SUSTAINABLE TECHNOLOGY FOR HIGHER PRODUCTIVITY IN MULBERRY SERICULTURE

By
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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**SUSTAINABLE TECHNOLOGY FOR HIGHER PRODUCTIVITY IN MULBERRY SERICULTURE**" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara
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ANILKUMAR, A.S.

CERTIFICATE

Certified that this thesis entitled "SUSTAINABLE TECHNOLOGY FOR HIGHER PRODUCTIVITY IN MULBERRY SERICULTURE" is a record of research work done independently by **Sri. ANILKUMAR, A.S.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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CONTENTS

ABBREVIATIONS

AVP	Azospirillum + Vesicular Arbuscular Mycorrhizae + Phosphorus Solubilising Bacteria	AZO	Azospirillum
BCR	Benefit Cost Ratio	BF	Biofertilizer
CGR	Crop Growth Rate	CPE	Cumulative Pan Evaporation
Cu	Consumptive Use	CWUE	Crop Water Use Efficiency
DMP	Dry Matter Production	ER	Effective Rainfall
F	Recommended Fertilizer Doze	FLP	Fresh Leaf Production
FWUE	Field Water Use Efficiency	GI	Gross Income
GM	Green Manure	HI	Harvest Index
I	Irrigation Levels	kc	Crop Coefficient
KUP	Potassium Uptake	LAI	Leaf Area Index
LDMP	Leaf Dry Matter Production	LML	Leaf Moisture Loss
LN	Leaf Number	LP	Leaf Protein
MAP	Months After Planting	MC	Moisture Conservation
NAR	Net Assimilation Rate	NI	Net Income
NUP	Nitrogen Uptake	PG	Planting Geometry
PSB	Phosphorus Solubilising Bacteria	RDMP	Root Dry Matter Production
RGR	Relative Growth Rate	RSR	Root Shoot Ratio
S	Shade Levels	SDMP	Stem Dry Matter Production
SL	Shoot Length	SLW	Specific Leaf weight
SYI	Sustainable Yield Index	TFLP	Total Fresh Leaf Production
TKUP	Total Potassium Uptake	TLDMP	Total Leaf Dry Matter Production
TLN	Total Leaf Nitrogen	TNUP	Total Nitrogen Uptake
TPUP	Total Phosphorus Uptake	TSDMP	Total Stem Dry Matter Production
TSL	Total Shoot Length	V	Variety
VAM	Vesicular Arbuscular Mycorrhizae		

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

Introduction

INTRODUCTION

Sericulture is an important agrobased labour intensive but non-exhaustive rural industry ideally suited to all developing countries in the tropical belt where unemployment and underemployment continue to be a serious problem. Mulberry sericulture in India employs over six million persons, produces 9600 tons of raw silk per annum and earns foreign exchange of about Rs. 3300 million per annum through the export of silk products.

Silk is increasingly becoming popular in many countries for many reasons. Silk, which is traditionally used to be reserved mainly for evening or occasional wear of women of affluent class, has become a casual wear for use at any time of the day. With innovative product range entering the market, today silk is becoming more popular as a men's wear too.

Silk, being a protein fibre is close to human skin. It can absorb moisture upto 30 % of its weight and make the user more comfortable. Ecologically too, silk consumes very little chemicals by way of pesticides in its production process and thus is more user friendly. It is estimated that our requirement of raw silk will be about 20000 tons per annum by the turn of the century. Export prospects are promising because silk production in Japan which was once a major silk producing country has been declining over the years. There is stagnation in silk output in China, currently the largest producer and exporter of silk. The international situation is favourable for the nation to emerge as the second largest producer and exporter of silk in the world.

Mulberry being the sole food of the silkworm, it is obvious that the quality of mulberry leaf has a dominating influence on the development of worms and the quality of cocoon. Mulberry leaf is the main source of protein for silkworms to biosynthesise the silk. Nearly seventy per cent of the silk is made up of proteins called fibroin and serecin that are directly derived from the proteins of mulberry leaf. Sixty per cent of the cost of cocoon production accounts for raising mulberry, the sole food plant of silkworm. Therefore, the productivity and profitability in sericulture depend mainly on maximisation of leaf yield per unit area at reasonable cost. Eventhough, mulberry is a hardy plant capable of thriving under a variety of agroclimatic conditions current level of leaf production is far below the potential. Lack of economically viable technology for mulberry cultivation under diverse land use systems is the main cause for poor productivity. Indian sericulture is confined to the poor sector of agriculturists for centuries, and is likely to be so for a long time to come. Great emphasis, hence need to be given for the technology for `subsistence farming' than to `affluent farming' for continuing as a sustained industry. Since India is a vast country with complex agroclimate there is wide scope for developing low cost hi-tech production technologies and newer varieties towards sustaining sericulture.

Soil is a vital natural resource the proper use of which greatly determines the capability of life supporting systems and the socio economic development of the people. However, its capacity to produce is limited and the limit to production are set by its intrinsic characteristics, agroecological settings and its use and management. Any land use strategy must consider the question of limited soil resources and sustainability of their productivity. A sustainable agriculture backed up by `green technologies' in an integrated farming system has been considered as a primary and potential pathway for achieving higher productivity in mulberry sericulture.

Integrated plant nutrition system is essential for the maintenance of soil fertility, sustaining increased agricultural productivity and improving farmers profitability. It involves the judicious and efficient use of inorganic fertilizers, organic manures and biofertilizers. Such an approach in sericulture may help for the maintenance of ecological balance and augmentation of biomass production besides bringing cost effectiveness.

Year round production of silkworm cocoons and silk reeling are essential for maximum utilization of infrastructure facilities developed in sericulture. To ensure this, year round availability of quality mulberry leaf is necessary. Mulberry leaf production is often limited by the amount of available soil moisture and it can be substantially increased by supplemental irrigation. Identification of suitable varieties and scheduling of irrigation in addition to development of soil moisture conservation techniques utilizing agricultural wastes may help to ensure the supply of quality leaf throughout the year for hygienic growth of silkworms.

Green manuring may be the most viable alternative to mineral fertilization for sustaining agricultural productivity. It may improve the physical, chemical and biological properties of soils, minimise soil erosion, reduce ground water pollution and regenerate degraded lands. Due to increased biotic pressure and intensive cultivation of land no space is available for the production of green manure. Investigations on *in situ* cultivation and incorporation or *in situ* composting of green manure by changing the geometry of planting keeping the plant population constant under partial shade and open may help to evolve suitable cropping systems with plantation crops and in the homesteads without affecting the productivity of mulberry.

It is in this context that the present project is designed with the objective of developing an efficient nutrient management system involving inorganic fertilizers, organic manures and biofertilizers for irrigated mulberry. It is also intended to estimate the consumptive use of two varieties of mulberry and to assess the effect of different moisture conservation techniques on the productivity and profitability. Modification of the traditional planting pattern of mulberry to accommodate green manure crops under open and partial shade are also attempted. The project also envisages to measure the suitability of the technology generated in terms of sustainable yield index.

Review of Literature

2. REVIEW OF LITERATURE

Mulberry (*Morus alba* L) is an economically important plant and forms the sole food source for silkworm (*Bombyx mori* L.). Nutrient and soil moisture management are the most important factors deciding the quality and yield of mulberry. *In situ* green manuring to this effect can be made possible by adjusting the planting geometry and providing space for accommodating green manures.

The investigation entitled `Sustainable technology for higher productivity in mulberry sericulture' was undertaken with the objective of developing an integrated nutrient management strategy involving organic manures, inorganic fertilizers and microbial inoculants for mulberry grown under irrigated condition. Estimation of consumptive use, crop coefficient and water use efficiency were also attempted besides developing agrotechniques for soil moisture management. In addition to the above, steps were taken for developing techniques for improving organic carbon in mulberry garden for sustainable production.

The relevant literature on the effect of nutrient sources including organic manures inorganic and biofertilizers, irrigation, soil moisture conservation techniques and planting geometry on the growth, yield components, yield and quality of mulberry and cocoon production are reviewed hereunder.

2.1. Nutrient sources

In order to get optimum yield of good quality leaf, nutrients should be provided in adequate amounts through various sources. Mulberry soils have to be continuously replenished through periodical application of organic manures, fertilizers and biofertilizers.

2.1.1. Organic manure

Organic matter content of a soil is intimately related to its productivity because it acts as a storehouse for nutrients, increases exchange capacity, provides energy for microbial activity, increases water holding capacity, improves soil structure, reduces crusting and increases infiltration, reduces effects of compaction and buffers the soil against changes in acidity, alkalinity and salinity (Tisdale *et al.*, 1993). The efficacy of organic manures such as, FYM, compost, oil cakes and green manures have been tested in various crops and cropping systems.

2.1.1. a. Effect of FYM, compost and oil cake on leaf yield and quality

Organic manuring seems to play a predominant role in the production of quality mulberry leaf. Pain (1961) observed that application of FYM or compost at the rate of 30 tons ha^{-1} increased the foliage yield by 75 per cent. He also observed an increase in crude protein, crude fat, sugar, starch, pH and K besides increased silk content and filament length per cocoon. In sandy soil Itto and Maotsuda (1966) observed better growth of mulberry with localized placement of FYM. Application of compost increased the larval survival , cocoon quality and silk yield.

Among the organic sources of nitrogen tried, viz, groundnut cake, castor cake, neem cake and FYM, application of groundnut cake equivalent to 25 kg nitrogen ha^{-1} gave the highest leaf yield as compared to inorganic nitrogen at 25 kg ha^{-1} (Kasiviswanathan and Iyengar, 1970).

The review indicates that organic matter application influences the leaf quality in addition to quantity. Organic matter also enhances the larval survival rate, cocoon and silk yield in addition to increased foliage through increased activity of microorganisms.

2.1.1. b. Green manuring

The value of leguminous green manure crops in improving soil fertility has been recognized since very early times. The benefits credited to them include increase in organic matter content and available plant nutrients and improvement in the microbiological and physical properties of soil. Of these, the role of green manures in supplying plant nutrients, particularly nitrogen is most predominant. The addition of organic matter in the form of green manures greatly influenced the transformation and availability of nitrogen and several other essential plant nutrients through its impact on the chemical and biological properties of soils. On mineralisation green manure released phosphorus to the soil in plant available forms (Bin, 1983; Watanabe, 1984). Application of green manure to soil could stimulate formation of ethylene, which acts as a plant hormone for regulating root growth. Small concentrations of volatile and nonvolatile fatty acids could modify plant growth (Smith, 1976).

Singh *et al.* (1992) stated that decomposition and release of mineral nitrogen from green manures were affected by several factors. These included green manure characteristics (nitrogen content, C:N ratio, lignin content, polyphenol content, and concentration of various other organic compounds), environmental factors (temperature and soil moisture), and management factors (quantity and method of incorporation of green manure and cropping pattern)

Das *et al.* (1990) reported significant increase in mulberry leaf yield due to green manuring with *Dolichos biflorus, Vigna unguiculata* and *Phaseolus aconitifolius* under rainfed condition. Green manuring mulberry with *Dolichos biflorus* resulted in maximum leaf yield with an increase of 16.2 per cent over control. Among the three green manure crops tested, *Phaseolus aconitifolius, Vigna sinensis* and *Dolichos biflorus*, the crop *Phaseolus aconitifolius* recorded maximum leaf yield (Dacayanan, 1986). Green manuring with horse gram and cowpea increased the total leaf nitrogen by 22.2 % and 17.9% respectively, over control (Das *et al.*, 1990).

Green manuring did not influence any of the economic characters of silkworms. Das *et al.* (1990) did not observe any significant improvement in cocoon quality due to green manuring in a bioassay trial with silkworms.

Since mulberry is a perennial crop and bottom pruning is practised every year with the onset of South West Monsoon, there is no competition between the main crop and the intercrop for solar radiation and soil moisture and as such the crop is amenable for *in situ* green manuring. It is evident from the above that green manures are beneficial in improving the physical, chemical and microbiological properties of soils besides increasing the production potential.

2.1.2. Inorganic fertilizers

The importance of minerals in plant nutrition is recognised universally. It is also fully realised that an increase in crop yield per unit area of land depends upon the mineral nutrition because the native soil fertility alone can not be relied upon. In general, the average leaf yield of mulberry in tropical countries is low due to low yielding genotypes, drought, diseases and nutritional constraints. Nutritional disorders occur because being a perennial, mulberry occupies the same impoverished soil year after year with little or no fertilizer application. As a result of crop uptake, large quantities of nutrients are depleted and becomes less available, in turn bringing down the leaf yield and quality.

The growth and development of silkworm larvae, *Bombyx mori,* and the economic characters of cocoons were generally influenced by the nutritional content of mulberry leaves (Krishnaswami *et al.,* 1971). Of the three major elements, viz, nitrogen, phosphorus and potassium, nitrogen is the most important and vital factor for increased production of quality leaves.

2.1.2. a. Effect of nutrients on growth characters

Mulberry responded very well to nutrient application. A progressive increase in growth parameters was observed due to increase in nitrogen from 50 to 150 kg ha^{-1} $year^{-1}$. Nitrogen application @ 150 kg ha^{-1} was found to be sufficient for maximum growth. Higher supply of nitrogen resulted in enhanced growth of shoot and root (Bongale, 1994). Kasiviswanathan *et al.* (1980) revealed that there was an increase in plant height, length of shoot, number of leaves per shoot, weight of leaves per plant due to application of 600 kg nitrogen $hectare^{-1}$ $year^{-1}$ compared to 300 kg.

Different levels of phosphorus had no significant effect on growth parameters (Das *et al.,* 1993).

The beneficial effect of potassium in improving mulberry growth was reported by Shanker and Krishnamurthy (1978).

Anilkumar *et al.* (1994) reported that NPK application @ 130:65:65 kg ha^{-1} significantly increased plant height, number of leaves and branches in mulberry grown as an intercrop in coconut garden under rainfed condition. Meerabai (1997) reported that the highest nutrient level, 300:120:120 kg NPK ha^{-1} $year^{-1}$ recorded highest plant height, plant spread, number of leaves and LAI both under open and the partial shade of coconut.

2.1.2. b. Effect of nutrients on leaf yield

Requirement of nitrogen for mulberry varied from 50 to 500 kg ha^{-1} $year^{-1}$ depending on the biomass productivity of 5000 to 50000 kg ha^{-1} $year^{-1}$ (Bongale, 1993).

Kasiviswanathan and Iyengar (1965) revealed that application of nitrogen up to 100 kg ha^{-1} increased leaf yield significantly when compared to no application. Further response to nitrogen application increased with moisture availability. Split application of 200 kg nitrogen per hectare significantly increased the leaf yield in mulberry over 100 kg (Kasiviswanathan and Iyengar, 1970).

Observations on the residual effect of nitrogen showed that for sustained productivity 300 kg N ha^{-1} was needed every year (Kasiviswanathan *et al.*, 1979). Increasing levels of nitrogen progressively increased the leaf yield up to a maximum level of 400 kg ha^{-1} $year^{-1}$ and there was an increase of 54 % in the leaf yield with the application of 400 kg nitrogen ha^{-1} $year^{-1}$. Application of 400 kg nitrogen ha^{-1} $year^{-1}$ gave an yield of 26.45 tons as against 17.18 tons ha^{-1} $year^{-1}$ in control plots (Fotedar *et al.*, 1988). Sengupta *et al.* (1972) reported 19 and 36 per cent higher yield due to application of 600 and 900 kg N ha^{-1} $year^{-1}$ when compared to application of 300 kg N ha^{-1} $year^{-1}$. Though Kasiviswanathan and Venkataraman (1973) obtained increased yield up to 900 kg N ha^{-1} $year^{-1}$, increase in foliage yield beyond 600 kg N ha^{-1} $year^{-1}$ was not significant.

Kasiviswanathan and Iyengar (1968) reported no significant difference in leaf yield among different forms of nitrogenous fertilizers, viz, ammonium sulphate, ammonium sulphate nitrate, calcium ammonium nitrate and urea.

Shankar and Krishnamurthy (1978) and Rao (1982) observed that foliage yield of mulberry could be increased with the application of phosphorus and potassium fertilizers in addition to nitrogen.

Potassium content in leaf was found to increase with increasing levels of potassium fertilizer application. Significantly higher levels of potassium (2.43%) was recorded at 300 kg K application while it was the lowest (1.68%) in the treatment without potassium fertilizer (Leina, 1991). Roso (1942) observed no response of mulberry to varying levels of potassium. Kasiviswanathan and Iyengar (1966) reported that the application of P and K had no significant effect on leaf yield.

Leaf yield was found to be influenced by nutrient levels. Application of NPK @ 130:65:65 kg ha^{-1} year^{-1} was found necessary for maximum leaf production of intercropped mulberry in coconut garden under rainfed condition (Anilkumar *et al.*, 1994). Meerabai (1997) revealed the significance of yield attributing characters in mulberry both under open and coconut garden. The highest nutrient level, 300:120:120 kg N ha^{-1} year^{-1} recorded highest leaf and total dry matter.

2.1.2. c. Effect of nutrients on leaf quality

Fresh green and healthy leaves of softer texture are generally preferred by the silkworm which usually avoids the coarse, hairy and dry or withered leaves. However, leaf quality must confirm to the stage-wise requirements of the silkworms (Benchamin and Nagaraj, 1987). Feeding of diseased leaves lead to unequal development of larvae and increased larval duration with deleterious effects on cocoon characters which may be due to poor nutritive value of diseased leaves, which have reduced moisture, crude protein and sugar contents (Rao *et al.*, 1981 ; Sundareswaran, *et al.*, 1988).

Moisture and protein are the important biochemical constituents influencing the food value of leaves. For young larvae, leaves containing a higher percentage of moisture and protein are desirable, while for late age larvae, those having comparatively low moisture and high protein contents are preferred (Ullal and Narasimhanna, 1987). Deficiency of certain nutrients or an imbalance of nutrients in the diet affects the digestibility and metabolic activity of larvae (Itto, 1972). Hence, silkworm larvae should be fed on leaves containing balanced nutrient components.

Nitrogen had the greatest influence on the quality of mulberry leaves. Higher nitrogen increased the protein and moisture contents of leaves and decreased the percentage of sugars, phosphoric acid, potash and calcium (Ushiodoa 1954). Ali *et al.* (1994) reported that urea spray @ 3% increased the nitrogen and protein content of mulberry leaves. Sengupta *et al.* (1972) reported that nitrogen fertilization increased protein synthesis in mulberry leaves. Though nitrogen application increased the crude protein content of leaves from 16.6 to 21.5%, moisture, starch, crude fibre and mineral content remained unaffected (Pain, 1965). Too high dozes of nitrogen without phosphorus and potassium deteriorated the feed value of mulberry (Ides and Okada, 1963 ; Benchamin and Jolly 1985).

Rao (1982) observed that the application of potash along with nitrogen to mulberry gave a characteristic smell to the leaves and improved the feed value. Application of higher dozes of nitrogen in combination with phosphorus and potassium increased the crude protein content from 15 to 23.5% while other constituents in the leaf remained unchanged (Anon., 1976). There was considerable increase in leaf quality when nitrogen, phosphorus and potassium were applied in combination (Sidhu *et al.*, 1969). The relation between soil nutrient status and leaf composition was highly positive with regard to N, K, S and Zn. Though not significant negative correlation existed between available soil Fe and leaf Fe (Rupa *et al.*, 1993).

Nutrient content of mulberry leaves greatly influenced the growth and development of silkworm larvae and also the economic characters of cocoon. In general, leaves grown under nitrogen fertilization and fed to worms did not show any harmful effect on cocoon crop (Narayana *et al.*, 1966). Higher nitrogen application to mulberry improved larval weight, cocoon weight, shell weight and absolute silk content.

Silkworm fed on the non-phosphorus fertilized mulberry leaves did not make cocoons (Kurose, 1967). Ides (1966) demonstrated that P and K content of mulberry leaves influenced the silkworm growth significantly. P and K increased the body weight of silkworms and significantly enhanced cocoon production. It is emphasised that the supply of these nutrients to mulberry plants in appropriate ratio is very important for the production of good quality mulberry leaves for the good growth of silkworms and cocoon production (Takagishi, 1967).

The effect of potassium was found to be pronounced when compared to phosphate application. Improvement in single cocoon weight, shell weight, filament length, denier and cocoon yield was observed with potash fertilization (Sidhu *et al.,* 1969). Bhat (1968) demonstrated that the silkworm larvae fed with leaves deficient in minerals showed restricted growth and the extent of suppression increased with the age of larvae. Leaves deficient in N, K and S caused maximum retardation in weight gain which indicated the relative importance of these elements.

Chemical composition of mulberry leaf was significantly influenced by the available nutrient status. Leaf moisture and protein are the important biochemical constituents influencing the food value of mulberry. Available evidences indicate that leaf moisture and protein could be improved by increasing the levels of nitrogen. A positive correlation between leaf composition and rearing performance also exists. In general, optimum doze of nitrogen, phosphorus and potassium is essential for improving leaf quality and rearing performance.

2.1.3. Combined application of organic and inorganic fertilizers

Addition of organic materials improves the physical properties of soil. Regular addition of organic manure improves the organic carbon, structural status and water retention capacity of soil. The beneficial effects of organic manure alone or in combination with fertilizers in increasing the percentage of water stable aggregates and there by improving the soil structure have also been observed by several workers. The long term fertilizer experiments have shown that neither the organic manure nor the mineral fertilizer can sustain high productivity under intensive mulberry cultivation, where the nutrient turn over in the soil - plant system is quite high. Organic manure alone may suffice for lower nutrient demand under low to medium intensity cropping but combination of organic manures and inorganic fertilizers becomes imperative to sustain productivity of soil and thereby sustaining a high mulberry yield (Bose and Mukherjee, 1993).

Ray *et al.* (1973) opined that a combination of organic and inorganic nutrients enhanced the quality of leaves in terms of moisture, crude protein and sugar. They observed a good response to application of FYM at 20 t ha^{-1} which was further benefitted by additional doze of 336:180:120 kg N, P_2O_5 and K_2O respectively. Jolly (1986) suggested that under irrigated condition combined application of 20 tons of FYM as basal doze and 255 : 255: 255 kg N, P_2O_5 and K_2O ha^{-1} year^{-1} was better for harvesting higher quality leaves required for chawki worms.

2.1.4. Biofertilizers

In recent years, biofertilizers have been emerged as a supplement to mineral fertilizers and hold a promise to improve the yield of crops. The biofertilizers were found to have positive contribution to soil fertility resulting in an increase in crop yield without causing any type of environmental, water or soil hazards. Out of many microorganisms which are identified and included in the list of biofertilizers, Azospirillum, PSB and VAM have a significant role in mulberry nutrition.

Soil microorganisms are more abundant in the region of contact between root and soil *ie.,* the rhizosphere than in soil beyond the influence of plant roots. Rhizosphere population and activity are increased in this zone because of the availability of carbonaceous and nitrogenous materials arising from sloughed off root hairs or epidermal cells. The quantitative and qualitative nature of the root surface-rhizosphere population is determined to a large extent by the plant root exudates which in turn depend on root metabolism. Root metabolism is influenced by a number of factors such as physical and chemical properties of soil, crop growth stage etc. The concept of controlled rhizosphere approach is that the root surface-rhizosphere microflora can be manipulated to the nutritional advantage of the host plant. Rhizosphere is controlled in such a way that immobilisation is reduced to the minimum. It is also possible to alter the chemical nature of the plant exudates through foliar application of chemical compounds including fertilizers like urea (Anilkumar and Tajuddin, 1996). It may be possible to improve the efficiency of single or combined application of biofertilizers with inorganic fertilizers and green leaf manure.

2.1.4.1. Azospirillum

The leaf being rich in protein, mulberry absorbs large quantities of nitrogen from the soils. However, owing to high cost, farmers apply only a part of the required quantity of fertilizers. In addition, organic manures are in short supply. Further, the high temperature of the atmosphere and increased exposure of soil to hot sun accelerates the loss of nitrogen both from fertilizers and manures applied to the soil. This considerably reduces the nitrogen use efficiency of mulberry cropping systems. Because of these factors mulberry is largely cultivated under nitrogen stress conditions. This environment is infact favourable for biological nitrogen fixation. Thus there is a wide scope for efficient utilization of nitrogen fixing bacterial systems in mulberry cultivation. Among the different groups of nitrogen fixing bacteria, the species of Azospirillum are found to be effective in supplementing the nitrogen requirement of mulberry.

2.1.4.1. a. Effect of Azospirillum on growth characters

Santhanakrishnan and Oblisami (1980) reported the stimulatory effect of Azospirillum on mulberry. Inoculation with Azospirillum considerably increased the number of roots, length of roots and root weight. The percentage of bud development, number of leaves and leaf weight were also increased. Mulberry variety K-2 responded better to Azospirillum which indicated the potential of Azospirillum for the early establishment of mulberry garden under low cost technology (Santhanakrishnan *et al.*, 1983).

Several workers reported better root development due to application of Azospirillum (Dobereiner and Day, 1975 ; Barea and Brown, 1974 and Tien *et al.*, 1979). *Root elongation was improved in a number of crops* by Azospirillum both under green house and field conditions. Consequent to application, Azospirillum adsorbs to and proliferates on the roots and apparently invades root internal parts (Patriquin *et al.*, 1983). Inside the roots it promotes root hair development and branching (Kapulnik *et al.*, 1983). Azospirillum produced plant growth hormones in pure culture which in turn are responsible for growth response. Plant growth responses observed consequent to *inoculation of* Azospirillum was due to nitrogen fixation and hormone production by the bacteria (Tien *et al.*, 1979 ; Hubbel *et al.*, 1979).

Azospirillum had no significant influence on growth characters in mulberry but there was an increasing trend in plant height, plant spread, number of leaves and leaf area index (Meerabai, 1997). Chunchunkumar *et al.* (1998) opined that the inconsistency in yield responses to inoculation was probably the result of ecological and environmental factors. The success of inoculation depends on many factors, including the choice of the carrier and inoculum, the ability of the bacterium to establish itself and to compete with the native microflora, favourable soil chemical and physical conditions such as pH, aeration, available nutrients including nitrogen, climatic conditions and agricultural practices.

2.1.4. 1.b. Effect of Azospirillum on leaf yield

Yadav and Kumar (1991) reported higher foliage yield in mulberry subjected to Azospirillum inoculation. He observed an yield increase of 13.2% due to combined effect of Azospirillum inoculation with reduced levels of nitrogen rather than inoculation alone. The increase in yield was due to the possible release of growth substances by Azospirillum in the rhizosphere of mulberry.

With respect to foliage yield, mulberry inoculated with Azospirillum @ 20 kg ha^{-1} and supplemented with 150 kg N ha^{-1} was on par with 300 kg nitrogen application (Yadav and Kumar, 1989). This indicated that Azospirillum increased the plant nitrogen uptake in mulberry without affecting the leaf and nitrogen yield in leaves. Reddy *et al.* (1995) observed a 25% increase in leaf yield due to Azospirillum application. However, Meerabai (1997) observed only 10 to 12 increase in leaf yield of mulberry grown under coconut garden and open conditions due to Azospirillum inoculation. She also revealed that yield attributing characters like leaf dry matter, total dry matter and biomass production were highest in Azospirillum inoculated plants in both the situations.

2.1.4. 1.c. Effect of Azospirillum on leaf quality

Azospirillum inoculation improved the economic characters of silkworm and silk characters. The larval characters, viz, length, breadth, pupal weight, shell weight, shell percentage and silk characters, viz, silk filament length and weight of silk were improved on feeding leaves from Azospirillum inoculated plants (Nagarajan *et al.,* 1986). Azospirillum increased the larval weight and single cocoon weight in bioassay with silkworm (Meerabai, 1997).

2.1.4.2. Phosphorus Solubilising Bacteria

Phosphorus is one of the major nutrients taking up second position next to nitrogen in the plant nutrient chart. It plays a major role in the balanced nutrition of plants to increase crop productivity. Many of the cultivated soils contain high amount of total phosphorus but availability is limited due to insoluble phosphorus forms. Unless they become water soluble, there is no use for the crop plants. Many bacteria are capable of solubilising insoluble soil phosphorus of which the role played by Phosphorus solubilising Bacteria *(Bacillus megatherium var phosphaticum)* is significant (Sen and Paul, 1957). Basavana (1980) reported the significance of soil microorganisms in supplying the growing plants with available phosphorus.

The phosphate solubilising microorganisms increased the availability of phosphorus status in the soil by bringing about favourable changes in the soil reaction by producing organic acids. While elucidating the microbial mineralisation of organic phosphate in rhizosphere soil of wheat by phosphorus solubilising bacteria Rasal *et al.* (1988) reported that inorganic phosphate can be dissolved by bacterial organic acids like lactic, glycolic, oxalic and citric acids.

2.1.4.2. a. Effect of phosphorus solubilising bacteria (PSB) on the performance of mulberry

Radha *et al.* (1980) studied the effect of phosphorus deficiency on mulberry plant under pot culture with Kanva-2 mulberry variety. Plant height was reduced in phosphorus deficient nutrient solution. Deficiency in phosphorus resulted in lowering of almost all other mineral contents in the leaves.

Application of rock phosphate at the rate of 120 kg P_2O_5 ha^{-1} with PSB enhanced the morphological attributes, viz, plant height, number of leaves per plant and internodal length, leaf yield and leaf moisture and crude protein content (Jotheeswari, 1997).

Beneficial influence of artificial inoculation with PSB has been observed for different crops under diverse agroclimatic conditions. The increase in crop yield has been attributed to increased soluble phosphate nutrition to plants, synthesis of growth promoting substances and production of antibiotic like compounds.

2.1.4.3. Vesicular Arbuscular Mycorrhizae

VA mycorrhizae are well known for their ability to absorb nutrients from the soil, particularly phosphorus. Their impact in tropical agriculture will be greater than in temperate regions for the reason that in tropics phosphorus deficient soils are more wide spread.

Population of bacteria, actinomycetes, fungi and other microorganisms in the rhizosphere of mycorrhizal roots are distinctly different from those of non-mycorrhizal roots. Foster and Marks (1967) first used the term `mycorrhizosphere' to distinguish the differences in rhizosphere organisms associated with mycorrhizal root from those associated with non-mycorrhizal roots. Quantitative and qualitative differences between mycorrhizal and non-mycorrhizal roots with respect to bacteria and fungi were reported by Neal *et al.*, 1964. Bagyaraj and Menge (1978) showed that the Vesicular - arbuscular mycorrhizal fungus *Glomus fasiculatus* increased populations of Azotobacter and general rhizosphere bacteria and actinomycetes above those around non-mycorrhizal roots. Moose (1976) revealed that mycorrhizal fungi increased nodulation in legumes, especially in low phosphate soils. Daft and Giahmi (1976) demonstrated that mycorrhizal fungi in plant roots increased plant growth, seed yield, nodule number and weight and acetylene reduction rates over plants that had no mycorrhizal fungus present. They further demonstrated that most but not all this increase was due to increase in phosphorus levels in mycorrhizal plants. Several hypothesis have been proposed to explain the improved nutrition of mycorrhizal plants. One hypothesis is that the mycorrhizal root surface is a more efficient nutrient absorber, that is physiological changes due to infection occur in the infected root causing it to more readily absorb soil nutrients. A second hypothesis is that mycorrhizal root systems are able to use nutrient sources that are unavailable or less available to non -mycorrhizal roots. A third is that the soil network of hyphae is able to absorb nutrients from a larger soil volume and translocate them to the infected roots. A fourth possibility is that mycorrhizal root segments remain functional as nutrient absorbers longer than do non-mycorrhizal segments. The last hypothesis suggests that mycorrhizal infection alters root morphology to enable the entire root system to be larger and more efficient for nutrient absorption (Safir and Nelson, 1981).

It is generally believed that the development of an extensive network of hyphae by the VAM in the soil surrounding the root, together with the capacity of the hyphae for nutrient absorption and transport to the cortical root cells results in modification of the nutrient uptake properties of a root system. VAM play a significant role in nutrient cycling in ecosystem. The external mycelium extends several centimetres from the root surface and it bypasses the depletion zone surrounding the root and exploits soil microhabitats beyond the nutrient depleted area where rootlets or root hairs cannot thrive. VAM have greater exploring ability than the root. Anilkumar and Tajuddin (1996) opined that VAM inoculation helped mulberry in several ways and it could be included in integrated nitrogen management.

2.1.4.3.a. Effect of VAM on growth characters

Kandasamy *et al.* (1986) reported that all the four varieties of mulberry, viz, S-41, MR-2, S-54, and Kanva-2 recorded enhanced shoot and root length due to VAM infection. Maximum per cent VAM infection was observed in the roots of S-54. Inoculation of VAM either individually or in combination with Azospirillum enhanced the shoot and root length, number of leaves and the growth of plants (Kumutha *et al.*, 1993).

Ambika *et al.* (1994) isolated five genera of VA mycorrhizae (*Glomus, Acaulospora, Sclerocystis, Gigaspora and Scutellispora)* from the rhizosphere soil of twenty five mulberry genotypes. Though the root samples of all the genotypes showed the presence of vesicles and arbuscules, there was no significant correlation between VAM colonisation and growth. Das *et al.* (1995) revealed that the inoculation of nursery beds with VA mycorrhiza increased the growth, development and survival of mulberry saplings in comparison to uninoculated control.

2.1.4.3. b. Effect of VAM on leaf yield

Kumutha *et al.* (1993) reported that the combined inoculation of VAM with diazotropic Azospirillum yielded more mulberry leaf biomass with high nutrient level than inoculation of individual organisms.

2.1.4.3.c. Effect of VAM on leaf quality

Mycorrhizal inoculation enhanced the nitrogen and phosphorus levels of the leaves of mulberry varieties (Kandasamy *et al.*, 1986). Mulberry mycorrhizal association resulted in mobilisation, translocation and supply of phosphorus (Thiripurasundari and Vivekanandan, 1994). Ambika *et al.* (1994) reported increased uptake of leaf nitrogen and phosphorus due to natural VAM association in mulberry. Das *et al.* (1995) revealed an increase in nitrogen, phosphorus and potassium contents in leaf of VAM inoculated mulberry saplings in nursery over uninoculated.

2.1.4.4. Interaction of beneficial microorganisms

Biological nitrogen fixation depends appreciably on the available form of phosphorus. The nitrogen fixing microorganisms like Azotobacter, Azospirillum and Rhizobia are more benefitted when applied along with PSB. There are several reports about the synergistic effect of VAM on other beneficial microorganisms.

2.1.4.4. a. Dual inoculation of Azospirillum and VAM

Nagarajan *et al.* (1987) observed increase in plant height, shoot biomass and leaf weight due to combined inoculation of Azospirillum and VAM. It is reported that growth substances produced by Azospirillum are continuously released from root surfaces into the rhizosphere where Azospirillum grows with photosynthates supplied by the host plant. The growth regulators might have enhanced the growth of root (Thimann, 1972).

Azospirillum inoculation influenced VAM infection of mulberry roots. The growth hormones synthesised by Azospirillum interacted with VAM infection and thereby caused better growth and development of mulberry (Harley, 1989). Dual inoculation enhanced the shoot and root growth, number of leaves and growth of plants. Development of an extensive root system might have favoured the VAM colonisation (Kumutha *et al.,* 1993).

2.1.4.4. b. Interaction of PSB with other bacteria

Biological nitrogen fixation depends appreciably on the available form of phosphorus. The nitrogen fixing microorganisms like *Azotobacter, Azospirillum* and *Rhizobium* are more benefitted when applied along with PSB.

Kuberanarayanan (1995) reported increase in mulberry plant height and yield due to the combined inoculation of Azospirillum and PSB at reduced levels of nitrogen and phosphorus application. The number of mulberry leaves and leaf area were enhanced by 21 and 43%, respectively. Maximum effective rate of rearing to the extent of 98 per cent was obtained due to Azotobacter and PSB inoculation. Balasubramanian *et al.* (1992) reported that the combined inoculation of Azospirillum and PSB enhanced the leaf yield by 7.5 per cent over no inoculation.

2.1.4.4.c. Biological interactions of VAM fungi

Of the various microorganisms colonizing the rhizosphere, VAM fungi occupy an unique ecological position as they are partly inside and partly outside the host. The tripartite association of plants,VAM fungi and nitrogen fixing bacteria has been well established. Nearly 25 genera of free living bacteria can fix atmospheric nitrogen. Species of *Azotobacter, Beijerinkia, Derxia, Clostridium* and *Azospirillum* are well known among these. Bagyaraj and Menge (1978) studied the interaction between *Azotobacter chroococcum* and the VAM fungus *Glomus fasciculatum* in tomato and found a synergistic effect on plant growth. Mycorrhizal colonisation increased the *A. chroococcum* population in the rhizosphere which was maintained at a high level for a longer time and *A. chroococcum* enhanced colonization and spore production in the presence of mycorrhizal fungus. The beneficial effect on plant growth from free-living nitrogen fixing organisms was mainly due to hormone production rather than, or in addition to, nitrogen fixation.

Bagyaraj (1984) and Linderman (1988) revealed that PSB survived for a longer period in the rhizosphere of mycorrhizal roots. The PSB rendered more P soluble, while VAM enhanced P uptake. Thus with combined inoculation there was a synergistic effect on P supply and consequent plant growth. PSB also produced hormones and vitamins. The hormones and vitamins synthesised by these organisms might have contributed significantly to VAM development and plant growth.

2.2. Varietal reaction

Indian sericulture is confined to the poor sector of agriculturists for centuries, and is likely to be so for a very long time to come. Greater emphasis hence, need to be given to the technology for `subsistence farming' than to `affluent farming' for purpose of attaining a sustained industry, while the reverse will be true for purpose of developing the industry in the context of international marketing. India being a vast country with a complex agroclimate, presents wide scope for having a number of mulberry varieties for development of sericulture in different parts.

2.2.1. Management practices and yield potentials

Mulberry cultivation in China is characterised by high input management. Rainfall and application of organic manure, fertilizer and irrigation are of very high order in China resulting in high yields of upto 60 tons ha^{-1} year^{-1} of high quality leaf (Kasiviswanathan, 1988). This is no way comparable to Indian sericulture which is a low input system resulting in poor leaf yields of the order of 5 to 20 tons ha^{-1} year^{-1} of low quality leaf.

2.2.2. Yield potentials of Indian mulberry varieties

Local varieties under irrigated condition could yield upto 25000 kg leaf under optimum conditions though the realisable yield under normal field condition was around 12000 to 15000 kg ha^{-1}. Similarly, Kanva-2 could yield upto 30000 to 35000 kg leaf ha^{-1} year^{-1} under optimum levels, while its actual yield was only around 15000 to 20000 kg ha^{-1} in the field. The recently evolved variety S-54 with an yield potential of 40000 and 60000 kg ha^{-1} under optimum and high input levels, respectively were comparable to those cultivated in southern China (Sengupta and Dandin, 1989).

2.2.3. Nutritive value and germplasm assessment

Eventhough attempts made to evaluate the exotic and Indian varieties are scanty, available information indicates the following.

1. Among eight mulberry varieties viz, K-2, S-54, C-1, MR-2, Kitchili, Roso, Japan and Kosen studied by biochemical analysis and silkworm assay, MR-2, C-1, S-54, Kitchili and Roso were preferable in the order of merit for silkworm rearing in Tamil Nadu (Periasami, 1986).

2. Among the four mulberry varieties viz, K-2, S-54, Kosen and LM-2 tested under Marathwada conditions, S-54 showed better performance with different characters such as larval duration, larval weight, cocoon weight and cocoon yield (Tayade and Jawale, 1984).

3. Evaluation of eight mulberry varieties viz, K-2, Mysore local, S-54, Roso, Kosen, MR-2, C-1 and Japan indicated overall order of merit as MR-2 > S-54 > C-1 > Roso > K-2 > Mysore Local indicating the superiority of MR-2 and S-54 varieties over others with respect to leaf yield (Periasami, 1986).

2.3. Irrigation

Mulberry leaf production is often limited by the amount of available soil moisture and it can be substantially increased by supplemental irrigation. Of all the inputs in mulberry cultivation, irrigation is known to bear the highest correlation with leaf production. Irrigation interacted remarkably with every other input (Rangaswamy and Jolly, 1991). Jolly (1987) recommended a general irrigation schedule for mulberry grown under ridge and furrow system. Irrigation with 1.5 to 2.0 acre inches of water at 10 to 15 days interval for loamy and clayey soils was found to be beneficial.

Ullal and Narasimhanna (1987) worked out the evapo-transpiration loss in mulberry to about 4 to 5 mm per day under tropical conditions and recommended irrigation to ensure maximum production of mulberry leaf.

The frequency of irrigation varied, depending on the growth stage of the plant, soil type and other agroclimatic conditions. Ganga and Chetty (1997) recommended an irrigation frequency of 8 - 10 days for sandy soils and 15 days for clayey soil. They showed the need for more frequent irrigation for young plants than old ones.

2.3.1. Leaf temperature and plant water stress

Leaf temperature status is an indirect measure of plant water stress (Ides *et al.*, 1978). When plants are well supplied with water, transpiration would be at the potential rate and the leaves will be relatively cool. They also observed a declining trend in transpiration during moisture deficit situation and the concomitant increase in leaf temperature which led to the reduction in photosynthesis and consequent decline of total biomass production. Decreasing soil moisture resulted in reduced plant water status and stomatal conductance leading to elevated leaf temperature (Mtui *et al.*, 1981).

2.4. Soil moisture conservation techniques

Appropriate soil moisture conservation techniques help to reduce tillage operations, reduce weed growth, slow down soil evaporation, increase infiltration rate of water into the soil, regulate soil temperature, induce better root growth , enhance nutrient availability and increase the organic matter content of soil. Crop residues either used for mulching or incorporation increased the infiltration rate besides reducing soil evaporation (Gupta, 1975). Lal (1972) reported the beneficial effects of mulches in improving the water conservation characteristics of soils. Mulched plots had a higher soil moisture content throughout the growing season compared to plots under no mulch for both 0 - 10 and 10 - 20 cm depth. Mulching indirectly influenced the water holding capacity and moisture release characters of soil. Various byproducts of crops can be effectively used for soil moisture conservation.

2.4.1. Coir pith

Coir pith, a by-product of coir industry is one of the major industrial wastes of agricultural importance.

Coir pith has a surface area of 290 m^2 per gram and is a lignocellulosic material which binds fibres (Idiculla, 1983). It has low bulk density of 0.1525 g cc^{-1}, low particle density of 0.49 g cc^{-1}, low thermal conductivity and a porosity of 76.77 per cent. It can absorb eight times its weight of water and release it slowly. Incorporation of two per cent by weight of pith with sandy soil, resulted in 40 per cent increase in water holding capacity. Coir pith with about 30 per cent carbon and a C:N ratio of 112:1 which is presently available in abundance is a good source of carbon especially for tropical climates (Joseph, 1995).

Ramaswamy and Sreeramulu (1983) reported its suitability in rain water conservation and increasing yield. Mayalagu *et al.* (1983) and Nagarajan *et al.* (1987) recorded increased yield of crop plants by pith application. Gopinathan (1996) studied the rain water conservation capacity of coir pith and recommended it for vertical mulching. Application of coir dust at the rate of 20 t ha^{-1} improved water retension capacity of the porous and open textured sandy soil (Lokanathan and Lakshminarasimhan, 1979). Mayalagu *et al.* (1983) reported that incorporation of coir pith might have reduced the bulk density and increased the infiltration rate thus improving rainfall entry and retension in soil. Gopinathan (1995) concluded that vertical mulching with coirpith in trenches across the slope increased the *in situ* rain water harvest and reduced the run off up to 90 per cent over the control. The absorption trenches treated with coirpith significantly extended the moisture availability to banana crop than those treated with municipal solid waste and farm waste.

According to Raghothama (1981) paddy husk and coir dust were most effective in conserving soil moisture and reducing the number of irrigations required for cardamom. Usefulness of coir pith as a moisture conserving agent in rainfed agriculture has been reported by Ramaswamy and Kothandaraman (1985) and Veerabadran (1991). The moisture content of the subsoil upto 60 cm depth was consistently higher in the coir waste mulch treatment. A 40 per cent increase in the water holding capacity of the soil due to coir pith addition was also reported.

Water holding capacity of cinnamon lands of Srilanka was increased in direct proportion to the amount of coir pith incorporated into the soil (Santhirasegaram, 1965). Liyange *et al.* (1993) reported the beneficial effects of coir dust in coconut gardens. Maximum benefit was obtained when coir dust was buried in layers of 8 cm thickness alternated with 5 cm thick soil layers.

2.4.2. Coconut husk

Coconut husk is commercially utilized for coir manufacture. In major coconut producing countries the husk is available in large quantities which can be put to alternate uses.

Experimental results indicated that husk burial in coconut gardens raised under unirrigated conditions and subject to drought, is beneficial to the palms and the effects lasted for about five to six years. Husks acted as a water reservoir in the soil and also supplied small amounts of potash present in them. A fully soaked husk was able to retain about six to eight times its weight of water (Thampan, 1982).

2.4.3. Silkworm litter

The main product of silkworm rearing is cocoon. However, there are many wastes and by-products in mulberry sericulture which can be utilized for sustainable leaf production. Majumdar (1997) quantified silkworm litter production and waste accumulation in silkworm industry which could be utilized as manure. A larval population of 1000 require about 42 kg mulberry leaf of which 22.5 kg is ingested and the remaining 19.5 kg is wasted. Though 22.5 kg leaf is consumed by silkworms about 13 kg is excreted as silkworm litter which can be used for recycling. Silkworm litter contains 12.2 per cent moisture, 1.4 per cent nitrogen, 0.4 per cent phosphorus, 0.8 per cent potassium, 2.6 per cent crude fat, 19.8 per cent crude fibre and growth hormone.

2.5. Planting Geometry

High plant density brings out certain modifications in the growth of plants. Plant height increases with increase in plant population due to competition for light. Sometimes it may happen that moderate increase in plant population may not increase but decrease plant height due to competition for water and nutrients but not for light. Increase in plant height due to higher plant population is advantageous for better light interception due to exposure of individual leaves at wider vertical interval. Another adaptation of dense plant stands is reduction in leaf thickness. Leaf orientation is also altered due to population pressure. The leaves are erect, narrow and are arranged at larger vertical intervals under high plant densities. This is a desirable architecture to intercept maximum light. Dry matter production per unit area increases with increase in plant population upto a limit when the reduction in the growth of a plant is more than compensated by increase in the number of plants per unit area.

Optimum plant population is necessary to obtain maximum yield. It depends on the size of plant, elasticity, foraging area, nature of the plant, capacity to reach optimum leaf area at an early date and spacing. Reddy and Reddi (1997) opined that optimum plant population for any crop varies considerably due to environment under which it is grown. Sustainable utilization of resources is possible only when the plant population exercises maximum pressure on all the production factors.

Mulberry planted at high density provided greater vegetative growth and leaf yield when inputs were not limited (Kasiviswanathan *et al.,* 1977). However, wider spacing was found better with respect to carrying out intercultural operations (Choudhury *et al.*, 1989).

2.5.a. Effect of planting geometry on growth characters

Wider spacing, 120 x 90 cm significantly increased the height, length of leaf bearing shoots, number of shoots per plant and number of leaves per plant in mulberry (Das *et al.,* 1993). Under closer spacing number of branches per plant and average length of plant decreased, the number of shorter branch : normal branch ratio increased, length and width of leaf decreased sharply and chlorosis in lower part of the branch occurred heavily (Kuno,1979 and Lee *et al.,* 1994).

Kasiviswanathan *et al.* (1977 and 1979) reported greater vegetative growth at higher plant density when inputs were not limited. With increase in plant density the number of shoots per unit area increased (Kikuchi, 1980). Plant height and number of branches per plant increased at a plant density of 27800 plants hectare^{-1} (Das and Krishnaswami, 1969). Leaf yield of mulberry was very much governed by the height and the number of branches per plant under 60 x 60 cm spacing. However, Sarkar *et al.*, (1987) gave a different picture possibly due to closer spacing in which plants would compete for light and tend to grow tall due to crowding. He further stated that increasing internodal distance negatively correlated with leaf yield could have resulted in a non-significant correlation of plant height with leaf yield.

Krishnaswami *et al.* (1970) reported that a spacing of 60 x 90 cm was better than 90 x 90 cm. A higher plant density at 30 x 10 cm was found favourable for repeated bottom prunings in mulberry when compared to a wider spacing of 90 x 90 cm (Kasiviswanathan and Krishnaswami 1979).

Krishnaswamy *et al.* (1970) reported that a spacing of 60 x 90 cm was better than 90 x 90 cm. Kasiviswanathan and Krishnaswami (1979) suggested that shoot pruning could be effectively employed in high density planting under 30 x 10 cm spacing than wider spacing of 90 x 90 cm. Meerabai (1997) reported that spacing had no significant influence on the growth characters like plant height, plant spread and number of leaves of mulberry grown as an intercrop in coconut garden and sole crop under open condition. However, intercropped mulberry recorded higher plant height compared to open. Leaf area index was more in closely spaced plants at 60 x 60 cm spacing than 90 x 90 cm under both the situations.

2.5.b. Effect of planting geometry on leaf yield

Das *et al.* (1993) observed that wider spacing of 120 x 90 cm did not increase the leaf yield over 90 x 90 cm due to significant reduction in plant density. Choudhuri *et al.* (1991) recommended a spacing of 60 x 60 cm with step up method of shoot harvest for maximising leaf yield in mulberry under irrigated condition. Further widening of spacing over 60 x 60 cm resulted in sharp decline in leaf production per unit area. Higher leaf yield was observed when mulberry was planted at a spacing of 60 x 60 cm (Bari *et al.*, 1987).

High plant density coupled with leaf picking and pruning once a year gave maximum leaf production in mulberry (Kasiviswanathan and Iyengar, 1970). A closer spacing of 45 x 8 cm (277777 plants ha^{-1}) was significantly superior to 45 x 23 cm spacing (96618 plants ha^{-1}) and 45 x 45 cm spacing (49382 plants ha^{-1}) with respect to leaf yield (Kasiviswanathan *et al.*, 1979). Wijesiriwardana (1984) reported a general increase in leaf yield with increase in planting density. A closer spacing of 45 x 8 cm was significantly superior to 45 x 23 cm spacing in increasing mulberry leaf yield (Kasivisvanathan *et al.*, 1979). They also related the method of harvest and plant density towards leaf yield. A spacing of 45 x 45 cm with leaf picking gave significant increase of 30.6 per cent leaf yield over 45 x 15 cm spacing with whole shoot harvest.

Gangwar *et al.* (1993) revealed that a spacing of 90 x 90 cm was better for quality and quantity leaf production compared to 60 x 60 cm and 60 x 30 cm. Anilkumar *et al.* (1994) noticed that density of planting significantly increased the leaf yield in mulberry. A spacing of 75 x 75 cm was found beneficial for higher leaf production during the first year but a closer spacing of 60 x 60 cm was sufficient in subsequent years under partial shade.

The mulberry variety, K-2 under closer spacing of 45 x 8 cm with 300 kg nitrogen per ha per year and frequent irrigation gave quality leaf at economic cost (Kasiviswanathan and Iyengar, 1969)

Spacing significantly increased the fresh leaf yield in mulberry both in coconut garden and open. The fresh leaf yield was highest at closer spacing (60 x 60 cm) since plant population was more compared to other spacings, 75 x 75 and 90 x 90 cm. In addition to the above, leaf dry matter and total dry matter production were also significantly influenced by spacing. The yield attributing characters were highest at a closer spacing of 60 x 60 cm but biomass production was higher at wider spacing of 90 x 90 cm (Meerabai, 1997).

Several experiments have been conducted so far to find out the optimum plant population for mulberry. The effect of spacing on mulberry yield is not uniform and both positive and negative trends have been reported with changes in planting density. But in most cases, a spacing of 60 x 60 cm was found sufficient for enhancing mulberry leaf production.

2.5.c. Effect of planting geometry on leaf quality

Biochemical constituents of mulberry are influenced by planting geometry. The widely spaced plants receive adequate supply of sunlight, nutrients and water thereby creating a favourable condition for the formation of biochemically important substances. Thus, the nutritive value of leaves grown under wider spacing is comparatively better than those grown under closer spacing. A high protein content was reported in the leaves of mulberry grown at a spacing of 90 x 90 cm than those at 90 x 60 cm while moisture and mineral contents were higher in 90 x 60 cm spacing than those at 90 x 90 cm (Krishnaswamy *et al.*, 1970). Wijesiriwardana (1984) and Habthymer (1985) observed that spacings did not show any significant difference in moisture content of leaves. However, an increase in cocoon yield was observed by feeding leaves of plants under wider spacing. Choudhuri *et al.* (1991) also observed significantly higher soluble and crude protein contents in the leaves of irrigated mulberry grown at a spacing of 60 x 60 cm than those grown at a spacing of 60 x 30 cm. Planting at wider spacing of 90 x 90 cm resulted in leaves of high quality but moisture content was more in closely spaced plants at 60 x 60 cm (Meerabai, 1997).

Das *et al.* (1990) reported a significant improvement in leaf-cocoon ratio and absolute silk content when silkworms were fed on leaves of rainfed mulberry grown at 120 x 90 cm spacing compared to those at 90 x 90 cm. Gangwar *et al.* (1993) reported that cocoon yield and returns per 100 disease free layings were better with mulberry gardens under 90 x 90 cm spacing followed by that under 60 x 60 cm and least by that under 60 x 30 cm. Highest nitrogen doze of 300 kg ha^{-1} $year^{-1}$ and wider spacing of 90 x 90 cm significantly improved the leaf cocoon ratio (Bongale and Chaluvachari, 1993). However, Sengupta *et al.* (1973) did not find any significant effect due to different spacing of mulberry plants on the cocoon yield and quality. On the other hand, Krishnaswami *et al.* (1971) observed a significant increase in the larval and cocoon weights, effective rate of rearing and absolute silk content by feeding mulberry leaves grown under closer spacing compared to wider spacing. Meerabai (1997) revealed that spacing has no significant influence on the larval weight and single cocoon weight.

Similar to leaf production, the effect of spacing on leaf quality and reeling performance is not uniform and both positive and negative trends have been reported with changes in planting density. However, in majority of the cases, wider spacing was found to improve the quality parameters and silkworm rearing performance.

Materials and Methods

3. MATERIALS AND METHODS

Experiments were conducted at the College of Horticulture, Vellanikkara during 1994-96 to develop an efficient nutrient management strategy involving inorganic fertilizers, organic manures and biofertilizers for irrigated mulberry. It was also intended to evaluate the response of two varieties of mulberry to irrigation and to find out the effects of moisture conservation techniques, planting geometries and shade levels on leaf yield and quality of mulberry. Following were the experiments undertaken.

Experiment I	Cost effectiveness in mulberry nutrition under irrigated condition
Experiment II	Utilization of agricultural byproducts for economising water use and improvement in leaf quality and productivity of mulberry
Experiment III	Shade tolerance and *in situ* development of green manure sources in mulberry

3.1. Location

The experiments were conducted at the Instructional Farm attached to the College of Horticulture, Vellanikkara situated at 10^0 31` N latitude and $76^0$ 13` E longitude and at an altitude of 40.3 m above mean sea level.

3.2. Soil

The soil of the experimental site is sandy clay loam. The soil depth is only about one m overlying a hard lateritic pan. The mechanical composition, soil moisture characteristics and chemical properties of the soil are summarised in Table 1.

3.3. Climate

The weather data recorded during June 1994 to May 1996 are given in Appendix I and graphically presented in Figs. 1 and 2. The abstract of the weather data is given in Table 2.

Table 1 Mechanical composition, soil moisture characteristics and chemical properties of soil

Particulars	Content	Method used
A. Mechanical composition		
Coarse sand (%)	27.08	Robinson's International Pipette Method (Piper, 1968)
Fine sand (%)	23.54	
Silt (%)	22.31	
Clay (%)	27.07	
B. Soil moisture characteristics		
Field capacity (%)	19.01	Pressure plate apparatus (Richard, 1947)
Permanent wilting point (%)	10.89	Pressure plate apparatus (Richard, 1947)
Bulk density (g/cc)	1.35	Core method (Blake, 1965)
Particle density (g/cc)	2.15	Pycnometer method (Blake, 1965)
C. Chemical properties		
Organic carbon (%)	0.38	Walkley and Black rapid titration method (Jackson, 1958)
Available N (kg/ha)	243.45	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg/ha)	45.82	Bray's calorimetric method (Jackson, 1973)
Available K_20 (kg/ha)	104.35	Ammonium acetate method (Jackson, 1973)
Soil reaction (pH)	5.10	1:2.5 soil suspension using pH meter (Jackson, 1973)

During 1994-95, the daily maximum temperature ranged from 28.6 °C to 37.6°C with a mean of 32.6°C. During 1995-96, it ranged from 29.9°C to 36.4°C with a mean of 32.6°C. In 1994-95, the minimum temperature ranged from 22.2 to 23.4°C with a mean of 23.15°C. During 1995-96, it ranged from 21.3 °C to 25.2°C with a mean of 23.4°C.

The total rainfall of 1994-95 and 1995-96 were 3683 mm and 2563 mm respectively. The periods December to February 1994-95 and December to March 1995-96 received no rainfall. The peak rainfall season coincided with June to August in both the years.

In 1994-95, the mean RH ranged from 58 to 91 per cent with a mean of 73.2 per cent. During 1995-96, it ranged from 53 to 89 per cent with a mean of 72.8 per cent. RH was low during December, January, February and March (RH ranging from 53 to 60 per cent) and high during June, July, August and September (RH ranging from 78 to 91 per cent).

During 1994-95, the monthly evaporation ranged from 84.2 mm to 190.2 mm with a mean of 134.56 mm. In 1995-96, it ranged from 88.5 to 219.2 mm with a mean of 142.2 mm. The monthly evaporation was highest (157 to 219 mm) during January to April and lowest (84.2 to 137.9 mm) during June to November.

The bright sunshine hours per day ranged from 1.44 to 10.59 with a mean of 6.95 during 1994-95. During 1995-96 it ranged from 2.12 to 9.87 with a mean of 7.1. Sun shine hours were low during June, July and August (ranging from 1.44 to 3.73 h per day) and high during December to March (ranging from 9.07 to 10.59 h per day). The area enjoys a warm humid tropical climate.

Table 2 Abstract of weather during 1994-95 and 1995-96

Weather elements	1994-95		1995-96	
	Range	Mean	Range	Mean
Maximum temperature (°C)	28.6 to 37.6	32.6	29.9 to 36.4	32.6
Minimum temperature (°C)	22.2 to 24.9	23.15	21.3 to 25.2	23.4
Annual rainfall (mm)	-	3682.9	-	2562
RH (%)	58 to 91	73.2	53 to 89	72.8
Monthly evaporation (mm)	84.2 to 190.2	134.56	88.5 to 219.2	142.2
Daily sunshine hours	1.44 to 10.59	6.95	2.12 to 9.87	7.1

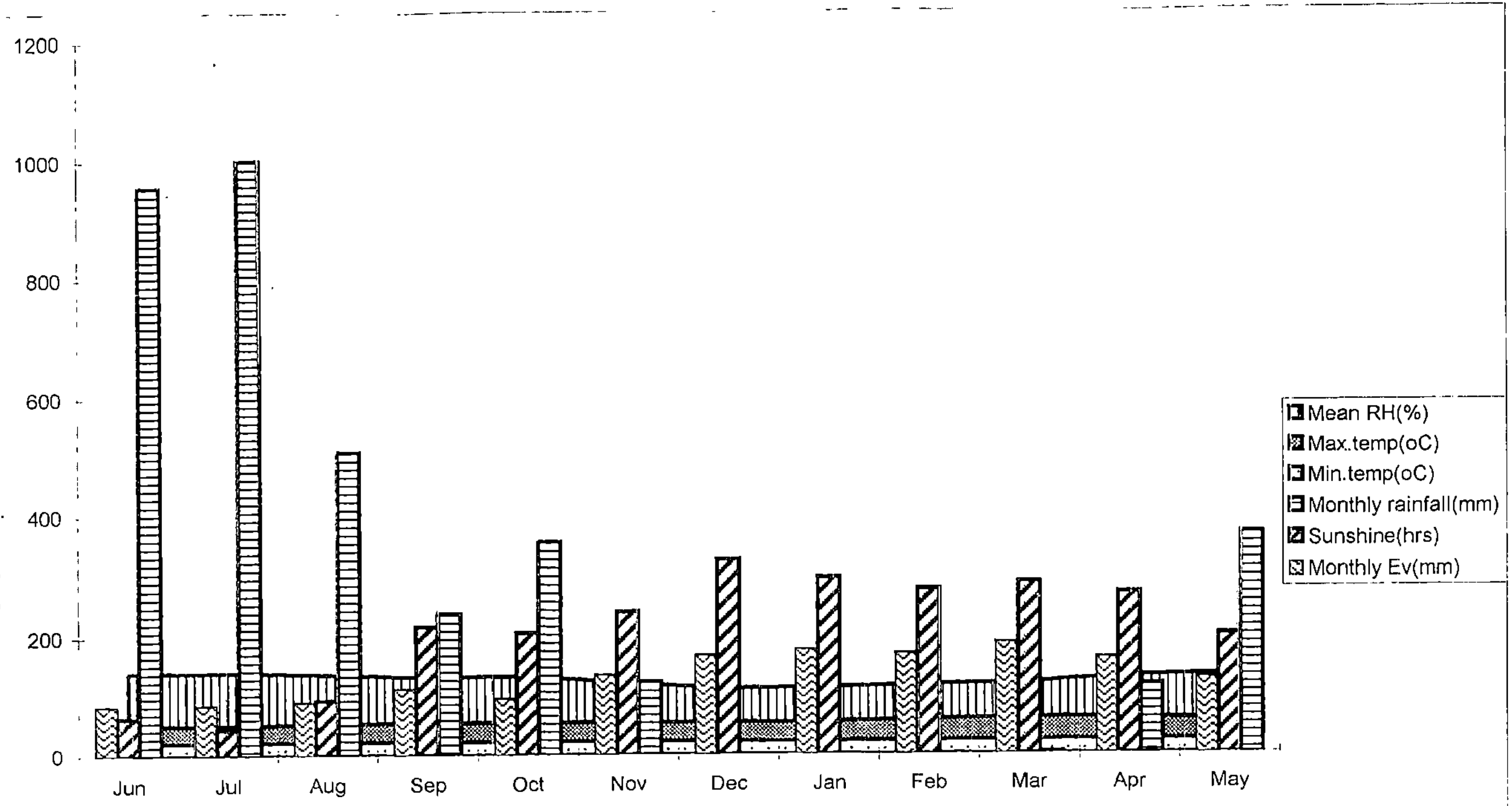


Fig 1 Weather parameters during 1994-95

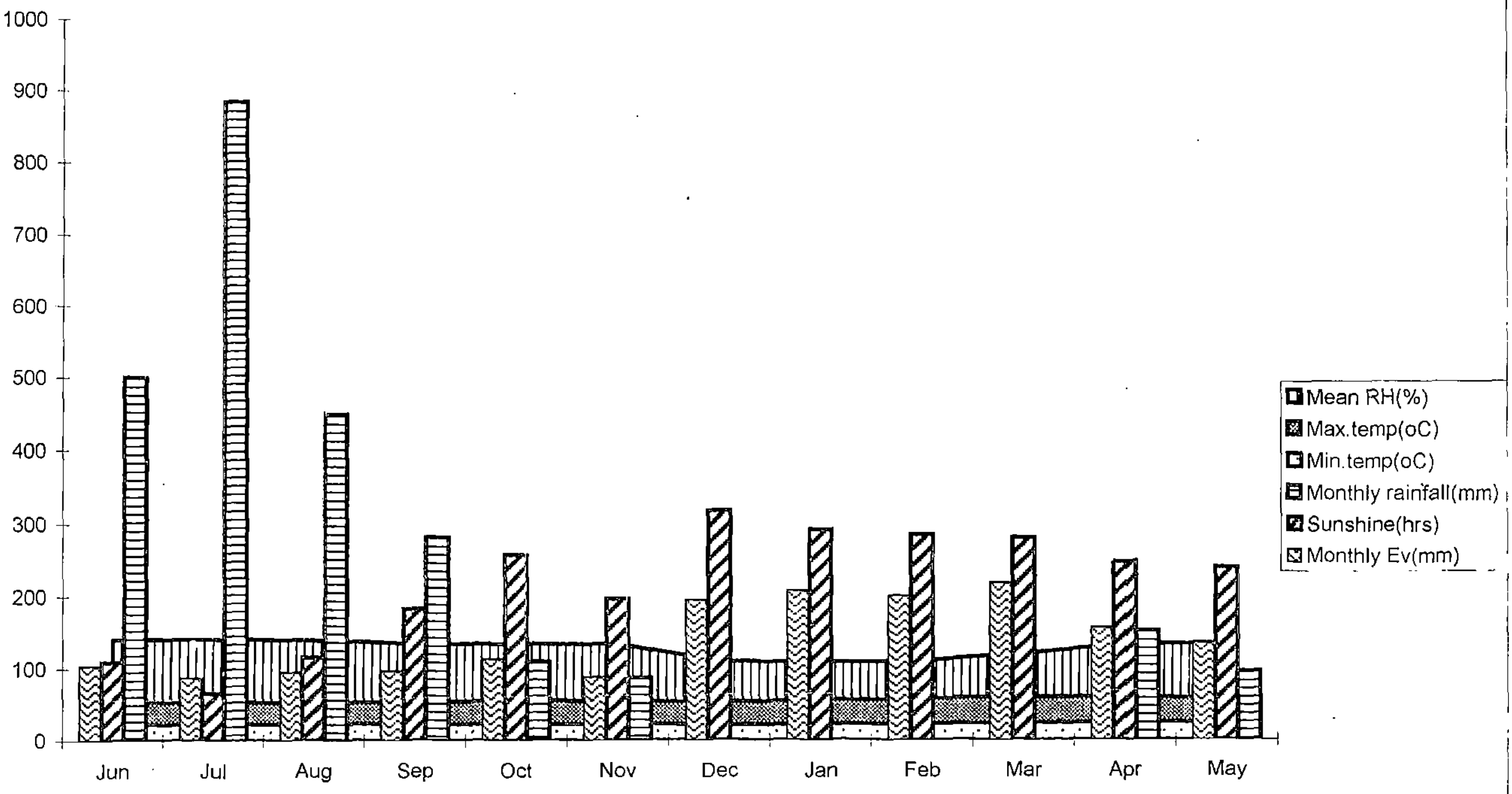


Fig 2 Weather parameters during 1995-96

3.4. Experiment I. Cost effectiveness in mulberry nutrition under irrigated condition

The main objective of the experiment was to develop an integrated nutrient management strategy involving inorganic fertilizers, organic manures and biofertilizers for mulberry grown under irrigated conditions.

3.4.1. Treatments

a) Levels of inorganic fertilizers (3)

F1) F50 - 150:60:60 kg NPK ha^{-1} year^{-1}

F2) F75 - 225:90:90 kg NPK ha^{-1} year^{-1}

F3) F100 - 300:120:120 kg NPK ha^{-1}year^{-1}

b) Green manuring (4)

M1) GMI - *In situ* cultivation of cowpea and its incorporation

M2) GMC - *In situ* cultivation of cowpea and *in situ* composting

M3) GML - Green leaf manuring with cowpea

M4) GM0 - No green manuring

c) Biofertilizers (5)

B1) AZO - Inoculation of cuttings with Azospirillum

B2) VAM - Inoculation of VA Mycorrhizae at planting hole

B3) PSB - Inoculation of cuttings with Phosphorus Solubilising Bacteria

B4) AVP - Combined application of B1, B2 and B3

B5) BF0 - Control

3.4.2. Design : Split plot

Treatment combinations : 3 x 4 x 5 = 60

Fig.3 Lay out plan - Cost effectiveness in mulberry nutrition under irrigated condition

Replication I

F1M1B1	F2M1B4	F1M3B2	F3M4B3	F3M2B3	F2M2B1	F2M4B4	F1M2B4	F3M3B5	F1M4B2	F2M3B1	F3M1B3
F1M1B4	F2M1B3	F1M3B1	F3M4B2	F3M2B4	F2M2B4	F2M4B5	F1M2B5	F3M3B4	F1M4B1	F2M3B5	F3M1B4
F1M1B5	F2M1B2	F1M3B3	F3M4B1	F3M2B2	F2M2B2	F2M4B3	F1M2B3	F3M3B1	F1M4B5	F2M3B2	F3M1B5
F1M1B3	F2M1B1	F1M3B4	F3M4B5	F3M2B5	F2M2B5	F2M4B1	F1M2B1	F3M3B2	F1M4B3	F2M3B4	F3M1B2
F1M1B2	F2M1B5	F1M3B5	F3M4B4	F3M2B1	F2M2B3	F2M4B2	F1M2B2	F3M3B3	F1M4B4	F2M3B3	F3M1B1

Replication II

F2M4B1	F1M1B5	F3M2B3	F1M4B3	F1M3B5	F1M2B4	F2M1B1	F2M3B1	F3M4B4	F3M1B3	F2M2B3	F3M3B2
F2M4B3	F1M1B4	F3M2B5	F1M4B1	F1M3B3	F1M2B5	F2M1B2	F2M3B2	F3M4B2	F3M1B4	F2M2B1	F3M3B3
F2M4B5	F1M1B1	F3M2B2	F1M4B5	F1M3B2	F1M2B1	F2M1B4	F2M3B5	F3M4B1	F3M1B5	F2M2B2	F3M3B4
F2M4B4	F1M1B3	F3M2B4	F1M4B2	F1M3B1	F1M2B3	F2M1B3	F2M3B4	F3M4B5	F3M1B1	F2M2B4	F3M3B1
F2M4B2	F1M1B2	F3M2B1	F1M4B4	F1M3B4	F1M2B2	F2M1B5	F2M3B3	F3M4B3	F3M1B2	F2M2B5	F3M3B5

Main plot treatments : Combinations of levels of nutrients and organic manures

Sub plot treatments : Biofertilizers

Replications : 2

Spacing : 60 x 60 cm

Plot size : Gross plot : 4.2 x 3.6 m

Net plot : 3.6 x 2.4 m

The lay out plan is given in Fig 3.

3.4.3. Cultivation details

The selected area was dug twice, stubbles removed, clods broken, levelled and laid out into plots as per the lay out plan.

3.4.3.1. Variety

A promising variety, MR-2 identified at the varietal trials conducted at the College of Agriculture, Vellayani was chosen for the study. This mildew resistant variety was evolved at Central Sericultural Research station, Coonoor and the planting materials were obtained from College of Agriculture, Vellayani.

3.4.3.2. Production of mulberry saplings

Six month old mulberry shoots were cut into pieces of 20 cm length and planted in polythene bags filled with potting mixture (1:1:1 mixture of sand, soil and cowdung). The polythene bags were kept under partial shade for two months and watered once in two days. Saplings reached six to seven leaves age at the time of planting.

3.4.3.4. Planting

Pits of size 35 x 35 x 35 cm were taken at a spacing of 60 x 60 cm and farm yard manure was applied @ 20 tons ha^{-1} as basal and again at 12 months after planting. Two months old mulberry saplings were planted on Ist June 1994. Gap filling was done after two weeks of planting.

3.4.4. Imposition of treatments

a. Levels of inorganic fertilizers

Inorganic fertilizers were applied as per the technical programme. Urea (45.8 per cent N), mussoriphos (20.1 per cent P_2O_5) and muriate of potash (60 per cent K_2O) were the nutrient sources. During the first year, nitrogen was applied in five equal splits (basal; two, four, seven and nine months after planting) and phosphorus and potassium in two equal splits (basal and four months after planting). In the second year also, nitrogen was applied in five equal splits at twelve, fifteen, sixteen, twentyone and twentythree months after planting, and phosphorus and potassium in two equal splits at twelve and fifteen months after planting.

b. Green manuring

i. *In situ* cultivation and incorporation of cowpea

Cowpea variety C-152 obtained from College of Horticulture, Vellanikkara was sown in the interspaces of mulberry as a green manure crop adopting a seed rate of 20 kg ha^{-1} and was incorporated at 60 days after sowing. After pulling out the green manure, it was added to the base of the mulberry plants and covered with soil. This was repeated during the second year.

ii. *In situ* cultivation of cowpea and *in situ* composting

Cowpea green manure was raised in the interspace of mulberry as above and the plants were pulled out at 60 days after sowing and added to the small trenches of 20 cm width and depth taken in between the mulberry rows. Cowdung was applied @ 5 tons ha^{-1} in the trenches and covered with soil. This was repeated during the second year.

iii. Green leaf manuring

A sole crop of cowpea was raised in an adjacent plot by maintaining uniform population. The plants were pulled out after sixty days of sowing and was added to the base of mulberry plants and covered with soil. This was practised during the second year as well.

iv. Control

A sole crop of mulberry was raised in the control plot.

c. Biofertilizers

i. Inoculation of cuttings with Azospirillum

Fresh culture of *Azospirillum brasilense* (acid tolerant strain) with an activity of 10^8 g^{-1} of culture obtained from College of Agriculture, Vellayani was thoroughly mixed with cowdung slurry and the mulberry cuttings were dipped in this slurry for thirty minutes and the saplings raised as explained earlier.

ii. Inoculation of VA mycorrhizae (VAM) at planting hole

Inoculum of VAM containing more than 15 spores per gram of air dried soil and infected root fragments of rhodes grass (*Chloris gayana)* was obtained from the College of Agriculture, Vellayani. The species used was *Glomus fasiculatum.* A planting hole of five cm depth and two cm width was made the already filled in polythene bag and the inoculum was applied @ five g per hole and the cuttings were planted in such a way that the cut surface was in contact with the inoculum.

iii. Phosphorus solubilising bacteria (PSB)

Mulberry cuttings were inoculated with fresh culture of *Bacillus megatherium* var *phosphaticum* obtained from Tamil Nadu Agricultural University, Coimbatore as in the case of inoculation of Azospirillum.

iv. Combined application of Azospirillum, PSB and VAM

Mulberry cuttings were inoculated with Azospirillum and PSB and then planted in planting holes treated with VAM as in single inoculation of VAM.

v. Control

Two months old saplings raised without inoculation with biofertilizers were used.

3.4.5. Post planting care

The crop was raised following the package of practices recommendations of Central Silk Board.

3.4.6. Harvest

The harvest schedule is furnished in Table 3.

Table 3. Schedule of leaf harvest and pruning

Month and year	Stage of crop	Method of harvest	Remarks
6/1995	12 MAP*	Bottom pruning	Pruned all branches at a height of 10 cm from ground level
9/1995	15 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from ground level
10/1995	16 MAP	Shootlet harvest	Harvested the shootlets alone
3/1995	21 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from ground level
5/1995	23 MAP	Middle pruning	Pruned all branches at a height of 50 cm from ground level
6/1995	24 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from ground level

* MAP - Months After Planting

3.4.7. Observations

Five plants per plot were selected at random for recording all observations unless otherwise specified. The methods followed for recording of observations are furnished below.

