INFLUENCE OF COW MANURE AND AZOLLA ON THE GROWTH AND YIELD OF CLUSTER BEAN *(Cyamopsis tetragonoloba* (L.) Taub. Var, Pusa navbahar)

BY

UMADEVI, S

(Reg. No. 03 MP 52)

A DISSERTATION SUBMITTED TO THE AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER EDUCATION FOR WOMEN, DEEMED UNIVERSITY, COIMBATORE – 641 043.

In partial fulfilment of the requirements for the degree of

MASTER OF PHILOSOPHY IN LIFE SCIENCES

AUGUST 2004

CERTIFICATE

This is to certify that the dissertation entitled "INFLUENCE OF COW MANURE AND AZOLLA ON THE GROWTH AND YIELD OF CLUSTER BEAN [*Cyamopsis tetragonoloba* (L.) TAUB. VAR. PUSA NAVBAHAR]" submitted to the Avinashilingam Institute for Home Science and Higher Education for Women – Deemed University, Coimbatore, in partial fulfilment of the requirements for the award of the degree of MASTER OF PHILOSOPHY in Life Sciences, is a record of original research work done by UMADEVI, S. during the period of her study in the Department of Life Sciences, Avinashilingam Institute for Home Science and Higher Education for Women – Deemed University, Coimbatore, under my supervision and guidance and the dissertation has not formed the basis for the award of any Degree / Diploma /Associateship / Fellowship or other similar title to any candidate of any other University and it represents entirely an independent work on the part of the candidate

Signature of the Guide

Forwarded

Sarojini Sukumar
19 . 8 . 04

Signature of the Head of the Department

DECLARATION

I hereby declare that the dissertation entitled "INFLUENCE OF COW MANURE AND AZOLLA ON THE GROWTH AND YIELD OF CLUSTER BEAN (*Cyamopsis tetragonoloba* (L). TAUB)" submitted in partial fulfilment for the award of the degree of MASTER OF PHILOSOPHY in Life sciences is a record of original research work done by me during the period of my study in the Department of Life Sciences, Avinashilingam Institute for Home Science and Higher Education for Women – Deemed University, Coimbatore, under the supervision and guidance of Mrs. Rita Joseph, M.Sc., B.Ed., M.Phil., Ph.D., Professor and Head, Department of Botany, and that the dissertation has not formed the basis for the award of any Degree / Diploma / Associateship / Fellowship or other similar title to any candidate of any University.

Signature of the candidate

Countersigned

Signature of the Guide

Acknowledgement

ACKNOWLEDGEMENT

The authoress is grateful to Padmashree Hon. Colonel **Dr.(Tmt.) Rajammal. P. Devadas**, M.A., M.Sc., Ph.D. (Ohio State), D.Sc. (Madras), Hon. D.H.L. (Oregon State), Hon. D.Sc. (C.Azad Agricultural University, Kanpur), Hon. D.Sc. (University of Ulster, Northern Ireland), Former Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women, Deemed University, Coimbatore for providing me the opportunity to study in this esteemed University.

I wish to record my profound sense of gratitude to **Dr.K.Kulandaivel**, M.A., M.A. (Ohio State), Ph.D. (Madras), Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women, Deemed University, Coimbatore for giving me the facilities to conduct the investigation.

I gratefully by record my sincere thanks to **Dr. (Mrs.) M. Chandramani**, M.Sc. (Baroda), M.Ed., Ph.D (Madras), Vice Chancellor, Avinashilingam Institute for Home Science and Higher Education for Women, Deemed University, Coimbatore for giving me the provision to do my research work.

I acknowledge sincerely the facilities provided by **Dr. (Mrs.) Saroja Prabhakaran**, M.A., Dip. Ed. (Madras), Ph.D. (Mother Theresa), Registrar, Avinashilingam Institute for Home Science and Higher Education for Women, Deemed University, Coimbatore to complete my dissertation.

I owe my indebtedness to **Dr. (Mrs.) S. Sivakamasundari**, M.Sc. (Annamalai), M.Phil. Ph.D. (Madras), Dean, Faculty of Science and

Professor and Head, Department of Chemistry for the support extended to me during the period of investigation.

Wholeheartedly and profusely I thank my guide **Dr. (Mrs.) Rita Joseph**, M.Sc. B.Ed. (Kerala), M.Phil. Ph.D. (Bharathiar), Professor and Head, Department of Botany, for her valuable, meticulous guidance, innovative ideas, constructive thoughts, constant support and encouragement to bring out this piece of research successfully.

I take this opportunity to thank **Dr. (Mrs.) Sarojini Sukumar,** M.Sc., Dip.Ed., Ph.D. (Madras) Professor and Head of the Department of Life Sciences for her encouragement during my research work.

I extend my sincere thanks to all the staff members of the Department of Botany for their valuable help.

It is a pleasure to thank my friends who were always by my side to help me whenever I needed them.

I express my heartful thanks to **Ms.Hiranmai Yadav**, **R**., Ph.D. Scholar for her help rendered throughout the course of this investigation.

My cordial thanks to my beloved parents **Mr. Itty Sevanan** and **Mrs. Parvathi** for their motivation, encouragement, prayers and lovable care which have been the source of strength.

Above all, I thank God Almighty for showering His blessings for the successful completion of my studies.

Contents

CONTENTS

List of Tables

LIST OF TABLES

List of Plates

LIST OF PLATES

List of Figures

LIST OF FIGURES

List of Abbreviations

Introduction

CHAPTER I

INTRODUCTION

The Food and Agricultural Organization (FAO) in Rome also dwells upon the fact that world shortage and price increases of raw materials have created a fertilizer shortage in many countries. It is therefore of utmost importance and urgency to increase the utilization of agricultural, municipal and other wastes as a source of plant nutrients, particularly of nitrogen. Consequently it is imperative that developing countries like ours should immediately organize and adopt adequate and safe methods for collection, processing and utilization of organic waste materials.

In the last few decades, the health conscious generations have shown a preference for organically produced food products. In Austria and Switzerland, organic farming accounts for as much as 10 per cent of the food system while in countries like USA, France, Japan and Singapore the growth rate of organic farming exceeds 20 per cent annually (Uday *et al.*, 2001).

Organic farming is a production system which avoids or largely excludes the use of inorganic fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral bearing rocks and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests.

According to the produced codex definition (FAO), organic agriculture is production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological and mechanical methods, as opposed to use synthetic materials, to fulfill any specific function within the system (Arun, 2001).

In the Western World, organic agriculture is fairly well developed. There is a growing market for these products based on consumers willingness to pay a substantial premium for reliably labelled, organically grown foods. Various types and methods of organic agriculture have been developed in the Northern Hemisphere, such as the biological-organic and biodynamic method.

Organic farming is the pathway that leads us to live in harmony with nature. Organic agriculture is the key to a sound development and a sustainable environment. It minimises the environmental pollution and the use of non-renewable natural resources. It conserves soil fertility and soil erosion through implementation of appropriate conservation principles.

Organic agriculture is viable and alternative to conventional agriculture. It protects the soil from erosion, strengthens natural resources and sustains biological production at levels commensurate with the caring capacity of managed agro-ecosystem because of reduced dependence of fertilizers and plant protection chemicals; problems of environmental pollution are greatly reduced if not totally avoided. The practice leads to regeneration of ecosystem. There is now a worldwide demand for organically grown foods, which command a premium in export markets. The demand for such safe foods is increasing annually and this opportunity needs to be exploited.

The fast development of technology for increasing production without given due importance to the agro-ecosystem balance resulted in disturbed natural cycles of carbon, nutrient and food chain of flora and fauna. The results are visible in terms of decreasing yield and increasing unsustainability in agro-ecosystem. The need is to revive natural balance with sustainable farming concept. There are several approaches have been recommended by various scientists, farmers and forums. Organic farming is one such approach which emphasise on maintaining the cycle of input-output with ecofriendly methods, is becoming widely recognised by researchers and farmers and gaining popularity in the international market.

Organic farming can help farmers to maintain the health of soil and ground water. Organic food has better nutritional amount and low content of heavy metals like aluminium, cadmium, lead and mercury. It is helpful in reducing environmental pollution and health hazards (Oinam, 2004).

Organic farming is an important approach for obtaining sustainable production. The tremendous depend for organically produced foods led to the creation of new export avenues for the developing world. Since demand for a variety of foods year-round makes it impossible for any country to satisfy all its organic food needs domestically, many developing countries have started to tap the lucrative export materials for organically grown products (Uday *et al.*, 2001).

Organic manures constitute a dependable source of both major and minor plant nutrient elements. Addition of organic manures improves the physical, chemical and biological properties of soil. Various organic manurial experiments conducted in vegetables revealed the positive influence of organic manures with respect to the growth, yield and quality of vegetables. Increased yield and improved quality was reported for gourds, bhindi, chilli, brinjal and certain leafy vegetables due to the substitution of chemical fertilizers with organic manures. Also organically grown vegetables have better taste and extended shelf life. During decomposition these organic manures yield many organic compounds, organic acids as well as antibiotic substances as intermediate products (Meerabai and Asha, 2001).

Organic resources available in our country possess all kinds of nutrients essential for crop growth and yield. Important organic manures, available and generally used are farmyard manure, compost, biogas manure, manure from the sources of poultry, dairy, sheep, fish, dead bodies of men and animals etc., (Tulasiram *et al.*, 1996).

Cow dung is an important organic source of animal nutrient. It is mostly used for fuel purpose instead of using it as a source of organic manure. The total availability of wet dung is 655 million tons per annum. If it is properly converted into manure, the country's organic manure supply will increase by 130 million tons. It is more economical and rich in N, P, K contents and better than heavy dosage of costly chemical fertilizers. It helps in checking pollution, fertilizer shortage and improvement of hygiene, sanitation and better health for community in rural area (Rohilla and Bujar, 1999).

Biofertilizers, more appropriately called microbial inoculants are the products containing living cells of different micro-organisms, which have an ability to mobilize nutritionally important elements from non-usable to usable forms through biological processes. Biofertilizers are apparently environmental and farmer-friendly renewable sources. They are non-bulky, low cost agricultural inputs, playing a vital role in improving nutrient availability to the crop plants. The performance of biofertilizers is highly unpredictable due to their biological nature and susceptibility to biotic and abiotic stress (Arora and Dan, 2003).

Biofertilizer is a term now being used widespread in agricultural field. The real biofertilizers are the green manures and organic materials of biological origin which are added to supply nutrients to the plants. Various agencies have come forward to produce the biofertilizers in a big commercial way. By virtue of the usage of biofertilizer,there are possibilities of lesser pollution both by way of production and application of synthetic fertilizers. The soil health will be maintained and there may not be any problem of excessive nutrients causing contents by synthetic fertilizer usage. The bio-fertilizers are less costly and easily amenable for a sustained production (Vasudevan and Rangasamy, 1995).

For a common farmer, biofertilizers can be understood as living micro-cells. These living cells, primarily are helpful to farmers by nitrogen fixation and in crop growth. These are also helpful, secondarily to farmers in releasing and making available nutrients like sulphur, carbon and phosphorus to plant (Tulasiram *et al.*, 1996).

The importance of soil organic matter in relation to soil fertility is widely recognized. In the formation of fertile soil, organic substances play a direct role as they are the sources of plant nutrients, which are liberated in available form during mineralization (Singh et al., 1981).

Biological productivity of soil is most important for sustainable production and depends on organic matter and type of soil. Agroforestry, silvi-pastoral system, by farming and crop rotation help in addition of organic matter in the soil (Rao, 1996).

Organic matter is often used as an index of soil fertility. A high level of organic matter in the long run stabilizes the crop production through the improvement of physical, chemical and biological properties of the soil. Long term effects of organic manures are many i.e. it improves the soil physical properties, provides the balanced nutrition by replenishing the deficient nutrient, helps in the slow release of plant nutrients, enhances the fertilizer use efficiency, improves the microbial activity including various biochemical transformations, controls the occurrence of some pests and diseases, acts as buffering medium for toxic effects of pesticides and sudden changes in pH, checks soil erosion and helps in soil conservation.

Organic materials having manurial value may be classified into different categories based on the origin viz., plant origin, animal origin and miscellaneous. Organic materials of plant and animal origin have been considered as resources of immense practical value to soil productivity.

Recycling of the nutrients through addition of these organic materials is relevant to agricultural production because the natural soil-plant-animal-soil system is economically feasible in operating the principles of bio-processing and bio-conversion. The use of these organic materials can be regulated based on the composition of the materials, soil conditions and climate (Rao, 1996).

The materials mainly constitute dung are rich in nitrogen. So far dung is utilized as a direct fuel (dung cakes) and indirectly for the production of biogas. After setting aside about 50 per cent of these materials for non-agricultural purposes, the remaining 50 per cent can be diverted or would offer greater potential to meet the partial requirement of the organic matter.

It is further suggested that nutrient requirements of a crop can be made available through integrated nutrient management system using organic manures and biofertilizers so as to sustain optimum yield, improve / maintain the biological productivity and this system provides crop nutrition packages which are technically sound, economically attractive, practically feasible and environmentally safe (Rao, 1996).

Azolla is a free floating water fern which fixes atmospheric nitrogen in association with N fixing cyanobacterium. *Azolla microphylla* a fast growing and higher nitrogen fixing type with tolerance to higher temperature and salinity (Kannaiyan, 1992). Azolla can be applied as a green manure crop and as a dual crop, to promote growth and yield of plants. Organic manures and biofertilizers are vital natural resources which can be utilized to boost the overall nutrient turnover (Arora and Dan, 2003).

Realizing the importance of the conjunctive use of organic manures and biofertilizers, a study was designed to determine the suitable nutrients in commercial cluster bean cultivation, therefore organic manure like cow dung and biofertilizer like *Azolla microphylla* were suitably selected to evaluate the influence of these nutrients on cluster bean *(Cyamopsis tetragonoloba* L. Taubert), family–Fabaceae. common names–Guar, Cluster bean, Siambean, Calcutta lucerne.

Guar is grown as a cover crop, green manure, forage for cattle and protein supplement. Young pods are eaten as vegetable. Used as flocculant and filter acid in mining industry. Used in cosmetics, and in paper manufacturing. Cluster bean is an important leguminous Kharif crop of India. Seeds of cluster bean are rich in protein, calcium, phosphorus and iron. It is a good supplement to staple foods.

Medicinally, the fruit is laxative and is used in bioliusness. Leaves are eaten to cure night blindness. Boiled seeds are used for poultices for head swellings, enlarged liner, plague and swelling caused by broken bones. Ashes of burnt guar, mixed with oil, are applied to boils on animals.

The objectives of the study are,

- To promote the conservation and sustainable utilization of biological resources – Azolla.
- To assess the influence of organic manure (CD).
- To assess the influence on growth and yield of the test plant.
- To assess the physico-chemical nature of the post harvest soil samples.
- To estimate the total protein and chlorophyll content of the leaves.

It is important to note that sustainable agriculture is really a long term goal, not a specific set of farming practices. In temperate zones sustainable agriculture was defined as a philosophy based on human goals and on understanding the long-term impact of our activities on the environment and on other species. Use of this philosophy guides our application of prior experiences and the latest scientific advances to create integrated, resource – conserving, equitable farming systems. These systems reduce environmental degradation, maintain agricultural productivity, promote economic viability in both the short and long term and to maintain stable rural communities and quality of life (Arun, 2001).

According to the definition of FAO, organic farming should involve successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the quality of the environment and consuming natural resources (Krishnaveni and Balamurugan, 2002).

With the exploding population of the country and rapid depletion and degradation of natural resource base sustainable agriculture has assumed great significance. Thus the scope of biofertilizers, in enhancing productivity and fertility of the soil appears to be bright (Arora and Dan, 2003).

Fertilizer is a key input for supplementing nutrition depletion and increasing crop production. The green revolution in India owes much of its success to chemical fertilizers. Today fertilizer has become an indispensable input for intensive agriculture. The consumption of chemical fertilizers during 2000 – 2001 is estimated to be more than 17 million tonnes in our country (Arora and Dan, 2003).

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Organic farming involves an approach to food production. It seeks to create a sustainable agriculture system that relies first and foremost on ecological interactions and biological processes rather than chemical inputs. The aim of organic farming is to produce optimum yields with minimum harm to the surrounding environment.

This review chapter is mainly confined to the literature related to this investigation. The literature is reviewed and presented scientifically on various aspects like organic manures, bio-fertilizers and biochemical, biometric and yield parameters of the test plant.

2.1 ORGANIC FARMING – AN OVERVIEW

India's population figure may touch an all time high of 100 crores by the end of this century. To feed this population, we need to increase the present production of 190 million tonnes of food grains per year to 230 million tonnes per year. Fertilizers contribute to the extent of 50 per cent increase in the crop yields. Now a days, farmers are using high yielding varieties of crops and hence, the use of fertilizers is increasing day by day. Indiscriminate use of fertilizers associated with low and excess application at times by farmers is leading to many problems like degradation of soil productivity, environment pollution etc. Hence the use of chemical fertilizers should be reduced to the minimum paving the way for integrated use of manures and fertilizers (Tulasiram *et al.,* 1996).

2.2 ORGANIC FARMING – A BOON TO AGRICULTURAL PRODUCTION

From the available sources, India annually produces about 650 million tonnes of rural composts, 11 million tonnes of urban composts and 100 million tonnes of city sewage. It has been estimated that about 400 million tonnes of cow dung is utilized as a domestic fuel annually and a fuel substitute for this can help in providing substantial plant nutrients (Ashok *et al.,* 1976). The organic wastes are very useful to the farmers in several ways. These wastes can very efficiently be utilized in counteracting undesirable properties of soil (Ashok *et al.,* 1976).

The organic wastes improve the structure and to some extent the texture of the soil, thus increasing aeration, water holding capacity besides supplying plants with essential nitrogen and other nutrients. Continuous application of chemical fertilizers on light textured irrigated soils have shown nutrient deficiency, where as the application of organic manures have positive effect on the release of these nutrients and availability to plants. These manures are not only a substitute for nutrients, but also greatly increases the efficiency of applied fertilizers and produces favourable effect on the physical properties of soils (Ashok *et al.,* 1976).

Organic wastes are alternatives or supplementary sources of nutrients which when harnessed and used could not only reduce the dependence on fertilizers but also build up soil fertility on a sustainable basis. It is estimated that about 6m.t of fertilizer nutrients could be supplemented through organics and biofertilizers (Sankaran and Subbian, 1996).

Today, exclusive organic food shops, natural and health food stores are on the increase in the U.S, European Union and Japan, who sell a wide range of organically grown certified labelled products like cereals, millets, fruits, vegetables, cheese, butter, egg, meat, beef, pork, spices, beverages such as bio-coffee, bio-tea and bio-cocoa drink etc. Even with higher price-tag, people are ready to buy them due to increased awareness of the health hazards associated with conventionally grown foods which carry high residues of chemicals and pesticides. People look for healthy and pollution free food centres. "Eco" labelled textiles have also been introduced by the German textile industry wherein fabrics have to be manufactured from organically grown cotton with natural colours avoiding chemical dyes and using environment-friendly processing methods (Hegde, 1997).

Organic farming also employs natural pest control measures such as biological control, plants with pest control properties rather than synthetic pesticides. Reduction in the use of toxic synthetic pesticides, which poison and estimated three million people each year leads to improved health of the consumers (Uday, 2001).

The excessive use of fertilizers though increases crop production, results in polluted environment and causes deterioration of soil health. The chemical residues in food products are also hazardous to both human beings as well as livestock. The chemical fertilizers are costly. Hence it is considered necessary to switch to an alternative source of nutrient supply to the crops and as such emphasis on the use of fertilizers of biological origin gained importance (Arora and Dan, 2003).

2.3 CONJUNCTIVE USE OF ORGANIC AND BIOFERTILIZERS AND ITS SIGNIFICANCE

Kannaiyan and Rajeswari (1983) found that higher levels of fertilizer nitrogen, along with Azolla inoculation recorded considerably more tillers. Roy (1984) reported that when Azolla was applied with inorganic nitrogen, the mineralisation of Azolla was higher and availability of N to rice crop was more. Kannaiyan *et al.* (1984) found that Azolla alone and with urea stimulated growth and significantly increased grain yield. Ramaswamy *et al.* (1984) obtained highest grain yield with 500kg fresh Azolla inoculated with 60kg N ha^{-1} as urea and it was equal to that obtained with 90 kg N ha^{-1}.

The use of Azolla as green manure and also as dual cropping with rice has been well documented by several investigators (Liu, 1985; Mabbayod, 1985; Watanabe, 1985; Kannaiyan, 1985; Laddawan and Cholskararengsa, 1985; Fiore, 1985; and Diara *et al.*, 1985). Latha (1985) reported the highest plant height in rice plant with application of N a USG and Azolla as dual crop.

Kannaiyan (1987) reported that a layer of Azolla covering a hectare of rice field contains about 15 – 25 t biomass. Singh and Singh (1987) reported that maximum N and P uptake in rice were obtained by growing two crops of Azolla after transplanting in addition to its incorporation before transplanting.

Manna and Singh (1988) in a field study indicated that contribution of Azolla in respect of grain yield was more with ammonium sulphate and farmyard manure than urea supergranule and urea.

Kannaiyan (1989) reviewed the potential value of Azolla as biofertilizer for rice production. The author established that pre-soaking of dried sporocarps of *A. microphylla* in growth regulators and phosphorus have activated the spore germination.

The use of Azolla biofertilizer along with urea super granules has been recently reported by Kannaiyan (1990). The author also reported the induction of sporulation in Azolla with inorganic amendments such as dried pig manure, dried poultry manure and fresh cattle dung and the induction of sporulation in *A. microphylla* with GA_3 at 100ppm.

Organic residues including green manures, animal wastes serve as effective sources of plant nutrients and humus (Samanta and Patro, 1996). Organic manures from animal wastes play an important role in soil fertility in association with chemical fertilizers. Due to expensive chemical fertilizers, animal wastes are regaining importance as organic fertilizers. According to a recent estimate, the production of dung and urine from bovine population in India works out to be 1002 and 658 million tonnes respectively, contributing about 5.71 million tonnes of NPK based on the average percentage of nutrient in the dung and urine (Samanta and Patro, 1996).

Amudhasurabi and Longanathan (2000) stated that the organic manure through the process of decomposition and humification gives humus which helps to improve the physical, chemical and biological properties of soil. The organic acid released during decomposition of organic manure controls certain fungal pathogen infestations. Commonly available organic manures like FYM, crop residues, poultry and sheep manure and other farm wastes will effectively be utilized for nutrient supplement. This helps the plants to grow better in all the treatments expect control. There are reports that suitable mixing of cattle dung / weed on residues may substantially improve the methane production efficiency digesters.

Organic manures and biofertilizers should be used in judicious combinations to maintain the soil fertility at desired level (Kumaraswamy, 2002). The organic manures are mostly of plant origin and are utilized either directly or after having been used once as food by animals and humans (Basavannappa and Biradar, 2003).

2.4 INFLUENCE OF ORGANIC MANURES: BIOMETRIC ASPECTS

Pate and Dart (1961) documented that small amount of N to legumes has been stimulated nodule formation. Nitrogen improved the vegetative growth and increased diameter and weight of bulb. Andhale and Kalbhor (1980) reported that N application increased the plant height in H*elianthus annus.*

Organic manures significantly increased the groundnut productivity (Ali *et al.,* 1974 and Kumaresan *et al.,* 1984). Dr. S.P. Chaudhari, Chief Agronomist, Shrivan Khad programme in a press note (The Tribune Nov, 22, 1975) has reported that rural compost can add to the soil 2.62 million tonnes of nitrogen, 1.75 million tonnes of phosphorus and 1.75 million tonnes of potash. Cattle urine can add 2.62 million tonnes of nitrogen, 0.04 million tonnes of phosphorus and 1.85 million tonnes of potash. Besides the major nutrients, organic wastes are also an important source of certain micronutrient elements viz., zinc, copper, iron and manganese (Ashok *et al.,* 1976).

The organic manures supplied available nutrients to the plants and also had solubilizing effects on fixed form of other nutrients (Sinha *et al.,* 1981). Reddy (1984) reported that the application of 10 tonnes of FYM plus 120L:60:60 kg ha^{-1} of NPK resulted in healthy and taller maize plants.

Organic manures improved the growth of rice crop directly by providing considerable macro and micro nutrients and indirectly by way of improving the physico-chemical and microbiological properties of soil. By the way of combined application, the organic matter brought matrix for the adsorption and retention of nutrients (Anilakumar *et al.,* 1993).

Organic wastes (solid and liquid) actually are the wasted organics. They are a resource for organic farming – as a feed (substrate) for the soil process (Uday, 1995). Organic manures, fertilizers and biofertilizers must be used in judicious combinations to maintain the soil fertility at desired levels and plant production measures through mechanical, cultural, chemical and biological methods. The two years results reveal that all the sources and levels of organic manures improved the productivity of wheat crop in sorghum-wheat and pearlmillet cropping systems (Singh *et al.*, 1998).

