STUDIES ON ORGANIC FARMING IN MAIZE-SUNFLOWER-GREENGRAM CROPPING SYSTEM

By

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CERTIFICATE

Mr.K.TEJESWARA RAO has satisfactorily prosecuted the course of research and that the thesis entitled **"STUDIES ON ORGANIC FARMING IN MAIZE-SUNFLOWER-GREENGRAM CROPPING SYSTEM"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

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This is to certify that the thesis entitled **"STUDIES ON ORGANIC FARMING IN MAIZE-SUNFLOWER-GREENGRAM CROPPING SYSTEM"** submitted in partial fulfilment of the requirements for the award of degree of **DOCTOR OF PHILOSOPHY (Agriculture) in Agronomy** to the Acharya N.G.Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Mr.K.TEJESWARA RAO** under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted by the student for the award of any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

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DECLARATION

I, **Mr.K.TEJESWARA RAO** here by declare that the thesis entitled **"STUDIES ON ORGANIC FARMING IN MAIZE-SUNFLOWER-GREENGRAM CROPPING SYSTEM"** submitted to Acharya N.G.Ranga Agricultural University, Hyderabad for the award of degree of **DOCTOR OF PHILOSOPHY (Agriculture) in Agronomy** is the result of original research work done by me. It is further declared that the material contained in this thesis or any part thereof has not been published earlier elsewhere in any manner.

Date: 01/07/06

K.TEJESWARA RAO

ABSTRACT

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Title of the Thesis	**STUDIES ON ORGANIC FARMING IN MAIZE - SUNFLOWER - GREENGRAM CROPPING SYSTEM**
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Investigations entitled **"Studies on Organic Farming in Maize - Sunflower - Greengram Cropping System"** were carried out for two consecutive years (2003-04 and 2004-05) at S.V. Agricultural College Farm (ANGRAU), Tirupati (Southern Agro-Climatic Zone of Andhra Pradesh). In these investigations, maize was grown during late *kharif* season and sunflower during late *rabi*. Greengram was raised as residual crop during summer. The experiment was laid out in a randomized block design, replicated thrice and the same layout was followed during both the years of study. There were fourteen treatments comprising of six different sources of nitrogen *viz*., farm yard manure, vermicompost, neem leaf, poultry manure, pig manure and fertilizer to supply recommended dose of nitrogen on equal nitrogen basis and one treatment of no manuring through any source. All the seven treatments were tried with or without the foliar application of *panchagavya,* thus making the total treatments to fourteen. The treatments were imposed to maize and sunflower crops, while their residual effect was studied on succeeding greengram crop without imposing any treatments. The test cultivars of maize, sunflower and greengram were DHM-103, MSFH-17 and LGG-460, respectively.

Various parameters of the three crops in the cropping system and the system as a whole was influenced differently by varied manurial practices tried. However, during both the years of investigation, the trend was largely similar between the two years, with respect to all the parameters of each of the three crops studied.

All the growth and yield attributes, yield (grain as well as stover) harvest index, nitrogen uptake and the grain quality parameters (protein content, starch content and amino acid content) and gross returns as well as net returns of maize were at their best with recommended dose of fertilizer either with or without *panchagavya* spray. However, all the above mentioned parameters were significantly higher with the application of farm yard manure or pig manure or vermicompost in combination with foliar application of *panchagavya* than with any other organic manurial practices tried.

The highest phosphorus uptake of maize was recorded with poultry manure, while the potassium uptake was the highest with vermicompost. Irrespective of the source of nutrient supply, application of *panchagavya* did not exert any measurable effect on the nutrient uptake of maize. Among the organic sources, the highest net returns of maize were realized with farm yard manure in combination with *panchagavya*. The highest benefit-cost ratio was recorded with poultry manure in combination with *panchagavya* spray, which was however, comparable with poultry manure alone or farm yard manure along with *panchagavya* spray.

All the growth and yield attributes, yield, nutrient uptake, harvest index, grain quality parameters and economic returns of maize were at their lowest with non-manuring through any source, which were statistically similar to those with foliar application of *panchagavya* alone.

All the growth and yield attributes, yield (seed as well as stalk) harvest index, nitrogen uptake and gross returns as well as net returns of sunflower were at their best with recommended dose of fertilizer either with or without *panchagavya* spray. However, all the above mentioned parameters were significantly higher with the application of any of the five organic manures in combination with foliar application of *panchagavya* than with the use of respective organic manures alone without the use of *panchagavya*. The highest oil content of the seed was recorded with neem leaf manure in combination with *panchagavya*, which was however, comparable with all the other four organic sources tried in combination with *panchagavya*, but significantly higher than with the fertilizer either with or without the use of *panchagavya*.

The highest phosphorus uptake of sunflower was recorded with poultry manure either with or without the spray of *panchagavya*, while the potassium uptake was the highest with vermicompost either with or without the spray of *panchagavya*. Irrespective of the source of nutrient supply, foliar application of *panchagavya* resulted in higher nutrient uptake of sunflower than with the use of respective organic manures alone without the use of *panchagavya*. Among the organic sources tried, the highest net returns and benefit-cost ratio of sunflower were realized with poultry manure in combination with *panchagavya*.

All the growth and yield attributes, yield, nutrient uptake, harvest index, oil content of the seed and economic returns of sunflower were at their lowest with non-manuring through any source, which were statistically similar to those with foliar application of *panchagavya* alone.

All the growth and yield attributes, yield (seed as well as haulm), harvest index, gross returns, net returns and benefit-cost ratio of green gram were at their best with the residual effect of poultry manure either with or without the use of *panchagavya*. Nitrogen uptake by greengram crop and protein content of seed was significantly higher with the residual effect of various organic sources either with or without the use of *panchagavya* than with fertilizer either with or without the use of *panchagavya*.

The highest phosphorus uptake of greengram was recorded with the residual effect of poultry manure either with or without the spray of *panchagavya*, while the potassium uptake was the highest with vermicompost either with or without the spray of *panchagavya*. The uptake of phosphorus and potassium by greengram crop was significantly higher with the residual effect of various organic sources either with or without the use of *panchagavya* than with fertilizer either with or without the use of *panchagavya*. Gross returns, net returns and benefit-cost ratio of greengram were significantly lesser with the residual effect of fertilizer than with any of the organic sources tried.

All the growth and yield attributes, yield, nutrient uptake, harvest index, protein content of the seed and economic returns of greengram were at their lowest with the residual effect of non-manuring through any source to either maize or sunflower, which were statistically similar to those with foliar application of *panchagavya* alone to the preceding two crops.

The highest biomass production and economic yield (maize grain equivalent yield) by the cropping system was produced with recommended dose of fertilizer in combination with spray *panchagavya* applied to maize and sunflower. However, the economic yield (maize grain equivalent yield) realized from the cropping system with recommended dose of fertilizer in combination with spray *panchagavya* was statistically similar to that with the application of pig manure in combination with spray *panchagavya* applied to maize and sunflower, which was closely followed by poultry manure or farm yard manure or vermicompost in combination with *panchagavya*.

The highest gross and net returns from the cropping system were realized with recommended dose of fertilizer in combination with *panchagavya* applied to maize and sunflower. However, gross returns from the cropping system realized with recommended dose of fertilizer in combination with spray *panchagavya* were comparable with those with the application of pig manure in combination with spray *panchagavya* applied to maize and sunflower, closely followed by poultry manure or farm yard manure or vermicompost in combination with *panchagavya*. The net returns from the cropping system realized with recommended dose of fertilizer in combination with spray *panchagavya* were statistically similar to those with the application of poultry manure in combination with spray *panchagavya* applied to maize and sunflower. The highest benefit-cost ratio of the cropping system was recorded with the application of poultry manure in combination with spray *panchagavya* applied to maize and sunflower.

Performance of the cropping system in terms of productivity and economic returns was obviously the poorest with non-manuring through any source to any of the crops in the cropping system, which was statistically similar to that with foliar application of *panchagavya* alone to maize and sunflower.

Regarding the dynamics of various soil fertility parameters *viz*., soil organic carbon, available nitrogen, available phosphorus and available potassium, all of them were found built up to a considerable extent with the use of organic manures to maize and sunflower, while the application of fertilizer to maize and sunflower could just maintain the soil fertility status with neither considerable replenishment nor deterioration. Soil organic carbon and available nitrogen were replenished more with neem leaf manure, poultry manure and vermicompost. The build up of soil available phosphorus with varied manurial practices was in the descending order of poultry manure, fertilizer, pig manure, neem leaf manure, vermicompost and farm yard manure. The build up of soil available potassium status with varied manurial practices was in the descending order of vermicompost, pig manure and neem leaf manure. Foliar application of *panchagavya* along with any of the organic sources to maize and sunflower crops did not exert any measurable positive influence on any of the four soil fertility parameters compared to the application of respective organic sources without the combination of *panchagavya* spray.

As regards the balance sheet of soil available N, P and K, the highest positive balance of soil available nitrogen was found associated with neem leaf manure, and that of phosphorus was associated with poultry manure while that of potassium was with vermicompost. However, all the organic manures could result in higher balance than with application of fertilizer to maize and sunflower crops. Irrespective of the manurial sources, use of *panchagavya* did not exert any noticeable effect on fertility enrichment of the soil.

In conclusion, it can be inferred from the investigation that maize crop can be sustained with farm yard manure or pig manure or vermicompost along with foliar application of *panchagavya*. Sunflower crop can be sustained with neem leaf manure or poultry manure along with foliar spray of *panchagavya* as pure organic additives, as they performed nearly equal with that of recommended dose of fertilizers. In case of residual effect of organic manures on greengram, poultry manure performed better over others. Considering the cropping system as a whole, maize- sunflower - greengram cropping system can be sustained with organic manures along with combination of *panchagavya* not only in terms of productivity and economic returns, but also in terms of sustaining the soil fertility status at fairly high level. Supply of N through exclusive organic sources could nearly meet the crop demand for nutrients and performed equally with that of recommended dose of fertilizer. Foliar application of *panchagavya* seems to be promising in improving the productivity and quality of maize and sunflower crops.

Introduction

CHAPTER - I

INTRODUCTION

The green revolution technologies involving greater use of synthetic agrochemicals such as fertilizers and pesticides with nutrient-responsive, high yielding varieties of crops have boosted up the output in most of the cases. In the process of attaining higher levels of agricultural productivity to match the demands of burgeoning population, we have inadvertently ignored the detrimental effect to the natural resource base and environment.

Further, it is not certain whether we could meet the challenge of feeding the people to the desired extent with the right quality of safe food, with the present version of farm technologies. Food security in terms of production totals is meaningless if the agricultural resource base that produces the gains itself is threatened. There are several reasons for decreasing trend in productivity, the major being the drastic decline in soil nutrients, particularly in areas where fertilizers are being used in increasing quantities year after year, without adequate supplementation of organic matter.

The gravity of environmental degradation has drawn the attention of the scientists and planners towards finding out ecologically sound, viable and sustainable farm technologies, keeping in view of the needs of the future generations.

Most of the Indian soils contain less than 0.5 per cent organic carbon. Unless it is raised to 0.9 – 1 per cent level, productivity of the soil can not be optimized (Veeresh, 2002). In view of the resurgence of interest in alternative agriculture in recent years, organic farming has been considered to be sound and viable option in most of the countries.

Organic farming is not a new concept to Indian farmers, because they have practiced it since times immemorial. Organic farming system relies on crop rotations, crop residues, animal manures, legumes, green manures, off-farm wastes and biological pest control.

Complete organic farming movement is a challenge to the scientists, which needs to be looked into more critically, seeking answers to a few pertinent questions. An eternal question debated at several platforms is, whether agriculture using organic sources of nutrients alone could keep pace with the increase in production to feed the huge population. Proper nutrient management is likely to play a dominant role in enhancing crop productivity and sustaining the food production of an organic cropping system if planned and implemented prudently.

Yields in organic farming are lower than chemical farming during initial years of practice and it takes a few years to stabilize the yields. However, in the long run, if properly followed, yields with organic farming would be far greater than those obtained with chemical farming. Another big question that is often being posed by the detractors of organic farming is, whether the available organic sources of nutrients are sufficient for pure organic farming. The answer is being debated. Huge quantities of organic materials such as farm yard manure, poultry manure, pig manure, vermicompost, green manures, and crop residues can substitute the inorganic fertilizers to a large extent to maintain productivity and environmental quality (Chaudhary, 2002).

Extensive studies carried out in India showed that there is much to be learnt by the agricultural scientists from the traditional wisdom and Indigenous Technical Knowledge (ITK) of Indian farmers. Though it is believed to be region specific, it can be extrapolated to similar agro-climatic conditions, because most of the indigenous agricultural technologies have got scientific rationale (Sabarathnam, 1997). Now the need has come to re-examine and then gradually re-introduce the effective traditional methods of plant nutrition using organic sources.

As a salvation, our Indian knowledge system is a treasure trove of information and *panchagavya* has been one such piece of traditional wisdom. It is meant to safeguard plants and soil micro - organisms and its successful usage in promoting the vigour and health of the crops on which it has been used as foliar spray was known since the time of VEDAS. It contains plant growth stimulants which can enhance the biological efficiency of crops and the quality of the produce (Pathak and Ram, 2002).

Scientific studies are limited to disclose the productivity levels, their stability and profitability that can be achieved through pure organic sources of nutrient supply in comparison with inorganic sources. It is very much essential to develop strong, viable and compatible packages of nutrient management through organic sources for various crops and cropping systems to suit the local conditions.

Among various cropping systems evaluated under irrigated upland conditions in the Southern Zone of Andhra Pradesh, maize based cropping system recorded the higher productivity potential (RARS, 2002). Among various maize based cropping systems, maize – sunflower – green gram was reported to be the most potential cropping system to suit the climatic conditions and to fetch remunerative economic returns to the farmers.

Information on the response of crops in maize – sunflower – greengram cropping system to the use of various organic sources along with the foliar nutrition of *panchagavya* and the extent of yield discount when compared to purely chemical nutrition is not available. In light of the above, investigations were taken up for two consecutive years, with the following objectives.

- To study the response of maize and sunflower to different organic manures.

- To investigate the influence of *Panchagavya* on the productivity and quality of maize and sunflower.

- To trace out the carry over effect of organic manures applied to maize and sunflower on the succeeding greengram.

- To assess the performance of the cropping system as a whole with different organic manures and *Panchagavya*.

- To work out the dynamics of soil fertility in the cropping system.

- To suggest the best organic manurial practice for the cropping system, based on productivity, economic viability and sustenance of soil fertility.

Review of Literature

CHAPTER - II

REVIEW OF LITERATURE

Green revolution technology helped India to tide over the food needs, but at the same time overexploited all the natural resources and thereby now we are in the phase of bearing the ill effects of soil, water and climatic problems. Recently, the agricultural research is focused on conserving ecology with more emphasis on use of organics. A large number of natural, ecofriendly indigenous technologies were evolved by the farmers since ancient times, but they were overlooked in favour of exploitive farming with fertilizer responsive modern genotypes of crops. However, for long term sustainability, the refinement of the Indigenous Technical Knowledge and use of organics appears to be inevitable. The available literature from the recent investigations (since a lot of old literature is available on the use of organics) pertaining to the present study is reviewed and presented in this chapter.

2.1 MAIZE-BASED CROPPING SYSTEMS

Crop intensification is the only way to achieve the target of 250 million tonnes of food grains by 2010 AD (Gangwar and Sharma, 1994). The net cropped area became stagnant and the only option is to increase the number of crops in an year, in order to ensure food security (Kanwar, 1997). Efficient utilization of native inputs could be possible through cropping system approach (Sankaran *et al.*, 2002).

Maize - sunflower - greengram system was one of the best suitable to the agro-climatic conditions and socio-economic needs of Southern Agroclimatic Zone of Andhra Pradesh (RARS, 2002).

Somasundaram (2003) reported that maize based cropping systems were found more profitable than others under I.D conditions of Tamil Nadu. He also found overall improvement in soil physical, chemical and biological properties with maize - sunflower - greengram cropping system.

In Andhra Pradesh, the importance of maize has increased in recent times, due to its requirement to poultry farming and maize was found best fitted in the irrigated dry cropping systems, with high realizable yield potential (Ramana Reddy and Sreenivasa Raju, 2005).

2.2 PERFORMANCE OF MAIZE WITH ORGANIC MANURES

Application of biogas slurry (BGS) improved the growth and yield of maize. The nutrients in BGS were more readily available than those in FYM and also resulted in residual effect (Lampkin, 1990).

The response of maize to BGS was more spectacular than with other sources tried (Pawar *et al.,* 1991).

Gorodonii *et al.,* (1994) reported increased yield of maize with the application of vermicompost.

Kamalakumari and Singaram (1996) found that application of FYM (10 t ha^{-1}) along with recommended dose of NPK fertilizers to maize has significantly increased the growth parameters, yield attributes and yield along with the nutrient uptake.