3.4.7.1. Growth characters

i. Plant height

The tallest shoot of the plant was considered for the height which was measured from the base of the plant to the tip of the shoot and was expressed in cm.

ii. Plant spread

The maximum spread of the plant was measured by using a thread and scale and was expressed in cm.

iii. Leaf area index

The leaf area of the harvested leaves of all the branches per plant were measured using the electronic leaf area meter (LICOR - 3100) and the leaf area index (LAI) was worked out using the formula suggested by William (1946).

$$\text{LAI} = \text{Leaf area} / \text{Land area}$$

3.4.7.2. Yield components and yield

i. Total length of leaf bearing branches

The length in cm between the lowest leaf and the tip of all branches in each plant was recorded and the total was worked out.

ii. Number of leaves per plant

During each harvest the total number of leaves per plant were counted and the mean was worked out.

iii. Fresh leaf yield

Fresh weight of harvested leaves from the net plot was recorded and expressed in kg ha^{-1}.

iv. Leaf dry matter

The fresh leaves picked from the five observation plants were sun dried and then oven dried to a constant weight at 70 ^{0}C and expressed as dry matter yield per hectare.

v. Total dry matter production

Leaf, stem and root were separated and oven dry weight recorded. Total dry matter production was worked out from leaf, stem and root dry matter.

3.4.7.3. Growth analysis

i. Net Assimilation Rate (NAR)

At any instant during crop growth,

$$NAR = 1\ .\ dw / A.dt$$ (Tesar, 1988)

where dw/dt is the change in dry weight per unit time and A is the leaf area.

NAR is expressed in mg cm^{-2} day^{-1}

ii. Relative Growth Rate (RGR)

At any given instant during growth,

$$RGR = 1.\ dw / w.dt$$ (Tesar, 1988)

where w is the plant dry weight and

dw / dt is the change in dry weight per unit time. RGR is expressed in mg g^{-1} day^{-1}

iii. Crop Growth Rate (CGR)

Crop growth rate was computed by the following formula and expressed in g m^{-2} day^{-1}.

$$CGR = W_2 - W_1 / SA\ (t_2 - t_1)$$ (Tesar, 1988)

W_1 and W_2 are crop dry weight at beginning and end of interval

t_1 and t_2 are the corresponding days and

SA is the soil area occupied by the plant at each sampling

iv. Specific leaf weight (SLW)

Specific leaf weight was computed by the following formula and expressed in mg cm^{-2}

$$SLW = LW / LA$$

LW = leaf oven dry weight and LA = leaf area

v. Root : shoot ratio

Root : shoot ratio (R:S ratio) was found out by the formula

$$\text{R:S ratio} = \text{Root dry weight} / \text{Shoot dry weight}$$

vi. Harvest index

Harvest index was computed by dividing economic yield (leaf) with biological yield (leaf + stem) and expressed as percentage.

3.4.7.4. Leaf quality

3.4.7.4.1. Leaf protein

The nitrogen concentration of leaf was estimated by microkjeldahl method (Jackson, 1973). Leaf protein content was calculated by multiplying the nitrogen content of the plant with the factor 6.25 (Simpson *et al.*, 1965) and expressed as percentage.

3.4.7.4.2. Leaf moisture loss pattern

100 leaves including tender, medium and coarse were collected and arranged in loose bundles and were kept in open laboratory condition. Weight was recorded after 3, 6, 9, 12 and 24 hrs and the samples were oven dried. Leaf moisture loss pattern was estimated and from these values.

Moisture loss (%) = (A-B) x 100 / A

A = Initial weight and

B = Second reading at which the loss of moisture is calculated

3.4.7.4.3. Bioassay

Silkworm rearing was conducted during May 1996 to assess the feeding quality of mulberry leaves following the improved technique laid out by Krishnaswami (1978).

a) Feeding of the larvae

Chopped mulberry leaves of the following size were fed to various larval instars.

Larval instars	*Leaf size*
I	0.5 cm^2 - 2 cm^2
II	2.0 cm^2 - 4 cm^2
III	4.0 cm^2
IV	Whole leaf
V	Whole leaf

Leaves were weighed and fed to the larvae four times daily at 7 am, 11 am, 3 pm and 7 pm.

b) Bed cleaning

Bed cleaning was adopted once in the first instar, twice in the second instar and daily during the later instars. For chawki rearing cotton nets of 2 - 10 mm^2 were used. But for late age worms nylon nets of 20 mm^2 size were used.

c) Mounting

Plastic collapsible mountages were used for mounting. The spinning worms along with mountages were kept in a separate room, where the temperature and relative humidity were maintained at 25 °C and 60 - 70 per cent, respectively. The mounting density was 40 - 60 worms per square feet.

d) Harvesting of cocoons

Harvesting of cocoons was done on the sixth day of spinning.

e. Observations recorded

The larval observations were recorded at the rearing house and the reeling parameters at Central Sericultural Research and Training Institute, Mysore.

i. Leaf consumption

The quantity of leaves given at the time of feeding was noted. At the time of bed cleaning the fresh weight of the left over leaf was noted. Leaf consumption was recorded at every instar and the total was worked out.

ii. Mature larval weight

Mature larval weight was recorded one day prior to spinning when the worms showed maximum weight. Ten larvae were selected at random from each tray and weighed in a digital electronic balance and the mean weight was worked out.

iii. Mature cocoon weight

After the harvest of cocoons, 10 cocoons selected at random were weighed and the mean weight was worked out.

iv. Shell weight

After recording cocoon weight, the cocoons were cut open and the pupae taken out. The shell weight was recorded and the mean worked out.

v. Shell ratio

Shell ratio percentage gives an indication of the quantity of raw silk that can be reeled from fresh cocoons. It was calculated in percentages as

Shell ratio = Weight of cocoon shell x 100 / Weight of whole cocoon

3.4.7.4.4. Chemoassay

3.4.7.5. Uptake of nitrogen, phosphorus and potassium through leaf

Nitrogen content was estimated by modified microkjeldahl method, phosphorus by Vanado - molybdo - phosphoric yellow colour method, and potassium by flame photometric method (Jackson, 1973). Nutrient contents were multiplied with dry matter production and expressed as the uptake of nutrients in kg ha^{-1}.

3.4.7.6. Rhizosphere studies

3.4.7.6.1. VAM

VAM association was studied by collecting fine mulberry roots along with 500 g rhizosphere soil. Fine roots and soil were used for observing root colonisation and spore count, respectively.

i. VAM root colonisation studies

VAM colonisation in roots were studied following the procedure of Phillips and Hayman (1970). The feeder roots from sample were thoroughly washed and cut into one cm bits. The bits were then treated with 10 per cent KOH solution and autoclaved at 121°C for five minutes for clearing and softening. The roots were further rinsed in water and immersed in an alkaline solution of H_2O_2 for final clearing. The roots were again washed with water several times to remove traces of H_2O_2. KOH was neutralised by adding one per cent HCl. The roots were further washed with distilled water to remove acid. The root pieces were stained by simmering in 0.05 per cent Trypan blue in lactoglycerol for five minutes. The stained root bits were then arranged on a clean glass slide, covered with cover glass and observed under the microscope for scoring mycorrhizal colonisation. The per cent mycorrhizal colonisation was calculated using the following formula.

Per cent VAM colonisation =

$$\frac{\text{Number of root bits scored positive for colonisation} \times 100}{\text{Number of root bits observed}}$$

ii. VAM spore load in mulberry rhizosphere

20 g air dried soil was processed by wet sieving and decanting procedure (Gerdemann and Nicolson, 1963). The soil samples were taken in 250 ml conical flasks and sufficient quantity of water was added to the soil and stirred thoroughly and allowed the heavier particles to settle. The suspension was passed through a series of sieves of pore size 1000, 300, 100 and 45 μm, keeping one below the other in the same order. The soil and the spores collected on the bottom two sieves were transferred to Whatman No. 1 filter paper and were counted under a stereoscopic microscope.

3.4.7.6.2. Azospirillum

Soil population of Azospirillum was estimated by dilution plate technique using Okon's medium. One gram soil sample was added to 99 ml of sterile water in a conical flask and mixed well. From this soil suspension one ml was pipetted out to another 99 ml of sterile water in a conical flask using a sterile pipette so as to get a dilution of 10^{-4}. From this one ml was pipetted out to sterile petri plate using a sterile pipette and to this about 10-15 ml of the corresponding medium was poured and swirlled to mix the soil suspension with the media uniformly. After this the petri plates were incubated at 28 ^{0}C for observing the colonies of Azospirillum. For estimation of soil population of the bacteria in the rhizosphere, random samples were taken from each plot and mixed together to get composite samples and from these composite samples one gram was taken for estimation of the bacteria. The rhizosphere population of Azospirillum was estimated after three and twelve months of planting.

3.4.7.6.3. Phosphorus Solubilising Bacteria

Isolation of phosphate solubilisers was made by using a medium suspended with *insoluble - phosphates such as tri-calcium phosphates* (Tilak,1993). The production of clearing zones around the colonies of the organism was an indication of the presence of phosphate solubilising organisms (Rao and Sinha, 1963). The number of phosphorus solubilising organisms were counted and expressed as cfu/ml of the suspension.

3.5. Experiment No.II Utilization of agricultural byproducts for economising water use and improvement in leaf quality and productivity of mulberry

The main objectives of the experiment were to investigate the potential and prospects of utilization of agricultural byproducts for soil moisture conservation and to evaluate the response of two varieties of mulberry to irrigation.

3.5.1. Treatments

a) Varieties (2)

- V_1) K-2
- V_2) S-54

b) Irrigation (4)

- I_1) I_0 - Control
- I_2) I_{15} - Irrigation at 15 mm of CPE
- I_3) I_{30} - Irrigation at 30 mm of CPE
- I_4) I_{45} - Irrigation at 45 mm of CPE

c) Soil moisture conservation techniques (4)

- C_1) MCP - Coir pith @ 5 tons ha^{-1}
- C_2) MCH - Coconut husk @ 3 $plant^{-1}$
- C_3) MCS - Silk worm litter @ 5 tons ha^{-1}
- C_4) MC_0 - No moisture conservation technique

3.5.2. Design : Split plot

Treatment combinations	:	2 x 4 x 4 = 32
Main plot treatments	:	Combinations of varieties and levels of irrigation
Sub plot treatments	:	Soil moisture conservation techniques
Replication	:	3
Spacing	:	60 x 60 cm
Plot size : Gross plot	:	4.2 x 3.6 m
Net plot	:	3.6 x 2.4 m

The lay out plan is given in Fig 4.

3.5.3. Cultivation details

Land preparation, production of mulberry saplings and planting were carried out as specified in Experiment number 1. Planting was done on 2 June 1994.

3.5.4. Treatment imposition

a. Varieties

i. K-2 (Kanva-2)

Kanva-2, an improved open pollinated hybrid selection from a local variety evolved at Central Sericultural Research and Training Institute (CSR&TI), Mysore and popular in South India was collected from College of Horticulture, Vellanikkara.

ii. S-54

S-54, a high yielding variety released from CSR&TI, Mysore and recommended for cultivation under irrigated conditions of South India was collected from the above institute.

b. Irrigation

The crop was irrigated from 15th November to 30th May during both the years. Pre treatment irrigation was given to bring the soil to field capacity. The quantity of

Fig.4 Lay out plan - Utilization of agricultural byproducts for economising water use and improvement in leaf quality and productivity of mulberry

Replication I

V1I1C1	V2I3C4	V2I4C1	V1I3C4	V2I1C1	V1I4C1	V1I2C4	V2I2C4
V1I1C3	V2I3C2	V2I4C3	V1I3C2	V2I1C3	V1I4C4	V1I2C2	V2I2C3
V1I1C4	V2I3C3	V2I4C2	V1I3C3	V2I1C4	V1I4C3	V1I2C1	V2I2C1
V1I1C2	V2I3C1	V2I4C4	V1I3C1	V2I1C2	V1I4C2	V1I2C3	V2I2C2

Replication II

V2I3C4	V1I1C4	V2I4C4	V1I3C4	V1I2C1	V2I1C1	V2I2C3	V1I4C3
V2I3C2	V1I1C3	V2I4C3	V1I3C1	V1I2C3	V2I1C4	V2I2C2	V1I4C4
V2I3C1	V1I1C2	V2I4C2	V1I3C3	V1I2C4	V2I1C2	V2I2C1	V1I4C2
V2I3C3	V1I1C1	V2I4C1	V1I3C2	V1I2C2	V2I1C3	V2I2C4	V1I4C1

Replication III

V1I3C1	V2I3C1	V1I1C4	V2I2C3	V2I4C2	V1I2C3	V1I4C1	V2I1C4
V1I3C4	V2I3C3	V1I1C1	V2I2C1	V2I4C4	V1I2C2	V1I4C2	V2I1C3
V1I3C2	V2I3C2	V1I1C2	V2I2C2	V2I4C3	V1I2C4	V1I4C3	V2I1C1
V1I3C3	V2I3C4	V1I1C3	V2I2C4	V2I4C1	V1I2C1	V1I4C4	V2I1C2

water applied per plot was calculated by taking the depth of irrigation as 3.3 cm. The volume of water to be applied to bring the soil to field capacity was calculated and the details are shown below.

$d = dw \times As \times D / 100$

where,

`d' is the depth of water applied in cm, `dw' is the readily available moisture (%) `As' is the apparent specific gravity and `D' is the depth of root zone (60 cm)

$d = 4.06 \times 1.35 \times 60 / 100 = 3.3$ cm

Volume of water applied per plot =

Depth of water applied in m x Area irrigated in m^2

$= 3.3$ m x 15.12 m^2 = 0.498 m^3 = 500 l

Irrigation water was measured with a water meter and applied @ 500 l / plot during one irrigation. The details of irrigations given are presented in Table 4.

Table 4. Details of irrigation given

Treatments	Total number of irrigation	Quantity of water applied (mm)	Pre-treatment irrigation (mm)	Effective rainfall (mm)	Total qty. of water (mm)
T1 - Control	10	330	33	265	628
T2 - CPE15mm	78	2574	33	82	2689
T3 - CPE30mm	39	1287	33	172	1492
T4 - CPE45mm	27	891	33	233	1157

i. Control

Life saving irrigation alone was given. A total of 10 irrigations were given and the total quantity of water applied was 330 mm.

ii. Irrigation at CPE 15 mm

Irrigations were scheduled when the cumulative pan evaporation values attained 15 mm. A total of 2574 mm of water was applied in 78 irrigations.

iii. Irrigation at CPE 30 mm

When the cumulative pan evaporation values attained 30 mm, the crop was given irrigation. A total of 1287 mm of water was applied in 39 irrigations.

iv. Irrigation at CPE 45 mm

The crop was irrigated when the cumulative pan evaporation values reached 45 mm. A total of 891 mm of water was applied in 27 irrigations.

c. Moisture conservation techniques

i. Coir pith

After five months of planting coir pith was applied around the basins of plants @ 180 g per basin to a radius of 30 cm and mixed with soil.

ii. Coconut husk

After five months of planting coconut husks were placed around the base of the plant as a mulch followed by partial covering with soil during subsequent fertilizer application.

iii. Silkworm litter

Silkworm litter was applied after five months of planting around the basins of plants @ 180 g per basin in a radius of 30 cm and mixed with soil.

iv. No moisture conservation technique

Mulberry was raised without any moisture conservation technique.

3.5.5. Post planting care

i. Inorganic fertilizers

The nutrient sources used for Experiment I were utilized for the present study. During the first year nitrogen was applied in five equal splits (basal; two, five, seven, eight and eleven months after planting) and phosphorus and potassium in two equal splits (basal and five months after planting). During the second year, nitrogen was applied in five equal splits at twelve, thirteen, fifteen, seventeen and twentyone months after planting and phosphorus and potassium in two equal splits at twelve and seventeen months after planting.

The crop was raised following the package of practices recommendations of Central Silk Board, Bangalore.

3.5.6. Harvest

The harvest schedule is furnished in Table 5.

3.5.7. Observations

All the observations and analysis relating to growth characters, yield components and yield, growth analysis, leaf quality and nutrient uptake through leaf were carried out following the same methods outlined under Experiment 1. The observations were recorded at five, eight, eleven, thirteen, fifteen, seventeen, twentyone and twentyfour months after planting coinciding with corresponding leaf harvests.

3.5.7.1. Soil moisture studies

i. Soil moisture

Soil sampling was done using screw auger at a distance of 15 cm away from the base of the plant from three depths viz, 0-15, 15-30 and 30-45 cm, before and 48 h after irrigation and the soil moisture was worked out gravimetrically.

Table 5. Schedule of leaf harvest and pruning

Month and year	Stage of crop	Method of harvest	Remarks
11/1994	5 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from the ground level
02/1995	8 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from the ground level
05/1995	11 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from the ground level
07/1995	13 MAP	Middle pruning	Pruned all branches at a height of 50 cm from ground level
09/1995	15 MAP	Middle pruning	Pruned all branches at a height of 50 cm from ground level
11/1995	17 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from the ground level
03/1996	21 MAP	Middle pruning	Pruned all branches at a height of 50 cm from ground level
06/1996	24 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from the ground level

MAP - Months After Planting

ii. Consumptive use of water

The consumptive use of water by mulberry under different treatments was worked out using the formula developed by Dastane (1972).

$$Cu = \sum_{i=1}^{N} (Ep \times 0.6) + \sum_{1}^{n} \frac{(M\,ai - M\,bi)}{100} \times Asi \times Di + ER$$

Where,

Cu = Consumptive use of water (mm)

Ep = Pan evaporation value from USWB class A open pan evaporimeter for the period from the date of irrigation to the date of soil sampling after irrigation.

0.6 = A constant used for obtaining ET value from Ep value for the given period of time

Mai = Per cent soil moisture (w/w) of the i th layer of the soil at the time of sampling after irrigation

Mbi = Per cent soil moisture (w/w) of the i th layer of the soil at the time of sampling before irrigation.

Asi = Apparent specific gravity of the i th layer of soil

Di = Depth (mm) of i th layer of soil

ER = Effective rainfall, if any, during the season (mm)

n = Number of soil layers

N = Number of days between irrigation and post irrigation soil moisture sampling

iii. Irrigation requirement

Irrigation requirement was estimated by directly adding the quantity of water used for irrigation in each treatment.

iv. Water use efficiency

Crop water use efficiency (CWUE) and field water use efficiency (FWUE) were computed using the following formulae and are expressed as kg mm^{-1}.

CWUE = Leaf yield (kg) / Consumptive water use (mm)

FWUE = Leaf yield (kg) / Total water applied (mm)

v. Crop coefficient (Kc)

The Kc was worked out by dividing the consumptive use during a given period by the pan evaporation values during that period.

vi. Soil moisture depletion pattern

The average relative soil moisture depletion from each soil layer was worked out for each irrigation interval and converted into per cent utilization over the total moisture used by the crop up to 45 cm.

3.5.7.2. Leaf diffusive resistance, leaf temperature and transpiration rate

A steady state porometer (Model LI - 1600, LI - Cor, Nebraska, USA) was used to measure diffusive resistance, temperature and transpiration rate of leaves. Physiologically mature leaves well exposed to solar radiation were selected for measurements. Diffusive resistance and transpiration rate measurements were taken at 08 00 and 14 00 h and temperature measurements at 08 00 and 12 00 h from the five plants selected from each treatment and the mean values worked out.

3.6. Experiment III. Shade tolerance and *in situ* development of green manure sources in mulberry

The main objectives of the experiment were to investigate the effect of *in situ* cultivation and incorporation of green manure on growth, yield attributes and yield and to study the effect of planting geometry on the shade tolerance of mulberry.

3.6.1. Treatments

a) Planting geometry (3)

- P_1) PGN - Normal row planting at 60 x 60 cm
- P_2) PGP - Paired row planting at 30 / 105 x 60 cm
- P_3) PGH- High density planting at 30 / 105 x 30 cm

b) Intensity of shade (3)

- S_1) S_0 - No shade
- S_2) S_{25} - 25% shade
- S_3) S_{50} - 50% shade

c) Green manure intercropping (5)

- G_1) GMV - *Vigna sinensis*
- G_2) GMM - *Mimosa invisa*
- G_3) GMD - *Desmodium intortum*
- G_4) GMC - *Calopogonium muconoides*
- G_5) GM_0 - No green manure

3.6.2. Design : Split plot

Treatment combinations : 3 x 3 x 5 = 45

Main plot treatments : Combinations of planting geometry and levels of shade

Sub plot treatments : Green manure crops

Replication : 3

Plot size : Gross plot : 4.2 x 3.6 m Net plot : 3.6 x 2.4 m

The lay out plan in given in Fig 5.

3.6.3. Cultivation details

Land preparation and production of mulberry saplings (variety K-2) were carried out as specified in Experiment I. Planting was carried out on 3rd June 1999.

Fig.5 Lay out plan - Shade tolerance and *in situ* Development of green manure sources in mulberry

Replication I

P1S1G1	P1S2G5	P2S1G2	P2S2G4	P3S1G2	P2S3G2	P1S3G4	P3S3G5	P3S2G4
P1S1G5	P1S2G4	P2S1G1	P2S2G1	P3S1G3	P2S3G3	P1S3G2	P3S3G4	P3S2G2
P1S1G4	P1S2G3	P2S1G4	P2S2G3	P3S1G1	P2S3G4	P1S3G3	P3S3G2	P3S2G1
P1S1G3	P1S2G2	P2S1G5	P2S2G2	P3S1G4	P2S3G5	P1S3G1	P3S3G1	P3S2G3
P1S1G2	P1S2G1	P2S1G3	P2S2G5	P3S1G5	P2S3G1	P1S3G5	P3S3G3	P3S2G5

Replication II

P2S3G1	P3S1G4	P2S1G2	P1S2G5	P1S3G3	P3S2G3	P2S2G2	P3S3G4	P1S1G4
P2S3G5	P3S1G5	P2S1G5	P1S2G1	P1S3G2	P3S2G2	P2S2G3	P3S3G4	P1S1G2
P2S3G2	P3S1G3	P2S1G4	P1S2G3	P1S3G1	P3S2G1	P2S2G4	P3S3G2	P1S1G1
P2S3G4	P3S1G2	P2S1G3	P1S2G2	P1S3G4	P3S2G5	P2S2G1	P3S3G1	P1S1G3
P2S3G3	P3S1G1	P2S1G1	P1S2G4	P1S3G5	P3S2G4	P2S2G5	P3S3G3	P1S1G5

Replication III

P3S2G3	P2S3G5	P1S2G2	P2S1G3	P1S3G1	P3S3G3	P3S1G3	P1S1G2	P2S2G1
P3S2G5	P2S3G4	P1S2G5	P2S1G5	P1S3G5	P3S3G4	P3S1G2	P1S1G1	P2S2G4
P3S2G2	P2S3G2	P1S2G4	P2S1G1	P1S3G3	P3S3G1	P3S1G5	P1S1G5	P2S2G5
P3S2G4	P2S3G3	P1S2G3	P2S1G2	P1S3G4	P3S3G5	P3S1G1	P1S1G3	P2S2G2
P3S2G1	P2S3G1	P1S2G1	P2S1G4	P1S3G2	P3S3G2	P3S1G4	P1S1G4	P2S2G3

3.6.4. Treatment imposition

a. Planting geometry

i. Normal row planting at 60 x 60 cm

Saplings were planted in normal rows at a spacing of 60 x 60 cm.

ii. Paired row planting at 30 / 105 x 60 cm

Saplings were planted at 30 cm between two rows making up a pair, 105 cm between two such paired rows and 60 cm between plants within the rows.

iii. High density planting at 30 / 105 x 30 cm

Saplings were planted at 30 cm between two rows making up a pair, 105 cm between two such rows and 30 cm between plants with in the row.

b. Intensity of shade

i. No shade

The crop was cultivated without providing any external shade.

ii. 25% shade

Pandals were erected using bamboo poles and covered with unplaited coconut leaves. The leaves were arranged in such a way to get the desired level of shade. Sides were covered to prevent the direct entry of slant rays and clearance was given to facilitate air movements. Shade levels were adjusted using LI-COR Integrating quantum radiometer with line quantum sensor.

iii. 50% shade

The above procedure was followed for maintaining 50% shade.

c. Green manure

i. *Vigna sinensis*

Seeds of cowpea (*Vigna sinensis*) were obtained from the College of Horticulture, Vellanikkara and dibbled in the interspaces immediately after planting mulberry saplings by maintaining uniform population in all the plots. After 90 days of sowing the green manure was slashed very close to the ground and spread around the base of mulberry plants. The weight of green manure produced per plot was also quantified. This process was repeated during second year. During second year, seeds were sown after first bottom pruning in June.

ii. *Mimosa invisa*

Seeds obtained from Dhoni Farm, Palghat were put in hot water for one minute to soften the seed coat, dried under partial shade and broadcast in the interspaces of mulberry adopting a seed rate of 5 kg ha^{-1}. The green manure was slashed as above. This process was repeated during second year. During the second year, seeds were sown after first bottom pruning in June.

iii. *Desmodium intortum*

Seeds brought from Kerala Livestock Development and Milk Marketing Board, Mattuppetty, were subjected to hot water treatment, dried under partial shade and sown in the interspaces of mulberry immediately after planting adopting a seed rate of 5 kg ha^{-1}. The slashing was done as above. During the second year, seeds were sown after first bottom pruning in June.

iv. *Calopogonium muconoides*

Seeds collected from Dhoni Farm, Palghat were put in hot water for one minute, dried under shade and broadcast in the interspaces immediately after planting mulberry adopting a seed rate of 20 kg ha^{-1}. Slashing was done as above. During the second year, seeds were sown after first bottom pruning.

v. No green manure

The crop was cultivated without any green manure in the interspaces.

3.6.5. Post planting care

i. Inorganic fertilizers

The nutrient sources used for the Experiment I were utilized for the present study. N, P and K were applied @ 300:120:120 kg ha^{-1} year^{-1}.

During the first year, nitrogen was applied in five equal splits (basal; two, four, seven and nine months after planting) and phosphorus and potassium in two equal splits (basal and four months after planting). During the second year, nitrogen was applied in five equal splits at twelve, fifteen, eighteen, nineteen and twentyone months after planting and phosphorus and potassium in two equal splits at twelve and fifteen months after planting.

The crop was raised following the package of practices recommendations (Central Silk Board).

3.6.6. Harvest

Harvest schedule is furnished in Table 6.

3.6.7. Observations

All the observations and analysis relating to growth characters, yield components and yield, growth analysis, leaf quality and nutrient uptake through leaf were carried out following the same methods outlined under Experiment 1.

3.6.7.1. Dry matter accumulation of green manure and nutrient addition

Nitrogen, phosphorus and potassium addition to soil through in situ green manuring was worked out by estimating the nutrient concentrations and the dry matter production.

3.7. Soil analysis

The composite soil samples collected prior to the commencement of field experiments and the soil samples collected from individual plots after completion of

Table 6. Schedule of leaf harvest and pruning

Month and year	Stage of crop	Method of harvest	Remarks
12/1994	6 MAP	Middle pruning	Pruned all branches at a height of 50 cm from ground level
03/1995	9 MAP	Bud clipping and leaf harvest	Removed the apical bud and picked the leaves alone
06/1995	12 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from ground level
09/1995	15 MAP	Topping	Removed the terminal 15 cm of shoot and picked the leaves alone
12/1995	18 MAP	Middle pruning	Pruned all branches at a height of 50 cm from ground level
03/1996	21 MAP	Bud clipping and leaf harvest	Removed the apical bud and picked the leaves alone
06/1996	24 MAP	Bottom pruning	Pruned all branches at a height of 10 cm from ground level

MAP - Months After Planting

experiments were analysed for available nitrogen, available phosphorus and available potassium. Available nitrogen was estimated by alkaline permanganate method (Subbiah and Asija, 1956), available phosphorus by Bray method (Jackson, 1973) and available potassium by neutral normal ammonium acetate method (Jackson, 1973).

3.8. Economic analysis

Economics of cultivation was worked out after taking into account the cost of cultivation and the prevailing market price of mulberry leaves. In working out the cost involved, different variable cost items like planting material, manures and fertilizers, plant protection chemicals, irrigation, labour charges etc. were considered at prevailing market rates during 1994-97. The economic life span of a mulberry garden is fifteen years and hence the expenditure incurred for the initial establishment of the garden including material cost divided by fifteen was taken as non-recurring expenditure. The net income and benefit : cost ratio were calculated as follows.

Net income (Rs ha^{-1}) = Gross income - Total expenditure

Benefit : cost ratio = Gross income / Total expenditure

3.9. Sustainability

The sustainable yield index (SYI) is defined as

$$SYI = \overline{Y} - \sigma / Y_{max}$$ Singh *et al.* (1990)

where,

$\overline{Y}$ is the estimated average yield of a practice over years,

σ is the estimated standard deviation and

Y_{max} is the observed maximum yield in the experiment.

In calculating SYI, the negative values of $(\bar{Y}-\sigma)$ should be taken as zero since yield is always a positive quantity. In this index, σ quantify the risk associated with the average performance $\bar{Y}$ of a treatment. When, $\sigma = 0$ and $\bar{Y} = Y_{max}$, SYI = 1. This is an ideal treatment. This treatment gives consistently maximum yield in all the years indicating its sustainability. If the standard deviation is very high then the value of the index will be less, thereby indicating the unsustainable nature of the treatment.

3.10. Statistical analysis

The data were statistically analysed for analysis of variance as per the procedure outlined by Panse and Sukhatme (1978).

Results

4. RESULTS

An investigation entitled `Sustainable technology for higher productivity in mulberry sericulture' was undertaken at the College of Horticulture, Vellanikkara. The project comprised of three field experiments viz, `Cost effectiveness in mulberry nutrition under irrigated condition, `Utilization of agricultural byproducts for economising water use and improvement in leaf quality and productivity of mulberry' and `Shade tolerance and *in situ* development of green manure sources in mulberry'. Development of an integrated nutrient management strategy and tailoring of technology to save irrigation water and to conserve soil moisture besides maintaining soil health were attempted. The results obtained are presented in the following sections.

4.1. Experiment I. Cost effectiveness in mulberry nutrition under irrigated condition

Inorganic fertilizers were tried at three levels ; the highest level F_{100} means application of NPK @ 300:120:120 kg ha^{-1} $year^{-1}$ which is the present package of practices recommendation for growing irrigated mulberry, the medium level F_{75} means application of NPK @ 225:90:90 kg ha^{-1} $year^{-1}$ which is the 75% of the present recommended doze and the lower level F_{50} means application of NPK @ 150:60:60 kg ha^{-1} $year^{-1}$ which is the 50 %of the present recommended doze. Effect of green manuring was tested among cowpea grown *in situ* and incorporated (GMI), *in situ* composting of cowpea(GMC), green leaf manuring (GML) and no green manure (GM_0). Effect of biofertilizers were tested after inoculation with Azospirillum (AZO), Vesicular Arbuscular Mycorrhizae (VAM), Phosphorus Solubilising Bacteria (PSB), a combination of all the above (AVP) and no biofertilizer inoculation (BF_0). Notations such as F_{100}, F75 and F50 for inorganic fertilizer levels, GMI, GMC, GML and GM0 for green manuring treatments and AZO, VAM, PSB, AVP and BF0 for biofertilizers are conveniently used to express the treatments in the following sections.

4.1.1. Plant height

Data relating to mean plant height as influenced by the varying levels of inorganic fertilizers, green manuring and biofertilizer sources recorded at 12, 15, 16, 21, 23 and 24 MAP are presented in Table 7.

Levels of inorganic fertilizers showed significant effect on plant height from 16 MAP onwards and application of F100 resulted in maximum height at different harvests. However, at 16 and 24 MAP, the above treatment was on par with application of F75.

It was observed that green manuring and biofertilizer treatments had no significant effect on plant height at any stage.

A notable and significant interaction was observed at 16 MAP when F75 was jointly applied with PSB when the plant height increased to 168 cm (Table 37). Similarly, combined application of inorganic fertilizers, green manures and biofertilizers resulted in taller plants in the treatment combinations F75 x GML x PSB at 16 MAP and F100 x GMI x AVP, F100 x GML x AZO and F100 x GM0 x VAM at 23 MAP (Table 39).

Variation in the height of mulberry plants, either increase or decrease among observations at different months after planting are due to different methods of pruning practised and the varying intervals of harvest.

4.1.2 Plant spread

Data recorded on the effect of treatments on mean plant spread at 12, 15, 16, 21, 23, and 24 MAP are presented in Table 8.

Table 7 Plant height (cm) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	106.93	157.52	118.89	126.58	122.70	116.98
F75	104.33	148.95	136.34	136.71	133.33	127.23
F100	113.58	166.79	136.71	149.08	150.65	128.18
SEm ±	3.57	12.47	4.47	3.92	4.30	2.65
C.D (0.05)	NS	NS	13.93	12.21	13.40	8.27
Green manuring						
GMI	102.30	186.47	125.49	130.77	132.17	117.97
GMC	105.40	153.12	127.07	140.44	134.23	123.10
GML	106.52	143.78	142.16	138.78	135.87	123.77
GM0	118.33	147.64	127.87	139.83	139.97	131.67
SEm ±	4.12	14.40	5.17	4.53	4.97	3.07
C.D.(0.05)	NS	NS	NS	NS	NS	NS
Biofertilizers						
AZO	106.83	177.70	124.96	139.68	137.38	127.42
VAM	108.17	147.42	131.05	137.07	137.67	127.50
PSB	106.17	148.11	140.60	139.35	134.42	123.79
AVP	116.92	147.27	133.81	137.11	134.33	123.92
BF0	103.29	168.26	122.81	134.07	134.00	118.00
SEm ±	4.62	17.07	4.67	4.46	3.53	4.03
C.D.(0.05)	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 8 Plant spread (cm) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F_{50}	71.63	75.94	88.30	92.15	84.80	76.23
F_{75}	72.65	100.13	108.58	99.33	90.30	84.10
F_{100}	73.70	79.58	99.90	108.85	97.00	84.30
SEm ±	2.03	13.77	9.09	2.38	2.86	2.49
C.D (0.05)	NS	NS	NS	7.40	8.93	NS
Green manuring						
GMI	72.03	80.97	109.20	96.20	86.50	76.63
GMC	73.63	77.97	95.68	97.33	88.50	82.57
GML	70.47	76.47	93.53	99.33	93.67	82.57
GM_0	74.50	105.45	97.29	100.90	94.13	84.40
SEm ±	2.35	15.90	10.49	2.74	3.31	3.88
C.D.(0.05)	NS	NS	NS	NS	NS	NS
Biofertilizers						
AZO	73.83	80.98	93.56	97.67	90.42	83.79
VAM	70.71	76.89	121.47	98.63	94.21	80.42
PSB	72.67	79.25	94.19	100.00	88.21	79.33
AVP	72.38	80.58	93.12	99.29	91.17	83.88
BF_0	73.71	108.35	92.29	96.63	89.50	80.29
SEm ±	1.97	17.26	11.44	3.40	3.40	2.65
C.D.(0.05)	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Inorganic fertilizers did not influence plant spread except at two stages viz, 21 and 23 MAP. At both stages F100 resulted in significantly higher plant spread than F50. However, plant spread was unaffected by any of the green manure and biofertilizer treatments.

No interactive effect between any of the treatment components was observed with respect to spread of plants at all stages of growth.

4.1.3. Leaf area index

The effect of treatments on leaf area index (LAI) recorded at 12, 15, 16, 21, 23, and 24 MAP are given in Table 9.

The significant influence of varying levels of inorganic fertilizers, green manuring and biofertilizer application on LAI were observed throughout the period of growth. At four stages of growth viz, 12, 15, 23 and 24 MAP, highest LAI was observed with the application of F75. However, this treatment was on par with F100 at all the above four stages. At 16 and 21 MAP F100 recorded the maximum values which were in turn at par with F75. *In situ* cultivation and composting of cowpea resulted in the highest values of LAI at 15, 16, 21 and 24 MAP. This was on par with GMI at 15 MAP, GML at 16 and 21 MAP and GMI 24 MAP. At 12 and 23 MAP GMI recorded maximum values but was on par with GMC at 12 MAP and GMC and GLM at 23 MAP. Inoculation with any of the biofertilizer such as AZO, VAM or PSB or combined application of all biofertilizers (AVP) significantly enhanced the LAI at all the stages of growth than no biofertilizer application. AVP maintained consistently higher LAI throughout the period of growth. However, after 23 and 24 months of planting single inoculation of VAM was found to be on par with the combined application.

Table 9 Leaf area index as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F_{50}	4.39	5.98	1.48	4.73	3.68	3.27
F_{75}	5.28	6.71	1.65	5.81	4.44	4.02
F_{100}	5.22	6.43	1.77	6.12	4.28	3.90
SEm ±	0.08	1.14	0.02	0.08	0.07	0.08
C.D (0.05)	0.27	0.46	0.07	0.25	0.23	0.24
Green manuring						
GMI	5.64	6.86	1.79	6.12	4.63	4.22
GMC	5.62	7.07	1.89	6.52	4.53	4.38
GML	5.24	6.73	1.85	6.40	4.47	4.12
GM_0	3.36	4.82	1.00	3.18	2.89	2.19
SEm ±	0.10	0.17	0.02	0.09	0.08	0.09
C.D.(0.05)	0.31	0.53	0.09	0.29	0.27	0.28
Biofertilizers						
AZO	4.67	6.37	1.78	5.66	3.88	3.92
VAM	6.54	7.35	1.99	7.19	5.15	4.72
PSB	4.23	5.33	1.55	4.65	3.87	3.12
AVP	7.05	8.03	2.14	7.94	5.36	4.89
BF_0	2.34	4.77	0.70	2.34	2.40	1.98
SEm ±	0.17	0.12	0.03	0.12	0.11	0.12
C.D.(0.05)	0.47	0.35	0.09	0.34	0.32	0.33

MAP - Months after planting

The interaction effects of inorganic fertilizer x green manure, inorganic fertilizer x biofertilizer, green manure x biofertilizer and inorganic fertilizer x green manure x biofertilizer were found to be significant at certain stages of growth. F_{75} x GMC at 12 MAP resulted in significantly higher LAI than F_{75} x GMI or GML. However, F_{100} x GMC was at par with F_{100} x other green manure methods. At 21 MAP also F_{100} x GMC resulted in the highest LAI than all other treatment combinations. The differential positive response of GMC at varying levels of inorganic fertilizers was conspicuous at 23 and 24 MAP also (Table 36).

With respect to inorganic fertilizer x biofertilizer interaction, the effects were significant at 12, 15, 16, 21, and 24 MAP and at all these stages the treatment combination F_{75} x AVP resulted in maximum LAI. The above treatment combination was on par with F_{75} x VAM at 12, 16 and 21 MAP. F_{50} x AVP behaved similarly to F_{75} x VAM and F_{100} x VAM at several stages with regard to LAI (Table 37). Significant influence of combined application of green manure x biofertilizer was observed throughout the growth stages. Combined application of biofertilizer (AVP) together with GMC was found to result in consistently high LAI during several growth stages. GMI also acted almost alike to GMC, but GML failed to produce similar effect. At 12 MAP, the treatment combination, GMC x AVP which was on par with GMI x VAM, GMI x AVP, GMC x VAM and GML x AVP recorded maximum LAI. At 15, 16 and 24 MAP, GMI x AVP showed maximum value. GML x AVP combination performed better at 21 and 23 MAP (Table 38).

Inorganic fertilizer x green manure x biofertilizer interactions were significant at 15, 16, 21 and 23 MAP. F_{75} x GMC x AVP, F_{75} x GMI x AVP, F_{75} x GMC x AVP and F_{75} x GMI x VAM respectively, showed maximum LAI (Table 39).

F75 x GMC x VAM was also found to be similar to F75 x GMI x AVP and F75 x GML x AVP at several stages. However, with F100 these combinations didn't perform to this extent.

4.1.4. Shoot length

Data recorded on the effects of treatments on shoot length (SL) at 12, 15, 16, 21, 23 and 24 MAP and total shoot length (TSL) are given in Table 10.

Shoot length of mulberry was found to be varying with the levels of fertilizers only at one stage ie. at 21 MAP when the application of F100 significantly enhanced SL, over the lower doze, but at par with F75. TSL was also unaffected by levels of inorganic fertilizers. Neither the green manure nor the biofertilizer could make any significant impact on this character.

No significant interaction between the treatment combinations were observed at any of the growth stage with respect to shoot length.

4.1.5. Leaf number

The data on leaf number (LN) recorded at 12, 15, 16, 21, 23 and 24 MAP and total leaf number (TLN) are presented in Table 11.

Significant influence of levels of inorganic fertilizers was observed on LN at 15, 16, 21 and 23 MAP and TLN. At all the above stages, application of F100 resulted in higher LN. However, this treatment was on par with F75 at all the above stages except 16 and 23 MAP.

Neither the TLN nor the LN per harvest was significantly affected by green manures and biofertilizers. Likewise the treatment combinations also did not produce any significant interactive effect with regard to the production of leaves.

Table 10 Shoot length (cm) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Total
Levels of inorganic fertilizers							
F_{50}	542.13	632.28	711.63	679.68	674.80	699.00	3849.80
F_{75}	438.05	677.85	714.55	827.40	736.00	939.00	4333.73
F_{100}	447.38	698.35	817.40	954.45	1034.88	1097.50	5049.95
SEm ±	27.71	22.82	85.73	46.57	133.80	153.01	373.01
C.D (0.05)	NS	NS	NS	144.96	NS	NS	NS
Green manuring							
GMI	405.90	651.07	670.13	786.73	631.83	676.80	3822.47
GMC	438.33	697.43	708.93	815.57	830.03	862.80	4353.10
GML	427.27	635.40	752.70	825.17	981.27	1257.03	4879.53
GM_0	511.20	694.07	859.67	854.57	817.77	852.27	4589.53
SEm ±	31.99	26.35	98.99	53.77	154.49	176.68	430.790
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS
Biofertilizers							
AZO	470.79	646.46	721.75	797.75	756.63	788.29	4181.61
VAM	447.79	699.63	910.96	797.79	847.54	891.13	4594.83
PSB	408.42	638.75	658.29	849.67	961.71	1104.83	4621.67
AVP	452.71	700.67	793.83	898.58	713.58	794.63	4354.00
BF_0	449.54	661.96	654.46	758.75	796.67	982.25	4303.63
SEm ±	24.54	40.76	109.18	75.35	121.10	201.42	361.57
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 11 Leaf number as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Total
Levels of inorganic fertilizers							
F_{50}	145.45	159.78	180.33	180.08	115.20	135.33	916.17
F_{75}	148.33	179.43	208.33	190.43	123.98	150.35	1000.85
F_{100}	150.13	195.33	231.83	212.35	147.73	169.65	1107.02
SEm ±	9.32	7.94	6.93	8.21	7.37	10.08	27.09
C.D (0.05)	NS	24.73	21.59	25.57	22.96	NS	84.32
Green manuring							
GMI	145.57	171.77	196.97	188.17	113.57	134.03	950.08
GMC	147.47	190.70	201.20	192.03	139.60	159.53	1030.53
GML	143.77	172.23	210.26	196.23	128.13	151.60	1002.22
GM_0	155.07	178.00	218.87	200.70	134.57	161.93	1049.14
SEm ±	10.77	9.17	8.00	9.48	8.52	11.64	31.28
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS
Biofertilizers							
AZO	155.58	168.38	197.08	192.71	127.04	146.54	987.33
VAM	150.75	191.50	210.63	199.25	141.08	164.00	1057.21
PSB	139.25	170.25	195.79	196.29	123.21	151.50	976.29
AVP	147.17	194.21	217.00	185.25	123.92	145.17	1012.72
BF_0	147.08	161.54	213.63	197.92	129.58	151.67	1001.42
SEm ±	6.75	9.38	11.68	11.76	9.14	11.01	35.58
C.D.(0.05)	NS	26.01	NS	NS	NS	NS	NS

MAP - Months after planting

4.1.6. Fresh leaf production

Observations recorded on fresh leaf production (FLP) at 12, 15, 16, 21, 23 and 24 MAP and total fresh leaf production (TFLP) are presented in Table 12.

Significant influence of inorganic fertilizers on FLP was observed at all stages of growth except at 15 MAP. A TFLP of 25.55 t/ha was observed with F100 and the same trend was observed at four out of five harvests. This treatment was on par with application of F75 in all cases except at 16 MAP. The significant effect of green manuring on FLP was evident at all harvests and a TFLP of 27.70 t/ha/year was observed when cowpea was grown and composted *in situ* (GMC) which was on par with *in situ* cultivation and incorporation of cowpea (GMI). In general, the performance was superior in all the three green manure plots at all harvests compared to no green manuring (Fig. 6). Combined application of Azospirillum, VAM and PSB had significant effect on TFLP and the trend was evident on FLP at all harvests. Except at 15 MAP, combined application was on par with single inoculation of VAM.

The interaction between levels of fertilizers x green manures was significant and the combination, F75 x GMC gave the highest TFLP which was on par with F100 x GMC, F75 x GMI and F75 x GML (Fig 8). With respect to FLP, the interactive effect was manifested only at 12 MAP. As in the case of TFLP, F75 x GMC gave the highest yield which was on par with F100 x GMI, F75 x GMI, F75 x GML and F50 x GMC with respect to FLP (Table 36).

Levels of fertilizers x biofertilizers interaction revealed the significant influence of F75 x AVP with respect to TFLP which was on par with F75 x VAM. At 12 and 16 MAP also, a similar trend was observed (Table 37). The significant influence of green manure x biofertilizer is clearly brought about in Table 38. The combination

Table 12 Fresh leaf production (kg ha^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Total
Levels of inorganic fertilizers							
F_{50}	4773	4604	2459	5273	2810	3771	23094
F_{75}	5098	5173	2686	5918	3207	3463	25548
F_{100}	5183	5090	2511	6115	3022	3424	25348
SEm ±	61.03	285.06	44.73	135.72	83.63	67.18	358.32
C.D (0.05)	189.97	NS	139.24	422.42	260.32	209.11	1115.31
Green manuring							
GMI	5359	5319	2603	6625	3198	3502	26609
GMC	5468	6070	2690	6555	3367	3546	27699
GML	5348	4938	2719	6091	3215	3627	25940
GM_0	3899	3496	2196	3804	2273	2737	18406
SEm ±	70.47	329.16	51.65	156.72	96.57	77.57	413.75
C.D.(0.05)	219.36	1024.54	160.79	487.80	300.59	241.46	1281.86
Biofertilizers							
AZO	5254	4983	2337	5685	2877	3332	24471
VAM	5654	3217	2796	7391	3637	3767	29464
PSB	4914	1442	2400	4843	2709	3041	22051
AVP	5899	6349	2943	7643	3868	4054	30758
BF_0	3370	3089	2285	3282	1975	2570	16574
SEm ±	96.73	151.78	61.38	140.44	120.37	118.07	282.61
C.D.(0.05)	268.14	420.51	170.13	389.29	333.66	327.26	783.35

MAP - Months after planting

GMC x AVP resulted in the highest TFLP which was on par with GMI x AVP and GMC x VAM. When AVP was clubbed with any of the green manure treatments (GMI x AVP at 12 and 21 MAP, GMC x AVP at 15 and 23 MAP and GML x AVP at 16 MAP) it resulted in maximum FLP (Table 39).

4.1.7. Leaf dry matter production

Observations recorded on leaf dry matter production (LDMP) at 12, 15, 16, 21, 23 and 24 MAP and total leaf dry matter production (TLDMP) are furnished in Table 13. Significant influence of inorganic fertilizers was observed on LDMP at all stages except at 15 and 24 MAP and on TLDMP. In all the above cases application of F_{75} was on par with F_{100}. Green manures and biofertilizers exerted significant influence on LDMP. *In situ* cultivation and *in situ* composting of cowpea resulted in maximum TLDMP but was on par with *in situ* cultivation and incorporation of cowpea. Combined application of Azospirillum, VAM and PSB produced significantly higher TLDMP. Throughout the period of growth the above treatment was on par with single inoculation of VAM. The yield increase was 4744 and 4325 kg/ha for AVP and VAM, respectively over BF_0 (Fig. 7).

TLDMP and LDMP (at 12 MAP) were influenced by the interaction between inorganic fertilizers x green manures. The combination F_{75} x GMC recorded maximum TLDMP (on par with F_{100} x GMI and F_{75} x GMI) and LDMP at 12 and 15 MAP (on par with F_{100} x GMI, F_{100} x GMC, F_{100} x GML, F_{75} x GMI, F_{75} x GML and F_{50} x GMC) (Table 36 and Fig 9). Inorganic fertilizer x biofertilizer interaction was also significant. Highest LDMP was observed with F_{75} x AVP at 12 and 16 MAP. The same treatment showed the highest TLDMP which was on par with F_{75} x VAM (Table 37 and Fig 10). The interaction effect of combined application of green

Table 13 Leaf dry matter production (kg ha^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Total
Levels of inorganic fertilizers							
F_{50}	1549	1530	746	1846	952	1076	7702
F_{75}	1652	1696	831	2094	1095	1160	8532
F_{100}	1682	1659	777	2158	1024	1159	8461
SEm ±	18.09	96.40	18.59	47.98	30.53	24.88	120.56
C.D (0.05)	56.32	NS	57.89	149.36	95.04	NS	375.26
Green manuring							
GMI	1733	1752	808	2337	1074	1185	8891
GMC	1771	1980	828	2310	1158	1180	9229
GML	1731	1622	834	2143	1108	1226	8666
GM_0	1276	1159	670	1341	756	934	6138
SEm ±	20.89	111.31	21.47	55.41	35.26	28.733	139.21
C.D.(0.05)	65.03	346.47	66.84	172.47	109.75	89.43	433.30
Biofertilizers							
AZO	1696	1653	716	1995	968	1123	8154
VAM	1829	2038	859	2606	1247	1278	9860
PSB	1587	1359	739	1700	918	1024	7329
AVP	1914	2073	908	2701	1315	1366	10279
BF_0	1112	1019	703	1162	671	866	5535
SEm ±	33.82	51.28	20.03	49.16	41.90	40.29	98.49
C.D.(0.05)	93.75	142.15	55.54	136.27	116.14	193.43	272.99

MAP - Months after planting

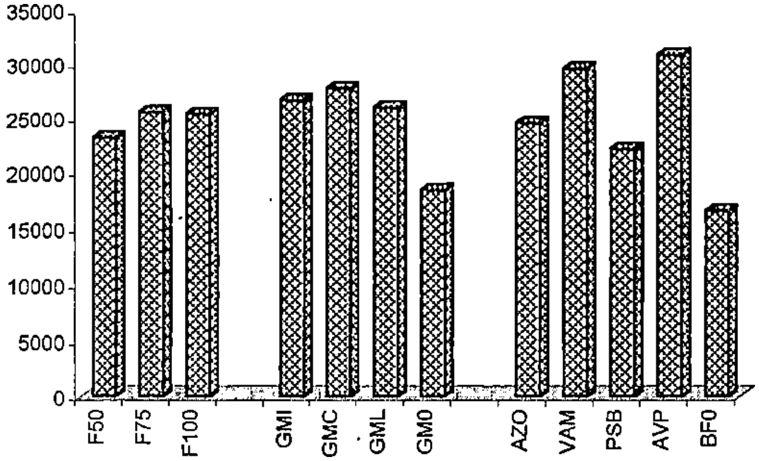


Fig 6 TFLP(kg/ha) as influenced by levels of inorganic fertilizers, green manures and biofertilizers

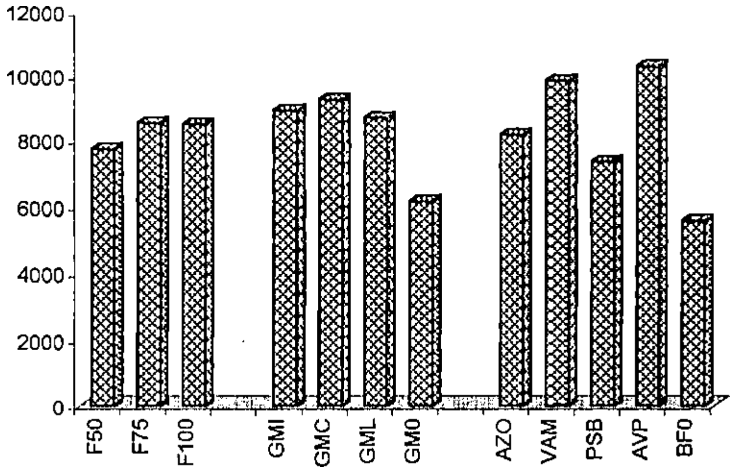


Fig 7 TLDMP(kg/ha) as influenced by levels of inorganic fertilizers, green manures and biofertilizers

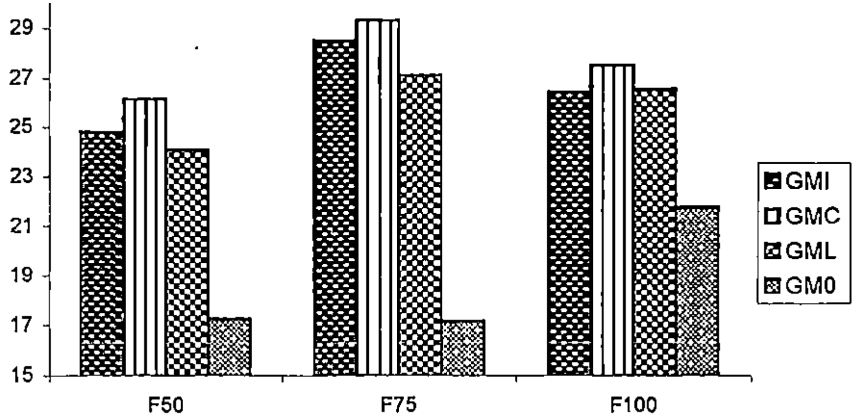


Fig 8 TFLP(t/ha) as influenced by the interaction effect of fertilizers and green manuring

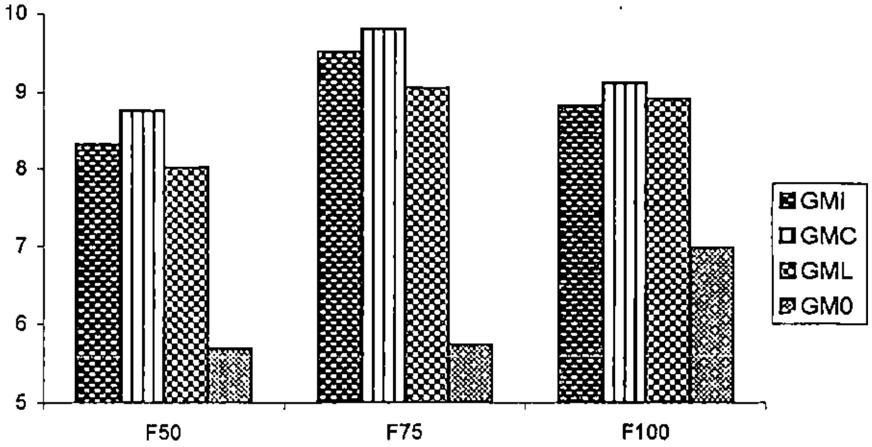


Fig 9 TLDMP(t/ha) as influenced by the interaction effect of fertilizers and green manuring

manures x biofertilizers also assumed significance in the majority of cases. GMC x AVP at 12, 15 and 23 MAP and GMI x AVP at 16 and 21 MAP recorded maximum LDMP. The same treatment combination (GMC x AVP) gave the highest TLDMP which was on par with GMI x AVP and GMC x VAM (Table 38 and Fig 14).

4.1.8. Stem dry matter production

The effects of treatments on stem dry matter production (SDMP) at 12, 15, 16, 21, 23 and 24 MAP and total stem dry matter production (TSDMP) are given in Table 14.

SDMP at 12, 15, 21 and 24 MAP and TSDMP were found to be significantly affected by levels of inorganic fertilizers. F75 produced maximum TSDMP which was on par with F100. SDMP at all stages except 16 MAP and TSDMP were also significantly influenced by green manures. The highest TSDMP was observed with GMC followed by GML. Almost a similar trend was observed at other stages of crop growth. The significant effect of biofertilizers was evident throughout crop growth and combined application of AZO, VAM and PSB resulted in maximum TSDMP (Fig. 11).

The inorganic fertilizers x green manure interaction effect was significant on TSDMP (Fig 46) and SDMP (at 12, 21 and 24 MAP). F75 x GMC which was on par with F100 x GMC, F100 x GM0 and F75 x GML recorded maximum TSDMP. The same treatment (F75 x GMC) at 12 (on par with F100 x GML and F75 x GMI) and 21 MAP (F100 x GMC, F75 x GMI, F75 x GML and F50 x GMI) recorded higher SDMP (Table 36). With respect to inorganic fertilizer x biofertilizer, F75 x AVP which was on par with F75 x VAM, F100 x AVP and F75 x VAM at 16, 21, 23 and 24 MAP produced maximum SDMP (Table 37). TSDMP was highest in the combination F75 x VAM which was on par with F100 x AVP and F75 x AVP (Table 37). Green

Table 14 Stem dry matter production (kg ha^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Total
Levels of inorganic fertilizers							
F_{50}	1562	1519	84	2132	982	1113	7395
F_{75}	1739	1607	83	2317	990	1280	8019
F_{100}	1733	1684	83	2278	1043	1291	8114
SEm ±	33.60	37.43	1.85	25.27	26.58	14.60	74.76
C.D (0.05)	104.60	116.53	NS	78.67	NS	45.44	232.70
Green manuring							
GMI	1813	1814	84	2448	1063	1232	8456
GMC	1826	1757	87	2475	1051	1303	8504
GML	1752	1743	89	2352	1018	1334	8290
GM_0	1321	1099	74	1695	890	1040	6121
SEm ±	38.80	43.23	2.14	29.18	30.69	16.85	86.32
C.D.(0.05)	120.78	134.56	NS	90.85	95.54	52.57	268.70
Biofertilizers							
AZO	1702	1600	80	2148	980	1170	7683
VAM	1898	2005	88	2793	1106	1413	9306
PSB	1651	1328	80	1938	960	1143	7103
AVP	1986	2101	89	2902	1153	1450	9684
BF_0	1153	981	80	1423	827	962	5438
SEm ±	42.21	46.73	1.34	56.95	28.83	42.53	107.34
C.D.(0.05)	117.01	129.53	3.73	157.87	79.93	117.89	297.54

MAP - Months after planting

manure x biofertilizer interaction revealed the superior performance of GMC x AVP (on par with GMI x AVP, GMC x VAM and GML x AVP)with respect to TSDMP (Table 38). At all stages of growth except 21 MAP significant effect was observed on SDMP and GMI x AVP at 12 and 15 MAP, GMC x AVP at 16 MAP, GMC x VAM at 23 MAP and GML x AVP at 24 MAP recorded higher SDMP (Table 38). F75 x GMC x AVP combination proved its superiority at 16 MAP (Table 39).

4.1.9. Root dry matter production

The data on root dry matter production (RDMP) at 12, 15, 16, 21, 23 and 24 MAP are presented in Table 15.

The significant effect of inorganic fertilizers on RDMP was evident from 15 MAP. Though application of F100 recorded maximum RDMP in all except at 24 MAP it was on par with F75 at all stages. The effect of green manure was significant and all the three green manuring methods were on par when compared to no green manure treatment throughout the period of growth. Application of any one of the biofertilizers or the combined application of all the biofertilizers were found to increase the RDMP significantly at all stages over no application. VAM performed significantly better than AZO and PSB consistently and was at par with AVP (Fig. 12).

Interaction effect of inorganic fertilizer x biofertilizer was significant. Though F100 x AVP produced highest RDMP at all stages of growth it was at par with F100 x VAM, F75 x VAM and F75 x AVP (Table 37 and Fig 13). Green manure x biofertilizer interaction effect was also significant with respect to RDMP at 15, 16, 23 and 24 MAP. Highest RDMP was recorded by GMC x AVP and this was on par with GMI x VAM, GMI x AVP and GMC x VAM (Table 38). Integrated nutrient management recorded the significance of F100 x GMC x AVP at 16 MAP which was on par with

Table 15 Root dry matter production (kg ha^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	1653	1942	2211	3015	3886	4860
F75	1868	2164	2504	3287	4168	5100
F100	1836	2287	2540	3298	4183	5032
SEm ±	60.19	73.31	64.58	31.18	45.66	53.89
C.D (0.05)	NS	228.20	201.03	97.07	142.12	167.76
Green manuring						
GMI	1887	2252	2527	3425	4311	5259
GMC	1909	2428	2641	3342	4190	5135
GML	1950	2250	2578	3379	4277	5098
GM0	1396	1593	1927	2654	3538	4528
SEm ±	69.50	84.65	74.57	36.01	52.72	52.23
C.D.(0.05)	216.33	263.50	232.13	112.09	164.11	193.71
Biofertilizers						
AZO	1810	2085	2426	3161	4066	5011
VAM	2026	2494	2836	3613	4495	5343
PSB	1635	1826	2155	2899	3741	4684
AVP	2119	2614	2820	3704	4562	5422
BF0	1339	1634	1853	2623	3532	4527
SEm ±	50.88	62.85	62.66	49.82	58.86	56.17
C.D.(0.05)	141.05	174.22	173.68	138.10	163.86	155.71

MAP - Months after planting

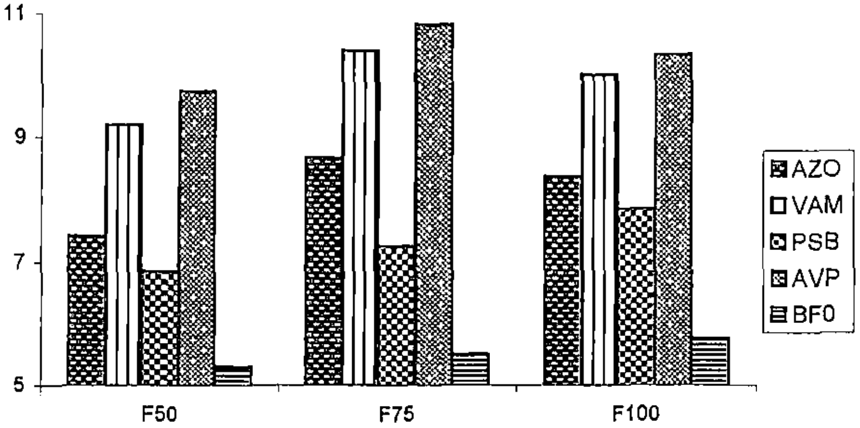


Fig 10 TLDMP(t/ha) as influenced by the interaction effect of fertilizers and biofertilizers

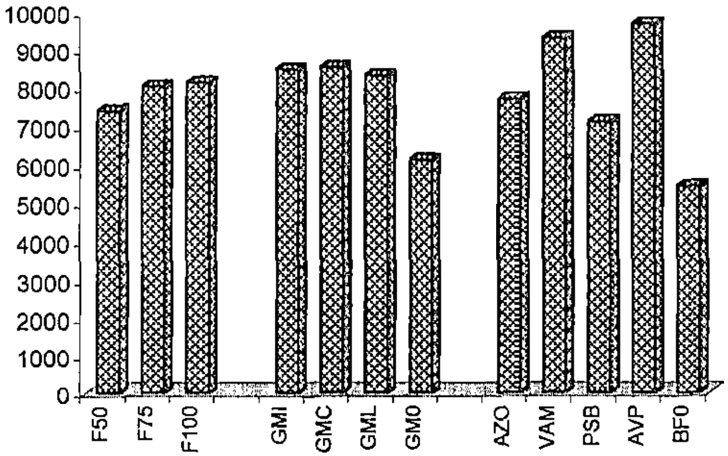


Fig 11 TSDMP(kg/ha) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

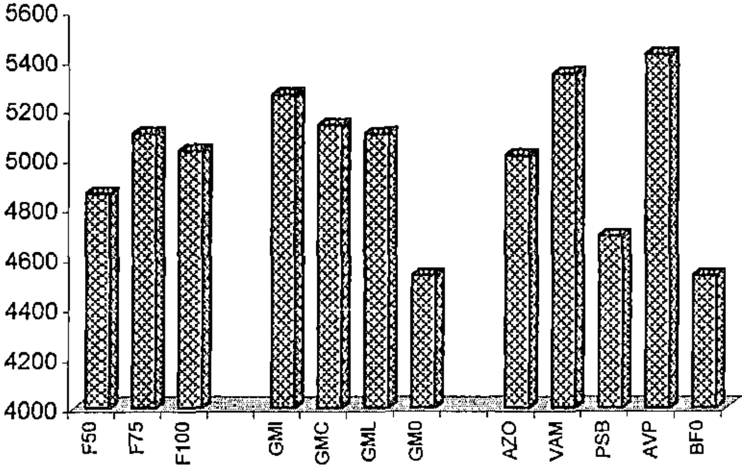


Fig 12 RDMP (kg/ha) at 24 MAP as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

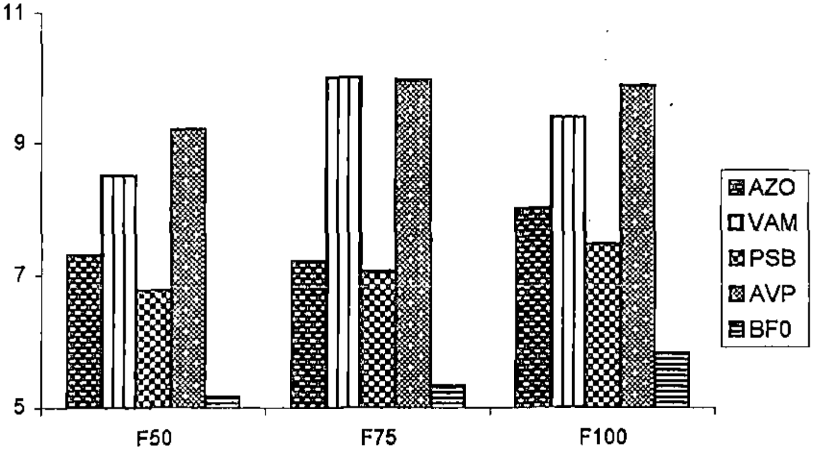


Fig 13 TSDMP(t/ha) as influenced by the interaction effect of fertilizers and biofertilizers

F100 x GMI x AVP, F100 x GML x VAM, F75 x GMI x VAM, F75 x GMI x AVP and F75 x GMC x AVP (Table 39).

The partitioning of dry matter into leaf, stem and root as influenced by inorganic fertilizers, green manuring and biofertilizers is depicted in Fig 26. F75, GMC and AVP resulted in higher LDMP compared to other treatments.

4.1.10. Net assimilation rate

Data on net assimilation rate (NAR) recorded at 12, 15, 16, 21, 23 and 24 MAP are furnished in Table 16.

The effect of inorganic fertilizers on NAR was insignificant in four out of six harvests (15,16,21 and 23 MAP). F50 which was on par with F75 showed maximum NAR at 12 and 24 MAP. NAR was not influenced by green manures and cultivation without green manure gave higher NAR from 16 MAP. Similarly, this character was not influenced by biofertilizer inoculation and the control gave significantly higher values. At 15 MAP, VAM produced significant effect on NAR but was on par with PSB.

The interaction between inorganic fertilizers x biofertilizers was significant at 12 MAP alone and the treatment combination F50 x BF0 gave maximum NAR (Table 37). With respect to green manure x biofertilizer interaction, the effect was significant only at 12 MAP and the treatment combination GMC x BF0 produced maximum NAR (Table 38).

4.1.11. Relative growth rate

Data relating to relative growth rate (RGR) observed at 12, 15, 16, 21, 23 and 24 MAP are given in Table 17.

Table 16 Net assimilation rate (mg^{-1} cm^{2} day^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	0.03	0.05	0.24	0.05	0.05	0.30
F75	0.03	0.05	0.24	0.05	0.06	0.27
F100	0.02	0.06	0.18	0.04	0.05	0.23
SEm ±	0.0010	0.0033	0.0118	0.0028	0.0027	0.0133
C.D (0.05)	0.0031	NS	NS	NS	NS	0.0413
Green manuring						
GMI	0.02	0.05	0.18	0.05	0.05	0.02
GMC	0.03	0.06	0.18	0.05	0.05	0.23
GML	0.03	0.05	0.21	0.05	0.05	0.24
GMo	0.03	0.05	0.30	0.06	0.06	0.38
SEm ±	0.0011	0.0038	0.0137	0.0032	0.0032	0.0154
C.D.(0.05)	0.0034	NS	0.0426	0.0099	NS	0.0479
Biofertilizers						
AZO	0.03	0.05	0.17	0.05	0.05	0.24
VAM	0.02	0.06	0.17	0.04	0.05	0.21
PSB	0.03	0.05	0.21	0.05	0.05	0.28
AVP	0.02	0.06	0.13	0.01	0.05	0.22
BFo	0.04	0.04	0.42	0.07	0.06	0.39
SEm ±	0.0014	0.0024	0.0165	0.0035	0.0042	0.0153
C.D.(0.05)	0.0038	0.0066	0.0457	0.0097	NS	NS

MAP - Months after planting

Table 17 Relative growth rate (mg^{-1} g^{-1} day^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	64.42	17.58	11.79	7.12	4.44	18.04
F75	71.42	17.11	1353.	7.89	4.92	18.89
F100	71.27	18.41	11.61	8.28	4.55	17.40
SEm ±	1.40	0.81	0.82	0.51	0.19	0.40
C.D (0.05)	4.36	NS	NS	NS	NS	NS
Green manuring						
GMI	7384	18.48	11.13	8.14	4.56	17.16
GMC	74.88	20.16	11.55	8.70	5.08	18.21
GML	73.86	17.54	12.78	8.17	4.77	18.19
GM0	53.56	14.61	13.78	6.06	4.14	18.88
SEm ±	1.61	0.93	0.95	0.59	0.22	0.46
C.D.(0.05)	5.04	2.91	NS	1.86	NS	NS
Biofertilizers						
AZO	70.68	17.63	11.77	7.86	4.49	18.19
VAM	78.36	20.76	11.43	9.15	5.37	18.59
PSB	65.95	13.84	12.87	7.48	4.51	18.35
AVP	82.11	20.69	9.71	8.70	5.38	18.54
BF0	48.07	15.56	15.78	5.64	3.44	16.87
SEm ±	1.50	0.96	1.00	0.22	0.27	0.80
C.D.(0.05)	4.18	2.67	2.79	0.63	0.75	NS

MAP - Months after planting

RGR was significantly influenced by inorganic fertilizers only at 12 MAP. F75 (on par with F100) resulted in maximum RGR. The significant effect of green manure was evident at 12, 15 and 21 MAP and in all the harvests *in situ* cultivation and *in situ* composting of cowpea showed its superiority over control. The effect of biofertilizer was pronounced on RGR and combined application of Azospirillum, VAM and PSB (on par with VAM) recorded the maximum value at 12, 15 and 23 MAP. At 21 MAP, VAM showed the highest value but was on par with the above treatment.

The interaction effect of green manure x biofertilizer was significant at 12, 15 and 21 MAP. At 12 MAP the combination, GMI x AVP (on par with GMI x VAM, GMC x VAM, GMC x AVP and GML x VAM) and at 15 and 21 MAP, the combinations GMC x AVP (on par with GMI x VAM, GMC x VAM and GML x VAM) and GMC x VAM respectively, indicated higher RGR (Table 38).

4.1.12. Crop growth rate

The data pertaining to crop growth rate (CGR) at different stages of crop growth are presented in Table 18.

The effect of inorganic fertilizers on CGR was evident at 12, 21 and 24 MAP and at all these stages the maximum doze of NPK ie., F100 resulted in the highest CGR. The effect of green manure on CGR was remarkable at 12, 21, 23 and 24 MAP and at all the four growth stages *in situ* cultivation and *in situ* composting of cowpea which was on par with the other two green manure treatments recorded significantly higher values when compared to control. The impact of biofertilizers on CGR is quite evident at 12, 15, 21, 23 and 24 MAP. At all the above growth stages combined application of Azospirillum, VAM and PSB produced higher CGR but was on par with single inoculation of VAM.

The effect of interaction between green manure x biofertilizer was significant at 15, 21 and 23 MAP. The combination which recorded maximum CGR, GMC x AVP

Table 18 Crop growth rate (g^{-1} m^{2} day^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	1.25	3.30	2.52	2.43	2.06	8.21
F75	1.35	3.73	3.15	2.80	2.39	7.09
F100	1.38	3.91	2.82	2.84	2.25	8.54
SEm ±	0.02	0.15	0.19	0.08	0.09	0.18
C.D (0.05)	0.08	NS	NS	0.25	NS	0.58
Green manuring						
GMI	1.43	4.06	2.74	3.02	2.32	8.64
GMC	1.45	4.40	2.94	3.07	2.53	9.03
GML	1.43	3.85	3.12	2.89	2.40	8.99
GM0	1.04	2.39	2.54	1.77	1.70	7.80
SEm ±	0.03	0.17	0.22	0.09	0.11	0.21
C.D.(0.05)	0.09	0.55	NS	0.28	0.34	0.67
Biofertilizers						
AZO	1.37	3.62	2.76	2.63	2.11	8.53
VAM	1.52	4.74	3.17	3.48	2.79	9.56
PSB	1.28	2.76	2.68	2.28	1.98	8.07
AVP	1.59	4.91	2.79	3.50	2.88	9.78
BF0	0.94	2.34	2.77	1.55	1.41	7.13
SEm ±	0.29	0.14	0.23	0.06	0.12	0.28
C.D.(0.05)	0.08	0.39	NS	0.18	0.34	0.80

MAP - Months after planting

at 15 and 21 MAP was on par with GMI x VAM, GMI x AVP and GMC x VAM. At 23 MAP the combination GMC x VAM showed the highest CGR but was on par with GMI x VAM, GMI x AVP, GMC x AVP and GML x AVP (Table 38).

4.1.13. Specific leaf weight

Data relating to specific leaf weight (SLW) recorded at 12, 15, 16, 21, 23 and 24 MAP are given in Table 19.

Inorganic fertilizers influenced SLW at 12, 16 and 21 MAP and at all the three growth stages F_{50} and F_{75} were on par and showed significantly higher SLW when compared to F_{100}. The effect of green manure on SLW was not evident in many cases and crop cultivation without green manure resulted in significantly higher values at 12, 16, 21 and 24 MAP. However, at 15 MAP, *in situ* cultivation and composting of cowpea recorded the highest SLW. The effect of biofertilizer on SLW was not noticed at any of the growth stages except at 15 MAP. At other stages of growth, crop cultivation without biofertilizer inoculation assumed importance and resulted in significantly higher SLW when compared to inoculated plants.