Concentrated organic manures that are rich in plant nutrients could replace the inorganic fertilizers on equivalent nutrient basis. Application of organic manures improves the physical, chemical and biological properties with direct impact on moisture retension, root growth and nutrient conservation etc. (Krishnakumar and Jawahar, 2001).

Application of organic manures will provide balanced proportion of all nutrients required by the crops. Harnessing the possible nutrient interaction will aid in boosting the crop yields (Latha, 2003). Although organic manures can supply all the essential plant nutrients, the full requirement of certain nutrients like nitrogen, phosphorus, potassium, calcium, magnesium and sulphur which are required relatively in larger amounts for the normal growth and high yields (Kumaraswamy, 2004).

2.5 EFFECT OF ANIMAL WASTES ON GROWTH AND YIELD CHARACTERS

Organic amendments of cattle manure promoted a rapid and high increase of soluble P (Felleca *et al.,* 1983). According to Malik and Dadlani (1984), 5kg of well rotten cow dung manure, 100g nitrogen, 100g phosphorus and 70g potash per plant had beneficial effect on flower production of rose.

The effect of cow dung on the yield of hyacinth bean was more prominent when applied with chemical fertilizers. The beneficial effect of cow dung may be expected as it contains approximately 0.5% N, 0.1% I, 0.5% K, 0.2% Mg and 0.1% S, 25kg N, 5kg P, 25kg K and 5kg S which produced favourable effects in increasing bean yields (Noor *et al.*, 1992).

Dahiya *et al.* (1998) reported higher grain yield of pearlmillet at 120kg N + 60kg P_2O_5 / ha as compared to 90kg N + 45kg P_2O_5 / ha due to the application of FYM.

The successive increase in FYM upto 20 t / ha resulted in significant increase in grain yield which might be attributed to significant increase in ears/m and improvement in the 1000 grain weight of pearlmillet. Higher doses of FYM also resulted in significant increase in stover yield due to significant increase in plant height. Positive effect of FYM application in cereals has also been reported by (Singh *et al.*, 1998).

Farmyard manure is one of the valuable organic manures. It includes the solid and liquid excreta of livestock generally mixed with a small amount of litter such as straw which has been used as bedding for the animals (Singh et al., 1998).

Agbim (1998) concluded that the total yield of maize increased with increasing proportion of cattle dung in a treatment rising from a value of 7.04mg ha^{-1} for 100% cassava peels to 9.22mg ha^{-1} for 100% dung. Also, he obtained the highest legume yam-bean yield with 50% cassava peels plus 50% cattle dung treatment.

2.6 BIOFERTILIZERS

The term biofertilizer or more appropriately a microbial inoculant can generally be defined as preparations containing live or latent cells of efficient strains of nitrogen-fixing, phosphate solubilizing or cellulolytic micro-organisms used for application to seed or composting areas with the objective of increasing the number of such micro-organisms and accelerate

The conjunctive use of cattle manure @ 8970kg ha^{-1} and NPK (each @ 22.4kg ha^{-1}) to rice was markedly superior with an yield increase of 7.6 per cent over NPK alone (Anilakumar *et al.*, 1993).

Improvement in root growth in maize was reported by Gajri *et al.* (1994) by the use of FYM @ 15 t ha^{-1}. Improved bulb yield of onion by the incorporation of FYM @ 10 t ha^{-1} was observed by Pritam and Ajit in 1994. Promoted yields of wheat, soyabean and oats due to the application of poultry manure to the soil without any previous treatment was registered by Wietholter *et al.* (1994). Pritam and Gupta (1994) considered 8 tonnes of FYM ha^{-1} and 90.25 kg ha^{-1} P_20_5 as optimum for wheat to get higher yield.

Organic farming involves harnessing of soil organisms to process plant and animal residues to produce slow release of nutrients as needed by the crop (Uday, 1995). Intodia *et al.* (1995) opined that the application of FYM @ 10 t ha^{-1} influenced the plant height and dry matter accumulation in groundnut.

The growth of cow pea such as number of pods per plant, 100 seed weight and dry weight of nodules were improved significantly by the addition of phosphorus along with organic manure (Nagaraju *et al.*, 1995).

Best yield in banana was obtained by Ray and Yadav in 1996 with 25 per cent FYM + green manuring and 75 per cent in organic fertilizers. FYM as the best starter material to maize over other starter materials like cow dung slurry, biogas slurry and mechanical compost was confirmed by Ravichandran *et al.* (1996).

those microbial processes which augment the availability of nutrients that can be easily assimilated by plants. Use of bio-fertilizers in all field crops and orchard crops increases the nitrogen fixation and uptake of nutrient. The yield will increase 20-25%, using bio-fertilizer is one way to achieve sustainable productivity and environmental security (Kanakamani, 2004).

Azolla fixes nitrogen in symbiotic association with a heterocystous Blue green Algae, *Anabaena azollae*. Azolla contains 0.2 - 0.4% nitrogen on fresh weight basis (3 – 5% N on dry weight basis). Azolla is used as fertilizer in Vietnam and China for centuries to rice. Central Rice Research Institute, Cuttack is the premier centre for research of Azolla in India. Azolla is a good source of potassium for rice in deficient soils. Azolla can be used both as a green manure before transplanting and as a dual crop after transplanting of rice. Incidentally, a well grown Azolla forms a thick mat reducing the availability of light and nutrient to weeds and suppress their growth. Integrated nutrient plant systems involving fertilizers, organic manures, biofertilizers and nutrient solubilizers with organic residues, have shown greater potential in stabilizing the yields of field crops cover over a period of time besides improving the soil properties (Sankaran and Subbian, 1996).

Azolla has been used as a green manure in wetland rice culture for centuries in Northern Vietnam and Southeastern China (Lumpkin and Plucknett, 1980).

Azolla is a free floating water fern which fixes atmospheric nitrogen in association with the N fixing cyanobacterium. *Azolla microphylla,* a fast growing and higher nitrogen fixing type with tolerance to higher temperature and salinity is used as biofertilizer for rice (Kannaiyan, 1992).

For a common farmer, biofertilizers can be understood as living microcell. These living cells, primarily, are helpful to farmers by nitrogen fixation and in crop growth. These are also helpful, secondarily, to farmers in releasing and making available nutrients like sulphur, carbon and phosphorus to plants (Tulasiram *et al.*, 1996).

To ensure better soil health, pollution free environment, clean water, higher crop yields coupled with yield stabilization, farmers have to be thoroughly educated regarding the importance of integrated nutrition for agriculture (Tulasiram *et al.*, 1996).

Pandey and Kumar (2002) reported that Azolla can rapidly double its biomass in 3-5 days and fix 60-80kg Nitrogen per hectare per crop. Besides supplementation of N to current crop Azolla also leaves substantial amount of residual effect on the succeeding crops.

Wide variety of biofertilizers with proven utility for a large number of crop species are now available in the market. Response on biofertilizers have been obtained in cereals, millets, pulses, legumes, oilseeds, sugarcane and cotton grown under different agroclimatic conditions. Biofertilizers are being promoted as an important component in supplementing plant nutrient needs of the country. They have been found to increase yield of crops from 10-60% and thus are more effective in meeting the food grain demand for 1000 million Indians (Arora and Dan, 2003).

Azolla is an aquatic fern widely found both in temperate and tropical conditions as well as in lowland rice growing regions. Azolla fixes atmospheric nitrogen in symbiotic association with Anabena algae. This association uses energy from photosynthesis to fix atmospheric nitrogen upon 100-150 kg ha^{-1} annually. It is more widely used now in paddy cultivation for better crop production (Arora and Dan, 2003).

2.6.1 Biometrical Aspects

Mallick *et al.* (1978) found a linear increase in the plant height with increasing level of nitrogen. Increase in plant height due to fertilizer N (Abdul Salam, 1984) and Azolla (Kannaiyan and Rajeswari, 1983; Latha, 1985 and Thangaraju *et al.,* 1992) has been reported. Similar increase in the plant height of rice due to the incorporation of Azolla and application of fertilizer N has been observed in the present study.

Applications of nitrogen helped in increasing the vegetative growth of plants and also plant dry matter (Saxena *et al.,* 2001). The green manure addition had a significant influence on the dry matter production of rice as well as the uptake of Zn and S in both the soils (Mythili *et al.*, 2003).

2.6.2 Yield Characters

Singh (1977) reported that the grain yield was higher with the incorporated Azolla than with non- incorporated Azolla. Azolla is widely used as potential biofertilizer for increasing the grain yield of rice. Azolla application was reported to increase grain yield by 18.6 to 54% (FAO, 1977; Singh, 1979; Swatdee and Seetanum, 1979). Kulasooriya and

De Silva (1977) studied the effect of Azolla on rice yield and compared with urea and the number of grains per panicle was increased followed by Azolla. Liu (1979) reported an increase of 18.6% rice yield due to Azolla application. Subudhi and Singh (1980) found that Azolla application significantly increased the straw and grain yields of rice.

Kannaiyan (1981) reported that inoculation of Azolla pinnata at 3t ha^{-1} as dual culture with rice yield with 25 kg fertilizer N ha^{-1}. He also observed an increase in yield of rice crop to the tune of 26.1% as dual cropping; 35.8% as green manure and 39.7% as both green manure and dual cropping.

Kannaiyan and Govindarajan (1982) found that 25 kg N ha^{-1} can be saved by applying Azolla. Integrated use of the organics and fertilizer nitrogen apparently increases the nitrogen utilization in the rice crop. In lowland rice soil ecosystem nitrogen can be effectively supplied by the use of Azolla, a biofertilizer.

The success of the use of Azolla biofertilizer depends on its rate of decomposition and mineralisation by which the organic nitrogen is made available to rice crop. Under flooded rice soil system the decomposition of incorporated plant materials generally depends on the physical, chemical and biological properties of the soil (Venkataraman and Kannaiyan (1984).

Venkataramanan and Kannaiyan (1984) studied Azolla inoculation as dual crop with rice in double row planting system and found significant increase in the grain yield of rice. Ito and Watanabe (1985) in a N_{15} study reported that larger amounts of Azolla nitrogen were available to rice when Azolla was incorporated than when it was placed on the soil surface.

Azolla was superior to top dressing and dual cropping. The highest grain yield (6.5 t / ha) was recorded with the application of 15t / ha Azolla + 15kg N/ha at panicle initiation stage. According to Veer and Patil (1989) the extent of yield increase, compared with the control, due to different treatment, varied from 5 to 107.55%. Azolla species improved the grain yield mainly due to increased number of grains per panicle.

In recent years due to over exploitation of natural resources, biofertilizers have emerged as an important component of integrated nutrient supply system (INSS) and hold a promise to improve the crop yields and nutrient supplies (Gill *et al.*, 2000).

Increasing trend in flowering and pod formation, higher leaf area index and dry – matter accumulation and improvement in yield traits. Both the efficiency of BNF and seed yield were improved significantly following basal application of 60kg N/ha (Praharaj and Dhingra, 2001). With higher doses of Azolla, productive tillers were 11 hill^{-1}, plant height was 71.96 cm (Alice *et al.*, 2003). Integrated use of GLM or FYM and FN to rice helps to maintain optimum crop yield (Reddy *et al.*, 2003).

2.7 SOIL

The application of Azolla enhances considerably the soil microbial and soil enzyme activity which in turn maintains the soil fertility (Kumar and Kannaiyan, 1992). Biological and physico-chemical management are essentially based on integrated approach to soil fertility management (Arun, 2001).

According to Arun (2001) soil fertility management is an ecological approach, which favoured balanced farming systems. Biological approach to soil fertility management will help to restore soil fertility and will solve many problems related to soil management. The biological soil fertility management is an ecological approach for sustainable development and is mainly concerned with the maintenance of yield closely associated with desires to conserve natural resources, including a greater value accorded to maintenance of biodiversity.

At the present situation of energy crisis, inclusion of locally available organics and phosphate solubilizers have a vital role to play in increasing the efficiency of low grade rock phosphate, besides maintaining the fertility of the soil in the long run (Ravichandran *et al.*, 2003).

Besides zinc, other essential plant nutrients are also supplied to the crop through the use of organic manures ensuring balance nutrition and maintaining the soil fertility (Latha, 2003). Integrated use of GLM or FYM and FN to rice helps to maintain optimum results in sustainable soil productivity on long – term basis (Reddy *et al.*, 2003).

2.8 NPK

According to Natarajan and Srinivasan (1989) application of NPK at 40:80:40 kg/ha resulted in significantly higher yield of Carødamom. Experimental evidences suggest that blending of chemical NPK with organic manures like FYM improves the physiological condition of the plant and increases the growth and yield of cotton crop (Sagre and Guhe, 1991). Subba Rao *et al.* (1993) found that application of NPK + FYM increased the fodder yield and straw yield of sorghum and available K in the soil. Application of NPK to papaya significantly increased the plant height, and yield per plant

(Ghanta *et al.*, 1995). Joseph (1995) stated that yield parameters of brinjal were significantly influenced by graded doses of NPK.

Singh *et al.* (1997) concluded that FYM @ 25t/ha along with NPK @ 10:25:25 gave highest yield of onion. Application of NPK caused marked increase in NPK content of leaf and yield of litchi according to Hasan and Chattopadhyay (1997). Venkitaswamy *et al.* (1997) recorded more growth and yield of coconut with application of NPK @ 500:250:1000g/palm/year. According to Avijit and Kumar (1998) application of 100% NPK + 20 kg biozyme resulted in the highest yield parameters and straw yield of wheat.

The seed protein content and oil content of soybean were higher with the application of biogas digested slurry and NPK according to Panneerselvam *et al.* (1998). Results of Panneerselvam and Christopher (1998) revealed that application of biodigested slurry and NPK distinctly increased all the yield attributing characters leading to increased soybean yield. Singh *et al.* (1998) obtained higher grain and straw yield of rice by application of 125 per cent NPK.

Maheswarappa *et al.* (1998) obtained significantly increased biometric attributes of arrowroot due to FYM + NPK treatment. Surekha and Rao (1998) applied NPK as straight fertilizer and recorded the highest fruit yield of bhendi. Vasanthi and Kumaraswamy (1998) observed that application of organic manure at tonnes per hectare plus 100 per cent NPK improved quality of forage from fodder crops. The application of NPK significantly increased the root yield of aswagandh (Muthumanickam and Balakrishamurthy, 1998).

According to Panneerselvam *et al.* (1999) application of bio-digested slurry @ 5.0t/ha+30: 120 : 40kg NPK/ha recorded the highest N uptake by soybean and soil available nitrogen. Application of NPK @ 1.0: 0.25: 20kg /palm/year increased growth parameters and yield attributing characters of coconut (Athmanathan *et al.*, 1999). Balasubramanian *et al.* (1999) applied pig manure along with NPK and received higher yield of dry chilli.

Brennan *et al.* (2000) observed that application of N, P, K increased the growth of *Pilotus exaltatus* Ness. According to Subramaniyan *et al.* (2000) successive increase in dose of NPK fertilizers upto 15% of recommended dose resulted in markedly higher yield and enhanced vegetative growth of two varieties of sesame.

Application of 100 per cent NPK significantly gave better effect on the growth and yield parameters of groundnut (Subramaniyan *et al.*, 2000). Sivamurugam *et al.* (2000) obtained higher seed yield, nutrient uptake and higher crude protein in sunflower with NPK at 80:40:40kg/ha. It also enhanced the yield attributing character and yield of sunflowers. The variety of pusa kranti fertilized with 150kg N/ha produced maximum yield and growth parameters according to Babu and Balamurugan (2001). Integrated use of organic manures with optimal levels of NPK fertilizers improves the soil health and stabilizes the crop yield of soybean and wheat was observed by Manna *et al.* (2001) by application of full recommended dose of inorganic fertilizers.

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

Organic agriculture alone can ensure a future that is both ecologically sound and economically sustainable. An efficient use of integrated organic manure (cow dung) along with biofertilizer (Azolla) is a pre-requisite for achieving higher productivity of crops. The details regarding the pot culture experiment, combinations of fertilizers used as treatments, the biometric observations recorded, the biochemical analysis of total protein and chlorophyll content, the analytical techniques followed for the analysis of the soil and the statistical evaluation of the data are described in this chapter.

3.1 COLLECTION OF VARIOUS MATERIALS FOR THE CONDUCT OF THE INVESTIGATION

3.1.1 Collection of Soil Samples

Red sandy loam soil samples were collected from the P and T colony, Saibaba Colony, Coimbatore.

3.1.2 Collection of Seeds

Seeds of cluster bean , (*Cyamopsis tetragonoloba* var, Pusa-1) were purchased from the Department of Seed Technology, Tamil Nadu Agricultural University, Coimbatore.

3.1.3 Collection of Organic Waste

The organic waste like cow dung (CD) was collected from the P and T colony, Edayarpalayam Road, Coimbatore.

3.1.4 Collection of Green Manure

The green manure, *Azolla microphylla* was bought from the Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore.

3.2 POT CULTURE EXPERIMENT

A pot culture experiment was conducted using cluster bean *(Cyamopsis tetragonoloba)* as the test crop to estimate the rate of influence of organic manure, cow dung (CD) along with green manure, Azolla. They are combinely used in different combinations.

3.3 DESIGN AND LAYOUT OF THE EXPERIMENT

The study was laid out in a completely randomized design, consisting of ten treatments. All the treatments were replicated three times. Hence a trial experiment was carried out at Avinashilingam Deemed University, Coimbatore to evaluate the effect of cow dung and Azolla at different percentage levels (25%, 50% and 100%).

3.4 CULTIVATION AND TREATMENT APPLICATION

The soil was cleaned absolutely by removing stones, pebbles and other unwanted materials and was homogenized properly. Then each pot was filled with 7kg of soil. Cow dung and Azolla in calculated amounts and in different combinations were applied in each pot. Then, the soil and the mixture were mixed thoroughly.

After the incorporation of organic waste and green manure, 10 seeds of cluster bean were sown in each pot on 9.2.04 and after germination and establishment, six healthy plants were maintained per pot. All cultural operations such as weeding and irrigation were done as per package of practices.

3.5 TREATMENT DETAILS

There were 9 treatments as given below which were evaluated against the control.

Crop	:	Cluster bean -*Cyamopsis tetragonoloba* (L.) Taub.
Variety	:	Pusa Navbahar

Treatment

T_1	:	Control
T_2	:	CD 100%
T_3	:	CD 50%
T_4	:	CD 25%
T_5	:	Azolla 100%
T_6	:	Azolla 50%
T_7	:	Azolla 25%
T_8	:	CD 100% + Azolla 100%
T_9	:	CD 50% + Azolla 50%
T_{10}	:	CD 25% + Azolla 25%

The treatments are described in detail below,

T_1	:	Control. To the 7kg of soil, no organic or green manure was applied and it was kept as an absolute control.
T_2	:	To the soil 100% of CD was applied
T_3	:	50% CD was mixed with soil
T_4	:	The soil was mixed with 25% of CD
T_5	:	The soil was impregnated with 100% of Azolla
T_6	:	50% of Azolla was mixed with soil

T_7	:	The soil was mixed with 25% of Azolla
T_8	:	This treatment contains 100% of CD and 100% of Azolla
T_9	:	A combination of 50% of CD and 50% of Azolla
T_{10}	:	Along with 25% of CD, 25% of Azolla was incorporated into the soil.

3.6 COLLECTION OF PLANT SAMPLES AT 30 DAS, 60 DAS AND 90 DAS

The plant samples were collected carefully at 30, 60 and 90 DAS after sowing and were recorded various biometric and yield parameters. The samples were also analysed for total protein and chlorophyll content.

3.7 BIOMETRICAL OBSERVATION OF PLANT SAMPLES

3.7.1 Stage Analysis

Plant samples were uprooted carefully at 30 DAS, 60 DAS and 90 DAS. The roots were cleaned thoroughly. The plant samples were air dried and then oven dried at 60^0C and the weights were recorded for the dry matter production (DMP).

Following biometrical parameters were measured and recorded accurately for all the samples.

Stage I – 30 DAS (09.02.2004)

Root length (cm)
Shoot length (cm)
Plant height (cm)
Number of leaves
Root volume (cc)

Fresh weight of root (g)

Fresh weight of shoot (g)

Fresh weight of plant (g)

Dry weight of root (g)

Dry weight of shoot (g)

Dry weight of plant (g)

Number of nodules

Stage II – 60 DAS (11.03.2004)

Root length (cm)

Shoot length (cm)

Plant height (cm)

Number of leaves

Root volume (cc)

Fresh weight of root (g)

Fresh weight of shoot (g)

Fresh weight of plant (g)

Dry weight of root (g)

Dry weight of shoot (g)

Dry weight of plant (g)

Number of nodules

Length of pods (cm)

Number of pods

Fresh weight of pods (g)

Dry weight of pods (g)

Stage III – 90 DAS (12.04.2004)

Root length (cm)

Shoot length (cm)

Plant height (cm)

Number of leaves

Root volume (cc)

Fresh weight of root (g)

Fresh weight of shoot (g)

Fresh weight of plant (g)

Dry weight of root (g)

Dry weight of shoot (g)

Dry weight of plant (g)

Number of nodules

Length of pods (cm)

Number of pods

Fresh weight of pods (g)

Dry weight of pods (g)

To evaluate the root volume, a measuring cylinder was taken and poured water to a certain level and the level was carefully noted. The root was placed fully in the water in the measuring cylinder and the rise in the level of water was noted. The difference between the initial and final levels of water represented the volume of the roots.

3.8 BIOCHEMICAL ANALYSIS

3.8.1 Estimation of Total Protein (Lowry *et al.*, 1951)

Principle

The blue colour developed by the reduction of the phosphomolybdic-phosphotungstic components in the Folin-Ciocalteau reagent by the amino acids tyrosine and tryptophan present in the protein, plus the colour developed by the biuret reaction of the protein with the alkaline cupric tartrate are measured in the Lowry's method.

Materials

- 2 per cent Sodium carbonate in 0.1 N Sodium hydroxide (Reagent A)
- 0.5 per cent Copper sulphate ($CuSO_4 . 5 H_2O$) in 1 per cent potassium sodium tartrate (Reagent B)
- Alkaline copper solution : Mix 50 ml of A and 1 ml of B prior to use (Reagent C)
- Folin-Ciocalteau reagent (Reagent D)

Protein Solution (Stock standard)

Weighed accurately 50 mg of bovine serum albumin (Fraction V) and dissolved in distilled water and made up to 50 ml in a standard flask.

Working standard

Diluted 10 ml of the stock solution to 50 ml with distilled water in a standard flask. One ml of this solution contained 200 μg of protein.

Procedure

Extraction of Protein from Sample

Extraction is usually carried out with buffers used for the enzyme assay. Weighed 500 mg of the sample and ground well with a pestle and mortar in 5 – 10 ml of the buffer. Centrifuged and used the supernatant for protein estimation.

Estimation of Protein

1. Pipetted out 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard into a series of test tubes.

2. Pipetted out 0.1 ml and 0.2 ml of the sample extract in two other test tubes.
3. In all the test tubes the volume was made upto 1 ml. A tube with 1 ml of water served as the blank.
4. Added 5 ml of reagent C to each tube including the blank and mixed well. Then it was allowed to stand for 10 minutes.
5. Then 0.5 ml of reagent D was added and mixed well and incubated at room temperature in the dark for 30 minutes. Blue colour was developed.
6. The adsorbent was measured at 660 nm.
7. The standard graph was drawn and the amount of protein in the sample was calculated.

Calculation

The amount of protein in the sample was showed as mg/g.

Estimation of Chlorophyll content

Chlorophyll a, b and total were analysed following the method of Arnon (1949).

One gram of leaves (on fresh weight basis) was cut into small bits and taken into a clean mortar. The leaf bits were ground to a fine pulp with the addition of 20 ml of 80 per cent (w/v) acetone. The mixture thus obtained was centrifuged (5000 rpm for 5 minutes) and the supernatant was transferred to a 100ml volumetric flask. This procedure was repeated until the residue became colourless. The washings were collected and the volume was made up in the flask to 100 ml with acetone. The absorbance of the solution was read in a spectrophotometer at 645 and 663 nm against the solvent blank (80 per cent acetone).

The amount of chlorophyll present in the extract was calculated (mg chlorophyll / g tissue) using the formula

$$\text{(i) mg chlorophyll 'a'/g tissue} = 12.7\, A_{(663)} - 2.69 A_{(645)} \times \frac{V}{1000 \times W}$$

$$\text{(ii) mg chlorophyll 'b'/g tissue} = 22.9\, A_{(645)} - 4.68\, A_{(663)} \times \frac{V}{1000 \times W}$$

$$\text{(iii) mg of total chlorophyll/g tissue} = 20.2 A_{(645)} - 8.02 A_{(663)} \times \frac{V}{1000 \times W}$$

where,

A – Absorbance at specific wavelength

V – Final volume of chlorophyll extract in 80 per cent acetone

W – Fresh weight of tissue extracted.

3.9 NUTRIENTS STATUS OF POST HARVESTED SOIL

Post harvested soil was analysed for pH and macronutrients like N, P and K.