The direct effect of FYM to maize resulted in improvement in plant height and dry matter accumulation over residual effect of FYM (Rameshwar and Singh 1998).

Maize crop succeeding green manures showed higher N accumulation in the grain (Carvalki *et al.,* 1999).

Application of graded levels of poultry manure along with different levels of fertilizers significantly increased the grain yield and protein content of maize (Dosani *et al.,* 1999).

Integrated use of manures like FYM, vermicompost and neem leaf manure improved the growth, yield and nutrient uptake of maize (Gopal Reddy and Suryanaryana Reddy, 2000).

Partial green manuring with greengram to the subsequent maize crop improved the production and increased organic carbon and organic matter content of the soil (Dash *et al.,* 2000).

The improvement in crop yield of maize with different organics was in the order of vermicompost, poultry manure, BGS, FYM and recommended NPK (Gopal Reddy and Suryanarayan Reddy, 2000).

Marinari *et al.* (2000) reported that vermicompost application to maize crop not only increased seed yield but also improved the soil physical and biological characteristics.

Grain and stover yield of maize were significantly higher with green manuring followed by poultry manure, among various organic sources tried like vermicompost, poultry manure, FYM and green manure (Itnal and Palled, 2001).

The full rate of inorganic fertilizer alone could not produce the optimum yields of sweet corn (Maynard, 2002).

High yield of maize depended on soil fertility management, particularly N (Parthipan and Premasekhar, 2002).

Application of zinc enriched poultry manure enhanced the yield of maize (Latha *et al.,* 2002).

Application of organic P enriched FYM and vermicompost increased the grain yield of maize (Kumaresan *et al.,* 2002).

Poultry waste composts application increased the dry matter production, LAI and grain yield of maize on the sandy loam soils of Bangalore (Abdul Kadir Iman *et al.,* 2002).

2.3 PERFORMANCE OF SUNFLOWER WITH ORGANIC MANURES

Ramamurthy and Shivasankar (1995) reported that application of FYM significantly improved the seed yield of sunflower.

Sharnappa and Shivaraja (1997) reported that incorporation of green manure improved the productivity of sunflower. The biomass yield and seed yield of sunflower was highest with green manuring.

Application of poultry manure @ 1.5 kg m^{-2} improved the yield and quality of sunflower (Lam *et al.,* 1997).

Singhshaktawat and Bansal (1999) observed that application of bio gas slurry @ 16 t ha^{-1} resulted in 53.6 per cent higher seed yield of *rabi* sunflower over control.

Devi Dayal *et al.* (1999) reported that yield of sunflower was substantially improved by the combined application of 5 t ha^{-1} vermicompost or 10 t ha^{-1} farm yard manure along with 80 : 40 kg N : P_2O_5 ha^{-1} when compared to their individual application.

Application of vermicompost @ 2 t ha^{-1} as band placement in seed rows recorded significantly higher seed yield of sunflower compared to FYM and no manure. Vermicompost was more efficient in increasing the seed yield of sunflower compared to the farm yard manure (Chinnamuthu and Venkatakrishnan, 2001).

The percent increase in yield of sunflower due to green manuring ranged from 5.9 to 50.2 (Bahl and Pasricha, 2001).

Leguminous green manures sown between rows of sunflower and chopped and incorporated before flowering resulted in highest dry matter production and increased seed yield up to 225 per cent (Laureti and Pieri, 2001).

Application of zinc enriched poultry manure improved the growth parameters, yield attributes and yield of sunflower (Latha *et al.,* 2002).

Organic phosphorus enriched vermicompost and FYM increased the sunflower seed yield and improved the soil nutrient status (Kumaresan *et al.,* 2002).

Latha *et al.* (2002) reported that application of organic manures significantly enhanced the seed yield of sunflower compared to nutrient supply through mineral fertilizer. They have also noticed that among organic manures, poultry manure was most effective.

Incorporation of *in-situ* or *ex-situ* green manures resulted in enhanced seed yield and oil content of sunflower (Franki *et al.,* 2004).

2.4 LEGUMES IN THE EXHAUSTIVE CROPPING SYSTEMS

In a cropping system, organic matter maintenance is important because it is the key property that decides the availability of nutrients. Nearly or almost 95 per cent of nitrogen and sulphur and 80 per cent of the soil phosphorus reside in organic matter and organic matter on decomposition releases almost all micronutrients (Stevenson, 1982).

According to Gaudencio *et al.* (1998) average seed yields of summer grown pulse crops were significantly increased by inclusion of sunflower and maize in the rotation and also stability of soil aggregates increased in sunflower - maize - soybean crop sequence.

With greengram as succeeding crop followed by supplementation with organic manures would benefit the subsequent maize crop much with a large production and increased organic carbon and organic matter content of the soil (Dash *et al.,* 2000).

In livestock less farms, a good previous crop like greengram or use of nitrogen fixing crops in the rotation was important (Berland *et al.,* 2000).

A rotation including legumes is better for intensive cereal production (Grignani *et al.,* 2001).

Most concentration should be given to organic matter management in the cropping system by the inclusion of legumes, green manures and other organic manures, which would curtail the use of fertilizers and chemicals (Murugappan *et al.,* 2001).

2.5 INFLUENCE OF FOLIAR APPLICATION OF *PANCHAGAVYA* ON CROPS

Panchagavya had its origin in the scripts of VEDAS and *Vrukshayurveda*, according to which the cosmic energy, when made to pass through a living system, it removes the imbalances in the basic elements and which revitalize the growth processes (Natarajan, 2002).

Panchagavya was known to contain plant growth stimulants which can enhance the biological efficiency of crops and the quality of the produce (Pathak and Ram, 2002).

Cow dung is rich in nitrogen, phosphorus, potassium, sulphur, micronutrients, bacteria, fungi and other microbial organisms. It is known for its properties against diseases (Nene, 1999).

Purushothama Rao (1993) reported that cow's urine after 5 times dilution with water and foliar sprayed on paddy, 3 times at fortnightly intervals from 20 DAT, performed as both growth stimulant and insect repellant.

Cow's urine is rich in urea, acts as nutritional supplement as well as hormone. It also contains uric acid, NaCl, sulphates of Ca and Mg, and Lippuric acid (Singh, 1996 and Reddy, 1998).

Cow's milk contain protein, fat, carbohydrates, amino acids, calcium, hydrogen, lactic acid and *Lactobacillus bacterium* and a good medium for saprophytic bacteria and acts as virus inhibitor (Nene, 1999).

Cow's ghee has been used since ancient times and it was used for managing seedling health. It contains vitamin A, B, C, fat, glycosides and other nutrients (Nene, 1999).

Cow's curd is rich in microbes (Manilal Chandha, 1996).

Sugarcane juice which is used as additive in *panchagavya* attracts microbes and helps in easy fermentation (Nene, 1999).

Coconut water contains kinetin, which increases the chlorophyll content of crops (Thangaraj and Sivasubramanian, 1992).

Increased chlorophyll content of soybean with application of coconut water was due to increased cytokinin content, which in turn increased the photosynthetic activity for longer period (Kalarani and Jeya Kumar, 1998).

Two per cent *Panchagavya* spray was found effective in enhancing the growth and yield of rice and advanced the harvest by 10 days. (Vivekanandan, 1999).

Panchagavya sprayed on chillies crop produced dark green colour foliage and new growth within 10 days (Subhashini Sridhar *et al.,* 2001).

Three per cent *panchagvava* spray improved the performance of greengram (Somasundaram *et al.,* 2003).

Somasundaram (2003) from Tamil Nadu reported the beneficial effect of *panchagavya* on all the crops included in the cropping system. In maize - sunflower - greengram cropping system, the spraying of *panchagavya* @ 3 per cent four times at 15, 30, 45 and 60 DAS resulted in enhancement of almost all growth and yield attributes, yield and quality of the produce.

Foliar spray of *panchagavya* @ 3 per cent on 15, 25, 40 and 50 DAS on greengram improved the grain yield (Somasundaram, 2003).

Combination of vermicompost application and foliar spray of *panchagavya* has resulted in the highest yield of french bean, which was 36 per cent higher than the recommended fertilizer schedule (Selvaraj, 2003).

2.6 NUTRIENT UPTAKE BY CROPS WITH ORGANIC MANURING

Addition of organic sources of nutrients improved the nutrient uptake and as a result had positive influence on crop yields (Raju *et al.,* 1991).

Bhiday (1994) reported that the usage of vermicompost as an integral part of organic farming improved the nutrient uptake of major and micronutrients by maize and sunflower.

Application of 10 t ha^{-1} of FYM improved the N, P and K uptake of maize and sunflower in the crop sequence of soybean - maize - sunflower (Ramamurthy and Shivashankar, 1995).

Sharanappa and Shivaraj (1997) reported that incorporation of green manure improved the uptake of N, P and K by maize and sunflower.

Application of poultry manure @ 15 t ha^{-1} improved the uptake of N, P, K, Ca, Mg, S and micronutrients by maize and sunflower (Lam *et al.,* 1997).

The uptake N, P and K of maize was found increased significantly with increased application of poultry manure (Dosani *et al.*, 1999).

2.7 QUALITY OF CROPS AS INFLUENCED BY ORGANIC MANURING AND *PANCHAGAVYA* SPRAY

In annual moringa, the quality parameters *viz.,* crude fibre, protein, ascorbic acid, carotene content and shelf life were higher under organic manuring in combination with *panchagavya* spray (Beaulah *et al.,* 2002).

Fodder quality of cowpea was improved by the application of organic P enriched FYM and vermicompost to maize - sunflower - fodder cowpea cropping system on sandy clay loam soils of Tamil Nadu (Kumaresan *et al.,* 2002).

Somasundaram (2003) reported that the application of organic manures like BGC, green manuring with *Sesbania* along with *panchagavya* spray improved the quality parameters like crude protein content and starch content of maize, oil content of sunflower and protein content of greengram. The cooking quality of maize and greengram were also found improved by using organic source of nutrients along with *panchgavya* spray.

2.8 SOIL FERTILITY STATUS UNDER THE INFLUENCE OF ORGANIC MANURING

Enhanced availability of most of the micronutrients including Zn, Fe, Mn and Cu due to green manuring was reported by Takkar and Nayyar (1986).

Lakhdive (1994) reported that organic manures like BGS improved the organic carbon content in soil where sunflower was grown.

Yadvinder Singh *et al.* (1994) found that the green manuring improved the soil organic carbon content by 20 per cent over control.

The available N, P, K, Fe, Cu, Mn and Zn in soil were significantly influenced by the application of organics like FYM, vermicompost, poultry manure and biogas slurry at the end of two cropping cycles in maize - soybean cropping system (Gopal Reddy and Suryanarayana Reddy, 2000).

Nutrient availability in the native soil was found to be the highest with vermicompost, closely followed by poultry manure, BGS and FYM in maize - soybean cropping system (Shepherd *et al.,* 2000).

Ray and Gupta (2001) reported that incorporation of green manure in rice improved the soil aggregation and there by decreased the bulk density and increased the saturated hydraulic conductivity, saturation percentage and soil strength and also suggested that the cropping system include exhaustive crops like maize required special management practices like green manuring for improving soil fertility.

Application of organics, inclusion of green manure and legumes in the cropping system had improved the fertility status of the soil, which also reflected on the growth and yield of second year cropping cycle (Ramesh, 2002).

2.9 ECONOMICS OF ORGANIC FARMING

Studies from western countries showed that net returns on investment were higher with the usage of organics, because they were available locally and when environmental costs were taken into account, the organic alternatives were clearly superior (Dahama, 1996).

The total income from organic farming was lower than inorganic farming in the initial years of cultivation, but the net profit was higher because of the use of low cost inputs, the cost of cultivation was lowered, which in turn resulted in higher net profit (Sundararaman *et al.,* 2001).

The highest benefit-cost ratio was recorded with foliar application of *panchagavya* along with basal application of poultry manure and neem cake with and without fertilizers in both main and ratoon crops of annual moringa (Beaulah, 2001).

The investment: income ratio was comparable between chemical and organic farming (Somasundaram, 2002).

Parrot and Marsdon (2002) reported that in many case studies the organic and agro-ecological approaches are presently being proven successful in meeting a range of diverse objectives, improving yields, farmer's income and soil health status and reversing established patterns of land degradation.

Natarajan (2002) opined that by reducing costly chemical inputs, *panchagavya* ensured economic gain to farmers.

Somasundaram *et al.* (2003) reported that additional revenue and higher B:C ratio were realized with foliar application of *panchagavya* to greengram.

Over viewing the literature presented in this chapter, it is quite meager, but the available quantum indicated that there is possibility to introduce organic sources of nutrients and *panchagavya* to substitute the chemical fertilizers, without a large sacrifice in the crop yields. Organic sources were found to exhibit marked influence on the growth parameters, yield attributes, yield and nutrient uptake of crops. Use of organic sources of nutrients not only helps to maintain optimum crop yields with remunerative economic returns, but also results in sustainable soil productivity on long term basis.

Materials and Methods

CHAPTER - III

MATERIALS AND METHODS

Field experiments were conducted at the wetland farm of Tirupati campus (S.V.Agricultural College) of Acharya N.G. Ranga Agricultural University, Andhra Pradesh for two years from August 2003 to May 2005, with a view to study the prospects of organic farming practices for sustainable productivity of maize - sunflower - greengram cropping system. The details of the materials used and the methods employed during the course of investigation are described in this chapter.

3.1 FIELD LOCATION

The experiments were carried out in the wetland farm of S.V. Agricultural College, Tirupati (ANGRAU), which is geographically situated at 13.5°N latitude, 79.5°E longitude and at an altitude of 182.9 m above the mean sea level in the Southern Agro Climatic Zone (Zone III) of Andhra Pradesh.

3.2 WEATHER DURING THE CROP PERIOD

The data of the weather that prevailed during the cropping period of two annual cycles (2003-2004 and 2004-2005) of the cropping system is presented in Appendix A and B and depicted in Fig. 3.1a, 3.1b, 3.2a and 3.2b.

3.2.1 Cropping Cycle, 2003-04

During the cropping period of first year annual cycle (25.08.2003 to 27.05.2004), a total amount of 662.6 mm rainfall was received in 49 rainy days as against the decennial mean of 925.2 mm received in 49 rainy days for the corresponding period.

The weekly mean maximum temperature during the cropping period of the system ranged from 28.0°C to 43.0°C, with an average of 35.4°C. The decennial mean maximum temperature for the corresponding period was 34.2°C. The weekly mean minimum temperature during the cropping period of the system ranged from 16.7 to 29.4°C, with an average of 23.8°C. The decennial mean temperature for the corresponding period was 22.1°C.

The weekly mean relative humidity during the cropping period of the system ranged from 42.5 to 85.5 per cent, with an average of 62.9 per cent. The decennial mean relative humidity for the corresponding period ranged from 45.6 to 74.8 per cent, with an average of 60.4 per cent.

The weekly mean bright sunshine hours day^{-1} during the cropping period of the system ranged from 1.4 to 10.9, with an average of 7.4 hours day^{-1}. The decennial average for the corresponding period ranged from 4.1 to 10.0 with an average of 7.5 hours day^{-1}.