The interaction, inorganic fertilizer x green manure assumed importance at 12 MAP and the treatment combination F_{50} x GMC which was on par with F_{50} x GM_0 showed the highest SLW (Table 36). With respect to inorganic fertilizer x biofertilizer interaction, the treatment combination F_{50} x BF_0 resulted in higher SLW at 12 and 16 MAP and differed significantly from all other treatments (Table 37). Green manure x biofertilizer interaction assumed importance at 12 and 16 MAP. At 12 MAP, the treatment combination GM_0 x BF_0 (on par with GML x BF_0) and GMN x BF_0 (on par with GMI x BF_0 and GML x BF_0) at 16 MAP indicated higher SLW (Table 38)

Table 19 Specific leaf weight (mg^{-1} cm^2) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	4.16	2.57	6.67	4.43	2.64	3.47
F75	3.58	2.49	6.29	4.17	2.70	3.47
F100	3.48	2.58	5.05	3.71	2.46	3.17
SEm ±	0.09	0.20	0.26	0.14	0.07	0.16
C.D (0.05)	0.29	NS	0.80	0.46	NS	NS
Green manuring						
GMI	3.31	2.54	5.37	4.06	2.41	3.03
GMC	3.78	2.87	5.16	3.79	2.71	3.02
GML	3.72	2.37	5.59	3.75	2.53	3.26
GM0	4.16	2.42	7.89	4.80	2.76	4.57
SEm ±	0.10	0.23	0.30	0.17	0.08	0.18
C.D.(0.05)	0.34	NS	0.94	0.54	0.27	0.58
Biofertilizers						
AZO	3.80	2.59	4.56	3.85	2.61	3.15
VAM	2.95	2.78	4.55	3.66	2.48	2.92
PSB	3.98	2.63	5.75	4.07	2.45	3.59
AVP	2.78	2.61	4.36	3.52	2.54	3.05
BF0	5.19	2.14	10.79	5.40	2.92	4.30
SEm ±	0.17	0.10	0.28	0.21	0.15	0.15
C.D.(0.05)	0.48	0.28	0.78	0.60	NS	0.44

MAP - Months after planting

4.1.14. Root shoot ratio

The data on root shoot ratio (RSR) recorded at 12, 15, 16, 21, 23 and 24 MAP are provided in Table 20.

The significant effect of inorganic fertilizer was evident on RSR only at two stages ie, 21 and 24 MAP. Under both situations, F50 which was on par with F75 recorded higher values compared to the highest doze. *In situ* cultivation of cowpea and green leaf manuring had no effect on RSR and at both the above stages treatments without green manure recorded significantly higher RSR. Biofertilizers did not influence RSR in most cases and crop cultivation without any biofertilizer resulted in remarkably higher RSR.

The interaction effect of inorganic fertilizer x green manure was significant only at 24 MAP and maximum RSR was recorded in the combination F75 x GM0 (Table 36).

4.1.15. Harvest index

The mean values of harvest index (HI) recorded at 12, 15, 16, 21, 23 and 24 MAP are provided in Table 21.

Inorganic fertilizers showed no significant influence on HI in five out of six harvests. Application of green manure enhanced HI significantly over no green manuring at 21 and 23 MAP. Remarkable influence of biofertilizers was evident on HI at 16, 21 and 23 MAP and in all the three situations combined application of Azospirillum, VAM and PSB and single inoculation of VAM were on par and differed significantly from the control.

HI was not influenced by any of the interaction effects between treatment components..

Table 20 Root shoot ration as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	0.54	0.66	2.68	0.83	2.08	2.28
F75	0.56	0.70	2.74	0.80	2.08	2.20
F100	0.54	0.72	3.02	0.77	2.08	2.09
SEm ±	0.01	0.02	0.08	0.01	0.04	0.02
C.D (0.05)	NS	NS	NS	0.04	NS	0.08
Green manuring						
GMI	0.54	0.65	2.86	0.75	2.08	2.23
GMC	0.53	0.67	2.89	0.74	1.96	2.14
GML	0.57	0.71	2.83	0.80	2.09	2.06
GM0	0.55	0.73	2.65	0.90	2.01	2.34
SEm ±	0.01	0.03	0.10	0.01	0.05	0.03
C.D.(0.05)	NS	NS	NS	0.04	NS	0.10
Biofertilizers						
AZO	0.54	0.66	3.07	0.78	2.12	2.21
VAM	0.54	0.63	3.01	0.69	1.96	2.03
PSB	0.51	0.69	2.71	0.82	2.05	2.20
AVP	0.54	0.64	2.86	0.68	1.89	1.97
BF0	0.59	0.83	2.39	1.03	2.37	2.54
SEm ±	0.01	0.02	0.08	0.02	0.06	0.06
C.D.(0.05)	0.03	0.05	0.24	0.05	0.18	0.17

MAP - Months after planting

Table 21 Harvest index (%) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	50.08	49.55	89.75	46.05	48.60	48.55
F75	48.85	50.43	90.70	46.70	50.95	47.75
F100	49.25	49.48	90.10	48.08	49.18	47.08
SEm ±	0.49	1.53	0.26	0.62	0.43	0.64
C.D (0.05)	NS	NS	NS	NS	1.34	NS
Green manuring						
GMI	48.90	48.87	90.37	48.43	49.67	48.80
GMC	49.30	53.10	90.30	47.90	51.47	47.70
GML	49.93	47.53	90.10	47.20	51.40	47.60
GM0	49.43	49.77	89.77	44.23	45.77	47.47
SEm ±	0.57	1.76	0.30	0.72	0.49	0.75
C.D.(0.05)	NS	NS	NS	2.24	1.54	NS
Biofertilizers						
AZO	50.08	50.38	89.75	47.79	49.50	48.75
VAM	49.25	50.29	90.63	47.96	52.71	47.96
PSB	40.04	49.33	90.08	46.71	47.96	47.42
AVP	49.08	49.58	90.75	47.33	52.83	48.38
BF0	49.50	49.50	89.71	44.92	44.88	46.96
SEm ±	0.59	0.95	0.17	0.68	0.84	1.03
C.D.(0.05)	NS	NS	0.48	1.89	2.34	NS

MAP - Months after planting

Table 22 Leaf moisture loss (%) after three hours of harvest as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Mean
Levels of inorganic fertilizers							
F50	8.13	8.15	7.28	9.20	7.68	7.58	7.99
F75	8.25	7.95	7.10	9.20	7.70	7.58	7.96
F100	8.43	7.93	6.95	8.88	7.55	7.73	7.1
SEm ±	0.12	0.74	0.13	0.21	0.22	0.15	0.06
C.D (0.05)	NS	NS	NS	NS	NS	NS	NS
Green manuring							
GMI	8.27	7.97	7.07	8.83	7.47	7.80	7.89
GMC	8.33	7.93	7.30	9.00	7.80	7.50	7.98
GML	8.23	7.97	7.17	9.07	7.87	7.40	7.95
GMo	8.23	8.17	6.90	9.47	7.43	7.80	7.99
SEm ±	0.14	0.08	0.15	0.25	0.25	0.18	0.07
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS
Biofertilizers							
AZO	8.13	7.92	7.00	9.08	7.79	7.71	7.94
VAM	8.38	8.08	7.08	9.13	7.79	7.46	7.99
PSB	8.13	7.83	7.21	9.13	7.63	7.58	7.92
AVP	8.50	8.13	7.17	9.08	7.46	7.67	8.00
BFo	8.21	8.08	7.08	9.04	7.54	7.71	7.95
SEm ±	0.14	0.16	0.13	0.12	0.13	0.13	0.05
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 23 Leaf moisture loss (%) after six hours of harvest as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Mean
Levels of inorganic fertilizers							
F50	14.98	14.45	12.78	19.43	17.48	15.55	15.78
F75	15.88	14.30	13.38	19.08	17.50	15.45	15.93
F100	15.80	14.30	13.30	19.13	17.30	15.75	15.92
SEm ±	0.22	0.26	0.20	0.27	0.23	0.21	0.07
C.D (0.05)	0.70	NS	NS	NS	NS	NS	NS
Green manuring							
GMI	15.83	14.53	13.03	19.33	17.07	15.63	15.91
GMC	15.43	13.93	13.73	19.33	17.73	15.43	15.93
GML	15.57	14.87	12.83	19.20	17.60	15.63	15.95
GM0	15.37	14.07	13.00	18.97	17.30	15.63	15.72
SEm ±	0.26	0.30	0.23	0.31	0.26	0.24	0.08
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS
Biofertilizers							
AZO	15.21	14.21	13.21	19.08	17.25	15.63	15.77
VAM	15.71	14.46	13.13	19.29	17.42	15.25	15.87
PSB	15.46	14.29	13.17	19.00	17.58	15.71	15.86
AVP	16.33	14.38	13.04	19.38	17.33	15.88	16.06
BF0	15.04	14.42	13.21	19.29	17.54	15.46	15.83
SEm ±	0.26	0.19	0.13	0.21	0.12	0.25	0.07
C.D.(0.05)	0.72	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 24 Leaf moisture loss (%) after nine hours of harvest as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Mean
Levels of inorganic fertilizers							
F_{50}	25.20	23.08	18.33	28.33	27.35	25.38	24.61
F_{75}	25.63	24.10	18.65	28.60	26.78	24.78	24.75
F_{100}	25.48	22.45	18.60	28.40	27.25	25.00	24.53
SEm ±	0.29	0.70	0.24	0.22	0.18	0.29	0.15
C.D (0.05)	NS	NS	NS	NS	NS	NS	NS
Green manuring							
GMI	25.57	22.60	18.10	28.70	27.20	24.47	24.44
GMC	24.97	23.97	18.93	28.43	27.17	25.17	24.77
GML	25.37	23.60	18.60	28.17	27.03	25.37	24.69
GM_0	25.83	22.67	18.47	28.47	27.10	25.20	24.62
SEm ±	0.34	0.81	0.28	0.26	0.21	0.33	0.17
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS
Biofertilizers							
AZO	25.83	22.68	18.71	28.29	27.17	24.71	24.71
VAM	25.17	22.59	18.54	28.67	27.17	25.08	24.63
PSB	25.88	23.16	18.42	28.33	27.08	25.25	24.71
AVP	24.54	22.10	18.50	28.54	27.00	25.38	24.48
BF_0	25.75	22.92	18.46	28.38	27.21	24.83	24.63
SEm ±	0.28	0.19	0.19	0.19	0.10	0.31	0.11
C.D.(0.05)	0.78	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 25 Leaf moisture loss (%) after twelve hours of harvest as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Mean
Levels of inorganic fertilizers							
F50	30.98	29.85	29.45	36.68	35.80	33.50	32.71
F75	30.88	31.55	29.90	36.43	35.78	32.78	32.88
F100	31.03	29.23	29.63	36.15	35.70	33.65	32.56
SEm ±	0.24	0.60	0.31	0.19	0.19	0.52	0.17
C.D (0.05)	NS	1.86	NS	NS	NS	NS	NS
Green manuring							
GMI	30.77	29.47	29.37	36.60	35.90	32.57	32.45
GMC	31.07	30.77	29.93	36.37	36.10	33.27	32.92
GML	30.20	30.76	29.80	36.40	35.63	34.20	32.83
GM0	31.80	29.87	29.53	36.30	35.40	33.20	32.68
SEm ±	0.28	0.69	0.36	0.21	0.22	0.60	0.20
C.D.(0.05)	0.89	NS	NS	NS	NS	NS	NS
Biofertilizers							
AZO	31.21	30.29	29.58	36.38	35.92	33.46	32.81
VAM	30.88	30.83	29.63	36.46	35.38	32.92	32.68
PSB	31.00	29.46	29.83	36.50	35.92	33.25	32.66
AVP	30.42	30.08	29.79	36.38	35.88	33.67	32.70
BF0	31.29	30.38	29.46	36.38	35.71	33.25	32.74
SEm ±	0.32	0.32	0.13	0.09	0.15	0.29	0.08
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 26 Leaf moisture loss (%) after twenty four hours of harvest as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Mean
Levels of inorganic fertilizers							
F$_{50}$	56.28	54.60	49.70	53.58	55.75	54.05	53.99
F$_{75}$	56.85	55.98	69.85	54.10	56.38	54.48	54.60
F$_{100}$	56.78	54.68	49.83	54.30	56.20	54.60	54.39
SEm ±	0.22	0.38	-	0.36	0.30	0.33	0.12
C.D (0.05)	NS	1.20	NS	NS	NS	NS	NS
Green manuring							
GMI	56.87	55.03	49.77	53.90	56.37	54.07	54.34
GMC	56.30	55.37	49.93	54.13	56.13	54.33	54.37
GML	56.83	54.77	49.60	54.20	55.93	54.27	54.27
GM$_0$	56.53	55.17	49.89	53.70	56.00	54.83	54.35
SEm ±	0.02	0.44	0.29	0.42	0.35	0.38	0.14
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS
Biofertilizers							
AZO	57.04	54.92	49.83	53.38	56.13	54.08	54.23
VAM	56.21	55.08	49.75	54.17	55.88	54.29	54.22
PSB	56.46	45.79	49.71	54.04	56.50	53.96	54.24
AVP	56.83	56.21	49.79	54.08	56.08	54.79	54.47
BF$_0$	56.63	55.42	49.88	54.29	55.96	54.75	54.49
SEm ±	0.22	0.35	0.15	0.38	0.47	0.28	0.12
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 27 Leaf moisture content (%) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	Mean
Levels of inorganic fertilizers							
F_{50}	67.48	66.78	69.55	64.95	66.25	66.03	66.92
F_{75}	67.53	67.15	69.03	64.70	65.88	66.53	66.88
F_{100}	67.55	67.45	69.13	64.70	66.13	66.13	66.92
SEm ±	0.18	0.20	0.41	0.23	0.26	0.18	0.08
C.D (0.05)	NS	NS	NS	NS	NS	NS	NS
Green manuring							
GMI	67.67	67.07	68.87	64.70	66.47	66.13	66.87
GMC	67.60	67.37	69.20	64.77	65.60	66.70	66.94
GML	67.60	67.23	69.37	64.93	65.53	66.20	66.88
GM_0	67.20	66.83	69.50	64.73	66.73	65.87	66.95
SEm ±	0.21	0.23	0.47	0.27	0.30	0.20	0.10
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS
Biofertilizers							
AZO	67.71	66.83	69.29	64.92	66.25	66.29	66.93
VAM	67.63	67.21	69.29	64.75	65.96	66.04	66.88
PSB	67.63	67.04	69.25	65.00	66.21	66.25	66.96
AVP	67.58	67.33	69.21	64.67	66.04	66.33	66.13
BF_0	67.04	67.21	69.13	64.58	65.96	66.21	66.85
SEm ±	0.23	0.19	0.13	0.11	0.22	0.19	0.01
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

4.1.16. Leaf moisture loss pattern and leaf moisture content

Leaf moisture content determined immediately after harvest and the leaf moisture loss at three, six, nine, twelve and twentyfour hours after leaf harvest recorded at 12, 15, 16, 21, 23 and 24 MAP are given in Tables 22 to 27.

In general, the main effects and interaction effects of inorganic fertilizers, green manuring methods and biofertilizers were not significant in influencing the leaf moisture loss over time and leaf moisture content of mulberry.

4.1.17. Leaf protein content

Data relating to leaf protein (LP) recorded at 12, 15, 16, 21, 23 and 24 MAP are given in Table 28.

Levels of inorganic fertilizers influenced LP and F_{100} resulted in significantly higher LP throughout crop growth except at 15 MAP. The effect of green manure was pronounced on LP from 15 MAP. *In situ* cultivation and composting of cowpea recorded significantly higher values. The effect of biofertilizer was statistically significant at all stages and combined application of Azospirillum, VAM and PSB recorded maximum LP.

Interaction effect of inorganic fertilizer x green manure indicated the superior performance of the combination, F_{100} x GMI/GMC/GML in majority of cases (Table 36). Inorganic fertilizer x biofertilizer interaction highlighted the significance of the combination F_{100} x AVP in increasing LP at 16, 21 and 24 MAP (Table 37). Green manure x biofertilizer interaction indicated the significance of F_{75} x AVP and F_{100} x AVP in improving leaf quality (Table 38). Green manure x biofertilizer interaction was significant. All the biofertilizers significantly increased LP in the presence of green manure irrespective of its method of application over no application. AVP x GMC or

Table 28 Leaf protein (%) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
Levels of inorganic fertilizers						
F50	19.94	21.38	21.75	21.31	21.56	21.38
F75	22.25	22.38	22.82	22.38	22.44	22.31
F100	22.88	23.00	23.44	22.93	23.06	22.94
SEm ±	0.73	0.07	0.06	0.06	0.05	0.04
C.D (0.05)	2.29	NS	0.20	0.19	0.17	0.15
Green manuring						
GMI	22.50	23.94	23.00	22.63	22.82	22.69
GMC	22.38	22.38	22.88	22.38	22.43	22.31
GML	22.00	22.13	22.56	22.06	22.25	22.19
GM0	19.88	21.75	22.25	21.69	21.88	21.69
SEm ±	0.85	0.09	0.07	0.07	0.06	0.05
C.D.(0.05)	NS	0.28	0.23	0.22	0.20	0.17
Biofertilizers						
AZO	21.75	22.50	22.94	22.44	22.56	22.50
VAM	22.38	22.44	22.94	22.50	22.63	22.44
PSB	21.38	22.31	22.56	22.13	22.31	22.19
AVP	22.63	22.69	23.13	22.63	22.88	22.63
BF0	20.44	21.19	21.75	21.25	21.44	21.31
SEm ±	0.40	0.08	0.06	0.06	0.06	0.05
C.D.(0.05)	1.13	0.23	0.19	0.16	0.18	0.16

MAP - Months after planting

GMI was superior to AVP x GML. Inorganic fertilizer x green manure x biofertilizer interaction revealed the significance of F75 x GMC x AVP in increasing LP (Table 39).

4.1.18. Larval characters, cocoon characters and post cocoon parameters

Mean values of leaf consumption, larval weight, cocoon weight, shell weight, shell ratio, filament length, filament weight and denier recorded at the time of silkworm rearing are provided in Table 29 and Figs 15 to 17.

Levels of nutrients exerted significant effect on all the characters studied except larval weight and denier. F100 resulted in significantly higher leaf consumption, cocoon weight, shell weight, shell ratio, filament length and filament weight when compared to the lower levels of inorganic fertilizers. The effect of green manure on leaf consumption, larval weight, cocoon weight, shell weight and filament weight was quite remarkable and in general, *in situ* cultivation and incorporation or *in situ* composting of cowpea gave significantly higher values over green leaf manuring and no green manuring. The significant effect of biofertilizer was evident on leaf consumption, larval weight, cocoon weight, shell weight, shell ratio and filament weight. Combined application of Azospirillum, VAM and PSB was favourable for improving the above characters when compared to no application of biofertilizers.

4.1.19. Leaf nitrogen content and uptake

Content and uptake of nitrogen (NUP) by leaf at various stages and total nitrogen uptake (TNUP) are furnished in Table 30.

There was significant difference in the nitrogen content of leaves at all harvests. The plants received F100 had 7.31 to 14.73 % higher nitrogen content in different harvests over F50. Nitrogen content at F100 and F75 also showed significant difference at all harvests except at 12 MAP. Similarly, the green manuring treatments also resulted

Table 29 Larval characters, cocoon characters and post-cocoon parameters as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	Leaf con. (g)	Larvel wt. (g)	Coco. wt. (g)	Shell wt. (g)	Shell ratio	Filament length (cm)	Filament wt. (g)	Denier
Levels of inorganic fertilizers								
F50	1658	2.54	1.40	0.175	12.48	423	0.123	2.614
F75	1767	2.55	1.53	0.218	14.08	488	0.146	2.676
F100	1876	2.66	1.62	0.256	15.78	557	0.168	2.705
SEm ±	13.786	0.024	0.023	0.0040	0.222	4.616	0.0023	0.0198
C.D (0.05)	42.912	NS	0.071	0.0124	0.693	14.369	0.0071	NS
Green manuring								
GMI	1843	2.64	1.58	0.231	14.50	510	0.153	2.679
GMC	1778	2.64	1.58	0.226	14.14	504	0.151	2.684
GML	1749	2.55	1.46	0.210	14.27	477	0.142	2.673
GM0	1696	2.49	1.44	0.196	13.54	465	0.136	2.626
SEm ±	15.921	0.028	0.026	0.0046	0.257	50.330	0.0027	0.229
C.D.(0.05)	44.132	0.079	0.074	0.012	NS	NS	0.0074	NS
Biofertilizers								
AZO	1806	2.63	1.56	0.23	14.53	507	0.152	2.685
VAM	1799	2.59	1.53	0.226	14.62	508	0.151	2.667
PSB	1727	2.55	1.48	0.212	14.17	485	0.145	2.667
AVP	1849	2.62	1.58	0.229	14.28	506	0.151	2.674
BF0	1653	2.53	1.41	0.183	12.96	440	0.129	2.625
SEm ±	14.305	0.018	0.014	0.0032	0.235	50.479	0.0020	0.013
C.D.(0.05)	39.651	0.051	0.039	0.0088	0.653	NS	0.0055	NS

MAP - Months after planting

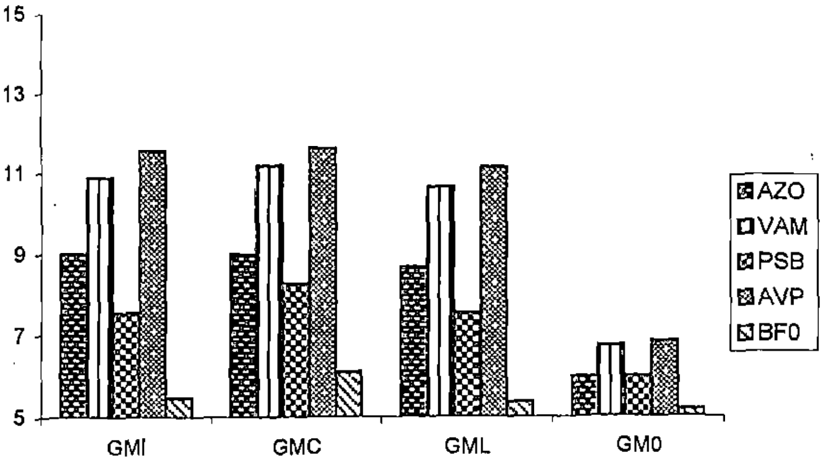


Fig 14 TLDMP(t/ha) as influenced by the interaction effect of green manuring and biofertilizers

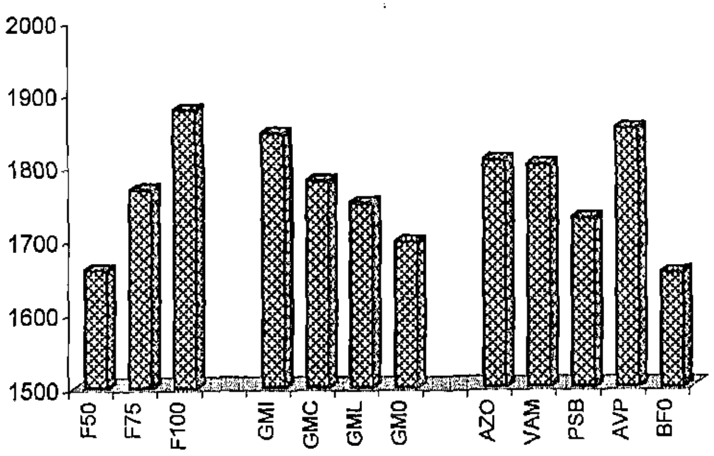


Fig 15 Leaf consumption(g /100) silkworm larvae as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

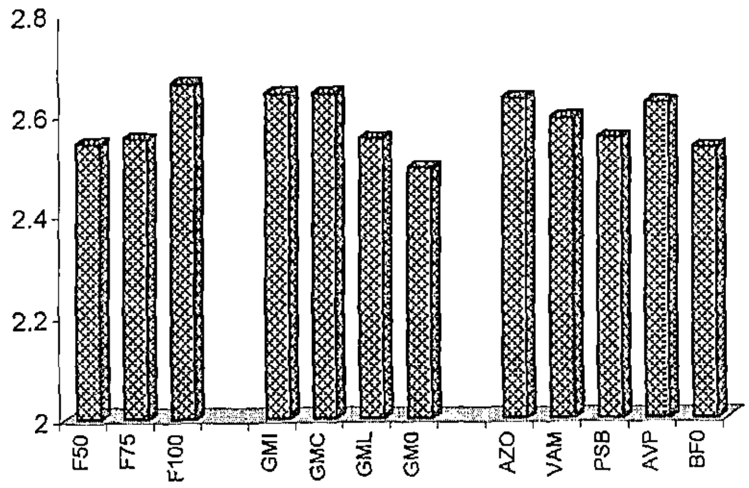


Fig 16 Silkworm larval weight(g) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

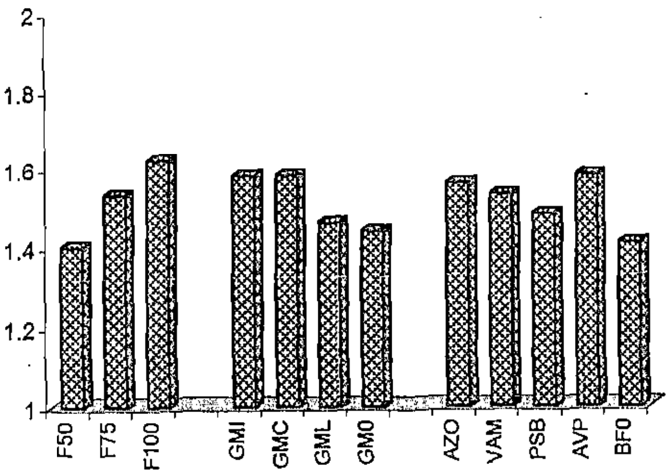


Fig 17 Cocoon weight(g) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Table 30 Leaf nitrogen content (%) and uptake (kg ha^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP		15 MAP		16 MAP		21 MAP		23 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Levels of inorganic fertilizers													
F_{50}	3.19	50.76	3.42	52.56	3.48	26.02	3.41	63.22	3.45	32.95	3.42	36.93	262.45
F_{75}	3.56	59.55	3.58	61.59	3.65	30.55	3.58	76.01	3.59	39.80	3.57	41.71	309.21
F_{100}	3.66	61.83	3.68	61.43	3.75	29.24	3.67	79.79	3.69	38.05	3.67	42.81	313.14
SEm ±	0.12	1.29	0.01	3.38	0.01	0.71	0.009	1.79	0.009	1.21	0.007	0.91	4.74
C.D (0.05)	0.37	4.04	0.04	NS	0.03	2.23	0.030	5.88	0.028	3.76	0.024	2.84	14.76
Green manuring													
GMI	3.60	62.95	3.83	64.42	3.68	29.44	3.62	85.64	3.65	39.63	3.63	43.31	325.89
GMC	3.58	63.79	3.58	71.54	3.66	30.49	3.58	83.58	3.59	41.98	3.57	42.38	333.78
GML	3.52	61.09	3.54	57.77	3.61	30.18	3.53	76.12	3.56	39.58	3.55	43.69	308.43
GM_0	3.18	41.67	3.48	40.38	3.56	23.78	3.47	46.69	3.50	26.55	3.47	32.58	211.63
SEm ±	0.14	1.49	0.01	3.91	0.01	0.83	0.01	2.07	0.010	1.39	0.009	1.05	5.47
C.D.(0.05)	NS	4.66	0.04	12.17	0.04	2.58	0.04	6.45	0.032	4.35	0.028	3.29	17.04
Biofertilizers													
AZO	3.48	60.11	3.60	59.84	3.67	26.36	3.59	72.22	3.61	35.05	3.60	40.58	294.15
VAM	3.58	65.63	3.59	73.48	3.67	31.63	3.60	94.36	3.62	45.25	3.59	46.12	356.48
PSB	3.42	54.97	3.57	48.84	3.61	26.74	3.54	60.33	3.57	32.90	3.55	36.39	260.17
AVP	3.62	69.46	3.63	75.85	3.70	33.75	3.62	98.48	3.66	48.46	3.62	49.75	375.75
BF_0	3.27	36.71	3.39	34.63	3.48	29.52	3.40	39.65	3.43	23.01	3.41	29.58	188.09
SEm ±	0.07	1.36	0.01	1.86	0.01	0.73	0.009	1.76	0.010	1.55	0.009	1.41	3.68
C.D.(0.05)	0.18	3.78	0.04	NS	0.03	2.03	0.026	4.90	0.029	4.30	0.026	3.92	10.20

MAP - Months after planting

in significantly higher nitrogen content than no green manure at all harvests. All the biofertilizer treatments also recorded significantly higher leaf nitrogen content than no biofertilizer application. However, the combined application of Azospirillum, VAM and PSB recorded the highest leaf nitrogen content at all harvests.

Levels of inorganic fertilizers exerted significant influence on TNUP and NUP at 12, 16, 21, 23 and 24 MAP. In all the cases, F100 and F75 were on par but resulted in higher nitrogen uptake than F50. Green manuring resulted in significant increase in NUP and TNUP over no green manure application. Although at par, GMC and GMI performed better than GML in increasing NUP. Biofertilizers exerted a significant influence on TNUP and NUP at all stages of growth except 15 MAP. Superior performance of combined application of Azospirillum, VAM and PSB was evident and it differed significantly from Azospirillum, PSB (Fig. 18).

Interaction effect of inorganic fertilizers x green manure was evident only on TNUP and F75 x GMI which was on par with F100 x GMI, F100 x GMC, F100 x GML and F75 x GMC resulted in relatively higher TNUP values (Table 36). Inorganic fertilizer x biofertilizer interaction effect was significant on TNUP and the treatment combination F75 x AVP (on par with F100 x AVP) showed the maximum value (Table 37). However, only at 16 MAP the interaction effect was pronounced and F75 x VAM which was on par with F100 x VAM and F100 x AVP indicated maximum NUP (Table 37). Green manure x biofertilizer interaction was evident on NUP at all stages except 24 MAP and TNUP. GMC x AVP at 12 and 15 MAP, GMI x AVP at 16 and 21 MAP and GMC x AVP at 23 MAP recorded maximum NUP (Table 38). The significant effect of the combination GMC x AVP on TNUP compared to other green manuring methods was remarkable, however, it was on par with GMI x AVP.

Table 31 Leaf phosphorus content (%) and uptake (kg ha^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP		15 MAP		16 MAP		21 MAP		23 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Levels of inorganic fertilizers													
F_{50}	0.31	4.84	0.39	6.14	0.32	2.41	0.31	5.71	0.32	3.01	0.32	3.41	25.51
F_{75}	0.33	5.51	0.34	5.86	0.33	2.79	0.33	7.02	0.34	3.71	0.33	3.89	28.78
F_{100}	0.35	5.89	0.35	5.93	0.36	2.78	0.35	7.71	0.35	3.62	0.35	4.07	29.99
SEm ±	0.003	0.067	0.042	0.827	0.003	0.066	0.003	0.163	0.002	0.096	0.004	0.104	0.809
C.D (0.05)	0.009	0.208	NS	NS	0.009	0.206	0.009	0.508	0.008	0.298	0.003	0.324	2.518
Green manuring													
GMI	0.34	5.92	0.34	6.05	0.35	2.84	0.34	8.09	0.34	3.71	0.34	4.11	30.72
GMC	0.33	5389	0.34	6.80	0.34	2.87	0.33	7.80	0.34	3.98	0.34	4.07	31.40
GML	0.32	5.63	0.33	5.52	0.34	2.79	0.33	7.02	0.33	3.64	0.33	4.01	28.62
GM_0	0.33	4.20	0.43	5.53	0.32	2.14	0.32	4.33	0.32	2.45	0.32	2.97	21.63
SEm ±	0.003	0.077	0.049	0.955	0.003	0.076	0.003	0.188	0.003	0.110	0.004	0.120	0.934
C.D.(0.05)	NS	0.240	NS	NS	0.011	0.238	0.010	0.587	0.009	0.344	0.014	0.374	2.909
Biofertilizers													
AZO	0.33	5.63	0.34	5.57	0.35	2.49	0.33	6.69	0.34	3.27	0.34	3.83	37.48
VAM	0.34	6.17	0.46	9.04	0.34	2.92	0.33	8.78	0.34	4.21	0.34	4.34	35.46
PSB	0.33	5.24	0.34	4.64	0.34	2.49	0.33	5.64	0.34	3.08	0.33	3.37	24.46
AVP	0.34	5.63	0.35	7.18	0.34	3.12	0.33	9.25	0.34	4.51	0.34	4.64	35.22
BF_0	0.31	3.49	0.33	3.44	0.33	2.28	0.32	3.70	0.32	2.16	0.32	2.77	17.84
SEm ±	0.002	0.119	0.054	0.947	0.002	0.040	0.002	0.171	0.003	0.132	0.002	0.131	0.970
C.D.(0.05)	0.009	0.331	NS	2.624	0.006	0.195	0.007	0.474	0.008	0.367	0.008	0.365	2.689

MAP - Months after planting

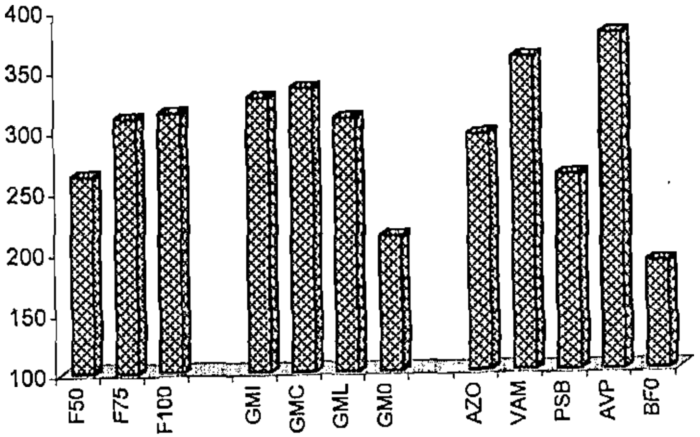


Fig 18 Nitrogen uptake(kg/ha) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

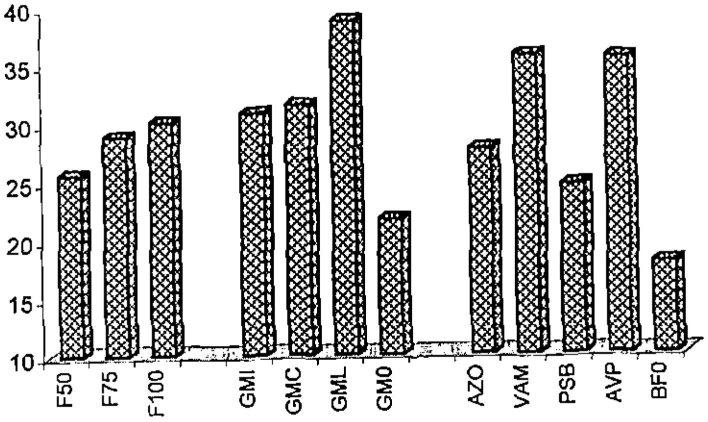


Fig 19 Phosphorus uptake(kg/ha)r as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

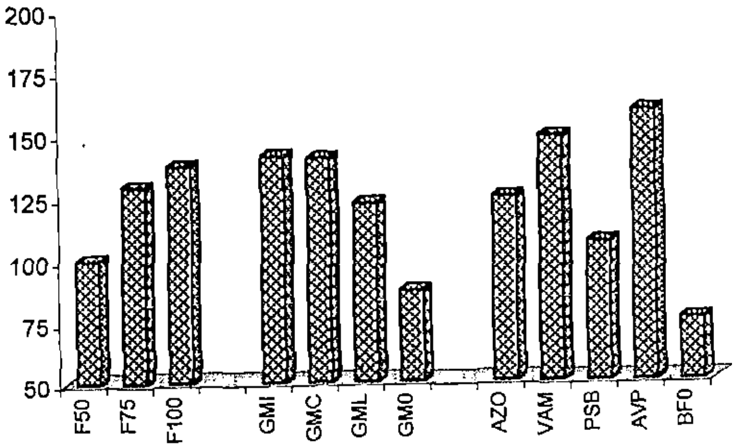


Fig 20 Potassium uptake(kg/ha) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

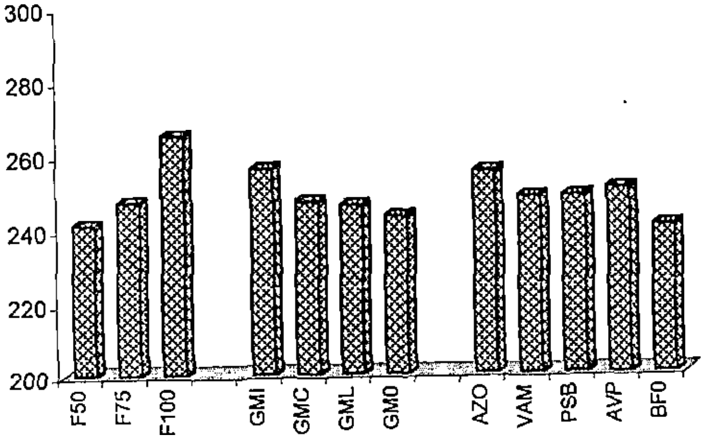


Fig 21 Available Nitrogen content (kg/ha) of soil after the experiment as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

4.1.20. Leaf phosphorus content and uptake

The data on phosphorus content and uptake (PUP) by leaf at 12, 15, 16, 21, 23 and 24 MAP and total phosphorus uptake (TPUP) are given in Table 31.

Phosphorus content of leaf varied with different nutrient levels at all harvests except at 16 MAP. There was increase in phosphorus content with increase in fertilizer addition. Compared to no green manuring, all the green manuring treatments significantly enhanced the phosphorus content at all stages except at 15 MAP. Similar to green manuring, biofertilizer treatments also increased the phosphorus content at all harvests except at 15 MAP. VAM alone, and combined application of Azospirillum, VAM and PSB significantly increased the phosphorus content at 12 MAP. However, the effect of Azospirillum was more pronounced in increasing phosphorus content at 16 MAP. From 21 MAP onwards, all the biofertilizers were equally effective in increasing the content compared to no biofertilizer application.

Significant effect of inorganic fertilizers was observed at all stages except at 15 MAP. F100 which was on par with F75 recorded the maximum PUP at the above stages and the same trend observed with respect to TPUP as well. With respect to green manures, the effect was significant on TPUP and the same trend continued in most cases and the control treatments were found to be inferior. Biofertilizer treatments exerted significant influence and application of VAM resulted in higher PUP, and it was at par with Azospirillum and AVP. Inoculation with PSB alone was not found to perform in the similar line, however, all the biofertilizer treatments significantly increased the PUP than no application of biofertilizer (Fig. 19).

Inorganic fertilizer x green manure interaction effect was significant on TPUP and PUP at 12 MAP. With respect to TPUP, the combination F75 x GMI which

107

was on par with F100 x GMI, F100 x GMC, F100 x GML, F75 x GMC and F x GML indicated the highest value. At 12 MAP, F75 x GMI was significant (Table 36). Inorganic fertilizer x biofertilizer interaction, recorded the superior performance of the combination F75 x AVP at 12 and 16 MAP (Table 37). Green manure x biofertilizer interaction effect was significant on TPUP (GMI x AVP on par with GMI x VAM, GMC x VAM, GMC x AVP and GML x AVP) and PUP at all growth stages except 15 MAP and in most of the stages GMI x AVP showed higher PUP (Table 38).

4.1.21. Leaf potassium content and uptake

The data on potassium content and uptake (PUP) at different growth stages and total potassium uptake (TPUP)are presented in Table 32.

Spectacular increase in leaf potassium content to the extent of 28% was observed due to the application of the highest dose of nutrients compared to the lowest level. Among the green manuring treatments, *in situ* cultivation and incorporation was found superior in influencing the potassium content. A 12% increase in leaf potassium content was observed due to combined application of Azospirillum, VAM and PSB.

Levels of fertilizers exerted significant influence and F100 resulted in maximum KUP throughout the growth stages except at 16 MAP which was again reflected on TKUP. The effect of green manure on KUP was evident at all stages and also on TKUP. *In situ* cultivation and incorporation and *in situ* composting of cowpea were on par and differed significantly from the other two treatments in influencing uptake. The significant superior performance of combined application of Azospirillum, VAM and PSB was again evident from KUP at different stages and TKUP (Fig 20).

Interaction effect of inorganic fertilizer x green manure was noticed on TKUP in the combination F75 x GMI (on par with F100 x GMI, F100 x GMC and F75 x GMC).

Table 32 Leaf potassium content (%) and uptake (kg ha^{-1}) as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	12 MAP		15 MAP		16 MAP		21 MAP		23 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Levels of inorganic fertilizers													
F_{50}	1.31	20.39	1.36	20.81	1.26	9.40	1.30	23.77	1.24	11.77	1.32	14.23	100.37
F_{75}	1.48	24.80	1.52	26.43	1.51	12.67	1.48	32.14	1.48	16.55	1.47	17.29	129.88
F_{100}	1.60	27.19	1.60	27.01	1.59	12.57	1.62	35.45	1.59	16.64	1.61	18.91	137.78
SEm ±	0.02	0.44	0.02	1.51	0.02	0.35	0.03	0.54	0.02	0.46	0.03	0.51	2.28
C.D (0.05)	0.07	1.38	0.07	4.71	0.05	1.10	0.08	1.69	0.07	1.44	0.09	1.59	7.10
Green manuring													
GMI	1.55	27.19	1.57	28.21	1.51	12.37	1.57	37.45	1.56	16.99	1.60	19.26	141.47
GMC	1.55	27.05	1.52	30.47	1.49	12.58	1.49	35.46	1.45	17.15	1.47	17.58	140.29
GML	1.39	24.23	1.45	23.73	1.40	11.79	1.60	29.97	1.37	15.34	1.38	17.04	122.11
GM_0	1.31	18.04	1.43	16.60	1.41	9.45	1.40	18.93	1.38	10.48	1.42	13.35	86.84
SEm ±	0.03	0.51	0.03	1.74	0.02	0.40	0.03	0.63	0.03	0.53	0.04	0.59	2.63
C.D.(0.05)	0.09	1.60	0.08	5.44	0.06	1.27	0.10	1.96	0.09	1.67	0.11	1.83	8.20
Biofertilizers													
AZO	1.49	25.64	1.53	25.67	1.49	10.73	1.50	30.53	1.48	14.38	1.51	17.06	124.00
VAM	1.48	27.16	1.51	31.06	1.47	12.76	1.49	39.60	1.49	18.79	1.48	19.28	148.65
PSB	1.47	23.46	1.47	20.03	1.46	10.86	1.44	24.61	1.41	12.92	1.44	14.78	106.67
AVP	1.52	29.25	1.55	32.79	1.50	13.84	1.51	41.35	1.49	19.91	1.53	21.01	158.12
BF_0	1.36	15.17	1.40	14.21	1.36	9.55	1.38	16.15	1.33	8.93	1.39	11.92	75.93
SEm ±	0.01	0.63	0.01	0.73	0.02	0.36	0.02	0.72	0.02	0.58	0.02	0.61	1.67
C.D.(0.05)	0.04	1.77	0.04	2.03	0.05	1.01	0.05	1.99	0.04	1.60	0.05	1.71	4.63

MAP - Months after planting

With respect to KUP the combination F75 x GMI recorded the maximum value at 12 and 21 MAP (Table 36). Inorganic fertilizer x biofertilizer interaction was evident on KUP at all growth stages and TKUP. F75 x AVP at 12, 15, 16 and 23 MAP and F100 x AVP at 21 and 24 MAP recorded the maximum value. TKUP was highest in the combination F100 x AVP (Table 37). With respect to green manuring x biofertilizer, the interaction effect was pronounced on KUP throughout the stages of growth and also on TKUP. At 12, 15, 16, 21 and 23 MAP the combination GMC x AVP and at 24 MAP the combination GMI x AVP recorded maximum uptake. Similar effect was reflected on TKUP also (Table 38). Inorganic fertilizer x green manure x biofertilizer interaction effect was evident on KUP at 23 MAP and also on TKUP. Under both the situations the combination, F75 x GMC x AVP showed maximum KUP and TKUP (Table 39).

4.1.22. Available nutrient status

Data on available nutrient status of the soil after the experiment are furnished in Table 33.

Levels of fertilizers were found to significantly influence available nitrogen. Increasing levels of fertilizers from F50 to F100 significantly increased the available nitrogen. Effect of green manure was also pronounced on available nitrogen alone and *in situ* cultivation and incorporation of cowpea enhanced the nitrogen status of soil (Fig. 21). However, biofertilizers influenced both available nitrogen and phosphorus contents of soil. Azospirillum inoculation was on par with combined application of Azospirillum, VAM and PSB in influencing available nitrogen. Though PSB showed maximum available phosphorus it was on par with VAM and combined application of Azospirillum, VAM and PSB. Application of Azospirillum alone failed to increase the available nitrogen status. None of the treatments affected available potassium content and Figs. 29 to 31.

Table 33 Available nutrient status (kg ha^{-1}) of the soil after the experiment as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	Nitrogen	Phosphorus	Potassium
Levels of inorganic fertilizers			
F_{50}	241.60	47.25	106.03
F_{75}	247.80	48.08	105.05
F_{100}	265.40	46.63	106.98
SEm ±	1.20	0.94	1.83
C.D (0.05)	3.75	NS	NS
Green manuring			
GMI	256.40	46.37	103.80
GMC	247.90	47.47	106.00
GML	246.87	48.70	107.70
GM_0	243.23	46.73	106.57
SEm ±	1.39	1.08	2.11
C.D.(0.05)	4.33	NS	NS
Biofertilizers			
AZO	255.04	40.25	108.79
VAM	248.54	52.50	101.71
PSB	248.25	52.83	103.33
AVP	250.67	51.58	109.71
BF_0	240.50	39.42	106.54
SEm ±	1.97	0.94	2.73
C.D.(0.05)	5.47	2.60	NS

Among the interaction effects, inorganic fertilizer x green manure alone was significant and F100 x GMI resulted in significant enhancement of available nitrogen status of mulberry soils (Table 36).

4.1.23. Rhizosphere population

Mean data on VAM spore load and per cent infection, Azospirillum and PSB colonisation recorded at three and twelve MAP are furnished in Table 34.

Though a significant change in the per cent infection of VAM was not observed, the spore load of VAM was found to increase significantly with increase in the fertilizer levels from F50 to F100 at three (Fig. 22) and twelve MAP. The Azospirillum count was significantly higher at the moderate level than either the lower (F50) or higher (F100) level (Fig. 23). The population of PSB was also found to increase with increasing levels of fertilizers and showed significant difference between F50 and F100 (Fig. 24). Considerable improvement in the rhizosphere population of VAM, Azospirillum and PSB was observed at twelve MAP when compare to three MAP.

The effect of green manure was significant on VAM spore load at three MAP, VAM per cent infection at twelve MAP and Azospirillum colonisation both at three and twelve MAP. *In situ* cultivation and incorporation of cowpea significantly improved the VAM spore load at three MAP which was on par with *in situ* cultivation and composting of cowpea. Though the spore load did not change significantly at 12 MAP, the per cent infection showed significant variation and it was lowest at GMC. Significantly higher population of Azospirillum was observed with GMI and GMC at both 3 and 12 MAP. PSB population was not affected by green manuring. Significant influence of biofertilizer was noticed in the rhizosphere population. With respect to VAM spore load and VAM infection, the two treatments ie, combined application of Azospirillum, VAM

Table 34 Rhizosphere microflora as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	Vesicular Arbuscular Mycorhizae				Azospirillum		PSB	
	Spore load (No/100g soil)		Per cent infection		(x 10^5 cfu/g soil)		(x 10^5 cfu/g soil)	
	3 MAP	12 MAP	3 MAP	12 MAP	3 MAP	12 MAP	3 MAP	12 MAP
Levels of inorganic fertilizers								
F50	45.95	52.25	22.63	29.03	9.68	11.68	10.23	11.00
F75	53.05	57.68	23.93	29.28	11.18	13.30	11.00	12.48
F100	60.68	70.08	22.73	28.75	9.93	11.35	11.78	12.95
SEm ±	1.73	1.65	0.88	0.90	0.21	0.21	0.36	0.33
C.D (0.05)	5.40	5.16	NS	NS	0.66	0.65	1.13	1.03
Green manuring								
GMI	60.97	64.90	23.27	29.23	10.93	13.23	10.77	12.37
GMC	54.53	57.27	21.57	25.90	10.87	12.20	11.33	12.60
GML	50.60	59.97	24.03	30.97	9.73	12.13	10.50	12.27
GM0	46.80	57.87	23.50	29.97	9.50	10.87	11.40	11.33
SEm ±	2.00	1.91	1.02	1.05	0.24	0.24	0.42	0.38
C.D.(0.05)	6.24	NS	NS	3.26	0.76	0.75	NS	NS
Biofertilizers								
AZO	29.75	38.21	21.38	26.58	12.83	15.29	7.67	9.13
VAM	89.50	100.92	27.96	36.96	9.50	11.13	7.63	8.04
PSB	30.00	36.25	23.13	27.75	9.50	10.46	17.45	18.92
AVP	92.46	95.88	28.96	35.92	13.50	15.38	16.83	18.67
BF0	24.42	28.75	14.04	17.88	5.96	8.29	5.42	5.96
SEm ±	2.02	2.13	1.11	0.98	0.41	0.49	0.45	0.56
C.D.(0.05)	5.61	5.92	3.09	2.72	1.15	1.37	1.27	1.57

MAP - Months after planting

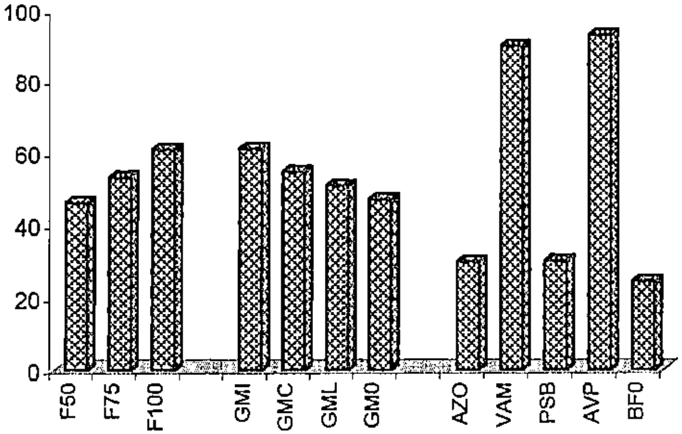


Fig 22 VAM spore load (No./100g soil)at 3 MAP as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

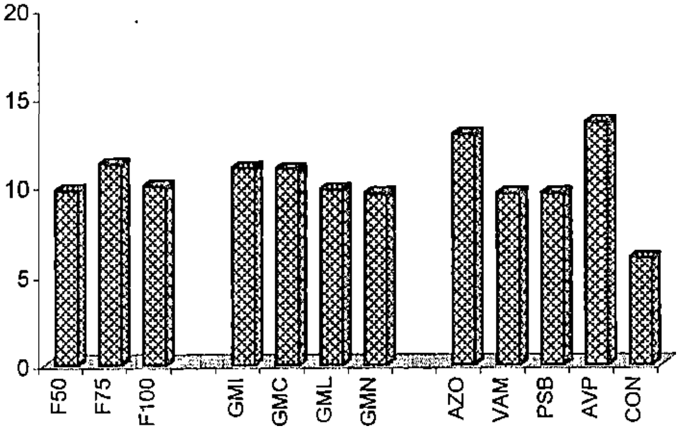


Fig 23 Azospirillum(x 10^5 cfu/g soil) at 3 MAP as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

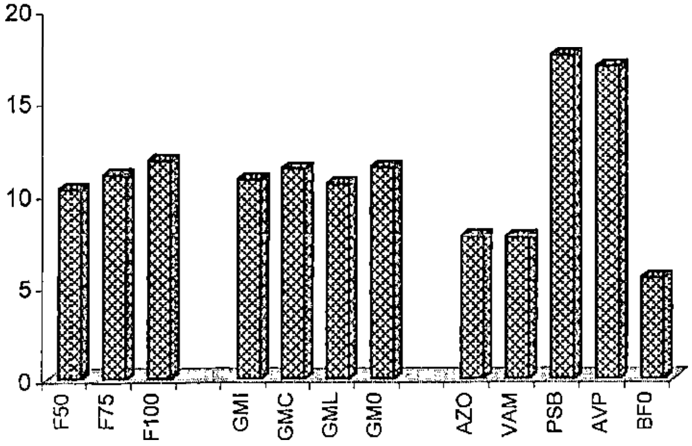


Fig 24 PSB(x 10^5 cfu/g soil) at 3 MAP as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

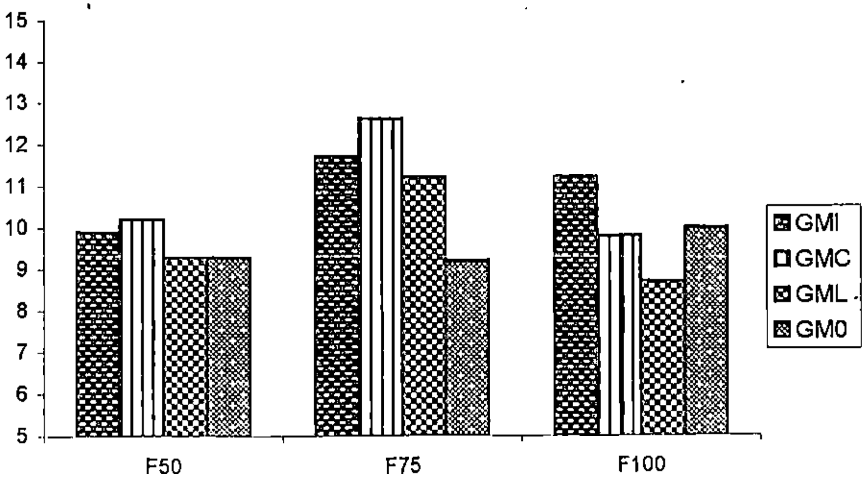


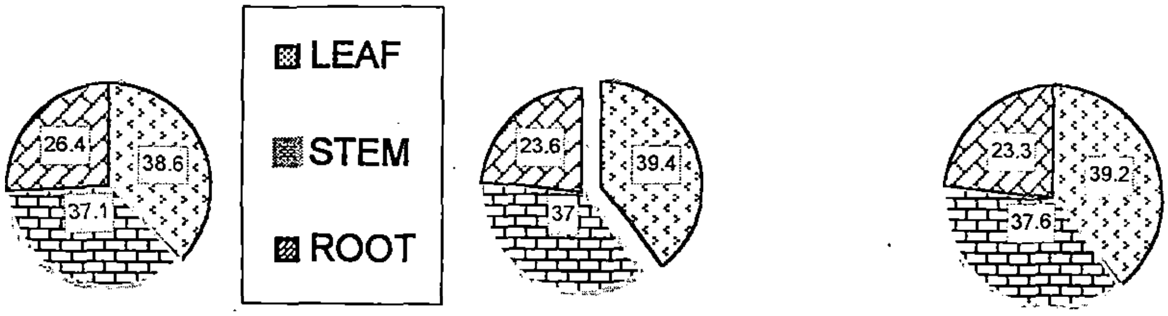
Fig 25 Azospirillum population at 3 MAP as influenced by the interaction effect of fertilizers and green manuring

and PSB and single inoculation of VAM were on par and differed significantly from all other treatments. Eventhough, combined application of Azospirillum, VAM and PSB recorded maximum colonisation of Azospirillum, it was on par with single inoculation of Azospirillum. Single inoculation of PSB was very effective in enhancing the colonisation of PSB but was on par with combined application of Azospirillum, VAM and PSB.

Interaction effect of inorganic fertilizers x green manures was quite evident particularly on Azospirillum colonisation. F75 x GMC on par with F75 x GMI recorded maximum population (Table 36 and Fig25). Interaction effect of inorganic fertilizer x biofertilizer was significant and the treatment combination F100 x AVP (on par with F100 x VAM), F100 x VAM (on par with F100 x AVP), F75 x VAM (on par with F100 x AVP and F50 x AVP), F75 x AZO (on par with F100 x AVP and F75 x AVP) and F100 x PSB (on par with F100 x AVP) recorded maximum VAM spore load at three and twelve MAP, VAM per cent infection at twelve MAP, colonisation of Azospirillum at three MAP and PSB colonisation at three MAP respectively (Table 37). The effect of green manure x biofertilizer interaction was pronounced on VAM spore load and Azospirillum colonisation only. The combination, GMI x AVP recorded significantly higher spore load at three MAP and GMI x AZO (on par with GMC x AZO) resulted in significantly higher Azospirillum population both at three and twelve MAP (Table 38). The interaction effect was significant with integrated nutrient management and F75 x GLM x AVP resulted in largest Azospirillum population at three MAP (Table 39).

4.1.24. Sustainable yield index

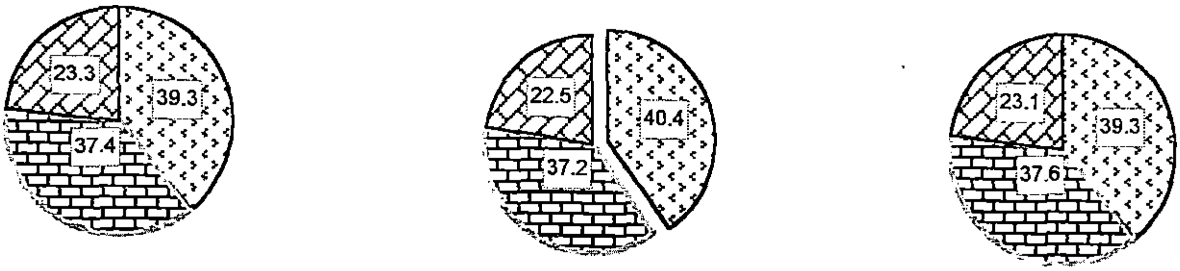
The data on sustainable yield index (SYI) are presented in Table 35.



NPK @150:60:60 kg per ha per year (TDMP 20.0 t/ha)

NPK @225:90:90 kg per ha per year (TDMP 21.7 t/ha)

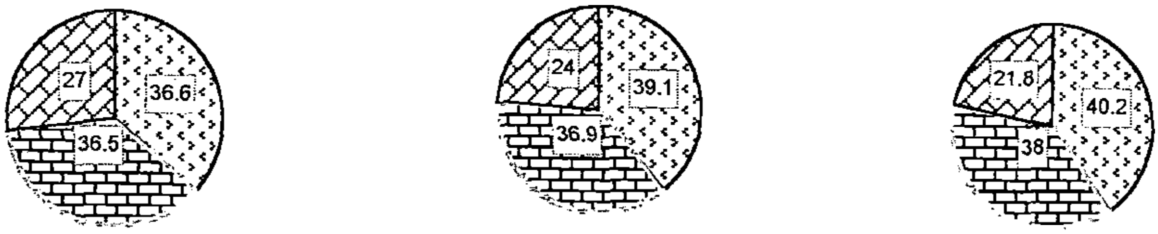
NPK @300:120:120 kg per h (TDMP 21.6 t/ha)



Incorporation of cowpea (TDMP 22.6 t/ha)

Composting of cowpea (TDMP 22.9 t/ha)

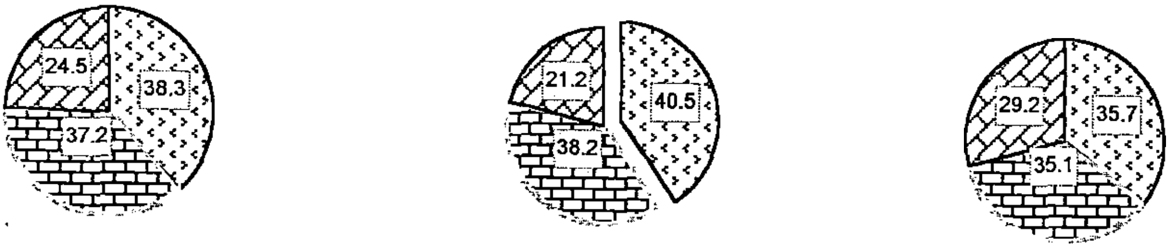
Green leaf manuring (TDMP 2



No green manuring (TDMP 16.8 t/ha)

Inoculation of Azospirillum (TDMP 20.8 t/ha)

Inoculation of VAM (TDMP 24.5



Inoculation of PSB (TDMP 19.1 t/ha)

Combined inoculation (TDMP 25.4 t/ha)

No inoculation (TDMP 15

Fig 26 Per cent distribution of dry matter as influenced by fertilizer levels, green manuring

114

SYI denotes the minimum guaranteed yield as a per cent to the maximum observed yield with high probability. The treatments, F75, GMC, and AVP resulted in the highest minimum guaranteed yield of 44, 47 and 54 per cent respectively of the maximum observed yield. Integrated nutrient management involving F75 x GMI/GMC x AVP resulted in achieving more than 65 per cent of the maximum observed yield indicating the sustainability of the technology (Table 39).

4.1.25. Economic analysis

Gross income (GI), net income (NI) and benefit:cost ratio (BCR) are furnished in Table 35.

Levels of nutrients exerted significant influence on GI, NI and BCR. F75 gave maximum values for the above parameters and was found to be on par with F100. The effect of green manure was very much pronounced and *in situ* cultivation and composting which resulted in maximum GI, NI and BCR. This treatment was on par with *in situ* cultivation and incorporation of cowpea. The excellent performance of combined application of Azospirillum, VAM and PSB was evident from the economic criteria as well. This treatment proved to be the best and significantly differed from all other treatments from the economic point of view.

Interaction effect of inorganic fertilizer x green manure was significant and the combination F75 x GMC found to be superior with respect to GI, NI and BCR (Table 36). The effect of inorganic fertilizer x biofertilizer interaction was remarkable and the combination F75 x AVP (on par with F75 x VAM) proved to be better on economic evaluation (Table 37). With respect to green manuring x biofertilizer interaction, the combination GMC x AVP resulted in maximum GI, NI and BCR (Table 38).

Table 35 Sustainable yield index and economics of mulberry cultiation as influenced by levels of inorganic fertilizers, green manuring and biofertilizers

Treatments	Sustainable yield index	Gross income (RS ha^{-1})	Net income (Rs ha^{-1})	BC ratio
Levels of inorganic fertilizers				
F50	0.39	46188	14857	1.47
F75	0.44	51097	18777	1.58
F100	0.43	50697	17409	1.52
SEm ±	-	716.63	716.63	0.02
C.D (0.05)	-	2230.60	2230.58	0.07
Green manuring				
GMI	0.45	53218	20679	1.64
GMC	0.47	55399	22860	1.70
GML	0.44	51881	19342	1.59
GM0	0.31	38813	5175	1.16
SEm ±	-	827.50	827.50	0.02
C.D.(0.05)	-	2293.67	2293.66	0.07
Biofertilizers				
AZO	0.41	48942	16629	1.51
VAM	0.51	58929	26615	1.82
PSB	0.37	44102	11788	1.36
AVP	0.54	61517	29204	1.90
BF0	0.28	33148	834	1.02
SEm ±	-	565.22	565.23	0.01
C.D.(0.05)	-	1566.69	1566.70	0.04

Table 36 Performance of mulberry as influenced by the interaction effect of levels of inorganic fertilizers (F) x green manuring (GM)

Fertilizer x Green manure	Leaf Area Index				FLP (Kg ha^{-1})	TFLP (Kg ha^{-1})	LDMP (Kg ha^{-1})		TLDMP (Kg ha^{-1})	SDMP (Kg ha^{-1})	
	12 MAP	21 MAP	23 MAP	24 MAP	12 MAP		12 MAP	15 MAP		21 MAP	24 MAP
F_{50} x GMI	5.38	5.30	3.88	3.87	5197	24851	1676	1777	8320	2506*	1131
F_{50} x GMC	4.81	5.80	4.09	3.52	5389*	26183	1758*	1755	8757	2351	1164
F_{50} x GML	4.68	5.41	4.11	3.84	5160	24083	1664	1648	8027	2182	1220
F_{50} x GMo	2.70	2.40	2.63	1.84	3347	17258	1097	1068	5701	1491	938
F_{75} x GMI	6.06	6.73	5.38	4.59	5588*	28512*	1803*	1866*	9521*	2492*	1312
F_{75} x GMC	6.10	6.69	4.92	5.19	5627*	29358*	1815*	2017*	9810*	2584*	1402*
F_{75} x GML	5.67	6.80	4.86	4.28	5431*	27145*	1762*	1781	9062	2495*	1418*
F_{75} x GMo	3.30	3.01	2.61	1.99	3746	17179	1230	1292	5740	1699	987
F_{100} x GMI	5.50	6.31	4.62	4.20	5292*	26462	1720*	1794	8832	2349	1255
F_{100} x GMC	5.93	7.07	4.61	4.42	5387	27557	1739*	1704	9119*	2492*	1348*
F_{100} x GML	5.36	6.98	4.44	4.22	5452	26592	1766*	1828*	8918	2379	1364*
F_{100} x GMo	4.08	4.12	3.43	2.77	4602	20782	1501	1604	6975	1895	1196
SEm ±	0.17	0.16	0.15	0.16	122.06	716.64	36.18	67.21	241.12	50.55	29.20
CD (0.05)	0.54	0.50	0.47	0.49	338.35	2230.64	112.64	209.20	750.51	157.35	90.88

Contd.....

Table 36 contd....

Fertilizer x Green manure	TSDMP (Kg ha^{-1})	LMC (%)	SLW (Mg^{-1} cm^{2})	RSR 24 MAP	TNUP (Kg ha^{-1})	PUP (Kg ha^{-1})	TPUP (Kg ha^{-1})	KUP (Kg ha^{-1})		TKUP (Kg ha^{-1})	Soil N (Kg ha^{-1})
								12 MAP	21 MAP		
F_{50} x GMI	8253	65.00	3.36	2.30	285	5.25	26.28	23.41	27.09	111	248
F_{50} x GMC	8076	66.80	4.78*	2.23	303	5.48	27.74	23.51	27.47	114	241
F_{50} x GML	7737	65.80	4.03	2.17	2.74	5.13	25.06	21.36	24.76	102	246
F_{50} x GM$_0$	5516	66.50	4.47*	2.40	186	3.47	22.94	13.27	15.74	73	230
F_{75} x GMI	8608	66.30	3.21	2.16	358*	6.38*	34.21*	29.21*	42.84*	160*	253
F_{75} x GMC	8954*	66.90	3.33	2.03	357*	6.08*	33.66*	28.92*	39.88*	155*	248
F_{75} x GML	8526*	66.50	3.64	2.00	321	5.76	29.44*	23.61	28.87	124	243
F_{75} x GM$_0$	5987	66.40	4.11	2.58*	198	3.80	17.79	17.47	16,95	78	246
F_{100} x GMI	8507	67.10	3.34	2.20	333*	6.13*	31.67*	28.98*	42.40*	151*	268*
F_{100} x GMC	8481	66.40	3.20	2.14	340*	6.09*	32.79*	28.71*	39.02	150*	254
F_{100} x GML	8608*	66.30	3.46	1.99	329*	6.00*	31.35*	27.73*	36.27	139	250
F_{100} x GM$_0$	6859	64.70	3.90	2.02	249	5.32	24.14	23.37	24.08	108.	252
SEm ±	149.52	0.36	0.18	0.05	9.48	0.13	1.61	0.89	1.09	4.56	2.41
CD (0.05)	465.41	1.12	0.58	0.17	29.52	0.41	5.04	2.77	3.39	14.20	7.51

Contd.....

Table 36 contd....

Fertilizer x Green manure	LP (%)					AZO		Gross Income (Rs ha^{-1})	Net Income (Rs ha^{-1})	Benefit Cost Ratio
	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	3 MAP	12 MAP			
F_{50} x GMI	21.35	21.75	21.25	21.69	21.43	9.90	13.20*	49703	18122	1.57
F_{50} x GMC	21.60	22.06	21.31	21.75	21.56	10.20	10.80	52366	20785	1.65
F_{50} x GML	21.36	21.56	21.25	21.19	21.31	9.30	11.60	48167	16686	1.52
F_{50} x GM_0	21.06	21.50	21.19	21.38	21.19	9.30	11.10	34517	3936	1.12
F_{75} x GMI	23.19	23.56	23.13	23.31	23.19	11.70	14.30*	57025*	24486*	1.75*
F_{75} x GMC	22.50	23.06	22.50	22.44	22.37	12.60*	14.50*	58716*	26177*	1.80*
F_{75} x GML	22.03	22.63	22.13	22.31	22.19	11.20	14.10*	54291*	21752*	1.66*
F_{75} x GM_0	21.57	22.00	21.56	21.75	21.50	9.20	10.30	34358	2692	1.08
F_{100} x GMI	23.44	23.69	23.38	23.44	23.38	11.20	12.20	52925	19429	1.57
F_{100} x GMC	23.00	23.44	23.19	23.13	23.00	9.80	11.30	55115*	21619	1.64
F_{100} x GML	23.00	23.38	22.81	23.06	23.00	8.70	10.70	53185	19689	1.58
F_{100} x GM_0	22.50	23.13	22.19	22.43	22.31	10.00	11.20	41564	8898	1.27
SEm ±	0.16	0.13	0.12	0.11	0.09	0.42	0.42	1433.27	1433.27	0.04
CD (0.05)	0.49	0.41	0.38	0.36	0.30	1.32	1.31	4461.21	4461.21	0.13

Table 37 Performance of mulberry as influenced by the interaction effect of levels of inorganic fertilizers (F) x Biofertilizers (B)

Fertilizer x Biofertilizer	Height (cm) 16 MAP	Leaf Area Index					FLP (Kg ha^{-1})		LDMP (Kg ha^{-1})		TLDMP (Kg ha^{-1})	SDMP (Kg ha^{-1})			
		12 MAP	15 MAP	16 MAP	21 MAP	24 MAP	12 MAP	16 MAP	12 MAP	16 MAP		16 MAP	21 MAP	23 MAP	24 MAP
F_{50} x AZO	116.6	4.41	6.46	1.73	4.94	3.69	4737	2346	1530	700	7427	83	2043	1065	1125
F_{50} x VAM	128.5	5.47	6.76	1.88	6.15	3.90	5545	2641	1785	800	9189	86	2661	982	1140
F_{50} x PSB	113.6	3.95	4.74	1.22	3.83	2.93	4661	2347	1504	714	6857	83	1781	897	1064
F_{50} x AVP	126.4	6.26	7.37	2.01	6.79	4.08	5585	2698	1806	826	9720	84	2865*	1191*	1316
F_{50} x BF_0	109.1	1.85	4.54	0.55	1.94	1.71	3349	2265	1114	692	5314	83	1312	787	921
F_{75} x AZO	120.7	4.31	6.30	1.75	5.78	3.90	5355	2528	1701	786	8666	79	2091	964	1218
F_{75} x VAM	128.1	7.42*	8.08	2.13*	8.16	5.50*	5793	3046	1838	944	10398	90*	3068*	1107*	1655*
F_{75} x PSB	168.7*	4.11	5.32	1.44	4.23	2.93	4807	2213	1578	682	7266	75	2026	990	1124
F_{75} x AVP	135.5	8.03*	8.98*	2.26*	8.86*	5.93*	6338*	2407*	2082	1066	10809*	96*	2968*	1031	1516*
F_{75} x BF_0	128.4	2.50	4.84	0.66	2.01	1.81	3198	2236	1065	687	5515	76	1432	860	885
F_{100} x AZO	137.4	5.28	6.34	1.86	6.24	4.17	5672	2137	1857	662	8368	78	2309	921	1168
F_{100} x VAM	136.4	6.71	7.21	1.96	7.25	4.73	5623	2701	1861	834	9992	86	2651	1229*	1446*
F_{100} x PSB	139.4*	4.62	5.91	1.99	5.88	3.49	5285	2641	1679	820	7863	82	2009	993	1240
F_{100} x AVP	139.4*	6.85	7.73	2.14*	8.14	4.66	5773	2724	1854	841	10306	87	2871*	1238*	1519*
F_{100} x BF_0	130.8	2.64	4.91	0.87	3.07	2.43	3563	2354	1157	730	5777	81	1552	835	1081
SEm±	8.09	0.29	0.22	0.06	0.21	0.21	167.55	106.31	58.58	34.70	170.59	2.33	98.65	49.95	73.66
CD (0.05)	22.43	0.82	0.61	0.17	0.60	0.58	464.43	294.68	162.39	96.20	472.84	6.46	273.44	138.45	204.19

Contd....

Table 37 contd...

Fertilizer x Biofertilizer	TSDMP (Kg ha^{-1})	RDMP (Kg ha^{-1})				TDMP (Kg ha^{-1})	NAR (Mg^{-1} cm^{2} day^{-1})	SLW (Mg^{-1} cm^{2})		LML (9 hrs) 23 MAP (%)	LP (%)			NUP (Kg ha^{-1})
		16 MAP	21 MAP	23 MAP	24 MAP			12 MAP	16 MAP		16 MAP	21 MAP	24 MAP	
F50 x AZO	7313	2225	2983	3858	4830	19570	0.030	3.81	4.84	27.37	21.88	21.44	21.63	24.56
F50 x VAM	8518	2530	3200	4025	4929	22636	0.029	3.40	4.38	27.00	22.00	21.56	21.62	28.24
F50 x PSB	6779	2185	2899	3724	4731	18368	0.034	4.12	6.94	27.62	21.44	21.06	21.13	24.57
F50 x AVP	9207	2309	3367	4277	5183	24111	0.025	2.91	4.40	27.13	22.13	21.63	21.75	29.30
F50 x BF0	5160	1804	2626	3548	4627	15101	0.050	6.56	12.77	27.63	21.13	20.63	20.75	23.38
F75 x AZO	7224	2448	3168	4065	4998	21389	0.035	4.06	5.09	27.00	23.25	22.82	22.63	29.42
F75 x VAM	10013*	3060*	3943*	4831*	5680*	26092	0.021	2.54	4.68	26.62	23.13	22.56	22.50	35.02
F75 x PSB	7062	2133	2823	3649	4619	18948	0.034	4.12	6.20	26.50	22.63	22.19	22.25	24.67
F75 x AVP	9968*	3020*	3879*	4728*	5571*	26349*	0.021	2.66	4.70	26.75	23.25	22.94	22.88	29.55
F75 x BF0	5329	1868	2623	3565	4633	15477	0.039	4.50	10.75	27.00	21.81	21.12	22.25	24.04
F100 x AZO	8012	2605	3332	4275	3205	21586	0.030	3.54	3.72	27.13	23.63	23.01	23.19	25.09
F100 x VAM	9388	2927*	3695	4628*	3421*	24802*	0.025	2.91	4.58	27.87	23.63	23.25	23.19	31.63*
F100 x PSB	7468	2148	2975	3851	4702	20034	0.030	3.68	4.10	27.12	23.50	22.30	23.13	30.95
F100 x AVP	9876*	3132*	3865*	4680*	5512*	25685*	0.022	2.75	3.97	27.12	24.00	23.19	23.31	32.37*
F100 x BF0	5825	1888	2620	3483	4323	15925	0.036	4.49	8.86	27.00	22.31	21.94	21.88	26.14
SEm±	185.93	108.53	86.30	101.96	97.30	331.67	0.0023	0.30	0.48	0.18	0.12	0.10	0.10	1.27
CD (0.05)	515.36	300.82	239.21	282.62	269.70	919.34	0.0063	0.83	1.35	0.51	0.33	0.29	0.29	3.52

Contd.....