3.10 STATISTICAL ANALYSIS

The data obtained from various biometrical observations of growth and yield parameters were subjected to the statistical analysis. Based on the results, inferences were drawn. Whenever the treatment differences were significant, critical differences were worked out.

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

Sustainable agriculture, the form of farming which produces sufficient food to meet the needs of present generation without eroding ecological assets and productivity of life supporting system of the future generation is:

-To protect the long term fertility of soil by maintaining organic matter levels, fostering soil biological activity and careful mechanical intervention.

-To provide crop nutrients indirectly by using relatively insoluble nutrient sources which are made available to the plants by the action of soil microorganisms.

A trial has been made to estimate rates of impact of the conjunctive use of organic manures like cow dung and biofertilizer like Azolla on cluster bean *(Cyamopsis tetragonoloba* (L.) Taub). Ten treatment combinations were laid out to evaluate the biometrical, yield and biochemical aspects of this test plant. The results of this study were evaluated scientifically, discussed critically and analysed statistically in this chapter.

4.1 STAGE I - VEGETATIVE STAGE – 30 DAS

The biometric parameters like root length, shoot length, plant height, number of leaves/plant, root volume, fresh weight of root, shoot and entire plant, dry weight of root, shoot and entire plant were estimated on 30 DAS as influenced by the application of different percentages of CD and Azolla (Table I and Plate I).

TABLE I – INFLUENCE OF THE TREATMENTS ON THE BIOMETRIC PARAMETERS OF CLUSTER BEAN (Cyamopsis tetragonoloba L. Taub) – 30 DAS

Treatments	Root length (cm)	Shoot length (cm)	Plant height (cm)	Number of leaves / plant	Root volume (cc)	Fresh weight of root (g)	Fresh weight of shoot (g)	Fresh weight of plant (g)	Dry weight of root (g)	Dry weight of shoot (g)	Dry weight of plant (g)
T_1	3.60	9.60	14.00	2.60	0.01	0.04	0.26	0.37	0.02	0.18	0.27
T_2	7.00	16.00	23.00	7.00	0.01	0.11	1.27	1.44	0.08	0.92	1.05
T_3	7.00	14.00	21.00	6.00	0.01	0.08	1.10	1.16	0.04	0.81	0.96
T_4	5.60	12.60	20.60	4.60	0.01	0.07	0.88	0.97	0.05	0.58	0.77
T_5	8.50	17.30	26.00	7.60	0.01	0.13	1.55	1.81	0.08	1.03	1.15
T_6	6.60	15.60	24.00	6.30	0.01	0.17	1.46	1.57	0.06	1.15	1.29
T_7	7.00	13.00	19.00	6.60	0.01	0.09	0.99	1.00	0.05	0.55	0.90
T_8	11.6	20.00	30.00	12.00	0.01	0.20	2.74	2.89	0.12	1.98	2.83
T_9	9.00	16.0	21.00	9.30	0.01	0.11	1.36	1.52	0.07	1.10	1.28
T_{10}	8.00	17.60	22.00	7.00	0.01	0.10	1.08	1.14	0.06	0.914	1.02
SED	**0.6872**	**0.7243**	**0.7888**	**0.6831**	**0.0002**	**0.1188**	**0.0819**	**0.0433**	**0.0063**	**0.320**	**0.0448**
CD	**1.9554**	**2.0611**	**2.2445**	**1.9438**	**0.0006**	**0.3379**	**0.2332**	**0.1232**	**0.0180**	**0.0911**	**0.1274**

4.1.1 ROOT LENGTH AS INFLUENCED BY TREATMENTS (FIG.1)

When compared to control, all the other treatments showed significant influence on the root length which varied from 6.6cm (T_6) to 11.6cm (T_8). The treatment T_8 with CD 100% + Azolla 100% revealed the maximum root length of 11.6cm. Only 3.6cm root length was noticed from control.

4.1.2 SHOOT LENGTH AS INFLUENCED BY TREATMENTS (FIG.2)

The shoot length at 30 DAS was positively enhanced by the treatments which ranged from 12.6cm (T_4) to 20.6cm (T_8). The control showed the shoot length of 9.6cm. The highest shoot length of 20.6cm was observed from T_8 (CD 100% + Azolla 100%).

4.1.3 PLANT HEIGHT AS INFLUENCED BY TREATMENTS (FIG-3)

There has been an appreciable influence of treatments on the plant height which varied from 21.0cm (T_3 and T_4) to 30.0cm (T_8) over control. The maximum value of 30.0cm was obtained from CD 100% + Azolla 100%

4.1.4 NUMBER OF LEAVES PER PLANT AS INFLUENCED BY TREATMENTS (FIG.4)

It is evident from the data that the maximum number of leaves per plant was estimated from T_8 with CD 100% + Azolla 100% and the minimum number was counted from the control with 2.6. Treatment T_8 showed a considerable increase in the number of leaves upto 12.0.

the fresh shoot weight of 5.18g as the plant was treated with CD 100% + Azolla 100%.

4.2.8 PLANT FRESH WEIGHT AS INFLUENCED BY TREATMENTS (FIG.8)

The results obtained for plant fresh weight at 60 DAS ranged from 3.2g (T_1) to 16.47g (T_8). The control plant with no application of organic manure and biofertilizer exhibited the minimum fresh weight of 3.27g. The plant treated with CD 100% + Azolla 100% (T_8) was significantly superior to other plants in its fresh weight (16.47g).

4.2.9 DRY WEIGHT OF ROOT AS INFLUENCED BY TREATMENTS (FIG.9)

Significant differences in the dry weight of roots were estimated and the treatment T_8 exhibited an appreciable increase in the dry weight of root as 6.27g when compared to control which gave the minimum weight. The treatment with Azolla and CD + Azolla showed considerable increase in dry weight of root compared to the plants treated with CD alone.

4.2.10 DRY WEIGHT OF SHOOT AS INFLUENCED BY TREATMENTS (FIG.10)

All the treatments exhibited significant impact on the dry weight of shoots as compared to control (T_1). The treatment T_8 treated with CD 100% + Azolla 100% was found to be very significant in the dry weight of the shoots when compared to control.

4.1.5 VOLUME OF ROOT AS INFLUENCED BY TREATMENTS (FIG.5)

Effect of various treatments on root volume was studied in all the plants. All the treatments showed equal effect on the root volume as 0.01cc.

4.1.6 FRESH WEIGHT OF ROOT AS INFLUENCED BY TREATMENTS (FIG.6)

An appreciable increase in the fresh weight was noticed from all the treatments (T_2 to T_{10}) and it was varied from 0.07g – 0.20g. The highest fresh weight of 0.20g was recorded in T_8 with CD 100% and Azolla 100% and the lowest rate 0.07g was obtained from the treatment T_4 with CD 25%. The control showed a decreased weight of the fresh roots as 0.04g.

4.1.7 FRESH WEIGHT OF SHOOT AS INFLUENCED BY TREATMENTS (FIG.7)

Fresh weight of shoot at 30 DAS was enhanced significantly by all the treatments. A maximum shoot weight was observed as 2.74g from T_8 with CD 100% + Azolla 100% and a minimum of 0.88g was weighed from the treatment with CD 25%. A fresh weight of 0.26g was showed from the control.

4.1.8 PLANT FRESH WEIGHT AS INFLUENCED BY TREATMENTS (FIG.8)

The fresh weight of the plant found to have a positive and significant response in all the treatments and the fresh weight was varied from 0.97g to 2.89g. The treatment T_8 (CD 100% + Azolla 100%) showed the highest plant fresh weight of 2.89g.

TABLE II – INFLUENCE OF THE TREATMENTS ON THE BIOMETRIC PARAMETERS OF CLUSTER BEAN (Cyamopsis tetragonoloba L. Taub) – 60 DAS

Treatments	Root length (cm)	Shoot length (cm)	Plant height (cm)	Number of leaves / plant	Root volume (cc)	Fresh weight of root (g)	Fresh weight of shoot (g)	Fresh weight of plant (g)	Dry weight of root (g)	Dry weight of shoot (g)	Dry weight of plant (g)	Number of nodules
T_1	9.00	24.00	19.00	18.60	0.01	0.30	0.54	3.27	0.04	0.50	0.57	1.66
T_2	19.00	50.00	28.00	27.30	0.01	0.51	2.36	10.83	0.15	2.29	2.29	3.66
T_3	16.00	40.30	24.00	21.30	0.01	0.40	2.26	8.73	0.13	1.31	1.48	3.00
T_4	15.00	37.30	28.00	27.30	0.01	0.24	1.76	8.60	0.13	1.24	1.76	2.66
T_5	17.00	49.00	21.60	20.30	0.01	0.72	2.32	8.31	0.24	3.00	2.26	3.66
T_6	21.00	49.60	36.00	36.00	0.01	0.62	4.76	12.76	0.19	3.74	4.44	2.33
T_7	16.00	46.00	35.00	33.60	0.01	0.53	1.65	8.53	0.20	1.63	2.54	3.33
T_8	22.00	56.00	40.30	39.00	0.02	0.82	5.18	16.47	0.27	4.38	5.22	5.33
T_9	19.00	53.60	27.60	27.60	0.01	0.64	2.58	11.89	0.18	2.10	2.24	3.66
T_{10}	18.30	52.60	26.00	25.00	0.01	0.54	2.11	9.98	0.16	1.84	1.91	3.33
SED	**0.9189**	**1.9607**	**0.8165**	**1.1353**	**0.0037**	**0.0191**	**0.2449**	**0.8332**	**0.0176**	**0.2903**	**0.2316**	**0.5164**
CD	**2.1648**	**5.5792**	**2.3233**	**3.2304**	**0.0104**	**0.0545**	**0.6969**	**2.3709**	**0.0502**	**0.8261**	**0.6589**	**1.4694**

4.1.9 DRY WEIGHT OF ROOT AS INFLUENCED BY TREATMENTS (FIG.9)

A considerable increase in the dry weight of the root was noticed between the treated plants. The weight rate was varied from 0.04g to 0.12g. The minimum dry weight of root was seen in T_4 with CD 25%. The maximum weight of the dry roots was 0.12g in T_8 which treated with CD 100% + Azolla 100%.

4.1.10 DRY WEIGHT OF SHOOT AS INFLUENCED BY TREATMENTS (FIG.10)

A significant increase in the dry weight of shoot was recorded in 30 DAS. The combination treatments showed more response when compared to control. A weight of 1.98g of dry weight of shoot was observed by T_8 (CD 100% + Azolla 100%) as the maximum weight which is the highly significant rate when compared to control (T_1) and this treatment showed the least weight of 0.18g.

4.1.11 PLANT DRY WEIGHT AS INFLUENCED BY TREATMENTS (FIG.11)

The observation of plant dry weight indicate that when the treatments with only Azolla and in combination with CD proved a substantial increase. The maximum plant dry weight of 2.83g was observed from the treatment T_8 with CD 100% + Azolla 100%. The least value of 0.27g of plant dry weight was recorded from the T_1 (control).

4.2 STAGE II - FLOWERING STAGE – 60 DAS

At 60 DAS root length, shoot length, plant height, number of leaves, root volume, fresh weight of root, shoot and plant, dry weight of root, shoot and plant, number of nodules, length of pods, number of pods, fresh weight of pods, dry weight of pods derived as influenced by the application of organic manure (CD) and biofertilizer (Azolla). The results of these were critically analysed and explained statistically (Table II and Plate I).

4.2.1 ROOT LENGTH AS INFLUENCED BY TREATMENTS (FIG.1)

All the treatments from T_2 to T_{10} were significantly influenced the root length of cluster bean, when compared to control. Especially the higher dozes of organic manures promoted the root length greatly. The maximum root length of 22.0cm was measured in T_8 (CD 100% + Azolla 100%). The control showed only 9.0cm root length.

4.2.2 SHOOT LENGTH AS INFLUENCED BY TREATMENTS (FIG.2)

Shoot length at flowering stage was increased by the influence of the treatment which varied from 37.3cm (T_4) to 56.0cm (T_8). Only a minimum of 24cm shoot length was measured from control. A highly significant result was shown by the treatment T_8 with CD 100% + Azolla 100%.

4.2.3 PLANT HEIGHT AS INFLUENCED BY TREATMENTS (FIG.3)

Maximum variability in plant height was noticed between the treatments. The incorporation of CD 100% + Azolla 100% (T_8) showed 19.0cm height. This increment in plant height is because of the high nutrient availability in the organic which has been enhanced in the presence of biofertilizer.

4.2.4 NUMBER OF LEAVES PER PLANT AS INFLUENCED BY TREATMENTS (FIG.4)

The values obtained for number of leaves at 60 DAS ranged between 18.6 and 39.0. The treatment T_8 to which CD 100% + Azolla 100% applied registered the maximum number of leaves, which was documented as the significant rate compared to control with 18.6 number of leaves. All the other treatments also showed drastic increase in the number of leaves per plant, when compared to control.

4.2.5 VOLUME OF ROOT AS INFLUENCED BY TREATMENTS (FIG.5)

The treatment (T_8) with CD 100% + Azolla 100% alone recorded a root volume of 0.02cc and all the other treatment gave same volume of 0.01cc. This shows that no treatment except T_8 give much response in increasing the volume of root on 60 DAS.

4.2.6 FRESH WEIGHT OF ROOT AS INFLUENCED BY TREATMENTS (FIG.6)

The balanced application of organic manures and biofertilizers influenced the fresh weight of the root and the values were varied from 0.30g to 0.82g. The control crop weighed as 0.30g which is the minimum value. At the same time, the remarkable rise in the fresh weight of root 0.82g was noted from the T_8 (CD 100% + Azolla 100%).

4.2.7 WEIGHT OF SHOOT AS INFLUENCED BY TREATMENTS (FIG.7)

The values of fresh shoot weight at 60 DAS, showed highly significant rates compared to control. An appreciable influence is noticed in

4.2.11 PLANT DRY WEIGHT AS INFLUENCED BY TREATMENTS (FIG.11)

On 60 DAS, as usual the control crop exhibited the lowest dry weight of 0.57g and it was remarkably increased in T_8 treated with CD 100% + Azolla 100%. The next highest value was recorded in T_6 which is treated with only Azolla (50%).

4.2.12 NUMBER OF NODULES AS INFLUENCED BY TREATMENTS (FIG.12)

It is evident from the result that the number of nodules increased significantly in all the treated crops at 60 DAS. The treatment T_8 with CD 100% + Azolla 100% resulted in the maximum number of nodules.

4.3 STAGE III – HARVEST STAGE – 90 DAS

At harvest stage it was evident that root length, plant height, number of leaves per plant, root volume, fresh weight of root, shoot and plant, dry weight of root, shoot and plant, number of nodules, length of pods, number of pods per plant, fresh and dry weight of pods were notably influenced by the application of different combinations of cow dung and Azolla. (Table III and Plate III).

4.3.1 ROOT LENGTH AS INFLUENCED BY TREATMENTS (FIG.1)

The response of treatments with various combinations and concentrations of CD and Azolla was highly significant in the root length as compared to control crop, which was estimated as the minimum length of 10.0cm in contrast to T_8 (CD 100% + Azolla100%) and it gave the longest root length of 26.0cm at 90DAS.

TABLE III – INFLUENCE OF THE TREATMENTS ON THE BIOMETRIC PARAMETERS OF CLUSTER BEAN (*Cyamopsis tetragonoloba* L. Taub) – 90 DAS

Treatments	Root length (cm)	Shoot length (cm)	Plant height (cm)	Number of leaves / plant	Root volume (cc)	Fresh weight of root (g)	Fresh weight of shoot (g)	Fresh weight of plant (g)	Dry weight of root (g)	Dry weight of shoot (g)	Dry weight of plant (g)	Number of nodules
T_1	10.00	27.66	37.00	20.00	0.01	0.32	0.57	3.78	0.05	0.54	0.56	1.33
T_2	19.33	56.00	74.00	30.00	0.02	0.55	3.21	11.90	0.15	3.15	2.93	3.33
T_3	17.00	49.00	62.33	24.00	0.01	0.50	3.17	8.30	0.13	2.48	2.47	2.33
T_4	16.00	40.00	53.66	22.33	0.02	0.37	2.00	7.64	0.11	1.97	2.09	2.33
T_5	24.00	53.33	68.33	30.00	0.01	0.72	4.63	10.08	0.26	4.93	5.30	5.00
T_6	21.00	51.33	62.33	31.33	0.01	0.68	3.53	15.07	0.17	4.26	4.50	3.66
T_7	20.00	48.00	50.66	26.00	0.01	0.65	3.12	10.97	0.20	2.80	2.41	3.00
T_8	26.00	65.33	84.33	39.66	0.02	0.88	6.31	20.01	0.31	4.97	5.62	6.00
T_9	23.00	61.00	75.33	30.00	0.02	0.80	5.15	13.16	0.20	3.31	2.89	4.00
T_{10}	20.33	59.00	65.00	27.00	0.02	0.71	4.89	11.22	0.17	2.60	2.48	3.33
SED	**0.9189**	**1.0111**	**3.2076**	**1.2910**	**0.0037**	**0.0309**	**0.2247**	**0.3036**	**0.0102**	**0.2107**	**0.1669**	**0.6325**
CD	**2.6148**	**2.8769**	**0.1272**	**3.6735**	**0.0104**	**0.0880**	**0.6393**	**0.8640**	**0.0291**	**0.6167**	**0.4749**	**1.7986**

4.3.2 SHOOT LENGTH AS INFLUENCED BY TREATMENTS (FIG.2)

Highly significant differences in shoot length were obtained from plants treated with different application of CD and Azolla and their values were markedly ranged from 27.66cm (T_1) to 65.33cm (T_8). The minimum result was expressed by (T_1) control. Application of CD 100% +Azolla 100% resulted in the maximum shoot length of 65.33 cm in T_8. This increment is due to the high nutrient availability from CD which is enhanced by the combined use of biofertilizer.

4.3.3 PLANT HEIGHT AS INFLUENCED BY TREATMENTS (FIG.3)

By 90 DAS each treatment substantially influenced the plant height which markedly varied from 37.00cm to 84.33cm. The treatment T_8 with CD 100% + Azolla 100% viewed significantly highest plant height of 84.33cm as compared to control which showed only 37.00cm height.

4.3.4 NUMBER OF LEAVES PER PLANT AS INFLUENCED BY TREATMENTS (FIG.4)

In total, there were distinct differences in the number of leaves per plant noticed among the 10 treatments on 90 DAS. The incorporation of CD 100% and Azolla 100% in T_8 treatment resulted in the maximum number of leaves at this stage. Except control (T_1) all the other treatments showed significant increase in the number of leaves per plant. This is due to the positive influence of organic manure and biofertilizer.

4.3.4 ROOT VOLUME AS INFLUENCED BY TREATMENTS (FIG.5)

On comparing the root volume of the crops treated with 10 treatments with CD and Azolla was shown almost equal effects. It was evident from the data that the root volume of treatments T_1, T_3, T_5, T_6, and T_7 was 0.01mm and the treatments T_2, T_4, T_8 and T_{10} expressed 0.02cc.

4.3.6 FRESH WEIGHT OF ROOT AS INFLUENCED BY TREATMENTS (FIG.6)

The values obtained for fresh weight of root at 90 DAS ranged from 0.32g (T_1) to 0.88g (T_8). The treatment T_8 with CD 100% + Azolla 100% significantly enhanced the fresh weight of crop root as the maximum weight of 0.88g.

4.3.7 FRESH WEIGHT OF SHOOT AS INFLUENCED BY TREATMENTS (FIG.7)

The treatments from T_2 to T_{10} indicated statistically significant variations in the shoot fresh weight of crops at 90 DAS compared to control. The rates of weight were varied greatly from 0.57g (T_1) to 6.31g (T_8). The application of CD 100% + Azolla 100% gave the enhanced fresh weight of shoot as 6.31g against the control T_1 (0.57g). It is evidenced from the data that the combined effect of CD and Azolla in different combinations helped to increase the shoot fresh weight drastically in T_8, T_9 and T_{10}.

4.3.8 FRESH WEIGHT OF PLANT AS INFLUENCED BY TREATMENTS (FIG.8)

Remarkable variations and magnificant increase in the plant fresh weight were shown by all the treatments on 90 DAS. The minimum effect on fresh weight of 3.78g was exhibited by control (T_1). The maximum fresh weight of 20.01g was obtained by the treatment T_8 (CD 100% and Azolla 100%) at harvest. This highest rate of fresh weight shows the positive response of the treatments on the crop.

4.3.9 DRY WEIGHT OF ROOT AS INFLUENCED BY TREATMENTS (FIG.9)

The analysis of root dry weight treated with 10 treatments revealed great variations among treatments and the weights were gradually increased and varied from 0.05g to 0.31g. The treatment T_8 with CD 100% + Azolla 100% showed a considerable increase in the root dry weight as 0.31g at 90 DAS against the control.

4.3.10 DRY WEIGHT OF SHOOT AS INFLUENCED BY TREATMENTS (FIG.10)

On 90 DAS, the plants showed significant increase in their shoot dry weight which varied from 3.1g (T_2) to 4.97g (T_8). The treatment, T_1 (control) gave the minimum dry weight of 0.54g. At the same time the maximum result was recorded as 4.97g by T_8 (CD 100% and Azolla 100%).

4.3.11 PLANT DRY WEIGHT AS INFLUENCED BY TREATMENTS (FIG.11)

The outcome of all the treatments were recorded as a highly significant one. The least plant dry weight of 0.56g was shown by T_1

(control) and the highest value was registered as 5.30g and 5.62g against the treatment T_5 with Azolla 100% and T_8 with CD 100% + Azolla 100% respectively. Application of Azolla has improved the soil productivity by giving the nutrients to the soil especially nitrogen.

4.3.12 NUMBER OF NODULES AS INFLUENCED BY TREATMENTS (FIG.12)

Compared to control, other 9 treatments showed highly significant increase in the number of nodules. This could be attributed to the positive role of organic manures like CD and Azolla.

The above results of biometric parameters are supported by:

Addition of organic matter was also reported to improve nodulation Nazis *et al.* (1970) and Gowda *et al.* (1991) in tuberose. Andhale and Kabhor (1980) found that N application increased the plant height in *Helianthus annus*. Increase in plant height due to fertilizer N (Abdulsalam, 1984) and Azolla (Kannaiyan and Rajeswari, 1983; Latha, 1985 and Thangaraju *et al.*, 1992) has been reported. Similar increase in the plant height of rice due to the incorporation of Azolla and application of fertilizer N has been observed in the present study. Kannaiyan *et al.* (1984) found that Azolla alone and with urea stimulated growth in rice plant. Latha (1985) reported highest plant height in Kharif with application of Na USG and Azolla as dual crop.

According to Banker and Mukhopadhyay (1990), higher dose of nitrogen increased the length of spike and rachis and number of flower spike in tuberose. The root, shoot and dry matter production by the rice seedlings were significantly higher when inoculated with immobilized *A. azollae*

(Mahesh and Kannaiyan, 1993). Improvement in root growth in maize was reported by Gajri *et al.* (1994) by the use of FYM at 15t ha^{-1}.

Higher doses of FYM also resulted in significant increase in straw yield due to significant increase in plant height. Positive effect of FYM application in cereals has also been reported by (Singh *et al.*, 1998). The two years results reveal that all the sources and levels of organic manures improved the productivity of wheat crop in both cropping systems (Singh *et al.*, 1998). Application of organic manures improves the physical, chemical and biological properties with direct impact on moisture retension, root growth and nutrient conservation (Krishnakumar and Jawahar, 2001). Application of nitrogen helped in increasing the vegetative growth of plants and also plant dry matter (Saxena *et al.*, 2001). Increasing trend in flowering and pod formation, higher leaf – area index and dry-matter accumulation and improvement in yield traits. Both the efficiency of BNF and seed yield were improved significantly following basal application of 60kg N ha^{-1} (Praharaj and Dhingra, 2001). This approach ensures balanced nutrients for better growth of plant without affecting the ecosystem (Pandey and Kumar, 2002). With higher doses of Azolla, productive tillers were 11 $hill^{-1}$, plant height was 71.96cm (Alice *et al.*, 2003). The organic manures are mostly of plant origin and are utilized either directly or after having been used once as food by animals and humans (Basavanneppa and Biradar, 2003).

4.4 YIELD CHARACTER – 60 DAS AND 90 DAS (TABLE IV PLATE I, II, AND III)

4.4.1 LENGTH OF PODS AS INFLUENCED BY TREATMENT (FIG.13)

On 60 DAS and 90 DAS, application of full dose of fertilizers gave significantly higher yield.. The treatment (T_8) with CD 100% and Azolla 100% recorded appreciable increase in the length of pods as 10.83 cm at 60 DAS and 11.50cm at 90 DAS which are the maximum rates observed compared to other treatments. Except control (T_1), other treatments with organic manures and biofertilizer showed significant results. This increment showed the positive role of growth ingredients present in the organic amendments.