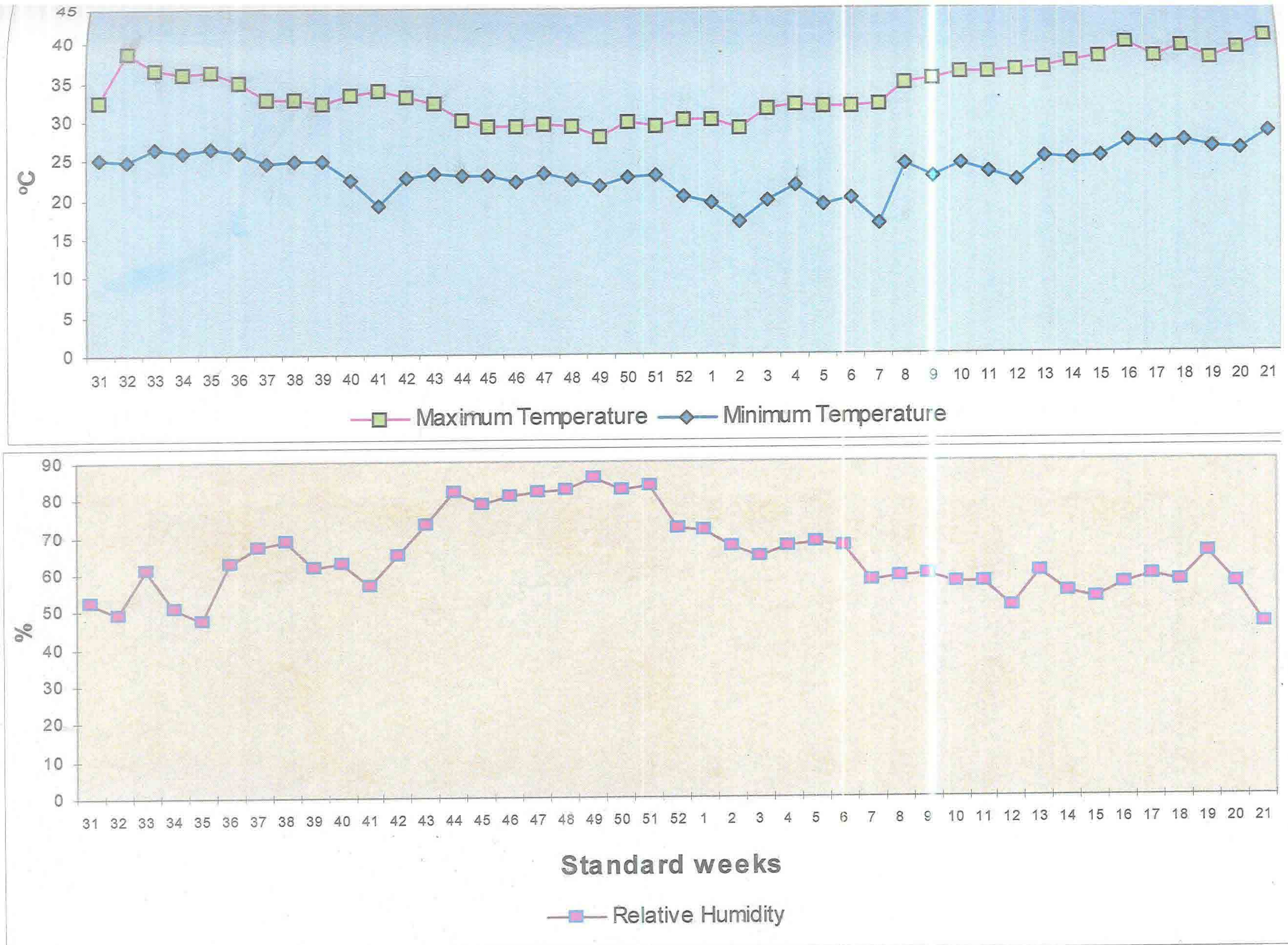


Fig 3.1a: Weekly meteorological data during the crop period (First Year Cropping Cycle, 2003-2004)

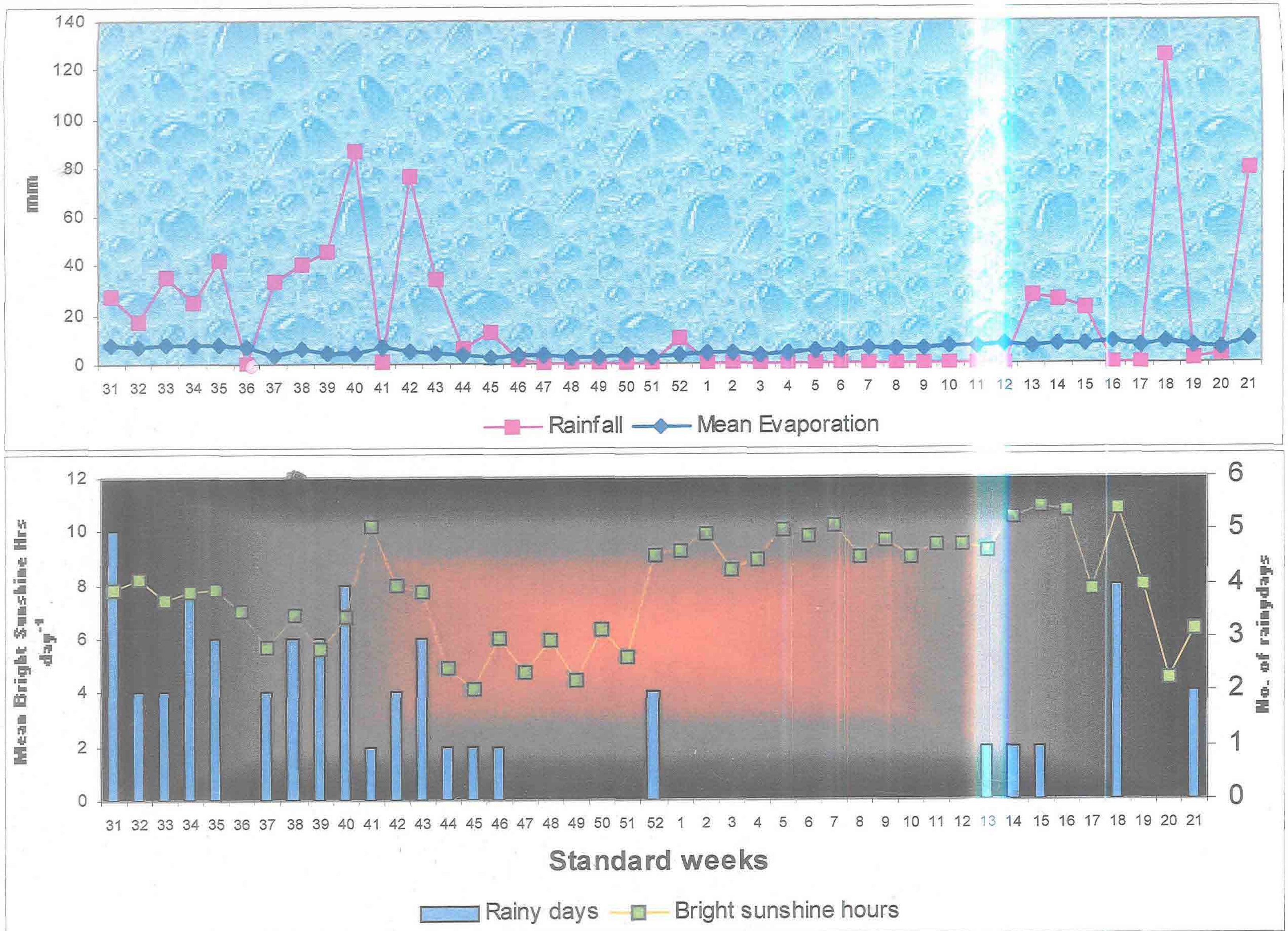


Fig 3.1b: Weekly meteorological data during the crop period (First Year Cropping Cycle, 2003-2004)

During the cropping period of the system, the evaporation (USWB class A open pan evaporimeter) ranged from 2.5 to 10.9 mm day^{-1}, with an average of 5.9 mm day^{-1}. The decennial mean for the corresponding period ranged from 3.5 to 9.2 mm day^{-1}, with an average of 6.1 mm day^{-1}.

3.2.2 Cropping Cycle, 2004-2005

During the cropping period of second year annual cycle (22.08.2004 to 27.05.2005), a total amount of 801.9 mm rainfall was received in 51 rainy days as against the decennial mean of 992.7 mm received in 49 rainy days for the corresponding period.

The weekly mean maximum temperature during the cropping period of the system ranged from 26.4 to 40.6°, with an average of 33.0°C. The decennial mean maximum temperature for the corresponding period was 33.7°C. The weekly mean minimum temperature during the cropping period of the system ranged from 13.8 to 27.4°C, with an average of 22.2°C. The decennial mean temperature for the corresponding period was 22.1°C.

The weekly mean relative humidity during the cropping period of the system ranged from 36.5 to 88.0 per cent, with an average of 62.0 per cent and the decennial mean relative humidity for the corresponding period ranged from 46.9 to 76.1 per cent, with an average of 60.3 per cent.

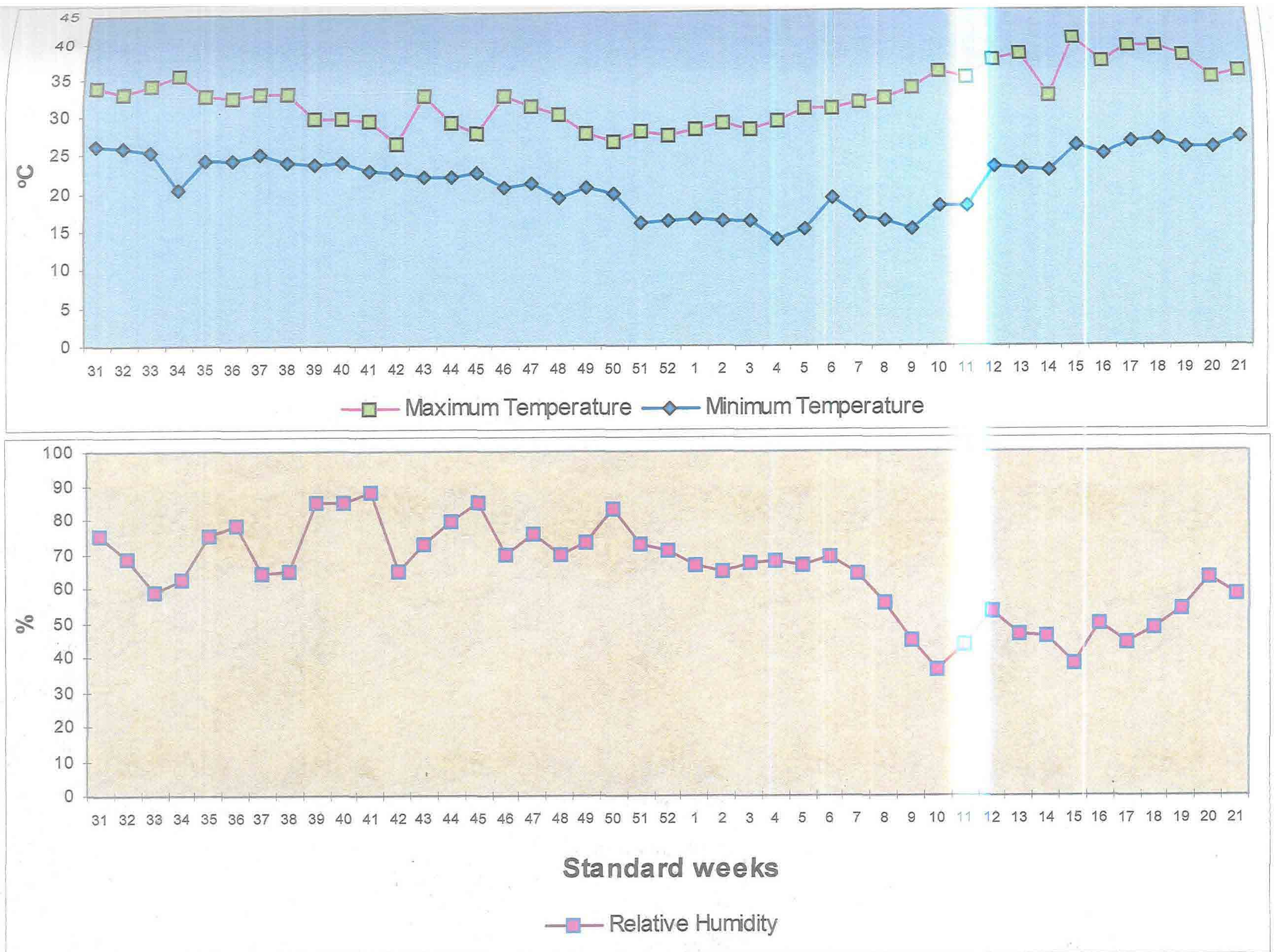


Fig 3.2a: Weekly meteorological data during the crop period (Second Year Cropping Cycle, 2004-2005)

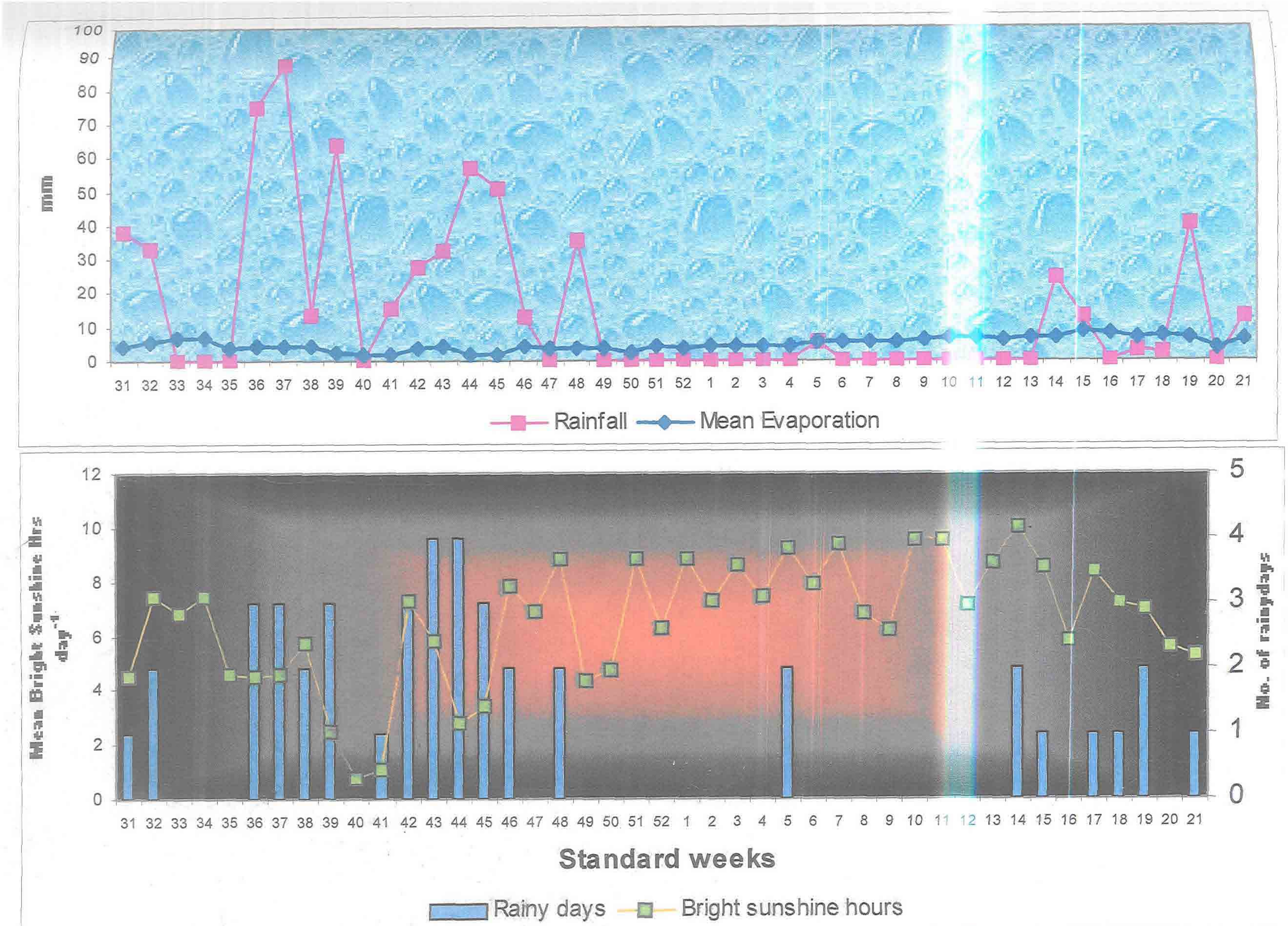


Fig 3.2b: Weekly meteorological data during the crop period (Second Year Cropping Cycle, 2004-2005)

The weekly mean bright sunshine hours day^{-1} during the cropping period of the system ranged from 0.8 to 10.0, with an average of 6.3 hours day^{-1}. The decennial average for the corresponding period ranged from 4.1 to 9.9, with an average of 7.4 hours day^{-1}.

During the cropping period of the system, evaporation (USWB class A open pan evaporimeter) ranged from 1.6 to 9.4 mm day^{-1}, with an average of 5.2 mm day^{-1}. The decennial mean evaporation for the corresponding period ranged from 3.6 to 8.9 mm day^{-1}, with an average of 6.0 mm day^{-1}.

3.3 SOIL CHARACTERISTICS

The study during both the years (2003-2004 and 2004-2005) was conducted on the same field (F.No. 50 of wetland farm). A composite soil sample was drawn from 0-30 cm depth of the experimental field initially and analyzed for physico - chemical properties. The results of physico-chemical analysis (Table 3.1) revealed that the soil was sandy loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen and medium in available phosphorus and available potassium. Soil samples were drawn plot wise, immediately after harvest of each of the crop to assess soil fertility dynamics.