Table 37 contd....

Fertilizer x Biofertilizer	TNUP (Kg ha^{-1})	PUP (Kg ha^{-1})		KUP (Kg ha^{-1})					
		12 MAP	16 MAP	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
F_{50} x AZO	254	4.68	2.27	19.27	20.22	8.79	22.88	11.99	13.61
F_{50} x VAM	318	5.61	2.55	23.13	27.80	9.98	28.59	13.82	15.46
F_{50} x PSB	228	4.68	2.31	20.82	16.96	8.94	19.36	10.08	13.16
F_{50} x AVP	338	5.76	2.66	24.13	26.11	10.44	33.71	14.83	17.57
F_{50} x BF_0	173	3.43	2.21	14.56	12.96	8.84	14.28	8.13	11.31
F_{75} x AZO	317	5.75	2.79	27.16	29.36	12.57	33.58	15.53	19.90
F_{75} x VAM	378	6.22	3.17	28.11	32.34	14.43	44.76*	21.70*	19.96
F_{75} x PSB	260	5.06	2.18	22.44	19.24	9.82	23.92	13.30	14.14
F_{75} x AVP	401	7.16	3.60	31.96	36.38	16.88	43.40	22.81*	20.48
F_{75} x BF_0	188	3.32	2.20	14.32	14.79	9.63	15.01	9.38	11.98
F_{100} x AZO	310	6.43	2.39	30.47*	27.41	10.81	35.13	15.61	17.66
F_{100} x VAM	373	6.67*	3.03	30.25*	33.02*	13.86	45.44*	20.82*	22.39*
F_{100} x PSB	291	5.97	2.96	27.10	23.87	13.82	30.55	15.38	17.04
F_{100} x AVP	387*	6.64*	3.08	31.54*	35.88*	14.16	46.94	22.09*	24.97*
F_{100} x BF_0	202	3.71	2.41	16.60	14.86	10.18	19.16	9.28	12.48
SEm±	6.37	0.20	0.12	1.10	1.27	0.63	1.24	1.00	1.07
CD (0.05)	17.68	0.57	0.33	3.06	3.52	1.76	3.45	2.78	2.96

Contd...

Table 37 contd.....

Fertilizer x Biofertilizer	TKUP (Kg ha^{-1})	VAM Spore		VAM Infection (%)	AZO	PSB	GI (Rs ha^{-1})	NI (Rs ha^{-1})	BCR
		3 MAP	12 MAP						
F_{50} x AZO	96	29.25	35.87	29.62	11.12	7.62	44573	13242	1.42
F_{50} x VAM	118	69.25	87.50	37.25	9.87	8.00	55109	23778	1.75
F_{50} x PSB	89	29.37	36.12	25.87	8.75	14.37	41239	9908	1.31
F_{50} x AVP	126	76.87	76.37	35.75*	12.12	14.37	58207	26876	1.85
F_{50} x BF_0	70	25.00	29.37	16.62	6.50	6.75	31813	482	1.01
F_{75} x AZO	138	31.62	39.50	25.25	15.25*	8.00	52267	19946	1.61
F_{75} x VAM	161	84.87	93.12	39.25	9.75	6.50	62316*	29995*	1.92*
F_{75} x PSB	102	31.00	38.25	26.00	9.37	17.50	43459	11138	1.34
F_{75} x AVP	171	90.37	89.75	37.37	14.25*	17.25	64576	32255*	1.99*
F_{75} x BF_0	75	27.37	27.75	18.50	7.25	5.75	32868	549	1.01
F_{100} x AZO	137	28.37	39.25	24.87	12.12	7.37	49988	16699	1.50
F_{100} x VAM	165	114.37*	126.12*	34.37	8.87	8.37	59361	26072	1.78
F_{100} x PSB	127	29.62	34.37	31.37	10.37	20.50	47608	14320	1.43
F_{100} x AVP	175	110.12*	121.50*	34.62*	14.12*	18.87*	61788	28480	1.85
F_{100} x BF_0	82	20.87	29.12	18.50	4.12	3.75	34761	1473	1.04
SEm±	2.89	3.58	3.70	1.70	0.72	0.79	979.00	979.00	0.03
CD (0.05)	8.03	9.72	10.26	4.71	1.99	2.20	2713.60	2713.60	0.08

Table 38 Performance of mulberry as influenced by the interaction effect of green manuring (GM) x biofertilizers (B)

Green manuring x Biofertilizers	Leaf Area Index						FLP (Kg ha^{-1})					TFLP (Kg ha^{-1})
	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	
GMI x AZO	5.56	6.97	1.96	6.13	4.32	4.15	5958*	5777	2333	6583	2939	27024
GMI x VAM	7.31*	8.29	2.34*	7.91	6.00*	5.38*	6094*	6889*	2903*	8650*	3915*	32462
GMI x PSB	4.77	5.46	1.53	4.71	4.10	3.64	5129	4193	2262	5127	2788	22706
GMI x AVP	7.91*	9.09	2.41*	9.18*	6.13*	5.92*	6360*	6874*	3240*	9156*	4300*	34470*
GMI x BFo	2.63	4.49	0.70	2.64	2.58	1.98	3255	2863	2279	3609	2048	16381
GMC x AZO	5.23	7.13	2.07	6.96	4.52	4.56	5712	5767	2603	6355	3117	26950
GMC x VAM	7.57*	8.58*	2.32*	8.24	3.72	5.75*	5962	7276*	3128*	8639*	4242*	33519*
GMC x PSB	4.73	5.77	1.87	5.94	4.03	3.34	5515	5403	2499	5438	3060	24943
GMC x AVP	8.13*	8.99*	2.39*	1.90	6.16*	5.72*	6344*	7642*	3158*	9082*	4423*	34843*
GMC x BFo	2.41	4.84	0.75	2.55	2.25	2.31	3807	4264	2063	3263	1996	18241
GML x AZO	1.86	6.61	2.20	6.52	3.91	4.59	5623	5056	2430	6051	3085	26010
GML x VAM	7.01	7.54	2.17	8.41	5.46	5.12	6109*	6790	2957	8007	3964*	31691
GML x PSB	4.79	5.39	1.82	5.09	4.09	3.23	5318	3591	2642	5099	2774	22658
GML x AVP	7.31*	8.96*	2.38*	9.62	6.18	5.49*	6225*	6873*	3181	8022	4257	33146
GML x BFo	2.21	5.13	0.67	2.34	2.68	2.13	3262	2379	2387	3278	1996	16196
GMo x AZO	3.01	4.76	0.89	3.00	2.76	2.37	3724	3335	1981	3752	2368	17901
GMo x VAM	4.24	4.98	1.13	4.17	3.40	2.59	4451	3912	2195	4268	3964*	20184
GMo x PSB	2.61	4.68	0.97	2.86	3.24	2.06	3694	3381	2198	3708	2774	17896
GMo x AVP	4.85	5.07	1.36	4.02	2.94	2.43	4667	4007	2194	4313	4257*	20674
GMo x BFo	2.08	4.60	0.65	1.83	2.09	1.53	2957	2848	2411	2978	1996	15476
SEm ±	0.34	0.25	0.07	0.25	0.23	0.24	193.47	303.42	122.76	280.89	2368.00	563.23
CD (0.05)	0.95	0.70	0.19	0.69	0.65	0.67	536.28	841.02	340.26	778.58	667.32	1566.70

Table 38 contd...

Green manuring x Biofertilizers	LDMP (Kg ha^{-1})					TLDMP (Kg ha^{-1})	SDMP (Kg ha^{-1})					TSDMP (Kg ha^{-1})
	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP		12 MAP	15 MAP	16 MAP	23 MAP	24 MAP	
GMI x AZO	1915*	1908	723	2304	998	9003	1948	1944	79	983	1136	8574
GMI x VAM	1980*	2275*	892	3059*	1318*	10890	2021*	2306*	91*	1145	1489*	10111
GMI x PSB	1649	1373	709	1796	922	7540	1749	1277	77	1033	1154	7324
GMI x AVP	2046*	2256*	1010*	3233*	1456*	11539	2220*	2437*	94*	1278*	1446*	10700*
GMI x BF$_0$	1074	951	707	1293	675	5484	1124	1107	78	874	919	5573
GMC x AZO	1855	1916	807	2233	1043	8988	1756	1701	87	945	1159	7931
GMC x VAM	1914*	2353*	960*	3038	1496*	11186	2039*	2271*	92*	1313*	1638*	10778*
GMC x PSB	1784	1750	765	1902	1057	8265	1855	1434	86	934	1206	7519
GMC x AVP	2051*	2436*	973*	3225*	1508*	11605*	1993*	2401*	97*	1216*	1589*	10513*
GMC x BF$_0$	1249	1426	636	1151	684	6100	1486	960	76	845	932	5777
GML x AZO	1799	1674	736	2127	1045	8659	1834	1693	85	1085	1270	8160
GML x VAM	1975*	2218*	918*	2829	1375*	10637	2046*	2281*	95*	1074	1507*	9835
GML x PSB	1703	1197	810	1790	960	7538	1750	1464	83	991	1241	7699
GML x AVP	2036*	2268*	977*	2823	1460*	11128*	2080*	2315*	93*	1159*	1623	10462*
GML x BF$_0$	1141	754	727	1147	697	5369	1052	960	87	783	1018	5296
GM$_0$ x AZO	1213	1115	599	1315	788	5966	1271	1063	68	907	1096	6066
GM$_0$ x VAM	1975*	2218*	666	1500	798	6727	1487	1165	73	892	1021	6501
GM$_0$ x PSB	1703	1197	671	1311	731	5972	1248	1119	75	883	960	5870
GM$_0$ x AVP	2036*	2268*	671	1522	835	6840	1649	1253	74	960	1144	7061
GM$_0$ x BF$_0$	1141	754	742	1057	628	5187	951	894	79	806	981	5106
SEm ±	1213.00	1115.00	40.07	98.33	83.80	196.98	84.43	9.46	2.69	37.67	85.06	214.69
CD (0.05)	187.51	284.31	110.08	272.55	232.29	545.99	234.03	259.07	7.46	159.87	235.78	595.08

Table 38 contd...

Green manuring x Biofertilizers	RDMP (Kg ha^{-1})				TDMP (Kg ha^{-1})	NAR (Mg^{-1} cm^2 day^{-1})	RGR (Mg^{-1} g day^{-1})			CGR (g^{-1} m^2 day^{-1})			
	15 MAP	16 MAP	23 MAP	24 MAP			12 MAP	15 MAP	21 MAP	12 MAP	15 MAP	21 MAP	23 MAP
GMI x AZO	2395	2753	4500	5450	23028	0.02	80.8	19.2	8.14	1.57	4.40	3.01	2.04
GMI x VAM	2751*	3178*	4858*	5681*	26683	0.02	84.4*	23.8*	9.55	1.63	5.54*	3.96*	2.94*
GMI x PSB	1722	2093	3815	4671	19536	0.02	67.1	11.8	7.73	1.30	2.50	2.39	2.06
GMI x AVP	2817*	2741	4876*	5752*	27992	0.02	90.0*	21.6	9.47	1.75	5.48*	4.07*	3.07*
GMI x BFo	1573	1869	3507	4591	15648	0.03	46.7	15.7	5.77	0.91	2.36	1.64	1.49
GMC x AZO	2186	2504	4006	4938	21858	0.03	74.7	19.9	8.70	1.45	4.07	2.88	2.12
GMC x VAM	2781*	3023	4756*	5661*	27625	0.02	84.3*	22.7*	11.13	1.63	5.52*	4.24*	3.60*
GMC x PSB	1979	2321	3733	4740	20625	0.03	73.3	14.8	8.10	1.43	3.27	2.45	2.12
GMC x AVP	3089*	3409*	5050*	5855*	27974*	0.02	84.8*	26.7*	9.81	1.64	6.19*	4.24*	3.32*
GMC x BFo	2104	1947	3406	4480	16358	0.06	57.0	16.4	5.74	1.12	2.94	1.53	1.44
GML x AZO	2240	2599	4245	5153	21973	0.03	76.1	17.2	8.08	1.47	3.77	2.77	2.47
GML x VAM	2730	3070*	4794*	5512	25984	0.02	84.8	22.2*	9.40	1.64	5.33	3.70	2.85
GML x PSB	2015	2304	3973	4888	20125	0.03	71.9	12.9	7.88	1.40	2.78	2.52	2.11
GML x AVP	2735	3063*	4660	5415	27005*	0.02	88.2*	21.1	9.83	1.71	5.34	3.86	3.25*
GML x BFo	1532	1866	3711	4521	15187	0.04	48.0	14.0	5.62	0.93	1.99	1.57	1.29
GMo x AZO	1520	1848	3512	4501	16534	0.03	50.9	14.0	6.51	0.99	2.22	1.82	1.80
GMo x VAM	1715	2072	3571	4520	17749	0.02	59.8	14.1	6.48	1.16	2.56	1.99	1.79
GMo x PSB	1588	1904	3444	4437	16280	0.04	51.2	15.6	6.18	0.99	2.48	1.75	1.63
GMo x AVP	1816	2078	3661	4666	18568	0.02	65.2	13.2	5.68	1.27	2.63	1.81	1.85
GMo x BFo	1326	1732	3505	4517	14812	0.03	40.4	16.0	5.41	0.78	2.06	1.46	1.41
SEm ±	125.71	125.32	117.73	112.35	382.98	0.0027	3.01	1.92	1.27	3.01	0.28	0.13	0.24
CD (0.05)	348.45	347.36	326.35	311.43	1061.57	0.0074	8.36	5.34	0.45	8.36	0.78	0.37	0.68

Table 38 contd...

Green manuring x Biofertilizers	SLW (mg^{-1} cm^{2})		LML (24 hrs) (%)		LP (%)					NUP (Kg ha^{-1})				
	12 MAP	16 MAP	MAP	16 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	12 MAP	15 MAP	16 MAP	21 MAP	23 MAP
GMI x AZO	3.52	3.68	57.8	50.3	23.13	23.44	23.00	23.31	23.19	70.26	71.14	27.23	81.05	37.33
GMI x VAM	2.81	3.81	36.0	50.0	23.13	23.50	23.13	23.25	23.19	72.99*	84.24*	33.64	114.03*	49.16*
GMI x PSB	3.48	4.71	36.6	49.6	22.63	22.94	22.69	22.75	22.56	59.72	50.23	26.11	65.43	33.68
GMI x AVP	2.62	4.18	36.8	49.1	23.25	23.56	23.19	23.56	23.25	75.66*	84.43*	38.24*	120.23*	55.02*
GMI x BFo	4.08	10.43*	37.0	49.6	21.00	21.63	20.94	21.25	21.13	36.09	32.04	24.47	43.45	22.95
GMC x AZO	3.61	3.93	36.0	49.8	22.38	23.13	22.75	22.81	22.56	67.50	68.62	29.90	81.73	38.12
GMC x VAM	2.62	4.14	36.0	50.0	22.63	23.06	22.50	22.56	22.69	69.40*	85.37*	35.56*	109.74	34.07*
GMC x PSB	3.77	4.33	55.6	50.0	22.31	22.75	21.94	22.31	22.13	63.63	62.97	27.95	67.05	37.93
GMC x AVP	2.53	4.07	56.1	50.1	23.44	23.75	23.19	23.38	23.19	76.53*	92.46*	37.08*	119.97*	56.48*
GMC x BFo	6.32*	9.32	57.6	49.6	21.06	21.56	21.25	21.19	21.00	41.91	48.25	21.97	39.38	23.27
GML x AZO	3.75	3.40	57.5	49.1	22.38	22.88	22.31	22.19	22.52	63.67	60.30	26.98	76.19	37.16
GML x VAM	2.90	4.22	56.0	50.1	22.19	22.69	22.25	22.38	22.19	69.94*	79.01	33.51	100.96	49.45*
GML x PSB	3.62	4.54	57.6	49.3	22.38	22.25	21.87	22.00	22.06	59.60	42.89	29.07	62.79	34.03
GML x AVP	2.81	4.10	37.3	49.5	22.19	22.75	22.25	22.56	22.31	72.45*	80.77	35.57*	100.77	52.84
GML x BFo	5.47*	11.66*	56.8	49.8	21.38	22.06	21.63	21.81	21.75	39.77	25.86	25.74	39.88	24.38
GMo x AZO	4.31	7.20	56.8	50.0	21.88	22.25	21.69	21.81	21.69	39.00	39.27	21.31	45.89	27.56
GMo x VAM	3.47	6.03	56.0	30.1	21.69	22.31	21.88	22.13	21.75	50.19	45.28	23.81	52.67	28.35
GMo x PSB	5.02	9.42	57.6	49.3	21.81	22.19	21.81	22.06	21.88	36.91	39.27	23.79	46.04	25.96
GMo x AVP	3.13	5.07	57.3	49.5	21.81	22.50	21.69	22.00	21.81	53.19	45.73	24.06	52.98	29.46
GMo x BFo	4.87	11.76*	56.8	49.5	21.25	21.75	21.13	22.31	21.25	29.06	32.35	25.90	35.84	21.42
SEm ±	0.34	0.56	56.80	50.00	0.17	0.14	0.12	0.14	0.12	2.72	3.72	1.46	3.53	3.10
CD (0.05)	0.96	1.56	1.23	0.84	0.47	0.38	0.33	0.37	0.33	7.56	10.32	4.07	9.81	8.60

Table 38 contd...

Green manuring x Biofertilizers	TNUP (Kg ha^{-1})	PUP (Kg ha^{-1})					TPUP (Kg ha^{-1})	KUP (Kg ha^{-1})					
		12 MAP	16 MAP	21 MAP	23 MAP	24 MAP		12 MAP	15 MAP	16 MAP	21 MAP	23 MAP	24 MAP
GMI x AZO	333	6.43	2.59	7.90	3.43	4.02	30.85	30.36	31.89	11.58	38.19	16.32	18.99
GMI x VAM	404	7.07*	3.15	10.64	4.60*	4.90*	38.32*	31.39*	37.02	13.92	50.18*	21.50*	22.41
GMI x PSB	274	5.73	2.51	6.10	3.22	3.70	26.06	26.26	21.10	10.94	27.89	14.32	17.29
GMI x AVP	430*	7.16*	3.63*	11.60*	5.08*	3.40*	40.87*	32.74*	38.11	16.26*	52.67*	23.56	26.32*
GMI x BFo	185	3.22	2.32	4.15	2.21	2.50	17.49	15.21	12.89	9.10	18.28	9.22	11.29
GMC x AZO	326	6.22	2.83	7.35	3.63	3.96	30.49	28.50	29.32	11.93	34.30	15.62	17.15
GMC x VAM	405	6.34	3.36*	10.53	5.09*	4.91*	38.14*	29.45	36.79	14.75*	47.01	23.01*	21.73
GMC x PSB	295	5.74	2.58	6.45	3.56	3.45	27.90	26.46	25.48	10.89	26.47	13.96	14.18
GMC x AVP	434*	7.16*	3.43*	11.04*	5.36	4.99*	40.49*	34.05*	41.51*	16.29*	53.95*	24.41*	22.48
GMC x BFo	206	3.94	2.09	3.62	2.21	3.02	19.96	16.75	19.23	9.03	15.55	8.72	12.36
GML x AZO	310	3.92	2.59	7.35	3.55	4.36	29.54	26.24	25.51	10.80	31.25	14.66	19.02
GML x VAM	379	6.55	3.03	9.04	4.55	4.30	35.23	27.53	32.15	13.19	40.09	19.78	18.35
GML x PSB	265	5.47	2.76	5.79	3.09	3.45	24.54	23.93	17.58	12.01	24.96	13.18	14.85
GML x AVP	398	6.63*	3.27	9.33	4.79*	5.11	36.77*	28.40	32.72	13.38	37.54	20.12	21.13
GML x BFo	187	3.59	2.32	3.58	2.19	2.83	16.98	15.03	10.66	9.57	15.98	8.95	11.84
GMo x AZO	206	3.92	1.93	4.15	2.44	2.97	19.01	17.42	15.93	8.59	18.37	10.91	13.07
GMo x VAM	235	4.71	2.14	4.87	2.57	3.24	30.14	20.29	18.26	9.16	21.11	10.84	14.60
GMo x PSB	204	4.01	2.10	4.18	2.43	2.87	19.32	17.16	15.93	9.59	19.12	10.23	12.79
GMo x AVP	239	5.15	2.13	5.00	2.80	3.03	22.74	21.63	18.81	9.39	21.23	11.55	14.10
GMo x BFo	173	3.20	2.37	3.44	2.01	2.73	16.92	13.66	14.02	10.49	14.78	8.83	12.19
SEm ±	7.36	0.23	0.14	0.34	0.26	0.26	1.94	1.27	1.46	0.73	1.44	1.16	1.23
CD (0.05)	20.41	0.66	0.39	0.94	0.73	0.72	5.37	3.54	4.07	2.03	3.99	3.21	3.42

Table 38 contd....

Green manuring x Biofertilizers	TKUP (Kg ha^{-1})	VAM Spure	AZO		GI (Rs ha^{-1})	NI (Rs ha^{-1})	BCR
			3 MAP	12 MAP			
GMI x AZO	147.34	33.33	16.16*	18.16*	54048	21509	1.66
GMI x VAM	176.45	100.50	10.50	12.00	64925	32386	1.99*
GMI x PSB	117.82	29.16	8.83	11.00	45411	12873	1.39
GMI x AVP	189.68*	112.50*	13.50	11.16*	68941*	36403*	2.11*
GMI x BFo	76.02	29.33	5.66	7.83	32763	224	1.00
GMC x AZO	136.82	26.83	14.00*	16.66*	53900	21362	1.65
GMC x VAM	172.75	94.16	9.16	11.16	67035*	34500	2.06*
GMC x PSB	117.44	30.16	9.66	8.83	49888	17349	1.53
GMC x AVP	192.72	94.50	13.66	14.50	69637*	37148*	2.14*
GMC x BFo	81.65	27.00	7.83	9.83	36482	3944	1.12
GML x AZO	127.51	30.66	11.83	15.00	52020	19481	1.60
GML x VAM	151.11	86.33	8.83	10.50	63382	30843	1.94
GML x PSB	106.53	30.66	9.50	11.00	45316	12777	1.39
GML x AVP	153.31	83.66	13.33	16.33	66292	33754	2.03*
GML x BFo	72.06	21.66	5.16	7.83	32393	-145	0.99
GMo x AZO	84.30	28.16	9.33	11.33	35802	4164	1.12
GMo x VAM	94.29	77.00	9.50	10.83	40370	8732	1.27
GMo x PSB	84.85	30.00	10.00	11.00	35793	4155	1.13
GMo x AVP	96.74	79.16	13.50	13.50	41148	9511	1.30
GMo x BFo	73.99	19.66	5.16	7.66	30953	-634	0.97
SEm ±	3.34	4.05	0.83	0.99	1130.45	1130.45	0.06
CD (0.05)	9.27	11.23	2.30	2.75	3133.39	3133.39	0.16

Table 39 Performance of mulberry as influenced by the interaction effect of inorganic fertilizers (F) x green manuring (GM) x biofertilizers (B)

Fertilizers x Green manuring x Biofertilizers	Height (cm)		Leaf Area Index				SDMP (Kg ha^{-1}) 16 MAP	RDMP (Kg ha^{-1}) 21 MAP	NAR (mg^{-1} cm^{2}day^{-1}) 12 MAP	SLW (mg^{-1}cm^{2})	
	16 MAP	23 MAP	15 MAP	16 MAP	21 MAP	23 MAP				12 MAP	16 MAP
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
F50 x GMI x AZO	126.3	121.5	6.76	1.90	5.26	3.88	36.0	3247	0.02	3.34	3.27
F50 x GMI x VAM	118.5	123.5	7.34	2.20*	6.86	4.54	36.5	3746	0.02	2.98	4.02
F50 x GMI x PSB	111.3	116.5	5.12	1.20	4.31	3.91	36.0	3038	0.03	3.35	5.74
F50 x GMI x AVP	133.3	123.0	8.18	2.31*	7.96	4.92	36.5	3702	0.02	2.90	3.97
F50 x GMI x BF0	108.5	116.0	4.15	0.65	2.15	2.16	36.5	2860	0.03	4.24	12.01
F50 x GMC x AZO	112.0	124.0	7.72	2.14	6.66	4.57	36.5	2996	0.03	3.56	3.88
F50 x GMC x VAM	123.1	130.5	7.51	2.16	7.27	4.48	36.0	3345	0.03	3.36	4.17
F50 x GMC x PSB	108.1	130.5	5.17	1.41	5.48	3.97	36.5	2846	0.03	3.75	5.71
F50 x GMC x AVP	116.1	113.5	7.29	2.33*	7.44	5.01	36.0	3831	0.02	2.68	3.74
F50 x GMC x BF0	125.0	130.0	4.45	0.52	2.18	2.40	35.5	2501	0.08*	10.55*	11.65
F50 x GML x AZO	115.1	132.5	6.77	2.16	6.09	3.99	36.0	3074	0.02	3.34	3.41
F50 x GML x VAM	150.1	102.5	6.94	1.89	7.16	4.56	36.0	3212	0.03	3.55	4.12
F50 x GML x PSB	115.1	100.0	4.76	1.72	3.64	4.33	36.0	3274	0.03	3.50	3.99
F50 x GML x AVP	118.8	120.0	8.06	2.36*	8.36	4.84	36.0	3342	0.02	2.95	3.77
F50 x GML x BF0	114.8	124.5	4.98	0.50	1.80	2.79	35.5	2863	0.04	6.81	14.16*
F50 x GM0 x AZO	113.1	122.0	4.60	0.73	1.75	2.17	35.0	2617	0.04	4.99	8.82
F50 x GM0 x VAM	122.3	146.0*	5.26	1.28	3.31	3.10	33.5	2499	0.03	3.70	5.23
F50 x GM0 x PSB	119.8	110.0	3.94	0.55	1.88	2.78	34.5	2441	0.04	5.89	12.33*
F50 x GM0 x AVP	137.3	125.0	5.95	1.04	3.42	2.96	35.5	2595	0.03	3.10	6.12
F50 x GM0 x BF0	88.3	142.5	4.57	0.54	1.63	2.15	36.0	2280	0.03	4.66	13.28*

Table 39 contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
F_{75} x GMI x AZO	112.0	143.5	7.20	1.99	7.22	5.02	77.5	3621	0.03	3.78	4.12
F_{75} x GMI x VAM	106.1	151.0*	9.08	2.49*	8.78	8.04*	91.5	4468*	0.02	2.49	3.89
F_{75} x GMI x PSB	138.3	129.5	5.30	1.45	4.87	4.00	67.0	2863	0.03	3.69	4.08
F_{75} x GMI x AVP	133.3	106.5	10.52*	2.51*	10.61*	7.13*	100.0*	4176*	0.02	2.46	4.54
F_{75} x GMI x BF_0	121.0	112.0	4.68	0.64	2.20	2.67	68.0	2476	0.03	3.66	10.31
F_{75} x GMC x AZO	143.8	133.0	6.91	2.18*	6.65	4.52	91.5	3135	0.03	3.97	3.96
F_{75} x GMC x VAM	136.8	156.5*	10.19*	2.44*	9.10	6.93*	101.0*	4011	0.02	2.30	4.29
F_{75} x GMC x PSB	123.3	113.5	5.93	2.30*	5.16	4.30	78.0	2728	0.03	3.73	2.81
F_{75} x GMC x AVP	144.8	120.0	10.71	2.36*	10.72*	7.13*	105.5*	4451*	0.02	2.46	4.81
F_{75} x GMC x BF_0	116.1	133.0	5.29	0.63	1.80	1.72	79.0	2513	0.04	4.22	10.77
F_{75} x GML x AZO	114.1	115.0	6.63	2.08	7.03	3.96	79.0	3350	0.03	4.02	4.11
F_{75} x GML x VAM	138.0	139.0	8.41	2.40*	9.63*	6.77*	93.0*	4072	0.02	2.29	4.10
F_{75} x GML x PSB	277.6*	141.0	5.11	1.41	4.98	3.81	72.0	3205	0.03	3.76	5.32
F_{75} x GML x AVP	134.0	164.0*	10.53*	2.46*	10.33*	7.20*	98.5*	3881	0.02	2.60	4.56
F_{75} x GML x BF_0	131.1	131.0	5.29	0.67	2.05	2.54	83.5	2936	0.05	5.56	12.24*
F_{75} x GM_0 x AZO	113.1	128.5	4.46	0.75	2.23	2.12	71.4	2564	0.04	4.44	8.18
F_{75} x GM_0 x VAM	131.6	116.0	4.63	1.20	5.12	3.91	77.5	3223	0.02	3.09	4.46
F_{75} x GM_0 x PSB	135.5	152.5	4.93	0.59	1.92	2.21	85.0	2496	0.04	5.32	12.62*
F_{75} x GM_0 x AVP	130.1	119.0	4.16	1.72	3.80	2.84	83.5	3007	0.02	3.15	4.91
F_{75} x GM_0 x BF_0	145.5	162.5*	4.13	0.67	1.98	1.98	76.0	2566	0.03	4.59	9.69

Table 39 contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
F_{100} x GMI x AZO	125.3	154.5	6.94	1.99	5.90	4.05	86.0	3620	0.03	3.45	3.64
F_{100} x GMI x VAM	124.1	120.0	8.46	2.33*	8.11	5.43	91.5*	3831	0.02	2.97	3.54
F_{100} x GMI x PSB	151.0	159.5	5.96	1.96	4.95	4.38	89.0*	2925	0.02	3.40	4.32
F_{100} x GMI x AVP	137.1	179.0*	8.56	2.42*	8.99	6.36	94.5*	4216*	0.02	2.49	4.04
F_{100} x GMI x BF_0	135.7	127.0	4.64	0.81	3.56	2.90	79.5	2585	0.03	4.36	8.99
F_{100} x GMC x AZO	144.6	161.0*	6.77	1.91	7.59	4.47	82.0	3398	0.02	3.30	3.96
F_{100} x GMC x VAM	136.3	139.5	8.04	2.36*	8.36	5.76	89.0*	4000	0.02	2.20	3.97
F_{100} x GMC x PSB	130.8	150.0*	6.21	1.92	7.18	3.83	90.5*	3141	0.03	3.84	4.46
F_{100} x GMC x AVP	141.1	145.5*	8.98	2.48*	8.55	6.33	96.5*	4593*	0.02	2.46	3.68
F_{100} x GMC x BF_0	103.5	133.0	4.80	1.12	3.66	2.62	72.0	2639	0.03	4.20	5.55
F_{100} x GML x AZO	147.3	170.5*	6.44	2.35*	6.45	3.79	79.0	3635	0.03	3.90	2.67
F_{100} x GML x VAM	147.4	155.0*	7.29	2.23*	8.45	5.06	94.5*	4318*	0.02	2.87	4.43
F_{100} x GML x PSB	138.0	153.5*	6.31	2.34*	6.64	4.13	80.5	2993	0.03	3.61	4.31
F_{100} x GML x AVP	143.6	136.5	8.29	2.33*	10.19*	6.50	91.5*	3900	0.02	2.88	3.98
F_{100} x GML x BF_0	146.8	153.0*	5.12	0.83	3.19	2.71	78.0	2637	0.03	4.05	8.58
F_{100} x GM_0 x AZO	132.3	143.0	5.22	1.18	5.08	4.00	65.5	2677	0.03	3.50	4.62
F_{100} x GM_0 x VAM	137.8	172.5*	5.04	0.91	4.08	3.18	72.5	2632	0.03	3.61	6.39
F_{100} x GM_0 x PSB	138.0	156.5*	5.17	1.76	4.77	4.75	71.0	2842	0.03	3.86	3.31
F_{100} x GM_0 x AVP	135.6	160.0*	5.11	1.31	4.83	3.04	69.0	2753	0.02	3.16	4.19
F_{100} x GM_0 x BF_0	137.1	143.5	5.09	0.73	1.89	2.16	94.5*	2621	0.04	5.36	12.32*

Table 39 contd...

Fertilizers x Green manuring x Biofertilizers	LML (12 hrs) 23 MAP	KUP (Kg ha^{-1}) 21 MAP	TKUP (Kg ha^{-1})	AZO	LP (%)					Sustainable yield index
					15 MAP	16 MAP	21 MAP	23 MAP	24 MAP	
(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
F_{50} x GMI x AZO	36.0	29.01	111.92	14.50	23.94	23.75	23.75	24.06	24.00	0.34
F_{50} x GMI x VAM	36.5	32.00	137.48	95.00	23.94	24.31	23.94	23.94	23.94	0.48
F_{50} x GMI x PSB	36.0	19.87	94.28	8.00	23.56	24.00	23.69	23.63	23.38	0.34
F_{50} x GMI x AVP	36.5	39.11	146.04	11.00	24.06	24.31	23.94	24.06	24.06	0.48
F_{50} x GMI x BF_0	36.5	19.50	69.66	6.50	21.56	21.75	21.56	21.56	21.50	0.29
F_{50} x GMC x AZO	36.5	25.07	109.46	11.00	23.25	23.81	23.44	23.75	23.31	0.40
F_{50} x GMC x VAM	36.0	35.80	136.43	11.00	23.13	23.63	23.31	23.25	23.50	0.48
F_{50} x GMC x PSB	36.5	21.25	100.24	9.00	23.31	23.75	23.19	23.50	23.31	0.39
F_{50} x GMC x AVP	36.0	41.17	142.50	12.00	24.12	24.38	23.94	24.00	23.88	0.50
F_{50} x GMC x BF_0	35.5	14.02	31.58	8.00	21.19	21.63	22.00	21.25	21.19	0.27
F_{50} x GML x AZO	36.0	23.27	97.95	10.00	22.94	23.44	22.88	23.19	23.38	0.39
F_{50} x GML x VAM	36.0	28.75	122.36	10.00	23.31	23.56	23.06	23.31	23.00	0.44
F_{50} x GML x PSB	36.0	21.36	93.24	8.50	23.06	23.38	22.69	22.69	23.25	0.36
F_{50} x GML x AVP	36.0	34.68	130.09	10.50	23.44	23.69	22.94	23.56	23.13	0.48
F_{50} x GML x BF_0	35.5	15.73	67.23	7.50	22.19	22.88	22.44	22.56	22.38	0.24
F_{50} x GM_0 x AZO	35.0	14.17	67.79	9.00	22.63	23.00	22.13	22.25	22.19	0.30
F_{50} x GM_0 x VAM	33.5	17.80	78.95	9.00	22.25	23.13	22.63	22.69	22.38	0.34
F_{50} x GM_0 x PSB	34.5	14.97	69.63	9.50	22.94	23.00	22.44	22.69	22.56	0.31
F_{50} x GM_0 x AVP	35.5	19.89	88.63	15.00	22.31	23.50	22.06	22.31	22.31	0.34
F_{50} x GM_0 x BF_0	36.0	11.86	61.89	4.00	22.50	22.94	21.75	22.44	22.37	0.25

Table 39 contd...

(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
F$_{75}$ x GMI x AZO	36.5	41.44	172.76	18.00*	23.75	24.06	23.75	23.56	23.63	0.50
F$_{75}$ x GMI x VAM	34.5	59.35*	202.08	12.00	23.69	24.25	23.88	23.94	23.94	0.61
F$_{75}$ x GMI x PSB	36.0	32.22	130.49	8.50	23.50	23.81	23.50	23.75	23.44	0.38
F$_{75}$ x GMI x AVP	37.0	61.75*	222.52*	14.00	23.94	24.31	23.94	24.13	23.88	0.67
F$_{75}$ x GMI x BF$_0$	34.0	19.42	75.94	6.00	21.06	21.63	23.75	21.19	21.13	0.28
F$_{75}$ x GMC x AZO	35.0	40.90	157.99	18.00*	22.69	23.63	23.19	22.81	22.75	0.50
F$_{75}$ x GMC x VAM	37.0	55.72	198.02	8.00	22.88	23.38	22.69	22.38	22.38	0.64
F$_{75}$ x GMC x PSB	37.0	26.59	115.34	9.50	21.94	22.38	21.50	21.69	21.56	0.44
F$_{75}$ x GMC x AVP	36.0	62.95*	225.96*	15.50*	24.06	24.31	24.06	24.06	23.94	0.65
F$_{75}$ x GMC x BF$_0$	36.5	13.26	82.30	12.00	21.13	21.69	21.06	21.44	21.25	0.31
F$_{75}$ x GML x AZO	35.0	36.70	150.88	15.50*	22.81	23.31	22.63	22.00	22.56	0.51
F$_{75}$ x GML x VAM	35.5	41.84	149.20	8.50	21.94	22.63	21.88	22.44	22.06	0.59
F$_{75}$ x GML x PSB	35.0	21.80	95.38	9.00	22.06	22.38	22.25	22.56	22.25	0.36
F$_{75}$ x GML x AVP	34.5	29.40	149.55	18.50*	21.88	22.50	22.19	22.56	22.19	0.61
F$_{75}$ x GML x BF$_0$	35.0	14.59	76.84	4.50	21.38	22.44	21.75	22.06	21.87	0.30
F$_{75}$ x GM$_0$ x AZO	37.5	15.27	70.83	9.50	21.81	22.06	21.69	21.87	21.63	0.27
F$_{75}$ x GM$_0$ x VAM	34.5	22.14	96.03	10.50	21.63	22.25	21.94	22.12	21.09	0.34
F$_{75}$ x GM$_0$ x PSB	35.0	15.06	70.26	10.50	21.69	22.06	21.56	22.00	21.75	0.26
F$_{75}$ x GM$_0$ x AVP	37.0	19.50	89.69	9.00	21.81	22.06	21.63	21.88	21.63	0.33
F$_{75}$ x GM$_0$ x BF$_0$	36.5	12.77	65.41	6.50	20.94	21.50	21.06	20.88	20.75	0.24

Table 39 contd...

(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
F_{100} x GMI x AZO	36.0	44.12	157.34	16.00*	21.75	22.00	21.50	22.19	22.00	0.44
F_{100} x GMI x VAM	35.0	59.20*	189.79	10.00	21.75	22.06	21.68	21.81	21.69	0.56
F_{100} x GMI x PSB	37.0	31.57	128.69	10.00	20.81	21.06	20.88	20.94	20.87	0.38
F_{100} x GMI x AVP	35.0	57.16*	200.48	15.50*	21.81	22.06	21.69	22.50	21.81	0.60
F_{100} x GMI x BF_0	36.0	19.94	82.47	4.50	20.50	21.50	20.56	21.00	20.81	0.28
F_{100} x GMC x AZO	36.0	36.93	143.08	13.00	21.31	21.93	21.69	21.94	21.63	0.44
F_{100} x GMC x VAM	35.5	49.50	183.82	8.50	21.93	22.31	21.56	22.00	22.19	0.59
F_{100} x GMC x PSB	36.0	31.57	136.75	10.50	21.75	22.19	21.19	21.88	21.63	0.42
F_{100} x GMC x AVP	35.5	57.75*	209.71	13.50	22.19	22.56	21.63	22.00	21.75	0.61
F_{100} x GMC x BF_0	36.0	19.37	81.08	3.50	20.81	21.31	20.69	20.94	20.56	0.30
F_{100} x GML x AZO	36.0	33.79	133.70	10.00	21.38	21.94	21.44	21.44	21.69	0.41
F_{100} x GML x VAM	34.5	49.67	181.76	8.00	21.36	22.00	21.81	21.50	21.50	0.57
F_{100} x GML x PSB	36.5	31.72	130.99	11.00	22.06	21.06	20.63	20.88	20.75	0.41
F_{100} x GML x AVP	37.0	48.54	180.30	11.00	21.31	22.00	21.63	21.50	21.75	0.60
F_{100} x GML x BF_0	36.0	17.63	72.10	3.50	20.69	20.93	20.69	20.81	21.13	0.28
F_{100} x GM_0 x AZO	35.0	25.66	114.30	9.50	21.31	21.68	21.31	21.38	21.31	0.34
F_{100} x GM_0 x VAM	36.0	23.39	107.88	9.00	21.21	21.62	21.13	21.69	21.19	0.34
F_{100} x GM_0 x PSB	35.5	27.34	114.66	10.00	20.94	21.50	21.50	21.63	21.31	0.37
F_{100} x GM_0 x AVP	34.5	24.32	111.90	16.50*	21.31	21.94	21.50	21.75	21.63	0.35
F_{100} x GM_0 x BF_0	35.0	19.71	94.67	5.00	20.38	20.81	21.39	20.56	20.56	0.31
SEm±	0.53	2.49	5.79	1.44	0.29	0.24	0.21	0.23	0.21	--
CD (0.05)	1.48	6.91	16.07	3.99	0.81	0.66	0.58	0.65	0.57	-

135

Experiment II Utilization of agricultural byproducts for economising water use and improvement in leaf quality and productivity of mulberry

The response of two varieties of mulberry ie, K-2 and S-54 to four levels of irrigation ie, control, irrigation at CPE 15 mm, CPE 30 mm and CPE 45 mm and four soil moisture conservation practices ie, incorporation of coir pith, mulching with coconut husk, incorporation of silkworm litter and no soil moisture conservation technique were studied.

4.2.1. Plant height

The data on mean plant height recorded at 5, 8, 11, 13, 15, 17, 21 and 24 MAP are furnished in Table 40.

Mulberry varieties showed considerable variation in plant height throughout the period of growth. The variety S-54 was taller when compared to K-2. Significant influence of summer irrigation on plant height was observed from 8 MAP onwards and in general irrigation at CPE 30 mm increased plant height. At 15 MAP this treatment was on par with irrigation at CPE 45 mm and both differed significantly from the control. The effect of moisture conservation techniques was evident from 8 MAP onwards and utilization of coconut husk resulted in significantly taller plants. Incorporation of coconut pith and silkworm litter behaved similarly and resulted in taller plants than those with no soil moisture conservation treatment.

The effect of interaction of variety x irrigation was pronounced from 8 MAP and from 11 MAP, the combination S-54 x CPE 30 which was on par with S-54 x CPE 15 showed significantly higher values at all stages (Table 72). Variety x soil moisture conservation showed significant interaction effect from 8 MAP. At 11 MAP S-54 x coconut husk interaction resulted in significantly taller plants (Table 73). Interaction

Table 40 Height (cm) influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	29.49	76.58	88.93	69.05	70.27	72.65	73.91	51.56
S-54	54.10	95.14	110.24	83.91	86.56	82.26	97.29	79.68
SEm ±	1.07	1.46	1.31	0.97	1.34	0.79	1.79	0.97
CD (0.05)	3.26	4.43	3.99	2.94	4.09	2.41	5.44	2.95
Levels of irrigation								
I_0	42.59	40.69	78.75	60.76	60.61	71.66	62.72	47.71
I_{15}	41.12	105.08	105.39	79.22	80.57	79.33	87.35	71.89
I_{30}	41.23	102.09	110.35	85.36	87.76	80.36	98.64	72.63
I_{45}	42.24	95.56	103.85	80.58	84.73	78.46	93.69	70.27
SEm ±	1.52	2.06	1.86	1.37	1.90	1.12	2.53	1.37
CD (0.05)	NS	6.26	5.64	4.16	5.78	3.42	7.69	4.18
Moisture Conservation								
MCP	40.14	88.11	97.38	77.14	77.89	73.20	83.87	58.91
MCH	41.21	104.25	112.26	85.65	88.91	85.37	101.99	77.63
MCL	43.50	83.15	96.83	75.58	78.66	77.12	84.18	67.00
MC_0	42.34	67.91	91.86	67.55	68.49	74.12	72.35	58.96
SEm ±	1.09	3.74	1.44	1.24	1.21	1.34	2.14	1.78
CD (0.05)	NS	10.38	3.99	3.45	3.38	3.72	5.95	4.95

MAP - Months after planting

137

influenced height from 11 MAP and CPE 30 x coconut husk combination resulted in significant elongation of plants (Table 74). The effect of interaction of variety x irrigation x soil moisture conservation was evident at 11, 13, 15 and 24 MAP and at all these stages the combination S-54 x CPE 30 x coconut husk recorded significantly higher plant height.

4.2.2. Plant spread

Observations recorded on plant spread at 5, 8, 11, 13, 15, 17, 21 and 24 MAP are summarised in Table 41.

Plant spread was significantly higher in the variety S-54 throughout the period of growth. From 8 MAP the effect of irrigation was remarkable in increasing the spread of plants when compared to the control. All the irrigation treatments irrespective of the frequency of irrigation produced plants with uniform spread. Consistent increase in spread of plants was noticed from 8 MAP when coconut husk was used for mulching and the difference was significant with respect to control except at 15 and 21 MAP.

Significant interaction effects of variety x irrigation, variety x soil moisture conservation and irrigation x soil moisture conservation were noticed at certain stages. With respect to variety x irrigation interaction, the combination S-54 x CPE 15, S-54 x CPE 30 and S-54 x CPE 45 were on par and differed significantly from other combinations at 11 and 24 MAP (Table 72). Variety x soil moisture conservation interaction influenced spread at 17 and 21 MAP and S-54 x coconut husk and S-54 x silkworm litter respectively, resulted in more spread (Table 73). At 17 MAP, the combination CPE 45 x coconut husk which was on par with CPE 30 x coconut husk produced maximum spread (Table 74).

4.2.3. Leaf area index

The data relating to leaf area index (LAI) recorded at 5, 8, 11, 13, 15, 17, 21 and 24 MAP are furnished in Table 42.

Table 41 Plant spread (cm) influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	29.15	56.43	63.87	53.32	58.64	62.21	65.01	53.20
S-54	52.21	58.23	71.81	63.71	65.19	66.65	70.35	64.49
SEm±	1.18	2.26	1.02	1.68	2.12	0.68	1.62	0.94
CD (0.05)	5.72	NS	3.11	5.11	6.44	2.07	4.91	2.87
Levels of Irrigation								
I_0	39.12	35.34	69.83	47.28	57.66	61.12	60.97	50.46
I_{15}	41.04	65.66	70.42	58.71	69.11	64.32	69.23	59.61
I_{30}	40.39	65.11	70.42	64.32	65.01	65.99	70.52	62.78
I_{45}	42.16	63.21	71.42	63.77	61.89	66.28	69.98/	62.54
SEm±	1.68	3.20	1.45	2.38	3.00	0.96	2.29	1.34
CD (0.05)	NS	9.71	NS	7.24	9.11	2.92	6.95	4.06
Moisture Conservation								
MCP	39.32	55.07	69.46	58.45	58.80	63.68	66.98	57.08
MCH	39.27	62.59	70.31	62.27	69.80	67.33	68.82	61.63
MCS	42.54	60.79	66.01	60.28	60.91	65.20	68.99	60.76
MC_0	41.59	50.86	65.58	53.08	58.16	61.51	65.91	55.92
SEm±	1.10	3.48	1.00	1.90	3.35	0.77	1.99	1.08
CD (0.05)	NS	9.65	2.78	5.27	NS	2.14	NS	3.00

MAP - Months after planting

Table 42 Leaf area index as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	0.59	1.59	4.42	3.23	1.07	1.51	3.62	3.28
S-54	0.91	1.98	6.76	4.55	1.54	2.56	6.09	4.32
SEm±	0.01	0.02	0.08	0.07	0.04	0.05	0.09	0.10
CD (0.05)	0.03	0.08	0.25	0.22	0.12	0.15	0.27	0.30
Levels of Irrigation								
I_0	0.64	1.37	4.14	2.44	0.97	1.40	2.41	2.60
I_{15}	0.78	1.90	5.79	4.19	1.45	2.28	5.57	3.97
I_{30}	0.83	1.94	6.49	4.52	1.44	2.22	6.04	4.29
I_{45}	0.77	1.97	5.93	4.40	1.36	2.23	5.40	4.32
SEm±	0.01	0.03	0.11	0.10	0.05	0.07	0.12	0.14
CD (0.05)	0.05	0.11	0.35	0.31	0.17	0.21	0.38	0.43
Moisture Conservation								
MCP	0.69	1.76	5.45	3.68	1.32	2.09	4.89	3.67
MCH	0.87	1.99	6.38	5.00	1.46	2.26	6.01	4.45
MCS	0.78	1.73	5.48	3.77	1.24	2.03	4.69	3.38
MC_0	0.67	1.69	5.05	3.10	1.20	1.75	3.82	3.68
SEm±	0.01	0.05	0.22	0.13	0.05	0.07	0.11	0.16
CD (0.05)	NS	0.15	0.62	0.37	0.14	0.21	0.32	0.44

MAP - Months after planting

The variety S-54 recorded significantly higher LAI over K-2 throughout the period of growth. At all stages, the influence of irrigation on LAI was considerable when compared to control and at 5, 8, 11, 13, 21 and 24 MAP irrigation at CPE 30 mm statistically recorded maximum LAI. At 17 MAP all the irrigation treatments produced similar LAI. The effect of moisture conservation was evident at all stages except at 5 MAP and mulching with coconut husk was beneficial for this and in general, it recorded significantly higher values of LAI when compared to other treatments.

Variety x irrigation, variety x soil moisture conservation, irrigation x soil moisture conservation and variety x irrigation x soil moisture conservation interaction effects were significant at certain stages of growth. Variety x irrigation interaction was significant upto 21 MAP and in general S-54 x CPE 15 and S-54 x CPE 30 combinations were on par and recorded significantly higher LAI (Table 72). Variety x soil moisture conservation interaction resulted in significantly higher LAI in the combination S-54 x coconut husk at 8, 15, 17, 21 and 24 MAP (Table 73). The interaction effect of irrigation x soil moisture conservation was evident at 17 and 21 MAP and CPE 45 x coconut husk and CPE 30 x coconut husk recorded significantly higher LAI (Table 74). Variety x irrigation x soil moisture conservation interaction revealed the significance of the combination S-54 x CPE 45 x coconut husk and S-54 x CPE 30 x coconut husk which produced the highest LAI at 13 and 21 MAP respectively (Table 75).

4.2.4. Shoot length

Data recorded on the effect of treatments on shoot length (SL) at various stages and total shoot length (TSL) are presented in Table 43.

The variety S-54 differed significantly from K-2 with respect to SL at all stages except at 8 MAP. This trend was noticed with respect to TSL as well. The effect of

Table 43 Shoot length (cm) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Total
Varieties									
K-2	29.49	251.89	401.56	302.21	188.35	495.71	348.29	223.73	2241.13
S-54	54.10	243.27	512.99	473.23	257.10	588.37	500.67	329.15	2951.54
SEm±	1.07	7.91	17.48	10.79	3.64	7.05	16.29	9.72	25.15
CD (0.05)	3.26	NS	53.04	32.74	11.06	21.39	49.41	29.51	76.31
Levels of Irrigation									
I_0	42.59	164.88	370.42	256.33	114.54	498.27	270.92	190.71	1878.79
I_{15}	41.12	265.42	482.25	434.17	224.38	571.88	467.13	308.88	2805.33
I_{30}	41.23	286.38	495.66	436.63	277.54	547.04	493.25	307.63	2889.63
I_{45}	42.24	273.67	480.71	423.75	274.46	550.96	466.63	298.54	2811.58
SEm±	1.52	11.19	24.73	15.26	5.15	9.97	23.03	13.75	35.57
CD (0.05)	NS	NS	75.02	46.31	15.64	30.25	69.88	41.73	107.92
Moisture Conservation									
MCP	40.14	256.00	448.13	361.88	228.79	522.00	397.25	259.17	2523.92
MCH	41.21	266.08	508.08	469.17	267.83	605.19	514.21	335.21	2995.50
MCS	43.50	236.63	449.29	376.50	203.38	542.42	395.50	270.54	2504.96
MC_0	42.34	231.63	423.63	343.33	190.92	498.54	390.96	240.83	2360.96
SEm±	1.09	80.62	20.69	13.53	11.52	10.14	17.87	11.65	37.05
CD (0.05)	3.02	NS	57.35	37.52	31.93	28.12	49.53	32.29	102.70

MAP - Months after planting

142

irrigation treatments on SL as well as TSL was considerable and irrigation at CPE 30 mm which was on par with irrigation at CPE 15 and 45 mm recorded significantly higher values compared to control. The effect of moisture conservation treatments on SL and TSL was spectacular and mulching with coconut husk resulted in significantly higher values from 11 MAP onwards. At 5 MAP, incorporation of silkworm litter resulted in higher SL.

The interaction between varieties x irrigation was significant with respect to SL at 11, 13, 15, 21 and 24 MAP and TSL. The combination S-54 x CPE 15 and S-54 x CPE 30 showed significantly higher values (Table 72). Variety x soil moisture conservation interaction effect was evident on TSL as well as SL at 13, 21 and 24 MAP. In all the cases, the combination, S-54 x CPE 15 recorded maximum length (Table 73). Significant irrigation x soil moisture conservation interaction was observed on TSL and SL at 13, 15 and 24 MAP. In general, CPE 30 x coconut husk showed significant improvement in length (Table 74). A significant variety x irrigation x soil moisture conservation interaction also indicated the importance of the combination S-54 x CPE 30 x coconut husk in influencing and TSL (Table 75).

4.2.5. Leaf number

The data on leaf number per plant (LN) recorded at 5, 8, 11, 13, 15, 17, 21, and 24 MAP and total leaf number (TLN) are given in Table 44.

Varietal difference on TLN and LN at various stages was quite evident. In general, the variety, S-54 recorded significantly higher values over K-2. Irrigation at CPE 30 mm which was on par with irrigation at CPE 15 mm and CPE 45 mm resulted in significantly higher TLN over control. Almost a similar trend was observed with respect to LN at various stages. The effect of coconut husk on moisture conservation

Table 44 Leaf number as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Total
Varietes									
K-2	11.32	62.07	105.66	57.29	59.72	138.19	73.67	53.76	561.83
S-54	19.94	56.72	135.27	90.49	82.94	163.74	97.64	86.94	734.04
SEm±	0.41	2.05	2.63	2.42	2.28	2.77	1.83	4.94	9.88
CD (0.05)	1.25	6.24	7.98	7.36	6.86	8.42	5.56	15.01	29.98
Levels of Irrigation									
I_0	15.38	34.92	90.29	47.05	46.03	111.60	61.26	48.61	455.54
I_{15}	15.44	66.50	129.43	89.59	73.11	156.29	88.05	86.50	704.96
I_{30}	16.14	64.94	134.78	85.61	84.16	167.09	97.82	76.81	727.63
I_{45}	15.56	71.23	127.36	73.29	82.02	168.88	95.50	69.47	703.63
SEm±	0.58	2.98	3.72	3.43	3.20	3.92	2.59	6.99	13.98
CD (0.05)	NS	8.82	11.29	10.42	9.71	11.91	7.86	21.23	42.40
Moisture Conservation									
MCP	14.97	56.24	119.72	74.59	69.13	144.90	82.33	72.53	634.63
MCH	15.89	66.60	132.67	84.53	86.07	173.07	96.65	82.04	737.92
MCS	16.04	59.90	107.09	74.03	71.33	148.07	86.71	67.41	630.83
MC_0	15.61	54.84	122.38	62.39	58.79	137.82	76.96	59.36	588.38
SEm±	0.51	2.87	3.09	3.16	2.72	4.35	3.79	6.45	10.31
CD (0.05)	NS	NS	8.56	8.76	7.56	12.07	10.50	NS	31.28

MAP - Months after planting

14?

was highest over coir pith and silkworm litter and was more pronounced from 11 MAP onwards.

The treatment combinations S-54 x CPE 15 and S-54 x CPE 30 showed significant interaction effects on TLN and LN at 11, 13, 15, 17 and 21 MAP (Table 72 and Fig 28). Variety x soil moisture conservation interaction revealed the significance of S-54 x coconut husk with respect to TLN and LN at 5, 11, 13 and 17 MAP (Table 73). Irrigation x soil moisture conservation interaction on TLN and LN was more pronounced at 17 MAP. Under both situations the effect of the combinations CPE 30 x coconut husk and CPE 45 x coconut husk was remarkable (Table 74). Variety x irrigation x soil moisture conservation interaction effect was quite evident from the combination S-54 x CPE 30 x coconut husk with respect to TLN (Table 75).

4.2.6. Fresh leaf production

Observations recorded on fresh leaf production (FLP) at 5, 8, 11, 13, 15, 17, 21 and 24 MAP and total fresh leaf production (TFLP) are presented in Table 45.

The varietal reaction was considerable and the variety S-54 was superior to K-2 at all stages of growth. This was evidenced in TFLP as well (Fig 27). Eventhough irrigation at 30 mm resulted in maximum TFLP and the trend was similar in FLP at all harvests, this treatment was on par with irrigation at CPE 15 and CPE 45 mm. All these treatments differed significantly from the control. Mulching with coconut husk followed by partial earthing up resulted in significantly higher TFLP and FLP at various harvests, over other soil moisture conservation treatments as well as control.

The significant effect of the interaction, variety x irrigation was evident at all harvests and the combination S-54 x CPE 30 recorded significantly higher yield throughout crop growth (on par with S-54 x CPE 15 and S-54 x CPE 45 at

Table 45 Fresh leaf yield (kg ha^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Total
Varieties									
K-2	517	2455	4272	2889	2087	2556	4276	4806	23861
S-54	729	3939	5453	3739	3114	4579	6824	7294	35674
SEm±	14.84	110.43	165.71	70.68	72.73	68.37	94.25	131.33	300.01
CD (0.05)	45.01	334.99	502.69	214.42	220.61	207.41	285.90	398.39	910.05
Levels of Irrigation									
I_0	394	1881	2657	2442	1737	2137	3638	3866	18754
I_{15}	662	3417	5070	3448	2829	3947	5982	6477	31835
I_{30}	731	3688	5821	3750	2877	4215	6360	7038	34483
I_{45}	705	3801	5902	3617	2959	3970	6201	6819	33998
SEm±	20.98	156.18	234.36	99.96	102.88	96.70	133.29	185.73	424.27
CD (0.05)	63.66	473.75	710.91	303.23	312.00	293.33	404.33	563.41	1287.00
Moisture Conservation									
MCP	590	2983	4634	3142	2410	3302	5455	5651	28170
MCH	714	4037	5628	3869	2839	4250	5985	6973	34298
MCS	609	2800	4831	3192	2562	3401	5611	5930	28939
MC_0	580	2968	4357	3054	2591	3315	5149	5646	27664
SEm±	16.31	106.25	176.59	91.43	89.25	83.43	132.71	199.62	379.97
CD (0.05)	45.22	294.51	489.47	253.44	NS	231.27	367.85	553.31	1053.22

MAP - Months after planting

certain stages). A similar trend was noticed with respect to TFLP as well (Table 72 Fig. 29). S-54 x coconut husk recorded significantly higher TFLP (Table 73). Irrigation x soil moisture conservation interaction effect, highlighted the significance of CPE 30 x coconut husk as well as CPE 45 x coconut husk in influencing TFLP and FLP (Table 74). The effect of interaction of variety x irrigation x soil moisture conservation resulted in maximum TFLP in the combination S-54 x CPE 30 x coconut husk and S-54 x CPE 45 x coconut husk Table 75). The trend was same in FLP at 5, 11, 13, 17 and 21 MAP.

4.2.7. Leaf dry matter production

Data on leaf dry matter production (LDMP) recorded at 5, 8, 11, 13, 15, 17, 21 and 24 MAP and total leaf dry matter production (TLDMP) are given in Table 46.

The variety S-54 recorded significantly higher LDMP at all harvests as well as TLDMP over K-2. Irrespective of the frequency, irrigation at 15, 30 or 45 mm of CPE was found to increase the yield by 60 to 110% over control. Maximum TLDMP was observed when irrigation was given at CPE 30 mm but was on par with CPE 45 mm. The trend was similar with respect to LDMP. Among the soil moisture conservation measures, use of coconut husk consistently proved better than other treatments to produce significantly higher LDMP and TLDMP. Incorporation of coconut pith had little effect on LDMP, however, use of silkworm litter was found to increase LDMP at 11, 17 and 21 MAP and TLDMP over control.

The positive interaction effects among variety x irrigation, variety x soil moisture conservation, irrigation x soil moisture conservation and variety x irrigation x soil moisture conservation were observed on TLDMP and LDMP at certain stages. In general, S-54 x CPE 30 on par with S-54 x CPE 15 resulted in significantly higher

Table 46 Leaf dry matter production (kg ha^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Total
Varieties									
K-2	176.8	834.2	1437.2	973.4	703.9	869.8	1463.2	1621.4	8080
S-54	240.4	1298.3	1787.8	1223.4	1028.6	1508.7	2262.8	2400.9	11751
SEm±	4.95	37.25	51.97	23.44	22.83	20.22	34.37	46.11	104.71
CD (0.05)	15.02	113.00	157.67	71.12	69.25	61.34	104.26	139.89	317.63
Levels of Irrigation									
I_0	137.9	662.4	916.3	846.1	602.3	739.2	1268.3	1348.9	6522
I_{15}	218.8	1130.9	1678.1	1128.8	937.1	1318.1	2011.0	2145.9	10568
I_{30}	242.9	1220.0	1915.3	1229.4	953.2	1385.4	2124.9	2311.6	11383
I_{45}	234.8	1251.0	1940.1	1189.3	972.6	1314.4	2047.6	2238.0	11188
SEm±	7.00	52.68	73.50	33.16	32.28	28.60	48.61	65.22	148.08
CD (0.05)	21.24	159.80	222.98	100.58	97.94	86.75	147.45	197.84	449.20
Moisture Conservation									
MCP	197.2	987.7	1547.8	1042.8	807.0	1108.4	1807.3	1884.2	9382
MCH	239.1	1338.9	1850.1	1273.4	941.7	1405.5	2007.5	2290.8	11347
MCS	203.6	942.4	1610.6	1061.4	856.4	1138.9	1914.7	1989.3	9717
MC_0	194.4	996.1	1441.5	1016.0	860.1	1104.3	1722.4	1880.1	9215
SEm±	50.08	34.72	57.94	30.27	29.14	27.04	44.28	62.49	119.77
CD (0.05)	14.09	96.24	160.61	83.91	80.77	74.95	122.74	173.22	331.99

MAP - Months after planting

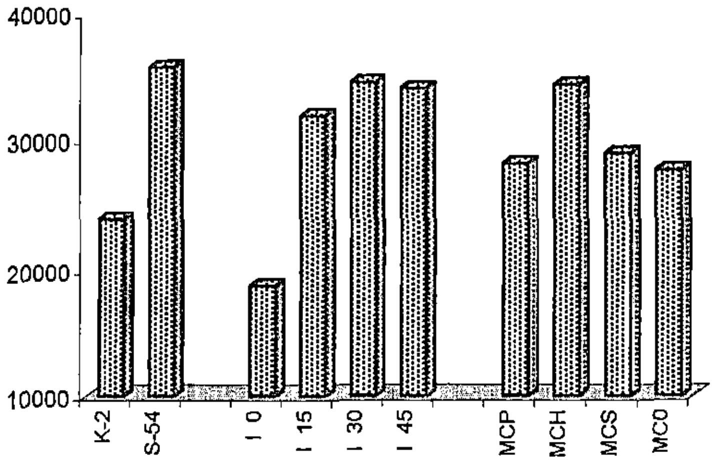


Fig 27 TFLP(kg/ha) as influenced by varieties, irrigation and soil moisture conservation practices

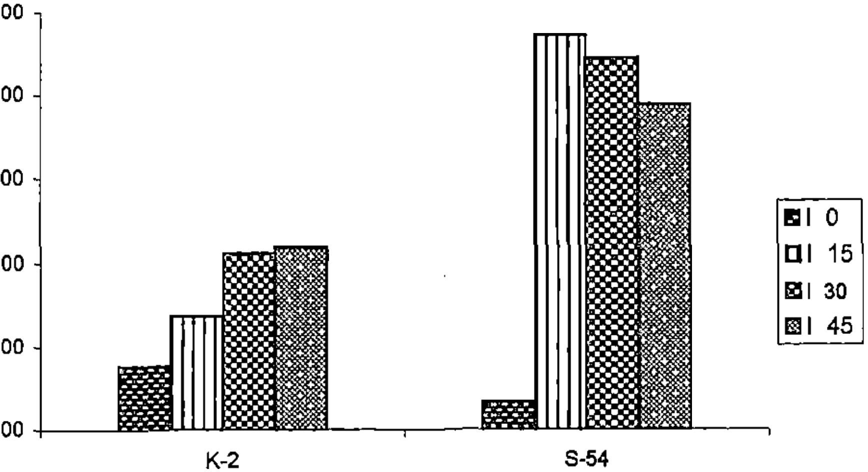


Fig 28 Total leaf number of two varieties as influenced by levels of irrigation

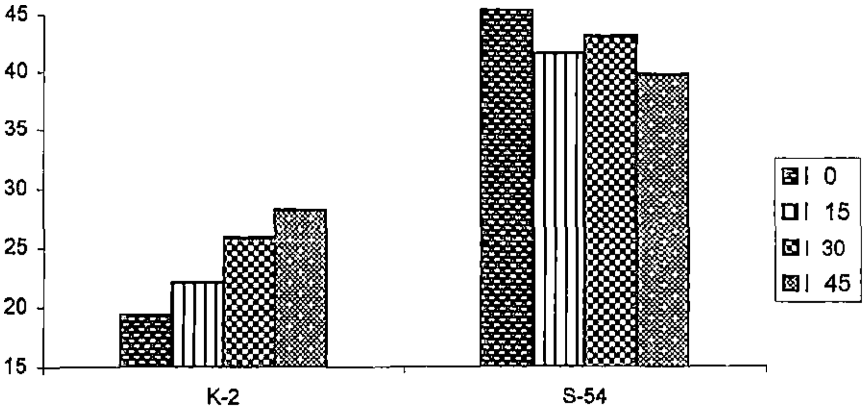


Fig 29 TFLP(t/ha) of two varieties as influenced by levels of irrigation

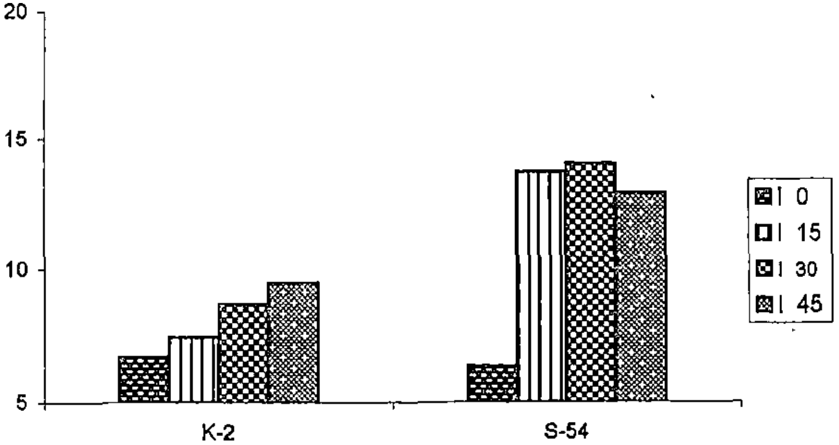


Fig 30 TLDMP(t/ha) of two varieties as influenced by levels of irrigation

TLDMP and LDMP at all harvests (Table 72 and Fig 30). The interaction effects of S-54 x coconut husk was significantly superior with respect to TLDMP and LDMP at 8 and 17 MAP (Table 73). The interaction effect of irrigation x soil moisture conservation brought about considerable increase in TLDMP and LDMP at 8, 17 and 21 MAP in the combinations CPE 45 x coconut husk and CPE 30 x coconut husk (Table 74). In general, the combination, S-54 x CPE 30 x coconut husk produced maximum TLDMP (Table 75) and LDMP at 5, 17 and 21 MAP.

4.2.8. Stem dry matter production

The data pertaining to stem dry matter production (SDMP) recorded at various stages and total stem dry matter production (TSDMP) are furnished in Table 47.

The significant response of the variety S-54 was evident on SDMP and TSDMP. Irrigation at CPE 15, 30 and 45 mm were on par in increasing SDMP and TSDMP over control. Similar to leaf dry matter production, SDMP and TSDMP were also the highest when coconut husk was used for soil moisture conservation.

Interaction between variety x irrigation indicated the significance of the combinations S-54 x CPE 45, S-54 x CPE 30 and S-54 x CPE 45 with respect to SDMP at 8, 11, 15 and 17 MAP and S-54 x CPE 15 and S-54 x CPE 30 with respect to TSDMP (Table 72). Though SDMP at 11, 15 and 17 MAP were found to be influenced by irrigation x soil moisture conservation interaction effects no specific trend could be observed. TSDMP was not at all influenced by irrigation x soil moisture conservation interaction effects (Table 74).

4.2.9. Root dry matter production

Data on root dry matter production (RDMP) recorded at various stages are furnished in Table 48.

Table 47 Stem dry matter production (kg ha^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Total
Varieties									
K-2	268.9	1054.2	1414.5	694.8	801.7	989.5	1430.1	1567.1	8221
S-54	332.2	1220.7	1491.7	775.9	910.7	1294.5	1732.9	1956.6	9715
SEm±	7.62	33.22	40.82	30.29	19.13	35.39	61.68	40.62	84.84
CD (0.05)	23.12	100.77	NS	NS	58.05	107.37	187.12	123.23	257.36
Levels of Irrigation									
I_0	207.90	887.20	1043.10	585.70	704.90	852.20	1241.90	1409.20	6932
I_{15}	314.6	1149.5	1525.4	763.9	862.9	1264.4	1665.3	1902.2	9448
I_{30}	341.5	1221.4	1636.0	760.7	929.3	1233.4	1761.8	1814.4	9701
I_{45}	338.2	1292.2	1607.5	828.3	927.8	1218.3	1657.3	1921.5	9791
SEm±	10.77	46.98	57.73	42.84	27.06	50.05	87.24	57.45	119.98
CD (0.05)	32.69	142.51	175.13	129.97	82.09	151.84	264.63	174.27	363.97
Moisture Conservation									
MCP	292.3	1146.8	1473.1	671.4	858.5	1116.0	1540.1	1754.8	8853
MCH	331.3	1274.5	1553.4	840.5	848.1	1222.9	1648.2	1823.2	9542
MCS	295.2	1008.5	1395.1	706.5	851.9	1096.8	1611.5	1781.7	8747
MC_0	283.4	1120.4	1391.0	723.2	866.5	1132.4	1526.4	1687.5	8731
SEm±	8.77	35.71	41.60	25.71	22.16	22.45	34.74	37.74	90.41
CD (0.05)	24.33	98.98	115.33	71.26	NS	62.24	NS	NS	250.62

MAP - Months after planting

RDMP varied between the two varieties and S-54 recorded significantly higher values throughout the period of study. Effects due to irrigation at CPE 15, 30 and 45 mm were on par and significantly higher than the control with respect to RDMP. Incorporation of either coconut pith or silkworm litter did not increase the RDMP at any stage of observation. However, the effect of coconut husk mulching was significantly superior in all observations.

The interaction effect of the combination variety x irrigation was pronounced during first year of crop growth particularly at 5, 8, 11, 13 and 15 MAP and S-54 x CPE 30, S-54 x CPE 15 and S-54 x CPE 45 were on par and found better than other combinations (Table 72). Though irrigation x soil moisture conservation interaction effect was significant at 11 and 17 MAP, no specific trend could be observed with respect to RDMP (Table 74).

Varietal influence, levels of irrigation and moisture conservation practices on dry matter partitioning are given in Fig. 31. The vaiety S-54, irrigation at CPE 30 mm and mulching with coconut husk registered maximum LDMP.

4.2.10. Net assimilation rate

Data relating to net assimilation rate (NAR) recorded at 5, 8, 11, 13, 15, 17, 21 and 24 MAP are given in Table 49.

In general, the variety K-2 registered significantly higher NAR when compared to S-54 and significant difference could be observed at 5, 15, 17 and 21 MAP. Irrigation improved NAR and the increase was significant at 5, 11, 13 and 21 MAP; however, the irrigation frequency did not influence the NAR.

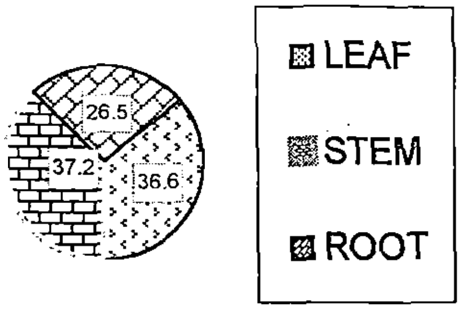
4.2.11. Relative growth rate

The data on relative growth rate (RGR) recorded at various stages are furnished in Table 50.