4.4.2 NUMBER OF PODS AS INFLUENCED BY TREATMENTS (FIG.14)

A spectacular increase in the number of beans was estimated from the data collected. The treatment T_8, which received CD 100% + Azolla 100% resulted in the maximum number of pods of 11.0 at 60 DAS and of 12.33 at 90 DAS. The increase in yield is due to the high nutrient content of organic manure and biofertilizer (Azolla). It is evident from the data that each treatment (T_2 to T_8) gave notable increase in the number of pods per plant which varied from 7.33 to 11.00 compared to control (T_1).

4.4.3 FRESH WEIGHT OF PODS AS INFLUENCED BY TREATMENTS (FIG.15)

From the table IV, it is evident that a considerable amount of nurients were released by the organic manures. The results obtained for good yield

TABLE IV – INFLUENCE OF TREATMENTS ON YIELD PARAMETERS OF CLUSTER BEAN (Cyamopsis tetragonoloba L. Taub) AT 60 DAS and 90 DAS

Treatment	Length of pods (cm)		Number of pods/plant		Fresh weight of pods (g)		Dry weight of pods (g)	
	60DAS	90DAS	60DAS	90DAS	60DAS	90DAS	60DAS	90DAS
T_1	6.50	6.50	4.00	3.66	3.00	3.11	1.14	2.20
T_2	9.16	9.33	7.33	7.00	9.05	9.14	5.27	5.88
T_3	8.83	9.00	7.00	6.00	6.88	8.14	3.49	4.29
T_4	8.66	8.83	5.66	5.66	5.80	7.05	5.36	3.23
T_5	9.56	9.83	7.33	9.33	9.29	9.46	3.46	6.20
T_6	8.60	9.16	6.66	8.33	8.80	9.33	4.87	5.44
T_7	8.16	8.83	6.00	7.66	6.90	8.16	5.13	4.73
T_8	10.83	11.50	11.00	12.33	12.66	17.38	8.81	9.16
T_9	9.66	1016	8.00	10.33	10.57	13.17	5.65	7.44
T_{10}	9.00	9.66	7.00	9.00	8.87	10.66	4.31	5.84
SED	0.3333	0.3838	0.6992	1.0111	0.3417	0.5958	0.3185	0.1374
CD	0.9485	1.0922	1.9896	2.8769	0.9722	1.6952	0.9064	0.3911

for different treatments showed positive effect for the application of both cow dung and Azolla. The perusal of fresh weight of pods at 90 DAS indicated increase in the rates of fresh weights at 90 DAS compared to 60 DAS by all the treatments. Pods showed the maximum variation in their fresh weight which was varied from 3.00g (T_1) to 12.66g (T_8) at 60 DAS and from 3.11g to 17.38g at 90 DAS. The treatments T_8 with CD 100% and Azolla 100% showed a spectacular increase in the pod weight as 12.66g at 60 DAS and as 17.38g at 90 DAS.

4.4.4 DRY WEIGHT OF PODS AS INFLUENCED BY TREATMENTS (FIG.16)

A remarkable rise with pod dry weight was estimated from the values obtained at 60 DAS and 90 DAS. Without the application of nutrients, the control (T_1) gave 1.14g and 2.20g as pod dry weight at 60 DAS and 90 DAS respectively. The treatments T_2 to T_{10} recorded a significant increase in the dry weight on both the days. The treatment T_8 was resulted in 8.81g on 60 DAS and 9.16g on 90 DAS by the application of CD 100% and Azolla 100% when compared to the control. All the other treatments showed significantly higher weights of pods when treated with organic manure like CD and biofertilizer like Azolla.

The above results of yield characters are supported by:

Organic manures significantly increase the groundnut productivity (Ali *et al.*, 1974 and Kumaresan *et al.*, 1984). Singh (1997) reported that the grain yield was higher with the incorporated Azolla than with non-incorporated Azolla. Subudhi and Singh (1980) found that Azolla application significantly increased the straw and grain yields of rice. The for different treatments showed positive effect for the application of both cow dung and Azolla. The perusal of fresh weight of pods at 90 DAS indicated increase in the rates of fresh weights at 90 DAS compared to 60 DAS by all the treatments. Pods showed the maximum variation in their fresh weight which was varied from 3.00g (T_1) to 12.66g (T_8) at 60 DAS and from 3.11g to 17.38g at 90 DAS. The treatments T_8 with CD 100% and Azolla 100% showed a spectacular increase in the pod weight as 12.66g at 60 DAS and as 17.38g at 90 DAS.

4.4.4 DRY WEIGHT OF PODS AS INFLUENCED BY TREATMENTS (FIG.16)

A remarkable rise with pod dry weight was estimated from the values obtained at 60 DAS and 90 DAS. Without the application of nutrients, the control (T_1) gave 1.14g and 2.20g as pod dry weight at 60 DAS and 90 DAS respectively. The treatments T_2 to T_{10} recorded a significant increase in the dry weight on both the days. The treatment T_8 was resulted in 8.81g on 60 DAS and 9.16g on 90 DAS by the application of CD 100% and Azolla 100% when compared to the control. All the other treatments showed significantly higher weights of pods when treated with organic manure like CD and biofertilizer like Azolla.

The above results of yield characters are supported by:

Organic manures significantly increase the groundnut productivity (Ali *et al.,* 1974 and Kumaresan *et al.,* 1984). Singh (1997) reported that the grain yield was higher with the incorporated Azolla than with non-incorporated Azolla. Subudhi and Singh (1980) found that Azolla application significantly increased the straw and grain yields of rice. The agronomic potential of Azolla is quite significant particularly for rice crops and it may be applied as biofertilizer for increasing rice yields (Watanabe *et al.*, 1981 and Kannaiyan *et al.*, 1982)

Kannaiyan and Govindarajan (1982) found that 25kg N ha^{-1} can be saved by applying Azolla. Kannaiyan *et al.* (1984) found that Azolla alone and with urea significantly increased rice grain yield. Ramaswamy *et al.* (1984) obtained highest grain yield with 500 kg fresh Azolla inoculated with 60kg N ha^{-1} as urea and it was equal to that obtained with 90 kg N ha^{-1}.

Azolla and farmyard manure improved the quality of rice seedlings and rice yield significantly (Maskina *et al.*, 1985). Azolla green manure contributed 50% of the N requirement, while *Sesbania rostrata* supplied as high as 184kg N ha^{-1}. Rice grain yield was valued at $170.73/t (IRRI Annual report for 1987).

The conjunctive use of cattle manure at 8970kg ha^{-1} and NPK (each at 22.4kg ha^{-1}) to rice was markedly superior with an yield increase of 7.6 per cent over NPK alone (Anilakumar *et al.*, 1993). Improved bulb yield of onion by the incorporation of FYM at 10t ha^{-1} was observed by Pritam and Ajit Rajna in 1994. Promoted yield of wheat, soyabean and oats due to the application of poultry manure to the soil without any previous treatment was registered by Withholder *et al.* (1994).

The growth of cow pea such as number of pods per plant, 100 seed weight of nodules were improved significantly by the addition of phosphorus along with organic manure (Nagarajir *et al.*, 1995). Best yield in banana was obtained by Roy and Yadav in 1996 with 25 per cent FYM + green manuring + 75 per cent in organic fertilizers.

The successive increase in FYM upto 20t/ha resulted in significant increase in grain yield which might be attributed to significant increase in ears/m and improvement in the 1000 grain weight of pealmillet (Singh *et al.*, 1998).

In 1998, Agbim concluded that the total yield of maize increase with increasing proportion of cattle dung in a treatment rising from a value of 7.04mg ha^{-1} of 100% cassava peels to 9.22mg ha^{-1} for 100% dung. Also the author obtained the highest legume yam-bean yield with 50% cassava peels plus 50% cattle dung treatment. Grain (30.38q ha^{-1}) and straw (54.26q ha^{-1}) yield was significantly increased due to addition of green manuring through green leaf foliage of glyricidia at $stha^{-1}$, than no green manuring (28.41) and 49/51q ha^{-1} (Turkhede *et al.*, 1998).

Use of nitrogen fixing legumes as green manures to improve soil fertility and enhance crop yields is a wide spread farming practice in India (Sharma et al., 2000). In recent years due to over- exploitation of natural resources, biofertilizers have emerged as an important component of integrated nutrient supply system (INSS) and hold a promise to improve the crop yields and nutrient supplies (Gill *et al.*, 2000).

The crop gave significantly higher seed and biological yields with 60kg N/ha and beyond this level there was a marginal increase in yield, the increase being 12.6 and 18.7% over 30 kg N/ha (Singh *et al.*, 2001).

The higher doses of Azolla gave an increased yield of 4.091, 33kg ha^{-1} d the lowest yield was obtained from plots treated with inorganic fertilizer one (Alice *et al.*, 2003). The result revealed that incorporation of Gliricidia eaves alone or in combination with fertilizer N enhanced the yield of cluster bean (Petal *et al.*, 2003). Application of organic manures will provide balanced proportion of all nutrients required by the crops. Harnessing the possible nutrient interaction will aid in boosting the crop yields (Latha, 2003).

Organic farming is possible where plenty of organic manures like FYM would be available as in dairy based forms and where horticultural crops like flowers, vegetables and certain fruit crops, requiring low amounts of nutrients are cultivated (Kumaraswamy, 2004). Organic manure and inorganic fertilizers in various combinations increased the yield characters. (Sabitha and Pushpa, 2004). Addition of green manure to the cropping system improved the crop yield. (Jayakumar *et al.*, 2004).

4.5 INFLUENCE OF TREATMENTS ON THE CHEMICAL PROPERTIES OF POST HARVEST SOIL SAMPLES (TABLE VII)

The pH values of the samples varied from 7.9 (T_3) to 8.5 (T_6). The utilization of various combinations of CD and Azolla were significantly increased the pH.

The available nitrogen status of the soil was ranged from 21 ppm (T_1) to 69 ppm (T_8). The available nitrogen content was positively improved in the treatment (T_8) (CD 100% + Azolla 100%) which revealed the highest amount.

TABLE VII – AVAILABLE NPK STATUS OF THE POST HARVEST SOIL SAMPLES AS INFLUENCED BY THE TREATMENTS

Treatment	pH	N	P	K
T_1 – Control	8.2	21	15.0	210
T_2 – CDI 100%	8.0	38	80.0	282
T_3 – CD 50%	7.9	31	17.5	282
T_4 – CD 25%	8.1	28	118.0	280
T_5 – Azolla 100%	8.4	45	32.5	186
T_6 – Azolla 50%	8.5	41	12.5	196
T_7 – Azolla 25%	8.4	40	17.5	240
T_8 – CD 100% + Azolla 100%	8.3	69	158.0	287
T_9 – CD 50% + Azolla 50%	8.0	63	92.5	235
T_{10} – CD 25% + Azolla 25%	8.2	58	143.0	215

The available phosphorus content of the soil varied from 15.0 ppm (T_1) to 158 ppm (T_8). The application of CD 100% + Azolla 100% (T_8) favourably increased the available phosphorus up to 158 ppm when compared to control which gave the least quantity.

The available potassium status of the soil was range from 210 ppm (T_1) to 287 ppm (T_8). The treatment, T_8 treated with CD 100% + Azolla 100% positively improved the available potassium status of the post harvest soil samples.

Organic manures are reported to improve the physical properties of the soil (Obi 1959, Djokoto and Stephens, 1961). The water holding capacity of the soil was found to be influenced with the application of Azolla (Mandal *et al.,* 1992).

Considering such effects, continued green manuring over a long period of time would not only improve the soil fertility but also result in significant residual effect in intensive cropping systems (Palaniappan, 1992). Azolla has a capacity to fix upto 900 kg N ha^{-1} in the soil. Other sources of biofertilizers are green manures like sesbania, sunhemp, berseem etc. Thus biofertilizers are potential alternatives to chemical fertility for sustainable crop productivity particularly in relation to physical, chemical and biological properties of soil on long term basis (Sengar and Pant, 1998).

The organic manures play a direct role by supplying macro and micronutrients and an indirect role by improving the physico-chemical and biological environment of soils (Yadav, 2000). Organic manures and biofertilizers should be used in judicious combinations to maintain the soil fertility at desired levels (Kumaraswamy, 2002). Soil is a complex media supporting the growth of the plants and providing the essential nutrients for their development. The ability of soil to support the growth of a growing crop/plant is formed as the fertility of soil. Incorporation of green manure, leguminous crop viz., sunhemp, daincha, gur, mung and soybean etc. into the soil have the beneficial effect on cane productivity and soil fertility (Ramesh *et al.*, 2003).

The use of organic manure improved the soil fertility and its physical condition for sustaining the productivity of the soil (Petal *et al.*, 2003). Addition of green manure sustains the soil fertility (Jaya Kumar *et al.*, 2004). Organic farming means adopting techniques that maintain soil fertility indefinitely. It refers to the concept of the form as an organism, in which all the component parts-soil minerals, organic matter, plant etc., to create a coherent whole (Sanjay, 2004).

4.6 INFLUENCE OF TREATMENTS ON THE BIOCHEMICAL PARAMETERS OF CLUSER BEAN LEAVES AT 30 DAS, 60 DAS AND 90 DAS

4.6.1 TOTAL PROTEIN (TABLE - V AND FIG.17)

Organic manuring enchanced significantly the total protein content of cluster bean at 30 DAS, 60 DAS and 90 DAS. From the data collected, it has been proved that all the treatments showed increased variations in all the three days when compared to control which gave the minimum values like 0.3433mg/g, 0.6470 mg/g and 0.5960mg/g at 30 DAS, 60 DAS and 90 DAS respectively. On comparing all the treatments, the maximum protein content was estimated from T_8 as 0.9557 mg/g treated with CD 100% and Azolla

TABLE V – TOTAL CONT ENT OF CLUSTER BEAN (Cyamopsis tetragonoloba L. Taub) AT 30 DAS, 60 DAS AND 90 DAS

Treatments	Protein mg/g		
	30 DAS	**60 DAS**	**90 DAS**
T_1 – Control	0.3433	0.6470	0.5960
T_2 – CDI 100%	0.3757	0.6870	0.7313
T_3 – CD 50%	0.6593	0.8563	0.7613
T_4 – CD 25%	0.6633	0.9357	0.6570
T_5 – Azolla 100%	0.8700	0.8737	0.8440
T_6 – Azolla 50%	0.7417	0.8437	0.7813
T_7 – Azolla 25%	0.7387	0.9447	0.7090
T_8 – CD 100% + Azolla 100%	0.9557	0.9140	0.9037
T_9 – CD 50% + Azolla 50%	0.9527	0.8703	0.8627
T_{10} – CD 25% + Azolla 25%	0.8540	0.9347	0.8110
SED	**0.1075**	**0.1149**	**0.0486**
CD	**0.3059**	**0.3268**	**0.1383**

100% at 30 DAS, from T_7 as 0.9447 mg/g treated with Azolla 25% at 60 DAS and from T_8 as 0.9037 mg/g treated with CD 100% + Azolla 100% at 90 DAS.

A. azollae immobilized with hollow fibre and silk cotton, have supported higher protein contents. Increase in the contents of protein and aminonitrogen by immobilization of *A. azollae* could reflect on nitrogen contribution in natural rice soil ecosystem (Mahesh and Kannaiyan, 1993). The protein content increased significantly with increasing levels of nitrogen. This result confirm the findings of Pradhan *et al.* (1995). Protein content in seed was found to be the highest following 60kg N ha^{-1} applied at planting (Praharaj and Dhingra, 2001). Significant improvement in oil and protein yield was recorded with application of N (Singh *et al.,* 2001). Biochemical component like protein was estimated from 30-day-old fresh tissues of lady's finger collected from each plot using standard protocols (Manonmani and Anand, 2002). It was also observed that protein content increased from 37.9 to 39.2 per cent (Prabhakaran, 2003). Legumes have a special role to play in areas where the diet is poor in protein because they are an excellent source of high quality protein (Sharma, 2003).

4.6.2 CHLOROPHYLL CONTENT (TABLE - VI AND FIG.18)

On the basis of the data presented it was concluded that the chlorophyll a, b and total content were significantly influenced by various treatments (T_1 - T_{10}) at 30 DAS, 60 DAS and 90 DAS.

On the 30^{th} day after sowing chlorophyll 'a' showed the minimum quantity of 0.4893 mg/g by T_4 and the maximum of 0.6013 mg/g by T_3. Regarding chlorophyll 'b' and total chlorophyll treated with only red loamy

TABLE VI – EFFECT OF TREATMENTS ON THE AVAILABLE CHLOROPHYLL CONTENT CLUSTER BEAN (Cyamopsis tetragonoloba L. Taub) AT 30 DAS, 60 DAS and 90 DAS

Treatments	Chlorophyll (mg/g fresh leaf weight)								
	30 DAS			60 DAS			90 DAS		
	a	B	Total	a	b	Total	a	b	Total
T_1 – Control	0.1433	0.2341	0.3774	0.2153	0.6047	0.8200	0.7047	0.4123	1.117
T_2 – CDI 100%	0.5273	0.2629	0.5359	0.3120	0.7793	1.0913	0.9007	0.2196	1.1203
T_3 – CD 50%	0.6013	0.3021	0.9034	0.2691	0.7347	1.0038	0.8507	0.3121	1.1628
T_4 – CD 25%	0.4893	0.2092	0.6985	0.1721	0.4200	0.5921	0.4693	0.1981	0.6674
T_5 – Azolla 100%	0.4873	0.4561	0.9434	0.6281	0.7553	1.3834	0.4947	0.5621	1.0568
T_6 – Azolla 50%	0.4367	0.1281	0.5648	0.6232	0.8007	1.4239	0.5767	0.1261	0.7028
T_7 – Azolla 25%	0.4773	0.2921	0.7694	0.5217	0.7947	1.3164	0.4767	0.2153	0.6920
T_8 – CD 100% + Azolla 100%	0.4807	0.2896	0.7703	0.4320	0.7693	1.2013	0.6393	0.4801	1.1194
T_9 – CD 50% + Azolla 50%	0.5560	0.1956	0.7516	0.3212	0.7667	1.0879	0.7553	0.2697	1.0250
T_{10} – CD 25% + Azolla 25%	0.3560	0.2810	0.637	0.2693	0.6020	0.8713	0.7353	0.2305	0.9658
SED	**0.5294**	**0.4629**	**0.6432**	**0.5832**	**0.6056**	**0.5272**	**0.6562**	**0.5698**	**0.6582**
CD	**1.5063**	**1.4327**	**1.3962**	**1.6734**	**1.7231**	**1.3627**	**1.3689**	**1.3021**	**1.4303**

soil (control) revealed the minimum values as 0.2341mg/g and 0.3774 mg/g respectively. The maximum rates were measured from T_5 with Azolla 100% as 0.4561 mg/g for chlorophyll 'b' and as 0.9434 mg/g for total chlorophyll.

On the 60^{th} day, high level of chlorophyll 'a' and 'total' chlorophyll were recorded in T_5 as 0.6281 mg/g and in T_6 as 1.4239 mg/g respectively. Maximum value of chlorophyll 'b' was observed as 0.8007 mg/g in T_6. The least contents of chlorophyll 'a', 'b' and 'total' (0.1721 mg/g, 0.4200 mg/g and 0.5921 mg/g) were noticed in T_4.

On the 90^{th} day, the least weight of chlorophyll 'a', 'b' and total were observed as 0.4693 mg/g (T_4), 0.1261 mg/g (T_6) and 0.667 mg/g (T_4). At the same time the maximum variabilities on chlorophyll content were exhibited as 0.9007 mg/g (T_2), 0.5621 mg/g (T_5) and 1.1628 (T_3).

The sustainance of a plant depends upon green photosynthetic pigments, the chlorophylls 'a' and 'b' and their contents in the photosynthesizing leaves (Patel *et al.,* 1998). Organic manures containing auxins and essential amino acids increase the chlorophyll content of leaf, which in turn enhances metabolite synthesis resulting in crop productivity (Ghosh & Das, 1998). The leaf chlorophyll content plays an important role in the production of total dry matter in soybean genotypes and ultimately better partitioning of dry matter leading to high economic productivity. Biochemical component such as protein and chlorophyll were estimated from 30-day-old fresh tissues of lady's finger collected from each plot using standard protocols (Manonmani and Anand, 2002).

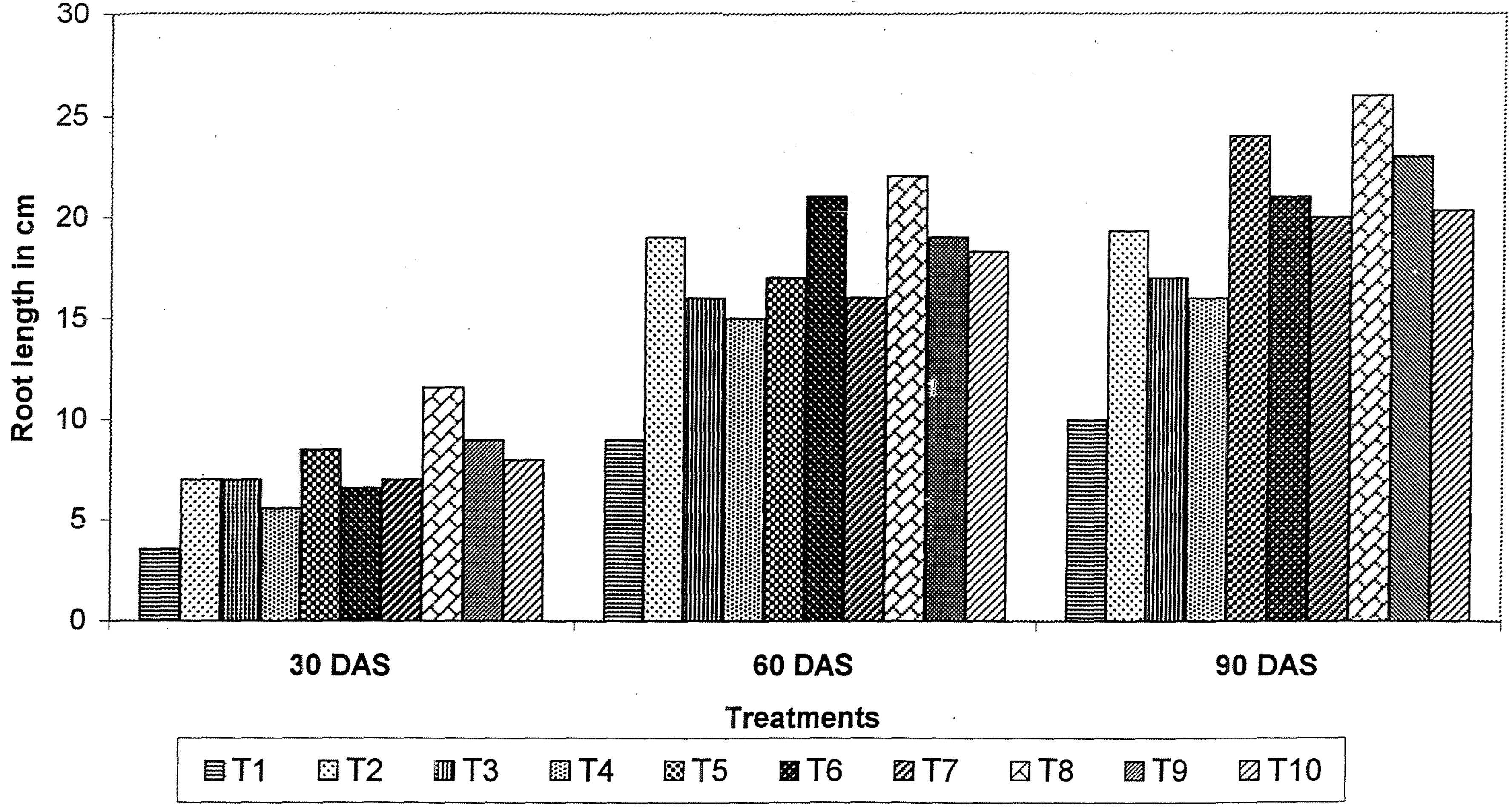


FIG. 1. Effect of treatments on the root length of *Cyamopsis tetragonoloba L.* Taub on 30 DAS, 60 DAS and 90 DAS

