			

Grand Mean 56.933

CV 27.59

Randomized Complete Block AOV Table for Leaf Number at 60 DAT

Source	DF	SS	MS	F	P
Replication	2	69.50	34.75		
Treatment	2	2665.64	1332.82	8.98	0.0332
Error	4	593.51	148.38		
Total	8	3328.65			

Grand Mean 62.511

CV 19.49

Appendix V. Analysis of Variance (ANOVA) of No. of Bud of Marigold at Different DATs

Randomized Complete Block AOV Table for No. of Bud at 30 DAT

Source	DF	SS	MS	F	P
Replication	2	24.2222	12.1111		
Treatment	2	54.8889	27.4444	6.68	0.0531
Error	4	16.4444	4.1111		
Total	8	95.5556			

Grand Mean 7.7778

CV 26.07

Randomized Complete Block AOV Table for No. of Bud at 45 DAT

Source	DF	SS	MS	F	P
Replication	2	16.222	8.1111		
Treatment	2	124.222	62.1111	17.20	0.0109
Error	4	14.444	3.6111		
Total	8	154.889			

Grand Mean 10.889

CV 17.45

Randomized Complete Block AOV Table for No. of Bud at 60 DAT

Source	DF	SS	MS	F	P
Replication	2	20.667	10.333		
Treatment	2	220.667	110.333	16.55	0.0116
Error	4	26.667	6.667		
Total	8	268.000			
Grand Mean	17.000				
CV	15.19				

Randomized Complete Block AOV Table for No. of Bud at 75 DAT

Source	DF	SS	MS	F	P
Replication	2	2.8889	1.4444		
Treatment	2	20.2222	10.1111	7.91	0.0407
Error	4	5.1111	1.2778		
Total	8	28.2222			

Grand Mean	9.4444
CV	11.97

Randomized Complete Block AOV Table for No. of Bud at 90 DAT

Source	DF	SS	MS	F	P
Replication	2	2.8889	1.4444		
Treatment	2	50.8889	25.4444	4.40	0.0975
Error	4	23.1111	5.7778		
Total	8	76.8889			

Grand Mean	12.889
CV	18.65

Appendix VI. Analysis of Variance (ANOVA) of No. of flower per plot of Marigold at Different DATs

Randomized Complete Block AOV Table for No of flower per plot at 75 DAT

Source	DF	SS	MS	F	P
Replication	2	2.8889	1.44444		
Treatment	2	6.8889	3.44444	1.00	0.4444
Error	4	13.7778	3.44444		
Total	8	23.5556			

Grand Mean 6.7778

CV 27.38

Randomized Complete Block AOV Table for No of flower per plot 90 DAT

Source	DF	SS	MS	F	P
Replication	2	4.6667	2.3333		
Treatment	2	32.6667	16.3333	14.00	0.0156
Error	4	4.6667	1.1667		
Total	8	42.0000			

Grand Mean 8.3333

CV 12.96

Appendix VII. Analysis of Variance (ANOVA) of flower size of Marigold at Different DATs

Randomized Complete Block AOV Table for Flower size

Source	DF	SS	MS	F	P
Replication	2	1.926	0.963		
Treatment	2	668.361	334.180	11.63	0.0215
Error	4	114.984	28.746		
Total	8	785.270			

Grand Mean 55.558

CV 9.65

Appendix VIII. Analysis of Variance (ANOVA) of Total Yield of Marigold/Plot of Marigold at Different DATs

Randomized Complete Block AOV Table for Total Yield of Marigold/Plot

Source	DF	SS	MS	F	P
Replicationon	2	6.0000	3.0000		
Treatment	2	32.6667	16.3333	7.00	0.0494
Error	4	9.3333	2.3333		
Total	8	48.0000			

Grand Mean 15.667

CV 9.75

Appendix IX. Analysis of Variance (ANOVA) of Flower Number per hectare of marigold at Different DATs

Randomized Complete Block AOV Table for Flower Number per hectare

Source	DF	SS	MS	F	P
Replication	2	2.667E+10	1.333E+10		
Treatment	2	1.452E+11	7.259E+10	7.00	0.0494
Error	4	4.148E+10	1.037E+10		
Total	8	2.133E+11			