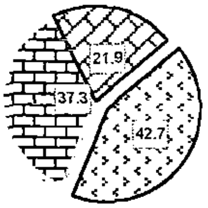
Table 48 Root dry matter production (kg ha^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	206.0	889.3	1715.0	1916.5	2484.2	3126.4	5330.9	5806.7
S-54	252.7	1047.8	1787.2	2200.2	2732.6	3307.5	5489.9	6028.2
SEm±	6.00	29.00	35.41	36.02	32.34	36.36	22.74	44.48
CD (0.05)	18.22	29.00	NS	109.28	98.12	110:31	68.98	134.92
Levels of Irrigation								
I_0	157.3	743.4	1353.9	1741.9	2403.0	2990.7	5264.5	5701.4
I_{15}	232.5	1008.9	1797.2	2114.2	2716.5	3282.7	5468.9	6034.8
I_{30}	266.1	1038.8	1924.4	2234.9	2597.2	3284.6	5505.5	5953.8
I_{45}	261.5	1082.9	1929.1	2142.3	2677.6	3309.7	5402.8	5979.7
SEm±	8.49	41.02	50.08	50.94	34.51	51.43	32.16	62.91
CD (0.05)	25.77	124.44	151.91	154.54	104.69	156.01	97.55	190.83
Moisture Conservation								
MCP	227.6	955.8	1743.2	2025.2	2614.1	3222.6	5365.9	5915.4
MCH	252.6	1066.3	1873.9	2214.1	2737.2	3323.3	5491.3	6071.8
MCS	223.1	891.9	1707.2	2026.4	2628.0	3155.4	5400.1	5831.9
MC_0	214.2	960.2	1680.3	1967.7	2589.0	3166.5	5384.4	5850.6
SEm±	2.34	27.05	45.87	29.78	25.72	29.41	31.67	33.51
CD (0.05)	20.34	74.98	127.16	82.55	NS	81.54	87.79	92.89

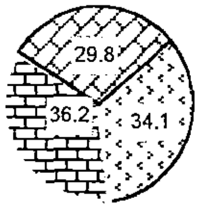
MAP - Months after planting



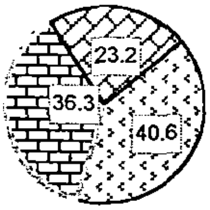
Variety K-2 (TDMP 22.1 t/ha)



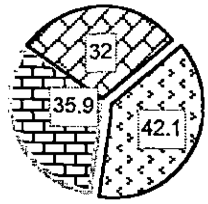
Variety S-54 (TDMP 27.5 t/ha)



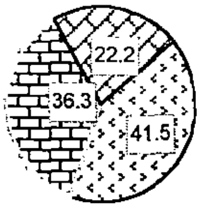
No irrigation (TDMP 19.2 t/ha)



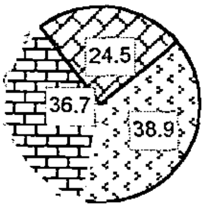
Irrigation at CPE 15mm (TDMP 26.0)



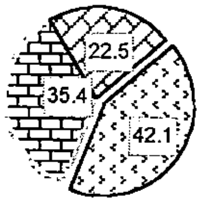
Irrigation at CPE 30mm (TDMP 27.0 t/ha)



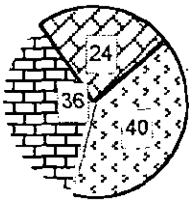
Irrigation at CPE 45mm (TDMP 26.9 t/ha)



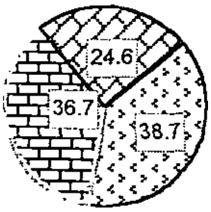
Incorporation of coir pith (TDMP 24.1 t/ha)



Mulching with coconut husk (TDMP 26.9 t/ha)



Incorporation of silkworm litter (TDMP 24.2 t/ha)



No moisture conservation technique (TDMP 23.7 t/ha)

Fig 31 Per cent distribution of drymatter of two varieties as influenced by levels of irrigation and soil moisture conservation practices

Table 49 Net assimilation rate (mg^{-1} cm^{2} day^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	0.055	0.163	0.094	0.105	0.307	0.255	0.125	0.182
S-54	0.0148	0.158	0.071	0.092	0.241	0.217	0.107	0.181
SEm±	0.0018	0.0051	0.0018	0.0058	0.0153	0.0078	0.0049	0.0083
CD (0.05)	0.0054	NS	0.0054	NS	0.0464	0.0236	0.0148	NS
Levels of Irrigation								
I_0	0.040	0.151	0.071	0.128	0.315	0.238	0.176	0.197
I_{15}	0.051	0.158	0.085	0.098	0.249	0.242	0.104	0.195
I_{30}	0.056	0.166	0.086	0.082	0.246	0.233	0.090	0.167
I_{45}	0.059	0.168	0.089	0.087	0.288	0.231	0.095	0.169
SEm±	0.0026	0.0072	0.0025	0.0082	0.0217	0.0110	0.0069	0.0118
CD (0.05)	0.0078	NS	0.0075	0.0248	NS	NS	0.0209	NS
Moisture Conservation								
MCP	0.053	0.161	0.085	0.094	0.265	0.216	0.110	0.184
MCH	0.050	0.172	0.083	0.081	0.244	0.238	0.096	0.163
MCS	0.049	0.146	0.080	0.102	0.291	0.235	0.125	0.214
MC_0	0.053	0.164	0.080	0.118	0.298	0.255	0.135	0.167
SEm±	0.0028	0.0076	0.0042	0.0067	0.0176	0.0118	0.0045	0.0128
CD (0.05)	NS	NS	NS	0.0185	NS	NS	0.0124	0.0654

MAP - Months after planting

RGR was significantly higher in S-54 at 13, 17, 21 and 24 MAP. The variety S-54 resulted in significantly higher RGR than K-2. In general, irrigation at CPE 30 mm which was on par with CPE 45 mm resulted in higher RGR. The beneficial effect of coconut husk was quite evident from the RGR recorded at 5, 8, 17 and 24 MAP.

The combination, S-54 x CPE 15 was significant in improving RGR at 5, 17 and 24 MAP (Table 72). The interaction effect of variety x soil moisture conservation revealed the significance of the combination K-2 x control (at 13 MAP) and K-2 x silkworm litter (at 17 and 21 MAP) (Table 73). With respect to irrigation x soil moisture conservation interaction, the combination CPE 45 x coconut husk showed maximum RGR at 13 MAP (Table 74). At 21 MAP, the combination S-54 x CPE 15/CPE 30 x coir pith/ coconut husk/ silkworm litter/ control registered higher RGR.

4.2.12. Crop growth rate

The data on crop growth rate recorded at different growth stages are furnished in Table 51.

At all stages of growth the variety S-54 showed significant difference when compared to K-2. Managing irrigation at CPE 30 mm was on par with CPE 45 mm and CPE 15 mm in general and proved to be superior with respect to control. There was considerable improvement in CGR with respect to mulching with coconut husk.

The interaction effect of variety x irrigation was evident at all stages of growth and the combination S-54 x CPE 30 and S-54 x CPE 15 recorded considerable improvement in CGR (Table 72). With respect to irrigation x soil moisture conservation interaction effect, CPE 45 x silkworm litter at 11 and 15 MAP, CPE 45 x coconut husk at 13 MAP and CPE 30 x coconut husk at 21 MAP showed maximum CGR (Table 74).

Table 50 Relative growth rate ($mg^{-1}\ g^{-1}\ day^{-1}$) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	26.23	93.86	48.23	16.45	14.61	13.41	12.45	9.08
S-54	22.39	98.92	50.46	20.02	14.84	17.17	13.98	12.44
SEm±	0.57	2.44	2.56	0.89	0.54	0.33	0.28	0.23
CD (0.05)	NS	NS	NS	2.72	NS	1.03	0.86	0.72
Levels of Irrigation								
I_0	10.96	97.27	39.79	18.99	14.42	11.97	11.94	7.95
I_{15}	20.28	98.68	51.46	17.85	15.11	16.88	13.67	11.67
I_{30}	23.27	91.24	57.83	18.07	13.47	16.12	13.95	11.39
I_{45}	22.71	98.38	48.30	18.02	15.90	16.20	13.31	12.05
SEm±	0.80	3.45	3.63	1.27	0.77	0.48	0.40	0.33
CD (0.05)	2.44	NS	11.01	NS	NS	1.45	1.22	1.02
Moisture Conservation								
MCP	18.55	94.86	48.67	16.53	14.71	15.02	13.11	10.51
MCH	22.31	105.47	51.10	20.12	13.83	16.57	13.24	11.79
MCS	18.72	86.06	50.29	18.19	15.05	14.49	13.45	10.68
MC_0	17.66	99.19	47.33	18.09	15.32	15.08	13.06	10.06
SEm±	0.66	3.64	2.29	1.06	0.52	0.42	0.24	0.31
CD (0.05)	1.85	10.11	NS	NS	NS	1.17	NS	0.87

MAP - Months after planting

Table 51 Crop growth rate (g^{-1} m^{2} day^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	0.32	2.49	4.15	2.59	3.00	3.70	4.14	5.27
S-54	0.44	3.21	4.66	3.77	3.52	5.19	5.01	7.41
SEm±	0.01	0.07	0.11	0.12	0.09	0.07	0.07	0.12
CD (0.05)	0.03	0.22	0.33	0.37	0.27	0.23	0.23	0.39
Levels of Irrigation								
I_0	0.21	2.05	2.91	2.79	2.78	3.18	3.84	4.54
I_{15}	0.39	2.96	4.58	3.41	3.39	4.94	4.79	6.93
I_{30}	0.45	3.11	5.14	3.64	3.27	4.85	4.95	6.82
I_{45}	0.44	3.26	4.99	3.50	3.59	4.81	4.71	7.07
SEm±	0.01	0.10	0.15	0.17	0.12	0.10	0.10	0.18
CD (0.05)	0.04	0.31	0.47	0.53	0.38	0.32	0.32	0.55
Moisture conservation								
MCP	0.36	2.77	4.36	3.05	3.22	4.32	4.49	6.15
MCH	0.43	3.32	4.84	3.88	3.29	4.97	4.73	7.06
MCS	0.36	2.53	4.35	3.25	3.24	4.20	4.64	6.26
MC_0	0.34	2.77	4.08	3.16	3.31	4.29	4.44	5.90
SEm±	0.01	0.08	0.13	0.12	0.08	0.09	0.06	0.16
CD (0.05)	0.03	0.22	0.36	0.34	NS	0.26	0.18	0.44

MAP - Months after planting

4.2.13. Specific leaf weight

The data pertaining to specific leaf weight (SLW) recorded at various growth stages are given in Table 52.

The varietal difference on SLW was not significant from 15 MAP; however, at earlier harvests there was significant improvement in SLW for the variety K-2. No specific trend was observed due to imposition of irrigation treatments. However, upto 11 MAP irrigation irrespective of its frequency resulted in significantly higher SLW compared to rainfed condition. Among the soil moisture conservation treatments there was significant difference only at 8 MAP and mulching with coconut husk showed its superiority over other methods.

Though interaction effects were significant at certain stages, no specific trend was observed.

4.2.14. Root shoot ratio

The data on mean root shoot ratio recorded at 5, 8, 11, 13, 15, 17, 21 and 24 MAP are presented in Table 53.

The variety K-2 recorded significantly higher RSR over S-54 and the difference was significant except at 5 and 13 MAP. Cultivation of the crop under rainfed condition resulted in higher RSR. In general, moisture conservation techniques failed to influence RSR.

Variety x irrigation interaction indicated the significance of the combination S-54 x no irrigation and S-54 x no irrigation in influencing RSR at 11, 15, 17, 21 and 24 MAP (Table 72). Only at one stage (21 MAP) variety x soil moisture conservation interaction was significant and K-2 x coir pith gave maximum RSR (Table 73). Irrigation x soil moisture conservation interaction had no positive effect on RSR (Table 74).

Table 52 Specific leaf weight (mg^{-1} cm^{2}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	3.08	5.27	3.23	3.42	7.15	5.96	4.34	5.52
S-54	2.64	6.45	2.70	2.95	6.74	6.08	4.40	5.75
SEm±	0.09	0.20	0.09	0.13	0.36	0.19	0.17	0.26
CD (0.05)	0.28	0.60	0.29	0.42	NS	NS	NS	NS
Level of Irrigation								
I_0	2.47	4.88	2.24	3.85	6.63	5.53	5.83	5.82
I_{15}	2.86	5.85	3.06	3.19	6.61	6.08	3.97	5.84
I_{30}	2.98	6.35	3.12	2.84	6.94	6.31	3.68	5.57
I_{45}	3.13	6.36	3.45	2.86	7.59	6.16	4.02	5.32
SEm±	0.13	0.28	0.13	0.19	0.51	0.27	0.25	0.38
CD (0.05)	0.40	0.86	0.41	0.59	NS	NS	0.76	NS
Moisture Conservation								
MCP	2.94	5.71	3.01	3.13	6.39	5.40	4.08	5.59
MCH	2.79	6.67	3.07	2.68	6.69	6.27	3.75	5.17
MCS	2.68	5.23	2.92	3.23	7.16	5.97	4.67	6.52
MC_0	3.03	5.84	2.87	3.69	7.52	6.45	5.01	5.26
SEm±	0.10	0.27	0.16	0.18	0.41	0.29	0.19	0.36
CD (0.05)	NS	0.77	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 53 Root : shoot ratio as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	0.46	0.47	0.62	1.17	1.65	1.72	1.90	1.86
S-54	0.44	0.43	0.57	1.13	1.41	1.31	1.46	1.48
SEm±	0.0075	0.0074	0.0095	0.0276	0.0502	0.0386	0.0350	0.0413
CD (0.05)	NS	0.0224	0.0288	NS	0.1522	0.1170	0.1061	0.1252
Levels of Irrigation								
I_0	0.45	0.48	0.69	1.23	1.84	1.95	2.12	2.09
I_{15}	0.44	0.45	0.58	1.14	1.51	1.41	1.61	1.60
I_{30}	0.46	0.43	0.55	1.15	1.38	1.34	1.51	1.51
I_{45}	0.45	0.44	0.55	1.09	1.41	1.37	1.48	1.48
SEm±	0.0106	0.0105	0.0135	0.0390	0.0709	0.0546	0.0495	0.0584
CD (0.05)	NS	0.0318	0.0409	NS	0.2150	0.1656	0.1501	0.1771
Moisture Conservation								
MCP	0.47	0.45	0.59	1.22	1.57	1.56	1.71	1.72
MCH	0.44	0.42	0.57	1.08	1.53	1.43	1.61	1.59
MCS	0.45	0.47	0.60	1.16	1.54	1.55	1.66	1.66
MC_0	0.45	0.46	0.61	1.15	1.50	1.52	1.75	1.70
SEm±	0.0086	0.0095	0.0118	0.0357	0.0512	0.0464	0.0414	0.0346
CD (0.05)	NS	0.0263	NS	NS	NS	NS	NS	NS

MAP - Months after planting

4.2.15. Harvest index

Observations on harvest index (HI) recorded at various stages are furnished in Table 54.

The variety S-54 had higher HI throughout the period of growth. Irrigation in general enhanced HI over control and incorporation of coconut husk was beneficial for enhancing HI.

No significant interactions were observed among different treatment combinations.

4.2.16. Leaf moisture loss pattern and leaf moisture content

Observations on leaf moisture content (LMC) and leaf moisture loss (LML) recorded at 3, 6, 9, 12 and 24 hours after leaf picking at 5, 8, 11, 13, 15, 17, 21 and 24 MAP are presented in Table 55 to 60.

Though the difference in LMC between the varieties S-54 and K-2 was narrow it was significant and LML was higher for the variety S-54 at different intervals after leaf picking which indicated that leaf moisture retention capacity was higher for the variety K-2. The effect of irrigation on LMC was significant over control. In general, LML during the first nine hours of picking was influenced by irrigation treatments and irrigation at CPE 15, 30 and 45 mm accelerated LML when compared to no irrigation. Neither LMC nor LML was affected by any moisture conservation technique.

Though interaction effects of variety x soil moisture conservation and variety x irrigation x soil moisture conservation were significant at certain stages, no specific trend could be observed.

4.2.17. Leaf protein content

Data relating to leaf protein (LP) recorded at various harvests are presented in Table 61.

Table 54 Harvest index (%) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	39.71	43.75	49.76	58.58	46.13	46.50	50.46	50.63
S-54	41.88	50.43	53.31	61.25	62.39	52.85	56.06	54.19
SEm±	0.64	0.95	1.05	0.80	0.68	0.86	0.63	0.53
CD (0.05)	NS	2.89	3.20	2.45	2.06	2.63	1.93	1.61
Levels of Irrigation								
I_0	40.33	42.45	46.99	59.42	45.83	46.23	50.54	48.83
I_{15}	40.83	48.49	51.37	59.42	50.79	49.48	53.42	51.96
I_{30}	41.13	49.27	53.53	61.38	50.21	51.65	54.17	55.29
I_{45}	40.84	48.15	54.25	59.46	50.20	51.34	54.92	53.54
SEm±	0.91	1.34	1.49	1.14	0.96	1.22	0.90	0.75
CD (0.05)	NS	4.09	4.53	NS	2.91	3.72	2.74	2.28
Moisture Conservation								
MCP	39.96	45.55	50.53	60.42	47.88	49.08	53.00	51.04
MCH	41.77	50.08	53.10	60.46	51.92	51.79	53.83	54.67
MCS	40.54	46.43	52.26	59.88	48.33	49.38	53.46	51.67
MC_0	40.00	46.31	50.24	58.92	48.92	48.42	52.75	52.25
SEm±	0.58	0.73	1.08	0.69	0.82	0.63	0.63	0.70
CD (0.05)	NS	2.04	NS	NS	2.28	1.76	NS	1.94

MAP - Months after planting

Table 55 Leaf moisture loss (%) after three hours of harvest of mulberry as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Mean
Varieties									
K-2	16.92	10.48	7.00	7.29	7.06	9.79	10.50	7.29	8.26
S-54	10.69	12.56	10.63	10.58	10.98	12.33	13.58	11.35	11.49
SEm±	0.15	0.15	0.13	0.15	0.16	0.60	0.30	0.18	0.10
CD (0.05)	0.41	0.46	0.42	0.46	0.50	1.82	0.91	0.56	0.31
Levels of Irrigation									
I_0	7.38	9.58	7.54	7.33	7.38	9.71	9.71	7.96	8.27
I_{15}	9.50	12.25	9.58	9.50	9.75	12.58	13.25	10.25	10.75
I_{30}	9.13	12.21	9.00	9.50	9.38	11.04	12.75	9.54	10.25
I_{45}	9.21	12.04	9.13	9.42	9.58	10.92	12.46	9.54	10.24
SEm±	0.21	0.21	0.19	0.21	0.23	0.85	0.42	0.26	0.14
CD (0.05)	0.64	0.65	0.59	0.66	0.70	NS	1.28	0.79	0.44
Moisture Conservation									
MCP	8.42	11.46	8.92	8.96	8.88	10.87	11.50	9.29	9.74
MCH	9.21	12.42	9.00	8.54	9.29	11.33	11.63	9.58	10.30
MCS	8.85	10.96	8.50	9.08	9.21	10.75	11.83	9.50	9.71
MC_0	8.71	11.25	8.83	9.17	8.71	11.29	11.21	8.92	9.75
SEm±	0.17	0.24	0.20	0.16	0.18	0.28	0.25	0.19	0.13
CD (0.05)	0.48	0.66	NS	NS	NS	NS	NS	NS	0.36

MAP - Months after planting

Table 56 Leaf moisture loss (%) after six hours of harvest as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Mean
Varieties									
K-2	14.27	20.15	14.69	15.92	14.46	14.73	15.35	14.81	16.12
S-54	19.71	23.25	18.23	17.75	19.79	20.29	18.71	19.39	19.94
SEm±	0.24	0.28	0.23	0.42	0.33	0.23	0.31	0.37	0.16
CD (0.05)	0.73	0.86	0.69	1.28	1.02	0.71	NS	1.14	0.48
Levels of Irrigation									
I_0	14.79	17.96	15.33	15.46	15.67	14.83	15.81	15.29	15.94
I_{15}	16.54	22.96	16.50	16.75	18.25	18.83	17.43	18.13	18.75
I_{30}	16.79	22.67	16.33	17.21	17.63	17.58	17.49	17.83	18.33
I_{45}	16.25	23.21	17.67	17.92	17.96	18.79	18.56	17.17	19.11
SEm±	0.34	0.43	0.32	0.60	0.47	0.33	0.41	0.53	0.22
CD (0.05)	1.04	1.32	0.98	NS	1.44	1.01	NS	1.62	0.68
Moisture Conservation									
MCP	16.13	22.00	16.71	16.63	17.54	17.00	18.43	16.96	18.06
MCH	16.54	21.58	16.38	17.21	16.17	18.50	18.53	16.95	18.27
MCS	15.79	20.88	15.96	16.50	17.33	16.58	17.41	17.33	17.52
MC_0	15.92	22.33	16.79	17.00	17.46	17.96	17.81	17.17	18.29
SEm±	0.30	0.45	0.29	0.37	0.34	0.47	0.37	0.35	0.19
CD (0.05)	NS	NS	NS	NS	1.09	1.30	NS	NS	0.53

MAP - Months after planting

Table 57 Leaf moisture loss (%) after nine hours of harvest as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Mean
Varieties									
K-2	23.64	28.23	23.31	24.46	23.46	23.43	30.25	24.06	25.01
S-54	27.06	31.50	27.00	27.83	27.10	28.06	34.19	27.75	28.69
SEm±	0.36	0.43	0.27	0.48	0.37	0.43	0.51	0.50	0.16
CD (0.05)	1.09	1.30	0.82	1.47	1.12	1.31	1.57	1.53	0.07
Levels of Irrigation									
I_0	23.92	26.79	24.50	24.38	23.58	24.58	29.04	24.29	25.16
I_{15}	26.08	31.33	25.83	26.96	25.38	26.42	34.58	27.29	27.74
I_{30}	25.58	30.71	25.38	26.63	25.63	25.79	32.58	27.00	27.21
I_{45}	25.75	30.63	24.92	26.63	26.54	26.25	32.67	25.04	27.29
SEm±	0.50	0.60	0.38	0.68	0.52	0.61	0.73	0.71	0.22
CD (0.05)	1.54	1.84	NS	NS	1.59	NS	2.23	2.16	0.69
Moisture Conservation									
MCP	25.42	30.17	24.92	26.29	24.92	25.38	32.08	26.42	26.76
MCH	24.71	29.88	24.67	25.46	25.29	26.13	33.04	24.83	26.71
MCS	24.92	29.04	25.25	26.04	24.88	25.42	31.50	25.83	26.49
MC_0	26.29	30.38	25.79	26.79	26.04	26.08	32.25	26.54	27.42
SEm±	0.40	0.43	0.31	0.43	0.38	0.39	0.59	0.46	0.20
CD (0.05)	1.13	NS	NS	NS	NS	NS	NS	NS	0.57

MAP - Months after planting

Table 58 Leaf moisture loss (%) after twleve hours of harvest as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Mean
Varieties									
K-2	31.13	35.15	33.08	33.81	33.73	31.23	36.58	40.02	33.47
S-54	33.48	35.67	35.42	35.88	34.83	35.94	39.39	42.29	35.75
SEm±	0.31	0.44	0.58	0.50	0.61	0.49	0.43	0.68	0.27
CD (0.05)	0.95	NS	1.76	1.52	NS	1.50	1.33	2.06	0.83
Levels of Irrigation									
I_0	32.29	34.88	33.46	32.38	30.96	32.88	35.38	39.63	33.21
I_{15}	32.88	34.54	35.33	36.79	35.33	34.58	39.38	41.63	35.52
I_{30}	31.71	35.88	34.67	35.04	36.33	33.08	38.29	41.13	34.96
I_{45}	32.33	36.33	33.54	35.17	34.52	33.79	38.92	42.25	34.77
SEm±	0.44	0.62	0.82	0.70	0.87	0.70	0.62	0.96	0.38
CD (0.05)	NS	NS	NS	2.15	2.64	NS	1.88	NS	1.17
Moisture Conservation									
MCP	32.50	35.63	34.71	35.33	35.25	33.04	38.63	41.13	34.97
MCH	31.58	35.46	23.92	33.58	33.00	33.71	38.50	41.42	33.96
MCS	31.58	33.13	34.63	34.54	33.67	34.25	37.00	39.83	34.18
MC_0	33.54	37.42	34.75	35.92	35.21	33.33	37.83	42.25	35.34
SEm±	0.34	0.57	0.35	0.39	0.72	0.44	0.47	0.55	0.22
CD (0.05)	0.96	1.58	0.99	1.08	NS	NS	NS	NS	0.62

MAP - Months after planting

Table 59 Leaf moisture loss (%) after twenty four hours of harvest as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Mean
Varieties									
K-2	54.71	55.23	55.50	55.19	55.89	55.15	55.17	59.35	55.29
S-54	57.48	57.50	57.19	56.52	57.00	56.56	58.00	60.35	57.18
SEm±	0.29	0.25	0.35	0.33	0.30	0.34	0.33	0.27	0.23
CD (0.05)	0.88	0.78	1.07	1.00	0.93	1.04	1.01	0.84	0.64
Levels of Irrigation									
I_0	55.75	55.33	55.50	54.54	55.54	54.96	56.08	58.42	55.40
I_{15}	56.13	56.83	56.79	56.38	56.96	56.79	56.79	60.63	56.68
I_{30}	56.63	56.83	56.67	56.04	56.46	55.50	56.88	60.10	56.46
I_{45}	55.88	56.46	56.42	56.46	56.83	56.17	56.58	60.38	56.40
SEm±	0.41	0.36	0.49	0.47	0.43	0.48	0.47	0.39	0.32
CD (0.05)	NS	1.11	NS	1.42	NS	NS	NS	1.19	NS
Moisture Conservation									
MCP	55.83	56.33	56.21	56.00	56.71	55.83	55.83	59.79	56.12
MCH	56.25	56.54	56.54	55.79	56.21	56.00	57.50	60.33	56.42
MCS	56.04	56.33	56.21	55.58	56.21	55.04	56.46	59.25	56.01
MC_0	56.25	56.25	56.42	56.04	56.67	56.54	56.54	60.04	56.39
SEm±	0.30	0.30	0.26	0.33	0.36	0.32	0.39	0.31	0.19
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 60 Leaf moisture content (%) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	Mean
Varieties									
K-2	65.77	65.83	66.10	66.25	66.19	65.85	65.67	66.06	65.97
S-54	66.71	66.65	66.85	67.04	66.63	66.71	66.69	66.77	66.77
SEm±	0.20	0.17	0.17	0.21	0.13	0.17	0.14	0.21	0.11
CD (0.05)	0.21	0.52	0.53	0.64	0.40	0.52	0.44	0.64	0.35
Levels of Irrigation									
I_0	64.92	64.71	65.33	65.33	65.17	65.33	65.08	65.04	65.15
I_{15}	66.79	66.58	66.58	67.13	66.75	66.29	66.25	66.67	66.62
I_{30}	66.67	66.75	66.96	67.17	66.83	66.83	66.42	66.92	66.82
I_{45}	66.58	66.92	67.04	66.96	66.88	66.67	66.96	67.04	66.88
SEm±	0.28	0.24	0.25	0.30	0.18	0.24	0.20	0.30	0.16
CD (0.05)	0.87	0.74	0.76	0.91	0.56	0.74	0.62	0.91	0.50
Moisture Conservation									
MCP	66.38	66.58	66.38	66.63	66.38	66.13	66.36	66.46	66.43
MCH	66.13	66.54	66.83	66.92	66.46	66.46	66.29	66.88	66.56
MCS	66.21	65.75	66.08	66.46	66.17	66.08	66.58	66.00	66.05
MC_0	66.25	66.08	66.63	66.58	66.63	66.46	66.21	66.33	66.43
SEm±	0.22	0.18	0.23	0.21	0.18	0.25	0.19	0.22	0.11
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

The varieties significantly influenced the LP and the variety S-54 recorded significantly higher LP over K-2. All the irrigation treatments recorded significantly higher LP over no irrigation. Among the soil moisture conservation treatments, utilization of coconut husk resulted in higher leaf protein content.

4.2.18. Soil moisture studies

4.2.18.1. Mean moisture content before and after irrigation

The data regarding the gravimetric soil moisture content (% w/w) before and 48 hours after irrigation at depths of 0-15, 15-30 and 30-45 cm are given in Table 62. At all the three depths soil moisture content before irrigation was high in the plots of K-2. At 0-15 cm depth, the variety S-54 recorded lower values of soil moisture after irrigation. However, at 15 - 30 cm and 30 - 45 cm depths not much difference was observed between varieties after irrigation. At 0 - 15 cm depth maximum moisture content was recorded when irrigation was managed at CPE 15 mm both before and after irrigation. At 15 - 30 cm and 30 - 45 cm depths maximum values were registered when irrigations were given at CPE 45 cm before and after irrigation. Mulching with coconut husk registered maximum moisture content at 0 - 15 cm before irrigation and 15 - 30 cm and 30 - 45 cm after irrigation. However, incorporation of silkworm litter gave higher values at 15 - 30 cm and 30 - 45 cm before irrigation and 0 - 15 cm after irrigation.

4.2.18.2. Mean seasonal consumptive use and daily consumptive use

Observations on mean seasonal consumptive use and daily consumptive use are presented in Table 63 and Fig 32. Both seasonal consumptive use and daily consumptive use were higher for the variety S-54. Irrigation at CPE 15 mm resulted in higher seasonal consumptive use and daily consumptive use. Mulching with coconut husk was beneficial for improving the above parameters.

Table 61 Leaf protein content (%) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
Varietes								
K-2	22.06	22.00	21.88	22.50	22.50	22.13	22.44	22.00
S-54	22.8	22.69	22.63	23.43	23.25	22.94	22.94	22.81
SEm±	0.11	0.12	0.12	0.09	0.07	0.08	0.07	0.08
CD (0.05)	0.34	0.34	0.37	0.27	0.23	0.26	0.24	0.25
Levels of Irrigation								
I_0	22.00	21.94	22.00	22.69	22.63	22.13	22.44	22.06
I_{15}	22.50	22.50	22.31	23.00	23.06	22.81	22.93	22.56
I_{30}	22.75	22.56	22.38	23.13	22.88	22.56	22.69	22.50
I_{45}	22.44	22.38	22.31	23.00	23.06	22.63	22.81	22.44
SEm±	0.16	0.17	0.17	0.12	0.11	0.12	0.11	0.11
CD (0.05)	0.44	0.48	0.48	NS	0.30	0.34	0.31	0.33
Moisture Conservation								
MCP	22.38	22.31	22.25	22.88	22.88	22.44	22.81	22.38
MCH	22.69	22.50	22.25	23.13	22.94	22.63	22.63	22.44
MCS	22.44	22.38	22.38	22.88	22.88	22.44	22.56	22.44
MC_0	22.18	22.19	22.19	23.00	23.00	22.56	22.81	22.31
SEm±	0.07	0.07	0.08	0.06	0.06	0.09	0.07	0.07
CD (0.05)	0.20	0.20	NS	0.18	NS	NS	NS	NS

MAP - Months after planting

Table 62 Soil moisture content (%) as influenced by varieties, levels of irrigation and soil moisture conservation practices

Treatments	0 - 15 cm		15 - 30 cm		30 - 45 cm	
	BI	AI	BI	AI	BI	AI
Varieties						
K-1	8.09	10.40	8.50	12.09	14.03	16.22
S-54	7.88	10.20	9.44	12.73	13.52	16.44
Levels of Irrigation						
I0	6.34	6.95	9.02	10.11	13.51	14.91
I15	8.64	11.64	9.58	12.76	13.64	17.19
I30	8.54	11.31	9.56	13.05	13.80	16.76
I45	8.38	11.28	9.72	13.72	14.16	16.48
Moisture Conservation						
MCP	8.18	9.67	9.51	12.28	13.57	15.89
MCH	8.47	10.69	9.61	12.83	13.81	17.20
MCS	7.98	10.84	9.72	12.73	14.42	16.69
MCo	7.31	9.99	9.03	11.81	13.31	15.55

Single replication data
Statistically not analysed

4.2.18.3. Crop coefficient

The average crop coefficient values are given in Table 63. The variety S-54 recorded maximum value when compared to K-2. Among the irrigation treatments, crop coefficient was maximum when mulberry was irrigated at CPE 15 mm. Mulching with coconut husk improved crop coefficient when compared to other soil moisture conservation measures.

4.2.18.4. Water use efficiency

Data relating to crop water use efficiency and field water use efficiency are given in Table 63 and Fig 33 and it is seen that the variety S-54 was superior with respect to these parameters. Maximum crop water use efficiency was observed when irrigation was given at CPE 30 mm for the variety S-54. However, field water use efficiency was highest with respect to the variety S-54 with irrigation at CPE 45 mm. Maximum values for both crop water use efficiency and field water use efficiency were observed when coconut mulch was used for moisture conservation.

4.2.18.5. Relative soil moisture depletion

Data relating to soil moisture depletion at depths of 0-15, 15-30 and 30-45 cm are given in Table 64.

The variety K-2 extracted maximum quantity of water from 0 - 15 cm depth whereas S-54 from 15 - 30 cm depth. Frequency of irrigation decided relative soil moisture depletion. Under stressed situations when irrigation was not given the crop extracted maximum amount of moisture from the deeper layers of soil. Under irrigated condition maximum absorption was from 0 - 30 cm soil layer irrespective of the frequency of irrigation. Soil moisture conservation practices influenced relative soil moisture depletion and the pattern differed with practices.

Table 63 Consumptive use (mm), mean daily consumptive use (mm), crop coefficient, crop water use efficiency and field water use efficiency as influenced by varieties, levels of irrigation and soil moisture conservation practices

Treatments	Cu (mm)	Mean daily cu (mm)	Crop coeff.	CWUE (kg ha^{-1} mm)	FWUE (kg ha^{-1} mm)
Varieties					
K-2	920	2.76	0.48	18.19	13.27
S-54	1017	3.04	0.50	22.95	17.73
Levels of Irrigation					
I_0	554	1.067	0.29	21.78	19.17
I_{15}	1275	3.084	0.66	16.30	7.57
I_{30}	1028	3.09	0.53	21.99	15.36
I_{45}	1016	3.06	0.35	22.23	19.66
Moisture Conservation					
MCP	914	2.75	0.47	20.57	14.87
MCH	1028	3.09	0.53	22.20	17.56
MCS	969	2.92	0.51	19.91	14.99
MC_0	964	2.90	0.50	19.61	14.57

Single replication data
Statistically not analysed

Table 64 Soil moisture depletion pattern (%) as influenced by varieties, levels of irrigation and soil moisture conservation practices

Treatments	Soil moisture depletion (%)		
	0 - 15 cm	15 - 30 cm	30 - 45 cm
Varieties			
K-2	38.73	31.49	29.93
S-54	32.22	36.18	31.50
Levels of Irrigation			
I_0	35.07	28.68	36.30
I_{15}	34.27	33.09	32.63
I_{30}	35.64	33.64	30.72
I_{45}	36.91	39.93	23.20
Moisture Conservation			
MCP	29.16	39.09	31.75
MCH	32.76	31.55	35.46
MCS	40.63	32.33	27.09
MC_0	39.37	32.38	28.55

Single replication data
Statistically not analysed

4.2.19. Canopy temperature, leaf diffusive resistance and transpiration rate

Observations on canopy temperature, leaf diffusive resistance and transpiration rate are furnished in Table 65.

Leaf temperature status is an indirect measure of plant water status. S-54 recorded minimum leaf temperature (Fig 34), lowest leaf diffusive resistance and higher transpiration rate (Fig 35). Low canopy temperature, low leaf diffusive resistance and high transpiration rate were observed when mulberry was given frequent irrigation at CPE 15 mm. Mulching with coconut husk also helped to reduce canopy temperature and leaf diffusive resistance. But it increased transpiration rate.

4.2.20. Larval characters, cocoon characters and post cocoon parameters

There was significant variation between the two varieties and the variety S-54 recorded maximum leaf consumption, larval weight, cocoon weight, shell weight, filament length and filament weight (Table 66). Irrigation treatments significantly influenced only one parameter, ie, leaf consumption and irrigation at CPE 45 mm recorded the highest value. Similarly, among the soil moisture conservation practices, significant effect was noticed with respect to leaf consumption when coconut husk was used.

4.2.21. Leaf nitrogen content and uptake

Data on mean values of nitrogen content and uptake (NUP) estimated at 5, 8, 11, 13, 15, 17, 21 and 24 MAP and total nitrogen uptake (TNUP) are furnished in Table 67.

The variety S-54 recorded significantly higher leaf nitrogen content at all harvests and the increase ranged from 2.2 to 4.2% compared to K-2. Frequency of irrigation influenced leaf nitrogen and the content was significantly higher when irrigation was given at CPE 15 mm in most of the stages. The influence of soil moisture conservation

Table 65 Diffusive resistance (m mol m^{-2} s^{-1}), temperature (°C) and transpiration rate (μg H_20 cm^{-2} s^{-1})as influenced by varieties, levels of irrigation and soil moisture conservation practices

Treatments	Diffusive resistance	Temperature	Transpiration rate
Varieties			
K-2	35.71	55.83	2.52
K-54	35.34	54.50	2.70
SEm±	0.04	0.83	0.02
CD (0.05)	NS	NS	0.08
Levels of Irrigation			
I0	36.88	69.75	1.30
I15	34.60	43.46	3.10
I30	35.39	51.25	2.85
I45	35.23	56.21	2.65
SEm±	0.06	1.17	0.03
CD (0.05)	NS	3.56	0.11
Moisture Conservation			
MCP	35.58	55.50	2.47
MCH	35.31	53.71	2.54
MCS	35.60	54.88	2.48
MC0	35.59	50.58	2.42
SEm±	0.06	1.04	0.04
CD (0.05)	0.18	NS	NS

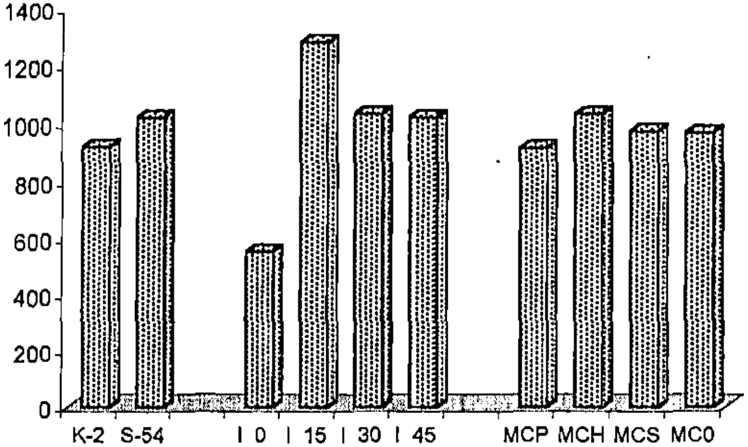


Fig 32 Consumptive use(mm) as influenced by varieties, irrigation and soil moisture conservation practices

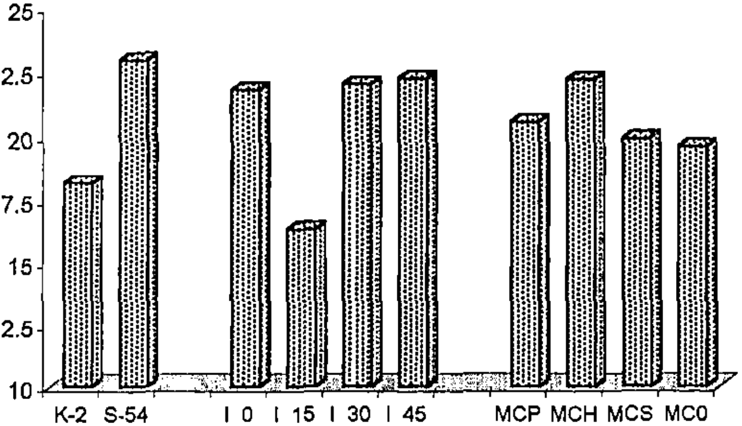


Fig 33 Crop water use efficiency(kg/hamm) as influenced by varieties, irrigation and soil moisture conservation practices

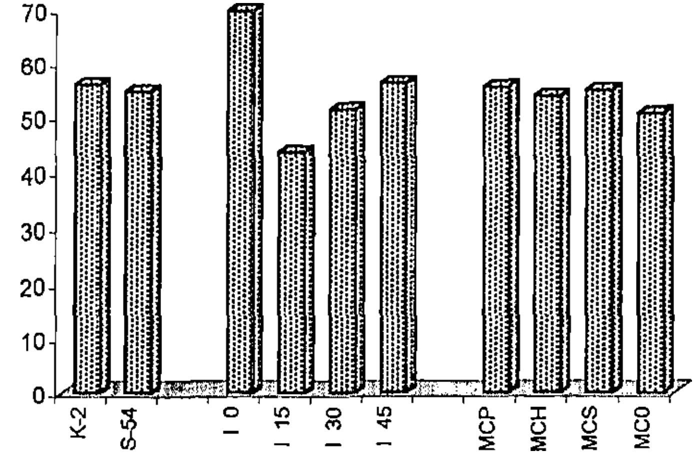


Fig 34 Leaf temperature(°C) as influenced by varieties, irrigation and soil moisture conservation practices

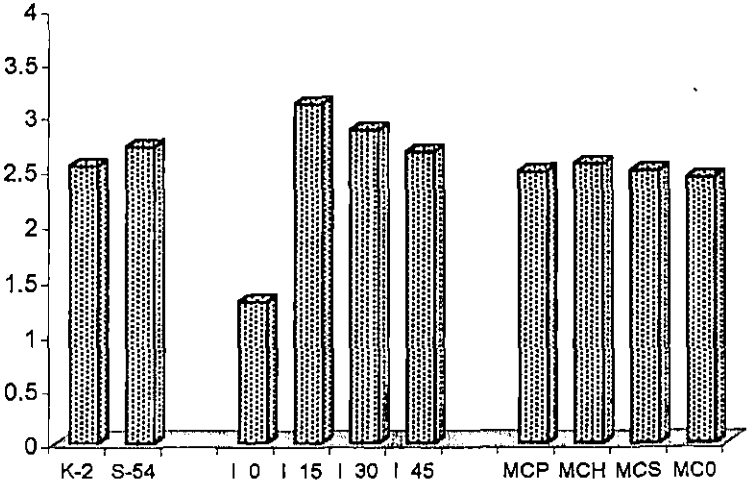


Fig 35 Transpiration rate as influenced by varieties, irrigation and soil moisture conservation practices

Table 66 Larval characters, cocoon characters and post-cocoon parameters as influenced by varieties, irrigation and moisture conservation practices

Treatments	Leaf con. (g)	Larvel wt. (g)	Coco. wt. (g)	Shell wt. (g)	Shell ratio	Filament length (cm)	Filament wt. (g)	Denier
Varieties								
K-2	1769	2.52	1.56	0.212	13.75	481	0.142	2.64
S-54	1914	2.72	1.72	0.249	14.58	550	0.164	2.67
SEm ±	14.17	0.04	0.02	0.006	0.37	10.98	0.003	0.01
CD (0.05)	42.99	0.13	0.08	0.02	NS	33.33	0.339	NS
Levels of Irrigation								
I_0	1752	2.55	1.55	0.220	14.21	500	0.147	2.64
I_{15}	1874	2.62	1.69	0.255	15.33	556	0.166	2.68
I_{30}	1865	2.62	1.62	0.216	13.42	487	0.145	2.67
I_{45}	1875	2.69	1.70	0.232	13.71	521	0.153	2.63
SEm ±	20.04	0.05	0.04	0.008	0.53	15.54	0.005	0.025
CD (0.05)	60.81	NS	NS	NS	NS	NS	NS	NS
Moisture conservation								
MCP	1814	2.55	1.63	0.237	14.58	525	1.157	2.69
MCH	1922	2.71	1.66	0.236	14.33	252	0.156	2.66
MCS	1836	2.59	1.64	0.224	13.67	507	0.150	2.64
MC_0	1793	2.62	1.63	0.227	14.08	506	0.148	2.62
SEm ±	14.99	0.03	0.02	0.005	0.33	9.42	0.003	0.02
CD (0.05)	41.57	NS	NS	NS	NS	NS	NS	NS

technique was observed only at 5, 8 and 13 MAP and mulching with coconut husk registered maximum concentration.

NUP and TNUP showed significant variation between varieties and the higher uptake values were associated with the variety S-54. Irrigation at CPE 30 mm and 45 mm were on par and resulted in maximum uptake over control. NUP at different stages as well as TNUP were higher in plots where coconut husk was used for soil moisture conservation.

Variety x irrigation interaction showed considerable difference and the combination S-54 x CPE 30 recorded maximum TNUP and NUP at different stages (Table 72). The significant effect of S-54 x coconut husk on TNUP and NUP at 8, 17 and 24 MAP was quite evident from the Table 73). With respect to irrigation x soil moisture conservation interaction, CPE 30 x coconut husk which was on par with CPE 45 x coconut husk resulted in maximum TNUP. The trend was similar at 8, 11, 15, 17 and 21 MAP with respect to NUP (Table 74). Variety x irrigation x soil moisture conservation interaction indicated the significance of S-54 x CPE 30 x coconut husk with respect to TNUP (Table 75) and NUP at 5, 11, 17 and 21 MAP.

4.2.22. Leaf phosphorus content and uptake

Observations on phosphorus uptake (PUP) recorded at various stages and total phosphorus uptake (TPUP) are presented in Table 68.

Similar to leaf nitrogen, leaf phosphorus content was also found to be higher for the variety S-54 at all harvests and the increase ranged from 3.6 to 11.1% compared to the local variety K-2. In general, leaf phosphorus content was unaffected by irrigation and soil moisture conservation techniques.

Table 67 Leaf nitrogen content (%) and uptake (kg ha^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP		8 MAP		11 MAP		13 MAP		15 MAP		17 MAP		21 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Varieties																	
K-2	3.53	6.24	3.52	29.41	3.50	50.44	3.60	35.07	3.60	25.36	3.54	30:81	3.59	52.53	3.52	57.14	287.13
S-54	3.65	8.83	3.63	47.41	3.62	64.87	3.75	46.06	3.72	38.50	3.67	55.77	..67	83.49	3.65	88.17	433.04
SEm±	0.02	0.17	0.02	1.39	0.02	1.94	0.01	0.82	0.01	0.87	0.01	0.78	0.01	1.39	0.01	1.78	4.17
CD (0.05)	0.05	0.53	0.06	4.22	0.05	5.89	0.04	2.49	0.04	2.63	0.04	2.37	0.03	4.22	0.04	5.42	12.67
Levels of Irrigation																	
I_0	3.52	4.85	3.51	23.25	3.52	32.17	3.63	30.71	3.62	21.84	3.54	26.17	3.59	45.50	3.53	47.56	232.29
I_{15}	3.60	7.93	3.60	41.06	3.57	60.18	3.68	41.85	3.69	34.86	3.65	48.72	3.67	74.22	3.61	78.05	386.71
I_{30}	3.64	8.89	3.61	44.35	3.58	68.97	3.70	45.79	3.66	35.04	3.61	50.54	3.63	77.51	3.60	84.14	415.13
I_{45}	3.59	8.47	3.58	44.97	3.57	69.29	3.68	43.91	3.69	35.99	3.62	47.74	3.65	74.81	3.59	80.85	406.21
SEm±	0.03	0.24	0.03	1.97	0.03	2.74	0.01	1.16	0.02	1.23	0.02	1.10	0.01	1.96	0.01	2.52	5.91
CD (0.05)	0.08	0.75	NS	5.97	NS	8.33	0.03	3.53	0.05	3.73	0.06	3.36	0.05	5.97	0.05	7.67	17.93
Moisture Conservation																	
MCP	3.58	7.10	3.57	35.49	3.56	55.25	3.66	38.29	3.66	29.63	3.59	40.21	3.65	66.31	3.58	67.85	340.04
MCH	3.63	8.74	3.60	48.48	3.56	65.86	3.70	47.37	3.67	34.76	3.62	51.42	3.62	72.97	3.59	83.05	412.33
MCS	3.59	7.38	3.58	34.12	3.58	58.07	3.66	39.13	3.66	31.51	3.59	41.36	3.61	69.72	3.59	72.13	353.63
MC_0	3.55	6.93	3.55	35.54	3.55	51.42	3.68	37.46	3.68	31.83	3.61	40.18	3.65	63.03	3.57	67.56	334.33
SEm±	0.01	0.18	0.01	1.27	0.01	2.10	0.01	1.11	0.01	1.04	0.01	0.96	0.01	1.52	0.01	2.27	4.35
CD (0.05)	0.03	0.51	0.03	3.53	NS	5.83	0.03	3.10	NS	2.90	NS	2.67	NS	4.39	NS	6.29	12.07

MAP - Months after planting

Table 68 Leaf phosphorus content (%) and uptake (kg ha^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP		8 MAP		11 MAP		13 MAP		15 MAP		17 MAP		21 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Varieties																	
K-2	0.29	0.51	0.28	2.31	0.27	4.01	0.28	2.71	0.28	1.98	0.28	2.46	0.28	4.09	0.28	4.51	22.81
S-54	0.31	0.73	0.30	3.89	0.30	5.47	0.31	3.79	0.29	3.06	0.30	4.51	0.31	6.89	0.31	7.23	35.44
SEm±	0.003	0.01	0.003	0.12	0.004	0.15	0.003	0.05	0.003	0.06	0.004	0.06	0.004	0.12	0.003	0.16	0.37
CD (0.05)	0.010	0.04	0.008	0.36	0.011	0.45	0.008	0.16	0.010	0.18	0.011	0.20	0.011	0.37	0.010	0.50	1.14
Levels of Irrigation																	
I_0	0.30	0.42	0.30	1.95	0.29	2.69	0.30	2.53	0.29	1.77	0.31	2.24	0.29	3.78	0.30	4.04	19.58
I_{15}	0.29	0.64	0.29	3.29	0.28	4.88	0.29	3.32	0.28	2.70	0.28	3.66	0.28	5.75	0.29	6.24	30.54
I_{30}	0.29	0.71	0.29	3.52	0.29	5.62	0.29	3.66	0.29	2.79	0.29	4.04	0.28	6.23	0.29	6.64	33.17
I_{45}	0.30	0.72	0.28	3.63	0.29	5.78	0.29	3.51	0.28	2.82	0.30	3.99	0.30	6.22	0.29	6.58	33.21
SEm±	0.005	0.02	0.003	0.17	0.005	0.21	0.004	0.07	0.005	0.08	0.005	0.09	0.005	0.17	0.005	0.23	0.53
CD (0.05)	NS	0.06	NS	0.52	NS	0.64	NS	0.22	NS	0.26	0.015	0.28	NS	0.52	NS	0.71	1.62
Moisture Conservation																	
MCP	0.29	0.59	0.29	2.91	0.28	4.45	0.28	3.02	0.28	2.29	0.29	3.21	0.29	5.31	0.29	5.50	27.29
MCH	0.30	0.72	0.28	3.86	0.29	5.44	0.29	3.76	0.29	2.79	0.30	4.09	0.28	5.79	0.28	6.56	33.04
MCS	0.29	0.61	0.29	2.73	0.29	4.79	0.30	3.24	0.29	2.54	0.29	3.32	0.29	5.64	0.29	5.86	29.13
MCo	0.29	0.57	0.29	2.89	0.29	4.29	0.29	3.00	0.28	2.46	0.30	3.30	0.30	5.22	0.29	5.58	27.04
SEm±	0.004	0.01	0.004	0.10	0.004	0.19	0.004	0.08	0.004	0.08	0.004	0.08	0.004	0.17	0.004	0.18	0.34
CD (0.05)	NS	0.05	NS	0.29	NS	0.54	NS	0.24	NS	0.24	NS	0.24	NS	NS	NS	0.51	0.94

MAP - Months after planting

TPUP and PUP at different stages were found to be significantly higher in the variety S-54 when compared to K-2. Irrigation at CPE 45 mm which was on par with CPE 30 mm enhanced TPUP. A similar trend was noticed with respect to PUP at different stages.

TPUP was influenced by the interaction effect of variety x irrigation and S-54 x CPE 30 which was on par with S-54 x CPE 15 recorded the maximum value. A similar trend was noticed with respect to PUP at different stages (Table 72). The interaction effect of irrigation x soil moisture conservation was evident on TPUP. The combination CPE 30 x coconut husk on par with CPE 45 x coconut husk recorded maximum TPUP and PUP at 8, 11, 13, 15 and 17 MAP (Table 74). With respect to variety x irrigation x soil moisture conservation interaction, the combination S-54 x CPE 30 x coconut husk registered maximum TPUP (Table 75). A similar trend was observed with respect to PUP at 5, 11 and 17 MAP.

4.2.23. Leaf potassium content and uptake

Data on content, total potassium uptake (TKUP) and potassium uptake (KUP) at 5, 8, 11, 13, 15, 17, 21 and 24 MAP are given in Table 69.

Similar to nitrogen and phosphorus, significant improvement in leaf potassium content to the extent of 15.2% compared to K-2 was observed. Significance of irrigation in influencing this character was noticed at most of the stages and irrigation at CPE 15 or 30 mm was found favourable for improving the potassium content. There was consistently significant increase in leaf protein content when coconut husk was used for soil moisture conservation.

Considerable variation was observed between varieties and the variety S-54 showed maximum TKUP and KUP at different stages. TKUP was highest when

Table 69 Leaf potassium content (%) and uptake (kg ha^{-1}) as influenced by varieties, irrigation and moisture conservation practices

Treatments	5 MAP		8 MAP		11 MAP		13 MAP		15 MAP		17 MAP		21 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Varieties																	
K-2	1.45	2.59	1.46	12.27	1.44	20.90	1.46	14.21	1.48	10.43	1.48	19.94	1.49	21.77	1.48	24.17	119.23
S-54	1.67	4.08	1.65	21.67	1.64	29.79	1.65	20.39	1.66	17.21	1.65	25.19	1.64	37.47	1.63	39.77	195.15
SEm±	0.102	0.08	0.10	0.57	0.011	0.89	0.010	0.41	0.009	0.36	0.016	0.34	0.012	0.51	0.012	0.79	1.68
CD (0.05)	0.035	0.24	0.031	1.74	0.035	2.72	0.032	1.25	0.028	1.10	0.049	1.03	0.037	1.54	0.037	2.42	5.10
Levels of Irrigation																	
I_0	1.51	2.07	1.48	9.80	1.47	13.39	1.50	12.69	1.53	9.19	1.53	11.33	1.53	19.47	1.51	20.39	98.21
I_{15}	1.62	3.63	1.58	18.42	1.58	27.09	1.58	18.07	1.59	15.22	1.57	21.23	1.57	32.28	1.61	35.04	170.54
I_{30}	1.57	3.89	1.59	19.77	1.57	30.49	1.59	19.83	1.59	15.46	1.59	22.73	1.61	34.67	1.57	37.12	183.79
I_{45}	1.58	3.77	1.57	19.88	1.56	30.39	1.55	18.61	1.56	15.39	1.57	20.95	1.55	32.06	1.56	35.34	176.21
SEm±	0.016	0.11	0.014	0.81	0.016	1.27	0.015	0.58	0.013	0.51	0.023	0.48	0.017	0.72	0.017	1.12	2.38
CD (0.05)	0.049	0.34	0.044	2.48	0.049	3.85	0.046	1.77	0.040	1.56	NS	1.86	NS	2.78	0.053	3.42	7.22
Moisture Conservation																	
MCP	1.54	3.06	1.55	15.51	1.53	23.90	1.56	16.35	1.55	12.65	1.56	17.62	1.54	28.19	1.55	29.63	146.71
MCH	1.59	3.91	1.59	21.86	1.59	30.00	1.59	20.63	1.61	15.46	1.61	23.31	1.60	32.80	1.59	37.13	184.96
MCS	1.60	3.32	1.56	15.16	1.56	25.62	1.55	16.75	1.57	13.64	1.56	18.17	1.57	30.54	1.58	32.15	155.08
MC_0	1.55	3.06	1.52	15.35	1.49	21.85	1.51	15.44	1.55	13.52	1.53	17.16	1.56	26.94	1.52	28.97	142.00
SEm±	0.017	0.09	0.016	0.51	0.011	0.97	0.016	0.55	0.015	0.50	0.015	0.47	0.014	0.68	0.014	0.96	2.01
CD (0.05)	0.048	0.27	0.045	1.42	0.030	2.70	0.045	1.54	NS	1.40	0.42	1.31	NS	1.90	0.039	2.66	5.59

MAP - Months after planting

irrigation was given at CPE 30 mm. However, at all the stages KUP was influenced by irrigation and it registered significantly higher KUP over control. Mulching with coconut husk recorded considerable improvement in TKUP and KUP at various stages. Incorporation of silkworm litter also increased KUP by leaf over control.

The interaction effect of variety x irrigation showed the superiority of the combination S-54 x CPE 30 and S-54 x CPE 15 in increasing TKUP and KUP at all stages (Table 72). TKUP and KUP at 8, 13, 17, 21 and 24 MAP were significantly higher in the combination S-54 x coconut husk (Table 73). With respect to irrigation x soil moisture conservation interaction, CPE 45 x coconut husk (on par with CPE 30 x coconut husk) resulted in maximum TKUP (Table 74) and KUP at different stages. Variety x irrigation x soil moisture conservation interaction was evident on TKUP (Table 75) and KUP and the combination S-54 x CPE 30 x coconut husk resulted in maximum uptake.

4.2.24. Available nutrient status of soil

Data on available nutrient status of soil after the experiment are furnished in Table 70.

Available nutrient status of soil was not at all influenced by mulberry varieties. The levels of irrigation had no effect on the available nutrients of soil. With respect to moisture conservation, coconut husk followed by silk worm litter and coir pith enhanced the available nitrogen over control. Available potassium content was highest in the plots where coir pith and coconut husk were used.

4.2.25. Sustainable yield index

The data on sustainable yield index (SYI) are presented in Table 71.

The variety S-54, irrigation at CPE 30 or 45 mm and incorporation of coconut husk were sustainable with respect to yield. The minimum guaranteed yield from these

Table 70 Available nutrient status (kg ha^{-1}) of soil after the experiment as influenced by varieties, levels of irrigation and soil moisture conservation practices

Treatments	Nitrogen	Phosphorus	Potassium
Varieties			
K-2	250.29	52.64	107.74
S-54	250.89	54.04	103.13
SEm±	1.25	1.14	2.15
CD (0.05)	NS	NS	NS
Levels of Irrigation			
I_0	250.73	50.88	104.38
I_{15}	249.92	54.63	109.83
I_{30}	252.04	53.25	105.46
I_{45}	250.08	54.71	102.00
SEm±	1.77	1.61	3.05
CD (0.05)	NS	NS	NS
Moisture Conservation			
MCP	252.75	55.00	123.92
MCH	256.33	51.38	123.25
MCS	254.67	53.08	87.00
MC_0	238.63	54.00	87.50
SEm±	1.96	1.74	2.08
CD (0.05)	5.43	NS	5.78

were 40, 39 and 38 per cent respectively, of the maximum observed yield. The minimum guaranteed yield with the treatment combination involving the high yielding variety S-54 x irrigation irrespective of frequency x mulching with coconut husk was more than 52 per cent of the maximum observed yield indicating the sustainability of the treatment combinations (Table 75).

4.2.26. Economic analysis of the system

The economic analysis of mulberry cultivation in terms of gross income (GI), net income (NI), and benefit cost ratio (BCR) are given in Table 71.

The variety S-54 was economical and it showed its superiority over K-2 in terms of GI, NI and BCR. Irrigation at CPE 30 mm was on par with CPE 45 mm and both the treatments proved their superiority over CPE 15 mm and control with respect to GI, NI and BCR. The effect of coconut husk in increasing GI, NI, and BCR over coir pith, silk worm litter and control was also evident.

The interactions effects assumed significance and the combinations S-54 x CPE 30 (Table 72 and Fig 112), S-54 x coconut husk (Table 73), CPE 30 x coconut husk on par with CPE 45 x coconut husk (Table 74) and S-54 x CPE 30 x coconut husk (Table 75) resulted in maximum GI, NI and BCR.

4.3. Experiment III. Shade tolerance and *in situ* development of green manure sources in mulberry

Three geometry of planting, viz, normal row planting, paired row planting and high density planting, three levels of shade, viz, no shade, 25% shade and 50% shade and five levels of intercropping with green manure crops, viz, cowpea (*Vigna sinensis*), mimosa (*Mimosa invisa*), desmodium (*Desmodium intortum*), calapagonium (*Calapagonium muconoides*) and no green manure were studied. Notations such as PGN,

Table 71 Sustainable yield index and economics of mulberry cultivation as influenced by varieties, levels of irrigation and soil moisture conservation practices

Treatments	SYI	Gross income (Rs)	Net income (Rs)	BC ratio
Varieties				
K-2	0.26	47723	15307	1.47
S-54	0.40	71348	38932	2.18
SEm±	-	600.02	600.02	0.01
CD (0.05)	-	1820.10	1820.10	0.05
Levels of Irrigation				
I_0	0.21	37509	7592	1.26
I_{15}	0.36	63670	28754	1.82
I_{30}	0.39	68967	36051	2.09
I_{45}	0.39	67997	36081	2.13
SEm±	-	848.55	848.55	0.02
CD (0.05)	-	2574.01	2574.01	0.07
Moisture Conservation				
MCP	0.32	56340	23174	1.69
MCH	0.38	68596	35430	2.05
MCS	0.32	57678	25712	1.79
MC_0	0.32	55328	24162	1.77
SEm±	-	759.95	159.95	0.02
CD (0.05)	-	2106.45	2106.45	0.06

Table 72 Effect of irrigation on the performance of two varieties of mulberry

Variety x Irrigation	Height (cm)							Spread (cm)	
	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	11 MAP	24 MAP
K-2 x I_0	43.5	82.9	65.0	60.8	71.2	63.1	47.8	59.3	54.2
K-2 x I_{15}	90.6	85.5	65.5	68.3	71.9	67.3	48.9	62.2	48.2
K-2 x I_{30}	93.4	90.8	71.7	74.8	73.7	80.7	52.2	66.0	53.8
K-2 x I_{45}	78.6	96.3	73.8	77.0	73.7	84.4	57.2	67.8	56.4
S-54 x I_0	37.8	74.5	56.4	60.3	72.1	62.3	47.6	60.0	46.6
S-54 x I_{15}	119.5*	125.2*	92.9*	92.8*	86.7*	107.3*	94.8*	77.4*	71.0*
S-54 x I_{30}	110.7*	129.8*	98.9*	100.6*	86.9*	116.5*	93.0*	74.8*	71.6*
S-54 x I_{45}	112.4*	111.3	87.2	92.3*	83.2*	102.9	83.2	74.9*	68.6*
SEm ±	2.92	2.63	1.94	3.69	1.59	3.58	1.95	2.05	1.89
CD (0.05)	8.86	7.98	5.89	8.18	4.83	10.88	5.91	6.23	5.75

MAP - Months after planting

Contd...

Table 72 contd....

Variety x Irrigation	Leaf No.					TLN	LAI						
	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP		5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP
K-2 x I_0	98.9	45.2	47.2	116.6	65.3	477	0.45	1.42	3.96	2.59	0.93	1.38	2.77
K-2 x I_{15}	100.0	56.1	59.0	130.0	66.0	538	0.55	1.49	4.08	2.67	1.16	1.36	3.10
K-2 x I_{30}	112.2	65.6	64.9	148.6	79.1	612	0.68	1.60	4.61	3.72	1.08	1.58	4.34
K-2 x I_{45}	111.4	62.1	67.6	157.4	85.2	619	0.68	1.86	5.01	3.91	1.11	1.70	4.25
S-54 x I_0	81.6	48.8	44.8	106.5	57.2	434	0.81	1.30	4.31	2.28	1.01	1.41	2.04
S-54 x I_{15}	158.8*	122.9	87.1	182.5*	111.0*	871*	1.01*	2.30*	7.50	5.72*	1.74*	3.19*	8.03*
S-54 x I_{30}	157.2*	105.5	103.3	185.5*	116.4*	843*	0.977*	2.27*	8.36	5.30*	1.79*	2.85*	7.74*
S-54 x I_{45}	143.3	84.4	96.3*	180.3*	105.8*	787	0.84	2.06	6.85	4.89	1.61*	2.76	6.54
SEm ±	5.26	4.85	4.52	5.55	3.66	19.77	0.02	0.05	0.16	0.14	0.08	0.10	0.18
CD (0.05)	15.97	14.73	13.73	16.84	11.12	59.97	0.07	0.16	0.50	0.45	0.24	0.30	0.55

MAP - Months after planting

Contd...

Table 72 contd...

Variety x Irrigation	SL (cm)					TSL (cm)	FLP (kg ha^{-1})							
	11 MAP	13 MAP	15 MAP	21 MAP	24 MAP		5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
K-2 x I_{0}	390.2	255.1	133.5	290.4	212.5	1979	443	1920	2922	2611	1877	2210	3452	3922
K-2 x I_{15}	369.5	278.3	162.5	312.8	215.8	2125	484	2286	3782	2840	1920	2295	3992	4446
K-2 x I_{30}	423.2	349.0	208.6	383.6	226.1	2400	559	2648	4833	3014	2238	2784	4590	5160
K-2 x I_{45}	423.1	326.2	248.6	406.2	240.3	2459	581	2966	5551	3091	2313	2935	5070	5697
S-54 x I_{0}	350.5	257.5	95.5	351.4	168.8	1777	345	1842	2392	2272	1596	2065	3823	3809
S-54 x I_{15}	594.9*	590.0	286.2	621.4*	401.9*	3485	839	4547*	6357*	4057	3738*	5599*	7971*	8508
S-54 x I_{30}	568.0*	524.1	346.4	602.8*	389.0*	3379	903*	4729*	6809*	4486*	3516*	5646*	8129*	8916*
S-54 x I_{45}	538.4*	521.2	300.2	527.0*	336.7*	3163	830*	4637*	6253*	4143*	3606*	5005	7372	7941
SEm ±	34.97	21.59	7.29	12.58	19.45	50.31	29.68	220.87	331.43	141.37	145.45	136.75	188.80	262.60
CD (0.05)	106.09	65.49	22.13	98.83	59.02	152.62	90.03	669.99	1005.38	428.84	441.23	414.83	571.81	796.70

MAP - Months after planting

Contd....

Table 72 ontd...

Variety x Irrigation	TFLP (kg ha^{-1})	LDMP (kg ha^{-1})								TLDMP (kg ha^{-1})
		5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	
K-2 x I_0	19630	154	673	1006	901	643	760	1207	1359	6707
K-2 x I_{15}	22049	162	769	1276	947	642	783	1362	1498	7444
K-2 x I_{30}	25829	189	894	1610	999	753	939	1567	1731	8687
K-2 x I_{45}	28207	199	998	1856	1044	776	995	1715	1895	9482
S-54 x I_0	18148	120	651	826	790	561	718	1329	1338	6336
S-54 x I_{15}	41620	274*	1492	2080	1310	1231*	1852*	2659*	2793*	13693*
S-54 x I_{30}	43138	295*	1546*	2220	1459*	1152*	1831*	2682*	2891*	14030
S-54 x I_{45}	39790	270*	1503*	2024	1333*	1168*	1633	2379	2580	12894
SEm ±	600.02	90.90	74.50	103.95	46.89	45.66	40.44	68.74	92.23	209.42
CD (0.05)	1820.10	30.00	226.00	315.34	142.25	138.51	122.69	208.53	279.78	634.27

MAP - Months after planting

Contd....

Table 72 contd...

Variety x Irrigation	SDMP (kg ha^{-1})					TSDMP (kg ha^{-1})	RDMP (kg ha^{-1})					TDMP (kg ha^{-1})
	5 MAP	8 MAP	11 MAP	15 MAP	17 MAP		5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	
K-2 x I_0	239	967	1169	751	919	7250	183	793	1460	1828	751	19629
K-2 x I_{15}	248	980	1323	742	960	7875	189	834	1625	1821	742	21162
K-2 x I_{30}	293	1089	1546*	838	1049	8670	224	909	1815	2089	838	23241
K-2 x I_{45}	294	1190	1618*	874	1029	9088	227	1019	1958*	1925	874	24399
S-54 x I_0	165	817	948	657	785	6615	131	693	1247	1655	657	18682
S-54 x I_{15}	569	1317*	1727*	983*	1568*	11021*	275*	1183*	1968*	2406*	983*	30942*
S-54 x I_{30}	389	1353*	1725*	1019*	1416*	10731*	308*	1167*	2032*	2379*	1019*	30836
S-54 x I_{45}	382	1394*	1596*	981*	1407*	10494	295*	1146*	1899*	2358*	981*	29519
SEm ±	15.24	66.44	81.65	38.27	70.79	169.68	12.01	12.01	70.82	72.05	38.27	374.40
CD (0.05)	46.24	201.55	247.67	116.10	214.74	514.73	36.45	36.45	214.84	218.56	116.10	1135.71

MAP - Months after planting

Contd....

Table 72 contd...

Variety x Irrigation	RGR (mg^{-1} g^{-1} day^{-1})			CGR (g^{-1} m^{2} day^{-1})						
	5 MAP	17 MAP	24 MAP	5 MAP	8 MAP	11 MAP	13 MAP	17 MAP	21 MAP	24 MAP
K-2 x I_0	13.58	12.02	7.70	0.258	2.15	3.25	2.92	3.25	3.71	4.41
K-2 x I_{15}	14.43	12.76	8.87	0.281	2.31	3.86	2.78	3.49	4.01	5.14
K-2 x I_{30}	18.19	14.91	9.55	0.354	2.58	4.53	3.03	4.09	4.42	5.61
K-2 x I_{45}	18.7	13.94	10.19	0.363	2.88	4.96	2.85	3.96	4.40	5.93
S-54 x I_0	7.92	11.92	8.18	0.153	1.95	2.55	2.66	3.11	3.96	4.66
S-54 x I_{15}	32.82	20.99	14.46*	0.641	3.60*	5.30*	4.03*	6.69	5.56*	8.71*
S-54 x I_{30}	28.36	17.31	13.22*	0.551	3.63*	5.74	4.25*	5.61	5.49*	8.03*
S-54 x I_{45}	26.72	18.45	13.90*	0.515	3.63*	5.04	4.14*	5.64	5.00	8.22*
SEm ±	1.14	0.67	0.47	0.02	0.14	0.22	0.24	0.15	0.15	0.25
CD (0.05)	3.45	2.06	1.44	0.06	0.44	0.66	0.75	0.46	0.46	0.78

MAP - Months after planting

Contd....

Table 72 contd...

Variety x Irrigation	RSR					NUP (kg ha^{-1})							
	11 MAP	15 MAP	17 MAP	21 MAP	24 MAP	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP
K-2 x I_{0}	0.681*	1.74*	1.86*	2.20*	2.09*	5.42	23.44	34.92	32.63	23.26	26.95	43.68	48.17
K-2 x I_{15}	0.643	1.80*	1.79*	1.98*	1.93*	5.71	27.13	44.52	34.01	23.14	27.78	49.15	53.06
K-2 x I_{30}	0.579	1.51	1.62*	1.79	1.76	6.74	31.64	56.79	36.02	26.92	32.99	55.55	60.53
K-2 x I_{45}	0.574	1.55	1.59*	1.63	1.65	7.09	35.40	65.52	37.60	28.11	35.50	61.71	66.76
S-54 x I_{0}	0.717*	1.93*	2.03*	2.04*	2.08*	4.28	23.05	29.43	28.78	20.40	25.37	47.31	46.94
S-54 x I_{15}	0.517	1.21	1.02	1.23	1.26	10.14*	34.99*	75.83*	49.67	46.58*	69.65*	99.28*	103.04
S-54 x I_{30}	0.517	1.24	1.06	1.22	1.24	11.05*	57.05*	81.15*	55.56	43.14*	68.08*	99.45*	107.73*
S-54 x I_{45}	0.531	1.25	0.07	1.33	1.30	9.84	54.52*	73.00*	50.21	43.87*	59.96	87.90	94.93
SEm ±	0.01	0.10	0.23	0.06	0.08	0.35	2.78	3.88	1.64	1.74	1.56	2.78	3.57
CD (0.05)	0.05	0.30	0.71	0.21	0.25	1.06	8.45	11.78	4.99	5.27	4.75	8.44	10.85

MAP - Months after planting

Contd......

Table 72 contd...

Variety x Irrigation	TNUP (kg ha^{-1})	PUP (kg ha^{-1})								TPUP (kg ha^{-1})
		5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	
K-2 x I_{0}	238	0.445	1.82	2.75	2.46	1.81	2.21	3.34	3.68	19.0
K-2 x I_{15}	264	0.462	2.15	3.55	2.56	1.78	2.14	3.79	4.28	21.0
K-2 x I_{30}	307	0.543	2.51	4.50	2.85	2.10	2.64	4.33	4.79	24.4
K-2 x I_{45}	338	0.583	2.75	5.23	2.94	2.21	2.82	4.87	5.30	26.8
S-54 x I_{0}	225	0.387	2.07	2.63	2.59	1.71	2.26	4.21	4.40	20.1
S-54 x I_{15}	509	0.822*	4.43*	6.20*	4.07	3.61*	5.18*	7.69*	8.19*	40.0*
S-54 x I_{30}	523	0.871*	4.52*	6.73*	4.45	3.48*	5.43*	8.12*	8.47*	41.9
S-54 x I_{45}	474	0.850*	4.50*	6.32*	4.07	3.41*	5.14*	7.56*	7.86*	39.5
SEm ±	8.35	0.03	0.24	0.30	0.10	0.12	0.13	0.24	0.33	0.75
CD (0.05)	25.35	0.09	0.73	0.91	0.32	0.37	0.40	0.74	1.00	2.29

MAP - Months after planting

Contd....

Table 72 contd...

Vairety x Irrigation	KUP (kg ha^{-1})								TKUP (kg ha^{-1})	GI (Rs ha^{-1})	NI (Rs ha^{-1})	BCR
	5 MAP	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP				
K-2 x I_0	2.24	9.69	14.17	13.02	9.48	11.38	18.07	20.35	98	38720	8804	1.29
K-2 x I_{15}	2.43	11.33	18.63	13.83	9.59	11.58	20.05	22.64	109	44099	9183	1.26
K-2 x I_{30}	2.73	13.11	23.36	14.86	11.14	13.92	23.71	25.62	128	51659	18743	1.56
K-2 x I_{45}	2.99	14.93	27.44	15.10	11.48	14.86	25.25	28.06	140	56414	24498	1.76
S-54 x I_0	1.88	9.91	12.60	12.34	8.90	11.27	20.86	20.42	98	36297	6381	1.21
S-54 x I_{15}	4.81*	25.51*	35.55*	22.30*	20.84	30.88*	44.49*	47.42*	231*	83241*	48325	2.38
S-54 x I_{30}	5.04*	26.42*	37.63*	24.79*	19.78	31.54*	45.63*	48.60*	239*	86276*	53360	2.61*
S-54 x I_{45}	4.54	24.82*	33.34*	22.11	19.29	27.03	38.86	42.61	212	79580	47664	2.49*
SEm ±	0.16	1.15	1.79	0.82	0.73	0.68	1.02	1.59	3.36	1200.03	1200.03	0.03
CD (0.05)	0.48	3.49	5.44	2.51	0.93	2.07	3.09	4.84	10.21	3640.20	3640.20	0.11

MAP - Months after planting

Table 73 Effect of soil moisture conservation techniques on the performance of two varieties of mulberry

Variety x Moisture conservation	Height (cm)							Spread (cm)		LN			
	8 MAP	11 MAP	13 MAP	15 MAP	17 MAP	21 MAP	24 MAP	17 MAP	21 MAP	5 MAP	11 MAP	13 MAP	17 MAP
K-2 x MCP	85.78	89.13	70.24	66.02	71.24	74.33	52.27	63.46	65.54*	10.73	111.08	51.67	134.87
K-2 x MCH	97.18*	94.36	73.57	81.38	72.74	84.55	56.33	62.29	70.71*	11.05	111.83	66.61	151.34
K-2 x MCS	60.68	85.86	66.44	70.24	73.16	72.44	48.94	62.88	64.49	10.98	80.91	53.15	131.49
K-2 x MCo	62.65	86.35	69.94	63.41	73.43	64.30	48.69	60.18	59.27	12.50	118.80	57.71	135.07
S-54 x MCP	90.43	106.61	84.02	89.16	75.16	93.41	65.53	63.88	68.41*	19.19*	128.36	97.50*	154.93
S-54 x MCH	111.32*	130.16	98.72	96.44	97.99	119.44	98.91	72.36	66.91	20.73*	153.50	102.44	194.80
S-54 x MCS	106.61*	107.80	84.71	87.07	81.07	95.91	85.05	67.52	73.49	21.09*	133.27	94.90*	164.65
S-54 x MCo	73.16	97.36	68.16	73.57	74.79	80.38	69.22	62.83	72.55*	18.72	125.94	67.08	140.57
SEm ±	14.69	5.65	4.88	4.78	5.26	8.42	7.01	3.03	7.82	2.00	12.11	12.39	17.07
CD (0.05)	5.30	2.03	1.76	1.72	1.90	3.03	2.53	1.09	2.82	0.72	4.37	4.47	6.16

MAP - Months after planting

Contd....