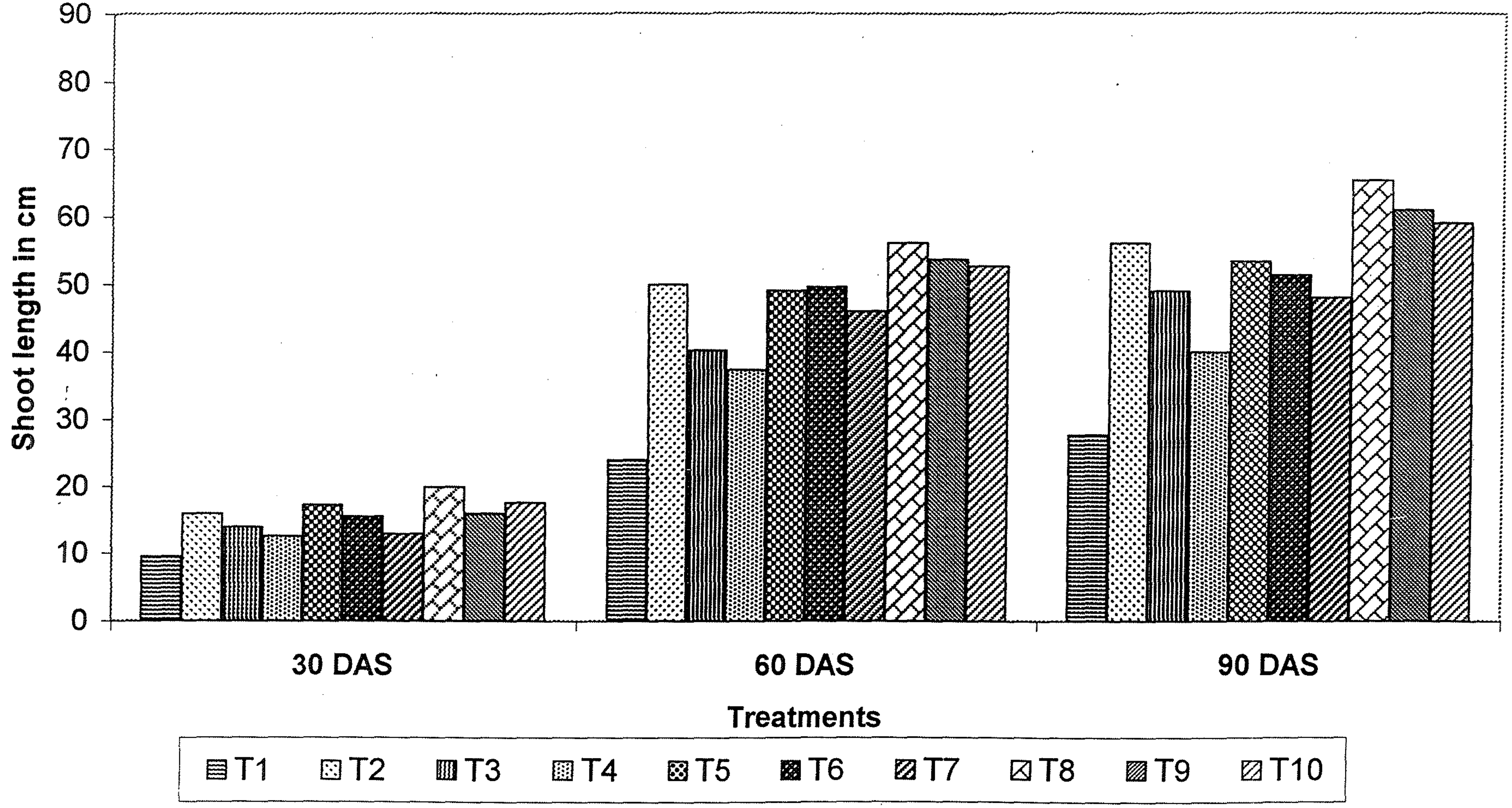


FIG. 2. Effect of treatments on the shoot length of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

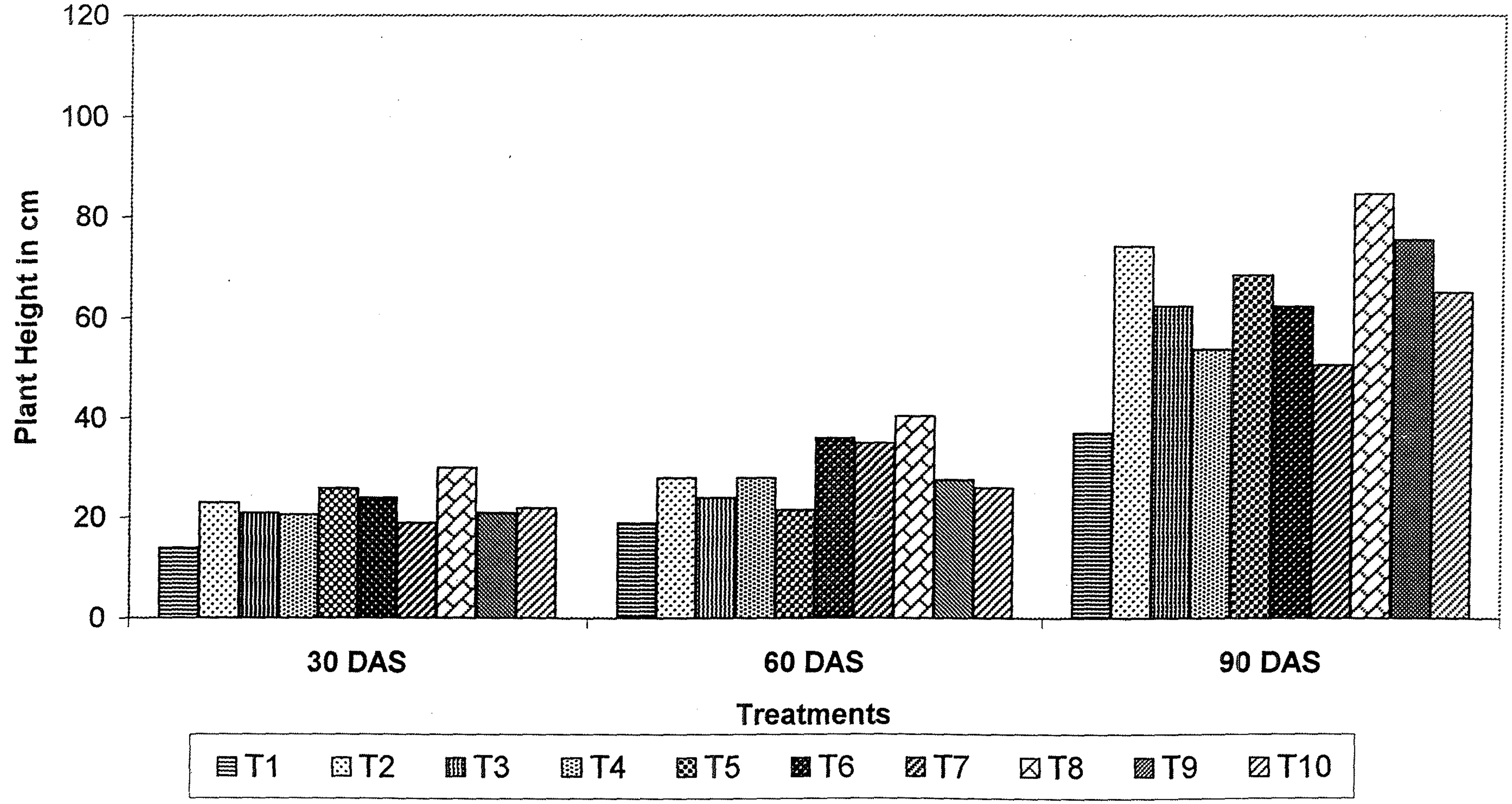


FIG. 3. Effect of treatments on the plant height of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

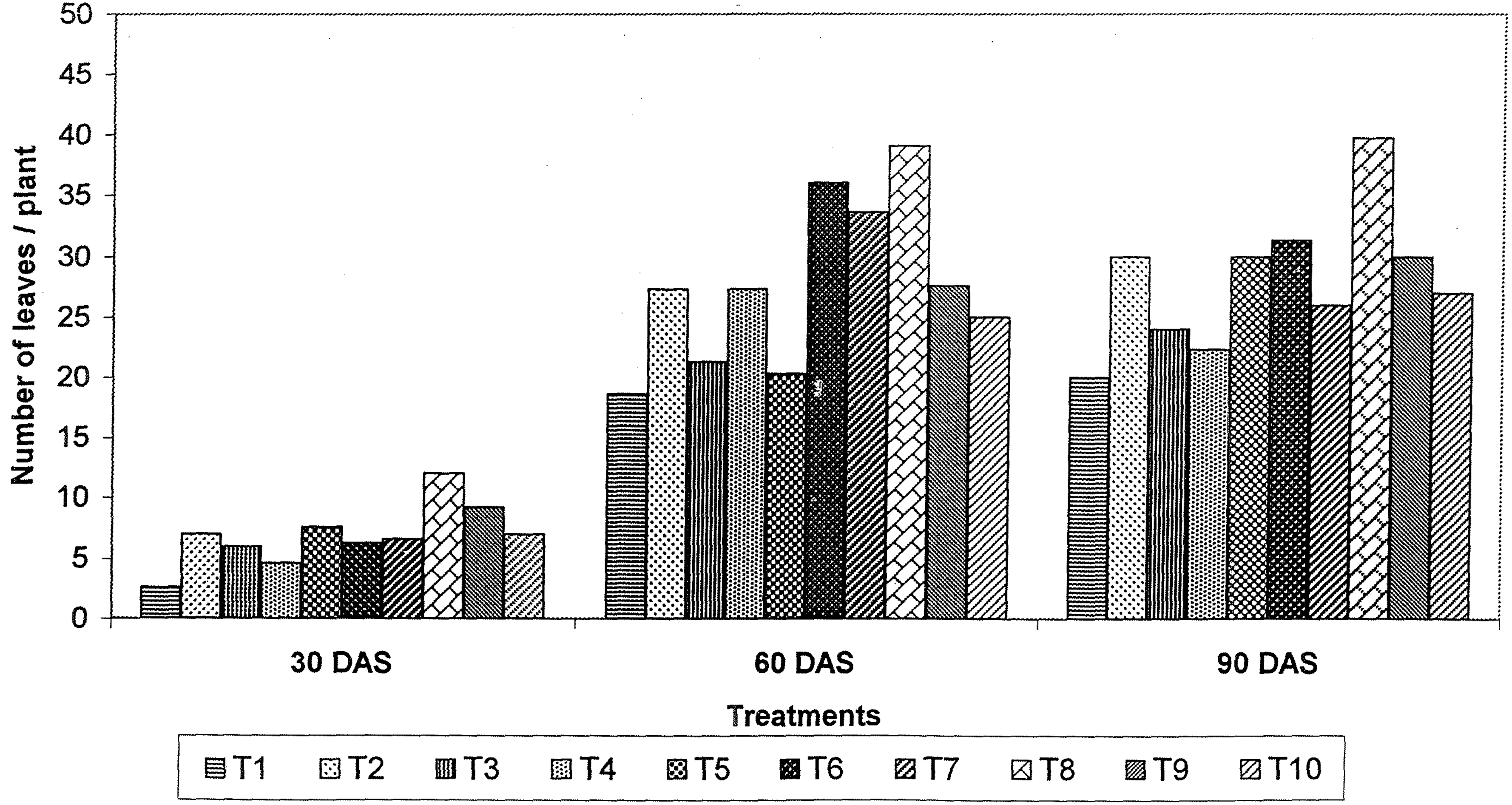


FIG. 4. Effect of treatments on the number of leaves / plant of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

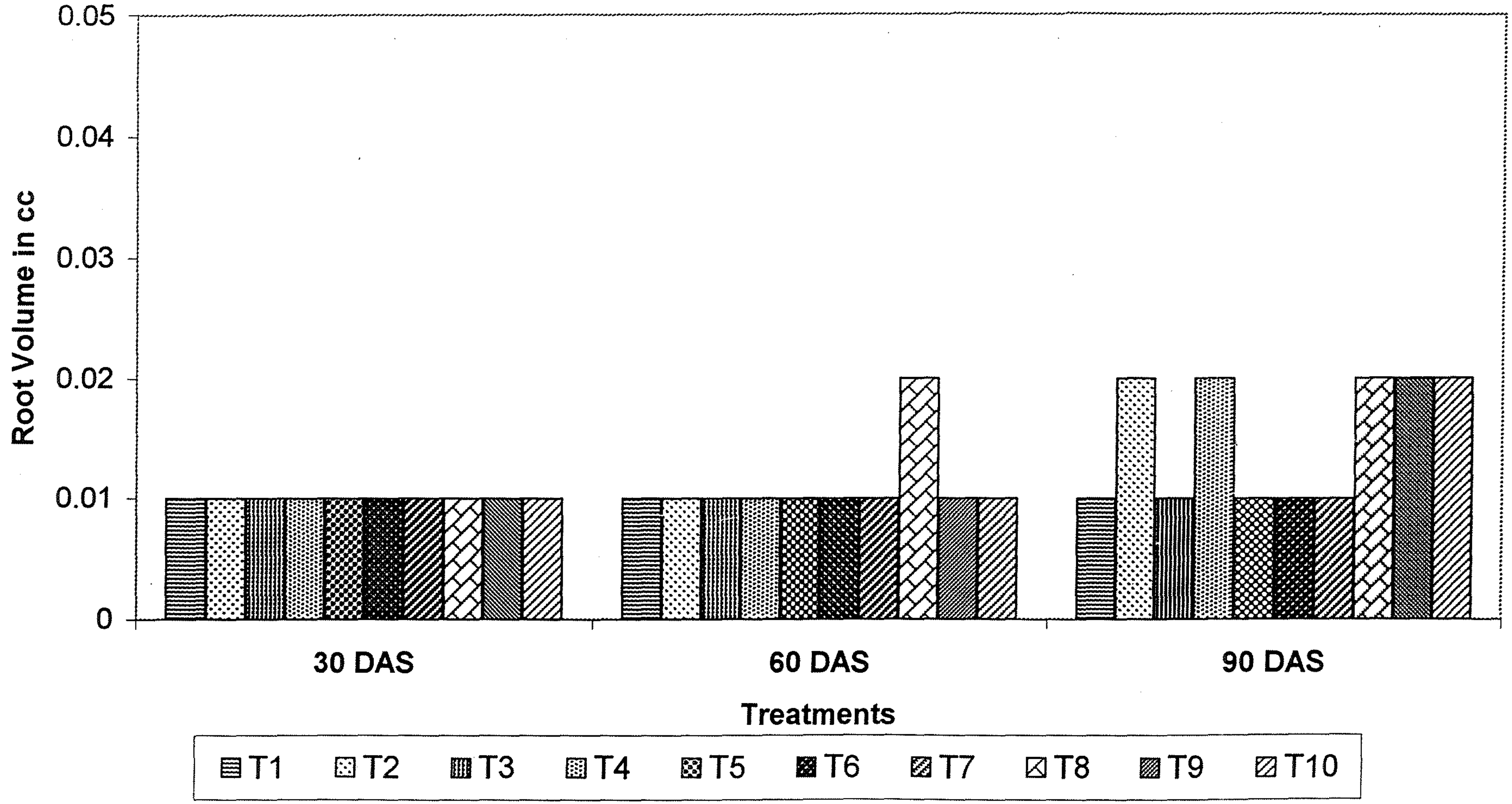


FIG. 5. Effect of treatments on the root volume of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

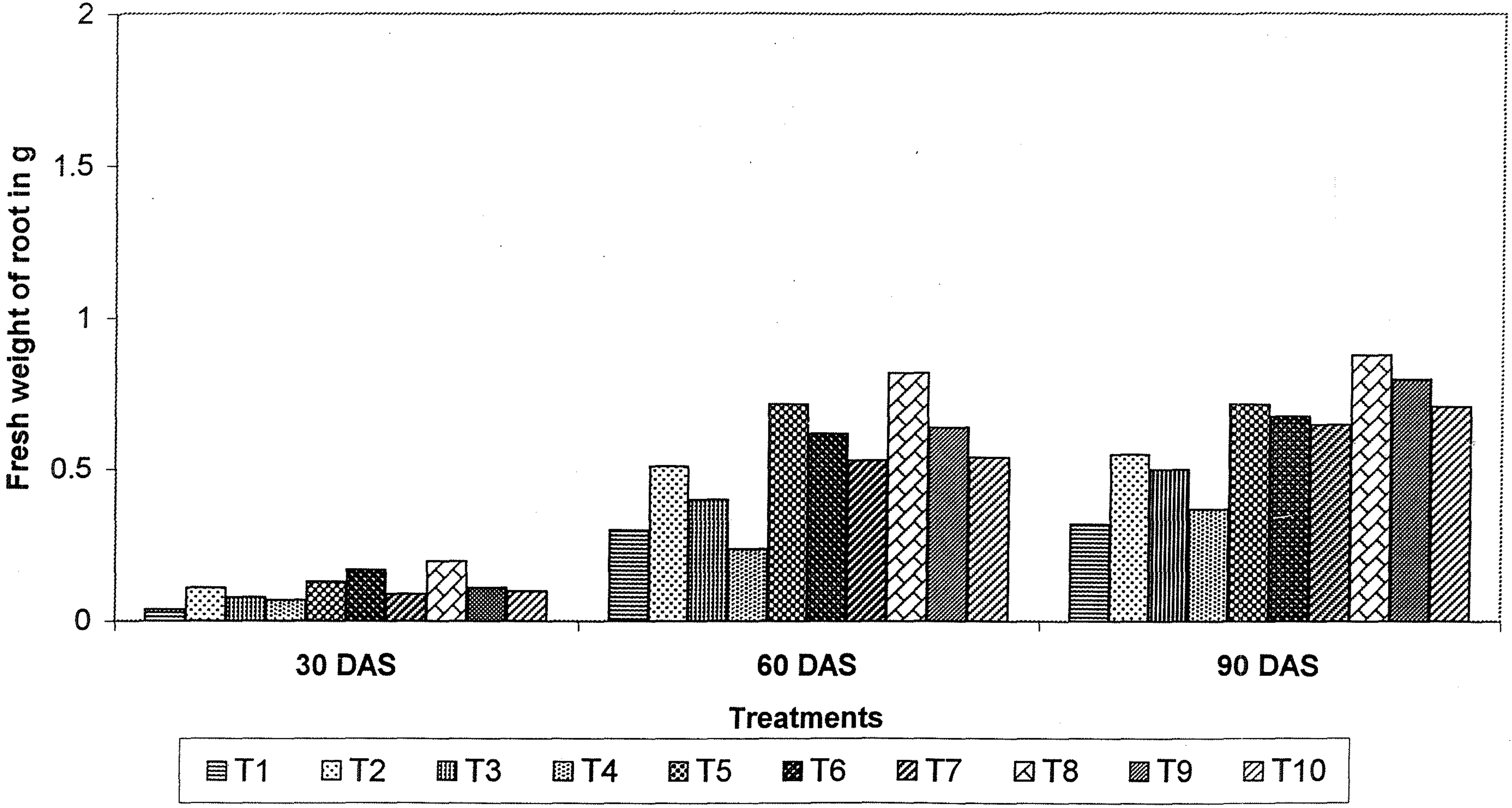


FIG. 6. Effect of treatments on the fresh weight of root of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

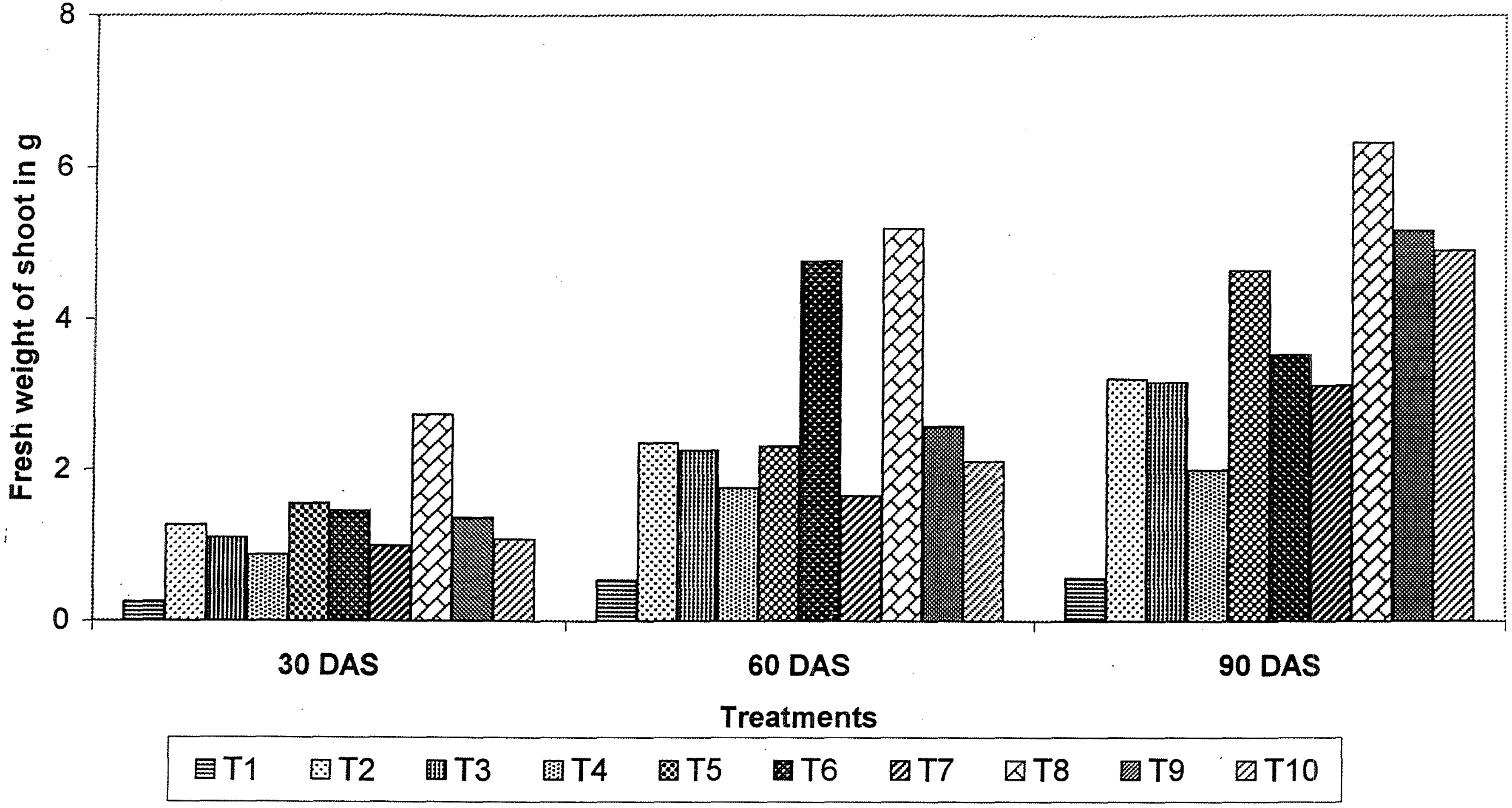


FIG. 7. Effect of treatments on the fresh weight of shoot of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

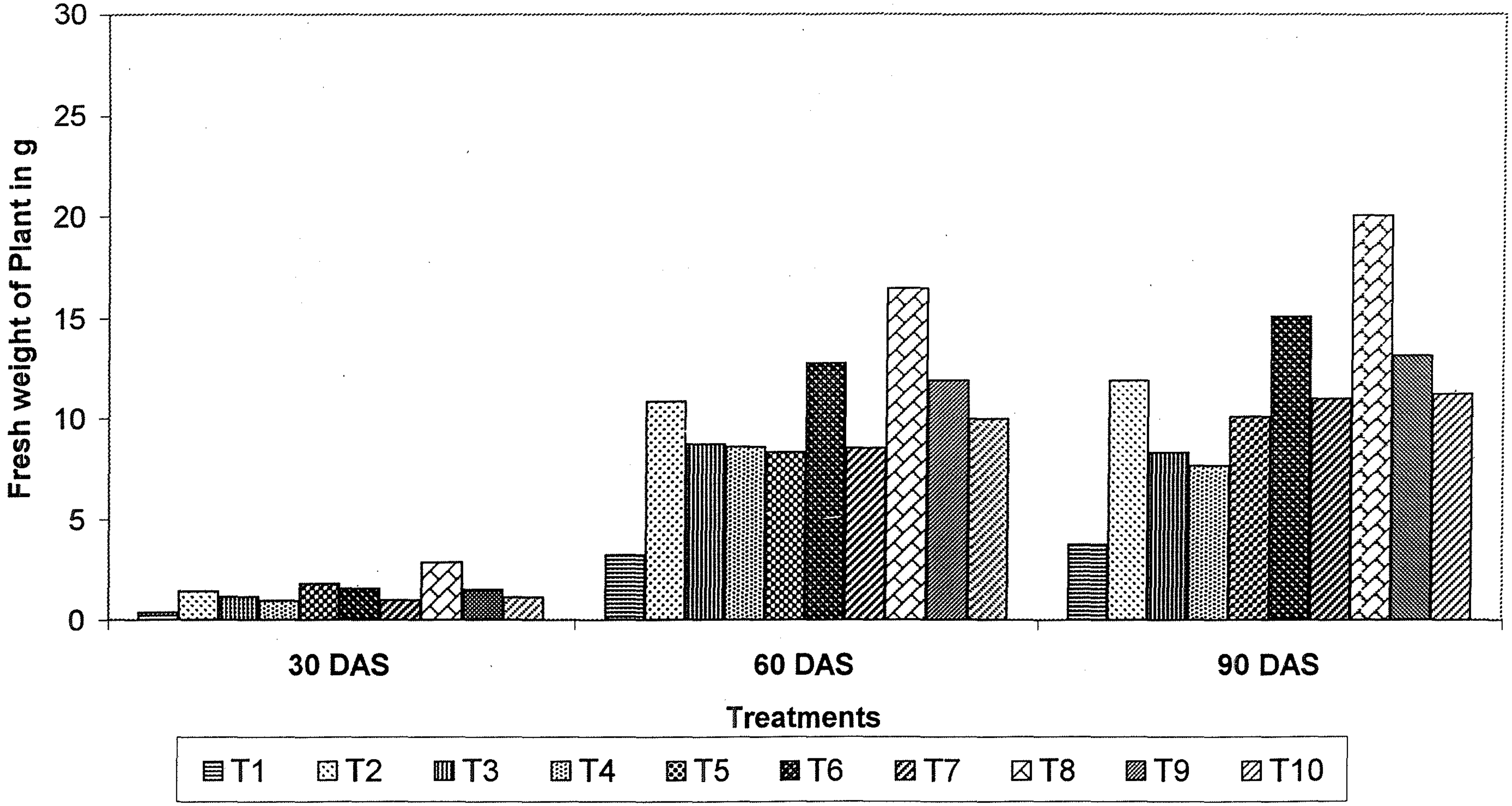


FIG. 8. Effect of treatments on the fresh weight of plant of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