Table 3.1: Physico - chemical soil characteristics of the experimental field

S.No.	Particulars	Value (0-30 cm depth)	Method
I.	**Mechanical analysis**		
	Coarse Sand (%)	37.2	International Pipette method (Piper, 1950)
	Fine sand (%)	44.1	
	Silt (%)	5.2	
	Clay (%)	13.5	
	Texture	Sandy clay loam	
II.	**Chemical analysis**		
	Organic carbon (%)	0.23	Rapid titration method (Walkley and Black, 1934)
	Available nitrogen (kg ha^{-1})	135.6	Alkaline permanganate method (Subbiah and Asija, 1956)
	Available P_2O_5 (kg ha^{-1})	17.63	Olsen's method (Olsen *et al.*, 1954)
	Available K_2O (kg ha^{-1})	176.5	Flame photometry (Jackson, 1973)
	pH (1:2.5 soil water suspension)	7.8	Glass electrode pH meter (Jackson, 1973)
	EC (dS m^{-1})	0.24	Conductivity bridge (Jackson, 1973)

3.4 CROPPING HISTORY OF EXPERIMENTAL FIELD

Cropping history of the experimental field during preceding three years of present investigations is furnished below.

Year	*Kharif*	*Rabi*	Summer
2000-01	Redgram	-	Fallow
2001-02	Redgram	-	Fallow
2002-03	Redgram	-	Fallow
2003-04	Maize	Sunflower	Greengram
2004-05	Maize	Sunflower	Greengram

3.5 EXPERIMENTAL DETAILS

The investigations were carried out in the same undisturbed layout during both the years. The experimental field was prepared with necessary primary and secondary tillage operations to bring the soil to required level of tilth and levelled uniformly. After drawing soil samples(for analysing the pre-experimental soil parameters) at random from different spots of the field, the plots were formed according to layout plan. Microlevelling was done in individual plots. The layout so formed was kept undisturbed through out the course of two-year study. Land preparation before sowing of each of the crops was done with in the plots with power tiller and spade digging.

3.5.1 Design and Layout

The experiment was laid out in randomized block design with three replications. The layout plan of the study is depicted in Fig. 3.3

3.5.2 Treatments

There were fourteen treatments comprising of different manurial practices in combination with or without foliar application of *panchagavya*.

T_1 No manure

T_2 No manure + *Panchagavya* spray

T_3 100% recommended dose of fertilizer

T_4 100% recommended dose of fertilizer + *Panchagavya* spray

T_5 Farm Yard Manure

T_6 Farm Yard Manure + *Panchagavya* spray

T_7 Vermicompost

T_8 Vermicompost + *Panchagavya* spray

T_9 Greenmanure *ex-situ* (Neem leaf)

T_{10} Greenmanure *ex-situ* (Neem leaf) + *Panchagavya* spray

T_{11} Poultry manure

T_{12} Poultry manure + *Panchagavya* spray

T_{13} Pig manure

T_{14} Pig manure + *Panchagavya* spray

N

Fig.3.3 Layout* plan of the experimental field

R_{III}		R_{II}		R_I
T_{14}		T_{11}		T_{14}
T_1		T_{13}		T_6
T_3		T_2		T_8
T_{11}		T_7		T_5
T_9		T_1		T_{11}
T_4		T_6		T_{13}
T_{10}	Irrigation channel	T_9	Irrigation channel	T_2
T_8		T_4		T_7
T_6		T_{10}		T_3
T_{12}		T_8		T_9
T_7		T_2		T_4
T_5		T_{14}		T_1
T_2		T_3		T_{10}
T_{13}		T_5		T_{12}

***The layout was undisturbed through out the period of study**
Crops: Maize (Late *kharif*) - Sunflower (Late *rabi*) – Greengram (Summer)
Design : RBD Replications : Three
Gross plot : 9.0 x 4.5 m
Net plot :
Maize : 8.2 x 3.0 m Sunflower : 7.8 x 2.7 m Greengram: 8.6 x 3.3 m
Treatments:

T_1	No manure
T_2	No manure + *panchagavya* spray
T_3	100% recommended dose of fertilizer
T_4	100% recommended dose of fertilizer + *panchagavya* spray
T_5	Farm Yard Manure
T_6	Farm Yard Manure + *panchagavya* spray
T_7	Vermicompost
T_8	Vermicompost + *panchagavya* spray
T_9	Green manure *ex-situ* (Neem leaf)
T_{10}	Green manure *ex-situ* (Neem leaf) + *panchagavya* spray
T_{11}	Poultry manure
T_{12}	Poultry manure + *panchagavya* spray
T_{13}	Pig manure
T_{14}	Pig manure + *panchagavya* spray

3.6 CROP VARIETIES

3.6.1 Maize (Late *kharif*)

The test variety of maize was DHM-103. It is a double cross hybrid consisting of four inbred lines (CM-120 x CM-118) (CM-119 x CM-208). The hybrid was developed and released by maize research station (ANGRAU), Amberpet, Hyderabad. This hybrid matures in 100 to 115 days and suitable both for rainfed and irrigated situations during *kharif* and *rabi* seasons. Stalks are tall with good stover yield. It is fairly resistant to leaf blight, leaf spot and stalk rot. This hybrid has yield potential of 6 t ha^{-1} under good management.

3.6.2 Sunflower (Late *rabi*)

The test variety of sunflower was MSFH-17. It grows to a height of 120-150 cm with broad and serrated leaves. The head diameter ranges from 15-20 cm with uniform maturity with 90-95 days duration. It has an yield potential of 2.0 to 3.0 t ha^{-1}. The oil content of seed ranges from 32-37 per cent.

3.6.3 Greengram (Summer)

The test variety of greengram was LGG-460, which was released from RARS, Lam (ANGRAU), Guntur, Andhra Pradesh. It is suitable for *kharif, rabi* and summer, with growth duration of 60-65 days and has an yield potential of 14-16 q ha^{-1}. It is resistant to yellow mosaic virus.

3.7 CULTIVATION DETAILS AND CROP MANAGEMENT

3.7.1 Field Preparation

The experimental field was ploughed with tractor drawn cultivator and rotavator in order to obtain fine tilth and to make the field free from clods. After levelling, plots and channels were formed and necessary micro leveling was done in each of the plots and sowing of first crop of the study was taken up. Land preparation within the plots was done by power tiller and spade digging for sowing subsequent crops.

3.7.2 Plot size and spacing

Details of gross and net plot size and spacing adopted for the three test crops are furnished below.

Particulars	Maize	Sunflower	Greengram
Gross plot size	9.0 x 4.5 m	9.0 x 4.5 m	9.0 x 4.5 m
Net plot size	8.2 x 3.0 m	7.8 x 2.7 m	8.6 x 3.3 m
Spacing	75 x 20 cm	45 x 30 cm	30 x 10 cm

3.7.3 Seeds and Sowing

Healthy, well-filled and mature seeds of all the three test crops were sown in their respective seasons @ two seeds hill^{-1}. After 15 DAS, thinning was done retaining one healthy seedling hill^{-1}.

3.7.4 Manures and Fertilizers

All the manures and fertilizers as per treatments were given to only maize and sunflower crops and greengram crop was raised as a residual crop, without any manures or fertilizers.

3.7.4.1 Fertilizers

The recommended dose of fertilizers was applied to T_3 and T_4 treatmental plots for maize (120-26-33 Kg N-P-K ha^{-1}) and sunflower (80-22-25 Kg N-P-K ha^{-1}) crops. Entire quantity of P_2O_5 and K_2O was applied as a basal dose. For maize, nitrogen was applied in three equal spits i.e. one third as basal, one third at knee high stage and the remaining one third at tasseling stage. For sunflower, nitrogen was applied in three equal spits i.e. one third as basal, one third at 30 DAS and the remaining one third at 45 DAS. The sources of N, P and K were urea, single super phosphate and muriate of potash, respectively. The fertilizers were applied by placement at 5 cm away and 5 cm below the seed rows.

3.7.4.2 Manures

Five organic manures on equal nitrogen basis were applied to respective treatments. All the organic manures were added to the soil and thoroughly incorporated, 10 days prior to sowing of crops. The details of organics used are detailed below. Nutrient content and quantities of different organic manures required to supply nitrogen on equal nutrient basis to respective crops are furnished in Table 3.2 and the quantities of P and K added correspondingly due to application of different organics are furnished in Table 3.3.

3.7.4.2.1 Farm yard manure

Well rotten farm yard manure collected from the college farm cattle yard was used in the study.

3.7.4.2.2 Vermicompost

Vermicompost was prepared in the college farm as per the standard procedure was used in the study.

3.7.4.2.3 Neem leaf manure

Neem leaf was collected from the trees surrounding the experimental field and used in the study.

3.7.4.2.4 Poultry manure

Poultry manure was collected from the poultry farm of College of Veterinary Science, ANGRAU campus and used in the study.

3.7.4.2.5 Pig manure

Pig manure was collected from the AICRP on Pigs at College of Veterinary Science, ANGRAU campus and used in the study.

Table 3.2: Nutrient content of different organic sources

S.No.	Organic sources of nutrients	Nutrient content (%)			Quantity on fresh weight basis (t ha^{-1}) to supply recommended dose of Nitrogen
		N	P	K	
1.	**Maize**				**120 Kg N ha^{-1}**
	Farm yard manure	0.68	0.20	0.50	17.64
	Vermicompost	1.20	0.50	1.50	10.00
	Neem leaf	0.50	0.28	0.35	24.00
	Poultry manure	2.54	2.00	1.40	4.72
	Pig manure	0.56	0.35	0.60	21.42
2.	**Sunflower**				**80 kg N ha^{-1}**
	Farm yard manure	0.68	0.20	0.50	11.76
	Vermicompost	1.20	0.50	1.50	6.66
	Neem leaf	0.50	0.28	0.35	16.00
	Poultry manure	2.54	2.00	1.40	3.14
	Pig manure	0.56	0.35	0.60	14.28

Table 3.3: Quantity of P and K (Kg ha^{-1}) added through different organic sources

Organic sources of nutrients	Maize		Sunflower	
	P	K	P	K
Farm yard manure	35.29	88.23	23.52	58.23
Vermicompost	50.00	150.00	33.33	99.99
Neem leaf	67.20	84.00	44.80	56.00
Poultry manure	94.48	66.13	62.98	44.08
Pig manure	74.99	128.57	49.99	85.71

3.7.5 Panchagavya

The following ingredients were used to prepare approximately 5 litres of *panchagavya* stock solution. Cow dung (1 kg), Cow's urine (750 ml), Cow's milk (500 ml), Cow's curd (500 ml) and Cow's ghee (250 ml). In addition, sugarcane juice (750 ml), tender coconut water (750 ml), pure honey (250ml) and ripe bananas (250g) were also added to accelerate the fermentation process.

All the materials were added to a wide mouthed earthern pot and kept open under shade. The contents were stirred twice a day for about 20 minutes, both in the morning and evening to facilitate aerobic microbial activity. After fifteen days, the contents were filtered to get the clear stock solution of *pacnchagavya*. The stock solution was diluted to five per cent spray solution and it was applied as foliar spray @ 500 l ha^{-1} to maize and sunflower crops (as per the treatments) at fortnightly intervals starting from 15 DAS to 15 days before harvest. The spray solution was sprayed with high pore size nozzle, to facilitate adequate interception by the crop foliage. *Panchagavya* stock solution prepared for the study was analysed on 15th day for its nutrient and microbial content as well as bio-chemical properties and the values along with their respective methods of analysis are presented in Table 3.4.

Table 3.4 Biochemical properties of *Panchagavya* Stock Solution

Property	Composition value	Methodology
Total N (mg kg^{-1})	380	Microkjeldhal - Humphries (1956)
Total P (mg kg^{-1})	258	Triple acid digestion (calorimetry), Jackson (1973)
Total K (mg kg^{-1})	430	Triple acid digestion (Flame photometry) Jackson (1973)
Total organic carbon (%)	0.85	Wet digestion Walkley & Black (1934)
Total sugars (µg ml^{-1})	215	Nelson Somogyi's hydrolysis - Somogyi (1952)
Reducing sugars (µg ml^{-1})	88	
Glucose (mg/dl)	7.5	Glucose oxidase - Malick and Singh (1980)
Sodium (mg kg^{-1})	105	Triple acid digestion (Flame photometry), Jackson (1973)
Calcium (mg kg^{-1})	28	
Yeast (CFU/ ml)	38×10^4	Saborauds agar medium
Actinomycetes (CFU/ml)	4×10^2	Ken Knight's medium, Ken Knight and Muncie (1939)
Lactic acid bacteria (CFU/ml)	26×10^6	MRS agar
Zn (mg kg^{-1})	0.28	DTPA extractant (AAS) Lindsay and Norvell (1978)
Fe (mg kg^{-1})	0.87	
Mn (mg kg^{-1})	0.20	
Cu (mg kg^{-1})	0.17	

3.7.6 Intercultivation

Weeding was done with star weeder in inter rows and by hand hoeing in intra rows, to keep the crops free from weeds. Two weedings were scheduled for each of the three crops. Weeding was done on 20 and 40 DAS for maize, on 25 and 40 DAS for sunflower, 20 and 35 DAS for greengram.

3.7.7 Irrigation

One irrigation was given to the organic manurial treatmental plots, immediately after incorporation of organic manures, to facilitate decomposition. A pre sowing irrigation was given prior to sowing of all the three crops. Thereafter, irrigations were given as and when required by the respective crops. Five irrigations were given to maize, seven irrigations were given to sunflower and three irrigations were given to greengram (Appendix D).

3.7.8 Plant Protection

No plant protection measures were taken up for any of the crops in the study, since the investigation pertains to organic farming. However, no major pests and diseases to drastically alter the performance of crops were noticed during the course of two-year experimentation.

3.7.9 Harvesting

Harvesting of the crops was done when the crops attained their harvest maturity, based on the standard and specified symptoms of maturity of respective crops. Maize was harvested when the sheaths of cobs were completely dried. Sunflower was harvested when the back of the heads turned to lemon yellow colour. Greengram was harvested by picking the matured pods twice. The plants of the border rows were harvested first and separated and later, the plants from the net plot area were harvested.

3.7.10 Threshing

Threshing of the produce from net plots of the crops was done as per the standard procedure for respective crops. The dehusked cobs of maize were sun dried, shelled and the kernels were cleaned and weighed separately for each plot. The heads of sunflower were sun dried, hand threshed and the seeds were cleaned and weighed separately for each plot. Greengram pods picked were sun dried immediately after each picking and pooled plot wise and threshed, cleaned and weighed separately plot wise.

3.8 SAMPLING FOR BIOMETRIC OBSERVATIONS

For recording periodical observations, which involved destructive sampling (leaf area, dry matter production and nutrient uptake), five plants were sampled each time from border rows, leaving the extreme row, while for recording other observations (non-destructive sampling), ten plants were labeled with tags at random from the net plots. At harvest the seed and by-product yields of the ten labeled plants were also added to the net plot yield for calculating the final yields. Different growth and yield parameters relevant to each of the three crops in the study were recorded as outlined below.

3.8.1 Maize

3.8.1.1 Plant height

Plant height of maize was recorded from tagged plants at 15 days intervals up to tasseling, by measuring from the base of the plant to the growing tip of top most leaf and the mean plant height was calculated and expressed in cm.

3.8.1.2 Leaf area index (LAI)

Leaf area of maize was computed at 15 days intervals till harvest. The leaf area was calculated, by measuring the length and maximum width of third leaf from the top and multiplied with the factor 0.75 (Elsahookie, 1985). Leaf area index was calculated by dividing the total leaf area with corresponding land area as per the formula suggested by Watson (1952).

$$\text{LAI} = \frac{\text{Total leaf area}}{\text{Unit land area}}$$

3.8.1.3 Dry matter production (DMP)

Five plants form the destructive sampling area were cut to the base, sun dried and then oven dried at 60°C till to a constant weight and expressed as kg ha^{-1}.

3.8.1.4 Days to tasseling, silking and maturity

Number of days taken for tasseling and silking of 50 per cent of the plants in each of the plots was recorded and presented as days to 50 per cent tasseling and 50 per cent silking. Number of days to attain harvest maturity was recorded from each of the plots and presented as days to maturity.

3.8.1.5 Cob length

Length of the cob from blunt end to the shank tip of ten randomly selected cobs was measured and the average for each treatment was expressed as cob length in cm.

3.8.1.6 Cob girth

The cob girth of ten randomly selected cobs was measured at the point of maximum girth using a thread and measured with a scale. The mean girth of the cob was computed and expressed in cm.

3.8.1.7 Cob weight

Randomly selected ten cobs were dried thoroughly under sun and their average weight was recorded and expressed in g.

3.8.1.8 Number of grain rows cob^{-1}

Total number of grain rows from ten randomly selected cobs was counted, averaged and expressed as number of seed rows cob^{-1}.

3.8.1.9 Number of grains row^{-1}

Total number of grains row^{-1} from ten randomly selected cobs was counted and the mean value was presented as number of seeds row^{-1}.

3.8.1.10 Hundred grain weight

Ten cobs from each treatment were randomly selected and shelled. From those, five samples of 100 grains each were drawn and weighed and the mean of the five samples was presented as 100 grain weight expressed in g.