Grand Mean 1.04E+06

CV 9.75

Appendix X. Analysis of Variance (ANOVA) of Leaf Length per hectare of Bottle Gourd at Different DATs

Randomized Complete Block AOV Table for Leaf Length at 30 DAT

Source	DF	SS	MS	F	P
Replication	2	4.4735	2.23674		
Treatment	2	12.2354	6.11768	3.84	0.1172
Error	4	6.3698	1.59244		
Total	8	23.0786			

Grand Mean 9.8956

CV 12.75

Randomized Complete Block AOV Table for Leaf Length at 45 DAT

Source	DF	SS	MS	F	P
Replication	2	4.8467	2.4233		
Treatment	2	33.2982	16.6491	4.04	0.1095
Error	4	16.4692	4.1173		
Total	8	54.6141			

Grand Mean 12.291

CV 16.51

Randomized Complete Block AOV Table for Leaf Length at 60 DAT

Source	DF	SS	MS	F	P
Replication	2	3.8598	1.9299		
Treatment	2	37.3365	18.6682	14.46	0.0148
Error	4	5.1631	1.2908		
Total	8	46.3594			

Grand Mean 12.967

CV 8.76

Appendix XI. Analysis of Variance (ANOVA) of Leaf Breadth of Bottle Gourd at Different DATs

Randomized Complete Block AOV Table for Leaf Breadth at 30 DAT

Source	DF	SS	MS	F	P
Replication	2	17.7244	8.86218		
Treatment	2	2.8478	1.42388	0.24	0.7957
Error	4	23.5193	5.87983		
Total	8	44.0914			

Grand Mean 11.094

CV 21.86

Randomized Complete Block AOV Table for Leaf Breadth at 45 DAT

Source	DF	SS	MS	F	P
Replication	2	5.9208	2.9604		
Treatment	2	62.8569	31.4284	7.30	0.0463
Error	4	17.2273	4.3068		
Total	8	86.0050			

Grand Mean 14.623

CV 14.19

Randomized Complete Block AOV Table for Leaf Breadth at 60 DAT

Source	DF	SS	MS	F	P
Replication	2	13.3443	6.6721		
Treatment	2	48.6333	24.3166	4.23	0.1030
Error	4	22.9771	5.7443		
Total	8	84.9546			

Grand Mean 16.770

CV 14.29

Appendix XII. Analysis of Variance (ANOVA) of Plant height of Bottle Gourd at Different DATs

Randomized Complete Block AOV Table for Plant Height At 45 DAT

Source	DF	SS	MS	F	P
Replication	2	1107.17	553.583		
Treatment	2	1413.17	706.583	2.02	0.2478
Error	4	1400.67	350.167		
Total	8	3921.00			

Grand Mean 75.500

CV 24.79

Randomized Complete Block AOV Table for Plant Height At 60 DAT

Source	DF	SS	MS	F	P
Replication	2	15.72	7.86		
Treatment	2	3086.06	1543.03	45.07	0.0018
Error	4	136.94	34.24		
Total	8	3238.72			

Grand Mean 87.944

CV 6.65

Appendix XIII. Analysis of Variance (ANOVA) of Fruit Length of Bottle Gourd

Randomized Complete Block AOV Table for Fruit Length (inch)

Source	DF	SS	MS	F	P
Replication	2	2.4980	1.24901		
Treatment	2	8.5010	4.25048	9.46	0.0305
Error	4	1.7975	0.44938		
Total	8	12.7965			

Grand Mean 11.659

CV 5.75

Appendix XIV. Analysis of Variance (ANOVA) of Yield/ha of Bottle Gourd

Randomized Complete Block AOV Table for Yield/ha

Source	DF	SS	MS	F	P
Replication	2	1.390E+08	6.951E+07		
Treatment	2	1.050E+09	5.252E+08	8.64	0.0353
Error	4	2.431E+08	6.078E+07		
Total	8	1.432E+09			

Grand Mean 16383

CV 47.59

Appendix XV. Plates Related to the Experiment