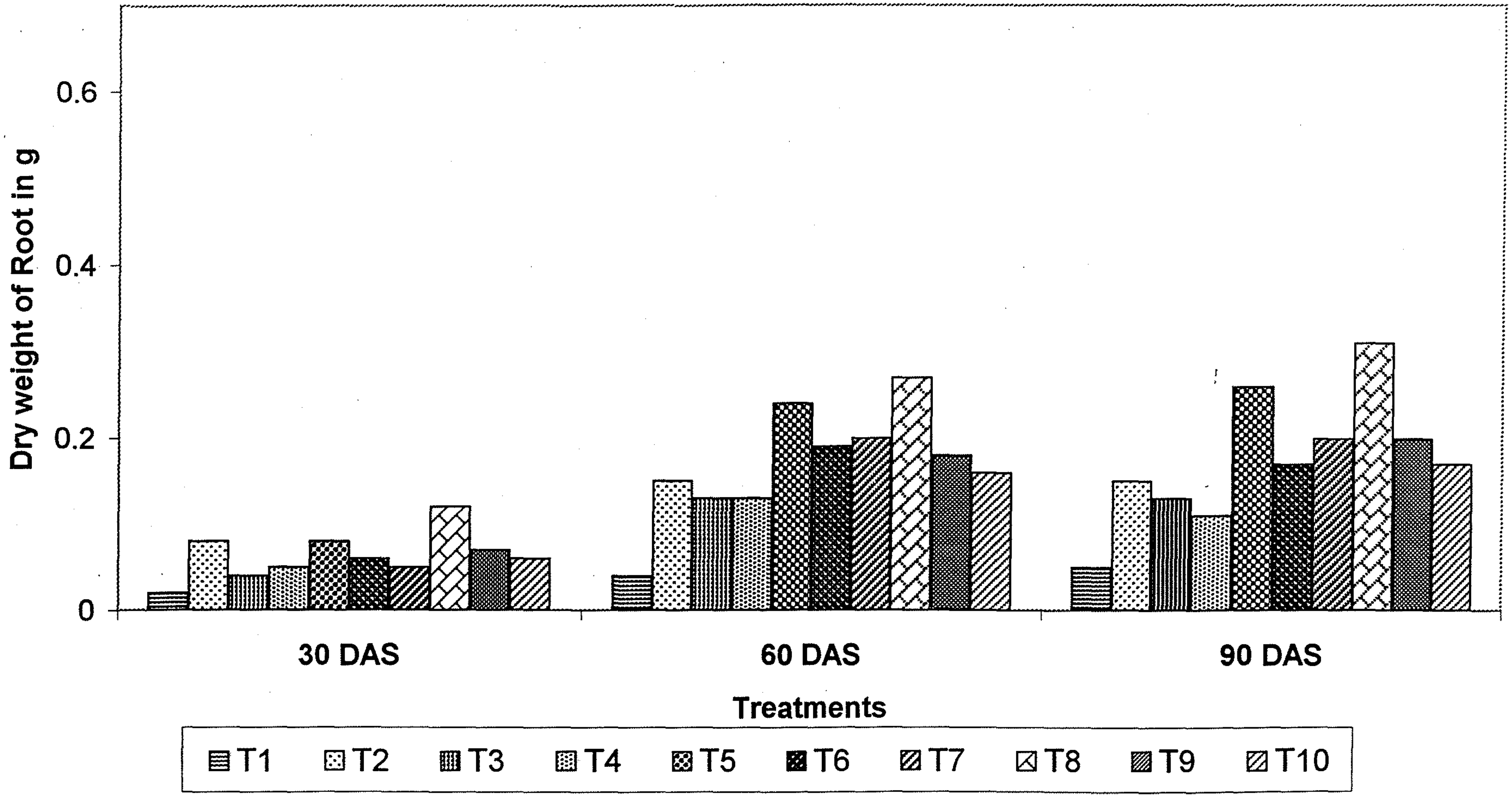


FIG. 9. Effect of treatments on the dry weight of root of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

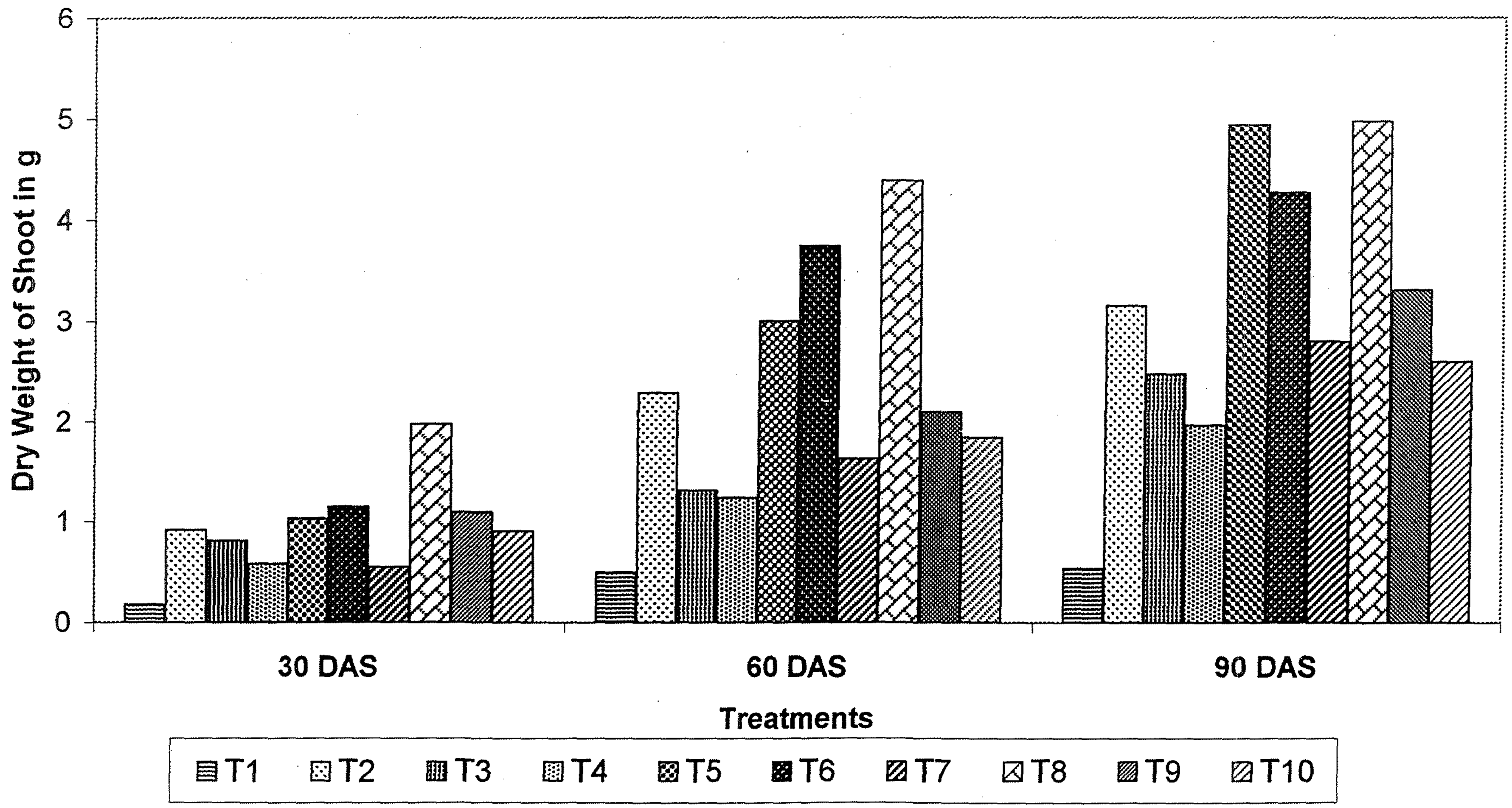


FIG. 10. Effect of treatments on the dry weight of shoot of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

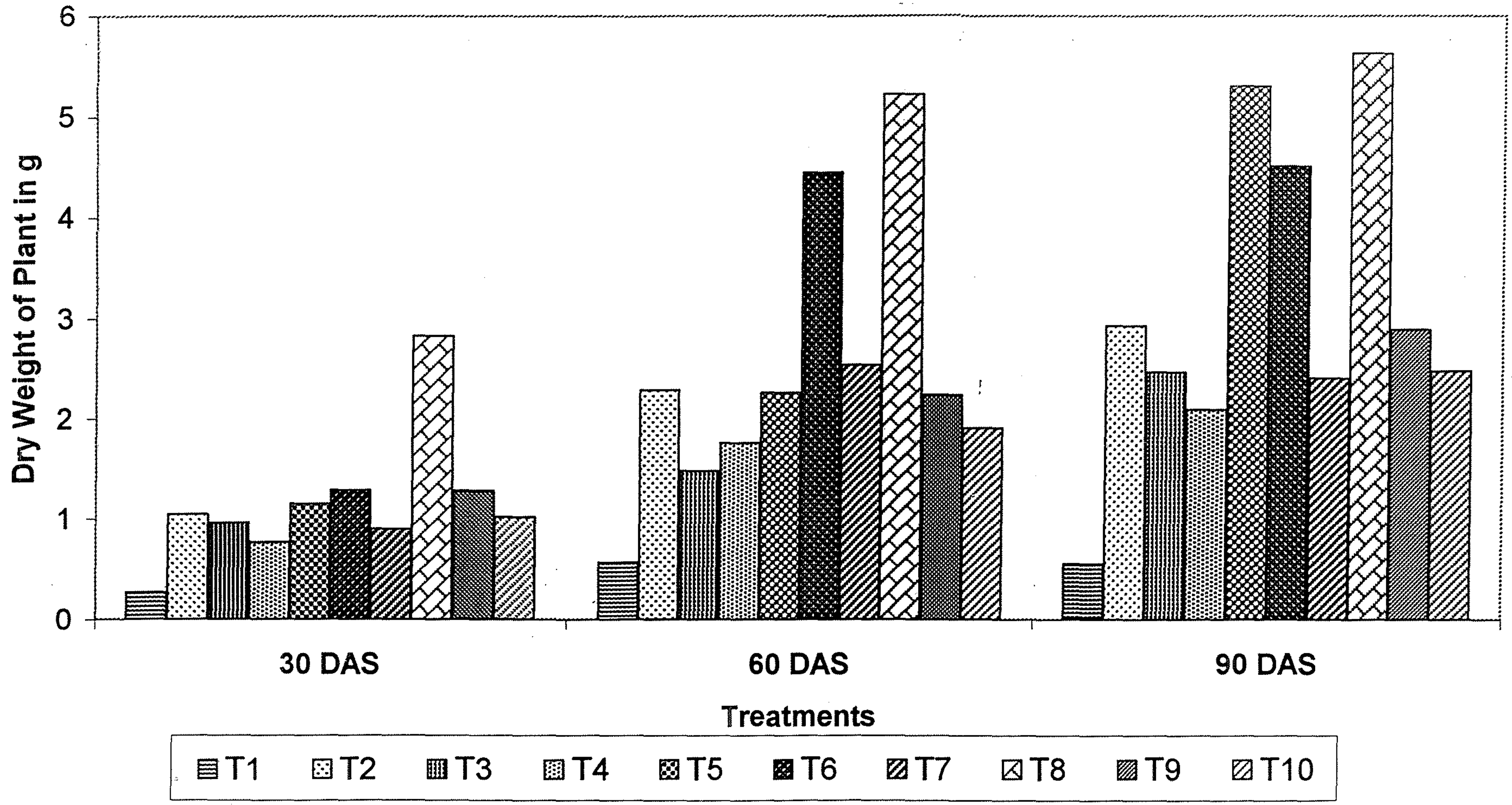


FIG. 11. Effect of treatments on the dry weight of plant of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

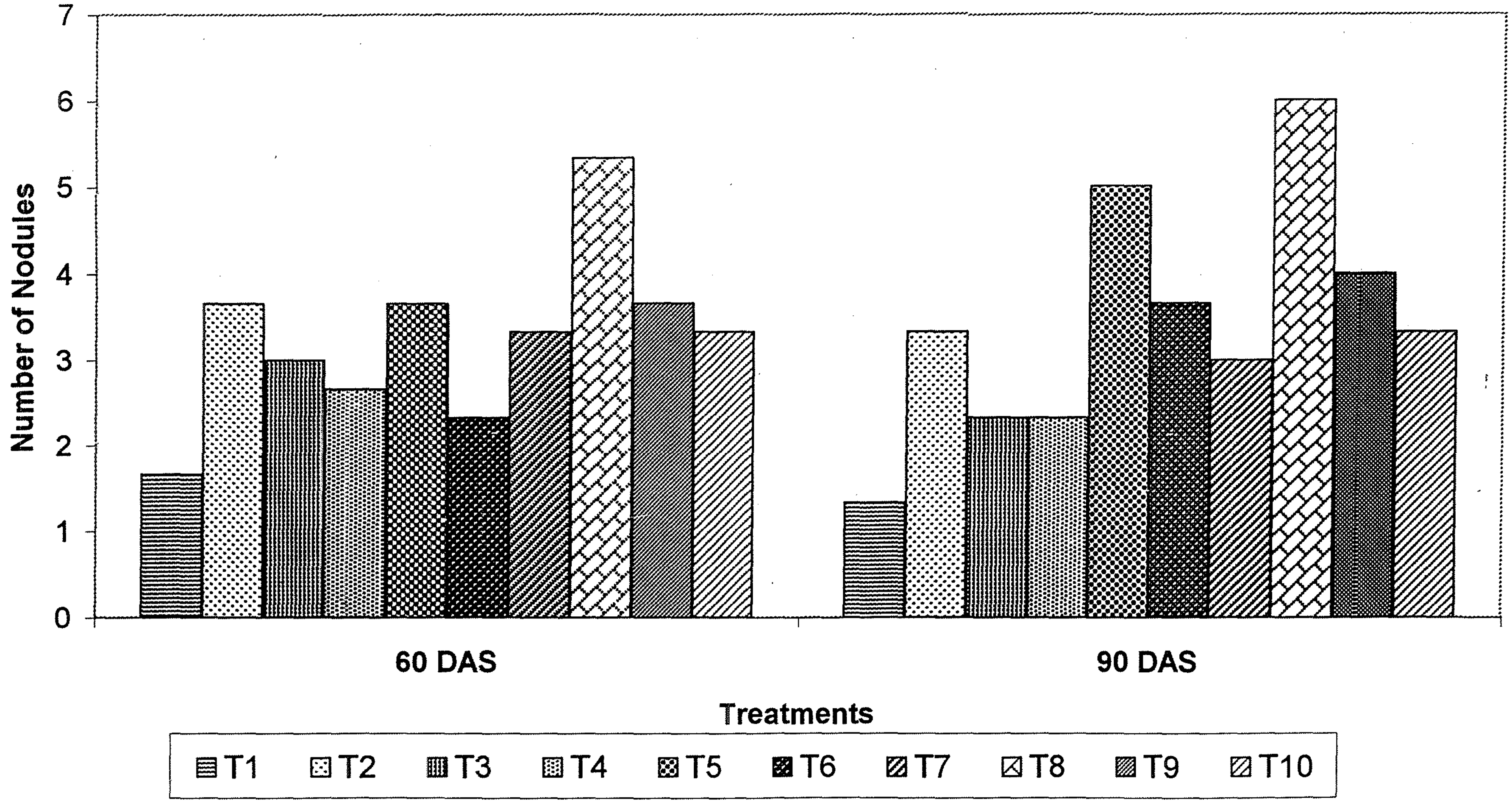


FIG.12. Effect of treatments on the number of nodules of *Cyamopsis tetragonoloba* L. Taub on 60 DAS and 90 DAS

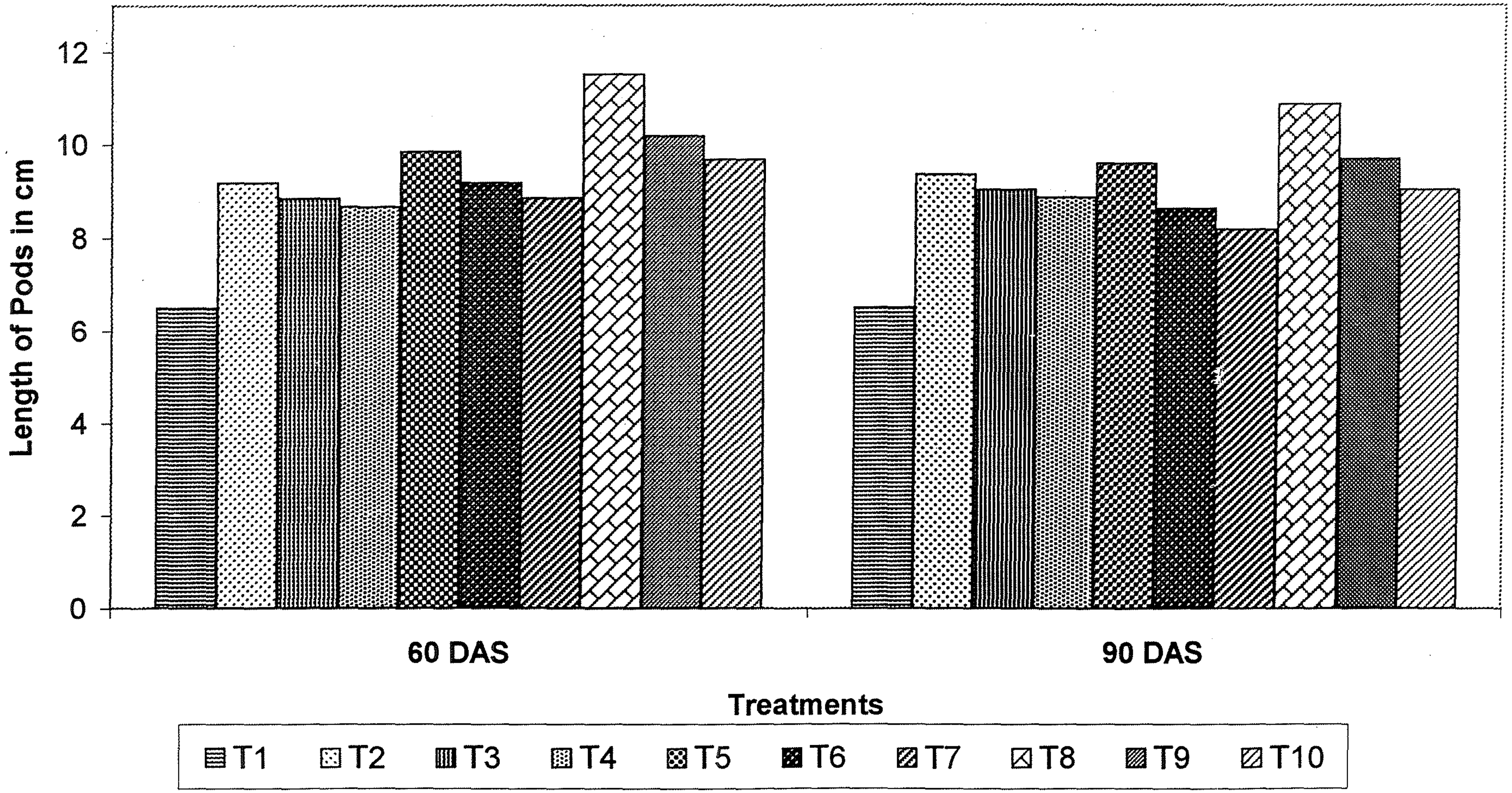


FIG. 13. Effect of treatments on the length of pods of *Cyamopsis tetragonoloba* L. Taub on 60 DAS and 90 DAS

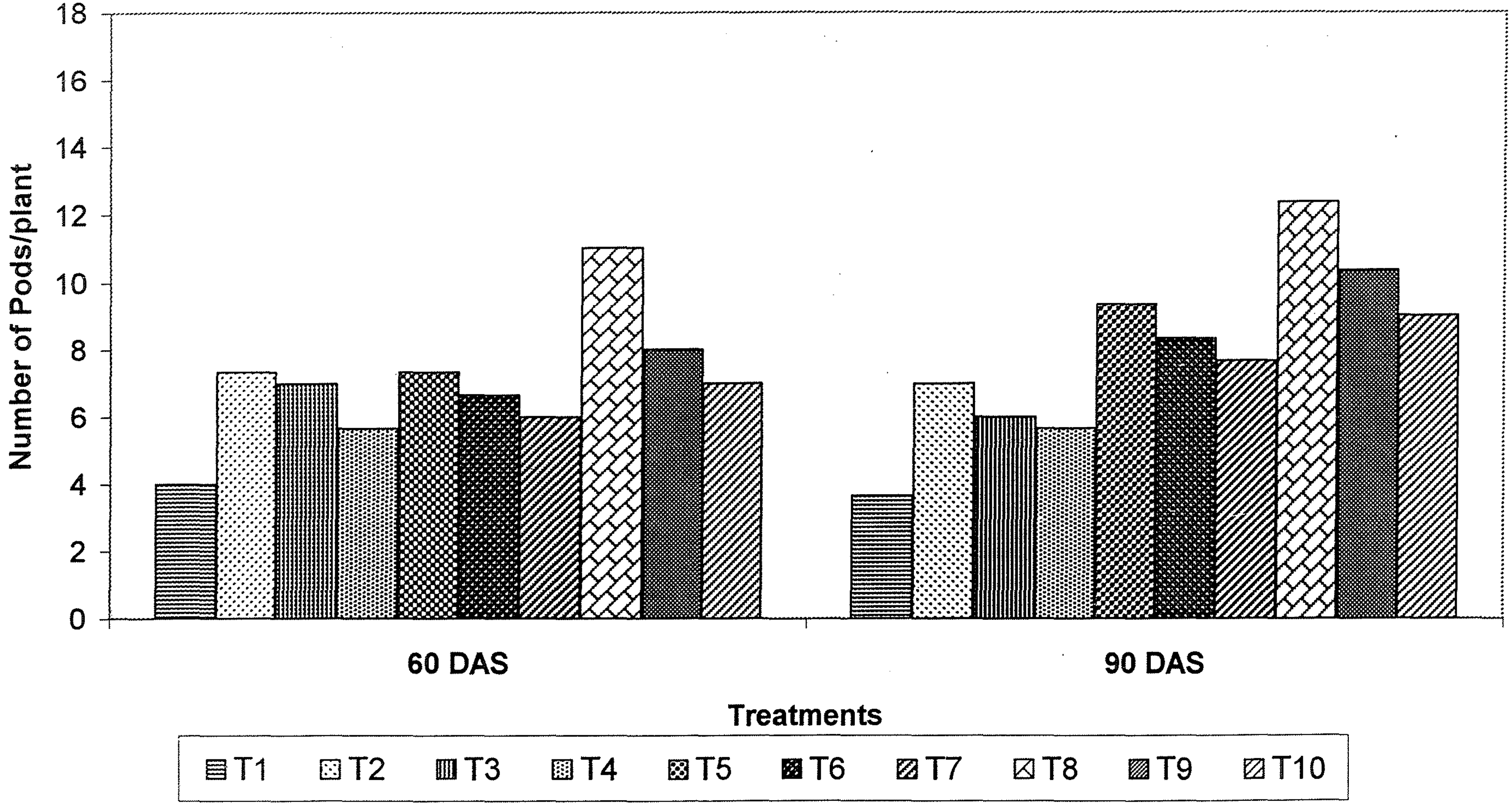


FIG. 14. Effect of treatments on the number of pods/plant of *Cyamopsis tetragonoloba* L. Taub on 60 DAS and 90 DAS