Table 73 contd...

Variety x Moisture conservation	TLN	SL (cm)			TSL (cm)	LAI					TFLP (kg ha^{-1})	LDMP (kg ha^{-1})	
		13 MAP	21 MAP	24 MAP		8 MAP	15 MAP	17 MAP	21 MAP	24 MAP		8 MAP	17 MAP
K-2 x MCP	553	279.58	368.91	220.91	2219	1.63	1.07	1.62	3.95	3.14	22614	761	842
K-2 x MCH	632	356.41	376.83	254.50	2460	1.71	1.18	1.65	4.12	3.87	27984	1044	981
K-2 x MCS	518	277.91	322.41	212.91	2134	1.43	0.96	1.23	3.20	2.53	22211	681	794
K-2 x MCo	543	294.91	325.00	206.58	2150	1.60	1.07	1.51	3.19	3.55	22636	850	860
S-54 x MCP	716	444.16	425.58	297.41	2828	1.87	1.56*	2.56	5.81	4.18	33726	1214	1374
S-54 x MCH	843	581.91	661.58	415.91	3530	2.27	1.74	2.86	7.89	5.02	40611	1633	1829
S-54 x MCS	743	475.08	468.58	328.16	2875	2.02	1.52	2.82*	6.18	4.23	35667	1203	1483
S-54 x MCo	633	391.75	456.91	275.08	2571	1.77	1.33	1.97	4.45	3.82	32692	1142	1348
SEm ±	14.58	53.06	70.05	45.66	52.39	0.21	0.20	0.29	0.45	0.63	537.37	136.11	106.00
CD (0.05)	40.42	19.14	25.27	16.47	145.24	0.07	0.07	0.10	0.16	0.22	1489.49	49.10	38.29

MAP - Months after planting

Contd....

Table 73 contd...

Variety x Moisture conservation	TLDMP (kg ha^{-1})	TDMP (kg ha^{-1})	RGR (mg^{-1} g day^{-1})		RSR 21 MAP	NUP (kg ha^{-1})			TNUP (kg ha^{-1})
			11 MAP	13 MAP		8 MAP	17 MAP	24 MAP	
K-2 x MCP	7618	21484	50.80	13.92	1.97	26.75	29.82	52.30	269
K-2 x MCH	9384	24251	53.26	15.20	1.72	36.95	34.92	65.30	333
K-2 x MCS	7601	21235	47.55	16.91	1.93	24.19	28.00	53.26	269
K-2 x MCo	7716	21460	41.30	19.76	1.98	29.71	30.47	57.66	275
S-54 x MCP	11146	26318	46.54	19.14	1.43	44.21	50.59	83.39	410
S-54 x MCH	13309	29670	48.94	25.03	1.50	59.99	67.90	100.80	491
S-54 x MCS	11834	27358	53.02	19.47	1.39	44.04	54.71	91.00	437
S-54 x MCo	10714	26133	53.34	16.42	1.51	41.36	49.88	77.46	393
SEm ±	169.38	227.47	8.98	4.16	0.17	5.00	3.77	8.90	6.16
CD (0.05)	469.50	630.52	3.24	1.50	0.05	1.80	1.36	3.21	17.08

MAP - Months after planting

Contd....

Table 73 contd...

Variety x Moisture conservation	KUP (kg ha^{-1})					TKUP (kg ha^{-1})	GI (Rs ha^{-1})	NI (Rs ha^{-1})	BCR
	8 MAP	13 MAP	17 MAP	21 MAP	24 MAP				
K-2 x MCP	11.14	13.24	12.44	20.03	22.03	111	45228	12062	1.36
K-2 x MCH	15.63	17.05	14.97	24.46	27.91	141	55969	22803	1.68
K-2 x MCS	10.02	12.74	11.71	21.58	22.78	111	44423	12257	1.38
K-2 x MC0	12.27	13.80	12.62	21.01	23.94	112	45272	14106	1.45
S-54 x MCP	19.88	19.52	22.79	36.36	37.23	182	67452	34286	2.01
S-54 x MCH	28.08	24.20	31.64	41.14	46.34	228	81223	48057	2.42
S-54 x MCS	20.29	20.76	24.61	39.49	41.51	198	71334	39168	2.19
S-54 x MC0	18.41	17.06	21.68	32.87	33.98	171	65385	34219	2.07
SEm ±	2.01	2.18	1.85	2.70	3.76	2.85	1074.74	1074.74	0.03
CD (0.05)	0.72	0.78	0.66	0.97	1.36	7.90	2978.97	2978.97	0.09

MAP - Months after planting

Table 74 Performance of mulberry as influenced by interaction effect of irrigation and moisture conservation techniques

Irrigation x Moisture conservation	Height (cm)					Spread (cm)	LN	TLN	LAI		
	11 MAP	13 MAP	15 MAP	17 MAP	24 MAP	17 MAP	13 MAP		15 MAP	17 MAP	21 MAP
I_0 x MCP	79.5	65.2	60.2	64.7	48.6	59.6	45.8	435	0.99	1.41	2.25
I_0 x MCH	81.3	67.5	65.0	67.7	50.3	60.2	49.8	527	1.23	1.41	3.03
I_0 x MCS	72.0	54.7	57.1	57.2	42.5	64.2	40.4	417	0.87	1.36	1.91
I_0 x MC_0	82.1	55.5	59.9	61.1	49.2	60.3	52.0	441	0.80	1.41	2.42
I_{15} x MCP	104.0	83.0	81.3	91.7	61.6	63.9	98.5*	743	1.47*	2.66*	5.99
I_{15} x MCH	117.0	87.4	95.7*	94.0	79.1	66.6	102.2*	774	1.56*	2.34*	6.49
I_{15} x MCS	98.5	76.6	79.2	79.1	74.8	64.6	85.8	648	1.41*	2.08	4.99
I_{15} x MC_0	101.9	69.6	65.8	84.4	71.9	62.0	71.8	653	1.38*	2.01	4.00
I_{30} x MCP	103.8	81.7	86.9	91.2	58.1	64.4	85.0	706	1.39*	2.06	6.09
I_{30} x MCH	128.3	97.2*	99.3*	129.4	94.0	69.9*	104.8*	834*	1.59*	2.51*	7.47*
I_{30} x MCS	114.4	88.7	92.3	101.9	79.7	67.3	90.8*	753	1.51*	2.37*	6.51
I_{30} x MC_0	89.6	73.7	72.3	71.9	58.6	62.2	61.6	616	1.26	1.91	4.08
I_{45} x MCP	102.0	78.4	81.8	87.7	67.1	66.7	68.9	652	1.42*	2.23	5.20
I_{45} x MCH	122.3	90.3*	95.5*	116.7	87.0	72.5*	81.2	815*	1.47*	2.76*	7.04*
I_{45} x MCS	97.2	82.2	85.8	98.4	70.8	64.5	78.9	703	1.18	2.29	5.36
I_{45} x MC_0	93.7	71.2	75.7	71.7	56.0	61.3	64.0	642	1.37	1.64	3.98
SEm±	2.88	2.49	2.43	4.29	3.57	1.55	6.32	20.62	0.10	0.15	0.23
CD (0.05)	7.99	6.90	6.76	11.90	9.91	4.29	17.52	57.16	0.28	0.42	0.64

MAP - Months after planting

Contd....

Table 74 contd....

Irrigation x Moisture conservation	SL (cm)			TSL (cm)	FLP (kg ha^{-1})					TFLP (kg ha^{-1})
	13 MAP	15 MAP	24 MAP		8 MAP	11 MAP	15 MAP	17 MAP	21 MAP	
I0 x MCP	275	127	196	1915	2062	2502	1646	1941	3705	18258
I0 x MCH	257	133	200	1989	2419	3011	2191	2408	3474	20713
I0 x MCS	214	79	174	1683	1274	2220	1363	1835	3553	16440
I0 x MC0	278	117	192	1927	1769	2895	1747	2365	3820	19606
I15 x MCP	479	244	257	2828	3190	4497	3003*	3656	5994	30602
I15 x MCH	500*	300*	367*	3166	4388	6640*	3043*	4753*	6350	37447
I15 x MCS	378	199	322	2631	2815	4369	2488	3523	5871	29119
I15 x MC0	379	152	287	2595	3275	4773	2782	3856	5711	30171
I30 x MCP	341	312*	276	2708	3416	5755*	2622	3972	6176	32877
I30 x MCH	567*	292*	408*	3445*	4133	6648*	3161*	4980*	7280*	39709
I30 x MCS	503*	267	303	3044	3741	6197*	2939	4541*	6768*	36066
I30 x MC0	334	238	242	2360	3462	4684	2786	3367	5215	29281
I45 x MCP	352	230	306	2643	3262	5782*	2368	3640	5944	30943
I45 x MCH	551	345*	364*	3381*	5206	6213*	2962	4861*	6836*	39322
I45 x MCN	410	267	282	2660	3370	6535*	3457*	3706	6551	34131
I45 x MC0	381	255	241	2560	3367	5077	3050	3673	5852	31598
SEm±	27.07	23.04	23.30	74.10	215.31	353.18	178.50	166.87	265.42	759.96
CD (0.05)	75.04	63.86	64.58	205.40	597.35	978.96	494.77	462.55	735.71	2106.45

MAP - Months after planting

Contd....

Table 74 contd....

Irrigation x Moisture conservation	LDMP (kg ha^{-1})			TLDMP (kg ha^{-1})	SDMP (kg ha^{-1})			RDMP (kg ha^{-1})		TDMP (kg ha^{-1})	RGR (mg^{-1} g da^{-1})
	8 MAP	17 MAP	21 MAP		11 MAP	15 MAP	17 MAP	11 MAP	17 MAP		13 MAP
Io x MCP	720	681	1268	6313	943	652	818	1270	2974	18791	21.12*
Io x MCH	854	827	1192	7113	1203	766	894	1494	3140	20386	17.68
Io x MCS	456	635	1283	5848	899	678	791	1206	2895	17923	20.07*
Io x MCo	618	812	1329	6812	1127	722	904	1444	2951	19523	17.08
I15 x MCP	1056	1233	1977	10201	1562	985*	1206	1757	3396*	25838	16.22
I15 x MCH	1434	1563*	2144	12352*	1780*	812	1339*	2088*	3384*	28654*	16.70
I15 x MCS	957	1212	2015	9806	1309	823	1285*	1655*	3115	24650	20.00*
I15 x MCo	1075	1263	1906	9915	1449	830	1226	1687	3234	25065	18.46
I30 x MCP	1107	1319	2039	10875	1761*	922*	1280*	2006*	3291*	26416	15.17
I30 x MCH	7364	1229*	2402*	12990*	1659*	934*	1255	1982*	3356*	28379*	21.00*
I30 x MCS	1249	1474	2307*	11936	1545	902*	1212	1835	3356*	27495	19.85*
I30 x MCo	1162	1118	1749	9731	1577	957*	1184	1873	3133	24864	16.25
I45 x MCP	1067	1198	1944	10139	1624*	873	1158	1938*	3228	25559	13.60
I45 x MCH	1701	1602*	2289*	12932*	1570	878	1402*	1930*	3411*	29423*	25.08*
I45 x MCN	1107	1233	2053	11280	1825*	1004*	1097	2131*	3253	27118	12.82
I45 x MCo	1128	1223	1903	10401	1409	955*	1214	1716	3345	25734	20.58
SEm±	69.44	54.08	88.56	239.54	83.21	44.33	44.91	91.75	58.83	321.70	2.12
CD (0.05)	192.49	149.90	245.48	663.98	230.65	122.89	124.49	254.32	163.08	891.70	5.89

MAP - Months after planting

Contd....

Table 74 contd....

Irrigation x Moisture conservation	CGR (g^{-1} m^{2} day^{-1}) 11 MAP	13 MAP	15 MAP	21 MAP	RSR 11 MAP	15 MAP	TNUP (kg ha^{-1})	TPUP (kg ha^{-1})	TKUP (kg ha^{-1})	GI (Rs ha^{-1})	NI (Rs ha^{-1})	BCR
I$_{0}$ x MCP	2.65	2.94	2.52	3.95	0.70*	1.92*	225	18	96	36516	5850	1.19
I$_{0}$ x MCH	3.24	2.86	3.08	3.72	0.68*	1.69*	252	21	106	41427	10761	1.35
I$_{0}$ x MCS	2.56	2.70	2.66	3.76	0.72*	1.97*	207	18	89	32880	3214	1.10
I$_{0}$ x MC$_{0}$	3.16	2.66	2.86	3.91	0.68*	1.75*	243	20	101	39213	10646	1.36
I$_{15}$ x MCP	4.44	3.27	3.72*	4.66	0.57	1.27	369	29	162	61204	25538	1.71
I$_{15}$ x MCH	5.63*	3.65	3.31	4.98*	0.53	1.56	450	35	204	74894	39228	2.10
I$_{15}$ x MCS	3.98	3.52	3.20	4.80	0.64	1.63	362	29	159	58239	23573	1.68
I$_{15}$ x MC$_{0}$	4.29	3.17	3.34	4.70	0.57	1.56	365	28	156	60342	26676	1.79
I$_{30}$ x MCP	5.39*	3.20	3.35	4.72	0.54	1.47	398	31	170	65755	32089	1.95
I$_{30}$ x MCH	5.45*	4.33*	3.31	5.33*	0.52	1.34	474*	37	218*	79419*	45753*	2.35
I$_{30}$ x MCS	5.13*	3.89	3.07	5.19*	0.51	1.37	436	35	195	72133	39467	2.20
I$_{30}$ x MC$_{0}$	4.57	3.14	3.37	4.57	0.61	1.32	351	28	151	58562	26896	1.85
I$_{45}$ x MCP	4.93	2.77	3.27	4.60	0.55	1.59	368	30	158	61886	29220	1.89
I$_{45}$ x MCH	5.03*	4.66*	3.44	4.87	0.55	1.50	471*	37	211*	78644*	45978*	2.40
I$_{45}$ x MCN	5.73*	2.89	4.00*	4.80	0.53	1.17	408	34	175	68262	36596	2.15
I$_{45}$ x MC$_{0}$	4.29	3.66	3.66	4.54	0.57	1.35	377	30	159	63196	32530	2.06
SEm±	0.26	0.25	0.17	0.13	0.02	0.10	8.71	0.68	4.03	1519.91	1519.91	0.04
CD (0.05)	0.73	0.69	0.48	0.36	0.06	0.28	24.15	1.89	11.18	4212.90	4212.90	0.12

MAP - Months after planting

Table 75 Performance of two varieties of mulberry as influenced by interaction effect of irrigation and soil moisture conservation techniques

Variety x Irrigation x Moisture conservation	TLN	LAI		TSL (cm)	TFLP (kg ha^{-1})	TLDMP (kg ha^{-1})	TDMP (kg ha^{-1})	TNUP (kg ha^{-1})	TPUP (kg ha^{-1})	TKUP (kg ha^{-1})	GI (Rs ha^{-1})	NI (Rs ha^{-1})	BCR	SYI
		13 MAP	21 MAP											
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
K-2 x I_0 x MC_P	432	2.21	2.44	1956	18459	6386	19158	226	17	95	36919	6253	1.20	0.22
K-2 x I_0 x MC_H	574	3.97	3.72	2027	23171	7816	21562	277	22	114	46343	15677	1.51	0.27
K-2 x I_0 x MC_S	403	1.73	1.74	1774	14976	5388	17389	192	15	77	29952	286	1.01	0.15
K-2 x I_0 x MC_0	498	2.44	3.16	2161	20834	7237	20409	259	21	107	41668	13001	1.45	0.23
K-2 x I_{15} x MC_P	572	2.82	3.90	2198	23021	7678	21532	272	20	109	46042	10376	1.29	0.26
K-2 x I_{15} x MC_H	602	4.34	3.40	2450	28185	9396	24300	335	26	145	56370	20704	1.58	0.31
K-2 x I_{15} x MC_S	423	1.51	2.26	1731	16504	5784	18404	206	17	84	33009	-1666	0.95	0.17
K-2 x I_{15} x MC_0	555	2.01	2.86	2120	20487	6916	20411	245	19	100	40974	7308	1.21	0.24
K-2 x I_{30} x MC_P	633	3.63	4.71	2321	24120	8066	22293	284	22	114	48240	14574	1.43	0.26
K-2 x I_{30} x MC_H	656	4.47	4.65	2744	28741	9639	24955	342	27	148	57483	23817	1.70	0.32
K-2 x I_{30} x MC_S	610	4.01	4.38	2537	27670	9217	23762	324	26	138	55340	22674	1.69	0.30
K-2 x I_{30} x MC_0	549	2.77	3.62	1997	22786	7825	21953	277	21	112	45572	13906	1.43	0.28
K-2 x I_{45} x MC_P	573	3.91	4.76	2401	24886	8343	22952	296	24	125	49712	17046	1.52	0.26
K-2 x I_{45} x MC_H	698	4.50	4.72	2618	31840	10687	26190	379	30	159	63681	31015	1.95	0.34
K-2 x I_{45} x MC_S	637	4.41	4.44	2495	29695	10014	25386	359	29	147	59390	27724	1.87	0.33
K-2 x I_{45} x MC_0	569	2.81	3.10	2322	26436	8885	23067	318	24	129	52872	22206	1.72	0.28

Contd....

Table 75 contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
S-54 x I_{0} x MCP	439	1.69	2.06	1873	18066	6241	18424	223	20	97	36112	5446	1.17	0.21
S-54 x I_{0} x MCH	479	2.64	2.34	1951	18255	6411	19211	228	20	97	36510	5844	1.19	0.22
S-54 x I_{0} x MCS	432	2.81	2.09	1592	17903	6307	18458	223	20	102	35807	6141	1.20	0.18
S-54 x I_{0} x MCo	385	1.97	1.68	1694	18379	6386	18637	228	20	95	36758	8091	1.28	0.20
S-54 x I_{15} x MCP	916	5.77	8.08	3458	38182	12724	30144	466	37	214	76365	40699	2.14	0.43
S-54 x I_{15} x MCH	946*	6.43	9.58	3881*	46709	15308	33008*	566	44	262	93419	57753	2.61	0.52
S-54 x I_{15} x MCS	873	5.78	7.73	3531	41734	13827	30895	519	40	235	83469	48803	2.40	0.47
S-54 x I_{15} x MCo	751	4.90	6.73	3071	39855	12915	29720	484	37	212	79710	46044	2.36	0.45
S-54 x I_{30} x MCP	779	4.62	7.47	3095	41636	13685	30639	511	40	225	83270	49604	2.47	0.47
S-54 x I_{30} x MCH	1012*	7.02	10.30	4146*	50678	16342	33804*	606	48	288	101356	67690	3.01*	0.55
S-54 x I_{30} x MCS	897	5.46	8.64	3650	44463	14656	31228	548	44	252	88927	56261	2.72	0.49
S-54 x I_{30} x MCo	683	4.12	4.54	2723	35775	11638	27775	425	35	190	71551	39885	2.26	0.42
S-54 x I_{45} x MCP	732	4.71	5.65	2886	37030	11935	28166	439	36	191	74060	41394	2.26	0.42
S-54 x I_{45} x MCH	933*	6.62	9.36	4144*	46804	15176	32657*	563	44	263	93608	60942	2.86*	0.52
S-54 x I_{45} x MCS	770	4.43	6.28	2826	38567	12545	28851	458	39	204	77134	45468	2.43	0.46
S-54 x I_{45} x MCo	714	3.78	4.86	2798	36760	11918	28402	435	37	189	73520	42854	2.39	0.45
SEm±	29.16	0.38	0.33	104.79		338.77	454.95	12.32	0.96	5.70	2149.48	2149.48	0.065	-
CD (0.05)	80.84	1.04	0.91	290.48		939.01	1261.05	34.16	2.67	15.81	5957.94	5957.94	0.180	-

PGP and PGH for normal row planting, paired row planting and high density planting, S0, S25 and S50 for no shade, 25% shade and 50% shade and GMV, GMM, GMD, GMC and GM0 for green manure *Vigna sinensis*, *Mimosa invisa*, *Desmodium intortum*, *Calapagonium muconoides* and no green manure respectively, are conveniently used to express the treatments in the following sections.

4.3.1. Dry matter production and nutrient accretion of green manures

Data on dry matter production (DMP) and nutrient addition of green manure crops during first year and the total for both the years are given in Table 76 and Figs. 39 to 39.

All the three factors ie, planting geometry, shade levels and green manure intercropping significantly influenced DMP and nutrient addition. Paired row planting, cultivation under open conditions and green manuring with mimosa significantly enhanced DMP and nitrogen, phosphorus and potassium addition and total DMP and total nitrogen, phosphorus and potassium addition.

4.3.2. Plant height

The effect of treatments on the height of plants at 6, 9, 12, 15, 18, 21 and 24 MAP are presented in Table 77.

In general, planting geometry failed to influence the height of plants except at the early stages of growth. Plants in the paired row planting attained significantly more height than others at 6 and 9 MAP. The shade levels influenced plant height and the height increased in proportion to the shade from zero to 50 per cent. At 21 MAP, because of bottom pruning done at 18 MAP a reduced height was observed, however, the difference among the treatments were similar. The effect of green manure intercropping on mulberry height was significant only at 6 and 15 MAP. Sole cropping

Table 76 Dry matter production and nutrient accumulation in green manure intercrops as influenced by planting geometry and levels of shade

Treatments	First year (90 days after sowing)				Second year (90 days after sowing)				Total			
	DM (t ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	DM (t ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	DM (t ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Planting Geometry												
PGN	1.46	47.29	3.644	29.78	1.35	43.31	3.36	26.95	2.81	90.61	6.99	56.73
PGP	1.62	52.54	4.04	32.66	1.48	45.81	3.58	29.69	3.11	98.35	7.62	62.33
PGH	1.37	44.53	3.42	28.07	1.30	41.46	3.19	26.28	2.67	85.99	6.61	54.35
SEm±	0.02	0.92	0.07	0.60	0.04	1.50	0.05	0.80	0.04	1.82	0.11	1.09
CD (0.05)	0.08	2.77	0.21	1.82	0.11	NS	0.25	2.40	0.12	5.45	0.34	3.29
Intensity of shade												
S_0	1.66	53.49	4.12	33.84	1.49	46.48	3.58	29.57	3.15	99.98	7.69	63.41
S_{25}	1.50	48.40	3.73	30.07	1.42	44.43	3.48	28.83	2.92	92.84	7.20	58.90
S_{50}	1.29	42.46	3.26	26.19	1.23	39.69	3.08	24.50	2.52	82.14	6.33	51.09
SEm±	0.02	0.92	0.07	0.60	0.04	1.50	0.08	0.80	0.04	1.82	0.11	1.09
CD (0.05)	0.08	2.77	0.21	1.82	0.11	4.49	0.25	2.40	0.12	5.45	0.34	3.29
Green manure intercrops												
GMV	1.82	45.37	3.63	34.48	1.69	42.25	3.38	31.41	3.51	87.63	7.01	65.89
GMM	1.99	73.89	5.59	41.94	1.75	63.47	4.90	36.81	3.75	137.37	10.49	78.75
GMD	0.98	27.56	2.16	18.00	1.03	28.73	2.26	19.51	2.01	56.29	4.42	37.51
GMC	1.14	45.66	3.41	26.25	1.04	39.65	2.98	22.80	2.18	85.32	6.38	49.05
SEm±	0.03	1.12	0.08	0.76	0.04	1.44	0.09	0.90	0.06	2.27	1.58	1.41
CD (0.05)	0.09	3.12	0.23	2.10	0.12	3.98	0.26	2.50	0.17	6.29	4.38	3.91

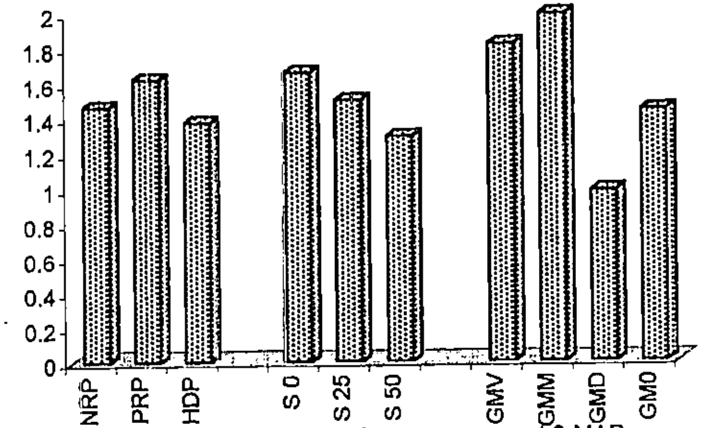


Fig 36 DMP(t/ha) of intercropped greenmanure at 3 MAP as influenced by planting geometry and shade intensity

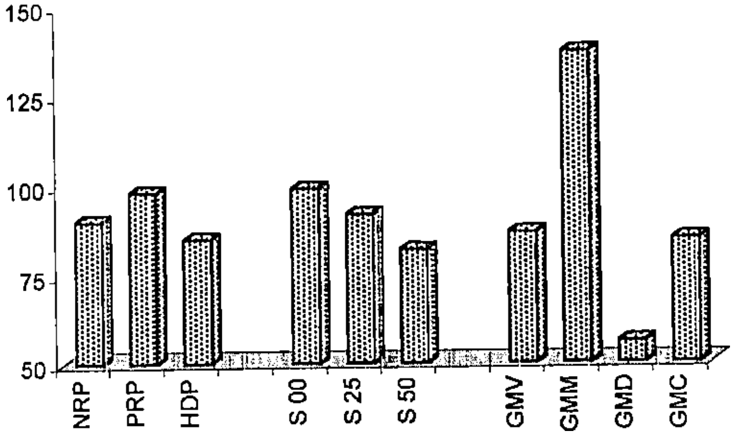


Fig 37 Total nitrogen addition(kg/ha) of intercropped greenmanure of two seasons as influenced by planting geometry and shade intensity

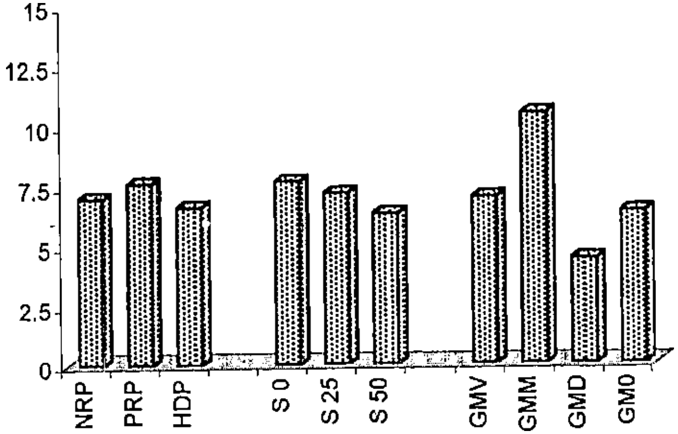


Fig 38 Total phosphorus addition(kg/ha) of intercropped greenmanure of two seasons as influenced by planting geometry and shade intensity

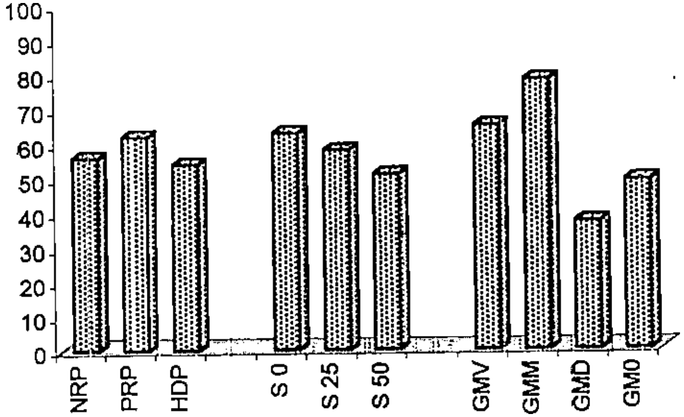


Fig 39 Total potassium addition(kg/ha) of intercropped greenmanure of two seasons as influenced by planting geometry and shade intensity

Table 77 Plant height (cm) as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	66.64	73.36	117.13	119.06	128.36	65.81	117.13
PGP	77.63	82.25	115.84	118.76	125.60	67.91	115.76
PGH	69.74	75.27	114.29	119.53	127.13	68.85	114.29
SEm±	0.71	77.84	2.18	3.28	2.95	2.17	2.18
CD (0.05)	2.15	2.33	NS	NS	NS	NS	NS
Intensity of shade							
S_0	54.89	62.72	111.36	103.23	111.07	61.19	111.28
S_{25}	69.29	78.74	118.22	113.59	121.96	65.85	118.24
S_{50}	89.82	89.42	117.69	140.52	148.07	75.53	117.66
SEm ±	0.71	1.12	2.18	3.28	2.95	2.17	2.18
CD (0.05)	2.15	3.38	NS	9.85	8.85	6.52	NS
Green manuring intercrops							
GMV	72.15	77.84	114.74	125.12	130.93	68.18	114.66
GMM	69.15	76.68	113.07	117.82	126.37	67.59	113.04
GMD	71.90	76.84	119.04	118.68	123.29	67.33	119.00
GMC	70.56	77.15	113.70	116.66	127.52	67.22	113.71
GM_0	72.94	76.29	118.22	117.29	127.04	67.28	118.22
SEm ±	0.72	0.98	1.86	2.10	2.35	0.66	1.87
CD (0.05)	1.99	NS	NS	5.84	NS	NS	NS

MAP - Months after planting

of mulberry on par with *in situ* cultivation of cowpea and desmodium resulted in significantly taller plants over *in situ* cultivation of mimosa and calapagonium at 6 MAP. Similarly at 15 MAP, *in situ* cultivation of cowpea had considerable influence on height over other treatments.

Significant interactive effect was observed between planting geometry x shade and planting geometry x shade x green manure. In the open condition, plants in the paired row planting grew significantly higher than plants grown in 25 or 50% shade. Also paired row planting under 50% shade resulted in plants with significantly higher height than those in zero or 25% shade and thus was at par with high density planting under 50% shade (Table 105). With respect to planting geometry x shade x intercropping with green manure interaction, all the combinations involving S_{50} showed higher values over S_0 and S_{25} (Table 108).

4.3.3. Plant spread

The data on plant spread at 6, 9, 12, 15, 18, 21 and 24 MAP are furnished in Table 78.

In general, no significant variation could be observed between treatments due to geometry of planting. Cultivation under open conditions enhanced plant spread over shade at both levels. Intercropping with green manure had no significant effect on plant spread.

Planting geometry x shade interaction indicated significant effect on this character at 15 MAP and all the combinations of planting geometry with S_{50} were on par and registered maximum plant spread (Table 105).

4.3.4. Leaf area index

Data relating to leaf area index (LAI) at various growth stages are presented in Table 79.

Table 78 Plant spread (cm) as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	48.68	61.29	73.96	68.98	63.40	69.01	67.61
PGP	54.43	64.24	77.62	71.78	64.84	69.08	69.31
PGH	50.91	60.45	73.93	69.84	62.16	67.22	69.86
SEm±	1.25	1.50	1.36	0.77	0.65	0.80	1.47
CD (0.05)	3.76	NS	NS	NS	1.96	NS	NS
Intensity of shade							
S_0	55.93	65.89	84.44	76.39	70.96	73.25	69.81
S_{25}	48.29	61.31	76.22	70.76	62.69	69.67	70.11
S_{50}	52.39	58.88	64.84	63.46	56.76	62.39	66.86
SEm±	1.25	1.50	1.36	0.77	0.65	0.80	1.47
CD (0.05)	3.76	4.50	4.68	2.31	1.96	2.40	NS
Green manure intercrops							
GMV	50.09	62.16	75.93	69.95	64.48	67.63	67.04
GMM	50.24	64.10	75.70	71.74	62.29	68.31	70.04
GMD	54.09	60.75	74.07	70.07	64.29	68.38	69.68
GMC	50.57	62.41	74.44	70.05	62.48	69.29	69.61
GM_0	52.06	60.72	75.70	69.19	63.78	68.57	68.27
SEm±	1.87	0.84	0.70	0.98	0.93	0.69	1.42
CD (0.05)	NS	2.33	NS	NS	NS	NS	NS

MAP - Months after planting

The effect of planting geometry was significant on LAI and paired row planting enhanced LAI at all stages of growth. Cultivation under open conditions increased LAI and proved to be superior over 50 per cent shade at all stages. Green manuring had no significant impact on LAI.

Planting geometry x shade interaction indicated the significant effect of PGP x S0 at 9, 15, 21 and 24 MAP (Table 105). Shade x intercropping with green manure interaction was significant at 12 MAP and the combination S0 x GMC on par with S0 x GMV/GMM/GMD registered maximum LAI (Table 107).

4.3.5. Shoot length

Data on shoot length (SL) recorded at 6, 9, 12, 15, 18, 21 and 24 MAP and total shoot length (TSL) are furnished in Table 80.

Paired row planting resulted in the production of highest TSL and SL at different stages followed by normal row planting. Both were significantly superior to high density planting. A very similar trend was observed with SL also at 15, 21 and 24 MAP. Shade levels also influenced TSL and cultivation under open conditions registered significantly higher TSL over both shade levels. A similar trend was observed with respect to SL at different stages. The effect of intercropping green manure in influencing TSL and SL was insignificant.

Planting geometry x shade, planting geometry x green manure, shade x green manure and planting geometry x shade x green manure interactions influenced SL at 18 MAP and PGP x S0, PGP x GMM, S0 x GMM and PGP x S0 x GMM showed maximum SL (Tables 105, 106, 107, 108). With regard to TSL, the paired row planting under open conditions resulted in the highest value (Table 105).

Table 79 Leaf area index of mulberry as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	0.80	1.91	4.19	4.83	1.23	4.34	4.09
PGP	0.97	2.42	4.30	5.39	1.46	4.94	4.76
PGH	0.75	1.97	3.99	4.21	1.23	3.95	3.71
SEm±	0.04	0.03	0.33	0.08	0.03	0.18	0.21
CD (0.05)	0.14	0.11	NS	0.26	0.09	0.56	0.65
Intensity of shade							
S_0	1.08	3.07	5.28	6.29	2.01	6.24	5.87
S_{25}	0.97	2.09	4.71	4.64	1.13	4.16	3.93
S_{50}	0.48	1.15	2.49	3.50	0.79	2.85	2.75
SEm±	0.04	0.03	0.33	0.08	0.03	0.18	0.21
CD (0.05)	0.14	0.11	0.99	0.26	0.09	0.56	0.65
Green manure intercrops							
GMV	0.86	2.13	4.18	4.74	1.29	4.50	4.08
GMM	0.84	2.13	4.21	4.69	1.27	4.57	4.37
GMD	0.84	2.05	4.30	4.84	1.37	4.38	4.21
GMC	0.84	2.09	4.11	4.94	1.32	4.18	4.09
GM_0	0.83	2.11	4.03	4.82	1.29	4.44	4.18
SEm±	0.01	0.06	0.07	0.08	0.03	0.14	0.01
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

Table 80 Shoot length (cm) as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Total
Planting geometry								
PGN	110.73	201.20	282.76	209.22	218.80	191.51	385.76	1601.66
PGP	146.44	247.38	325.96	199.76	246.44	198.80	370.97	1734.35
PGH	102.76	183.38	248.78	195.00	208.76	189.36	329.03	1457.24
SEm±	9.14	15.74	12.07	14.61	7.75	5.83	28.17	46.89
CD (0.05)	27.40	47.20	36.19	NS	23.25	NS	NS	140.59
Intensity of shade								
S_0	155.51	266.87	334.38	265.36	278.11	216.18	416.96	1933.33
S_{25}	123.20	197.53	296.80	178.93	226.13	184.96	403.83	1611.08
S_{50}	81.22	167.56	226.31	159.69	169.76	178.53	264.98	1248.24
SEm±	9.14	15.74	12.07	14.61	7.75	5.83	28.17	46.89
CD (0.05)	27.40	47.20	36.19	43.81	23.24	17.48	84.45	140.59
Green manure intercrops								
GMV	121.59	199.07	284.59	200.85	229.37	194.41	356.09	1585.96
GMM	116.07	219.11	285.04	189.56	232.00	192.37	390.37	1626.00
GMD	114.41	208.93	274.52	202.00	214.37	190.11	382.69	1587.44
GMC	111.29	205.19	292.70	205.22	227.19	201.07	347.50	1590.33
GM_0	136.52	220.96	292.29	209.00	220.41	188.15	332.94	1598.04
SEm±	5.80	10.08	9.63	10.12	5.28	6.04	19.34	85.42
CD (0.05)	16.09	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

4.3.6. Leaf number

Observations on total leaf number (TLN) and leaf number (LN) recorded at 6, 9, 12, 15, 18, 21 and 24 MAP are furnished in Table 81.

The effect of planting geometry was evident on TLN and LN. Significantly higher TLN was registered in paired row planting over other treatments. A similar trend was observed with respect to LN at various stages as well. Cultivation under open conditions enhanced TLN and LN at various stages over shade situations. At 6 MAP all the green manure intercropped treatments produced lower LN than control while at 15 MAP the situation was different. However, at other stages no significant effect due to green manuring intercropping was observed.

Planting geometry x shade interaction assumed significance at certain stages (6, 9, 12 and 18 MAP) and at all these stages PGP x S0 on par with PGN x S0 registered significantly higher LN (Table 105). PGP x GMV/GMM/GMD/GM0 were on par and recorded significantly higher LN at 15 MAP (Table 106). With respect to shade x intercropping with green manure interaction, S0 x GMM on par with S0 x GMV and S0 x GMC registered maximum LN (Table 107). TLN was not at all influenced by any of the interaction effects.

4.3.7. Fresh leaf production

Data on fresh leaf production (FLP) recorded at various stages and total fresh leaf production (TFLP) are given in Table 82.

Significant effect of planting geometry was observed on TFLP and FLP. Paired row planting consistently increased FLP followed by normal row planting. High density planting resulted in lower leaf yield. Increase in shade situation proportionately reduced leaf yield and 60 per cent increase in TFLP was observed under open condition

Table 81 Leaf number per plant as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Total
Planting geometry								
PGN	38.54	86.25	139.10	87.61	113.73	98.97	205.73	769.33
PGP	47.59	102.09	158.64	95.73	125.18	112.04	194.92	836.18
PGH	37.49	81.64	128.20	88.80	109.73	96.90	172.61	715.00
SEm±	1.41	3.10	4.68	3.65	3.92	3.75	14.00	19.42
CD (0.05)	4.23	9.30	14.04	NS	11.76	11.26	NS	58.24
Intensity of shade								
S_0	44.68	107.26	167.27	114.33	139.91	125.16	219.69	917.98
S_{25}	41.53	90.16	147.49	89.38	115.82	102.26	214.26	800.84
S_{50}	37.43	72.57	111.19	68.43	92.91	80.49	139.30	601.69
SEm±	1.41	3.10	4.68	3.65	3.92	3.75	14.00	19.42
CD (0.05)	4.23	9.30	14.04	10.94	11.76	11.26	41.99	58.24
Green manure intercrops								
GMV	42.74	90.70	141.19	91.15	116.67	108.53	191.06	781.82
GMM	39.73	92.51	142.91	93.84	122.19	99.15	199.02	788.56
GMD	41.19	90.57	137.69	89.52	110.37	100.00	200.80	770.15
GMC	37.25	89.59	144.22	92.28	115.85	104.81	188.72	772.19
GM_0	45.15	86.62	143.91	86.77	116.00	100.68	175.84	754.82
SEm±	1.39	1.66	4.19	1.62	4.01	3.20	11.71	15.30
CD (0.05)	3.85	NS	NS	4.49	NS	NS	NS	NS

MAP - Months after planting

compared to 50 per cent shade. Intercropping with green manure increased TFLP. Intercropping with cowpea was on par with mimosa and calapagonium (Fig. 40).

The interaction effect of planting geometry x shade showed the significance of the combination PGP x So at 6, 9, 12 and 18 MAP (Table 105). Interaction effect of planting geometry x shade x intercropping with green manure was significant at 18 MAP and all the combinations involving PGP x So with green manures registered higher FLP (Table 108).

4.3.8. Leaf dry matter production

Data pertaining to total leaf dry matter production (TLDMP) and leaf dry matter production (LDMP) recorded at various stages are presented in Table 83.

Paired row planting showed significant increase on TLDMP and LDMP over normal row and high density planting. Open conditions resulted in significantly higher TLDMP and LDMP over shade situations. The significant effect of cowpea intercropping was evident on TLDMP though on par with mimosa and calapagonium. However, LDMP at various stages were unaffected by green manuring.

Interaction effects assumed importance with respect to planting geometry x shade and planting geometry x shade x green manure interactions. PGP x So combination in many cases (6, 15, 18, 21 and 24 MAP) registered higher LDMP. TLDMP was also significantly higher in PGP x So (Table 105 and Fig 41). Planting geometry x shade x green manure interaction effect was pronounced only at 18 MAP and all the five combinations involving PGP x So with green manure showed higher LDMP (Table 108).

4.3.9. Stem dry matter production

The data pertaining to total stem dry matter production (TSDMP) and stem dry matter production (SDMP) at various stages are furnished in Table 84.

Table 82 Fresh leaf production (kg ha^{-1}) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Total
Planting geometry								
PGN	2708	2833	8765	8248	3405	4971	5223	36145
PGP	2998	3068	9336	9270	4488	5732	6047	40942
PGH	2503	2703	8419	7827	3134	4611	4986	34186
SEm±	42.26	131.58	294.76	250.69	151.23	221.83	172.88	537.49
CD (0.05)	138.68	NS	NS	751.62	452.42	665.07	518.33	1611.40
Intensity of shade								
S$_0$	3487	3830	10888	11081	4870	6560	6591	47310
S$_{25}$	2790	2926	7942	8441	3301	4791	5391	35585
S$_{50}$	1932	1838	7690	5823	2856	3962	4274	28379
SEm±	42.26	131.58	294.76	250.69	151.23	221.83	172.88	537.49
CD (0.05)	138.69	394.51	883.74	751.62	453.42	665.07	518.33	1611.44
Green manure intercrops								
GMV	2806	2952	8837	8988	3932	5428	5852	38799
GMM	2749	2964	9216	8633	4044	5206	5763	38578
GMD	2674	2760	8793	7869	3332	4752	5123	35306
GMC	2664	2769	8778	8875	3810	5303	5227	37430
GM$_0$	2789	2878	8577	7877	3261	4833.22	5127.14	35344
SEm±	55.88	68.87	301.70	267.55	149.28	268.74	255.34	649.67
CD (0.05)	NS	NS	NS	741.59	413.78	NS	NS	1800.75

MAP - Months after planting

Table 83 Leaf dry matter production (kg ha^{-1}) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Total
Planting geometry								
PGN	873.4	957.3	2891.1	2707.1	1156.1	1756.1	1698.7	12039
PGP	961.5	1013.5	2981.5	3010.2	1495.9	2023.2	1976.4	13462
PGH	814.3	904.2	2814.7	2547.2	1048.4	1613.8	1635.1	11378
SEm±	13.34	43.42	95.66	81.02	51.52	81.98	65.21	188.03
CD (0.05)	40.01	NS.	NS	242.93	154.46	245.81	195.53	563.74
Intensity of shade								
S_0	1102.3	1246.5	3361.3	3605.1	1610.7	2306.3	2080.3	15313
S_{25}	903.3	990.1	2660.9	2757.4	1112.2	1682.2	1783.9	11890
S_{50}	643.7	638.4	2665.0	1902.0	977.5	1404.6	1445.9	9677
SEm±	13.34	43.42	95.66	81.02	51.52	81.98	65.21	188.03
CD (0.05)	40.01	130.20	286.79	242.93	154.46	245.81	195.53	563.74
Green manure intercrops								
GMV	905.8	989.2	2922.2	2926.4	1310.9	1908.7	1924.0	12887
GMM	887.2	989.7	3010.3	2794.4	1349.8	1843.3	1860.2	12735
GMD	862.9	921.9	2898.5	2568.2	1136.2	1687.2	1675.4	11750
GMC	856.6	828.1	2864.4	2920.0	1277.9	1854.3	1726.8	12428
GM_0	902.9	962.7	2783.3	2565.1	1092.3	1695.0	1663.9	11665
SEm±	19.15	22.09	101.14	87.86	51.60	93.79	83.91	220.52
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	611.24

MAP - Months after planting

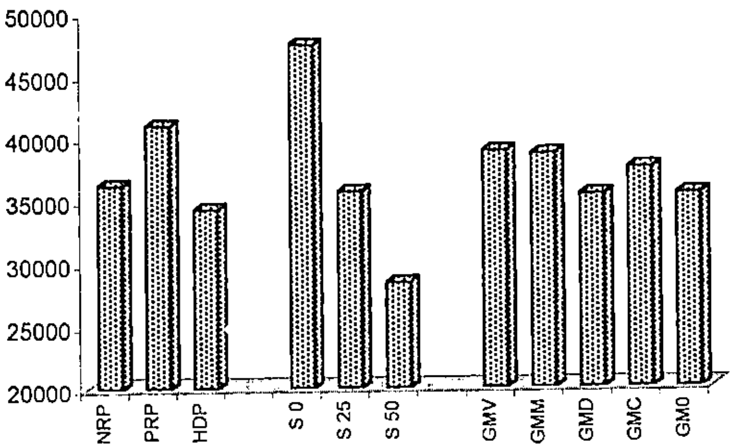


Fig 40 TFLP(kg/ha) as influenced by planting geometry, shade intensity and green manure intercropping

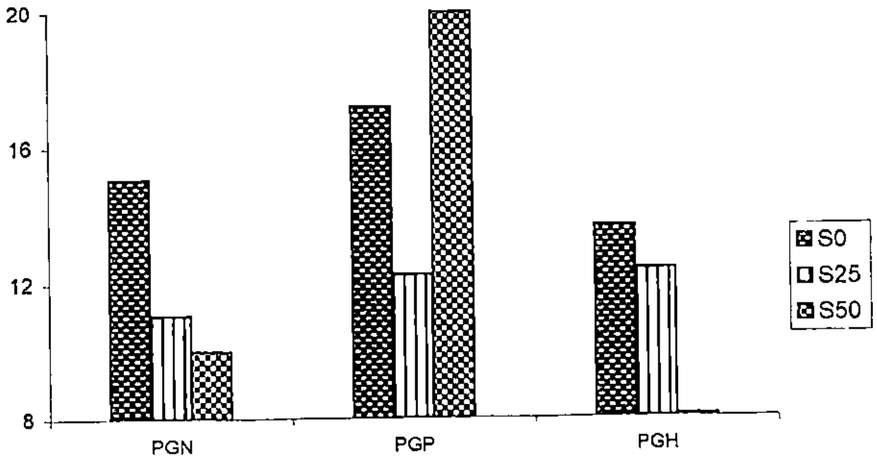


Fig 41 TLDMP(t/ha) as influenced by the interaction effect of planting geometry and shade levels

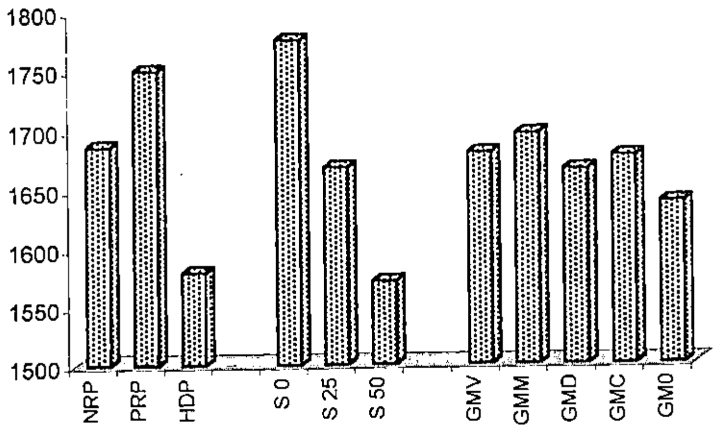


Fig 43 Leaf consumptiont(g/100 silkworm larvae) as influenced by planting geometry, shade intensity and green manure intercropping

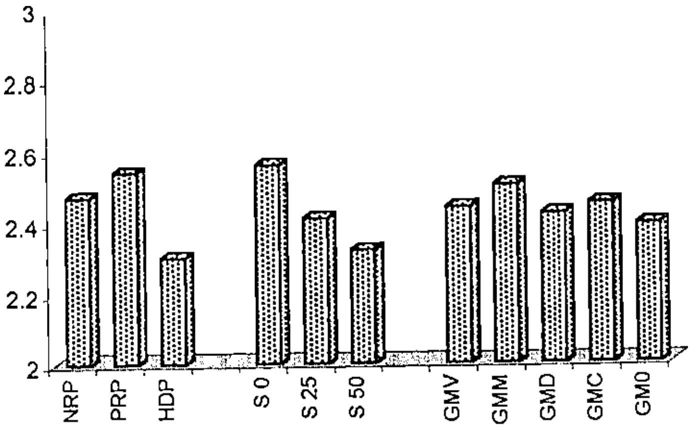


Fig 44 Larval weight(g) as influenced by planting geometry, shade intensity and green manure intercropping

Paired row planting was beneficial in increasing TSDMP over normal row and high density planting. Like, TLDMP, TSDMP and SDMP also showed significantly higher values under open conditions. Though the effect of green manuring was not significant TSDMP was highest in cowpea intercropped treatments.

None of the interaction effects were significant except planting geometry x shade levels at 15 MAP when PGP x S0 showed its superiority over all other combinations (Table 105).

4.3.10. Root dry matter production

Data pertaining to root dry matter production (RDMP) recorded at different stages are provided in Table 85.

Planting in paired rows significantly increased RDMP from 15 MAP and in general it was on par with normal row planting. Cultivation under open conditions and 25 per cent shade were on par in influencing RDMP from 15 MAP. Though none of the green manure treatments significantly influenced RDMP *in situ* cultivation of mimosa favoured maximum root growth except at 9 MAP.

The interaction effect of the combination PGP x S25 and PGP x S0 were on par in RDMP at 21 and 24 MAP (Table 105).

Dry matter partitioning as influenced by the effect of planting geometry, levels of shade and green manure intercropping is depicted in Fig. 42. Paired row planting, cultivation and open conditions and intercropping with cowpea registered maximum LDMP.

4.3.11. Net assimilation rate

Observation on net assimilation rate (NAR) recorded at various stages are given in Table 86.

Table 84 Stem dry matter production (kg ha^{-1}) as influenced by planting geometry, levels of shade and green manure intercrops

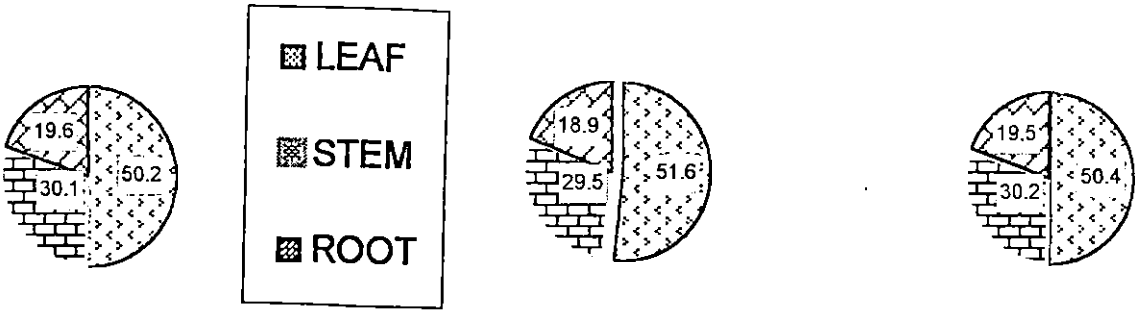
Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Total
Planting geometry								
PGN	783.8	734.9	2556.5	104.6	882.3	681.8	1481.9	7226
PGP	820.1	830.7	2564.5	124.0	1072.3	604.7	1681.0	7695
PGH	679.6	737.3	2390.8	96.3	839.2	700.5	1376.8	6820
SEm±	22.31	40.78	79.20	3.96	42.01	41.91	46.60	104.09
CD (0.05)	66.89	NS	NS	11.90	125.96	NS	139.71	312.09
Itensity of shade								
S_0	1019.9	840.2	2958.1	145.8	1073.3	594.4	1773.2	8405
S_{25}	730.8	807.7	2260.0	99.7	912.2	726.8	1441.7	6979
S_{50}	532.87	655.0	2293.6	79.4	806.4	665.8	1324.9	6358
SEm±	22.31	40.78	79.20	3.96	42.01	41.91	46.90	104.09
CD (0.05)	66.89	122.28	237.45	11.90	125.96	NS	139.71	312.09
Green manure intercrops								
GMV	767.7	806.2	2523.9	112.9	936.0	687.3	1573.4	7407
GMM	776.5	723.9	2667.6	116.2	1000.9	547.1	1560.0	7392
GMD	736.3	794.4	2446.0	103.4	907.8	767.1	1472.6	7227
GMC	716.6	772.3	2490.1	106.4	946.0	670.6	1473.9	7176
GM_0	808.9	741.2	2392.0	102.7	862.4	639.6	1486.3	7033
SEm±	21.69	30.17	81.79	3.04	38.49	49.69	80.33	463.04
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 85 Root dry matter production (kg ha^{-1}) as influenced by planting geometry, levels of shade and green manure crops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	329.5	672.7	1501.3	2429.5	2777.2	4127.2	4709.7
PGP	351.2	705.1	1546.7	2708.1	2808.0	4256.8	4943.0
PGH	335.0	641.8	1480.0	2175.6	2385.0	3711.7	4402.3
SEm±	6.64	19.14	83.98	135.57	109.78	84.84	51.91
CD (0.05)	NS	NS	NS	406.47	329.14	254.36	155.58
Intensity of shade							
S_0	350.8	729.4	1537.2	2611.5	2842.6	4400.4	5041.2
S_{25}	337.6	680.4	1610.8	2569.0	2846.2	4302.4	4912.2
S_{50}	327.2	609.8	1380.1	2132.7	2281.4	3392.9	4101.7
SEm±	6.64	19.14	83.98	135.57	109.78	84.84	51.91
CD (0.05)	NS	NS	NS	406.47	329.14	254.36	155.58
Green manure intercrops							
GMV	340.7	653.3	1549.8	2421.6	2714.9	4082.9	4780.7
GMM	349.3	701.9	1503.2	2476.6	2719.8	4377.3	4914.4
GMD	336.4	690.7	1512.9	2411.9	2643.1	3803.4	4484.4
GMC	333.5	663.3	1531.4	2494.0	2673.1	4052.4	4714.8
GM_0	332.9	656.9	1449.3	2384.6	2532.9	3843.5	4530.7
SEm±	7.31	18.94	34.96	44.58	56.19	77.42	78.77
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

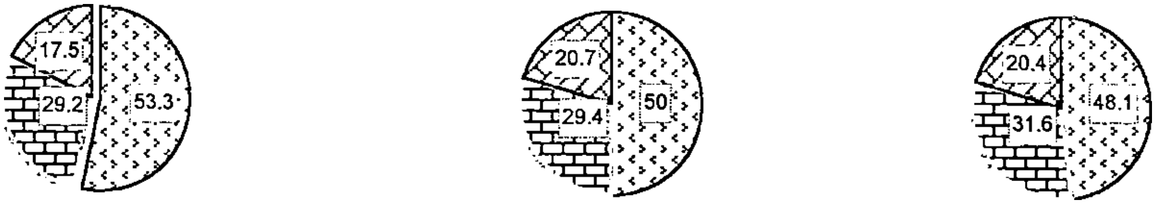
MAP - Months after planting



Normal row planting (TDMP 23.9 t/ha)

Pairedl row planting (TDMP 26.1 t/ha)

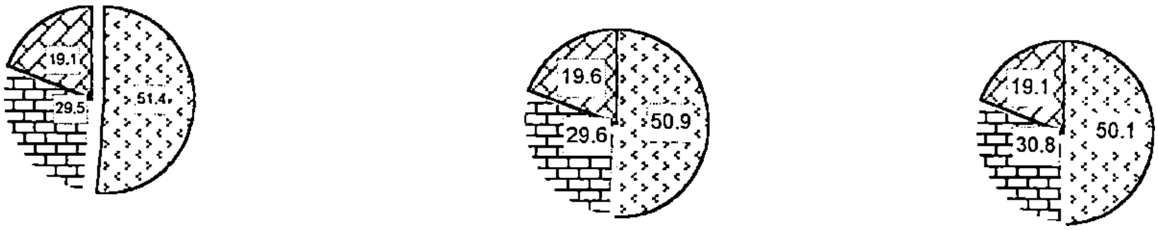
High density planting (TDMP 2



Open condition (TDMP 28.8 t/ha)

25% shade level (TDMP 23.7 t/ha)

50% shade level (TDMP 23.7 t/



Intercropping with cowpea (TDMP 25.1 t/ha)

Intercropping with mimosa (TDMP 25.0 t/ha)

Intercropping with desmodium (T t/ha)

Intercropping with calapagonium (TDMP 24.3 t/ha)

Sole cropping mulberry(TDMP 23.2 t/ha)

Fig 42 Per cent distribution of dry matter as influenced by planting geometry, shade levels and intercropping with green manure

In general, NAR was unaffected by planting geometry. Shade levels influenced NAR only at certain stages and 50 per cent shade though on par with no shade and 25 per cent under certain situations enhanced NAR. Green manuring failed to influence NAR at any of the stages.

However, the combinations planting geometry x shade and shade x green manure influenced NAR at 9 MAP. PGP x S50 on par with PGN x S0 and S50 x GM0 on par with S50 x GMV and S50 x GM0 recorded significantly higher NAR (Table 105 and 107).

4.3.12. Relative growth rate

Data on relative growth rate (RGR) recorded at various growth stages are given in Table 87.

The effect of planting geometry on RGR was evident only at 6, 9 and 18 MAP and maximum RGR was observed in paired row planting. Considerable improvement in RGR was observed under open conditions. None of the green manure crops was able to influence RGR in any of the stages.

None of the interaction effects, viz, planting geometry x shade, planting geometry x green manure, shade x green manure and planting geometry x shade x green manure were found to be significant.

4.3.13. Crop growth rate

Data pertaining to crop growth rate (CGR) recorded at different stages are furnished in Table 88.

Planting geometry significantly influenced CGR and paired row planting registered significantly higher CGR over normal row and high density planting in all most all cases. Considerable improvement in CGR was noted consequent to cultivation of mulberry under open conditions. Only at 18 MAP it was on par with 25% shade.

Table 86 Net assimilation rate (mg^{-1} day^{-1} cm^2) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	0.136	0.108	0.169	0.078	0.189	0.091	0.099
PGP	0.113	0.124	0.199	0.080	0.208	0.095	0.098
PGH	0.147	0.114	0.218	0.078	0.142	0.091	0.099
SEm±	0.0145	0.0027	0.0368	0.0050	0.0182	0.0100	0.0103
CD (0.05)	NS	0.0080	NS	NS	NS	NS	NS
Intensity of shade							
S_0	0.133	0.087	0.207	0.079	0.127	0.081	0.074
S_{25}	0.103	0.115	0.125	0.084	0.187	0.088	0.094
S_{50}	0.161	0.144	0.254	0.074	0.225	0.108	0.128
SEm±	0.0145	0.0027	0.0368	0.0050	0.0182	0.0100	0.0103
CD (0.05)	0.0434	0.0080	NS	NS	0.0545	NS	0.0308
Green manure intercrops							
GMV	0.136	0.116	0.195	0.083	0.187	0.091	0.120
GMM	0.130	0.109	0.188	0.082	0.213	0.095	0.091
GMD	0.127	0.120	0.220	0.073	0.162	0.085	0.089
GMC	0.123	0.116	0.181	0.083	0.178	0.111	0.101
GM_0	0.144	0.115	0.194	0.075	0.160	0.080	0.0921
SEm±	0.0051	0.0052	0.0193	0.0030	0.0115	0.0113	0.0078
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 87 Relative growth rate (mg^{-1} g^{-1} day^{-1}) as influenced by planting geometry, levels of shade and green manure crops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	49.33	45.36	50.22	19.24	7.06	10.08	0.71
PGP	54.00	48.47	48.89	23.25	9.42	11.08	0.86
PGH	45.33	42.51	50.67	17.23	5.92	11.14	0.77
SEm±	1.16	0.69	1.70	1.82	0.72	0.65	0.04
CD (0.05)	3.50	2.08	NS	NS	2.17	NS	NS
Intensity of shade							
S_0	63.56	55.24	55.33	25.94	8.05	12.10	0.85
S_{25}	48.89	47.24	47.11	19.44	7.14	10.64	0.69
S_{50}	36.22	33.87	47.33	14.35	7.20	9.56	0.80
SEm±	1.16	0.69	1.70	1.82	0.72	0.65	0.04
CD (0.05)	3.50	2.08	5.12	5.46	NS	1.97	NS
Green manure intercrops							
GMV	50.74	45.91	51.11	20.37	7.88	11.07	0.83
GMM	50.74	45.06	51.48	20.47	8.29	11.59	0.74
GMD	47.78	46.19	49.63	18.88	7.17	10.03	0.74
GMC	47.78	44.75	49.26	21.26	7.69	10.84	0.77
GM_0	50.74	45.33	48.15	18.56	6.29	10.30	0.823
SEm±	1.20	1.08	1.96	0.65	0.48	0.49	0.04
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 88 Crop growth rate (g^{-1} m^2 day^{-1}) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	9.92	2.11	6.308	3.67	2.02	3.44	3.42
PGP	10.74	2.30	6.42	4.35	2.72	3.80	4.11
PGH	9.04	2.01	6.09	3.26	1.63	3.34	3.33
SEm±	0.17	0.02	0.17	0.25	0.19	0.14	0.13
CD (0.05)	0.51	0.07	NS	0.75	0.57	NS	0.40
Intensity of shade							
S_0	12.62	2.60	7.26	4.92	2.54	4.21	4.29
S_{25}	9.84	2.23	5.85	3.79	2.06	3.58	3.45
S_{50}	7.24	1.59	5.70	2.56	1.76	2.79	3.13
SEm±	0.17	0.02	0.17	0.25	0.19	0.14	0.13
CD (0.05)	0.51	0.07	0.53	0.75	0.57	0.43	0.40
Green manure intercrops							
GMV	10.08	2.19	6.38	3.91	2.27	3.67	3.89
GMM	10.07	2.15	6.57	3.84	2.36	3.79	3.72
GMD	9.64	2.15	6.20	3.54	2.02	3.29	3.40
GMC	9.48	2.11	6.23	4.00	2.19	3.60	3.54
GM_0	10.24	2.11	5.97	3.49	1.78	3.28	3.55
SEm±	0.21	0.03	0.20	0.10	0.11	0.13	0.17
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Green manuring had no considerable effect on CGR but a marginal increase in CGR was evident when compared to control.

The effect of interaction of planting geometry x shade and planting geometry x green manure indicated the superiority of PGP x So (on par with PGN x So) at 6 MAP and PGP x GMV (on par with PGN x GMV, PGP x GMM/GMD/GMC) at 9 MAP (Table 105 and 106).

4.3.14. Specific leaf weight

Data relating to specific leaf weight (SLW) recorded at various stages are furnished in Table 89.

The effects of planting geometry and shade levels on SLW were not consistent in different stages. Eventhough, 50 per cent shade level enhanced SLW, it was on par with 25 per cent shade and no shade in majority of cases. *In situ* green manuring with cowpea, mimosa and calapagonium significantly increased SLW over control from 15 MAP onwards.

None of the interaction effects were found to be significant with respect to SLW at any of the growth stages.

4.3.15. Root shoot ratio

Data relating to root shoot ratio (RSR) at 6, 9, 12, 15, 18, 21 and 24 MAP are provided in Table 90.

The effect of planting geometry on RSR was not significant in any of the stages except 6 MAP. Shade levels influenced RSR at all stages and cultivation under shade significantly increased RSR over open conditions. Green manuring had no considerable effect on RSR.

Interaction effects of planting geometry x shade and planting geometry x shade x green manure were significant only at 6 and 21 MAP and 15 MAP respectively.

Table 89 Specific leaf weight (mg^{-1} cm^2) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	12.13	5.51	7.75	5.65	10.60	4.62	4.84
PGP	10.07	4.51	8.66	5.59	10.98	4.93	4.84
PGH	13.07	4.91	9.15	6.13	9.38	4.40	4.78
SEm±	1.21	0.22	1.36	0.17	0.56	0.54	0.47
CD (0.05)	NS	0.6790	NS	NS	NS	NS	NS
Intensity of shade							
S0	11.53	4.09	8.00	5.80	8.04	4.36	3.58
S25	9.40	5.11	5.71	6.02	10.38	4.16	4.96
S50	14.33	5.73	11.86	5.56	12.53	5.44	5.93
SEm±	1.21	0.22	1.36	0.17	0.56	0.54	0.47
CD (0.05)	3.64	0.67	4.10	NS	1.69	NS	1.41
Green manure intercrops							
GMV	12.11	5.07	8.95	6.23	10.78	4.74	5.93
GMM	11.56	4.85	8.55	6.06	11.82	4.41	4.74
GMD	11.29	4.93	8.31	5.28	8.96	4.37	4.33
GMC	11.07	4.89	8.39	5.92	10.41	5.74	4.74
GMo	12.74	5.15	8.43	5.48	9.63	4.00	4.37
SEm±	0.46	0.22	0.37	0.25	0.50	0.61	0.30
CD (0.05)	NS	NS	NS	0.69	1.41	NS	0.83

MAP - Months after planting

Table 90 Root : shoot ratio as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	0.21	0.42	0.29	0.93	1.48	1.78	1.58
PGP	0.21	0.40	0.29	0.93	1.19	1.73	1.44
PGH	0.24	0.39	0.29	0.89	1.34	1.69	1.56
SEm±	0.0039	0.0193	0.0214	0.0352	0.0845	0.0671	0.0520
CD (0.05)	0.0116	NS	NS	NS	NS	NS	NS
Intensity of shade							
S0	0.17	0.35	0.25	0.71	1.15	1.62	1.36
S25	0.21	0.38	0.34	0.93	1.52	1.89	1.62
S50	0.29	0.48	0.29	1.12	1.35	1.69	1.60
SEm±	0.0034	0.0193	0.0214	0.0352	0.0845	0.0671	0.0520
CD (0.05)	0.0116	0.0578	0.0641	0.1055	0.2533	0.2011	0.1559
Green manure intercrops							
GMV	0.22	0.38	0.30	0.86	1.28	1.63	1.42
GMM	0.23	0.43	0.28	0.91	1.23	1.96	1.55
GMD	0.23	0.42	0.30	0.98	1.45	1.63	1.54
GMC	0.22	0.41	0.30	0.88	1.29	1.71	1.57
GM0	0.21	0.39	0.29	0.96	1.44	1.74	1.55
SEm±	0.0059	0.0156	0.0121	0.0410	0.0647	0.0816	0.0827
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

PGH x S_{50} and PGN x S_{25} showed higher RSR at 6 and 21 MAP (Table 105). PGP x S_{50} x GMD recorded the maximum RSR at 15 MAP (Table 108).

4.3.16. Harvest index

The data on harvest index (HI) recorded at 6, 9, 12, 15, 18, 21 and 24 MAP are furnished in Table 91.

In general, HI was unaffected by planting geometry. However, it was significantly higher in paired row planting at 21 MAP. Significant improvement in HI was evident at 9, 18 and 21 MAP over 50 per cent shade. The effect of green manure intercropping was not evident on HI.

None of the interaction effects were significant in influencing HI.

4.3.17. Leaf moisture loss pattern

Data on leaf moisture loss (LML) at 3, 6, 9, 12 and 24 hours after picking leaves and leaf moisture content (LMC) observed at 6, 9, 12, 15, 18, 21 and 24 MAP are presented in Tables 92 to 97.

LMC was significantly influenced by geometry of planting and paired row planting recorded maximum LMC. The pattern was almost similar throughout the period of growth, however, the difference was significant at 6,12 and 18 MAP. The influence of shade levels on LMC was remarkable and cultivation under open conditions resulted in maximum LMC. Similar trend was observed at all stages of growth. Green manure intercropping had no significant effect on LMC.

LML over time was in general unaffected by planting geometry, shade intensity and green manure intercropping. However, LML was more in normal row planting and 50 per cent shade level.

The interaction effect of planting geometry x shade, planting geometry x green manure and planting geometry x shade x green manure were significant only at a few

Table 91 Harvest index (%) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting geometry							
PGN	53.33	56.00	53.18	96.09	56.49	70.87	53.76
PGP	54.22	54.53	53.89	95.91	57.24	77.38	54.04
PGH	54.89	54.60	53.98	96.18	55.07	68.29	53.73
SEm±	0.83	1.93	0.52	0.24	1.12	1.90	0.89
CD (0.05)	NS	NS	NS	NS	NS	5.7158	NS
Intensity of shade							
S_0	52.22	59.89	53.20	96.09	59.82	80.22	53.73
S_{25}	55.31	55.49	54.18	96.29	54.89	69.56	55.29
S_{50}	54.91	49.76	53.67	95.80	54.09	66.76	52.51
SEm±	0.83	1.93	0.52	0.24	1.12	1.90	0.89
CD (0.05)	2.49	5.817	NS	NS	3.367	5.71	NS
Green manure intercrops							
GMV	54.67	54.78	53.85	96.11	57.52	72.63	55.11
GMM	54.00	56.96	53.04	96.00	56.33	77.89	54.85
GMD	54.37	53.00	53.93	95.93	54.89	67.96	52.82
GMC	54.67	54.07	53.52	96.33	57.03	71.70	53.82
GM_0	53.04	56.41	54.07	95.93	55.52	70.70	52.63
SEm±	0.53	1.27	0.50	0.19	0.85	2.58	1.22
CD (0.05)	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

stages and no specific trend could be observed with respect to LMC and LML at any of the stages.

4.3.18. Leaf protein

Data relating to leaf protein (LP) recorded at 6, 9, 12, 15, 18, 21 and 24 MAP are given in Table 98.

The influence of planting geometry on LP was quite evident and paired row planting which was on par with normal row planting recorded significantly higher LP over high density planting. Considerable improvement in leaf quality was observed when mulberry was cultivated under open conditions. In general, green manure crops increased LP when compared to control.

Interaction effect of planting geometry x shade, shade x green manure intercropping and planting geometry x shade x green manure intercropping were significant at certain stages. In general, PGP x S0 enhanced LP at all stages (Table 105). Shade x green manure intercropping indicated the significant effect of the combination S0 x GMV/GMM/GMD/GMC in all most all cases (Table 107). The interaction effect of planting geometry x shade x green manure intercropping indicated the significance of the combination PGP x S0 x GMV in enhancing LP at 21 MAP (Table 108).

4.3.19. Larval characters, cocoon characters and post cocoon parameters

Observations on leaf consumption, larval weight, cocoon weight, shell weight, shell ratio, filament length, filament weight and denier recorded at the time of silk worm rearing are furnished in Table 99.