3.8.1.11 Grain yield

Grain from net plot was sun dried to moisture level of 11 per cent, cleaned thoroughly, weighed and expressed as kg ha^{-1}.

3.8.1.12 Stover yield

Stover obtained from net plot was thoroughly sun dried to constant weight and expressed as kg ha^{-1}.

3.8.1.13 Harvest index

The relation ship of economic yield to the total biological yield was expressed as harvest index (HI).

$$HI = \frac{\text{Grain yield}}{\text{Total Biological yield}} \times 100$$

3.8.1.14 Quality parameters of maize grain

The important quality parameters of maize grain were analysed in the laboratory as per the standard methods indicated below.

Quality Parameter	Method
Protein content (%)	Lowry's method (Lowry *et al.*, 1951)
Starch content (%)	Anthrone method (Hedge and Hofreiter, 1962)
Lysine content (%)	Colorimetric method (Sadasivam and Manickam, 1992)
Tryptophan content (%)	Colorimetric method (Sadasivam and Manickam, 1992)

3.8.2 Sunflower

3.8.2.1 Plant Height

Plant height of sunflower was recorded at 15 days interval up to heading, by measuring from base of the plants to the terminal bud of the ten tagged plants expressed in cm

3.8.2.2 Leaf Area Index

LI-COR model LI-3000 portable leaf area meter with the transparent belt conveyer (Model LI-3050A) utilizing an electrical display was used for measuring leaf area at 15 days interval till harvest. Leaf area index was calculated by dividing the total leaf area with corresponding land area as per the formula suggested by Watson (1952).

$$LAI = \frac{\text{Total leaf area}}{\text{Unit land area}}$$

3.8.2.3 Dry matter production (DMP)

Five plants from the destructive sampling area were cut to the base, sun dried and then oven dried at 60°C till to a constant weight and expressed as kg ha^{-1}.

3.8.2.4 Days to 50 per cent flowering

Sunflower crop was considered to have reached 50 per cent flowering, when 50 per cent of the flower buds opened their ray florets in each of the net plots, and reported as days to 50 per cent flowering.

3.8.2.5 Head diameter

Diameter of the heads from the labeled plants of each of the net plots was measured, averaged and expressed in cm.

3.8.2.6 Total number of seeds head^{-1}

Both filled and unfilled seeds from the heads of ten plants were counted and the mean value was expressed as total number of seeds head^{-1}.

3.8.2.7 Filled seeds head^{-1}

From the total number of seeds head^{-1}, filled seeds were separated, counted, averaged and expressed as filled seeds head^{-1}.

3.8.2.8 Thousand seed weight

Five composite samples of 1000 seeds each were drawn from net plot produce of each treatment and weights were recorded. The mean value was presented as thousand seed weight in g.

3.8.2.9 Seed yield

Seed obtained from the net plots was thoroughly sun dried to a moisture level of 8 per cent, weighed and expressed in kg ha^{-1}.

3.8.2.10 Stalk yield

Stalks obtained from net plots were thoroughly sun dried to a constant weight, weighed and expressed in kg ha^{-1}.

3.8.2.11 Harvest index

Harvest index is the ratio of seed weight to the total biological yield and is expressed as percentage.

$$HI = \frac{\text{Seed yield}}{\text{Total Biological yield}} \times 100$$

3.8.2.12 Oil content

Oil content of sunflower seeds was estimated by using ether extraction procedure in a soxhlet apparatus (AOAC, 1980) and also confirmed with NMR spectroscopy (Bruter Minispe P_2O_5 model) against a standard reference sample (Granlund and Zimmerman, 1975).

3.8.3 Greengram

3.8.3.1 Plant height

Plant height from ground surface to top most growing point was recorded from ten labeled plants of net plots, at 15 days interval till harvest and expressed in cm.

3.8.3.2 Leaf area index

LI-COR model LI-3000 portable leaf area meter with the transparent belt conveyer (Model LI-3050A) utilizing an electrical display was used for measuring leaf area at 15 days interval till harvest. Leaf area index was calculated by dividing the total leaf area with corresponding land area as per the formula suggested by Watson (1952).

$$LAI = \frac{\text{Total leaf area}}{\text{Unit land area}}$$

3.8.3.3 Dry matter production

Five plants were uprooted from the destructive sampling area at 15 days interval till harvest and the plants devoid of roots were sun dried and later oven dried at 60^0C to a constant weight, weighed and expressed in kg ha^{-1}.

3.8.3.4 Number of pods plant^{-1}

Total number of pods from ten labeled plants in each of the net plot were counted, averaged and expressed as number of pods $plant^{-1}$.

3.8.3.5 Number of seeds pod^{-1}

The number of seeds pod^{-1} from 20 pods taken at random from each treatment was counted, averaged and expressed as number of seeds pod^{-1}.

3.8.3.6 Thousand seed weight

Five seed samples were drawn from net plot yield of each treatment and weight of thousand seeds of each sample was recorded, averaged and expressed as 1000 seed weight in g.

3.8.3.7 Seed yield

Total seed yield obtained from two pickings from net plot area was sun dried to 8 per cent moisture, weighed and expressed as kg ha^{-1}.

3.8.3.8 Haulm yield

The haulms from each net plot area were sun dried to a constant weight, weighed and expressed in kg ha^{-1}.

3.8.3.9 Harvest index

Harvest index is the ratio of seed weight to the total biological yield and is expressed as percentage.

$$HI = \frac{\text{Seed yield}}{\text{Total Biological yield}} \times 100$$

3.8.3.10 Protein content

Seed samples were taken from each plot and analysed for total N by microkjeldhal method. The N content of the seed was multiplied with 6.25 (Dubez and Wells, 1968) to arrive at the crude protein content and expressed in percent.

3.9 PLANT ANALYSIS AND NUTRIENT UPTAKE

Plant samples collected for estimation of dry matter were used to estimate the nutrient uptake at periodical intervals during the crop growth period of all the three crops. The oven dried plant samples used for dry matter estimation were chopped and ground in to fine powder using Willey mill and were analysed for N, P, K by adopting the standard procedures as furnished below.

Nutrient	Method	Reference
Nitrogen	Microkjeldhal	Humphries (1956)
Phosphorus	Triple acid digestion (Colorimetry)	Jackson (1973)
Potassium	Triple acid digestion (Flame photometry)	Jackson (1973)

The up take of N, P, K at different stages of crop growth of all the three crops was calculated by multiplying the nutrient content with respective dry matter weights and the nutrient uptake was expressed in kg ha^{-1}.

3.10 SOIL FERTILITY DYNAMICS

Immediately after the harvest of each of the three crops during both the annual cropping cycles, soil samples were drawn from individual plots from all the replications and analysed for organic carbon, available N, P and K by following standard procedures furnished in Table 3.1

3.11 ECONOMICS

Gross and Net returns (Rs ha^{-1}) for each of the three crops were computed considering the existing market price of inputs and output. Benefit cost ratio (BCR) was worked out for different treatments by dividing the gross returns by corresponding cost of cultivation.

3.12 CROPPING SYSTEM AS A WHOLE

Performance of the cropping system as a whole as influenced by different manurial practices and *panchagavya* spray was assessed in terms of productivity (biomass production and economic yield in terms of maize grain equivalent yield), economics (gross returns, net returns and benefit-cost ratio) and soil fertility status (dynamics of soil organic carbon, available N, P and K).

3.12.1 Total Biomass Production of the Cropping System

Total dry matter production of the cropping system as a whole (year wise) was obtained for each treatment by summing up the total dry matter production of maize, sunflower and greengram.

3.12.2 Total Economic Yield of the Cropping System

Total dry matter production of the cropping system as a whole (year wise) was computed by summing up the grain yield of maize and converted maize equivalent yields of sunflower and greengram, treatment wise. Maize equivalent yield of sunflower and greengram was worked out using the following formulae.

$$\text{Maize equivalent yield of sunflower (kg ha}^{-1}) = \frac{\text{Seed yield of Sunflower (kg ha}^{-1}) \times \text{price of sunflower (Rs kg}^{-1})}{\text{Price of Maize (Rs kg}^{-1})}$$

$$\text{Maize equivalent yield of greengram (kg ha}^{-1}) = \frac{\text{Seed yield of greengram (kg ha}^{-1}) \times \text{price of greengram (Rs kg}^{-1})}{\text{Price of Maize (Rs kg}^{-1})}$$

3.12.3 Economics of the Cropping System

Gross returns of the cropping system were arrived at by summing up the gross returns realized from maize, sunflower and greengram, while the net returns of the cropping system were arrived at by subtracting the cost of cultivation of respective treatments from gross returns of corresponding treatments. Benefit-cost ratio of the cropping system was computed by dividing the gross returns of the cropping system with the total cost of cultivation of the cropping system of the corresponding treatments.

3.13 DYNAMICS OF SOIL FERTILITY OF THE CROPPING SYSTEM

Dynamics of the soil organic carbon, available N, P and K was assessed for each of the two annual cycles of cropping system, using the pre-experimental and post harvest values of all the three crops of cropping system.

3.14 NUTRIENT BALANCE OF THE CROPPING SYSTEM

Soil available balance of N, P and K in the cropping system (annual cropping cycle) as influenced by different manurial practices and *panchagavya* spray was computed as per the procedure outlined by Sadanandan and Mahapatra (1973).

3.15 STATISTICAL ANALYSIS

The data recorded on various parameters of all the three crops during the course of investigation and summed up data of the cropping system were statistically analysed following the analysis of variance for randomised block design as suggested by Panse and Sukhatme (1978). Wherever the treatmental difference were found significant ('F' test), critical difference was worked out at 0.05 probability level and the values were furnished. Treatmental differences that were non-significant were denoted by "NS".

Results

CHAPTER – IV

RESULTS

Results of the field experiment entitled "Studies on organic farming in maize - sunflower- greengram cropping system" conducted for two consecutive years (2003-2004 and 2004-2005) on sandy clay loam soils of S.V.Agricultural College Farm, Tirupati (ANGRAU), Andhra Pradesh are presented in the chapter.

The experiments were conducted for three seasons during each year of study, with maize during late *kharif,* sunflower during late *rabi and* Greengram during summer seasons. Treatments were imposed on maize and sunflower crops, while the residual effect of treatments imposed to two preceding crops was studied on greengram crop. The results are presented crop wise and the performance of the cropping system as a whole is presented by summing up the treatmental effects on individual crops.

4.1 MAIZE (late *kharif*, 2003 and 2004)

4.1.1 Plant Height

Plant height of maize measured at 15 DAS, 30 DAS and at tasseling was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.1).

Table 4.1: Plant height (cm) of maize as influenced by varied manurial practices and *panchagavya* spray

Treatments		2003			2004		
		15 DAS	30 DAS	At Tasseling	15 DAS	30 DAS	At Tasseling
T_1	No manure	8.8	16.0	64.0	8.6	15.6	64.8
T_2	No manure + *panchagavya*	9.1	20.8	72.2	8.9	20.2	72.6
T_3	Recommended dose of fertilizer	22.0	45.0	108.5	22.2	43.8	109.6
T_4	Recommended dose of fertilizer + *panchagavya*	22.8	46.0	110.3	22.3	44.3	110.5
T_5	Farm Yard Manure	21.2	36.2	93.8	20.8	35.2	95.4
T_6	Farm Yard Manure + *panchagavya*	22.2	41.2	102.6	21.9	40.0	103.2
T_7	Vermicompost	20.5	34.8	92.5	20.2	33.8	93.5
T_8	Vermicompost + *panchagavya*	21.2	40.2	99.4	21.0	39.0	101.8
T_9	Neem leaf	19.4	28.4	84.8	19.2	28.0	84.8
T_{10}	Neem leaf + *panchagavya*	19.7	29.2	85.2	19.4	28.6	85.4
T_{11}	Poultry manure	20.0	30.0	86.0	19.8	29.2	86.2
T_{12}	Poultry manure + *panchagavya*	20.3	30.6	86.4	19.8	29.6	86.8
T_{13}	Pig manure	20.8	35.4	93.6	20.4	34.8	94.6
T_{14}	Pig manure + *panchagavya*	21.5	41.0	100.8	21.4	39.6	102.8
	SEm±	1.06	1.30	1.90	1.13	1.27	2.18
	CD (P = 0.05)	3.0	3.5	5.4	3.2	3.6	6.2

At all the crop growth stages of observation, except at 15 DAS, the tallest plants of maize were recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and significantly taller than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure, and neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The shortest plants of maize were associated with unmanured plot (T_1).

At 15 DAS, plant height of maize was comparable with all the manurial practices tried, which was significantly higher than with no manuring either with or without *panchagavya* spray.

4.1.2 Leaf Area Index

Leaf area index (LAI) of maize at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.2 and 4.3).

Table 4.2: Leaf area index of maize as influenced by varied manurial practices and *Panchagavya* spray - 2003

Treatments		LAI					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	0.18	0.27	0.98	1.70	1.98	1.41
T_2	No manure + *panchagavya*	0.18	0.36	1.06	1.88	2.22	1.62
T_3	Recommended dose of fertilizer	0.32	0.75	1.47	2.75	3.12	2.45
T_4	Recommended dose of fertilizer + *panchagavya*	0.32	0.76	1.48	2.80	3.14	2.47
T_5	Farm Yard Manure	0.30	0.56	1.29	2.34	2.70	2.22
T_6	Farm Yard Manure + *panchagavya*	0.32	0.67	1.40	2.54	2.94	2.26
T_7	Vermicompost	0.28	0.55	1.28	2.30	2.65	2.02
T_8	Vermicompost + *panchagavya*	0.30	0.65	1.38	2.52	2.90	2.24
T_9	Neem leaf	0.26	0.45	1.16	2.06	2.40	1.80
T_{10}	Neem leaf + *panchagavya*	0.26	0.46	1.18	2.08	2.42	1.80
T_{11}	Poultry manure	0.26	0.47	1.19	2.08	2.44	1.82
T_{12}	Poultry manure + *panchagavya*	0.28	0.47	1.21	2.10	2.48	1.83
T_{13}	Pig manure	0.29	0.56	1.28	2.32	2.67	2.04
T_{14}	Pig manure + *panchagavya*	0.31	0.66	1.40	2.52	2.92	2.24
	SEm±	0.021	0.025	0.021	0.056	0.056	0.060
	CD (P = 0.05)	0.06	0.07	0.06	0.16	0.16	0.17

Table 4.3: Leaf area index of maize as influenced by varied manurial practices and *Panchagavya* spray – 2004

Treatments		LAI					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	0.20	0.31	0.82	1.86	1.98	1.56
T_2	No manure + *panchagavya*	0.21	0.38	0.94	2.08	2.20	1.72
T_3	Recommended dose of fertilizer	0.34	0.76	1.50	2.98	3.22	2.52
T_4	Recommended dose of fertilizer + *panchagavya*	0.34	0.76	1.51	3.00	3.24	2.55
T_5	Farm Yard Manure	0.31	0.59	1.28	2.62	2.72	2.18
T_6	Farm Yard Manure + *panchagavya*	0.32	0.69	1.39	2.82	2.98	2.37
T_7	Vermicompost	0.30	0.56	1.26	2.58	2.69	2.12
T_8	Vermicompost + *panchagavya*	0.31	0.68	1.38	2.78	2.95	2.32
T_9	Neem leaf	0.29	0.46	1.12	2.40	2.44	1.90
T_{10}	Neem leaf + *panchagavya*	0.29	0.48	1.12	2.42	2.44	1.91
T_{11}	Poultry manure	0.29	0.49	1.14	2.42	2.45	1.94
T_{12}	Poultry manure + *panchagavya*	0.30	0.49	1.16	2.44	2.46	1.96
T_{13}	Pig manure	0.31	0.58	1.26	2.60	2.71	2.15
T_{14}	Pig manure + *panchagavya*	0.32	0.68	1.38	2.80	2.96	2.34
	SEm±	0.025	0.018	0.032	0.039	0.074	0.046
	CD (P = 0.05)	0.07	0.05	0.09	0.11	0.21	0.13

At all the crop growth stages of observation, except at 15 DAS, the highest LAI was recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure, and neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest LAI of maize was associated with unmanured plot (T_1).

At 15 DAS, the LAI of maize was comparable with all the manurial practices tried, which was significantly higher than with no manuring with or without *panchagavya* spray.

4.1.3 Dry Matter Production

Dry matter production of maize measured at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.4 and 4.5).