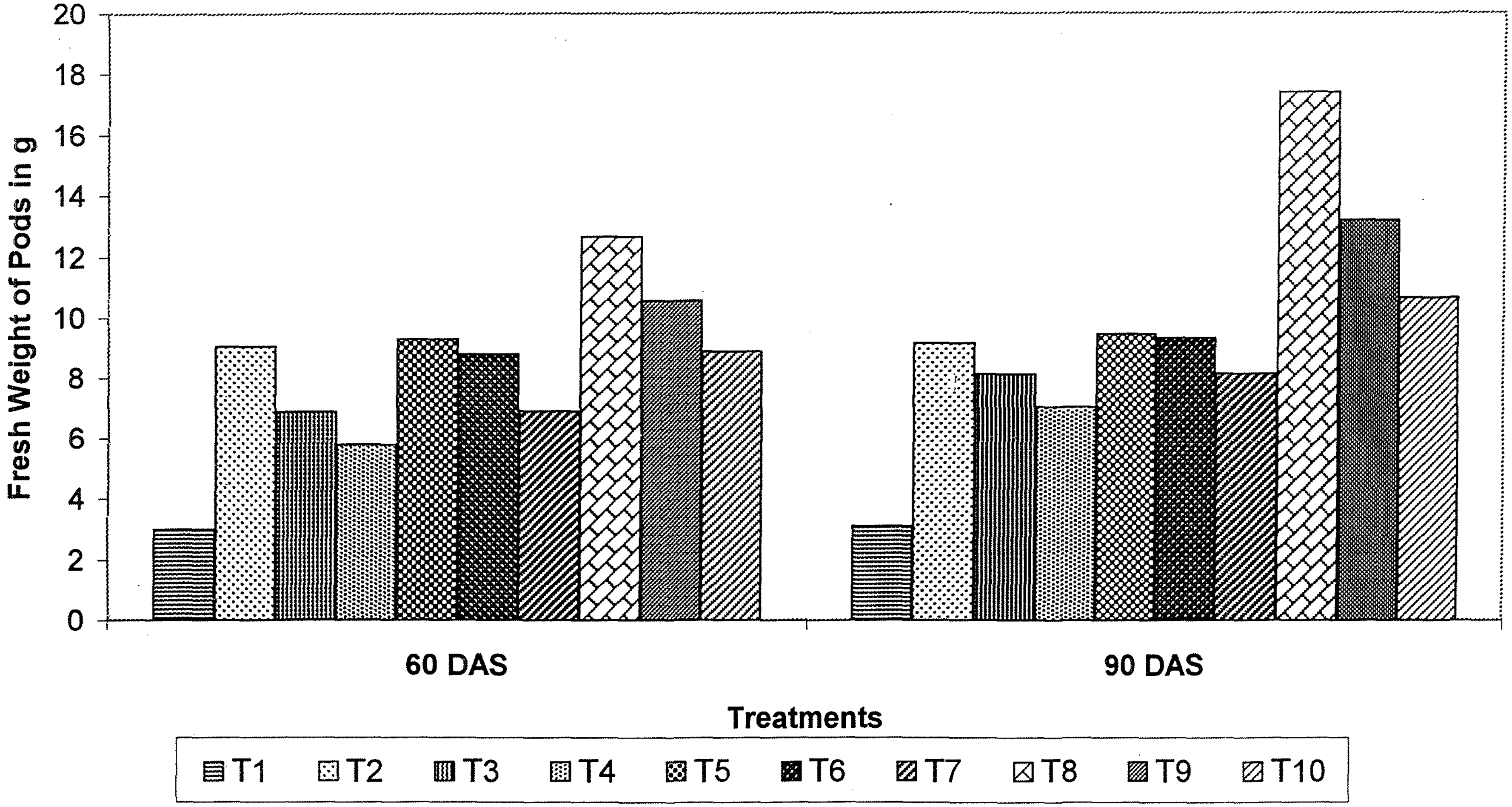


FIG.15. Effect of treatments on the fresh weight of pods of *Cyamopsis tetragonoloba* L. Taub on 60 DAS and 90 DAS

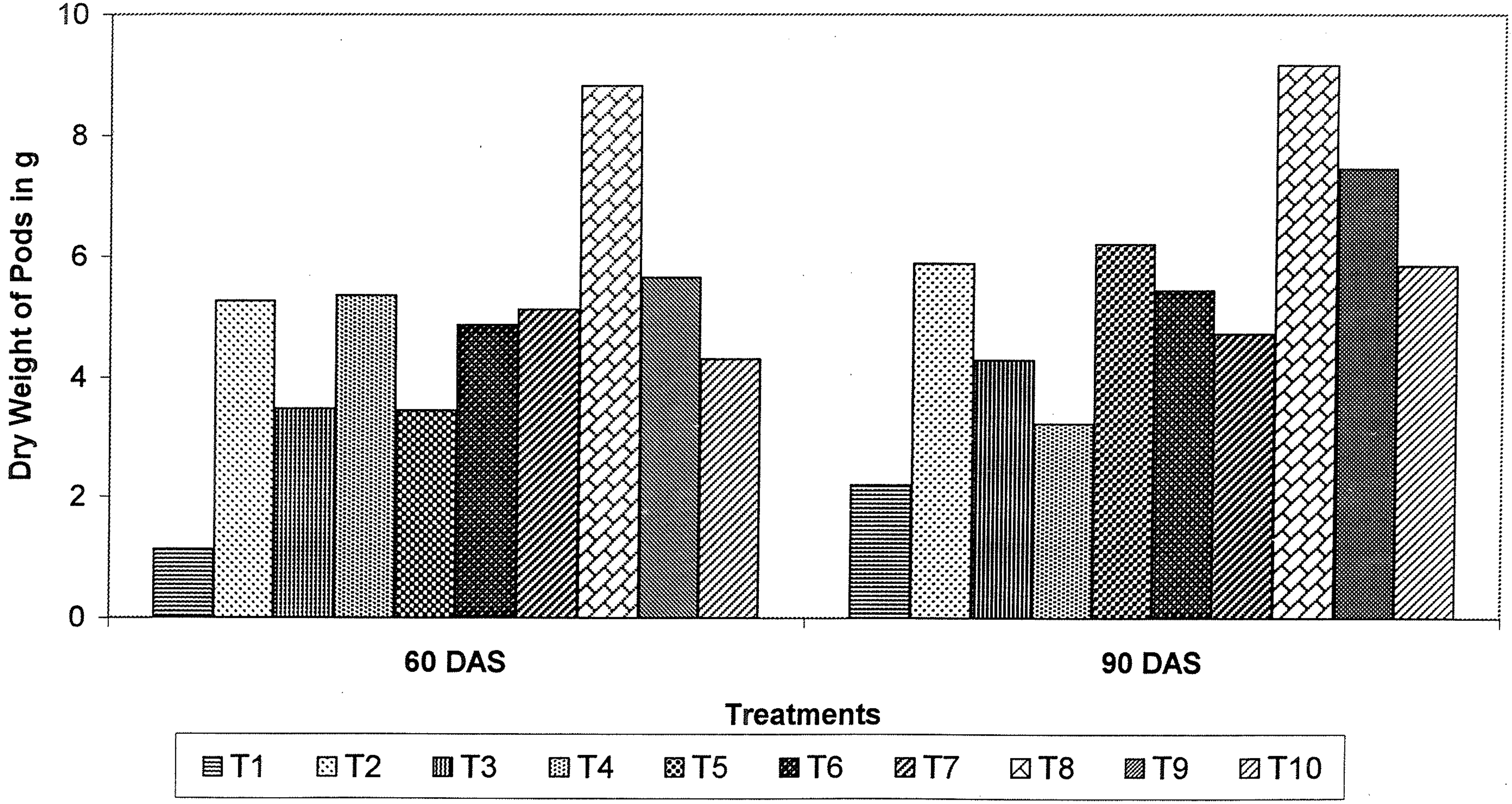


FIG. 16. Effect of treatments on the dry weight of pods of *Cyamopsis tetragonoloba* L. Taub on 60 DAS and 90 DAS

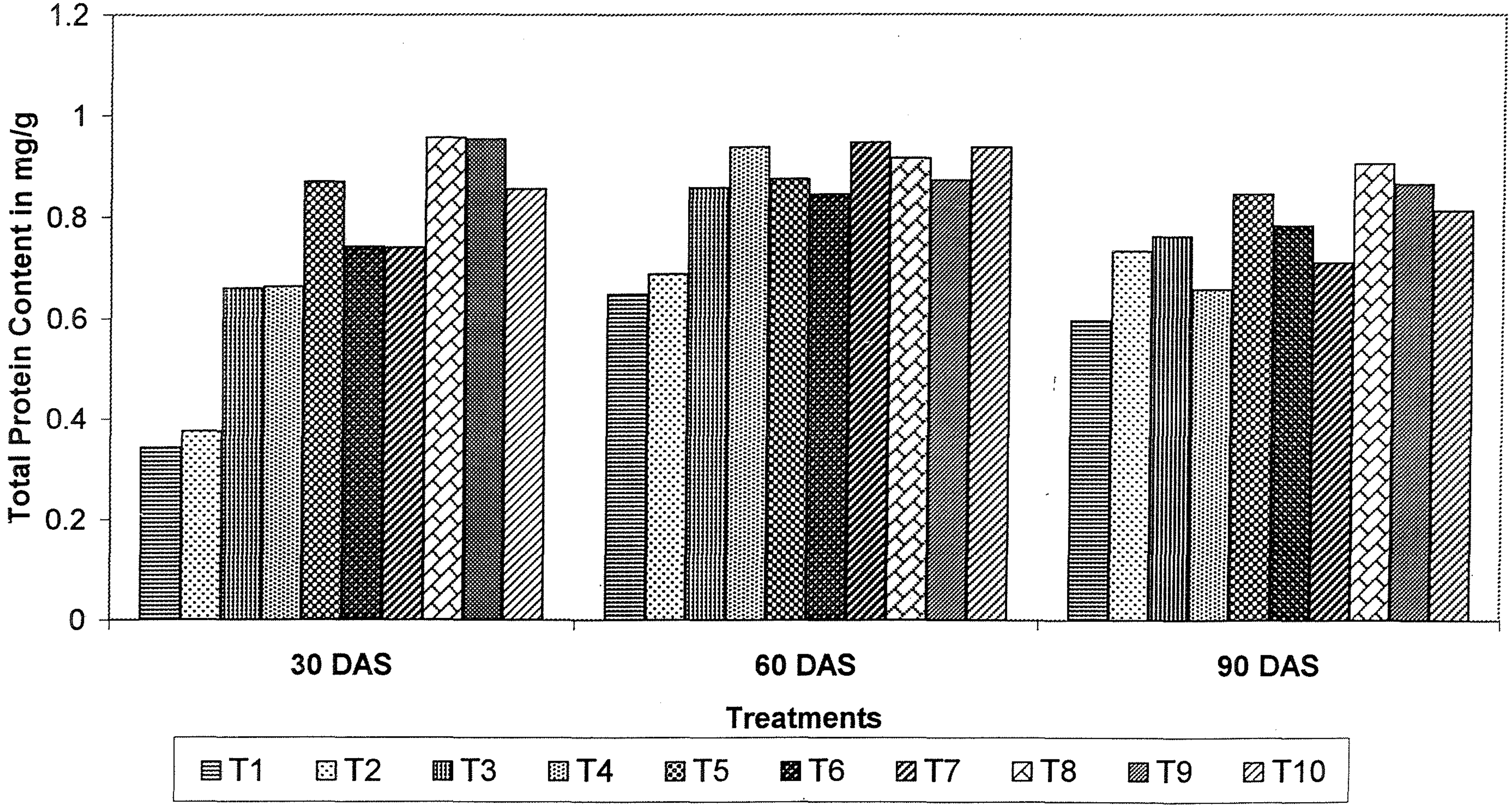


FIG. 17. Effect of treatments on the total protein content of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS and 90 DAS

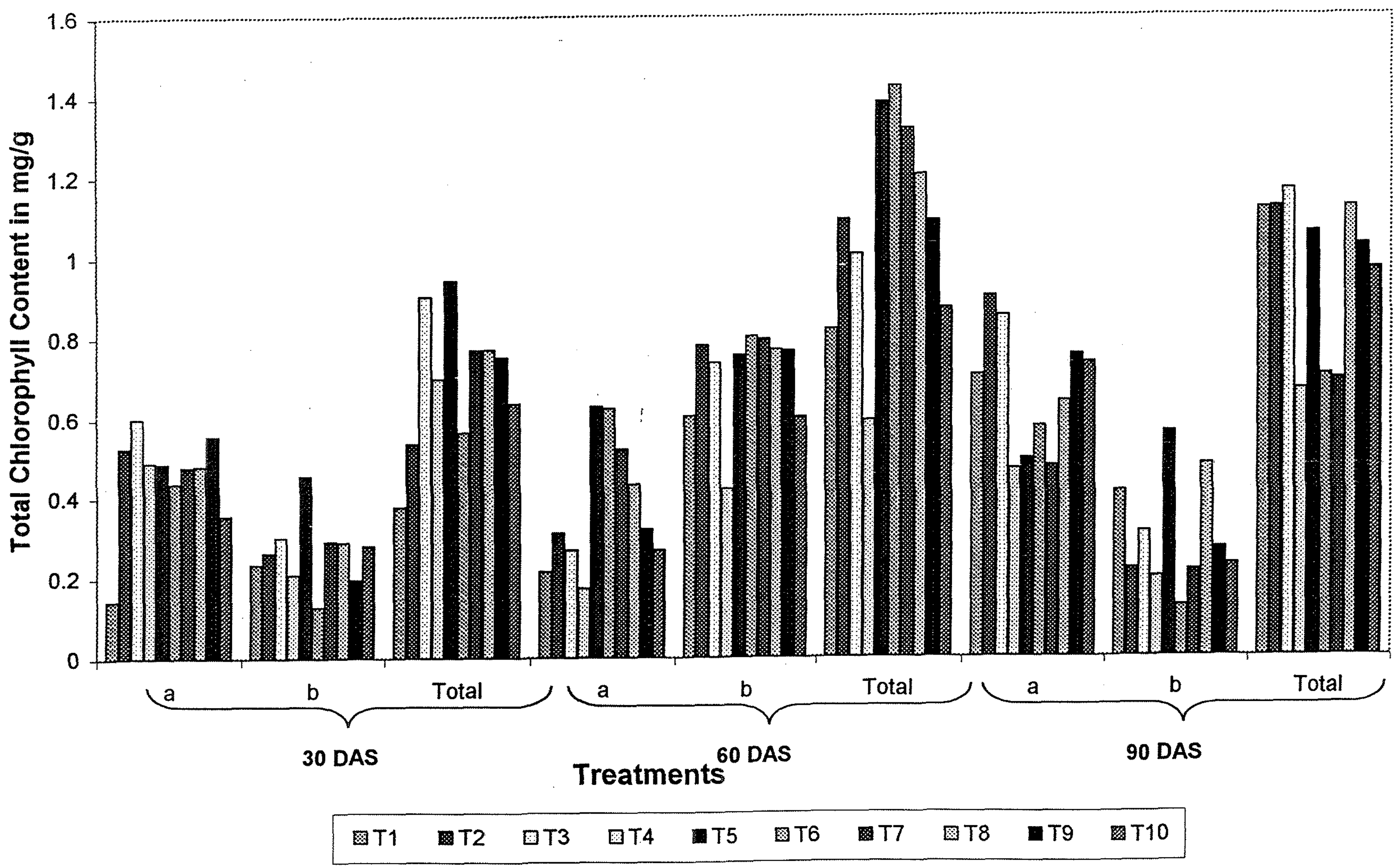


Fig. 18 Effect of treatments on the total chlorophyll content of *Cyamopsis tetragonoloba* L. Taub on 30 DAS, 60 DAS, 90 DAS

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Balanced use of plant nutrients corrects nutritional deficiencies, improves soil health, increase nutrients and water use efficiency, enhances crop and environmental qualities. Hence to sustain productivity, a continuous and regular application of organic manure and biofertilizer is essential to promote growth and yield of crops.

Therefore, a study was undertaken to evaluate the effects by collaborating organic manure (cow dung) and biofertilizer (Azolla) on the biometrical, yield and biochemical parameters of cluster bean.

A pot culture experiment was conducted in red soil with cluster beans as the test crop. There were 10 treatments in various doses of CD and Azolla including control where no fertilizer was applied and each treatment replicated three times. On 30 DAS, 60 DAS and 90 DAS, biometrical, yield and biochemical parameters were observed and analysed critically.

5.1. INFLUENCE OF TREATMENTS ON THE BIOMETRICL PARAMETERS

The combined effects of CD and Azolla on various biometrical parameters were tremendous when compared to control at 30 DAS, 60 DAS and 90 DAS. Of all the treatments, T_8 treated with 100% CD and 100% Azolla showed the statistically significant impact on all the parameters except root volume.

5.2 INFLUENCE OF TREATMENTS ON THE YIELD PARAMETERS

A close perusal of the data obtained for the yield parameters revealed that the collaborative use of organic manure and biofertilizer in the treatments strikingly enhanced the yield of the crop when compared to control at 60 DAS and 90 DAS.

As biometrical parameters, the yield characters also proved a magnificent increase in T_8 treated with 100% CD and 100% Azolla against all the other treatments.

5.3 INFLUENCE OF TREATMENTS ON THE BIOCHEMICAL ASPECTS

5.3.1 TOTAL PROTEIN CONTENT

Invariably all the treatments influenced the total protein content of the fresh leaves at 30 DAS, 60 DAS and 90 DAS.

5.3.2 CHLOROPHYLL CONTENT

Chlorophyll a, b and total content of the fresh leaf was influenced by the treatments at 30 DAS, 60 DAS and 90 DAS. The application of balanced fertilizers in these treatments provided better nutrition to the plants.

Hence the treatments treated with CD + Azolla and Azolla expressed the higher rates of chlorophyll a, b and total content when compared other treatments.

5.4 INFLUENCE OF TREATMENTS ON THE CHEMICAL PROPERTIES OF POST HARVEST SOIL SAMPLES

The post harvest soil samples were analysed for physico-chemical properties, like pH and NPK. The soil pH was maintained almost same in all the treatments except T_3 (CD 50%). Nitrogen, phosphorus and potassium were found to be increased substantially in T_8 (CD 100% + Azolla 100%) as 69 ppm, 158 ppm and 287 ppm respectively.

The study has shown that the conjunctive use of selected organic manure, cow dung and biofertilizer – Azolla could promote the growth and yield of cluster bean . They are the valuable manures which contain splendid nutrients.

Therefore growing crops may be encouraged by the integrated management of nutrients (CD and Azolla) and by the conservation of natural resources to revive natural balance.

Azolla, as a biofertilizer has tremendous potential to wrest the present day agriculture out of food and nutrition crisis.

References

REFERENCES

Abdulsalam, M. 1984. Fertilizer, Insecticide interaction on growth, root activity and yield of low land rice. **Ph.D. Thesis. TNAU. Coimbatore.**

Agbim, N.N. 1998. The effect of plant and animal waste combinations on intercropping yields in a tropical environment. **Biological Agriculture Horticulture, 5:** 143 – 154.

Ali, A.M., Mohan, J.C. and Santha, R. 1974. Response of ground nut to different moisture regimes and farmyard manure. **Madras Agric. J., 61:** 472 - 476.

Alice, J., Sujeetha, R.P. and Vengugopal, M.S. 2003. Effect of organic farming on management of rice brown planthopper. **IRRN, 28 (2):** 36 – 37.

Amudhasurabi, A. and Longanathan, M. 2000. Biological inputs. **Kisan World, 27(8):** 20.

Andhale, R.K. and Kalbhor, P.N. 1980. Pattern of dry matter accumulation of sunflower as influenced by irrigational schedules under various levels of nitrogen fertilization. **J. Maharashtra Agric. Univ., 5:** 9 – 14.

Anilakumar K., Johnkutty, I. and Kamalam, J. 1993. Long term effect of continuous fertilization by organic and inorganic sources of rice productivity, **J. Tropical Agric., 31:** 204 – 209.

Arnon, D.E. 1949. Copper enzymes in isolated chloroplast. **Pl. Physiol., 24:**1-5.

Arora, S. and Dan, S. 2003. Biofertilizers for sustainable Agriculture. **Kisan World, 30(5):** 35 – 36.

Arun, K.S. 2001. Cycle for survival. In: A handbook of organic farming. **Agrobios, India**, pp. 1- 40.

Ashok, K.V., Pawan K.S. and Vedprakash, K.P. 1976. Organic wastes v/s farm wealth. **Agric. & Agro – Industries J., 9(6):** 3 – 4.

Athmanathan, U., Karthikeyan, A. and Bhaskaran, R. 1999. New fertilizer ratio for hybrid coconut. **The Hindu Sci. and Tech.,** p.24.

Avijit S. and Kumar, S. 1998. Economisation of NPK on wheat (*Triticum aestivum* L.) through biofertilizer, biozyme. **Indian Agric., 42(4):** 247 – 251.

Babu, S. and Balamurugan, P. 2001. Optimising nitrogen to brinjal. **The Hindu Sci. and Tech.,** p.8.

Balasubramanian, G., Paulpandi, V.K. and Pakiaraj, S.P. 1999. Organic manure boosts chilli yield. **The Hindu Sci. and Tech.,** p.24.

Banker, G.J. and Mukhopadhyaya, A. 1990. Effect of NPK on growth and flowering in tuberose cv. Double. Laible. **Indian J. Hort., 47(1):** 120 – 126.

Basavannappa, M.A. and Biradar, D.P. 2003. Organic as a source of bionutrients in intensive agriculture. **Kisan World, 30 (6):** 61 –62.

Brennan, R.F., Webb, M.G. and Crowhurst, A.M. 2000. Yield responses of mulla mulla (*Plilotus exaltatus* Ness) seedlings to additions of nitrogen, potassium and phosphorus fertilizers. **Australian J. of experiment Agric., 40(6):** 867 – 871.

Dahiya, S.S., Malik, C.V.S. and Hooda, I.S. 1998. Studies on INM in cereal based cropping system —attributed effect on yield / and yield of Bajra crop. **Haryana J. Agron., 14:** 164 – 167.

Diara, H.F., Van Brandt, H. and Diop, A.M. 1985. Azolla and its use in rice culture in West Africa,Intl. Workshop on Azolla use. **Fujian Acad. Sci., Fuzhou, Fujian, China.**

Diokoto, R.K. and Stephens, D. 1961. Thirty long term fertilizer experiments under continuous cropping in Ghana. 1 Crop yields and responses to fertilizers and manures. **Empire J. Exp. Agric., 29:** 181 – 195.

FAO. 1977. China. Recycling of organic wastes in agriculture, **FAO, Soils Bull., 40:** 29 – 38.

Felleca, D., Rammunni, A. and Scialdone, R. 1983. Monthly variations of soluble P in a volcanic ash derived soil as affected by organic and mineral fertilizers. **Plant and soil, 74:** 67 – 74.

Fiore, M.F. 1985. Use of Azolla in Brazil, Intl. Workshop on Azolla use. **Fujian Acad. Sci. Fuzhou, Fujian, China.**

Gajri, P.R., Arora, V.K. and Chaudhary, M.R.1994. Maize growth responses to deep tillage, straw mulching and farmyard manure in coarse textured soils of N.W. India. **Soil use and management, 10:** 15 – 20.

Ghanta, P.K., Dhua, A.K. and Mitra, S.K. 1995. Effect of varying levels of nitrogen, phosphorus and potasssium on growth, yield and quality of papaya (*Carica papaya* L.). **Ann. Agric. Res., 16(4):** 405 – 408.

Ghosh, D.C. and Das, A.K. 1998. Effects of biofertilizers and growth regulators on growth and productivity of potato *(Solanum tuberosum).* **Indian Agriculture, 42 (4):** 109 – 113.

Gill, M.S., Singh, K. and Wakua, S.S. 2000. Use of Biofertilizers in agriculture. **Kisan world, 27(3):** 32 – 33.

Gowda, J.V., Jacob, S. and Huddar, A. 1991. Effect of N, P and K on growth and flowering of tuberose cv. Double. **Indian Perfumer, 35(2):** 100 – 101.

Hasan, M.A. and Chattopadhyay, P.K. 1997. Leaf nutrient status and their correlative relationship with yield in litchi CV. Bombay under the influence of N, P and K nutrient. **Indian Agric., 41(1):** 61 – 69.

Hegde, N.R. 1997. Organic farming. **Kisan World, 24(8):** 43 – 44.

Intodia, S.K., Mahnot, S.C. and Sahu, M.P. 1995. Effect of organic manures and phosphorus on growth and yield of ground nut (*Arachis hypogea* L.). **Crop Res., 9(1):** 22 – 26.

Jayakumar, J. Ramakrishnan, S., and Rajendran, G. 2004. Influence of poultry manure against *Meloidogyne incognita* infesting Tomato. **J.Ecobiol., 16(2)**: 151 – 152.

Joseph, P. 1995. Effect of graded doses of nitrogen, phosphorus and potassium on yield of brinjal (*Solanum melongena* Linn.). **J. Trop. Agric., 33(1995):** 167 – 170.

Kanakamani, P. 2004. Biofertilizer boon for crop production. **Kisan World, 31(7):** 47.