Rearing trial revealed the significant effect of planting geometry and shade levels on larval characters, cocoon characters and post cocoon parameters (Figs. 43 and 44). Paired row planting improved all the characters studied. The importance of site selection

Table 92 Leaf moisture loss (%) after three hours of harvest as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Mean
Planting geometry								
PGN	8.71	10.78	7.27	7.98	9.80	12.24	8.40	10.86
PGP	8.36	10.27	6.96	7.62	9.33	11.58	8.33	10.41
PGH	8.82	10.33	7.42	7.87	9.62	11.40	8.64	10.69
SEm±	0.06	0.10	0.11	0.14	0.15	0.56	0.10	0.08
CD (0.05)	0.18	0.32	NS	NS	NS	NS	NS	0.26
Intensity of shade								
S_0	8.04	9.51	6.71	7.80	8.84	10.80	7.56	9.88
S_{25}	8.56	10.71	7.13	7.71	9.51	11.73	8.58	10.66
S_{50}	9.29	11.16	7.80	7.96	10.40	12.69	9.24	11.42
SEm±	0.06	0.10	0.11	0.14	0.15	0.56	0.10	0.08
CD (0.05)	0.18	0.32	0.35	NS	0.45	1.70	0.31	0.26
Green manure intercrops								
GMV	8.63	10.52	7.26	7.93	9.52	12.04	8.19	10.68
GMM	8.70	10.48	7.15	7.74	9.59	11.85	8.41	10.65
GMD	8.59	10.33	7.29	7.78	9.59	11.70	8.56	10.64
GMC	8.56	10.52	7.15	7.78	9.67	11.11	8.56	10.56
GM_0	8.67	10.44	7.22	7.89	9.56	12.00	8.59	10.73
SEm±	0.11	0.13	0.11	0.11	0.17	0.59	0.14	0.11
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 93 Leaf moisture loss (%) after six hours of harvest as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Mean
Planting geometry								
PGN	17.07	18.82	19.29	14.38	16.71	16.89	15.40	16.62
PGP	16.62	18.13	12.89	13.89	16.58	17.33	14.80	15.35
PGH	16.38	17.80	15.49	14.00	16.60	17.18	15.82	15.91
SEm±	0.28	0.22	3.71	0.30	0.26	0.22	0.22	0.61
CD (0.05)	NS	0.67	NS	NS	NS	NS	0.66	NS
Intensity of shade								
S_0	16.24	17.33	12.64	14.31	16.64	17.73	14.64	15.37
S_{25}	16.47	18.29	15.16	14.22	16.20	16.73	15.58	15.73
S_{50}	17.36	19.013	19.87	13.73	17.04	16.93	15.80	16.79
SEm±	0.28	0.22	3.71	0.30	0.26	0.22	0.22	0.61
CD (0.05)	0.84	0.67	NS	NS	NS	0.67	0.66	NS
Green manure intercrops								
GMV	16.70	18.48	15.19	14.19	16.89	17.44	15.52	15.99
GMM	16.93	17.96	15.67	13.96	16.67	17.07	15.48	15.96
GMD	16.56	18.40	15.37	14.29	16.82	16.67	15.29	15.83
GMC	16.96	18.11	18.15	14.15	16.29	17.22	15.15	16.32
GM_0	16.29	18.29	15.07	13.85	16.48	17.26	15.26	15.70
SEm±	0.18	0.15	1.14	0.15	0.21	0.29	0.24	0.21
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 94 Leaf moisture loss (%) after nine hours of harvest as influenced by planting geometry, shade and green manure crops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Mean
Planting geometry								
PGN	25.82	26.93	21.09	21.38	25.69	26.16	23.22	23.89
PGP	25.24	26.33	20.47	21.16	26.11	26.60	22.87	23.74
PGH	25.73	26.07	21.78	20.82	25.82	25.78	25.04	24.16
SEm±	0.27	0.25	0.74	0.38	0.40	0.20	0.50	0.18
CD (0.05)	NS	NS	NS	NS	NS	0.60	1.52	NS
Intensity of shade								
S_0	25.13	25.62	20.58	21.73	26.71	26.24	23.02	23.90
S_{25}	25.44	26.62	20.51	21.76	24.98	26.20	23.60	23.75
S_{50}	26.22	27.09	22.24	19.87	25.93	26.09	24.51	24.15
SEm±	0.27	0.25	0.74	0.38	0.40	0.20	0.50	0.18
CD (0.05)	0.81	NS	NS	1.14	1.20	NS	NS	NS
Green manure intercrops								
GMV	25.82	26.59	20.96	21.22	25.74	25.89	23.85	23.91
GMM	25.44	26.56	21.04	21.07	26.07	26.26	24.15	24.01
GMD	25.44	26.52	20.82	21.48	25.96	26.11	23.52	23.89
GMC	25.70	26.32	21.33	20.82	25.82	26.04	23.59	23.88
GM_0	25.59	26.63	21.41	21.00	25.78	26.59	23.44	23.97
SEm±	0.18	0.17	0.48	0.17	0.21	0.25	0.24	0.12
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 95 Leaf moisture loss (%) after twelve hours of harvest as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Mean
Planting geometry								
PGN	31.67	34.56	29.96	29.87	35.09	34.33	30.93	31.97
PGP	31.36	34.40	28.91	29.89	35.33	34.56	30.47	31.75
PGH	31.53	34.27	29.67	29.78	34.53	34.78	32.38	32.11
SEm±	0.32	0.44	0.49	0.34	0.46	0.43	0.54	0.22
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Intensity of shade								
S_0	30.49	32.73	28.09	30.22	35.78	35.33	30.13	31.67
S_{25}	31.36	34.60	29.02	30.29	34.13	34.49	30.82	31.68
S_{50}	32.71	35.89	31.42	29.02	35.04	33.84	32.82	32.48
SEm±	0.32	0.44	0.49	0.34	0.46	0.43	0.54	0.22
CD (0.05)	0.97	1.34	1.49	NS	NS	NS	1.64	NS
Green manure intercrops								
GMV	31.33	34.37	29.37	29.82	35.04	34.85	31.63	32.01
GMM	31.56	34.37	29.33	29.85	34.56	34.70	31.37	31.89
GMD	31.48	34.44	29.48	29.74	35.00	34.04	30.82	31.76
GMC	31.74	34.63	29.67	29.85	35.11	34.29	31.04	31.95
GM_0	31.48	34.22	29.70	29.96	35.22	34.89	31.44	32.12
SEm±	0.18	0.21	0.19	0.18	0.19	0.27	0.21	0.09
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 96 Leaf moisture loss (%) after twentyfour hours of harvest as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Mean
Planting geometry								
PGN	54.53	56.73	55.02	54.93	55.22	55.42	55.58	55.12
PGP	55.44	56.00	54.62	55.07	54.98	55.98	55.13	55.20
PGH	54.78	55.78	54.93	55.11	55.40	55.42	55.20	55.14
SEm±	0.40	0.24	0.14	0.17	0.24	0.23	0.21	0.12
CD (0.05)	NS	0.72	NS	NS	NS	0.69	NS	NS
Intensity of shade								
S_0	54.62	55.09	54.60	54.89	55.42	56.22	55.73	55.25
S_{25}	54.42	56.93	54.96	54.96	55.20	55.49	55.09	55.01
S_{50}	55.71	56.49	55.02	55.27	54.98	55.11	55.09	55.19
SEm±	0.40	0.24	0.14	0.17	0.24	0.23	0.21	0.12
CD (0.05)	NS	0.72	NS	NS	NS	0.69	NS	NS
Green manure intercrops								
GMV	55.07	56.22	55.33	54.70	54.96	55.59	55.37	55.17
GMM	55.19	55.78	54.67	55.52	55.29	55.63	55.22	55.25
GMD	54.63	56.70	55.04	55.03	55.29	55.52	55.22	55.12
GMC	54.82	56.07	54.78	55.07	55.29	55.74	55.15	55.14
GM_0	54.89	56.07	54.48	54.85	55.14	55.56	55.56	55.08
SEm±	0.27	0.21	0.21	0.22	0.22	0.25	0.26	0.10
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

MAP - Months after planting

Table 97 Leaf moisture content (%) as influenced by planting geometry, shade and green manure intercrops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP	Mean
Planting geometry								
PGN	67.60	64.44	67.04	67.18	65.84	64.67	67.20	66.59
PGP	67.82	66.71	67.67	67.42	66.73	64.64	67.24	66.92
PGH	67.24	66.02	66.38	67.44	66.47	65.02	67.20	66.62
SEm±	0.08	0.91	0.31	0.10	0.15	0.16	0.21	0.06
CD (0.05)	0.25	NS	0.93	NS	0.47	NS	NS	0.18
Intensity of shade								
S_0	68.38	67.47	68.98	67.47	67.02	64.82	68.51	67.53
S_{25}	67.64	65.98	66.71	67.33	66.22	64.82	67.04	66.63
S_{50}	66.64	63.73	65.40	67.24	65.80	64.89	66.09	65.98
SEm±	0.08	0.91	0.31	0.10	0.15	0.16	0.21	0.06
CD (0.05)	0.25	2.73	0.93	NS	0.47	NS	0.65	0.18
Green manure intercrops								
GMV	67.56	65.48	66.78	67.26	66.37	64.89	66.96	66.64
GMM	67.56	65.89	66.96	67.44	66.74	64.63	67.89	66.87
GMD	67.56	65.67	66.93	67.37	65.93	64.48	67.00	66.54
GMC	67.67	65.56	67.11	67.26	66.33	64.93	66.96	66.71
GM_0	67.44	66.04	67.37	67.41	66.37	64.96	67.26	66.80
SEm±	0.10	0.30	0.27	0.16	0.21	0.21	0.29	0.09
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

· MAP - Months after planting

Table 98 Leaf protein (%) of mulberry as influenced by planting geometry, levels of shade and green manure crops

Treatments	6 MAP	9 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP
Planting Geometry							
PGN	22.56	22.88	2219	23.0	22.44	22.19	22.25
PGP	22.50	23.00	22.44	23.13	22.75	23.25	22.5
PGH	21.94	22.44	21.75	22.5	22.06	22.44	21.56
SEm±	0.05	0.35	0.10	0.07	0.06	0.10	0.04
CD (0.05)	0.16	0.35	0.31	0.28	0.20	0.31	0.13
Intensity of shade							
S_0	22.88	23.31	22.75	23.31	22.8	23.25	22.69
S_{25}	22.44	22.75	22.00	22.88	22.5	23.06	21.81
S_{50}	21.75	22.31	21.69	22.44	21.81	22.56	21.75
SEm±	0.05	0.35	0.10	0.07	0.06	0.10	0.04
CD (0.05)	0.16	0.35	0.31	0.22	0.20	0.31	0.13
Green manure intercrops							
GMV	22.50	23.00	22.31	23.06	22.44	23.00	22.25
GMM	22.63	23.06	22.38	23.06	22.56	23.19	21.19
GMD	22.50	22.88	22.31	23.00	22.56	23.06	22.06
GMC	22.56	23.00	22.19	23.00	22.56	23.13	22.31
GM_0	21.56	21.93	21.56	22.00	21.81	22.44	21.69
SEm±	0.07	0.09	0.08	0.09	0.09	0.03	0.07
CD (0.05)	0.21	0.26	0.24	0.26	0.26	0.23	0.22

in mulberry cultivation was evident fro the rearing trial. All the characters studied were found to be significantly affected by shade levels and cultivation under open conditions improved all the characters. The effect of green manure intercropping was not evident in any of the characters studied.

4.3.20. Leaf nitrogen content and uptake

Data relating to leaf nitrogen content, total nitrogen uptake (TNUP) and nitrogen uptake (NUP) at 6, 9, 12, 15, 18, 21 and 24 MAP are given in Table 100.

Geometry of planting influenced leaf nitrogen content. Normal row planting at 6 and 9 MAP and paired row planting at other harvests resulted in maximum concentration of leaf nitrogen. Normal row planting increased leaf nitrogen content to the extent of 2.8% at 6 MAP whereas paired row planting was favourable for increasing it to the tune of 4.3% at final harvest. There was an increase of 3.9 to 5.2% spread over different harvests when the crop was raised under open conditions. Intercropping mulberry with green manure mimosa registered maximum mulberry leaf nitrogen at all harvests except at 24 MAP. Intercropping with mimosa was beneficial for increasing leaf nitrogen to the tune of 4.9% over sole cropping mulberry.

The effect of planting geometry on TNUP was significant and paired row planting registered maximum TNUP. A similar trend was observed throughout the growth stages. With respect to shade levels, cultivation under open conditions resulted in significantly higher TNUP and NUP at various stages. Though TNUP was affected by green manuring NUP at various stages were unaffected by green manuring. Green manure intercropping with cowpea on par with mimosa registered maximum TNUP (Fig. 45)

The interaction effect of planting geometry x shade and planting geometry x shade x green manure were significant at certain stages. Both TNUP and NUP at 6, 15, 18, 21 and 24 MAP were significantly higher in the combination PGP x S0. At 15 and

Table 99 Larval charcters, cocon characters and post cocoon parameters as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	Leaf con. 100 larvae (g)	Larval wt. (g)	cocon wt. (g)	Shelll wt. (g)	Shell ratio	Filament lth (cm)	Filament wt.	Denter
Planting geometry								
PGN	1686	2.47	1.54	0.220	14.28	493	0.146	2.665
PGP	1749	2.54	1.58	0.237	15.82	520	0.156	2.691
PGH	1579	2.30	1.43	0.209	14.75	476	0.139	2.634
SEm±	15.77	0.03	0.02	0.0026	0.32	4.23	0.0016	0.01
CD (0.05)	43.73	0.09	0.06	0.0072	NS	11.73	0.0044	NS
Intensity of shade								
S_o	1775	2.56	1.62	0.244	15.17	539	0.161	2.690
S_{25}	1668	2.41	1.49	0.223	15.00	499	0.148	2.667
S_{50}	1.571	2.32	1.44	0.199	13.88	452	0.132	2.633
SEm±	15.77	0.03	0.02	0.0026	0.32	4.2332	0.0016	0.0189
CD (0.05)	47.35	0.10	0.06	0.0077	NS	12.6902	0.0047	NS
Green manure intercrops								
GMV	1680	2.44	1.53	0.226	14.94	503	0.149	2.656
GMM	1696	2.50	1.53	0.227	14.86	504	0.151	2.684
GMD	1666	2.42	1.49	0.217	14.52	485	0.143	2.648
GMC	1677	2.45	1.52	0.221	14.56	498	0.148	2.665
GMo	1638	2.39	1.51	0.219	14.55	493	0.146	2.664
SEm±	15.30	0.03	0.22	0.0031	0.28	6.18	0.0021	0.0159
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

18 MAP, the combinations involving PGP x S0 with any of the four green manure crops recorded significantly higher NUP (Table 105).

4.3.21. Leaf phosphorus content and uptake

The summary of the data on leaf phosphorus content, total phosphorus uptake (TPUP) and phosphorus uptake (PUP) at various stages are presented in Table 101.

Planting geometry influenced leaf phosphorus content only at two stages, viz, 18 and 21 MAP. At both the stages, normal row planting recorded significantly higher phosphorus contents. Significantly higher concentration of phosphorus was observed at all stages except at 9 MAP when mulberry was raised under open conditions. Intercropping with green manure crops had no significant effect in influencing leaf phosphorus concentration.

TPUP and PUP at various stages were influenced by planting geometry. Paired row planting resulted in significantly higher TPUP and PUP at 6, 18, 21 and 24 MAP. Shade levels influenced both TPUP and PUP and were maximum under open conditions and significantly varied from both shade levels. PUP at different stages were unaffected by green manuring, however, TPUP was significantly higher in plants intercropped and green manured with cowpea or mimosa (Fig. 46).

Interaction effect of planting geometry x shade showed its significance of TPUP and PUP at 18 and 21 MAP and the combination PGP x S0 recorded maximum values (Table 105). In general, any combination involving PGP x S0 and any intercrop green manure resulted in significant increase in PUP at 18 MAP (Table 108).

4.3.22. Leaf potassium content uptake

Data on leaf potassium content, total potassium uptake (TKUP) and potassium uptake (KUP) at various stages are given in Table 102.

Table 100 Leaf nitrogen content (%) and uptake (kg ha^{-1}) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP		9 MAP		12 MAP		15 MAP		18 MAP		21 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Planting geometry															
PGN	3.61	31.74	3.66	35.29	3.55	102.79	3.68	100.16	3.59	41.74	3.71	65.39	3.56	60.65	437.82
PGP	3.60	34.83	3.68	37.56	3.59	107.66	3.70	112.02	3.64	54.82	3.72	75.55	3.60	71.38	493.78
PGH	3.51	28.67	3.59	32.53	3.48	97.96	3.60	91.70	3.53	36.99	3.59	58.10	3.45	56.49	402.44
SEm±	0.008	0.48	0.019	1.66	0.016	3.35	0.012	2.81	0.011	1.83	0.016	3.09	0.007	2.28	6.46
CD (0.05)	0.026	1.46	0.057	NS	0.050	NS	0.036	8.44	0.033	5.50	0.049	9.26	0.021	6.85	19.39
Intensity of shade															
S_0	3.66	40.42	3.73	46.52	3.64	122.30	3.73	134.82	3.65	59.19	3.72	86.17	3.63	75.73	565.16
S_{25}	3.59	32.45	3.64	36.07	3.52	93.69	3.66	100.73	3.60	40.16	3.69	62.13	3.49	62.38	427.60
S_{50}	3.48	22.38	3.57	22.78	3.47	92.43	3.59	68.33	3.49	34.19	3.61	50.74	3.48	50.41	341.29
SEm±	0.008	0.48	0.019	1.66	0.016	3.35	0.012	2.81	0.011	1.83	0.016	3.09	0.007	2.28	6.46
CD (0.05)	0.026	1.46	0.057	4.97	0.050	10.04	0.036	8.44	0.033	5.50	0.049	9.26	0.021	6.85	19.39
Green manure intercrops															
GMV	3.60	32.82	3.68	36.63	3.57	104.35	3.69	108.64	3.59	47.52	3.68	70.71	3.56	68.62	469.41
GMM	3.62	32.32	3.69	36.81	3.58	108.00	3.69	104.09	3.61	49.22	3.71	68.68	3.55	66.41	465.37
GMD	3.60	31.23	3.66	33.91	3.57	103.41	3.68	95.16	3.61	41.31	3.69	62.57	3.53	59.43	426.89
GMC	3.61	31.12	3.68	34.38	3.55	101.91	3.68	108.33	3.61	46.41	3.70	68.92	3.57	61.88	453.11
GM_0	3.45	31.24	3.51	33.89	3.45	96.36	3.53	90.25	3.49	38.12	3.59	60.85	3.47	57.87	408.63
SEm±	0.012	0.70	0.015	0.84	0.014	3.69	0.015	3.21	0.015	1.88	0.013	3.48	0.012	2.96	8.08
CD (0.05)	0.034	NS	0.042	NS	0.038	NS	0.041	NS	0.041	NS	0.037	NS	0.035	NS	22.40

Table 101 Leaf phosphorus content (%) and uptake (kg ha^{-1}) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP		9 MAP		12 MAP		15 MAP		18 MAP		21 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Planting geometry															
PGN	0.32	2.85	0.31	3.04	0.35	10.07	0.33	8.87	0.34	3.98	0.33	5.90	0.35	5.92	40.75
PGP	0.33	3.15	0.30	3.15	0.34	10.22	0.31	9.38	0.33	5.06	0.32	6.46	0.35	6.88	44.24
PGH	0.32	2.61	0.31	2.82	0.35	9.77	0.32	8.09	0.32	3.48	0.32	5.20	0.35	5.70	37.69
SEm±	0.002	0.04	0.005	0.15	0.003	0.33	0.004	0.27	0.002	0.17	0.003	0.27	0.002	0.23	0.65
CD (0.05)	NS	0.12	NS	NS	NS	NS	NS	NS	0.007	0.52	0.009	0.83	NS	0.70	1.97
Intensity of shade															
S_0	0.32	3.69	0.32	3.97	0.36	12.12	0.33	11.74	0.35	5.72	0.34	7.86	0.36	7.48	52.76
S_{25}	0.33	2.96	0.31	3.10	0.35	9.29	0.32	8.85	0.34	3.71	0.32	5.36	0.35	6.27	39.48
S_{50}	0.30	1.94	0.30	1.93	0.33	8.64	0.30	5.76	0.31	3.09	0.31	4.35	0.33	4.76	30.47
SEm±	0.002	0.04	0.005	0.15	0.003	0.33	0.004	0.27	0.002	0.17	0.003	0.27	0.002	0.23	0.65
CD (0.05)	0.008	0.12	NS	0.46	0.010	1.01	0.014	0.81	0.007	0.52	0.009	0.83	0.008	0.70	1.97
Green manure intercrops															
GMV	0.33	2.97	0.32	3.15	0.34	9.97	0.32	9.28	0.33	4.37	0.33	6.27	0.35	6.68	42.52
GMM	0.32	2.84	0.31	3.09	0.32	10.42	0.31	8.77	0.34	4.60	0.32	6.02	0.35	6.49	42.29
GMD	0.32	2.82	0.30	2.85	0.35	10.01	0.32	8.19	0.33	3.83	0.32	5.47	0.35	5.94	39.14
GMC	0.33	2.82	0.31	2.89	0.35	9.99	0.32	9.48	0.34	4.37	0.32	6.03	0.34	5.97	41.52
GM_0	0.32	2.89	0.31	3.00	0.35	9.71	0.32	8.20	0.33	3.69	0.32	5.49	0.34	5.77	39.00
SEm±	0.003	0.06	0.003	0.08	0.002	0.33	0.003	0.31	0.003	0.18	0.002	0.30	0.002	0.29	0.77
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.15

Planting geometry and intercropping with green manure crops had no significant effect on leaf potassium content. However, shade levels exerted significant influence at all stages and cultivation under open condition registered higher values consistently.

TKUP and KUP recorded significantly higher values in paired row planting compared to normal row planting and high density planting except at 9 and 12 MAP. The influence of shade levels was also significant. Both TKUP and KUP at various stages were significantly higher in open condition. Significant difference occurred between the shade levels of 25 and 50% also. There was no significant influence of green manure intercropping on TKUP and KUP (Fig. 47).

Only planting geometry x shade interaction effect was significant on TKUP and KUP. The combination PGP x S0 recorded maximum TKUP and KUP at 6, 15, 18 and 21 MAP (Table 105).

4.3.23. Available nutrient status of soil

Data on available nutrient status of soil after the experiment are furnished in Table 103.

Planting geometry and shade levels exerted no significant influence on available nitrogen, phosphorus and potassium content of soil. The effect of green manure in enriching the soil with nitrogen and phosphorus was considerable. Mimosa on par with cowpea significantly increased the available nitrogen content (Fig. 48). All the four green manures tested, ie, cowpea, mimosa, desmodium and calapagonium were beneficial in enriching the soil with potassium. However, no significant effect of green manure intercropping was observed with respect to available phosphorus.

4.3.24. Sustainable yield index

The data on sustainable yield index (SYI) are presented in Table 104 and Fig. 163.

Table 102 Leaf potassium content (%) and uptake (kg ha^{-1}) as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	6 MAP		9 MAP		12 MAP		15 MAP		18 MAP		21 MAP		24 MAP		Total
	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	Content	Uptake	
Planting geometry															
PGN	1.44	13.16	1.45	13.34	1.60	46.86	1.47	41.28	1.50	17.77	1.49	26.69	1.59	27.60	187.62
PGP	1.48	14.72	1.42	14.96	1.57	47.27	1.44	45.03	1.51	23.44	1.46	30.30	1.61	32.30	208.04
PGH	1.49	12.59	1.45	13.67	1.58	45.38	1.45	38.29	1.55	16.59	1.47	24.38	1.62	27.31	178.00
SEm±	0.014	0.16	0.014	0.72	0.020	1.85	0.019	1.15	0.027	1.04	0.033	1.21	0.020	1.26	3.43
CD (0.05)	NS	0.50	NS	NS	NS	NS	NS	3.46	NS	3.13	NS	3.64	NS	3.78	10.30
Intensity of shade															
S_0	1.80	19.89	1.72	21.49	1.83	61.69	1.73	62.11	1.78	28.66	1.71	39.42	1.84	38.41	271.53
S_{25}	1.43	12.93	1.39	13.79	1.62	43.02	1.44	39.78	1.51	16.78	1.46	24.37	1.66	29.58	180.09
S_{50}	1.11	7.66	1.21	7.69	1.30	34.80	1.19	22.70	1.27	12.36	1.25	17.58	1.33	19.22	122.04
SEm±	0.014	0.16	0.014	0.72	0.020	1.85	0.019	1.15	0.027	1.04	0.033	1.21	0.020	1.26	3.43
CD (0.05)	0.041	0.50	0.044	20.17	0.060	5.56	0.059	3.46	0.081	3.13	0.098	3.64	0.062	3.78	10.30
Green manure intercrops															
GMV	1.47	13.87	1.42	14.52	1.61	46.99	1.46	43.90	1.51	20.52	1.48	28.77	1.61	31.39	199.85
GMM	1.47	13.55	1.45	14.99	1.57	48.07	1.46	42.64	1.53	21.22	1.46	27.94	1.62	30.36	198.70
GMD	1.48	13.30	1.43	13.77	1.56	45.96	1.44	38.44	1.54	18.01	1.48	25.45	1.61	27.89	182.78
GMC	1.47	13.07	1.45	14.02	1.58	45.76	1.44	43.98	1.50	19.73	1.47	27.81	1.61	28.30	192.48
GM_0	1.48	13.65	1.44	14.32	1.61	45.74	1.45	38.70	1.51	16.87	1.47	25.65	1.60	27.40	182.29
SEm±	0.040	0.37	0.015	0.38	0.018	1.67	0.013	1.44	0.017	0.84	0.014	1.52	0.014	1.49	3.73
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 103 Available nutrient status of the soil after the experiment as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	Nitrogen (kg^{-1} ha)	Phosphorus (kg^{-1} ha)	Potassium (kg^{-1} ha)
Planting geometry			
PGN	250.20	53.09	106.33
PGP	244.24	54.55	106.53
PGH	244.24	55.24	108.13
SEm±	1.37	1.49	2.85
CD (0.05)	NS	NS	NS
Intensity of shade			
S0	248.49	53.53	105.40
S25	246.16	52.81	105.96
S50	244.04	56.84	109.64
SEm±	1.37	1.49	2.85
CD (0.05)	NS	NS	NS
Green manure intercrops			
GMV	251.15	54.07	109.29
GMM	251.67	54.37	109.07
GMD	245.48	55.22	110.37
GMC	247.00	53.19	110.89
GM0	235.85	54.63	95.37
SEm±	1.43	1.67	2.72
CD (0.05)	3.96	NS	7.55

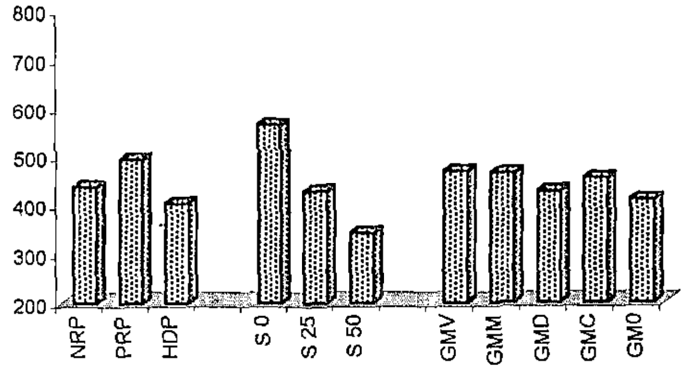


Fig 45 Nitrogen uptake(kg/ha) as influenced by planting geometry, shade intensity and green manure intercropping

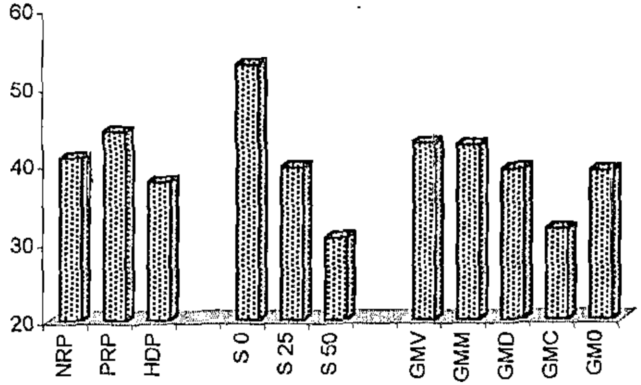


Fig 46 Phosphorus uptake(kg/ha) as influenced by planting geometry, shade intensity and green manure intercropping

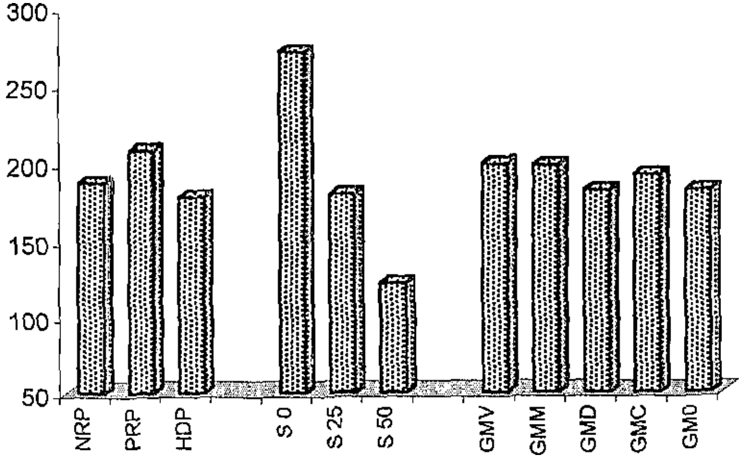


Fig 47 Potassium uptake(kg/ha) as influenced by planting geometry, shade intensity and green manure intercropping

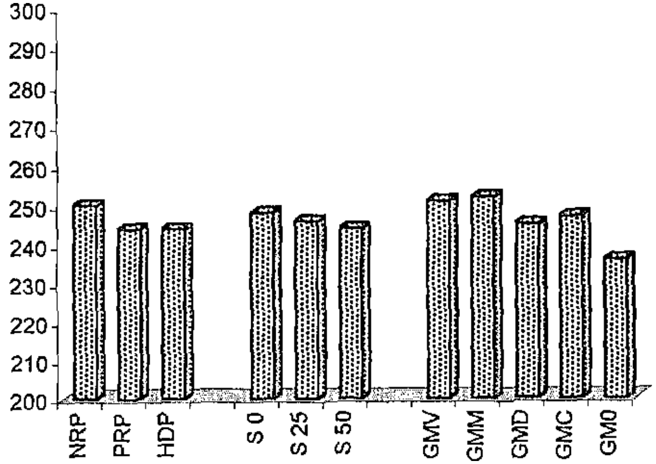


Fig 48 Available nitrogen content(kg/ha) of soil after the experiment as influenced by planting geometry, shade intensity and greenmanure intercropping

The three treatments, ie, paired row planting, cultivation under open conditions and intercropping with mimosa resulted in higher values of SYI and the minimum guaranteed yield were 28, 32 and 27 per cent respectively, of the maximum observed yield. The treatment combination, paired row planting x cultivation under open conditions x intercropping with mimosa resulted in achieving the highest minimum guaranteed yield of 40 per cent of the maximum observed yield (Table 108).

4.3.25. Economic analysis of the system

Data on gross income (GI), net income (NI) and benefit cost ratio (BCR) were worked out and presented in Table 104.

The effect of planting geometry was significant and paired row planting enhanced GI, NI and BCR. The effect of shade levels was evident on the economic criteria and cultivation under open conditions resulted in maximum GI, NI and BCR. Green manure intercropping also influenced the economic characters. Cowpea, mimosa and calapagonium were on par and significantly enhanced GI, NI and BCR.

The interaction effect of planting geometry x shade was significant and the combination PGP x So resulted in maximum GI, NI and BCR (Table 105).

Table 104 Sustainable yield index and economics of mulberry cultivation as influenced by planting geometry, levels of shade and green manure intercrops

Treatments	SYI	Gross income (Rs.)	Net income (Rs.)	BC ratio
Planting geometry				
PGN	0.24	72291	38440	2.14
PGP	0.28	81885	47477	2.40
PGH	0.22	68373	30077	1.79
SEm±		1074.98	997.89	0.03
CD (0.05)		32222.89	2991.77	0.09
Intensity of shade				
S_0	0.32	94621	59658	2.73
S_{25}	0.24	71171	35652	2.01
S_{50}	0.18	56758	20684	1.59
SEm±		1074.98	997.89	0.03
CD (0.05)		3222.89	2991.77	0.09
Green manure intercrops				
GMV	0.25	7798	41880	2.19
GMM	0.27	77156	41438	2.18
GMD	0.22	70613	34895	1.99
GMC	0.25	74860	39178	2.12
GM_0	0.25	70688	35932	2.06
SEm±		1299.34	12.98	0.03
CD (0.05)		3.60	35.98	0.10

Table 105 Performance of mulberry as influenced by the interaction effect of planting geometry and shade levels

Planting geometry x Shade	Height (cm)	Spread (cm)	Leaf No.				LAI				SL (cm)	
	9 MAP	15 MAP	6 MAP	9 MAP	12 MAP	18 MAP	9 MAP	15 MAP	21 MAP	24 MAP	18 MAP	21 MAP
PGN x S_0	59.3	75.5	45.8*	101.3*	165.0*	134.2*	3.02	6.47*	6.44*	5.95*	258.8	233.5*
PGN x S_{25}	74.1	68.4	35.8	49.5	143.2	112.5	1.53	4.36	4.11	3.73	217.2	166.0
PGN x S_{50}	86.5*	62.9	34.0	65.6	108.4	94.4	1.18	3.64	2.47	2.57	180.3	174.9
PGP x S_0	72.9	79.7*	50.7*	115.9*	175.2*	147.5*	3.37	6.90*	6.90*	6.67*	303.9*	220.0*
PGP x S_{25}	83.6	70.3	46.0*	93.2	154.0*	114.8	2.65	5.11	4.13	3.88	226.8	203.2*
PGP x S_{50}	90.1*	65.2	46.0*	97.1	146.6	113.2	1.23	4.16	3.80	3.70	208.5	173.1
PGH x S_0	55.8	73.8	37.4	97.7	160.9*	138.0*	2.80	5.48	5.36	4.98	271.5*	194.9
PGH x S_{25}	78.3	73.4	42.8	92.2	145.2	120.1	2.08	4.44	4.22	4.16	234.3	185.6
PGH x S_{50}	91.5*	62.1	32.2	54.9	78.4	71.0	1.03	2.70	2.26	1.97	120.4	187.5
SEm±	1.95	1.33	2.44	5.37	8.11	6.79	0.06	0.15	0.32	0.37	13.43	10.10
CD (0.05)	5.86	1.01	7.32	16.11	24.32	20.38	0.20	0.45	0.98	1.13	40.26	30.29

Contd...

Table 105 contd....

Planting geometry x Shade	TSL (cm)	FLP (kg ha^{-1})					LDMP (kg ha^{-1})					TLDMP (kg ha^{-1})
		6 MAP	15 MAP	18 MAP	21 MAP	24 MAP	6 MAP	15 MAP	18 MAP	21 MAP	24 MAP	
PGN x S_0	1978.33*	3532	11001	4504	6646*	6599	1116	3612	1496	2349*	2047*	15076
PGN x S_{25}	1674.33	2651	7528	2700	4072	4732	859	2474	925	1428	1588	11037
PGN x S_{50}	1150.53	1941	6214	3010	4194	4336	644	2034	1045	1490	1460	10006
PGP x S_0	2032.93*	3834	12676	6231	7586	7067	1204	4109	2069	2659	2265*	17204
PGP x S_{25}	1596.80	3003	8544*	4116	4904	3765	971	2772	1365	1739	1874	12236
PGP x S_{50}	1573.33	2158	6589	3119	4705	5309	708	2148	1062	1670	1789	10946
PGH x S_0	1788.73	3095	9567*	3874	5448	6105	986	3093	1265	1910	1928*	13658
PGH x S_{25}	1562.13	2716	9250*	3089	5398	5675	878	3025	1045	1878	1889	12397
PGH x S_{50}	1020.86	1697	4665	2439	2987	3178	577	1523	834	1062	1088	8078
SEm±	81.22	73.19	434.22	261.95	384.22	299.44	23.11	140.34	89.23	142.01	112.96	325.68
CD (0.05)	243.50	219.46	1301.84	785.35	1151.94	897.77	69.30	420.77	267.54	425.76	338.67	976.43

Contd....

Table 105 contd...

Planting geometry x Shade	SDMP (kg ha^{-1}) 15 MAP	TSDMP (kg ha^{-1})	RDMP (kg ha^{-1})		TDMP (kg ha^{-1})	RSR		NAR (mg cm^{-2} day^{-1}) 9 MAP	CGR (g m^{-2} day^{-1}) 6 MAP	NUP (kg ha^{-1})				
			21 MAP	24 MAP		6 MAP	21 MAP			6 MAP	15 MAP	18 MAP	21 MAP	24 MAP
PGN x S_0	136.7	8534*	4385*	4927*	28538	0.158	1.46	0.087	13.16*	41.95*	136.7	55.65	88.97*	75.46*
PGN x S_{25}	102.3	6744	4380*	4940*	22722	0.217	2.10*	0.143*	9.47	30.64	91.0	33.01	52.74	55.13
PGN x S_{50}	74.9	6400	3615	4261	20667	0.263	1.75*	0.141*	7.14	22.60	72.6	36.54	54.46	51.35
PGP x S_0	176.8	8907*	4441*	5303*	31414	0.164	1.51	0.085	13.68*	44.48*	155.9	77.45	100.98*	84.69*
PGP x S_{25}	102.7	7180	4506*	4999*	24416	0.192	2.00*	0.095	10.38	35.54	102.1	49.82	64.95	66.94
PGP x S_{50}	92.6	6999	3823	4525	22471	0.274	1.67	0.147*	8.14	24.47	77.9	37.16	60.70	62.50
PGH x S_0	123.9	7774	4374*	4892	26325	0.184	1.86*	0.089	11.02	34.80	111.7	44.45	68.54	67.03
PGH x S_{25}	94.1	7013	4021	4796	24206	0.219	1.55	0.110	9.66	31.14	108.9	37.64	68.70	65.07
PGH x S_{50}	70.9	5674	2740	3518	17271	0.317	1.63	0.143*	6.44	20.05	54.3	28.88	37.04	37.37
SEm±	6.87	180.30	146.94	89.91	487.76	0.0067	0.11	0.0047	0.29	0.84	4.88	3.18	5.353	3.96
CD (0.05)	20.61	540.57	440.57	269.56	1462.37	0.0200	0.34	0.0140	0.88	2.53	14.63	9.53	16.06	11.87

Contd...

Table 105 contd....

Planting geometry x Shade	TNUP (kg ha^{-1})	PUP (kg ha^{-1})			TPUP (kg ha^{-1})	KUP (kg ha^{-1})				TKUP (kg ha^{-1})	LML (%) (9 hrs) 21 MAP	LML (%) (24 hrs) 9 MAP
		15 MAP	18 MAP	21 MAP		6 MAP	15 MAP	18 MAP	21 MAP			
PGN x S_0	564	12.21*	5.35	8.10*	52.5	19.93	63.20	26.34	39.72*	52.5	25.53	35.26
PGN x S_{25}	395	8.14	3.24	4.89	38.0	12.34	37.00	14.11	21.70	38.0	25.93	57.73*
PGN x S_{50}	353	6.26	3.31	4.70	31.6	7.18	23.61	12.85	18.66	31.6	27.00*	57.20*
PGP x S_0	646	13.01*	7.36	9.11*	58.6	21.62	70.24	36.66	45.62*	58.6	27.33*	54.60
PGP x S_{25}	446	8.71	4.47	5.17	39.8	13.85	38.94	20.23	24.47	39.8	26.73*	57.53*
PGP x S_{50}	387	6.40	3.33	5.10	34.3	8.68	25.88	13.43	20.81	34.3	25.73	55.86
PGH x S_0	484	9.98	4.42	6.35	47.0	18.09	52.88	22.97	32.90	47.0	25.86	55.40
PGH x S_{25}	440	9.68	3.38	6.01	40.6	12.58	43.39	16.01	26.93	40.6	25.93	55.53
PGH x S_{50}	282	4.62	2.62	3.23	25.4	7.10	18.60	10.79	13.28	25.4	25.53	56.40*
SEm±	11.20	0.47	0.30	0.47	1.13	0.29	2.00	1.81	2.10	1.13	0.34	0.41
CD (0.05)	33.58	1.41	0.91	1.43	3.41	0.87	6.00	3.43	6.30	3.41	1.04	1.25

Contd...

Table 105 contd....

Planting geometry x Shade	LMC (%) 6 MAP	LP (%)						GI (Rs ha^{-1})	NI (Rs ha^{-1})	BCR
		6 MAP	12 MAP	15 MAP	18 MAP	21 MAP	24 MAP			
PGN x S_0	68.40*	23.44	23.59	23.63	23.13	23.69	23.00	93044	59748	2.79
PGN x S_{25}	67.60	22.25	21.81	22.94	22.25	23.00	21.69	65290	31994	1.95
PGN x S_{50}	66.80	21.88	21.63	22.25	21.81	22.81	21.94	58539	23576	1.67
PGP x S_0	68.60*	23.06	23.25	23.63	23.38	23.69	23.31	106890	73594	3.21
PGP x S_{25}	67.66	22.81	22.44	23.06	22.69	23.31	22.31	74108	39146	2.12
PGP x S_{50}	67.20	21.56	21.75	22.63	22.06	22.69	21.81	64655	29693	1.86
PGH x S_0	68.13*	22.00	21.81	22.56	21.94	22.38	21.75	83927	45631	2.19
PGH x S_{25}	67.66	22.73	21.75	22.50	22.50	22.81	21.50	74113	35817	1.93
PGH x S_{50}	66.93	21.68	21.63	22.25	21.63	22.06	21.44	47078	8782	1.22
SEm±	0.14	0.01	0.02	0.02	0.01	0.02	0.01	1861.91	1728.39	0.05
CD (0.05)	0.42	0.04	0.08	0.06	0.05	0.08	0.03	5582.22	5181.90	0.16

Table 106 Performance of mulberry as influenced by the interaction effect of planting geometry and green manure crops

Planting geometry x Green manure intercrops	LN 15 MAP	SL (cm) 18 MAP	LML (%) (6 hrs)		LML (%) (9 hrs) 18 MAP	LML (%) (12 hrs) 18 MAP	LML (%) (24 hrs) 9 MAP	LMC (%) 21 MAP	CGR (gm^{-2} day^{-1}) 9 MAP
			15 MAP	18 MAP					
PGN x GMV	90.07	219.1	14.4*	17.6*	25.0	35.1	56.1	65.0	2.24*
PGN x GMM	90.07	226.0	14.3*	16.7*	26.5*	35.1	56.2*	64.8	2.19
PGN x GMD	81.74	210.8	14.5*	16.4	25.7*	35.2*	57.0*	64.6	2.10
PGN x GMC	93.40	209.5	14.0*	16.1	24.7	34.2	57.2*	64.3	1.98
PGN x GMo	82.74	228.4	14.5*	16.5	26.3*	35.7*	57.1*	64.4	2.02
PGP x GMV	94.59*	241.8*	13.6	15.8	26.2*	35.2*	56.8*	64.1	2.42*
PGP x GMM	102.92*	265.7*	13.4	17.1*	26.0*	34.8	55.3	64.6	2.28*
PGP x GMD	96.18*	230.7	14.3*	17.2*	26.1*	35.2*	56.5*	64.8	2.33*
PGP x GMC	97.37*	246.6*	14.1*	16.2	26.4*	36.1	55.4	64.7	2.27*
PGP x GMo	88.55	247.1*	13.8*	16.4	25.7*	35.2*	55.7	64.7	2.20
PGH x GMV	88.77	227.1	14.4*	17.1*	26.0*	34.7	55.6	65.5	1.90
PGH x GMM	88.52	204.2	14.1*	16.1	25.6*	33.6	55.7	64.3	1.97
PGH x GMD	91.63	201.4	14.0*	16.7*	26.0*	34.5	56.5*	63.8	2.01
PGH x GMC	86.07	225.3	14.3*	16.5	26.2*	35.0	55.5	65.6*	2.06
PGH x GMo	88.99	185.6	13.1	16.4	25.2	34.6	55.5	66.6*	2.08
SEm±	2.81	9.15	0.26	0.36	0.38	0.33	0.38	0.37	0.06
CD (0.05)	7.79	25.37	0.74	1.01	1.05	0.93	1.05	1.03	0.18

Table 107 Performance of mulberry as influenced by the interaction effect of shade levels and green manure crops

Intensity of shade x Green manure intercrops	LN 15 MAP	SL (cm) 18 MAP	LAI 12 MAP	NAR (mg^{-2} day^{-1}) 9 MAP	LP (%)				
					9 MAP	15 MAP	18 MAP	21 MAP	24 MAP
S_0 x GMV	117.5*	271.2*	5.41*	0.088	23.56	23.69	22.88	23.31	23.13
S_0 x GMM	122.9*	294.5*	5.38*	0.091	23.69	23.75	23.06	22.56	22.81
S_0 x GMD	105.1	259.0	5.25*	0.090	23.56	23.56	23.25	23.50	22.75
S_0 x GMC	116.8*	287.7*	5.39*	0.083	23.50	23.63	23.13	23.69	23.00
S_0 x GM_0	109.1	278.0*	4.96	0.081	22.00	21.75	21.75	22.13	21.85
S_{25} x GMV	87.2	249.4	4.80	0.114	22.94	21.75	22.56	23.13	21.88
S_{25} x GMM	88.8	225.2	4.56	0.121	23.06	23.13	22.69	23.25	22.00
S_{25} x GMD	94.4	216.7	4.93	0.116	22.48	22.88	22.44	23.06	21.56
S_{25} x GMC	92.4	232.8	4.55	0.103	22.94	22.81	22.56	23.00	22.00
S_{25} x GM_0	83.8	206.3	4.73	0.122	22.25	22.31	22.13	22.75	21.69
S_{50} x GMV	68.6	167.4	2.30	0.147*	22.50	22.56	21.94	22.50	21.81
S_{50} x GMM	69.7	176.2	2.66	0.114	22.38	22.38	21.94	22.56	21.69
S_{50} x GMD	68.9	167.3	2.71	0.153	22.50	22.56	21.88	22.56	21.75
S_{50} x GMC	67.5	160.8	2.37	0.162*	22.56	22.63	21.94	22.50	21.88
S_{50} x GM_0	67.3	176.8	3.40	0.141*	21.50	21.88	21.50	22.44	21.44
SEm±	2.81	9.15	0.12	0.0091	0.02	0.02	0.02	0.02	0.02
CD (0.05)	7.79	25.37	0.34	0.02	0.07	0.07	0.07	0.06	0.06

Table 108 Performance of mulberry as influenced by the interaction effect of planting geometry, shade levels and green manure crops

Planting geometry x Intensity of shade x Green manure	Height (cm) 9 MAP	SL (cm) 18 MAP	FLP (kg ha^{-1}) 18 MAP	LDMP 18 MAP	RSR 15 MAP	LML (%) (24 hrs) 18 MAP	LMC (%) 18 MAP	LP (%) 21 MAP	NUP(kg ha^{-1})		PUP (kg ha^{-1}) 18 MAP	SYI
									15 MAP	18 MAP		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
PGN x S_0 x GMV	53.7	253.6	5862*	1894*	0.727	55.66*	67.66*	24.06	139.6	71.0	6.8*	0.37
PGN x S_0 x GMM	71.0	253.6	4967	1625	0.600	54.00	67.33*	23.88	141.1	60.4	5.8	0.35
PGN x S_0 x GMD	57.5	251.6	4265	1496	0.700	56.00*	65.00	24.06	136.0	56.8	5.3	0.30
PGN x S_0 x GMC	52.7	252.6	4327	1427	0.620	54.66	67.00*	24.00	150.7*	53.6	5.0	0.30
PGN x S_0 x GM_0	61.5	282.6	3100	1040	0.667	55.33	66.66*	22.31	116.1	36.2	3.7	0.28
PGN x S_{25} x GMV	77.4	222.0	3008	1053	0.930	56.00*	64.66	23.38	99.2	37.5	3.6	0.25
PGN x S_{25} x GMM	70.2	225.0	2962	967	1.053	57.00*	67.33*	23.00	85.3	34.5	3.4	0.20
PGN x S_{25} x GMD	78.8	207.6	2448	843	1.153*	55.00	65.33	23.25	75.1	30.2	2.9	0.22
PGN x S_{25} x GMC	73.7	237.3	2518	850	0.730	54.00	66.00	22.81	117.4	30.2	2.9	0.16
PGN x S_{25} x GM_0	70.4	194.0	2568	914	1.053	56.33*	64.33	22.50	78.0	32.5	3.1	0.19
PGN x S_{50} x GMV	88.0*	181.6	3077	1023	0.847	54.66	66.66*	22.75	90.6	36.1	3.0	0.20
PGN x S_{50} x GMM	82.6	199.3	2938	1001	1.130*	55.00	66.00	22.88	82.6	35.2	3.2	0.21
PGN x S_{50} x GMD	86.7	173.3	3507	1259	1.123*	56.00*	64.00	22.88	67.6	43.7	4.0	0.16
PGN x S_{50} x GMC	86.6*	138.6	3155	1132	1.290*	55.00	64.00	22.81	64.5	39.8	3.6	0.20
PGN x S_{50} x GM_0	88.7*	208.6	2375	811	1.337*	54.66	66.66*	22.63	57.8	27.6	2.5	0.15

Table 108 contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
PGP x S_0 x GMV	76.4	257.6	6116*	2018*	0.667	54.33	67.00*	23.94	159.7*	73.9*	7.0*	0.30
PGP x S_0 x GMM	71.3	357.6*	6618*	2229*	0.637	55.00	67.00*	23.88	177.3*	85.2*	8.3*	0.40
PGP x S_0 x GMD	70.4	272.3	5638*	1862*	0.700	55.66*	67.00*	24.00	140.9	71.0*	6.4	0.35
PGP x S_0 x GMC	71.1	312.6	6402*	2154*	0.650	55.00	66.33*	24.31	175.2	82.2*	7.6*	0.39
PGP x S_0 x GM_0	75.4	319.3*	6379*	2084*	0.843	55.66*	67.66*	22.25	126.3	72.8*	7.3*	0.39
PGP x S_{25} x GMV	86.8*	262.3	4751	1567	0.917	54.66	67.00*	23.19	105.4	57.4	5.0	0.30
PGP x S_{25} x GMM	86.8*	239.6	4682	1549	0.940	53.66	67.00*	24.00	103.0	58.2	5.0	0.29
PGP x S_{25} x GMD	79.5	199.0	4489	1511	0.857	54.66	66.33*	22.88	115.0	54.2	4.9	0.25
PGP x S_{25} x GMC	85.5*	215.3	3201	1044	0.970	55.66*	67.33*	23.25	100.1	38.2	3.4	0.25
PGP x S_{25} x GM_0	79.5	218.0	3453	1154	1.140	55.33	66.66*	23.31	86.9	40.9	3.8	0.26
PGP x S_{50} x GMV	89.6*	206.6	2553	860	0.900	54.00	66.33*	22.88	82.5	30.4	2.6	0.19
PGP x S_{50} x GMM	89.0*	200.0	4358	1481	1.230*	56.00*	66.00	22.81	75.9	52.8	4.8	0.23
PGP x S_{50} x GMD	92.2*	221.0	1534	545	1.460*	54.33	65.66	23.00	61.1	19.3	1.6	0.15
PGP x S_{50} x GMC	89.4*	212.0	4026	1343	1.087	56.00*	66.66*	22.69	85.7	47.5	4.3	0.25
PGP x S_{50} x GM_0	90.2*	204.0	3124	1030	0.920	54.66	67.00*	22.06	84.2	35.7	3.1	0.21

Table 108 contd...

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
PGH x S_0 x GMV	57.5	302.3	4076	1304	0.747	55.66*	68.00*	22.00	113.1	45.5	4.4	0.29
PGH x S_0 x GMM	56.0	272.3	3904	1263	0.707	57.33*	67.66*	22.88	112.8	44.6	4.3	0.30
PGH x S_0 x GMD	58.4	253.0	3232	1093	0.800	55.00	66.33*	22.38	108.4	38.9	3.7	0.25
PGH x S_0 x GMC	57.2	298.0	5052	1653	0.743	56.33*	67.33*	22.81	116.8	58.3	6.0	0.28
PGH x S_0 x GM_0	50.1	232.0	3108	1011	0.773	55.66*	67.33*	21.81	107.6	34.7	3.4	0.26
PGH x S_{25} x GMV	78.7	264.0	3083	1061	0.687	54.66	65.66	22.88	137.8	37.9	3.2	0.24
PGH x S_{25} x GMM	70.8	211.0	2992	1047	0.857	55.33	65.33	22.81	99.6	37.8	3.4	0.26
PGH x S_{25} x GMD	78.0	243.6	2761	921	0.957	55.66*	66.66*	23.06	97.7	33.4	3.0	0.21
PGH x S_{25} x GMC	84.1	246.0	3432	1136	0.840	55.66*	67.00*	23.06	108.8	41.2	3.7	0.25
PGH x S_{25} x GM_0	80.0	207.0	3178	1069	0.810	54.33	66.66*	22.38	101.0	37.7	3.5	0.26
PGH x S_0 x GMV	92.0*	115.0	2861	1023	1.290*	55.00	64.33	21.88	49.8	35.7	3.3	0.13
PGH x S_0 x GMM	92.1*	129.3	2978	983	1.047	54.33	67.00*	22.00	58.7	33.8	2.8	0.16
PGH x S_0 x GMD	89.6*	107.6	2113	692	1.060	55.33	67.00*	21.88	54.2	23.8	2.2	0.12
PGH x S_0 x GMC	93.6*	132.0	2182	760	0.987	55.33	65.33	22.00	55.3	26.3	2.3	0.14
PGH x S_{50} x GM_0	90.4*	118.0	2069	713	1.047	55.33	65.33	22.56	53.7	24.6	2.3	0.13
SEm±	2.96	15.85	447.86	154.83	0.12	0.67	0.63	0.04	9.64	5.65	0.54	-
CD (0.05)	8.20	43.95	1241.40	429.13	0.34	1.86	1.75	0.11	26.73	15.67	1.51	-

Discussion

5. DISCUSSION

The results of the three experiments presented in the previous chapter are discussed in the following paragraphs.

5.1 Experiment I Cost effectiveness in mulberry nutrition under irrigated condition

5.1.1 Crop growth

The growth of a plant is influenced by the metabolic activities which require adequate amounts of nutrients. NPK application @ 300:120:120 kg ha^{-1} $year^{-1}$ recorded the maximum plant height, plant spread and leaf number which suggest that the mulberry crop responded very well to nutrient application. The moderate level of NPK @ 225:90:90 kg ha^{-1} $year^{-1}$ resulted in lower values, though significantly superior to the lowest level of 150:60:60 kg ha^{-1} $year^{-1}$. Several researchers earlier reported that the above biometric characters were closely related to the quantity of nutrients applied especially nitrogen (Fotedar *et al.,* 1988, Bongale, 1994 ; Anilkumar *et al.,* 1994).

Significant effects of green manuring and biofertilizer inoculation were not observed on any of the growth character except leaf number at 15 MAP when combined application of biofertilizers was done. However, significant interactive effect was observed due to the integrated use of fertilizers and green manures, fertilizers and biofertilizers, green manures and biofertilizers, and fertilizers, green manures and biofertilizers. In most of the cases the combinations involving F_{75} x GMC followed by F_{75} x GMI, F_{75} x AVP, GMC/GMI/GML x AVP/VAM and F_{75} x GMC/GMI/GML x AVP were useful which indicate the significance of integrated nutrient management involving NPK @ 225:90:90 kg ha^{-1} $year^{-1}$, green manuring with cowpea and combined application of Azospirillum, VAM and PSB in influencing the growth characters of mulberry.

The value of green manure crops in improving soil health has been recognised since very early times. The benefits credited to them include increase in organic matter content and available plant nutrients and improvement in the microbiological and physical properties of soil. Of these, the role of green manures in supplying plant nutrients, particularly nitrogen is most striking. The addition of organic matter in the form of green manure greatly influences the transformation and availability of nitrogen and several other essential plant nutrients through its impact on the chemical and biological properties of soils (Bin, 1983 ; Watanabe, 1984).

The growth promoting effect of biofertilizers by way of increased production of growth hormones might have resulted in vigorous growth of inoculated plants. The stimulatory effects of Azospirillum and VAM have been reported by Santhanakrishnan and Oblisami (1980), Nagarajan *et al.,* 1989 and Das *et al.,* (1992). Apart from this, the nutrient assimilating ability of VAM especially with respect to phosphorus, zinc and also water is well documented (Bowen and Moose, 1969).

Though there was no consistent improvement in growth characters due to the main effects of green manuring and biofertilizer inoculation, the interaction effects assumed importance with and without the interaction of inorganic fertilizers. The green manure ensures prolonged availability of nutrients to the crop. But the immediate requirement of the crop has to be met through inorganic fertilizers. This assumes more importance in mulberry where every harvest is done by pruning. Hence there is an immediate requirement of nutrients in large quantities consequent to the special method of harvest for morphological development which could easily be met through inorganic sources. Hence a proper blend of inorganic and organic manures with microbial inoculants is always desirable in mulberry for meeting its nutritional requirement. Proper blending is also beneficial in reducing the recommended dose of inorganic nutrients by 25 per cent ie, from 300:120:120 kg ha^{-1} $year^{-1}$ to 225:90:90 kg ha^{-1} $year^{-1}$.

5.1.2 Growth analysis

The significant influence of inorganic fertilizers, green manuring and biofertilizer application on LAI was observed throughout the period of growth. Application of NPK @ 225:90:90 kg ha^{-1} $year^{-1}$ recorded maximum LAI in most of the cases. *In situ* cultivation and composting of cowpea was found favourable for enhancing LAI. Combined application of Azospirillum, VAM and PSB maintained consistently higher LAI. LAI is a function of leaf number and leaf size. Though the highest doze of NPK @ 300:120:120 kg ha^{-1} $year^{-1}$ resulted in the highest leaf number, maximum LAI was registered by the moderate dose of fertilizers probably due to the reduced leaf size associated with greater number of leaves. Green manuring and combined application of biofertilizers resulted in a prolonged availability of nutrients in the rhizosphere of mulberry and hence a consistent increase in LAI was observed. The nutrient assimilating ability of VAM and the enhancement in leaf area due to Azospirillum and PSB were reported earlier (Nagarajan, *et al.*, 1989 and Das *et al.*, 1992). In certain stages considerable reduction in leaf area observed is due to the shorter harvest interval and the method of pruning employed.

A reduced NAR was found associated with good management situations like higher dose of NPK application, green manuring and use of biofertilizers, significant at certain stages. Larger leaf area caused by good management practices but improportionate dry matter accumulation due to frequent leaf harvesting and pruning may be the possible reason for low NAR in mulberry.

Though fertilizer levels had no significant effect on RGR an increase in RGR was observed with increase in nutrient levels. CGR also increased with increase in nutrient levels. *In situ* cultivation and *in situ* composting of cowpea resulted in significantly higher RGR and CGR. Similarly, combined application of Azospirillum, VAM and PSB was most effective in increasing RGR and CGR. This must be due to continuous growth and more photosynthetic area put forth by the plant. Similar results were reported by Meerabai (1997) in a nutrient management trial on mulberry in red loam soils of Kerala. The increased dry weight and leaf area of the plants observed at higher nutrient levels, green manuring (GMC) and combined application of Azospirillum, VAM and PSB might have increased the RGR and CGR in mulberry.

5.1.3 Leaf yield and dry matter production

Fresh leaf production (FLP), total fresh leaf production (TFLP), leaf dry matter production (LDMP), total leaf dry matter production (TLDMP), stem dry matter production (SDMP), and total stem dry matter production (TSDMP) were analysed and it is seen that application of NPK @ 225:90:90 kg ha^{-1} $year^{-1}$ and 300:120:120 kg ha^{-1} $year^{-1}$ were equally effective in improving the productivity of mulberry.

Available evidence indicate the significance of nitrogen in mulberry nutrition. A progressive significant increase in TFLP upto 600 N ha^{-1} has been recorded (Choudhury *et al.,* 1976 ; Jolly 1982). But in the present situation nitrogen level up to 225 kg ha^{-1} was found sufficient for maximising leaf production probably due to balanced application of inorganic nutrients. Leaf yield is a function of leaf number, leaf area and specific leaf weight. Though leaf number was significantly higher at 300:120:120 kg NPK application per hectare per year, the leaf area index and specific leaf weight were maximum with moderate doses. Hence the total leaf yield was highest in the moderate

Plate 1 **Management of mulberry garden - Application of NPK @ 150:60:60 kg/ha/year + in situ cultivation and composting of cowpea + combined application of Azospirillum, VA mycorrhizae and phosphorus solubilising bacteria**

Plate 2 **Management of mulberry garden - Application of NPK @ 225:90:90 kg/ha/year + green leaf manuring with cowpea + combined application of Azospirillum, VA mycorrhizae and phosphorus solubilising bacteria**

level of fertilizer application. Since mulberry is a perennial crop and leaf being the economic product, the available nutrient reserves in the soil alone can not meet the nutrient requirement of the crop. Moreover, the crop is subjected to severe prunings frequently for harvesting leaves. Consequent to severe pruning, the crop requires large quantities of nutrients for regeneration. Under such situations, the application of essential elements, especially NPK in balanced proposition is the easy way for boosting foliage yield.

Although all the green manure treatments increased all the above characters considerably over control, the effect of *in situ* cultivation and *in situ* composting was striking. This might be because of the direct and indirect beneficial effects of green manure coupled with the benefits of *in situ* composting. Directly it acts as a source of plant nutrient and indirectly it influences the physical and chemical properties of soils. Thus it is one of the factors responsible for improving soil fertility, water holding capacity and over all soil productivity. Numerous macro and micro organisms act upon the organic material and develop a well balanced soil biota which not only supplies the plant nutrients but also releases many fixed minerals in soil solution (Singh *et al.*, 1992). Under tropical conditions, the organic matter content of soil gets degenerated very fast affecting soil health. Proper input of organic matter to soil is necessary to alleviate the situation. *In situ* cultivation and *in situ* composting is an ideal way of maintaining the soil health of tropical mulberry gardens.

Biofertilizers were very effective in increasing the productivity of mulberry. Considerable improvement in TFLP and TLDMP was observed due to combined application of Azospirillum, VAM and PSB. The effect of the above treatment was on par with inoculation of VAM alone on all the above characters. Combined application of Azospirillum, VAM and PSB had contributed to increased plant height, and plant spread. This has resulted in a corresponding increase in the number of leaves which in turn increased the LAI. Higher LAI equipped the inoculated plants for better utilization of solar energy for growth and development which again contributed to higher production. Combined application of microbial inoculants enhanced leaf yield at all harvests. Increased leaf yield was the outcome of increased morphological growth attributed to better rhizosphere situation. The total biomass production increased significantly due to combined inoculation of Azospirillum, PSB and VAM. Azospirillum, a micro-aerophilic bacterium is known to enter into associative symbiosis and lives inside the cortical cells and xylem vessels of plants and thus serves as an in situ nitrogen fixer. The inclusion of Azospirillum has contributed to the synergistic effect of the diazotroph with VAM fungi and PSB. The evolution of tripartite system (host-VAM-diazotroph) is reported to be contributed significantly to the economy of phosphates and nitrogen in natural environments. VAM fungi stimulates plants for uptake of zinc, copper, sulphur, potassium and calcium. The probable explanation for the increased uptake by mycorrhizal plants is that VAM explores the soil volume more thoroughly and so finds more of the point sources of phosphorus (Chandrasekhar *et al.*, 1996). The ability of different microorganisms especially PSB to solubilise bound phosphates has been well established. Solubilisation is generally due to the production of organic acids in the medium in which the microorganisms grow. These reactions take place in the rhizosphere and because solubilising microorganisms dissolve more phosphates than they require for their growth and metabolism, the surplus can be absorbed by plants (Subba Rao, 1979).

Interaction effects of inorganic fertilizer and green manure, inorganic fertilizer and biofertilizer and green manure and biofertilizer were beneficial in increasing the productivity. The interaction effect of F75 x GMC resulted in 71 per cent increase in TFLP over F75 x GM0. With respect to TLDMP, the interaction effect of the combinations, F75 x GM0 (71 per cent over F75 x GM0), F75 x AVP (96 per cent increase over F75 x BF0) and GMC x AVP (90 per cent over GMC x BF0) were found superior. Pattern was almost similar with respect to SDMP, RDMP and TDMP as well. The combined application of all the three biofertilizers with F50 resulted in 76 per cent increase in TLDMP over F75 with no biofertilizer clearly shows the beneficial effects of biofertilizers at lower doses of inorganic fertilizers in mulberry leaf production.

The beneficial effects of organic manure alone or in combination with fertilizers in increasing the percentage of water stable aggregates and there by improving the soil structure has been reported by Bose and Mukherjee (1993). The long term fertilizer experiments have shown that neither the organic manure nor the mineral fertilizer can sustain high productivity under intensive mulberry cultivation, where the nutrient turn over in the soil - plant system is quite high. Organic manure alone may suffice for lower nutrient demand under low to medium intensity cropping but combination of organic manures and inorganic fertilizers becomes imperative to sustain productivity of soil and thereby sustaining a high mulberry yield.

Reports regarding the synergistic effects of Azospirillum and PSB are available. A significant increase in root nitrogenase activity and yield of sorghum due to combined inoculation of Azospirillum and PSB over single inoculation was reported. There are reports regarding the possibility of saving 40 kg nitrogen and replacing the entire quantity of superphosphate with rock phosphate plus inoculation of Azospirillum and Pseudomonas or Bacillus.

Biological interaction of VAM fungi can be exploited in mulberry nutrition. Results relating to interaction of VAM with other beneficial bioinoculants are also encouraging as above. The interaction between Azotobacter and VAM was positive and a synergistic effect on plant growth was observed (Bagyaraj and Menge, 1978). Mycorrhizal colonisation increased the Azotobacter population in the rhizosphere, which was at a high level for a longer time and Azotobacter enhanced colonisation and spore production by VAM. Similar interactions have been observed between other free living nitrogen fixers and VAM by other workers. Sometimes, the beneficial effects on plant growth from free living nitrogen fixing organisms was attributed to hormone production rather than, or in addition to nitrogen fixation.

VAM-PSB interaction studies showed that PSB survived for a longer time in the rhizosphere of Mycorrhizal roots (Bagyaraj, 1984 ; Linderman, 1988). The PSB rendered more phosphorus soluble, while VAM enhanced phosphorus uptake. Thus, with combined inoculation there was a synergistic effect on phosphorus supply and dry matter production. PSB also produces hormones and vitamins. The hormones and vitamins synthesised by these organisms may also contribute significantly to VAM development and plant growth.

Rhizosphere studies carried out at two stages viz, three and twelve MAP also highlight the importance of integrated nutrient management in mulberry. There was considerable increase in VAM spore load and VAM infection per cent. In addition, considerable improvement in the rhizosphere colonisation of Azospirillum and PSB was observed under integrated nutrient management.

The results of the present study indicate the importance of integrating different nutrient sources for increasing the production potential of mulberry. A saving of 25 per

Plate 5 Performance of mulberry as influenced by IPNS (Integrated Plant Nutrition System) involving the application of NPK @ 225:90:90 kg/ha/year + in situ cultivation and composting of cowpea + combined application of Azospirillum, VA mycorrhizae and phosphorus solubilising bacteria

Plate 6 Performance of mulberry as influenced by IPNS (Integrated Plant Nutrition System) involving the application of NPK @ 225:90:90 kg/ha/year + in situ cultivation and composting of cowpea + application of Azospirillum alone

cent in inorganic nutrients amounting to 75:30:30 kg ha^{-1} $year^{-1}$ is possible by integrating with combined application of Azospirillum, VAM and PSB. *In situ* cultivation and *in situ* composting of cowpea integrated with combined application of all the three bioinoculants are beneficial for achieving higher production in mulberry.

5.1.4 Content and uptake of nutrients

A significant progressive increase in leaf nitrogen content from F50 to F100 was observed. An almost similar trend was observed in the case of leaf dry matter production also which indicate that nitrogen availability, nitrogen content and leaf production are very much related. The difference in leaf nitrogen content at first harvest at 12 MAP was very much higher than subsequent harvests. This is probably due to continuous production and harvesting of leaves and consequent dilution of nitrogen in plant tissues. From the earlier results on various growth parameters it is clear that green manuring and biofertilizer have also contributed towards nitrogen availability to the plants and a similar trend as in the case of inorganic fertilizer was also expected and observed with regard to leaf nitrogen content.

Quantitative expression of nutrient uptake is the product of nutrient content in plant tissue and the dry matter production. With regard to nitrogen uptake, it is already stated that nitrogen content and leaf production were positively influenced by increasing levels of nutrients, green manuring treatments particularly *in situ* cultivation and composting of cowpea and biofertilizer inoculation especially combined application of Azospirillum, VAM and PSB.

Phosphorus content of leaves also followed a similar trend as that of nitrogen. Inorganic fertilizers, green manuring and biofertilizer inoculation had no significant effect on leaf phosphorus content at 16 MAP. This must be due to the consequent effect of

Plate 7 Performance of mulberry as influenced by the application of NPK @ 225:90:90 kg/ha/year alone

Plate 8 Performance of mulberry as influenced by the application of NPK@ 150:60:60 kg/ha/year alone

special method of harvest followed. Variation in leaf phosphorus uptake was due to difference in phosphorus content and leaf dry matter production.

The role of potassium in plants is different than that of nitrogen and phosphorus. Being a non-structural element of plant tissues, its function is more in the metabolism of other elements particularly nitrogen and phosphorus. For the translocation of other elements within the plant and keeping the turgidity of plant cells it is very important. Whenever, nitrogen and phosphorus are abundantly available in soil, potassium uptake is mandatory in proportion to the available potassium in the soil solution. The inorganic fertilizers and green manures added sufficient amount of potassium in the soil which was taken up by the plants. The VAM served as supplementary nutrient absorbing media and created a balanced nutritional environment in the rhizosphere of mulberry. With regard to potassium uptake, the reasons explained in the case nitrogen and phosphorus stand valid here also.

5.1.5 Leaf quality

Nutrient levels had significant effect on leaf protein content. In the present study, the highest nutrient level of 300:120:120 kg NPK ha^{-1} year^{-1} recorded maximum protein content. The relationship between nitrogen content and protein is well established. Protein of mulberry leaf is the prime factor deciding the quality of leaf.

The mean protein content averaged over five harvests was 6.23 per cent higher in the treatment combination F100 x GMC x AVP compared to F100 x GM0 x BF0. This clearly indicates the need for integrated nutrient management involving inorganic, organic and biofertilizers for improving the quality of mulberry leaf. Enrichment of leaf protein was mainly due to better availability and efficient absorption of the nutrients especially nitrogen. One of the components of the integrated nutrient management system, viz, VAM plays a key role in the efficient absorption of nutrients.

Plate 9 One week after pruning a mulberry plant - Integrated nutrient management involving the application of NPK @ 225:90:90 kg/ha/year + in situ cultivation and composting of cowpea and combined application of Azospirillum, VA mycorrhizae and phosphorus solubilising bacteria

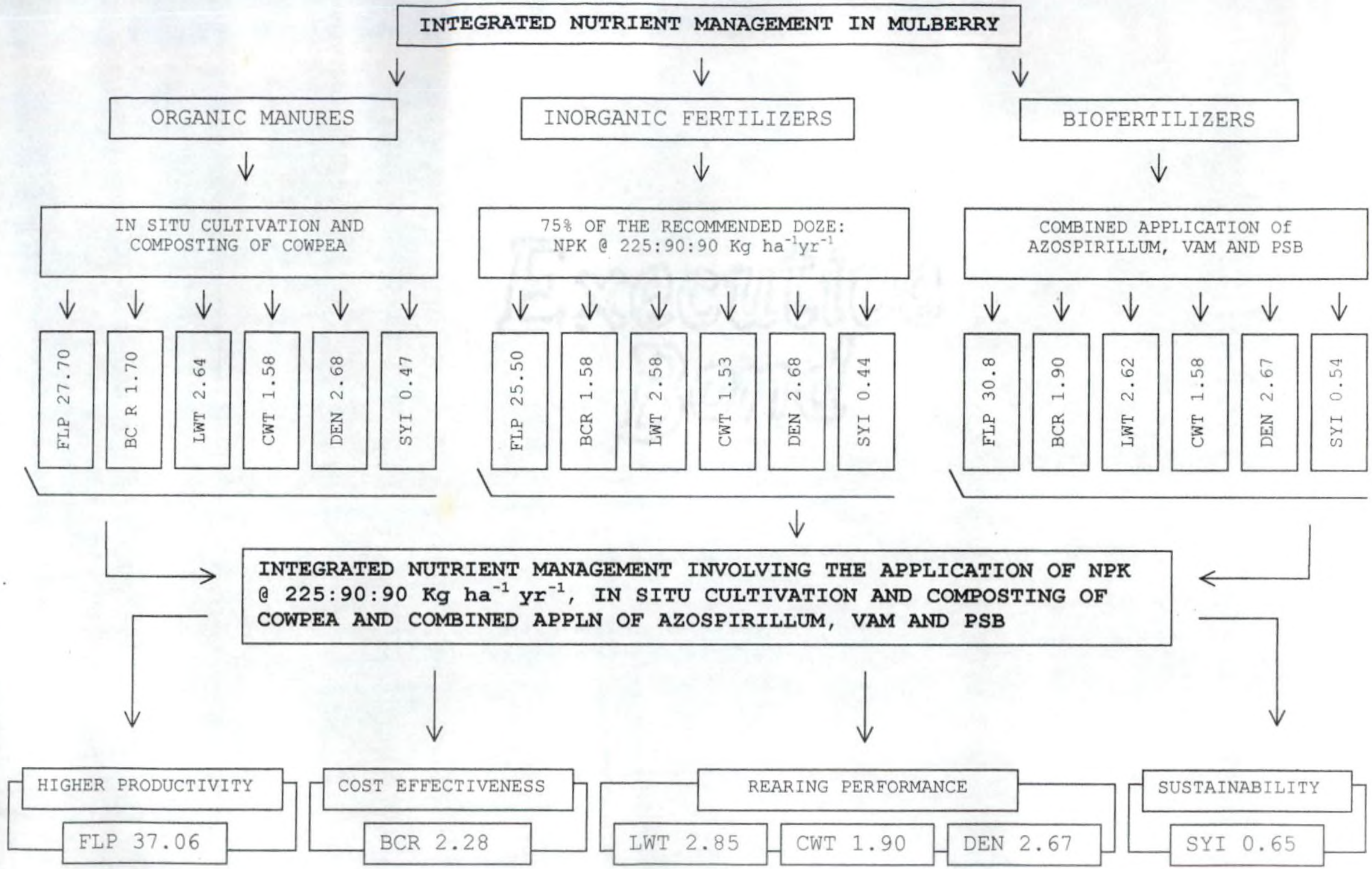
Plate 10 One week after pruning mulberry garden - Integrated nutrient management involving the application of NPK @ 300:120:120 kg/ha/year + green leaf manuring and combined application of Azospirillum, VA mycorrhizae and phosphorus solubilising bacteria results in rapid sprouting and luxuriant growth of mulberry

Leaf moisture content and leaf moisture retention over 24 hour storage are also factors deciding leaf quality. The nutritional factors tried in this experiment did not influence this parameter.

5.1.6 Larval characters, cocoon characters and post cocoon parameters

Increasing the levels of NPK application was beneficial for improving the rearing performance. Maximum leaf consumption, larval weight, cocoon weight, shell weight, filament length, filament weight and denier were recorded when NPK was applied @ 300:120:120 kg ha^{-1} $year^{-1}$. Protein is a major constituent of mulberry leaf and the crop is cultivated for leaf protein. Silk is a protein fibre produced by the silk worm for spinning cocoon. Basically there are two proteins which go to form the silk fibre viz, \`fibroin\` which constitute the core of the fibre and \`sericin\` a waxy substance which encases the \`fibroin.\` These proteins are synthesised by the silk worm from the mulberry leaf it feeds during its larval period of twenty five to thirty days, in two silk glands which run along the body of the silk worm on either side (Ullal and Narasimhanna, 1987). This shows the importance of balanced nutrition especially application of adequate quantities of nitrogen in mulberry for promoting leaf protein content.