Table 4.4 : Dry matter production (kg ha^{-1}) of maize as influenced by varied manurial practices and *Panchagavya* spray-2003

Treatments		Dry matter production					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	793	1076	1736	2248	2768	3752
T_2	No manure + *panchagavya*	797	1295	2085	2682	3228	4325
T_3	Recommended dose of fertilizer	1598	2318	6592	8095	9478	11846
T_4	Recommended dose of fertilizer + *panchagavya*	1604	2363	6690	8151	9542	11960
T_5	Farm Yard Manure	1540	1892	5746	7024	7986	10081
T_6	Farm Yard Manure + *panchagavya*	1585	2130	6248	7624	8796	11125
T_7	Vermicompost	1516	1846	5592	6892	7856	9801
T_8	Vermicompost + *panchagavya*	1562	2097	6106	7498	8648	10825
T_9	Neem leaf	1452	1508	5066	6125	6884	8792
T_{10}	Neem leaf + *panchagavya*	1468	1544	5125	6218	6968	8865
T_{11}	Poultry manure	1485	1586	5198	6386	7054	8963
T_{12}	Poultry manure + *panchagavya*	1504	1642	5264	6428	7186	9079
T_{13}	Pig manure	1528	1874	5684	6982	7912	9964
T_{14}	Pig manure + *panchagavya*	1580	2124	6185	7582	8724	10981
	SEm±	39.4	62.7	86.3	138.7	153.2	198.9
	CD (P = 0.05)	112	178	245	394	435	565

Table 4.5: Dry matter production (kg ha^{-1}) of maize as influenced varied manurial practices and *Panchagavya* spray-2004

Treatments		Dry matter production					
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	835	1112	1652	2242	2628	3864
T_2	No manure + *panchagavya*	843	1326	2016	2765	3182	4482
T_3	Recommended dose of fertilizer	1620	2803	7156	9074	10284	12216
T_4	Recommended dose of fertilizer + *panchagavya*	1624	2870	7231	9127	10365	12382
T_5	Farm Yard Manure	1514	2105	5417	7564	8416	10064
T_6	Farm Yard Manure + *panchagavya*	1582	2472	6385	8394	9425	11286
T_7	Vermicompost	1452	2062	5284	7425	8252	9945
T_8	Vermicompost + *panchagavya*	1532	2446	6124	8295	9284	11096
T_9	Neem leaf	1358	1608	4525	6462	7325	8702
T_{10}	Neem leaf + *panchagavya*	1364	1622	4580	6584	7402	8784
T_{11}	Poultry manure	1398	1658	4625	6645	7485	8865
T_{12}	Poultry manure + *panchagavya*	1428	1684	4682	6712	7580	8942
T_{13}	Pig manure	1496	2086	5337	7480	8324	10012
T_{14}	Pig manure + *panchagavya*	1546	2458	6268	8368	9360	11182
	SEm±	54.2	69.0	114.1	152.1	171.1	208.5
	CD ($P = 0.05$)	154	196	324	432	486	592

At all the crop growth stages of observation, except at 15 DAS, the highest quantity of dry matter was produced with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure, and neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest dry matter production was recorded with unmanured plot (T_1).

At 15 DAS, dry matter production of maize was comparable with all the manurial practices tried, which was significantly higher than with no manuring with or without *panchagavya* spray.

4.1.4 Days to 50% Flowering (Tasseling and Silking)

Days to 50% flowering (tasseling and silking) of maize was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.6).

Table 4.6: Days to 50% tasseling, 50% silking and maturity of maize as influenced by varied manurial practices and *Panchagavya* spray

Treatments		Days to 50% tasseling		Days to 50% silking		Days to maturity	
		2003	2004	2003	2004	2003	2004
T_1	No manure	41	44	53	53	92	93
T_2	No manure + *panchagavya*	42	45	53	53	92	93
T_3	Recommended dose of fertilizer	49	50	60	61	100	101
T_4	Recommended dose of fertilizer + *panchagavya*	49	50	60	61	100	101
T_5	Farm Yard Manure	47	48	57	58	97	98
T_6	Farm Yard Manure + *panchagavya*	47	48	57	58	97	98
T_7	Vermicompost	46	48	57	58	97	98
T_8	Vermicompost + *panchagavya*	46	48	57	58	97	98
T_9	Neem leaf	46	47	56	57	96	96
T_{10}	Neem leaf + *panchagavya*	46	47	56	57	96	96
T_{11}	Poultry manure	46	47	56	57	96	96
T_{12}	Poultry manure + *panchagavya*	46	47	56	57	96	96
T_{13}	Pig manure	46	47	56	57	97	98
T_{14}	Pig manure + *panchagavya*	46	47	56	57	97	98
	SEm±	0.46	0.48	0.81	0.83	0.85	0.82
	CD (P = 0.05)	1	1	2	2	2	2

The earliest flowering (tasseling and silking) of maize was noticed with no manure either with or without *panchagavya* (T_2 and T_1), which was significantly earlier than with all other manurial practices tried. Most delayed flowering (tasseling and silking) was observed with recommended dose of fertilizer with or without *panchagavya* spray, which took significantly more number of days than with all the organic sources of manuring with or without *panchagavya* spray, which were however, comparable among them.

4.1.5 Days to Maturity

Days to maturity of maize was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4. 6).

Maize crop was found matured at the earliest with no manure either with or without *panchagavya* (T_2 and T_1), which was significantly earlier than with all other manurial practices tried. Most delayed maturity of the crop was noticed with recommended dose of fertilizer with or without *panchagavya* spray, which took significantly more number of days than with all the organic sources of manuring with or without *panchagavya* spray, which were comparable among them.

4.1.6 Number of grain rows cob^{-1}

Number of grain rows cob^{-1} of maize differed significantly due to varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.7).

The highest number of grain rows cob^{-1} was observed with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest number of seed rows cob^{-1} of maize was recorded with unmanured plot (T_1).

4.1.7 Number of grains row^{-1}

Number of grains row^{-1} of cob differed significantly due to varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.7).

Table 4.7: Number of grain rows cob^{-1} and Number of grains row^{-1} of maize as influenced by varied manurial practices and *Panchagavya* spray

Treatments		Number of grain rows cob^{-1}		Number of grains row^{-1}	
		2003	2004	2003	2004
T_1	No manure	9.0	8.8	24.4	25.8
T_2	No manure + *panchagavya*	9.8	9.6	26.2	27.6
T_3	Recommended dose of fertilizer	12.5	12.4	35.8	37.4
T_4	Recommended dose of fertilizer + *panchagavya*	12.7	12.5	36.0	37.5
T_5	Farm Yard Manure	11.3	11.2	33.5	33.4
T_6	Farm Yard Manure + *panchagavya*	11.9	11.9	34.0	35.6
T_7	Vermicompost	11.2	11.1	31.5	33.2
T_8	Vermicompost + *panchagavya*	11.9	11.8	33.8	35.4
T_9	Neem leaf	10.4	10.2	28.2	29.2
T_{10}	Neem leaf + *panchagavya*	10.5	10.4	28.7	29.8
T_{11}	Poultry manure	10.5	10.3	28.6	29.6
T_{12}	Poultry manure + *panchagavya*	10.6	10.4	28.9	30.3
T_{13}	Pig manure	11.2	11.0	31.2	33.2
T_{14}	Pig manure + *panchagavya*	11.9	11.8	33.8	35.2
	SEm±	0.18	0.18	0.56	0.60
	CD (P = 0.05)	0.5	0.5	1.6	1.7

The highest number of grains row^{-1} of cob was observed with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest number of grains row^{-1} of cob was noticed in unmanured plot (T_1).

4.1.8 Cob Length

The length of maize cobs was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4. 8).

Maize cobs were the longest with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). Maize cobs of the shortest stature were noticed in unmanured plot (T_1).

4.1.9 Cob Girth

The girth of maize cobs differed significantly due to varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.8).

Maize cobs of the largest girth were produced with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). Maize cobs of the smallest girth were noticed in unmanured plot (T_1).

4.1.10 Cob Weight

The weight of maize cobs was significantly influenced by varied manurial practices and use of *panchagavya*, during both the years of study (Table 4. 8).

Maize cobs of the highest weight were produced with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The cobs of the lowest weight were noticed in unmanured plot (T_1).

Table 4.8: Cob length (cm), cob girth (cm), cob weight (g) and hundred grain weight (g) of maize as influenced by varied manurial practices and *Panchagavya* spray

Treatments		Cob length		Cob girth		Cob weight		Hundred grain weight	
		2003	2004	2003	2004	2003	2004	2003	2004
T_1	No manure	8.0	8.5	5.8	6.0	52.0	54.6	18.2	19.6
T_2	No manure + *panchagavya*	9.4	10.2	6.7	6.9	67.4	69.2	19.5	20.8
T_3	Recommended dose of fertilizer	17.2	17.6	10.6	11.5	128.6	130.5	26.2	27.2
T_4	Recommended dose of fertilizer + *panchagavya*	17.8	18.1	10.8	11.7	129.8	132.2	26.4	27.5
T_5	Farm Yard Manure	13.8	14.0	8.8	9.5	100.8	100.9	23.8	24.8
T_6	Farm Yard Manure + *panchagavya*	16.0	16.0	9.8	10.6	115.2	117.2	25.2	26.2
T_7	Vermicompost	13.0	13.8	8.6	9.2	98.0	98.2	23.2	24.2
T_8	Vermicompost + *panchagavya*	15.4	15.6	9.5	10.4	113.8	114.2	25.0	25.8
T_9	Neem leaf	11.0	11.8	7.4	7.8	80.8	82.8	20.8	22.2
T_{10}	Neem leaf + *panchagavya*	11.0	12.0	7.6	8.0	81.6	83.4	21.0	22.5
T_{11}	Poultry manure	11.2	12.0	7.8	8.0	83.2	84.2	21.2	22.6
T_{12}	Poultry manure + *panchagavya*	11.6	12.2	7.8	8.3	84.6	84.8	21.4	23.0
T_{13}	Pig manure	13.4	13.8	8.6	9.4	98.2	99.2	23.6	24.5
T_{14}	Pig manure + *panchagavya*	15.8	15.8	9.6	10.4	114.6	115.8	25.0	26.0
	SEm±	0.46	0.53	0.21	0.28	4.51	4.65	0.28	0.32
	CD (P = 0.05)	1.3	1.5	0.6	0.8	12.8	13.2	0.8	0.9

4.1.11 Hundred grain weight

Hundred grain weight of maize was significantly influenced by varied manurial practices and use of *panchagavya*, during both the years of study (Table 4.8).

The highest hundred grain weight of maize was recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest seed weight of maize was recorded with unmanured plot (T_1).

4.1.12 Grain Yield

Grain yield of maize was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.9).

Table 4.9: Yield (kg ha^{-1}) and harvest index of maize as influenced by varied manurial practices and *Panchagavya* spray

	Treatments	Grain yield		Stover yield		Harvest Index	
		2003	2004	2003	2004	2003	2004
T_1	No manure	966	1002	2245	2428	25.74	25.92
T_2	No manure + *panchagavya*	1147	1203	2708	2872	26.52	26.84
T_3	Recommended dose of fertilizer	3715	3894	7464	7845	31.36	31.88
T_4	Recommended dose of fertilizer + *panchagavya*	3791	3957	7725	7912	31.45	31.96
T_5	Farm Yard Manure	3016	3051	6428	6586	29.92	30.32
T_6	Farm Yard Manure + *panchagavya*	3402	3514	7068	7369	30.58	31.14
T_7	Vermicompost	2903	2982	6284	6432	29.62	29.98
T_8	Vermicompost + *panchagavya*	3273	3412	6965	7154	30.24	30.75
T_9	Neem leaf	2493	2499	5602	5698	28.36	28.72
T_{10}	Neem leaf + *panchagavya*	2530	2535	5762	5746	28.54	28.86
T_{11}	Poultry manure	2571	2578	5786	5824	28.68	29.08
T_{12}	Poultry manure + *panchagavya*	2629	2615	5845	5978	28.96	29.24
T_{13}	Pig manure	2967	3018	6312	6492	29.78	30.14
T_{14}	Pig manure + *panchagavya*	3340	3457	6972	7274	30.42	30.92
	SEm±	75.7	79.6	138.0	143.7	0.109	0.134
	CD (P = 0.05)	215	226	392	408	0.31	0.38

The highest grain yield of maize was produced with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure, and neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest seed yield of maize was recorded with unmanured plot (T_1).

4.1.13 Stover Yield

The stover yield of maize was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.9).

The highest stover yield of maize was produced with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14}

and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest stover yield of maize was recorded with unmanured plot (T_1).

4.1.14 Harvest Index

Harvest index of maize was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4. 9).

The highest harvest index of maize was recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than that with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity. The latter three treatments were significantly superior to poultry manure, and neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest value of harvest index of maize was recorded with unmanured plot (T_1).

4.1.15 Protein Content of Grain

Different manurial practices and use of *panchagavya* exerted significant influence on the protein content of maize grain, with unaltered trend during both the years of study (Table 4. 10).

The highest protein content of maize grain was recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest protein content of grain was recorded with unmanured plot (T_1).

Table 4.10: Protein and starch content (%) of maize as influenced by varied manurial practices and *Panchagavya* spray

Treatments		Protein content (%)		Starch content (%)	
		2003	2004	2003	2004
T_1	No manure	6.4	6.6	53.2	53.8
T_2	No manure + *panchagavya*	7.1	7.3	55.4	55.6
T_3	Recommended dose of fertilizer	10.3	11.0	63.2	64.0
T_4	Recommended dose of fertilizer + *panchagavya*	10.5	11.1	63.2	64.2
T_5	Farm Yard Manure	8.8	9.5	59.4	60.0
T_6	Farm Yard Manure + *panchagavya*	9.6	10.3	61.5	62.0
T_7	Vermicompost	8.8	9.2	59.2	59.6
T_8	Vermicompost + *panchagavya*	9.5	10.2	61.0	61.8
T_9	Neem leaf	7.8	8.2	57.2	57.4
T_{10}	Neem leaf + *panchagavya*	7.8	8.4	57.2	57.6
T_{11}	Poultry manure	7.9	8.5	57.4	57.8
T_{12}	Poultry manure + *panchagavya*	8.0	8.5	57.4	57.8
T_{13}	Pig manure	8.8	9.3	59.4	59.8
T_{14}	Pig manure + *panchagavya*	9.6	10.3	61.2	62.0
	SEm±	0.18	0.21	0.53	0.60
	CD (P = 0.05)	0.5	0.6	1.5	1.7

4.1.16 Starch Content of Grain

The starch content of maize grain was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4. 10).

The highest starch content of maize grain was recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest starch content of maize grain was recorded with unmanured plot (T_1).

4.1.17 Amino Acid (Lysine and Tryptophan) Content of Grain

The amino acid (Lysine and Tryptophan) content of maize grain was significantly altered by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.11).

Table 4.11: Amino acid content of maize grain as influenced by varied manurial practices and *Panchagavya* spray

Treatments		Lysine (%)		Tryptophan (%)	
		2003	2004	2003	2004
T_1	No manure	0.192	0.196	0.046	0.048
T_2	No manure + *panchagavya*	0.200	0.204	0.052	0.054
T_3	Recommended dose of fertilizer	0.271	0.278	0.071	0.075
T_4	Recommended dose of fertilizer + *panchagavya*	0.271	0.278	0.071	0.075
T_5	Farm Yard Manure	0.264	0.268	0.064	0.066
T_6	Farm Yard Manure + *panchagavya*	0.268	0.274	0.068	0.071
T_7	Vermicompost	0.264	0.268	0.063	0.065
T_8	Vermicompost + *panchagavya*	0.268	0.274	0.068	0.070
T_9	Neem leaf	0.258	0.260	0.058	0.059
T_{10}	Neem leaf + *panchagavya*	0.258	0.260	0.058	0.059
T_{11}	Poultry manure	0.260	0.262	0.058	0.060
T_{12}	Poultry manure + *panchagavya*	0.260	0.262	0.059	0.060
T_{13}	Pig manure	0.264	0.268	0.064	0.065
T_{14}	Pig manure + *panchagavya*	0.268	0.274	0.068	0.071
	SEm±	0.0007	0.0011	0.0007	0.0007
	CD (P = 0.05)	0.002	0.003	0.002	0.002

The highest amino acid (Lysine and Tryptophan) content of maize grain was recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure or neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest amino acid (Lysine and Tryptophan) content of maize grain was recorded with unmanured plot (T_1).

4.1.18 Nitrogen Uptake

Nitrogen uptake of maize estimated at 15, 30, 45, 60, 75 DAS and harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.12 and 4.13).