Kannaiyan, S. 1982. Multiplication and use of Azolla biofertilizer for rice production training, **TNAU. Coimbatore, Tamil Nadu, India,** p.58.

Kannaiyan, S., Thangaraju, M. and Oblisami, G. 1984. Effect of Azolla application on rice crop. **Nat. Acad. Sci. Lett., 7(11):** 323 – 324.

Kannaiyan, S. 1985. Potentiality of Azolla Biofertilizer for rice crop. In: Proc. Soil Biol. Symp. (eds). M.M. Mishra and K.K. Kapour, Haryana **Agri. Univ. Hisar, Haryana, India,** pp. 253 – 259.

Kannaiyan, S. 1987. Influence of temperature on the growth and nitrogen fixation by Azolla spp. **Phykos, 26:** 134 – 139.

Kannaiyan, S. 1989. Azolla biofertilizer for Rice. In: *In Vitro* Approaches to plant Breeding, **Natl. Seminar on Biotech. Mol. Boil. C.M.S college, Kottayam, Kerala, India,** pp.53 – 60.

Kannaiyan, S. 1989. Manipulation of spore germination in Azolla microphylla. 2nd **Cuban and International Seminar on Biotechnology, Cuba.**

Kannaiyan, S. 1990. Development of a new spore production technology of nitrogen fixing water fern Azolla and its biofertilizer effect on rice crop. Paper presented at the symopsium on Biotechnology and International trade, and beyond IFIAS. Maastricht, **The Netherland,** pp.157 – 184.

Kannaiyan, S. 1990. Azolla-Anabaena complex as Biofertilizer for rice. In Proc. Current Trends in Biotechnology. Cochin Univ. **Science and Technol. Cochin, Kerala, India,** pp.16 – 27.

Kannaiyan, S. 1992. Azolla biofertilizer technology for Rice Tech. Bull., **TNAU, Coimbatore, India,** p.56.

Kannaiyan, S. 2000. Integrated nutrient management strategy in wetland rice ecosystem. In: Integrated Nutrient management (ed) Kannaiyan *et al.* **TNAU, Dept. of Agric.**, p.1 – 32.

Kannaiyan, S. and Govindarajan, K. 1982. Usefulness of Azolla inoculation for rice crop. **Madras Agric. J., 62:** 254 – 255.

Kannaiyan, S. and Kumar, K. 1993. Experimental Techniques of Azolla biofertilizer, **TNAU. Coimbatore, Tamil Nadu, India,** pp. 28 – 29.

Kannaiyan, S. and Rajeswari, N. 1983. Comparative effect of fertilizer nitrogen and Azolla biofertilizer on the tiller production of rice. **Sci. Cult., 49(8):** 245 – 246.

Krishnakumar, S. and Jawahar, D. 2001. Coir pith compost. **Kisan World, 28(3):** 41.

Krishnaveni, A.S. and Balamurgan, P. 2002. Boosting Organic farming through farm wastes. **Kisan World, 29:** 28 – 29.

Kulasooriya, S.A. and De Silva. 1977. Effect of Azolla on yield of rice. **Intl. Rice Res. Newslett., 2(3):** 10.

Kumar, K. and Kannaiyan, S. 1992. Microbial decomposition of nitrogen fixing green manures in rice soil. Paper presented in 32nd **Ann. Conf. Assoc. Microbiologists of India, MKU. Madurai, Abst.,** pp.113.

Kumaraswamy, K. 2002. Organic, inorganic and integrated soil fertility management. **Kisan World, 28(1):** 23.

Kumarasway, K. 2004. Organic farming - A myth or miracle. **Kisan World, 31(1):** 33 – 34.

Kumaresan, K.R., Dhakshina Moorthy, M., Subramaniam, V.A. and Manickam, T.S. 1984. Effect of agricultural and industrial wastes on the availability of nutrients and yield of ground nut. **Madras Agric. J.,71:** 783 – 787.

Laddawan, L. and Cholskararengsa. 1985. Use of Azolla in Thailand. Intl. Workshop on Azolla use. Fujian Acad. Sci., Fuzhou, Fujian, China.

Latha, K.R. 1985. Studies on the effect of fertilizer nitrogen and Azolla on rice.**M.Sc. (Ag). Thesis, TNAU, Coimbatore, Tamil Nadu.** p.97.

Latha, M.R. 2003. Influence of zinc enriched organic manures on potassium uptake in maize – sunflower cropping system and potassium availability in the soil. **J. Ecobiol., 15(4):** 305 – 308.

Liu, C.C. 1979. Use of Azolla in rice production in China. In: Nitrogen and Rice. **Intl. Rice Res. Inst., Los Banos, Philippines,** pp.375 – 393.

Liu, C.C. 1985. Re evaluation of Azolla utilization in Agricultural production. Intl. Workshop on Azolla use. **Fujian Acad. Sci., Fuzhou, Fujian, China.**

Lowry, O.H., Rosenbrough, N.J., Farr, A.L. and Randall, R.J. 1951. Protein measurement with Folin-Phenol reagent. **J. Biol. Chem., 193:** 267 – 275.

Lumpkin, T.A. and Plucknett, D.L. 1980. Azolla-Botany, Physiology and use as a green manure. **Econ. Bot., 34:** 111: 153.

Mabbayad, B.B. 1985. The Azolla programme of the Philippines. Intl. Workshop on Azolla use **Fujian Acad. Sci., Fuzhou, Fujian, China.**

Mahesh, G. and Kannaiyan, S. 1993. Immobilization of Anabaena - Azollae in solid matrix on ammonia excretion. **Madras Agric. J., 80 (8):** 450.

Maheswarappa, H.P., Nanjappa, H.V. and Hegde, M.R. 1998. Effect of sett size, plant population and organic manures on growth components of arrow (*Maranta arundinacea* L.) as intercop in coconut garden. **Mysore J. Agric. Sci., 32:** 257 – 263.

Mallik, E.H., Gosh, H.M. and Barragi, P. 1978. Effect of nitrogen fertilizer on yield attributes and grain quality of two new strains of rice. **Curr. Agric., 2:** 73 – 77.

Malik, R.S. and Dodlani, N.K. 1984. Rose cultivation in India. **Indian Horti., 29(2):** 27 – 30.

Mandal, B.K., Das, N.C. and Ghosh, R.K. 1992. Influence of Azolla on some of the physical and chemical properties of the soil. **Oryza, 29:** 121 – 124.

Manna, A.B. and Singh, P.K. 1988. Effect of different nitrogen sources on growth, acetylene reduction activity of *Azolla pinnata* and yield of rice. **Plant and soil, 107:** 165 – 171.

Manna, M.C., Mandal, K.G., Hati, K.M. and Subadhu, K. 2001. Use of phosphate biofertilizers for crop production systems. **Indian Fmg., 50(10):** 52 – 55.

Manonmani, M. and Anand, R. 2002. Vermmicompost, an uprising fertilizer for lady's finger *(Hibiscus esculentus)*. **Kisan World, 29(1):** 40.

Maskina, M.S., Sandhu, P.S. and Meelu, O.P. 1985. Effect of integrated use of organic and inorganic nitrogen sources on growth and nutrient composition of rice seedlings. **Oryza, 22:** 11 – 16.

Meerabai, M. and Asha, K.R. 2001. Bio-farming in vegetables. **Kisan World , 28(4):** 15 – 16.

Muthumanickam, D. and Balakrishnamurthy, G. 1998. Nutrition for aswagandh. The Hindu Sci. and tech., p.24.

Mythili, S., Natarajan, K. and Kalpana, R. 2003. Impact of green manuring on rice yield, zinc and sulphur uptake. **Agri. Sci. Digest, 23(1):** 38 – 40.

Nagaraju, A.P., Shambulingappa, K.G. and Sridhara, S. 1995. Efficiency of levels and sources of fertilizer, phosphorus and organic manure on the growth and yield of cow pea (*Vigna unguiculata* (L.) Walp.). **Crop Res., 9(2):** 241 – 245.

Natarajan, P. and Srinivasan, K. 1989. Effect of varying levels of nitrogen, phosphorus and potassium on yield attributes and yield of cardamom *(Elettaria Cardamonum* Maton). **South Indian Horticulture, 37(2):** 97 – 100.

Nazis, D.O., Lopez , E.S. and Weber, D.E. 1970. **Pest Agropec bras., 5:** 129. (copied).

Noor, S., Huq, M.S., Yasmin, M. and Islam, M.S. 1992. Effect of fertilizer and organic manure on the yield of hyacinth bean (*Dolichos lablab* L.) **Leg. Res, 15(1):** 11 – 14.

Obi, J.K. 1959. The standard DNPK experiments Samaru Reg. Res. **Stn. Tech. Rep. 8, Min. Agric, Northern Nigeria**.

Oinam S.S. 2004. Organic farming. **Kisan World, 31(1)**: 24.

Palaniappan, S.P. 1992. Green Manuring: Nutrient potentials and management. In: Fertilizers. Tandon H.L.S. (ed.). **Organic manures, recycling wastes and biofertilizers,** pp.52 – 71.

Pandey, V. and Kumar, D. 2002. Biofertilizers for sustainable Agriculture. **Agric. Today, 5(8):** 44 – 47.

Panneerselvam, S. and Christopher, L.A. 1998. Effect of organic manures, inorganic fertilizers and weed management practices on the yield attributes and yield of soybean (*Glycine max* (L.) Merrill). **Legume Res., 21 (3/4):** 159 – 164.

Pannerselvam, S., Christopher L.A. and Balasubramaniam, N. 1999. Soil available nitrogen and N uptake of soybean (*Glycine max* (L.) Merrill) as influenced by organic manures, inorganic fertilizers and weed management practices. **Indian. J. Agric. Res., 33(4):** 233 – 239.

Pate, J.S. and Dart, P.J. 1961. Nodulation studies in legumes, IV. The influence of inoculum strain and time of application of ammonium nitrate on symbiotic response. **Plant and Soil, 15:** 329 – 346.

Patel, J.J., Patel, B.M., Patel, B.T. and Patil, R.G 2003. Study on use of *Gliricida sepicum* leaves for leaf manuring in cluster bean – Pearl millet Rotation under Dryland condition. **Agric. Sci. Digest, 23(1):** 10 –13.

Patel, R.S. Durivedi, S.K., Thakur, R.S., Agrawal, V.K. and Tiwari, A.B. 1998. Variation in Chlorophyll content and biomass accumulation in soybean (*Glycine max* (L.) Merr) genotypes. **Crop Res., 15 (2 & 3):** 290 – 293.

Prabhakaran, N.K. and Lourduraj, A.C. 2003. Nutrient management in soybean. A review: **Agric. Rev., 24(3):** 223 – 228.

Pradhan, L.D., Routi, D. and Mahapatra, B.K. 1995. Response of soybean to nitrogen and phosphorus. **Indian J. Agron., 40(2):** 305 – 306.

Praharaj, C.S. and Dhingra, K.K. 2001. Growth, productivity and biological nitrogen fixation in soy bean *(Glycine max)* under Bradyrhizobium inoculaiton, pendimethalin and nitrogen schedule, and their residual effect on succeeding wheat *(Triticum aestivum)* crop. **Indian J. Agric., 46(4):** 635 – 642.

Pritam, K.S. and Ajit, R. 1994. Effect of phosphorus on the bulb yield and P use efficiency as influenced by FYM in onion crop in acid soil from Western Himlayas, **J. Indian Soc. Soil Sci., 42(1):** 68 – 71.

Pritam, K.S. and Gupta, J.P. 1994. Phosphorus utlization and root cation exchage capacity in wheat as influenced by phosphorus, lime and FYM on an alfisal of Western Hjimalayas, **J. Indian Soci of Soil Sci.,** 42(1): 65 – 68.

Ramasamy, S., Kandasamy, O.S. and Saravanan, A. 1984. Dual cropping of Azolla in lowland rice. **Intl. Rice Res. Newslett., 9(3):** 26.

Ramesh, T., Chinnusamy, C. and Jayanthi, C. 2003. Green manuring in sugarcane-A Review: **Agri. Rev., 24(2):** 130 – 135.

Rao, A.V. 1996. Biological fertility and sustainability. **Indian farming, 46(7):** 52 – 54.

Ravichandra, B.C., Channabasave G.R., Basavaraj, B., Shiva Murthy, S.C. and Siddaramappa, R. 1996. Coir compost application on nutrient availability and growth of maize in an alfisol. **Mysore J. Agric. Sci., 30:** 127 – 132.

Ravichandran, V.K., Devarani, N. and Balasubramanian, T.N. 2003 Dissolution of low grade rock phosphate in the soil ameaded with organic manure and phosphobacteria. **J. Ecobiol., 15(1)**: 55 – 59.

Ray, P.K. and Yadav, J.P. 1996. Effect of combined use of organic manures and chemical fertilizers on growth and productivity of banana. **Ann. Agric. Res., 17(4):** 366 – 369.

Reddy, R.M. 1984. Performance of maize (*Zea mays* L) hybrids at different population and fertility levels. **M.Sc. (Ag.) Thesis, submitted to APAU, Hyderabad.**

Reddy, M.M., Reddy, D.M. and Reddy, B.B.2003. Effect of Nitrogen Management through organic and inorganic sources on yield of Rice. **J. Res., ANGRAU, 31(3):** 7 – 12.

Rohilla and Bujar, B. 1999. Effect of fortified organic manures on production of French beans. **Indian farming, 49(5):** 6.

Roy, B. 1984. Manuring of rice crop with Azolla. **Oryza, 21:**238 – 241.

Sabitha, B. and Pushpa, A. 2004. Influence of organic manure and inorganic fertilizer on the growth attributes of soybean. **National Symposium on Recent Trends in Applied Biology, January 28th and 29th 2004. Abstracts and Sourvenir,** p.138.

Sagre, B.N. and Guhe, Y.S. 1991. Response of *Hirsutum cotton* grown on typic chromustrats to enriched FYM products. **Ann. Pl. Physiol., 5(1):** 123 – 125.

Samanta, A.K. and Patro, N. 1996. Recycling of Farm wastes for Organic farming. **Indian farmers Digest, 29**: (10).

Sanjay, K.T. 2004. Organic farming: An environmental issue. **Kisan World, 31 (2):** 29 – 30.

Sankaran, S and Subbian, P. 1996. Importance of organic fertilizers. **Kisan World, 23(5):** 34 – 35.

Saxena, S.C., Manral, H.S. and Chandel, A.S. 2001. Effect of inorganic and organic sources of nutrients on soybean *(Glycine max)*. **Indian J. of Agron., 46(1):** 135 – 140.

Sengar, R.S. and Pant, R.C. 1998. Use of biofertilizers in agriculture. **Kisan World, 31(8):**16.

Sharma, S., Dev, S.P. and Rameshwar. 2000. Effect of green manuring of sunnhemp (*Crotalaria juncea* L.) on rice yield, nitrogen trunover and soil properties. **Crop Res., 19(3):** 418 – 423.

Sharma, S. 2003. Response of various isolates of Bradyrhizobium inoculation on protein content and its yield attributes of green gram *(Vigna radiata* (L) Wilczek)**.Crop Res., 15(6):** 216 - 124

Singh, P.K. 1977. Effect of Azolla on the yield of paddy with and without the application of N fertilizer. **Curr. Sci., 46:** 642 – 644.

Singh, P.K. 1979. Use of Azolla in rice production in India. In: Nitrogen and Rice. **IRRI., Los Banos, Philippines,** p.407 – 418.

Singh, A.L. and Singh, P.K. 1987. Influence of Azolla management on the growth, yield of rice and soil fertility. II. N and P contents of plant and soil. **Plant and Soil, 102:** 49 – 54.

Singh, S.P., Bansal, K.N. and Nepalia, V. 2001. Effect of nitrogen, its application time and sulphur on yield and quality of soybean *(Glycine max)* **Indian J. of Agric., 46(1):** 141 – 144.

Singh, P.K., Panigrahi, B.C. and Satapathy, K.B. 1981. Comparative efficiency of Azolla, Blue green algae and other organic manures in relation to N and P availability in a flooded rice soil, **Pl. and soil, 62:** 35 – 44.

Singh, K.P., Rinwa, R.S., Harbir, S. and Kathuria, M.K. 1997. Subsitution of chemical fertilizers with vermicompost in cereal based cropping systems. In:3rd IFOAM-Asia Scientific Conference and General Assembly. "Food Security in Harmony with Nature", **1st –4th Dec. 1997. Bangalore,** pp.59 – 60.

Singh, K.P., Harbir, S., Anwa, R. S., Kathuria, M.K. and Singh, S.M. 1998. Relative efficiency of vermicompost and some other organic manures integrated with chemical fertilizers in cereal based cropping systems. **Haryana J. Agron., 14(1):** 34 – 40.

Sinha, N.P., Prasad, B. and Ghosh, A.B. 1981. Effect of continuous use of fertilizers on yield and nutrient up take in wheat – soybean-potato cropping system. **J. Indian Soc. Soil Sci., 29:** 537.

Sivamurugan, A.P., Balasubramaian, A., Chinnamuthu, C.R. and Ramesh, G. 2000. Effect of NPK levels and seed setting treatments on the quality of oil, nutrient uptake and seed yield of sunflower. **Madras Agric. J., 87(10- 12):** 609 – 612.

Subba Rao, A., Bhonsle, N.S., Singh, M.. and Mishra, M.K. 1993. Optimum and high rate of fertilizer and farmyard manure application on wheat and sorghum (fodder) yields and dynamics of potassium in an alluvial soil. **J. Potassium Res., 9(1):** 22 – 30.

Subrahmaniyan, K., Kalaiselvan, P. and Arulmozhi, N.2000. Nutrient and growth regulators spray for ground nut. **The Hindu Sci. and Tech.,** p.32.

Subudhi, B.P.R. and Singh, P.K. 1980. Residual effect of Azolla application on rice yield. **Intl. Rice Res. Newlett., 5(4):** 24 – 25.

Surekha, J. and Rao, P.A. 1998. Influence of vermicompost and FYM on the incidence and management of pest complex of Bhendi. **J. Res, ANGRAU, 26(2):** 94.

Swatdee, P. and Seetanum, W. 1979. Azolla as nitrogen source for rice in Northeast Thailand. **Intl. Rice Res. Newslett., 4(5):** 24.

Thangaraju, M., Natarajan, K. and Kannaiyan, S. 1992. Evaluation of nitrogen fixing water fern *Azolla microphylla* in comparison with fertilizer nitrogen by ISN technique. **BNF and Biogas Technology**. pp. 67 – 76.

Tulasiram, J., Sambrani, R.M. and Prabhakar, A.S. 1996. Essentiality of Integrated Nutrition for Agriculture. **Kisan World, 23(5):** 47 – 49.

Turkhede, A.B., Choudhari, B.T., Chore, C.N., Kalpande, H.V., Jiotode, D.T. and Kalpande, V.V. 1998. Effect of green manuring with Glyricidia leaves and fertility levels on yield and physico-chemical properties of the soil in low land. **Crop Res., 16(3):** 300 – 303.

Uday, S.B. 1995. Vermiculture Technology, Benefits and Costs. **Kisan World, 22(5):** 41 – 42.

Uday, S.,Bunty, S. and Anil, H. 2001. Organic Farming – An approach for remunerative returns. **Kisan World, 28(12):** 21 – 22.

Vasanthi, D. and Kumaraswamy, K. 1998. Nutrient for forage crop. **The Hindu Sci. and Tech.,** p. 24.

Vasudevan, P. and Rangasamy, P. 1995. Biofertilizerss. **Kisan World, 22(3):** 27 – 28.

Veer, D.M. and Patil, P.L. 1989. A study on effects of Azolla, Blue Green Agae and 'N' on yield Paddy. **Nat. seminar: Biofertilizer Tech. Transfer,** pp.260 – 262.

Venkataramanan, S. and Kannaiyan, S. 1984. Influence of Azolla inoculation and double row planting on rice. Intl. Workshop to assess the potential of Azolla use in Tropical Asia, **NIFTAL, Project, Bangkok, Thailand,** p.11.

Venkitaswamy, R., Lourduraj, A.C., Devasenapathy, P., Sridharan, C.S., Madhiyazhagan, R. and Prabakran, N.K. 1997. Effect of NPK fertilization on coconut hybrid. **Madras Agric. J., 84(10):** 600 – 601.

Watanabe, I. 1985. Summary report of the Azolla programme of the international network on soil fertility and fertilizer evaluation for rice. Intl. Workshop on Azolla use. **Fujian Acad. Sci., Fijian, China.**

Watanabe, I., Craswell, E.T. and App, A.A. 1981. In: Nitrogen Cycling in South East Asia wet monsoonal ecosystem. (ed.) **R. Wetselaar, Aust. Acad. Sci. Canberra.** pp.4 – 17.

Wietholter, S., Siqueira, O.J.F.D.F., Peruzzo, G. and Ren, J.R. 1994. Effect of mineral and organic mineral fertilizers on yields of crops and on soil fertility factors. **Pesquisa Agropecuaria Brasilerira, 29(5):** 713 – 724.

Yadav, D.V. 2000. Nutrient management in sugarcane and sugarcane based cropping systems during 2000 – 2010. **Fertilizer News, 45(4):** 43 – 48.

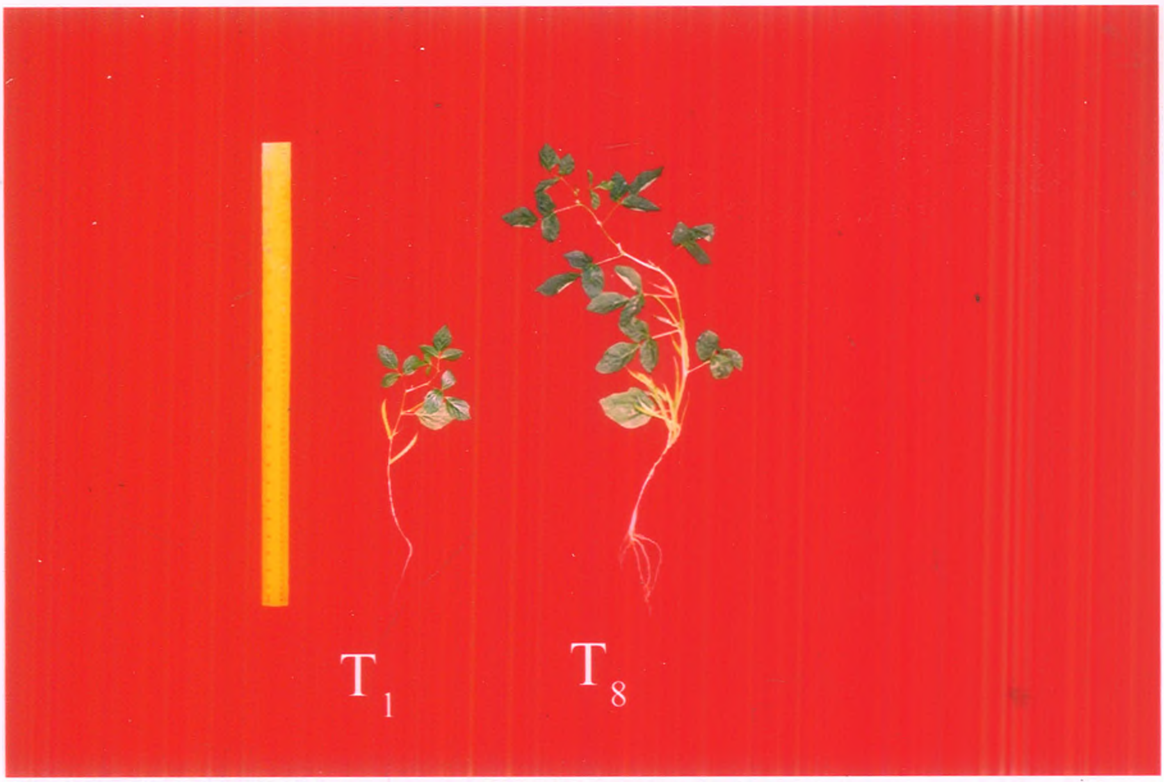
Zaman S.K., Panaullah, G.M., Saleque, M.A. and Bhuiyan, N.I. 1991. The use of dhaincha manuring as a substitute to urea for wetland rice. Progress. **Agric., 2(2):** 15 – 19.

PLATE -1

Influence of treatments on the biometric parameters of cluster bean at 30 DAS

PLATE -2

PLATE -3



Significant influence of T_8 on the biometric and yield parameters of cluster bean at 60 DAS

PLATE -4

Influence of treatments on the biometric and yield parameters of cluster bean at 90 DAS

PLATE -5

Significant influence of T_8 on the biometric and yield parameters of cluster bean at 90 DAS

PLATE -6

List of Abbreviations

LIST OF ABBREVIATIONS USED

CD	-	Cow dung
A	-	Azolla
N	-	Nitrogen
P	-	Phospherous
K	-	Potassium
DAS	-	Day After Sowing
@	-	At the rate of
t/ha^{-1}	-	Ton per hectare