Leaves from the treatment, *in situ* cultivation and incorporation of cowpea, improved all the above characters except cocoon weight. However, *in situ* cultivation and in situ composting of green manure gave maximum cocoon weight. Microbial inoculants were favourable for improving the rearing performance. The leaf consumption which is an indicator of the performance of silkworm race with respect to productivity is an important parameter for the efficient conversion of food into cocoons. The study revealed that the rearing performance was influenced by the agronomic practices governing the quality of mulberry leaf as detailed in earlier sections.



FLP-Total leaf production(tha^{-1}) BCR-Benefit cost ratio LWT-Larval weight(g) CWT-Cocoon weight(g) DEN-Denier SYI-Sustainable yield index

Fig 49 Sustainability pathway to soil fertility management in mulberry

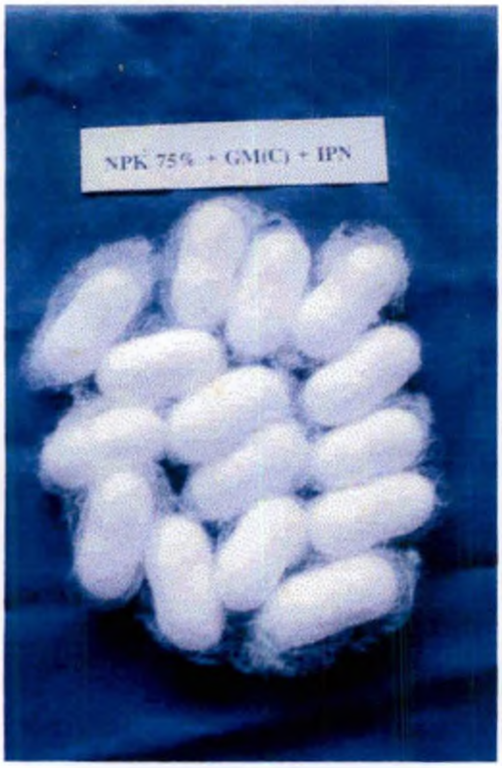


Plate 11 Cocoons from the bioassay trial utilising leaves from the treatment combination NPK @ 225:90:90 kg/ha/year + *in situ* cultivation and composting of cowpea and combined application of Azospirillum, VA mycorrhizae and phosphorus solubilising bacteria.

Plate 12 Cocoons from the bioassay trial utilising leaves from the treatment combination NPK @ 300:120:120 kg/ha/year + in situ cultivation and composting of cowpea and combined application of Azospirillum, VA mycorrhizae and phosphorus solubilising bacteria

5.1.7 Economic analysis and sustainable yield index

Application of NPK @ 225:90:90 kg ha^{-1} $year^{-1}$, *in situ* cultivation and *in situ* composting of cowpea and combined application of Azospirillum, VAM and PSB resulted in maximum gross income, net income and benefit cost ratio. These parameters are mainly decided by the effect of agrotechniques affecting leaf production as there is not much significant variation with respect to cost of production. A 25 per cent reduction in inorganic fertilizer application amounting to a saving of 75:30:30 kg NPK ha^{-1} $year^{-1}$ is possible. The possible reasons already explained under fresh leaf production hold good for the observed trend in gross income, net income and benefit cost ratio. Integrated nutrient management involving F_{75} x GMI/GMC x AVP resulted in achieving more than 65% of the maximum observed yield indicating the sustainability of the technology. Sustainability pathway to soil fertility management is given in Fig.49.

5.2 Experiment II Utilization of agricultural byproducts for economising water use and improvement in leaf quality and productivity of mulberry

5.2.1 Crop growth

In general, the variety S-54 recorded maximum plant height, plant spread, leaf number, total leaf number, shoot length and total shoot length over the variety K-2. The vigorous growth of the variety was due to its genetic potential indicating its suitability for cultivation under the prevailing agroclimatic condition. The variety S-54 evolved at Central Sericultural Research and Training Institute (CSR&TI), Mysore, is recommended for cultivation under irrigated condition and reported to yield almost double than that of the variety K-2 which is recommended for both irrigated and rainfed conditions.

Irrigation at CPE 30 mm was on par with irrigation at 15 mm and in certain cases with 45 mm and resulted in luxuriant growth of mulberry over control. This has resulted because mulberry under irrigated situation never faced water stress unlike rainfed condition. Water deficit is likely to affect two vital processes of growth viz, cell division and cell enlargement resulting in poor growth under rainfed condition. The favourable influence of higher levels of irrigation might be due to stimulation of metabolic activities resulting in better growth of mulberry. Variation in LAI is due to changes in leaf number and or leaf size. Leaf number depends on shoot length and rate of leaf production. Leaf size is determined by the number and size of cells by which the leaf is built and is influenced by light, moisture regimes and the supply of nutrients (Gupta, 1975). Effect of soil moisture on rate of leaf production and leaf size is remarkable. Irrigation at lower CPE tends to bring the soil to field capacity more frequently resulting in favourable soil moisture regimes for mulberry growth.

Mulching with coconut husk in mulberry garden for soil moisture conservation increased most of the biometric characters. This might be due to availability of sufficient moisture in the root zone of mulberry because of the lower rate of soil evaporation. Monteith (1973) revealed that evaporation directly from the soil surface may constitute a considerable proportion of the total ET, in both irrigated and dry land conditions. Various treatments such as mulching, tillage and irrigation which affect either the energy absorption or the water transport to the evaporative surface are likely to affect soil evaporation. Even under full vegetative cover, soil evaporation constitute more than 10% of the annual evapotranspiration for many agricultural crops (Tanner and Jury, 1976). The present study revealed the beneficial effect of coconut husk in reducing soil evaporation and increasing the available soil moisture.

The growth of mulberry is often limited by the amount of available soil moisture and it can be substantially improved by supplemental irrigation coupled with moisture conservation techniques.

Interaction effects were significant in influencing crop growth at certain stages. Varietal response to irrigation was very high and the variety S-54 resulted in 96% increase in total shoot length while variety K-2 had an increase of only 73% at the same level of irrigation over control. Similarly, varietal response to soil moisture conservation technique was also considerable and the variety S-54 produced 37% increase in total shoot length while var K-2 resulted in only 14% increase over control when mulching with coconut husk has been practised. Irrigation combined with moisture conservation technique (I_{30} x MCH) helped to extend the shoot length by 79% over control. The response of the variety, S-54 was very high with respect to total shoot length when it was irrigated at CPE 30 mm and coconut husk used for moisture conservation. Total leaf number was also influenced by all the interaction effects. S-54 x I_{15} (100% increase over S-54 x I_0), S-54 x MCH(18% increase over S-54 x MC_0), I_{30} x MCH (89% increase I_0 x MC_0) and S-54 x I_{30} x MCH (163% over S-54 x I_0 x MC_0) combinations proved better to increase the leaf number, one of the important components of mulberry yield. The interaction effects revealed that considerable improvement in growth attributes can be achieved if coconut husk is used for mulching to reduce the loss of irrigation water through soil evaporation.

5.2.2 Growth analysis

The variety S-54 recorded significantly higher LAI over K-2 throughout the period of growth. The capacity of this variety in maintaining higher LAI was due to the production of more number of functional leaves which is evident from Table 44. Higher rate of leaf production under irrigated condition gave higher LAI for the irrigated crop. Mulching with coconut husk resulted in higher LAI due to the production of large number of leaves. Variation in LAI is due to changes in leaf number or size. At

Plate 13 Soil moisture stress limits the growth of mulberry

Plate 14 General view of the experimental plots

different harvests, LAI varied from 0.59 to 4.42 in K-2 and from 0.91 to 6.76 in S-54. This variation has occurred due to factors such as, stage of crop, harvest interval and the method of pruning employed.

The variety K-2 recorded higher NAR because of increased rate of dry matter production per unit of leaf area when compared to S-54. The dry matter partitioning of the two varieties showed that in the case of K-2 36.6%, 37.2% and 26.5% were utilized for leaf, stem and root development, respectively. But, in S-54 the corresponding figures were 42.7%, 35.3% and 21.9%, respectively. This shows that the leaf dry matter production was relatively higher for the variety S-54 consequent to a higher LAI. The disproportionate increase in the LAI and the dry matter accumulation in the case of S-54 resulted in a lower NAR for the variety compared to K-2.

The variety S-54 showed higher RGR and CGR because of higher dry matter accumulation. Irrigation treatments improved NAR, RGR and CGR due to higher total dry matter production.

The specific leaf weight was more for the variety K-2 compared to the variety S-54 and is probably due to the relatively lower dry weight of leaves of S-54 owing to higher moisture content at harvest.

The root : shoot ratio was higher for the variety K-2 compared to the variety S-54. K-2 is a variety reported to be grown under rainfed situation and the mechanism for adaption under such a situation is greater root proliferation and exploiting larger volume of soil for extracting water. Under irrigated situation root : shoot ratio was found to be lower than the control irrespective of the frequency of irrigation. Under irrigated situation, root dry matter production is expected to be lower than the aerial parts.

Harvest index expressed as percentage ranged from 39.7 to 58.5; and 41.8 to 62.3 for the varieties K-2 and S-54, respectively. A higher leaf dry matter production resulted in higher harvest index for the variety S-54. The wide variation observed at various harvests is due to factors such as varying harvest intervals and pruning methods employed. With respect to irrigation, at the initial stage there was no significant difference, but significance was observed at later stages. In the establishment phase, dry matter partitioning was in favour of root and stem but at later stages the priority was shifted for foliage production. The role of water in increasing leaf production has already been discussed in section 5.2.1. Because of higher leaf production at later stages, irrigated treatments registered higher harvest index.

5.2.3 Leaf yield and dry matter production

The performance of the variety S-54 was superior in terms of fresh leaf production (FLP), total fresh leaf production (TFLP), leaf dry matter production (LDMP), total leaf dry matter production (TLDMP), stem dry matter production (SDMP), total stem dry matter production (TSDMP) and root dry matter production (RDMP) over K-2 probably due to high genetic potential. S-54 is a high yielding mulberry variety and the high LAI of the crop might have been responsible for the higher production of mulberry.

In general, all the three levels of irrigation influenced the productivity of mulberry when compared to control. However, the maximum production was observed when irrigation was managed at CPE 30 mm. This might be due to better growth of plants associated with favourable soil moisture regimes.

The effect of mulching with coconut husk was consistent in increasing the production throughout the period of growth and considerable increase in productivity was observed over other moisture conservation techniques. Mulching has been widely practised for many fruit trees and tropical plantation crops with superficial root systems. A surface mulch affects both the diurnal and seasonal fluctuations in soil temperature. Its principal effects on diurnal temperature is to reduce the mid day maximum temperature under hot and dry conditions. The mulched soil is much cooler during the heat of the day and rather warmer during the night. The mulches slow down the rate of evaporation from a wet soil very considerably. The rate of evaporation is controlled by the proportion of energy absorbed by the soil which is used for evaporating water, and by the rate of removal of water vapour from the region where it is being produced. So long as the wet soil is exposed to the air, the water vapour is rapidly removed by the general turbulence of the air, but if the water vapour must diffuse through a mulch which keeps the air almost stationary, then the rate of diffusion limits the rate of evaporation (Russel, 1973). From the present study it is assumed that a mulched soil especially with coconut husk can conserve more soil moisture due to the special properties of the husk. Coconut husk acts as a water reservoir in the soil and release small quantities of potash present in them to the soil. The potash content in the husk is soluble and readily available to mulberry. The husk is spongy in nature and when buried in the soil absorbs and retains moisture which will become available to mulberry roots. A fully soaked husk is able to retain about six to eight times its weight of water (Thampan, 1982). The beneficial effect of coconut husk is evident from the biometric characters of mulberry.

All the four interaction effects were significant with respect to TFLP, TLDMP and TDMP. The significance of S-54 x I30, S-54 x MCH , I30 x MCH and S-54 x I30 x MCH combinations in increasing the productivity of fresh leaf were observed in the study. The pattern was similar with respect to TLDMP except the effect of the combination irrigation x moisture conservation where the combination I45 x MCH registered the maximum TLDMP. TDMP also followed the same trend as that of TLDMP except the effect of the combination variety x irrigation, where S-54 x I15 was proved to be better.

The response of the variety S-54 was worth mentioning when it was given irrigation at CPE 30 mm and coconut husk used for soil moisture conservation. The possible reasons already explained in the section under the title crop growth hold good for this observed trend.

5.2.4 Content and uptake of leaf nutrients

There was 50 % increase in nitrogen uptake by the variety S-54 compared to K-2. TLDMP of S-54 also registered a similar increase to the extent of 45%. The increase in leaf nitrogen concentration in S-54 ranged from 2.2 to 4.2% compared to K-2. Higher TLDMP coupled with increase in nitrogen concentration had resulted in higher uptake of nitrogen.

The increase in leaf phosphorus uptake by S-54 was 55% compared to the local variety K-2. TLDMP with respect to S-54 also showed a similar increase. Higher leaf productivity associated with increase in leaf phosphorus concentration to the tune of 3.6 to 11.1% must have contributed to higher leaf phosphorus uptake. Considerable increase in phosphorus uptake to the extent of 69 and 22% were observed with respect to irrigation and soil moisture conservation treatments, respectively. As there was no significant difference in the concentration of this element in leaf tissues, it is assumed that the increase in TLDMP to the tune of 74 and 23% for irrigation and moisture conservation treatments, respectively might have contributed to higher phosphorus uptake.

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Although, there was only 45% increase in TLDMP with respect to S-54, leaf potassium uptake increased to the tune of 63%. This was mainly due to a very high increase in leaf potassium concentration to the tune of 15%. Irrigation and moisture conservation increased potassium uptake to the extent of 87 and 30%, respectively. Almost a similar trend was observed in TLDMP and nutrient concentration in leaf which explains the background for higher uptake of potassium with irrigation at CPE 15 mm and mulching with coconut husk followed by earthing up.

5.2.5 Leaf quality

Leaf moisture retention capacity was found to be more for the variety K-2. Moisture loss was minimum for the rainfed crop and the effect of soil moisture conservation practice was not consistent with respect to leaf moisture retention capacity. K-2 is a popular variety cultivated under rainfed conditions and the genotypic effect had resulted in higher leaf moisture retention capacity. Mulberry leaf composition is influenced by several factors. The nutritive value of the leaf changes according to the photosynthetic and respiratory activities of the leaf. Leaves harvested in the afternoon contain less water and more of carbohydrates due to active photosynthesis and transpiration taking place in day time. Such leaves when harvested continue transpiration even during preservation and wither quickly. On the otherhand, leaves picked from rainfed plots contain less leaf moisture, but retain moisture for longer time.

Varieties, levels of irrigation and moisture conservation practices influenced leaf protein content. The variety S-54, all the levels of irrigation, and mulching with coconut husk and incorporation of silkworm litter recorded considerable improvement in the quality of mulberry leaf by way of increase in leaf protein. A more favourable environment was available for the absorption and utilization of soil nutrients under irrigated condition which might have resulted in higher content of leaf protein in irrigation treatments. The composition of silkworm litter shows that it contains 1.4% of nitrogen which might have helped mulberry to absorb and assimilate more nitrogen resulting in higher leaf protein.

5.2.6 Larval characters, cocoon characters and post cocoon parameters

Between the two varieties, S-54 performed better with respect to leaf consumption, larval weight, cocoon weight, shell weight, shell ratio, filament length, filament weight and denier. Managing irrigation at CPE 45 mm registered maximum leaf consumption. Among the soil moisture conservation practices, mulching with coconut husk was found to enhance leaf consumption.

Total uptake of nutrients and uptake at different stages were influenced by the treatments. The variety S-54, irrigation at CPE 30 mm (in general) and incorporation of coconut husk gave higher uptake values mainly because of high LDMP. In general, S-54 x CPE 30 mm x coconut husk recorded maximum uptake due to the above reason.

Available nutrient status of soil was unaffected by varieties and irrigation. But coconut husk followed by silk worm litter and coir pith enhanced the available nitrogen over control. Coir pith followed by coconut husk enhanced the potassium content of soil. This might be due to variation in the composition of the mulches with respect to content and pattern of release of nutrients.

5.2.7 Canopy temperature, leaf diffusive resistance and transpiration rate

Leaf temperature status is an indirect measure of plant water status. The variety S-54 recorded minimum leaf temperature because the leaves contained more moisture when compared to K-2 at all stages of harvest (Table 60). Leaf diffusive resistance was also minimum in S-54 because of higher leaf water status (Table 60). S-54 recorded higher transpiration rate since the leaf moisture status was higher when compared to K-2 (Table 60)

Low canopy temperature, low leaf diffusive resistance and high transpiration rate were observed when mulberry was given frequent irrigation at CPE 15 mm. When plants were well supplied with water, transpiration would be at the potential rate and the leaves would be relatively cool (Ides *et al.*, 1978).

Mulching with coconut husk also helped to reduce canopy temperature and leaf diffusive resistance. But it increased transpiration rate. This was mainly due to increased availability of soil moisture for plant absorption.

5.2.8 Soil moisture studies

5.2.8.1 Mean soil moisture content before and after irrigation

Before irrigation, soil moisture content was high at all the three depths of sampling, ie, 0-15 cm, 15-30 cm and 30-45 cm when the mulberry variety K-2 was cultivated. This indicates that the consumptive use of this variety was low when compared to the variety S-54. S-54 is a shallow rooted variety and its consumptive use is quite high when compared to K-2. Because of these two factors the variety S-54 absorbed more water from the surface layer resulting in lowering of moisture content. Frequent irrigation resulted in higher soil moisture content at 0-15 cm depth both before and after irrigation. Mulching increased soil moisture content both before and after irrigation at all depths probably due to reduced rate of soil evaporation.

5.2.8.2 Mean seasonal consumptive use and daily consumptive use

Consumptive use was higher for the variety S-54 when compared to K-2. This was due to better growth attributes like plant height, number of leaves, total shoot length, plant spread and leaf area. The consumptive use increased with increasing levels of irrigation. The highest value was recorded when mulberry was irrigated at CPE 15 mm. Frequent moisture supply created more favourable conditions for higher evapotranspiration. Similar reports were put forward by Jacob (1986), Desai and Patil (1984), Thomas (1984) and Radha (1985). Mulching with coconut husk also increased the consumptive use. This might be due to retention of more moisture by coconut husk (Thampan 1982).

5.2.8.3 Crop coefficient

The variety S-54 recorded the maximum value because consumptive use of this variety was quite high when compared to K-2. Frequent irrigation (CPE 15 mm) recorded the highest value and there was a decrease in the crop coefficient with decrease in the degree of wetness of soil. The higher crop coefficient values with increase in wetness was due to the enhanced consumptive use with increase in the frequency of irrigation. Mulching with coconut husk increased the value as more moisture was available for meeting the evapotranspiration requirement of the crop consequent to reduced rate of soil evaporation coupled with higher retention of moisture in coconut husk.

5.2.8.4 Water use efficiency

The results revealed the superior performance of the variety S-54 with respect to crop water use efficiency and field water use efficiency. This was mainly due to increase in yield when compared to the local variety K-2. The water use efficiency decreased with increase in the level of irrigation. Water use efficiency is likely to increase with decrease in soil moisture supply until it reaches the maximum critical level because plants may actively try to economise water use in the range from minimum critical to optimum moisture level. Water above the optimum level may be lost in the form of excessive evaporation, transpiration or even as deep percolation.

Plate 15 General view of the experimental plots

Plate 16 General view of the experimental plots

5.2.8.5 Relative soil moisture depletion

The variety K-2 extracted maximum quantity of water from 0-15 cm layer. With respect to S-54 maximum absorption was from 15 - 30 cm range. Under rainfed condition, mulberry extracted more moisture from the lower soil layer (30-45 cm) when compared to wet regimes, possibly due to extensive proliferation of root system to utilize soil moisture from deeper layers. Similar observations were reported by Radha (1985) in pumpkin and Thomas (1984) in bittergourd. When coconut husk was used for soil moisture conservation the crop was able to utilize moisture from all the three layers at satisfactory levels and maximum absorption was from 30-45 cm layer. This indicates the favourable effect of coconut husk in the development of mulberry root system.

5.2.8.6 Economic analysis and sustainable yield index

The variety S-54 was found economical and it showed its superiority over K-2 in terms of gross income, net income and benefit cost ratio. Irrigation at CPE 45 mm and incorporation of coconut husk were also found favourable for increasing the above economic criteria.

The interactions effects assumed significance and the combinations S-54 x I30, S-54 x MCH , I30 x MCH and S-54 x I30 x MCH resulted in maximum GI, NI and BCR. Total fresh leaf production is the most important parameter deciding profit since there is not much variation in the cost of production of leaf. In all the above treatments and treatment combinations fresh leaf production was maximum and hence higher GI, NI and BCR were recorded. The minimum guaranteed yield with the treatment combination involving the high yielding variety S-54, irrigation irrespective of its frequency and mulching with coconut husk followed by earthing up was more than 52% of the maximum observed yield indicating the sustainability of this treatment combination. Sustainability pathway to soil moisture management is given in Fig.50.

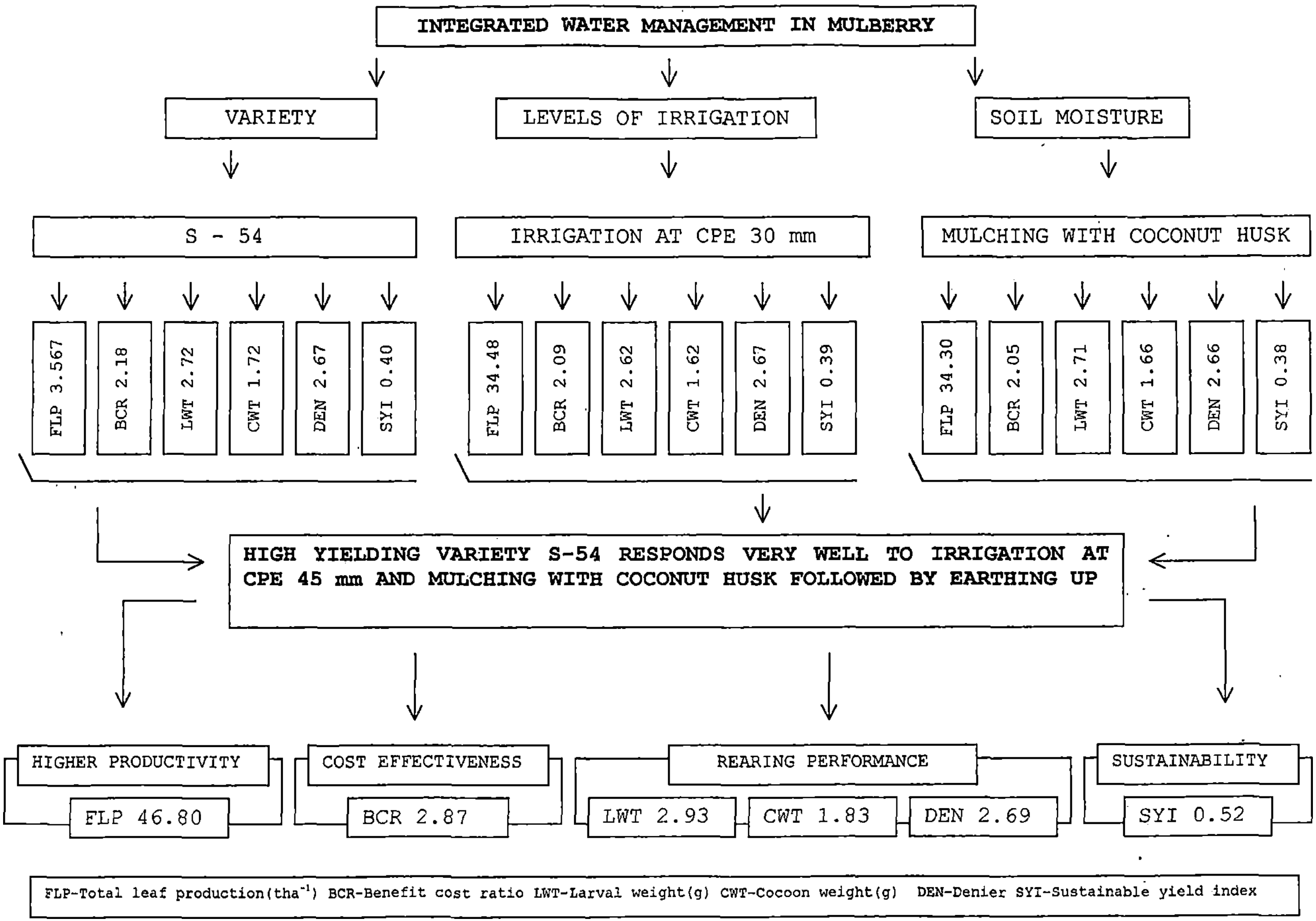

Fig 50 Sustainability pathway to soil moisture management in mulberry

5.3 Experiment III Shade tolerance and *in situ* development of green manure sources in mulberry

5.3.1 Growth of the intercropped green manure

Paired row planting facilitated successful intercropping of green manure as indicated by the significantly higher dry matter production. However, the dry matter production in the second year was relatively lower than the first year, probably due to the competition with established mulberry. Just like the mulberry crop the intercrops also produced higher dry matter under open condition and the dry matter production decreased significantly with increasing shade in the first year. In the second year, open condition and 25% shade were at par and produced significantly higher dry matter than 50% shade. Among the green manures, Mimosa followed by cowpea produced significantly higher dry matter over Desmodium and Calapagonium in both the years. This is mainly due to the habit of the intercrop, where cowpea was erect, mimosa was erect and creeping, but desmodium and calapagonium were purely creeping and competition for light might have caused lower dry matter production of the latter.

The NPK accumulation was higher in paired row system, open conditions and intercropping with mimosa. Nutrient accumulation in crops is a function of dry matter production and nutrient content. A remarkable total NPK accumulation was observed for mimosa due to its larger dry matter production and comparatively higher NPK content.

5.3.2 Crop growth

Planting geometry influenced the growth characters of mulberry and paired row planting in general resulted in maximum height, plant spread, leaf number, total leaf number, shoot length and total shoot length.

Planting mulberry at the normally recommended uniform row distances would afford little opportunity for in situ green manuring. On the otherhand, modification of the planting pattern would make in situ green manuring feasible. Paired row system of cultivation, a modification of the traditional planting pattern has been reported from many research centres. In a plot plants in the border rows grow better, produce higher yields than inside rows probably they receive more light and nutrients by way of border effect. When mulberry is planted in paired or double rows plants in each row get more space towards one side similar to border rows. While in the high density planting plants succumb to severe competition for space, light, nutrients and water resulting in poor growth.

Though cultivation of the crop under open conditions was ideal for increasing plant spread, leaf number, total leaf number, shoot length and total shoot length, the plant height was maximum when the crop was raised under 50% shade.

In this experiment a positive response to intercropping with green manure similar to those in the previous experiments is not observed in the growth of mulberry. The probable reason for this low response is that here the crop is grown under rainfed situation, supplemented only with life saving irrigation. For positive response to any kind of organic manure or fertilizer added sufficient soil moisture is absolutely necessary. Another reason which can be stated is that in this experiment the green manure was not incorporated but only cut and spread on the soil surface. However, significant difference in the plant height was observed at 6 and 15 MAP. At 6 MAP sole cropping of mulberry free from competition with intercropped green manure produced maximum height and higher leaf number. But in the second year three months after planting of the green manure intercrops, ie at 15 MAP sole cropping resulted in significantly lower plant height and leaf number. At this stage the mulberry crop has very well established with good competing ability, and competition between the crop and the green manure was the minimum. The nitrogen fixed by the legume green manures have contributed to the vigorous growth in the form of plant height and leaf number.

Plants grown in shade always grow taller than those grown in full sunlight. Sachs (1965) and Duncan (1975) revealed the significance of light inhibition of growth on stem elongation. Gibberellin concentration in the plant is more at low light intensity and its content goes down when the plants are exposed to light. The increase in height under 50% shade may possibly due to the maintenance of a higher concentration of gibberellic acid as light induced disintegration of this hormone is least in shade.

5.3.3 Growth analysis

Paired row planting of mulberry enhanced LAI throughout the period of growth. Cultivation under open conditions was favourable for enlargement of leaf area. Intercropping with green manure had no significant effect on LAI. Higher LAI was mainly due to the production of more number of leaves under favourable environment.

Geometry of planting influenced the various physiological parameters and paired row planting increased the NAR, RGR and CGR. Differences in NAR, RGR and CGR were due to variations in the availability and absorption of solar radiation. In paired row system, plants got a favourable environment due to `border effect` which is evidenced from the dry matter production. This might have contributed to higher NAR, RGR and CGR. The significant influence of planting geometry on SLW was observed only at 9 MAP and normal row planting recorded maximum SLW. The reasons for lower SLW associated with higher LAI explained in earlier sections are applicable here also.

When compared to shade situations, open conditions were found ideal for increasing the RGR and CGR probably because of higher photosynthetic efficiency due to more availability of solar radiation. There existed a relationship between NAR, RGR and CGR and production potential because dry matter production also showed an increasing trend as in the case of RGR and CGR. Intensity of shade influenced SLW and cultivation under 50% shade registered significantly higher values probably due to drastic reduction in leaf area compared to the open conditions.

Though intercropping with green manure had no effect on NAR, RGR and CGR the influence of intercropping with green manure cowpea was considerable in increasing the specific leaf weight of mulberry towards the later stages of crop development. From the crop compatibility point of view, cowpea was better than other green manures since it did not compete with mulberry for the resources. Though mimosa was beneficial in terms of total quantity of nutrients added there existed competition between mulberry and mimosa which is evident from the height of mulberry throughout its growth (Table 77). Cowpea closely followed mimosa in enriching soil with NPK which provided a competition free environment for efficient absorption of nutrients by mulberry which might have resulted in higher SLW.

Harvest index improved under open conditions. Greater production of leaf dry matter under open condition might have contributed to higher harvest index. There was considerable improvement in root : shoot ratio when the crop was raised under shade. No adverse effect due to shade was observed on root development during the early phase of establishment which resulted in better root dry matter production when compared to leaf and stem.

5.3.4 Leaf yield and dry matter production

The influence of geometry of planting on leaf production was considerable and paired row planting increased leaf dry matter production (LDMP), total leaf dry matter production (TLDMP), stem dry matter production (SDMP), total stem dry matter production, root dry matter production (RDMP) and total dry matter production (TDMP). All the crop growth characters such as plant height, plant spread, leaf number and leaf area index were higher under paired row planting which might have ultimately resulted in higher yield.

The role of sunlight was evident on the productivity of mulberry and open conditions resulted in significantly higher FLP, LDMP, TLDMP, SDMP, TSDMP, RDMP and TDMP. Cultivation under open conditions enhanced leaf yield throughout the growth stages. Leaf area development, growth rate and yield vary directly with the amount of sunlight intercepted by the canopy. Light regulates plant growth and development via informational signals detected by phytochromes (Sanderson *et al.*, 1997). It is presumed that photosynthetic rate of mulberry leaf under shade was low when compared to the open. The greater availability of sunlight in the open has greatly enhanced vigorous growth and growth attributing factors resulting in the higher production of larger leaves. Low yield under higher levels of shade might be due to the reduction in the availability of photosynthetically active radiation. Light quality, duration of the light period and light intensity affect plant development and plant processes to varying degrees in different plants. The spectral composition is changed by cloudiness and foliage cover. Depending on their growth performance under light of varying intensities, plants are classified as heliophytes (sun loving) and sciophytes (shade loving) (Venkataraman and Krishnan, 1992). The present study reveals that mulberry is a heliophyte and availability of photosynthetically active radiation under shade is insufficient to meet the requirement of photosynthesis. Hence, dry matter production of mulberry which is directly related to photosynthesis is influenced by the intensity of shade.

Though intercropping systems with green manure failed to influence FLP, SDMP and RDMP at different stages the effect was pronounced in TFLP, TLDMP, and TDMP. In all these cases green manuring with cowpea, mimosa or calapagonium was favourable. Green manuring with cowpea and mimosa was found to influence leaf yield at two harvests. This was due to the suppression of weed growth thereby ensuring better growth and leaf production. Similar results have been reported by Tikadar (1992) and Mandal (1993). Moreover, green manures enriched the soil fertility by various ways (Table 76). Soil organic matter plays a key role in the maintenance of soil fertility and productivity. The effect of organic matter may be either direct or indirect. It directly acts as a source of plant nutrients and food for microbes and indirectly influences the physical and physicochemical properties. The water retention capacity of soil is more pronounced with high organic matter content (Das *et al.*, 1997).

Interaction effects also showed the significance of the treatment combination PGP x S0 in influencing TLDMP, TSDMP and TDMP and 72%, 39% and 52% increase of TLDMP, TSDMP and TDMP over PGN x S50 were observed.

The results of the present study indicate the need for modifying the planting geometry of mulberry from the normal rows to the paired rows for accommodating the most promising green manure crop, cowpea in between paired row interspaces under open condition.

5.3.5 Content and uptake of nutrients

A lower concentration of leaf nitrogen in high density planting might be due to severe competition for soil nitrogen consequent to a higher planting density. A higher TLDMP coupled with high concentration of leaf nitrogen had contributed to increased uptake of nitrogen.

Variation in phosphorus uptake was due to differences in TLDMP. Though planting geometry exerted no significant effect on leaf phosphorus content in five out of seven harvests, it influenced leaf phosphorus uptake through a proportionate increase in TLDMP. The situation was similar in intercropping systems as well. With respect to shade levels, though TLDMP was high, the effect of nutrient concentration was conspicuous in increasing phosphorus uptake under open conditions.

The probable reasons attributed in earlier sections hold good for variation in potassium uptake as well.

5.3.6 Leaf quality

Like quantity, the leaf quality is also equally important from the point of view of silkworm rearing. Leaf produced must be acceptable and palatable to the silkworm apart from its nutrient contents. The important quality parameters are leaf moisture content, leaf moisture retention capacity and leaf protein.

Leaf moisture content was found to be significantly influenced by the geometry of planting and paired row planting recorded the maximum content. This is mainly because of the more availability of soil moisture in the paired row interspaces which resulted in more absorption. Similar results have been reported by earlier workers. While working on relative water loss between crop rows, Larson and Wills (1957) found that soil moisture increased from with in the row to the middle point between the rows. This was more pronounced in the wider rows and apparently reflects decreasing root activity as the distance from the row increases. At times of moisture stress, root elongates and extract water from the wide paired row interspaces. Eventhough, the situation is similar in high density planting, due to higher plant population, the stored soil moisture was insufficient to meet the evapotranspiration requirement of mulberry. The two shade levels adversely affected the moisture content. The possible reasons already explained under NAR, RGR and CGR hold good for the present situation.

The content of leaf protein was influenced by the geometry of planting. Paired row planting resulted in maximum leaf protein which is a function of nitrogen content of leaves. Dry matter production and nutrient addition of intercropped green manure were maximum in this treatment. This might have contributed to prolonged availability of nutrients for improving the quality of mulberry leaf.

When compared to the control all the green manure crops helped to increase the leaf protein content of mulberry probably due to nitrogen contribution by green manure and its absorption by mulberry. Though consistent effects of interactions were not observed, the combination PGP x S0 x GMV registered an increase in leaf protein content when compared to PGN x S50 x GM0.

The result indicates the adaptability of cowpea for *in situ* green manuring in paired row interspaces of mulberry under open conditions.

Paired row planting and cultivation under conditions improved leaf consumption, larval weight, cocoon weight, shell weight, filament length, filament weight and denier. Maximum values were recorded for the above characters when mulberry was raised under open conditions. Better larval characters, cocoon characters and post cocoon parameters were observed because in these treatments the leaf quality was excellent as evident from Tables 92 to 98. The Tables reveal that leaf moisture content and leaf protein, the two important parameters affecting leaf quality were highest in these treatments. Improvement in the quality of mulberry leaf consequent to adoption of better moriculture techniques might have resulted in improved larval characters, cocoon characters and post cocoon parameters.

Available nutrient status of soil was not at all influenced by planting geometry and shade levels. However, available nitrogen, phosphorus and potassium contents of the soil were found to be affected by green manure crops and mimosa on par with cowpea and calapagonium on par with cowpea, mimosa and desmodium influenced the available nitrogen and potassium contents of soil respectively. Mimosa contributed maximum dry matter closely followed by cowpea, calapagonium and desmodium. Addition of green manure crops might have changed the nutrient status of soil.

5.3.7 Economic analysis and sustainable yield index

Planting geometry, shade levels and green manure crops influenced the economic criteria and paired row system of planting, cultivation under open conditions and intercropping with green manure crops especially cowpea, mimosa and calapagonium gave maximum gross income, net income and benefit cost ratio. The interaction effect of planting geometry and shade was significant and the combination PGP x S0 resulted in maximum returns. Gross income, net income and benefit cost ratio are influenced by fresh leaf production since there is not much variation in the cost of production of the leaf. The higher leaf production in the above treatments have contributed to higher gross income, net income and benefit cost ratio. The treatment combination involving paired row planting, cultivation under open condition and intercropping with green manure mimosa resulted in achieving the highest minimum guaranteed yield of 40% of the maximum observed yield. Sustainability pathway to mulberry introduction in the predominant cropping systems of humid tropics is given in Fig.51.

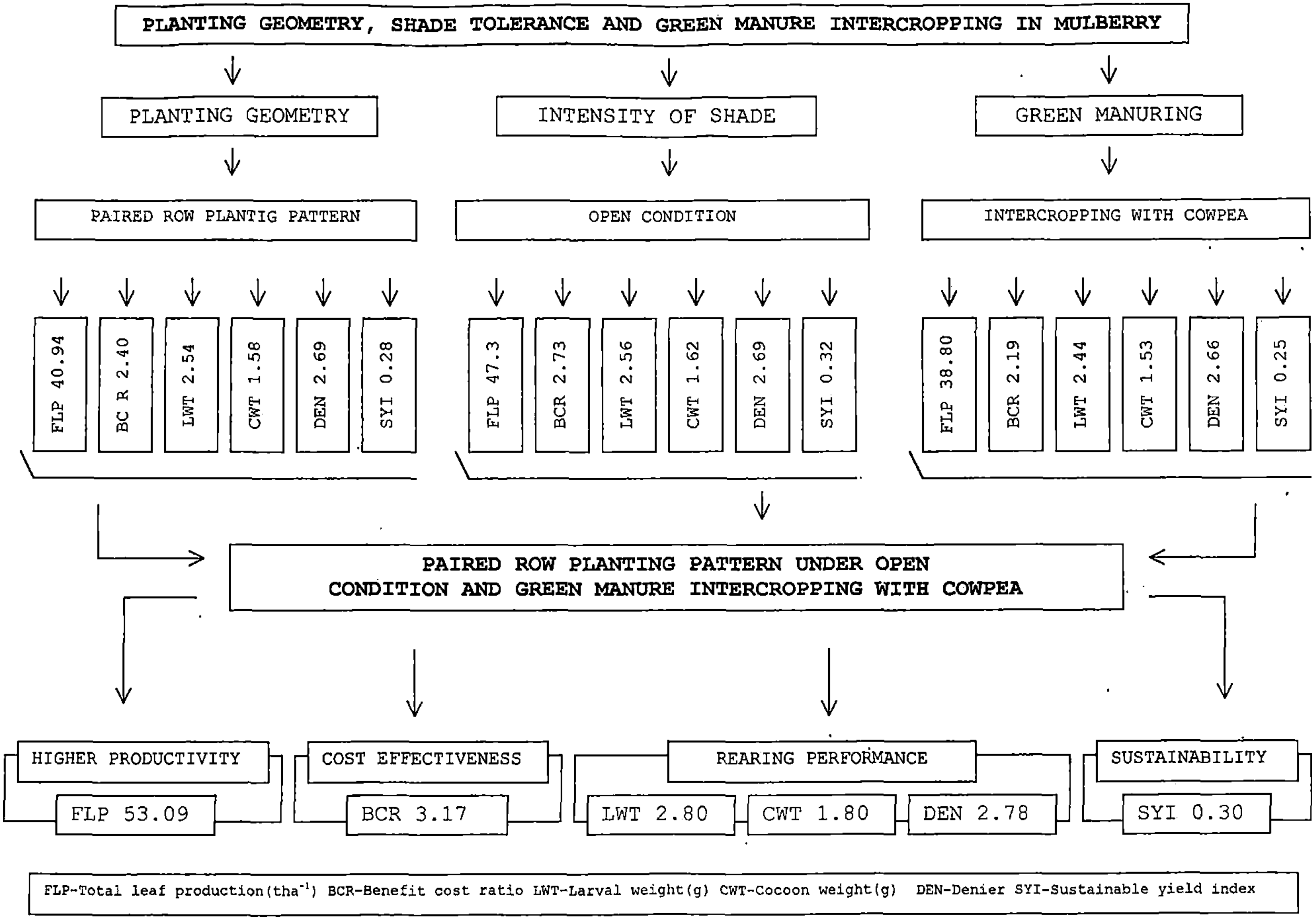

Fig51 Sustainability pathway to mulberry introduction in the predominant cropping systems of humid tropics

5.4 GENERAL DISCUSSION

Sericulture is an important agro-based industry in India which provides employment and source of livelihood to approximately six million people. In addition to economic considerations, sericulture has a social relevance, because, it is practised in large numbers by the poorer sections of rural community. Improvement of sericulture, therefore, fits well into the national objective of providing gainful employment and reducing disparities between different sections of our society.

A dominant part of sericulture in India is based on mulberry. As the single source of food for the silkworm, mulberry leaf sets the scale for silk production. Through breeding and evolution of relevant package of production and protection technologies, the productivity of mulberry has registered a commendable increase in the recent years. The increased yield potential has been dramatic in irrigated areas but relatively less obvious and less uniform in rainfed areas. Also, the conscious target has been quantitative improvement in yield. For sustained, stable and progressive improvement in Indian sericulture, more attention will have to be paid to both quantitative and qualitative increase in mulberry leaf productivity. To achieve this objective a series of experiments involving various production factors under a project entitled `Sustainable technology for higher productivity in mulberry sericulture` were carried out at the College of Horticulture, Vellanikkara.

Selection of site for mulberry cultivation assumes importance in the present day context of raising population pressure on land and intensive integrated farming systems. As the available space is already under other remunerative crops, the scope for extending mulberry cultivation to open areas is limited under tropical environment. Eventhough, the present study reveals that the performance of mulberry is superior under open conditions, it can be cultivated under 25 per cent shade by adopting appropriate production technologies. In a state like Kerala, where coconut based cropping system is predominant, mulberry can be successfully cultivated as an intercrop in adult coconut plantations for augmenting income from coconut stands. Studies conducted at the Central Plantation Crops Research Institute, Kerala revealed that light availability in the interspaces of old coconut palms was above 80% (Thampan, 1982). This indicates the amenability of adult coconut palms for mulberry intercropping.

High yield performance under low input systems has been the main concern of agricultural research. The same holds good for mulberry cultivation. There is a need for fertilizer responsive mulberry varieties suited for different agroclimatic regions of the country. Sericultural zones need to be identified depending upon various factors prevailing in the respective areas for evolving and identifying promising varieties. In this study it is revealed that the variety S-54 is high yielding compared to the local variety K-2 under irrigated condition in tropical areas.

Planting geometry influences mulberry leaf production considerably. Maximum conservation and optimum utilization of natural resources and monetary inputs can be achieved through modifying the planting geometry. Modification of the planting pattern to paired rows keeping the plant population constant had resulted in 13% increase in leaf yield compared to the normal rows. Efficient utilization of solar radiation besides rain water conservation and its optimum utilization had contributed to the better performance of the paired row system in the present context.

Leguminous green manure crops improve soil fertility in various ways. As the scope for green leaf manuring is limited due to want of land area attempts were made to develop sustainable technologies for *in situ* green manuring. *In situ* cultivation and incorporation or *in situ* cultivation and composting of cowpea in mulberry garden was found worth popularising and it increased leaf yield by 45% and 50%, respectively over no green manuring.

Biomass accumulation and nutrient addition of four green manure crops, viz, cowpea, mimosa, desmodium and calapagonium in association with mulberry were tested and its effect on the performance of mulberry was studied. It is proved that intercropping mulberry with cowpea during south west monsoon is ideal for improving the productivity of mulberry besides maintaining soil health.

In recent years, biofertilizers have emerged as a supplement to mineral fertilizers and hold a promise to improve the yield of crops. Out of many microorganisms which are developed as biofertilizers Azospirillum, VA mycorrhizae and PSB have a significant role in mulberry nutrition. In the present study, combined application of Azospirillum, VA mycorrhizae and PSB was found to improve the performance of mulberry by 85% compared to no inoculation of biofertilizers.

Mulberry responds very well to nutrient application. Nutritional disorders are common in mulberry because being a perennial it occupies the same impoverished soil year after year. Frequent harvests of mulberry leaf result in depletion of soil fertility at a faster rate. It is observed that under good management condition NPK application @ 225:90:90 kg ha^{-1} year^{-1} which is 25% less than that of the present recommended dose registers similar fresh leaf production as that of the higher dose.

Mulberry is considered as a hardy, drought resistant plant and is cultivated without meeting even its minimum requirement. Continued survival and production of small leaves by local mulberry under drought conditions is mistaken leading to the strong belief that `mulberry is a hardy plant'. Mulberry leaf production is often limited by the amount of available soil moisture and it can be substantially increased by supplemental irrigation. The results obtained show that irrigating mulberry at a CPE of 30 or 45 mm was ideal in increasing the production of quality leaves to the tune of 84 and 81% respectively, over rainfed condition under tropical situation.

Irrigation interval can be extended by reducing soil evaporation. The study clearly showed that mulching mulberry plants with coconut husk followed by earthing up was beneficial in conservation and efficient utilization of soil moisture. Utilization of coconut husk improved crop water use efficiency and field water use efficiency besides bringing substantial improvement in leaf production to the extent of 24% over no conservation treatment.

It is realised that the mulberry growth, leaf yield, leaf quality, rhizosphere microflora, soil moisture status etc., are significantly influenced by genotypes, planting geometry, shade levels, green manuring, inorganic fertilization, biofertilizer inoculation, irrigation based on CPE and soil moisture conservation techniques.

The positive and significant interaction effect of many of the above factors were expressed by several treatment combinations. The results of the present study indicate the need for modifying the planting pattern of mulberry from the normal rows to the paired rows for accommodating the most promising green manure crop, cowpea in between paired row interspaces under open condition. The importance of integrating different nutrient sources for increasing the leaf production of mulberry and sustaining soil fertility is well established in the study. Integrated nutrient management involving the application of NPK @ 225:90:90 kg ha^{1} year^{-1}, *in situ* cultivation and composting of cowpea and combined application of Azospirillum, VA mycorrhizae and PSB resulted in a greater leaf yield. Besides, this treatment combination was ideal for production of

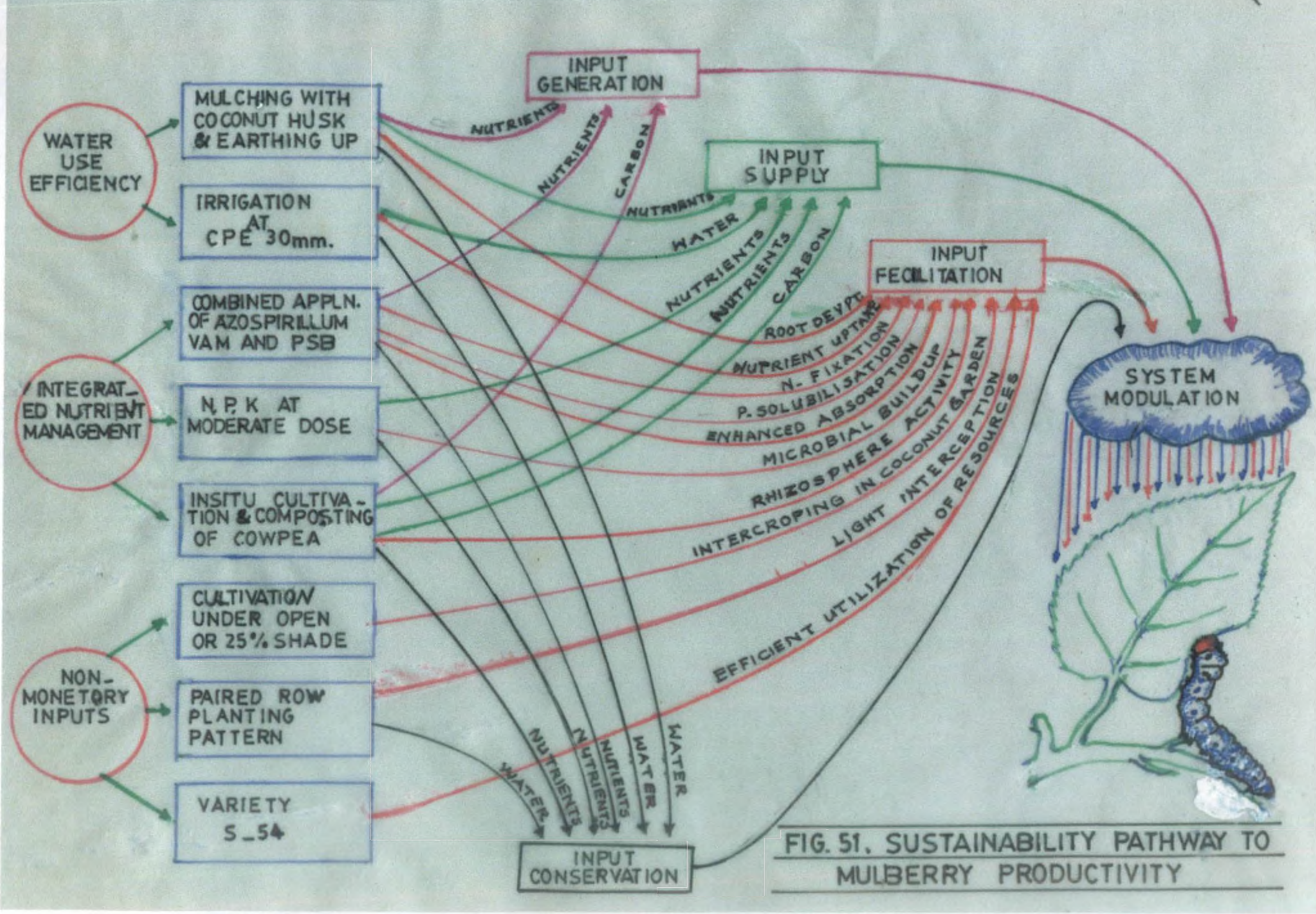

FIG. 51. SUSTAINABILITY PATHWAY TO MULBERRY PRODUCTIVITY

quality leaves for successful silkworm rearing. The sustainability of this treatment combination was also found to be more than 0.65 indicating the synergistic interaction among the components of the combination over time. The response of the variety S-54 was worth mentioning when it was given irrigation at CPE 30 mm and coconut husk used for soil moisture conservation.

Wide fluctuation in mulberry leaf and cocoon production are reported even today due to various reasons especially unscientific management of mulberry gardens. Being a perennial crop utmost care has to be exerted from the establishment of mulberry garden to sustain the sericulture units for a minimum period of 25 years. Appropriate technologies which are dependable and sustainable should be adopted. Sustainability is a concept which is considered as a skeleton around which the technology should be evolved to achieve higher production and productivity. Sustainable agriculture involves integrated nutrient management, integrated water management and other low cost techniques for efficient utilization of natural resources. It is also helpful for maintaining and enhancing the quality of the environment and conservation of natural resources. Such an approach is ideal under humid tropical conditions especially in Kerala where bimodel pattern of rainfall is prevalent and frequent occurrence of wet and dry spells are common. Several production factors tested in the different experiments have resulted in greater fresh leaf yield with higher sustainability index and can be adopted for sustainable mulberry production. The present project helped to identify some of the manipulable components of the production technology for achieving sustainability in mulberry leaf production. Bringing together all the component technologies to formulate an ideal mulberry management strategy for the humid tropics, cultivation of the variety S-54 in paired rows under open conditions or partial shade, adopting integrated nutrient management system involving *in situ* cultivation and composting of cowpea in the paired row interspaces, combined application of biofertilizers viz, Azospirillum, VA mycorrhizae and PSB and application of the moderate dose of NPK @ 225:90:90 kg ha^{-1} $year^{-1}$, and providing irrigation at CPE 30 or 45 mm followed by mulching with coconut husk around the mulberry basins for soil moisture conservation shall help to achieve higher production and productivity in mulberry both in terms of quantity and quality and also for successful silkworm rearing round the year.

Plate 17 A mulberry plant in fruiting phase

Plate 18 A mulberry twig in fruiting phase

Summary

6. SUMMARY

Three experiments were conducted under the research project entitled `Sustainable technology for higher productivity in mulberry sericulture' at the College of Horticulture, Vellanikkara during 1994-96. Development of an integrated nutrient management strategy and evolving technology to conserve soil moisture utilizing agricultural waste materials besides maintaining soil health were attempted.

Experiment I. Cost effectiveness in mulberry nutrition under irrigated condition

The experiment consisted of combinations of three levels NPK, ie, 150:60:60, 225:90:90 and 300:120:120 kg ha^{-1} year^{-1}, four green manuring methods, ie, *in situ* cultivation and incorporation of cowpea, *in situ* cultivation and composting of cowpea, green leaf manuring and no green manuring and five biofertilizer levels, ie, Azospirillum, VA mycorrhizae, PSB, combined application of Azospirillum, VA mycorrhizae and PSB and no biofertilizer.

1. Levels of inorganic fertilizers showed significant effect on plant height and application of NPK @ 300:120:120 kg ha^{-1} year^{-1} resulted in maximum plant height. Green manuring and biofertilizer treatments had no significant effect on plant height at any stage.
2. The significant influence of inorganic fertilizers, green manuring and biofertilizer application on LAI were observed throughout the period of growth. Application of NPK @ 225:90:90 kg ha^{-1} year^{-1} recorded maximum LAI in most of the stages. *In situ* cultivation and composting of cowpea was found favourable for enhancing LAI. Combined application of Azospirillum, VAM and PSB consistently maintained higher LAI.

3. Total shoot length was unaffected by levels of inorganic fertilizers. Neither the green manure nor the biofertilizer could make any significant impact on this character.
4. Application of NPK @ 300:120:120 kg ha^{-1} year^{-1} recorded the highest total leaf number. Neither total leaf number nor leaf number per plant was significantly affected by green manuring and biofertilizer treatments.
5. Application of NPK @ 225:90:90 kg ha^{-1} year^{-1}, *in situ* cultivation and composting of cowpea and combined application of Azospirillum, VAM and PSB resulted in TFLP of 25.5, 27.7 and 30.8 t ha^{-1} respectively. However, integrated nutrient management involving application of NPK @ 225:90:90 kg ha^{-1} year^{-1}, *in situ* cultivation and incorporation or composting of cowpea and combined application of Azospirillum, VAM and PSB resulted in a greater TFLP of 37.0 t ha^{-1}.
6. Significantly higher TLDMP was achieved at NPK application @ 225:90:90 kg ha^{-1} year^{-1}, *in situ* cultivation and composting of cowpea and combined application of Azospirillum, VAM and PSB. The combinations involving NPK @ 225:90:90 kg ha^{-1} year^{-1} x *in situ* cultivation and composting of cowpea, NPK @ 225:90:90 kg ha^{-1} year^{-1} x combined application of Azospirillum, VAM and PSB, and *in situ* cultivation and composting of cowpea x combined application of Azospirillum, VAM and PSB resulted in maximum TLDMP.
7. NPK application @ 300:120:120 kg ha^{-1} year^{-1}, *in situ* cultivation and composting of cowpea and combined application of Azospirillum, VAM and PSB were found favourable for maximising TSDMP.
8. At 24 MAP, RDMP was maximum when NPK was applied @ 225:90:90 kg ha^{-1} year^{-1}. Combined application of Azospirillum, VAM and PSB also resulted in higher RDMP at 24 MAP.

9. RGR was maximum with NPK @ 225:90:90 kg ha^{-1} year^{-1}, *in situ* cultivation and composting of cowpea, and combined application of Azospirillum, VAM and PSB.
10. NPK @ 300:120:120 kg ha^{-1} year^{-1} resulted in highest CGR. With respect to biofertilizers, combined application of Azospirillum, VAM and PSB which was on par with inoculation of VAM alone, produced maximum CGR.
11. In general, the main effects and interaction effects did not influence the leaf moisture content and its loss over time during 24 hour storage.
12. NPK @300:120:120 kg ha^{-1} year^{-1} and combined application of Azospirillum, VAM and PSB recorded the maximum leaf protein content.
13. Silkworm bioassay trial revealed the superiority of NPK application @ 300:120:120 kg ha^{-1} year^{-1}, *in situ* cultivation and incorporation or composting of cowpea and combined application of Azospirillum, VAM and PSB on improving leaf quality and consequent greater leaf consumption by silkworm larvae , cocoon weight, shell weight and filament length.
14. Application of NPK @ 300:120:120 kg ha^{-1} year^{-1}, *in situ* cultivation and incorporation or composting and combined application of Azospirillum, VAM and PSB or inoculation of VAM alone resulted in the highest uptake of nitrogen, phosphorus and potassium by the mulberry crop. Significant interaction effect was observed only with potassium uptake and was recorded by the treatment combination NPK @ 225:90:90 kg ha^{-1} year^{-1} x *in situ* cultivation and composting of cowpea x combined application of Azospirillum, VAM and PSB.
15. NPK @ 300:120:120 kg ha^{-1} year^{-1} and *in situ* cultivation and composting of cowpea were beneficial in enhancing the available nitrogen status of soil after the experiment. The available potassium content of soil was unaffected by the

treatments. Treatment with PSB resulted in higher available phosphorus content of soil after the experiment, however, it was on par with VAM and combined application of biofertilizers.

16. Though the levels of fertilizers did not influence per cent infection of VAM at 3 and 12 MAP, there was considerable improvement in infection per cent at 12 MAP.
17. VAM spore load in soil increased with increase in fertilizer levels and there was more than 9 per cent increase in spore load at 12 MAP when compared to 3 MAP irrespective of treatments.
18. Azospirillum count was significantly higher at moderate level of application of NPK @ 225:90:90 kg ha^{-1} $year^{-1}$. Azospirillum colonisation was increased by 21, 20 and 14 per cent under low, medium and higher doze of fertilizer application, respectively over a period of nine months spread between the first and last observations.
19. PSB population increased with increasing levels of fertilizers. After a period of nine months, ie, at 12 MAP 8, 13 and 10 per cent increase in PSB colonisation were observed at low, medium and high doze of fertilizers compared to 3 MAP.
20. VAM spore load at 3 MAP was influenced by green manuring. *In situ* cultivation and incorporation of cowpea resulted in maximum spore load. After a period of nine months, ie, at 12 MAP though not significant the increase in spore load in the above treatment was 6 per cent compared to 3 MAP.
21. Significantly higher population of Azospirillum was observed both at 3 and 12 MAP when *in situ* cultivation and composting of cowpea was practised and the increase in colonisation over a period of nine months ie, at 12 MAP was 21 per cent compared to 3 MAP.

22. Green manuring treatments had no significant effect on PSB colonisation.
23. With respect to VAM spore load and VAM infection, the two treatments, ie, combined application of Azospirillum, VAM and PSB and inoculation of VAM alone, were on par.
24. Combined application of Azospirillum, VAM and PSB recorded maximum colonisation of Azospirillum and the increase over a period of nine months at 12 MAP was 14 per cent compared to 3 MAP.
25. Eventhough, inoculation of PSB alone was very effective in enhancing the colonisation of PSB, combined application of Azospirillum, VAM and PSB was found favourable for the build up of PSB population over time.
26. The treatments, NPK application @ 225:90:90 kg ha^{-1} year^{-1}, *in situ* cultivation and composting of cowpea and combined application of Azospirillum, VAM and PSB were found to enhance gross income, net income and BC ratio.
27. The sustainability of the treatment combination involving NPK application @ 225:90:90 kg ha^{-1} year^{-1}, *in situ* cultivation and incorporation or composting of cowpea and combined application of Azospirillum, VAM and PSB, was established as indicated by a greater sustainable yield index of more than 0.65.

Experiment II. Utilization of agricultural byproducts for economising water use and improvement in leaf quality and productivity of mulberry

Response of two varieties of mulberry, ie, K-2 and S-54 to four irrigation levels ie, no irrigation, irrigation at CPE 15 mm, irrigation at CPE 30 mm and irrigation at CPE 45 mm and four soil moisture conservation techniques, ie, coir pith, coconut husk, silkworm litter and control were studied in this experiment. The results are summarised below.

1. The variety S-54, irrigation at CPE 30 mm and mulching with coconut husk were found to positively influence plant height. The interaction effect of the treatment combination, S-54 x irrigation at CPE 30 mm x mulching with coconut husk produced taller plants.
2. Plant spread was higher for the variety S-54. Irrigation irrespective of its frequency and mulching with coconut husk enhanced plant spread.
3. Higher LAI was observed for the variety S-54 throughout the period of growth. Mulching with coconut husk was beneficial in improving LAI.
4. Total shoot length was highest for the variety S-54. Irrigation at CPE 30 mm and mulching with coconut husk were also beneficial in increasing total shoot length. The treatment combination S-54 x irrigation at CPE 30 mm x mulching with coconut husk resulted in the highest total shoot length.
5. The variety S-54 recorded significantly higher leaf number and total leaf number over the variety K-2. Irrigation irrespective of its frequency and mulching with coconut husk improved the above characters. The treatment combination S-54 x irrigation at CPE 30 mm x mulching with coconut husk resulted in the maximum total leaf number.
6. The variety S-54, irrigation irrespective of its frequency and mulching with coconut husk were found superior in increasing fresh leaf production and total fresh leaf production. Significant improvement in total fresh leaf production was noticed in the treatment combinations S-54 x irrigation at CPE 30 or 45 mm x mulching with coconut husk.
7. LDMP, TLDMP, SDMP and RDMP were maximum with the variety S-54, irrigation at CPE 30 or 45 mm and soil moisture conservation utilising coconut

husk. The treatment combination S-54 x irrigation at CPE 30 mm x mulching with coconut husk produced maximum TLDMP.

8. RGR was significantly higher in S-54. In general, irrigation at CPE 30 mm and mulching with coconut husk resulted in higher RGR.
9. The variety S-54 showed higher CGR compared to K-2. Irrigation irrespective of its frequency and mulching with coconut husk were found superior in influencing CGR.
10. The variety K-2 recorded significantly higher root : shoot ratio over S-54. Cultivation under rainfed condition resulted in higher root : shoot ratio.
11. There was significant improvement in harvest index with the variety S-54, irrigation irrespective of frequency and mulching with coconut husk.
12. Leaf moisture content was maximum in S-54 variety. However, leaf moisture retention capacity during storage for a period of 24 hours was highest in K-2 variety.
13. Leaf protein content was higher in S-54. Irrigation irrespective of its frequency and mulching with coconut husk enhanced leaf protein content.
14. Seasonal consumptive use, daily consumptive use and crop coefficient were higher in the variety S-54. The above parameters were higher with irrigation at CPE 15 mm and mulching with coconut husk.
15. Maximum crop water use efficiency and field water use efficiency were observed for the variety S-54 when irrigation was given at CPE 45 mm. These characters were also highest when coconut husk was used for soil moisture conservation.
16. The variety K-2 extracted maximum quantity of water from 0-15 cm depth whereas S-54 from 15-30 cm depth. Frequency of irrigation influenced the soil moisture depletion pattern. Under moisture stressed situations the crop extracted maximum

amount of moisture from the deeper soil layers. Under irrigated condition maximum absorption was from 0-30 cm soil layer.

17. Silkworm feeding trial established the superiority of the variety S-54 over K-2 in terms of larval leaf consumption, larval weight, cocoon weight, shell weight, filament length and filament weight.
18. TNUP, TPUP and TKUP were maximum for the variety S-54 and soil moisture conservation using coconut husk followed by incorporation of silkworm litter. Both the conservation treatments were significantly superior to incorporation of coir pith and control. The treatment combination, S-54 x irrigation at CPE 30 mm x mulching with coconut husk gave maximum TNUP, TPUP and TKUP.
19. Available nutrient status of soil after the experiment were not at all influenced by the varieties and levels of irrigation. Coconut husk mulching enhanced the available soil nitrogen while coir pith increased available potassium content after the experiment.
20. The influence of the variety S-54, irrigation at CPE 30 or 45 mm and coconut husk mulching were found to increase gross income, net income and BC ratio significantly.
21. The highest minimum guaranteed yield in integrated water management involving the high yielding variety S-54, irrigation irrespective of its frequency and mulching with coconut husk was found to be more than 52 per cent of the maximum observed yield as indicated by the sustainable yield index of the combination.

row planting and high density planting, three levels of shade, ie, no shade, 25% shade and 50% shade and five intercropping systems with green manure crops, ie, cowpea, Mimosa, Desmodium, Calapagonium and subsequent slashing at 90 days after planting and no green manure crop were included in this experiment. The results are summarised below.

1. The planting geometry influenced plant height only during the early stages of crop growth. Paired row planting significantly increased plant height at 6 and 9 MAP. With increase in shade significant increase in plant height was observed.
2. Planting geometry and intercropping with green manure had no significant effect on plant spread. However, cultivation under open conditions enhanced plant spread compared to different shade levels.
3. Significantly higher LAI was observed due to paired row planting and cultivation under open conditions. Intercropping and subsequent green manuring had no significant effect on LAI.
4. Shoot length and total shoot length were significantly higher under paired row planting. Though cultivation under open condition enhanced shoot length and total shoot length, both these characters were unaffected by intercropping and subsequent green manuring.
5. Leaf number and total leaf number were significantly higher in paired row planting and cultivation under open condition.
6. Paired row planting, cultivation under open conditions and intercropping with green manure cowpea resulted in maximum FLP, TFLP and TLDMP.

7. Planting geometry and intercropping with green manure had no significant effect on NAR.
8. RGR and CGR were found to be favourably influenced by paired row planting and cultivation under open conditions.
9. Paired row planting and cultivation under open conditions recorded maximum leaf moisture content. However, leaf moisture retention during storage for 24 hour was not influenced by any of the treatments.
10. Improvement in leaf quality by way of increase in leaf protein content was observed under paired row system, cultivation under open condition and intercropping with green manure crops.
11. Silkworm rearing trial revealed the significant influence of planting geometry and shade levels on larval and cocoon characters and post cocoon parameters. Paired row planting and cultivation under open conditions resulted in the production of quality leaves which in turn improved all the characters studied.
12. Dry matter production of green manure crops and nutrient addition were found to be higher in paired row planting and cultivation under open conditions. Among the various intercrops tested mimosa produced maximum dry matter. NPK accumulation in mimosa was also found to be greater.
13. Paired row planting, cultivation under open conditions, and intercropping and subsequent green manuring resulted in maximum TNUP, TPUP and TKUP.
14. Planting geometry and shade levels exerted no significant influence on available nitrogen, phosphorus and potassium content of soil after the experiment. Intercropping with mimosa and cowpea and subsequent green manuring significantly increased the available nitrogen content of soil. Available phosphorus content of soil

after the experiment was not affected by intercropping with green manure crops. Intercropping with cowpea or Mimosa or Desmodium or Calapagonium was beneficial in improving the available potassium status of soil after the experiment.

15. Paired row planting, cultivation under open conditions and intercropping with cowpea or mimosa or calapagonium and subsequent green manuring increased gross income, net income and BC ratio.
16. The highest sustainable yield index was observed with paired row planting, cultivation under open conditions, and intercropping and subsequent green manuring with Mimosa.

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APPENDIX I

Weather parameters during 1994-95 and 1995-96

Months	Temperature °C		Mean relative humidity (per cent)	Total sunshine (h)	Total evaporation (mm)	Total rainfall (mm)	No. of rainy days
	Max.	Min.					
1994 Jun	28.9	22.9	90	63.9	84.2	955.1	27
1994 Jul	28.6	22.4	91	44.5	86.1	1002.1	29
1994 Aug	30.0	22.8	85	92.5	91.4	509.2	20
1994 Sep	31.8	23.2	78	217.7	113.9	240.5	8
1994 Oct	32.3	22.7	80	207.4	97.1	358.2	20
1994 Nov	31.8	23.3	68	242.5	137.9	125.3	5
1994 Dec	32.2	22.2	58	328.3	169.6	-	-
1995 Jan	32.9	22.4	59	298.4	178.5	-	-
1995 Feb	35.4	23.4	60	279.5	172.2	0.5	-
1995 Mar	37.6	23.8	60	289.5	190.2	2.8	-
1995 Apr	36.6	24.9	71	271.7	164.3	118.7	5
1995 May	33.5	23.9	78	201.9	129.3	370.5	13
1995 Jun	31.6	23.1	86	109.6	103.7	500.4	19
1995 Jul	29.9	23.2	89	65.6	88.5	884.7	26
1995 Aug	30.6	23.7	86	115.5	96.4	448.7	22
1995 Sep	30.1	23.5	82	184.4	97.7	282.5	13
1995 Oct	33.2	23.2	78	257.7	113.8	110.4	8
1995 Nov	31.3	22.5	80	196.7	89.1	88.4	5
1995 Dec	32.5	21.3	57	319.5	195.9	-	-
1996 Jan	33.1	22.4	53	292.7	208.6	-	-
1996 Feb	34.7	23.4	53	286.1	200.9	-	-
1996 Mar	36.4	24.3	60	281.3	219.2	-	-
1996 Apr	34.6	25.0	73	248.4	157.1	152.0	7
1996 May	32.8	25.2	77	240.1	135.0	95.6	4

SUSTAINABLE TECHNOLOGY FOR HIGHER PRODUCTIVITY IN MULBERRY SERICULTURE

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ABSTRACT OF A THESIS

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ABSTRACT

Cultivation of mulberry is a pre-requirement for silk industry. Being a perennial crop it will be well adapted to the West Coast. Formulation of sustainable production technology is a necessity for its popularisation.

Three experiments under the project `Sustainable technology for higher productivity in mulberry sericulture' were carried out at the College of Horticulture, Vellanikkara during 1994-96 to develop appropriate agro-techniques for mulberry cultivation under tropical condition. The first experiment consisted of combinations of three levels NPK, viz, 150:60:60, 225:90:90 and 300:120:120 kg ha^{-1} year^{-1}, four green manuring methods, viz, *in situ* cultivation and incorporation of cowpea, *in situ* cultivation and composting of cowpea, green leaf manuring and no green manuring and five biofertilizer treatments viz, Azospirillum, Vesicular Arbuscular Mycorrhizae (VAM), Phosphorus Solubilising Bacteria (PSB), combined application of Azospirillum, VAM and PSB and no biofertilizer. Response of two varieties of mulberry, viz, K-2 and S-54 to four irrigation levels ie, no irrigation, irrigation at CPE 15 mm, irrigation at CPE 30 mm and irrigation at CPE 45 mm and four soil moisture conservation techniques, ie, incorporation of coir pith, mulching with coconut husk, incorporation of silkworm litter and control were studied in the second experiment. In the third experiment, effect of combinations of three different planting geometry, ie, normal row planting, paired row planting and high density planting, three levels of shade, ie, no shade, 25% shade and 50% shade and five intercropping systems with green manure crops, viz, cowpea, mimosa, desmodium, calapagonium and no green manure crop were included. All the three experiments were laid out in split plot design.

Experiment I. Cost effectiveness in mulberry nutrition under irrigated condition

Integrated nutrient management involving the application of NPK @ 225:90:90 kg ha^{-1} $year^{-1}$, *in situ* cultivation and incorporation or composting of cowpea and combined application of Azospirillum, VAM and PSB was found to increase the total fresh leaf yield of mulberry. In the silkworm rearing trial, leaves from mulberry garden receiving NPK @ 300:120:120 kg ha^{-1} $year^{-1}$, *in situ* cultivation and incorporation or composting of cowpea and combined application of Azospirillum, VAM and PSB registered higher leaf consumption due to better leaf quality and consequently improved cocoon weight, shell weight and filament length. Though the level of fertilizers didn't influence the per cent infection of VAM, the spore load in soil was increased with increase in fertilizer levels. Moderate level of NPK viz, 225:90:90 kg ha^{-1} $year^{-1}$ recorded maximum colonisation of Azospirillum. PSB population increased with increasing levels of fertilizers. *In situ* cultivation and composting of cowpea and combined application of Azospirillum, VAM and PSB showed maximum colonisation of Azospirillum and PSB. The economic analysis of the system revealed the significance of NPK application @ 225:90:90 kg ha^{-1} $year^{-1}$, *in situ* cultivation and composting of cowpea and combined application of Azospirillum, VAM and PSB in terms of gross income, net income, benefit : cost ratio (BCR) and sustainable yield index (SYI).

Experiment II Utilization of agricultural byproducts for economising water use and improvement in leaf quality and productivity of mulberry

The combination of the variety S-54, irrigation at CPE 30 mm and mulching with coconut husk resulted in significantly higher total fresh leaf production. Leaf quality parameters such as leaf moisture and leaf protein contents were higher in the variety S-54, however, the moisture retention during 24 hour storage was more with the variety

K-2. Irrigation and mulching with coconut husk resulted in increased leaf protein content. Seasonal and daily consumptive use, and crop coefficient were higher in S-54, and increased with irrigation at CPE 15 mm and mulching with coconut husk. The variety S-54 irrigated at CPE 30 mm resulted in maximum crop water use efficiency. However, field water use efficiency was highest with respect to S-54 with irrigation at CPE 45 mm and mulching with coconut husk. The silkworm rearing trial revealed the superiority of the variety S-54 with respect to leaf consumption, larval weight, cocoon weight, shell weight, filament length and filament weight. The economic analysis of the system proved the significance of the variety S-54, irrigation at CPE 30 or 45 mm and mulching with coconut husk in relation to gross income, net income, BCR and SYI.

Experiment III. Shade tolerance and *in situ* development of green manure sources in mulberry

Paired row planting, cultivation under open conditions and intercropping with green manure cowpea resulted in maximum fresh leaf production at all harvests. Paired row planting and cultivation under open conditions resulted in the production of quality leaves with respect to leaf moisture and protein content which in turn improved the larval and cocoon characters and post cocoon parameters. Intercropping with green manure Mimosa improved the available nitrogen content of soil after the experiment. Intercropping with green manures, viz, cowpea, Mimosa, Desmodium or Calapagonium were beneficial in increasing the available potassium content of soil. The economic analysis of the system revealed the superior performance of paired row planting, cultivation under open conditions and intercropping with cowpea and subsequent green manuring in relation to gross income, net income and BCR. The combination paired row planting, cultivation under open conditions and intercropping with green manure Mimosa resulted in the highest SYI.