At all the crop growth stages of observation, except at 15 DAS, the highest nitrogen uptake was recorded with recommended dose of fertilizer

Table 4.12: Nitrogen uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *Panchagavya* spray – 2003

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	3.4	7.4	29.4	42.4	54.2	62.4
T_2	No manure + *panchagavya*	3.4	8.5	32.7	49.5	62.4	71.2
T_3	Recommended dose of fertilizer	8.7	19.6	60.2	122.8	141.2	172.4
T_4	Recommended dose of fertilizer + *panchagavya*	8.7	19.7	60.7	123.2	141.8	173.5
T_5	Farm Yard Manure	8.4	17.6	54.5	108.5	122.8	153.2
T_6	Farm Yard Manure + *panchagavya*	8.5	18.6	57.4	116.2	132.8	163.8
T_7	Vermicompost	8.4	17.5	54.4	107.6	121.5	151.2
T_8	Vermicompost + *panchagavya*	8.5	18.5	57.2	115.3	130.2	161.8
T_9	Neem leaf	8.0	16.5	51.2	99.2	112.4	139.5
T_{10}	Neem leaf + *panchagavya*	8.2	16.5	51.4	99.4	112.8	140.6
T_{11}	Poultry manure	8.2	16.6	51.4	100.6	113.5	141.2
T_{12}	Poultry manure + *panchagavya*	8.2	16.6	51.6	101.2	114.2	142.6
T_{13}	Pig manure	8.4	17.5	54.5	108.2	122.0	152.5
T_{14}	Pig manure + *panchagavya*	8.5	18.6	57.2	115.8	131.4	162.6
	SEm±	0.18	0.28	0.92	2.18	2.54	2.96
	CD (P = 0.05)	0.5	0.8	2.6	6.2	7.2	8.4

Table 4.13: Nitrogen uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *Panchagavya* spray - 2004

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	3.8	7.7	27.4	38.2	50.2	61.4
T_2	No manure + *panchagavya*	3.8	8.8	30.9	46.4	58.5	72.8
T_3	Recommended dose of fertilizer	9.5	20.5	71.2	115.2	140.8	175.6
T_4	Recommended dose of fertilizer + *panchagavya*	9.5	20.6	71.3	115.8	141.9	176.9
T_5	Farm Yard Manure	9.2	18.4	63.8	100.8	123.8	156.2
T_6	Farm Yard Manure + *panchagavya*	9.4	19.5	67.8	108.6	133.2	166.8
T_7	Vermicompost	9.2	18.2	62.6	99.8	121.6	154.8
T_8	Vermicompost + *panchagavya*	9.4	19.4	67.2	107.4	131.2	164.8
T_9	Neem leaf	9.0	17.0	58.2	91.5	111.4	143.6
T_{10}	Neem leaf + *panchagavya*	9.0	17.0	58.4	92.2	112.2	144.5
T_{11}	Poultry manure	9.0	17.2	59.0	92.8	112.8	145.2
T_{12}	Poultry manure + *panchagavya*	9.0	17.2	59.4	93.0	113.5	146.0
T_{13}	Pig manure	9.2	18.4	63.2	100.5	122.5	155.6
T_{14}	Pig manure + *panchagavya*	9.4	19.4	67.5	108.2	132.6	165.4
	SEm±	0.21	0.32	1.09	2.25	2.50	2.99
	CD (P = 0.05)	0.6	0.9	3.1	6.4	7.2	8.5

along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure, and neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest uptake of nitrogen was associated with unmanured plot (T_1).

At 15 DAS, nitrogen uptake of maize was comparable with all the manurial practices tried, which was significantly higher than with no manuring either with or without *panchagavya* (T_2 and T_1). The lowest nitrogen uptake was associated with unmanured plot (T_1).

4.1.19 Phosphorus Uptake

Phosphorus uptake of maize estimated at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4. 14 and 4.15).

Table 4.14: Phosphorus uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *Panchagavya* spray - 2003

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_1	No manure	0.90	1.24	3.58	5.64	7.40	10.80
T_2	No manure + *panchagavya*	0.92	1.24	3.60	5.68	7.42	10.86
T_3	Recommended dose of fertilizer	1.40	2.46	8.96	11.96	15.58	19.40
T_4	Recommended dose of fertilizer + *panchagavya*	1.40	2.46	8.98	11.98	15.62	19.46
T_5	Farm Yard Manure	1.42	2.48	8.98	12.12	15.70	19.56
T_6	Farm Yard Manure + *panchagavya*	1.42	2.48	9.02	12.15	15.72	19.62
T_7	Vermicompost	1.52	2.62	9.50	13.38	16.96	20.92
T_8	Vermicompost + *panchagavya*	1.53	2.62	9.50	13.38	17.05	20.95
T_9	Neem leaf	1.54	2.64	9.52	13.40	17.18	21.06
T_{10}	Neem leaf + *panchagavya*	1.54	2.64	9.52	13.42	17.26	21.14
T_{11}	Poultry manure	1.82	2.92	10.54	15.74	19.75	23.86
T_{12}	Poultry manure + *panchagavya*	1.85	2.96	10.59	15.80	19.81	24.00
T_{13}	Pig manure	1.64	2.78	10.04	14.56	18.48	22.48
T_{14}	Pig manure + *panchagavya*	1.66	2.78	10.06	14.58	18.52	22.54
	SEm±	0.032	0.042	0.162	0.394	0.419	0.451
	CD (P = 0.05)	0.09	0.12	0.46	1.12	1.19	1.28

Table 4.15: Phosphorus uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *Panchagavya* spray - 2004

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_1	No manure	0.96	1.34	3.78	5.82	6.85	11.30
T_2	No manure + *panchagavya*	0.98	1.36	3.82	5.88	7.12	11.54
T_3	Recommended dose of fertilizer	1.46	2.56	8.60	13.40	16.06	20.08
T_4	Recommended dose of fertilizer + *panchagavya*	1.48	2.56	8.60	13.46	16.08	20.24
T_5	Farm Yard Manure	1.48	2.58	8.62	13.52	16.16	20.42
T_6	Farm Yard Manure + *panchagavya*	1.49	2.58	8.62	13.58	16.22	20.48
T_7	Vermicompost	1.64	2.76	9.30	14.75	17.45	21.85
T_8	Vermicompost + *panchagavya*	1.64	2.76	9.30	14.82	17.56	22.06
T_9	Neem leaf	1.66	2.78	9.32	14.88	17.62	22.18
T_{10}	Neem leaf + *panchagavya*	1.66	2.78	9.32	14.90	17.64	22.20
T_{11}	Poultry manure	1.90	3.12	10.63	17.38	20.32	25.60
T_{12}	Poultry manure + *panchagavya*	1.91	3.16	10.78	17.46	20.48	25.70
T_{13}	Pig manure	1.78	2.95	9.97	16.08	18.96	24.00
T_{14}	Pig manure + *panchagavya*	1.79	2.96	9.98	16.12	19.08	24.10
	SEm±	0.032	0.049	0.218	0.398	0.423	0.465
	CD (P = 0.05)	0.09	0.14	0.62	1.13	1.20	1.32

The highest phosphorus uptake of maize was recorded with poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}). The next highest phosphorus uptake was associated with pig manure with or without *panchagavya* (T_{14} and T_{13}), which was significantly higher than with neem leaf manure or vermicompost with or without *panchagavya,* (T_{10}, T_9, T_8 and T_7), which in turn was statistically superior to farm yard manure or recommended dose of fertilizer with or without *panchagavya* (T_6, T_5, T_4 and T_3). The lowest uptake of phosphorus by maize crop was recorded with unmanured plots with or without the use of *panchagavya.*

4.1.20 Potassium Uptake

Potassium uptake of maize estimated at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.16 and 4.17).

The highest potassium uptake of maize was recorded with vermicompost either with or without the spray of *panchagavya* (T_8 and T_7). The next highest potassium uptake was associated with pig manure with or without *panchagavya* (T_{14} and T_{13}), which was significantly higher than with farm yard manure or neem leaf manure or poultry manure with or without *panchagavya,* (T_6, T_{10}, T_{12}, T_5, T_9, and T_{11}), which were comparable among them, but statistically superior to recommended dose of fertilizer

Table 4.16: Potassium uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *Panchagavya* spray - 2003

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_1	No manure	5.8	9.0	24.4	47.2	51.8	71.0
T_2	No manure + *panchagavya*	5.8	9.2	25.6	48.5	52.4	72.4
T_3	Recommended dose of fertilizer	8.2	12.8	48.4	69.6	73.2	107.4
T_4	Recommended dose of fertilizer + *panchagavya*	8.8	13.2	49.2	70.5	74.5	109.2
T_5	Farm Yard Manure	12.4	16.2	57.2	83.6	93.2	127.5
T_6	Farm Yard Manure + *panchagavya*	12.4	16.2	57.6	84.5	94.0	128.6
T_7	Vermicompost	15.8	21.4	69.4	99.6	110.8	145.8
T_8	Vermicompost + *panchagavya*	16.2	21.9	70.2	100.5	112.6	147.1
T_9	Neem leaf	12.2	15.8	56.2	81.6	91.4	126.2
T_{10}	Neem leaf + *panchagavya*	12.2	16.0	56.4	82.8	92.0	126.8
T_{11}	Poultry manure	12.0	15.6	54.8	80.2	88.6	124.8
T_{12}	Poultry manure + *panchagavya*	12.2	15.6	55.6	80.8	90.2	125.5
T_{13}	Pig manure	14.2	18.8	63.4	91.8	101.6	136.8
T_{14}	Pig manure + *panchagavya*	14.2	19.0	63.8	92.7	102.8	137.5
	SEm±	0.49	0.81	1.87	2.39	2.61	2.78
	CD (P = 0.05)	1.4	2.3	5.3	6.8	7.4	7.9

Table 4.17: Potassium uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *Panchagavya* spray - 2004

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At harvest
T_1	No manure	6.6	10.6	32.8	36.4	42.6	71.8
T_2	No manure + *panchagavya*	6.6	10.7	34.2	39.9	45.2	73.4
T_3	Recommended dose of fertilizer	9.4	15.2	49.4	66.8	83.8	96.3
T_4	Recommended dose of fertilizer + *panchagavya*	9.6	15.9	50.2	68.2	85.6	97.9
T_5	Farm Yard Manure	12.5	21.0	59.5	85.4	104.8	146.5
T_6	Farm Yard Manure + *panchagavya*	12.6	21.6	59.8	86.2	105.9	147.8
T_7	Vermicompost	16.3	27.0	71.9	102.0	122.6	165.8
T_8	Vermicompost + *panchagavya*	16.4	27.5	73.3	102.8	123.8	167.0
T_9	Neem leaf	12.4	20.4	59.2	83.4	102.6	144.9
T_{10}	Neem leaf + *panchagavya*	12.5	20.6	59.2	84.5	103.5	145.8
T_{11}	Poultry manure	12.2	20.2	58.0	81.4	100.8	143.2
T_{12}	Poultry manure + *panchagavya*	12.4	20.4	58.4	82.2	101.2	143.8
T_{13}	Pig manure	14.2	24.2	65.6	93.5	113.5	156.5
T_{14}	Pig manure + *panchagavya*	14.6	24.4	66.2	94.8	114.8	157.4
	SEm±	0.53	0.85	1.97	2.43	2.61	2.89
	CD (P = 0.05)	1.5	2.4	5.6	6.9	7.4	8.2

with or without *panchagavya* (T_4 and T_3). The lowest uptake of potassium by maize crop was recorded with unmanured plots with or without the use of *panchagavya*.

4.1.21 Gross Returns

Gross returns from raising of maize crop were significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4. 18).

The highest gross returns were realised with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which in turn maintained parity among them. The latter three treatments maintained statistical superiority over poultry manure, and neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest amount of gross returns were obtained with unmanured plot (T_1).

Table 4.18: Economics of maize as influenced by varied manurial practices and *Panchagavya* spray

	Treatments	Gross returns (Rs ha^{-1})		Net returns (Rs ha^{-1})		Benefit-cost ratio	
		2004	2005	2004	2005	2004	2005
T_1	No manure	6806	7105	26	325	1.00	1.05
T_2	No manure + *panchagavya*	8101	8510	1021	1430	1.14	1.20
T_3	Recommended dose of fertilizer	25649	26894	12869	14114	2.01	2.10
T_4	Recommended dose of fertilizer + *panchagavya*	26222	27302	13142	14222	1.99	2.09
T_5	Farm Yard Manure	20989	21270	10681	10962	2.04	2.06
T_6	Farm Yard Manure + *panchagavya*	23593	24400	12985	13792	2.22	2.30
T_7	Vermicompost	20246	20786	8966	9506	1.79	1.84
T_8	Vermicompost + *panchagavya*	22772	23691	11192	12111	1.97	2.05
T_9	Neem leaf	17479	17558	8299	8378	1.90	1.91
T_{10}	Neem leaf + *panchagavya*	17773	17796	8293	8316	1.87	1.88
T_{11}	Poultry manure	18030	18089	10306	10365	2.33	2.34
T_{12}	Poultry manure + *panchagavya*	18404	18380	10650	10356	2.29	2.29
T_{13}	Pig manure	20642	21029	8507	8894	1.70	1.73
T_{14}	Pig manure + *panchagavya*	23177	24015	10742	11580	1.86	1.93
	SEm±	370.9	395.8	231.7	278.9	0.046	0.051
	CD (P = 0.05)	1076	1124	658	792	0.13	0.14

4.1.22 Net Returns

Net returns from raising of maize crop were significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.18).

The highest net returns were realised with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however comparable with recommended dose of fertilizer (T_3) and farm yard manure in combination with application of *panchagavya* (T_6), which were significantly higher than with vermicompost or pig manure in combination with *panchagavya*, farm yard manure alone and poultry manure along with *panchagavya* (T_8, T_{14}, T_5, T_{12} and T_{11}), which were comparable among them, but significantly higher than with vermicompost or pig manure alone and neem leaf manure with or without *panchagavya* (T_7, T_{13}, T_9 and T_{10}), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest amount of net returns were obtained with unmanured plot (T_1).

4.1.23 Benefit - cost Ratio

Benefit -cost ratio of raising of maize crop was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.18).

The highest benefit -cost ratio was recorded with poultry manure along with *panchagavya* spray (T_{12}), which was however, comparable with Poultry manure alone (T_{11}) and farm yard manure in combination with application of *panchagavya* (T_6) and significantly higher than with all other manurial practices tried either with or without *panchagavya*, which were comparable among them, but significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest benefit -cost ratio was recorded with unmanured plot (T_1).

4.1.24 Post harvest Soil Fertility Status

4.1.24.1 Soil organic carbon

Post harvest soil organic carbon status after maize crop was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study, but differed in magnitude (Table 4.19 and 4.20).

The highest status of soil organic carbon post harvest of maize was recorded with neem leaf manure (T_9), which was however comparable with neem leaf manure in combination with *panchagavya* (T_{10}), vermicompost or farm yard manure with or without the use of *panchagavya* (T_7, T_8, T_5 and T_6) and significantly superior to pig manure or poultry manure either with or without *panchagavya* spray (T_{13}, T_{14}, T_{11} and T_{12}), which were comparable among them. The lowest status of post harvest soil organic carbon was recorded with unmanured plot with the use of *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1) and supply of recommended dose of nitrogen through fertilizer either with or without *panchagavya* (T_4 and T_3).

4.1.24.2 Soil available nitrogen

Post harvest soil available nitrogen status after maize crop was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study, but differed in magnitude (Table 4.19 and 4.20).

The highest status of soil available nitrogen post harvest of maize was recorded with neem leaf manure (T_9), which was however, comparable with neem leaf manure in combination with *panchagavya* (T_{10}) and significantly higher than with poultry manure either with or without p*anchagavya* spray (T_{11} and T_{12}), which was comparable between them and superior to vermicompost with or without the use of *panchagavya* (T_7 and T_8), which in turn was significantly higher than with pig manure or farm yard manure either with or without p*anchagavya* spray ($T_{13,}$ $T_{14,}$ T_5 and T_6), which were comparable among them. Supply of recommended dose of nitrogen through fertilizer with or without p*anchagavya* spray recorded significantly lesser status of soil available nitrogen than with any of the organic sources either with or without p*anchagavya* spray (T_4 and

Table 4.19 : Post harvest soil fertility status after maize as influenced by varied manurial practices and *Panchagavya* spray - 2003

Treatments		Organic Carbon (%)	Available Nitrogen (kg ha^{-1})	Available Phosphorus* (kg ha^{-1})	Available Potassium** (kg ha^{-1})
T_1	No manure	0.18	108.2	15.24	167.2
T_2	No manure + *panchagavya*	0.18	107.5	15.06	167.0
T_3	Recommended dose of fertilizer	0.21	128.4	38.28	228.2
T_4	Recommended dose of fertilizer + *panchagavya*	0.21	127.2	37.65	225.8
T_5	Farm Yard Manure	0.35	141.2	30.42	234.2
T_6	Farm Yard Manure + *panchagavya*	0.35	140.5	29.75	230.8
T_7	Vermicompost	0.36	150.4	33.04	254.8
T_8	Vermicompost + *panchagavya*	0.36	148.8	32.86	251.5
T_9	Neem leaf	0.38	158.6	36.2	236.4
T_{10}	Neem leaf + *panchagavya*	0.38	158.2	35.92	234.5
T_{11}	Poultry manure	0.28	155.2	41.86	229.5
T_{12}	Poultry manure + *panchagavya*	0.28	154.6	41.54	228.4
T_{13}	Pig manure	0.30	142.5	36.84	248.6
T_{14}	Pig manure + *panchagavya*	0.30	141.8	36.40	245.4
	SEm±	0.014	0.99	0.768	2.89
	CD (P = 0.05)	0.04	2.8	2.18	8.2

* P ** K

Table 4.20: Post harvest soil fertility status after maize as influenced by varied manurial practices and *Panchagavya* spray - 2004

	Treatments	Organic Carbon (%)	Available Nitrogen (kg ha^{-1})	Available Phosphorus* (kg ha^{-1})	Available Potassium** (kg ha^{-1})
T_1	No manure	0.16	90.4	11.85	142.6
T_2	No manure + *panchagavya*	0.16	90.1	11.72	140.8
T_3	Recommended dose of fertilizer	0.18	136.8	55.54	280.5
T_4	Recommended dose of fertilizer + *panchagavya*	0.18	134.9	55.12	276.4
T_5	Farm Yard Manure	0.42	178.2	35.94	292.4
T_6	Farm Yard Manure + *panchagavya*	0.42	175.6	35.70	288.2
T_7	Vermicompost	0.45	190.9	41.34	318.4
T_8	Vermicompost + *panchagavya*	0.45	189.8	40.54	315.8
T_9	Neem leaf	0.46	215.9	48.28	298.2
T_{10}	Neem leaf + *panchagavya*	0.46	214.8	47.65	295.8
T_{11}	Poultry manure	0.34	202.6	63.24	286.5
T_{12}	Poultry manure + *panchagavya*	0.34	201.7	62.85	282.8
T_{13}	Pig manure	0.35	181.2	53.92	312.4
T_{14}	Pig manure + *panchagavya*	0.35	180.6	50.98	309.5
	SEm±	0.18	1.90	1.324	3.70
	CD (P = 0.05)	0.05	5.4	3.76	10.5

* P ** K

T_3). The lowest status of post harvest soil available nitrogen was recorded with unmanured plot (T_1), which was however, comparable with unmanured plot with the use of *panchagavya* (T_2).

4.1.24.3 Soil available phosphorus

Post harvest soil available phosphorus status after maize crop was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study, but differed in magnitude (Table 4.19 and 4.20).

The highest status of soil available phosphorus post harvest of maize was recorded with poultry manure (T_{11}), which was comparable with poultry manure *along* with *panchagavya* (T_{12}) and significantly higher than with fertilizer or pig manure or neem leaf manure with or without *panchagavya* (T_3, T_4, T_{13}, T_{14}, T_9 and T_{10}), which were comparable among them and superior to vermicompost with or without *panchagavya,* (T_7 and T_8), which in turn were statistically superior to farm yard manure with or without *panchagavya* (T_5 and T_6). The lowest status of soil available phosphorus was recorded with unmanured plot with *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1).

4.1.24.4 Soil available potassium

Post harvest soil available potassium status after maize crop was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study, but differed in magnitude (Table 4.19 and 4.20).

The highest soil available potassium status post harvest of maize was recorded with vermicompost (T_7), which was however, comparable with vermicompost along *panchagavya*, pig manure with or without *panchagavya* (T_8, T_{14} and T_{13}) and significantly higher than with neem leaf manure or farm yard manure or poultry manure or fertilizer either with or without *panchagavya,* (T_9, T_{10}, T_5, T_6, T_{11}, T_{12}, T_3 and T_4), which were comparable among them. The lowest soil available potassium status was recorded with unmanured plot with *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1).

4.2 SUNFLOWER (LATE *RABI*, 2003 AND 2004)

4.2.1 Plant Height

Plant height of sunflower measured at 15, 30, 45 DAS and at heading was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.21).

Table 4.21: Plant height (cm) of sunflower as influenced by varied manurial practices and *Panchagavya* spray

Treatments		2003				2004			
		15 DAS	30 DAS	45 DAS	At heading	15 DAS	30 DAS	45 DAS	At Heading
T_1	No manure	8.7	12.5	39.6	64.5	8.9	14.2	41.9	62.4
T_2	No manure + *panchagavya*	8.7	16.2	52.8	78.7	8.9	18.9	53.0	72.5
T_3	Recommended dose of fertilizer	15.3	35.2	102.8	134.2	15.5	37.4	98.2	134.5
T_4	Recommended dose of fertilizer + *panchagavya*	15.4	35.7	103.6	135.6	15.9	38.1	100.8	137.4
T_5	Farm Yard Manure	14.6	28.8	81.4	110.2	14.6	30.8	82.8	106.2
T_6	Farm Yard Manure + *panchagavya*	15.2	32.4	93.5	123.5	15.2	34.2	91.4	122.8
T_7	Vermicompost	14.5	28.2	78.2	106.2	14.6	30.2	82.2	102.5
T_8	Vermicompost + *panchagavya*	15.0	31.8	91.2	121.6	15.0	34.0	91.2	120.6
T_9	Neem leaf	15.0	29.4	83.5	112.8	14.8	31.4	83.5	110.3
T_{10}	Neem leaf + *panchagavya*	15.3	33.1	95.2	125.8	15.2	35.0	91.6	124.2
T_{11}	Poultry manure	14.8	29.2	82.2	111.6	14.8	31.0	83.2	108.6
T_{12}	Poultry manure + *panchagavya*	15.2	32.8	94.6	124.6	15.2	34.6	91.4	123.3
T_{13}	Pig manure	14.5	28.6	80.6	108.8	14.6	30.4	82.4	104.8
T_{14}	Pig manure + *panchagavya*	15.2	32.2	93.2	122.8	15.0	34.0	91.2	121.6
	SEm±	0.39	0.67	2.39	2.78	0.46	0.77	2.25	2.89
	CD (P = 0.05)	1.1	1.9	6.8	7.9	1.3	2.2	6.4	8.2

At all the crop growth stages of observation, except at 15 DAS, the tallest plants of sunflower were produced with recommended dose of fertilizer + *panchagavya* spray (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and significantly taller than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} and T_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the plants of the shortest stature were recorded with no manure (T_1).

At 15 DAS, plant height of sunflower was comparable with all the manurial practices tried, which was significantly higher than with no manuring either with or without *panchagavya* spray.

4.2.2 Leaf Area Index

Leaf area index (LAI) of sunflower at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.22 and 4.23).

Table 4.22: Leaf area index of sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2003

		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	0.18	0.21	0.38	0.46	0.35	0.26
T_2	No manure + *panchagavya*	0.18	0.38	0.52	0.72	0.62	0.50
T_3	Recommended dose of fertilizer	0.62	0.83	1.48	1.81	1.65	1.40
T_4	Recommended dose of fertilizer + *panchagavya*	0.62	0.83	1.49	1.84	1.68	1.40
T_5	Farm Yard Manure	0.54	0.62	1.18	1.42	1.28	1.08
T_6	Farm Yard Manure + *panchagavya*	0.58	0.73	1.35	1.62	1.48	1.25
T_7	Vermicompost	0.54	0.60	1.18	1.40	1.28	1.06
T_8	Vermicompost + *panchagavya*	0.56	0.73	1.34	1.60	1.46	1.24
T_9	Neem leaf	0.56	0.63	1.20	1.43	1.30	1.10
T_{10}	Neem leaf + *panchagavya*	0.60	0.74	1.36	1.65	1.50	1.26
T_{11}	Poultry manure	0.55	0.63	1.20	1.42	1.30	1.10
T_{12}	Poultry manure + *panchagavya*	0.58	0.74	1.36	1.65	1.50	1.26
T_{13}	Pig manure	0.54	0.62	1.18	1.40	1.28	1.08
T_{14}	Pig manure + *panchagavya*	0.56	0.73	1.34	1.62	1.48	1.24
	SEm±	0.028	0.028	0.039	0.053	0.049	0.042
	CD (P = 0.05)	0.08	0.08	0.11	0.15	0.14	0.12

Table 4.23: Leaf area index of sunflower as influenced varied manurial practices and *Panchagavya* spray - 2004

		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	0.15	0.26	0.38	0.49	0.39	0.32
T_2	No manure + *panchagavya*	0.15	0.39	0.68	0.73	0.64	0.54
T_3	Recommended dose of fertilizer	0.62	0.84	1.66	1.84	1.68	1.42
T_4	Recommended dose of fertilizer + *panchagavya*	0.64	0.84	1.68	1.87	1.70	1.44
T_5	Farm Yard Manure	0.56	0.64	1.34	1.42	1.30	1.10
T_6	Farm Yard Manure + *panchagavya*	0.60	0.74	1.50	1.64	1.50	1.26
T_7	Vermicompost	0.54	0.64	1.32	1.40	1.30	1.10
T_8	Vermicompost + *panchagavya*	0.58	0.74	1.50	1.62	1.48	1.25
T_9	Neem leaf	0.56	0.66	1.35	1.45	1.32	1.12
T_{10}	Neem leaf + *panchagavya*	0.62	0.76	1.52	1.66	1.52	1.28
T_{11}	Poultry manure	0.56	0.66	1.35	1.45	1.32	1.12
T_{12}	Poultry manure + *panchagavya*	0.60	0.76	1.51	1.64	1.52	1.28
T_{13}	Pig manure	0.54	0.64	1.32	1.42	1.30	1.10
T_{14}	Pig manure + *panchagavya*	0.58	0.74	1.50	1.62	1.50	1.26
	SEm±	0.032	0.021	0.042	0.056	0.049	0.042
	CD (P = 0.05)	0.09	0.06	0.12	0.16	0.14	0.12

At all the crop growth stages of observation, except at 15 DAS, the largest LAI of sunflower was recorded with recommended dose of fertilizer + *panchagavya* spray (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly larger than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the lowest LAI was recorded with no manure (T_1).

At 15 DAS, the LAI of sunflower was comparable with all the manurial practices tried, which was significantly higher than with no manuring with or without *panchagavya* spray.

4.2.3 Dry Matter Production

Dry matter production of sunflower measured at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4. 24 and 4.25).

Table 4.24: Dry matter production (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2003

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	58	118	521	772	1028	1325
T_2	No manure + *panchagavya*	61	142	645	986	1412	1532
T_3	Recommended dose of fertilizer	150	252	1138	2018	2920	4448
T_4	Recommended dose of fertilizer + *panchagavya*	154	258	1156	2063	3004	4503
T_5	Farm Yard Manure	138	194	898	1528	2084	3752
T_6	Farm Yard Manure + *panchagavya*	146	228	1038	1786	2546	4187
T_7	Vermicompost	138	190	858	1472	1976	3677
T_8	Vermicompost + *panchagavya*	140	220	1008	1722	2462	4093
T_9	Neem leaf	138	204	932	1584	2175	3853
T_{10}	Neem leaf + *panchagavya*	148	234	1068	1842	2642	4252
T_{11}	Poultry manure	138	198	914	1545	2128	3800
T_{12}	Poultry manure + *panchagavya*	148	230	1052	1824	2598	4198
T_{13}	Pig manure	138	192	872	1496	2012	3707
T_{14}	Pig manure + *panchagavya*	142	224	1024	1758	2486	4142
	SEm±	4.9	6.7	21.8	43.7	90.8	63.7
	CD (P = 0.05)	14	19	62	124	258	181

Table 4.25: Dry matter production (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2004

Treatments		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	72	122	314	534	812	1436
T_2	No manure + *panchagavya*	78	148	542	762	1185	1724
T_3	Recommended dose of fertilizer	172	272	1386	1798	2312	4586
T_4	Recommended dose of fertilizer + *panchagavya*	172	275	1409	1844	2363	4642
T_5	Farm Yard Manure	156	188	982	1218	1798	3868
T_6	Farm Yard Manure + *panchagavya*	166	238	1198	1532	2076	4278
T_7	Vermicompost	154	180	948	1154	1738	3748
T_8	Vermicompost + *panchagavya*	162	228	1158	1482	2028	4168
T_9	Neem leaf	158	198	1024	1278	1854	3942
T_{10}	Neem leaf + *panchagavya*	170	244	1248	1596	2138	4364
T_{11}	Poultry manure	158	192	1006	1246	1826	3898
T_{12}	Poultry manure + *panchagavya*	166	240	1225	1564	2104	4304
T_{13}	Pig manure	154	186	964	1185	1765	3793
T_{14}	Pig manure + *panchagavya*	164	232	1184	1506	2052	4234
	SEm±	6.7	8.5	45.4	61.6	57.7	71.8
	CD (P = 0.05)	19	24	129	175	164	204

At all the crop growth stages of observation, except at 15 DAS, the highest dry matter production of sunflower was recorded with recommended dose of fertilizer + *panchagavya* spray (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly larger than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the lowest dry matter production was recorded with no manure (T_1).

At 15 DAS, dry mater production of sunflower was comparable with all the manurial practices tried, which was significantly higher than with no manuring with or without *panchagavya* spray.

4.2.4 Days to 50% Flowering

Days to 50% flowering of sunflower was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.26).

The earliest flowering of sunflower was noticed with no manure either with or without *panchagavya* (T_2 and T_1), which was significantly earlier than with all other manurial practices tried. Most delayed flowering (tasseling and silking) was observed with recommended dose of fertilizer with or without *panchagavya* spray, which took significantly more number of days than with all other organic sources of manuring with or without *panchagavya* spray, which were comparable among them.

4.2.5 Head Diameter

The diameter of sunflower head was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.26).

The largest diameter of sunflower head was noticed with recommended dose of fertilizer + *panchagavya* spray (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly larger than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the heads of smallest diameter were observed with no manure (T_1).

4.2.6 Total Number of Seeds Head^{-1}

Number of total seeds head^{-1} of sunflower was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4. 26).

The highest number of total seeds head^{-1} of sunflower was noticed with recommended dose of fertilizer + *panchagavya* spray (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the lowest number of total seeds head^{-1} of sunflower was observed with unmanured control (T_1).

4.2.7 Number of Filled Seeds Head^{-1}

Number of filled seeds head^{-1} of sunflower was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.26).

Table 4.26:Days to 50% flowering and yield attributes of sunflower as influenced by varied manurial practices *Panchagavya* spray

Treatments		Days to 50% flowering		Head diameter (cm)		Total seeds head^{-1}		Filled seeds head^{-1}		1000 seed weight	
		2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
T_1	No manure	52	53	7.3	7.8	153	169	117	135	29.4	31.2
T_2	No manure + *panchagavya*	52	53	9.5	10.0	186	202	168	182	32.4	33.2
T_3	Recommended dose of fertilizer	60	61	16.0	17.2	396	404	325	347	40.7	41.8
T_4	Recommended dose of fertilizer + *panchagavya*	60	61	16.3	17.5	403	412	331	352	40.9	42.1
T_5	Farm Yard Manure	55	56	12.0	13.2	290	288	252	280	37.2	37.0
T_6	Farm Yard Manure + *panchagavya*	56	57	14.0	15.2	350	353	294	318	39.2	40.0
T_7	Vermicompost	55	56	12.0	13.0	280	274	248	268	37.0	36.8
T_8	Vermicompost + *panchagavya*	56	57	13.8	15.0	340	336	284	310	39.0	38.8
T_9	Neem leaf	55	56	12.2	13.4	302	302	262	286	37.5	37.2
T_{10}	Neem leaf + *panchagavya*	57	58	14.2	15.5	362	368	304	324	39.4	40.2
T_{11}	Poultry manure	55	56	12.2	13.2	296	292	258	282	37.4	37.0
T_{12}	Poultry manure + *panchagavya*	57	58	14.0	15.5	358	361	298	320	39.2	40.0
T_{13}	Pig manure	55	56	12.0	13.0	284	280	250	275	37.2	36.8
T_{14}	Pig manure + *panchagavya*	56	57	13.8	15.0	345	348	288	312	39.0	38.8
	SEm±	0.70	0.70	0.49	0.53	10.21	11.27	6.69	7.39	0.42	0.49
	CD (P = 0.05)	2	2	1.4	1.5	29	32	19	21	1.2	1.4

The highest number of filled seeds head^{-1} of sunflower was noticed with recommended dose of fertilizer + *panchagavya* spray (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the lowest number of filled seeds head^{-1} of sunflower was recorded with unmanured control (T_1).

4.2.8 Thousand Seed Weight

Thousand seed weight of sunflower was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.26).

The highest thousand seed weight of sunflower was recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the heads of smallest diameter were observed with no manure (T_1).

4.2.9 Seed Yield

Seed yield of sunflower was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.27).

The highest seed yield of sunflower was produced with recommended dose of fertilizer + *panchagavya* spray (T_4), which was however, comparable with recommended dose of N through fertilizer (T_3) and significantly higher than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the lowest seed yield of sunflower was obtained with no manure (T_1).

Table 4.27: Seed Yield, stalk yield, harvest index and oil content of sunflower as influenced by varied manurial practices and *Panchagavya* spray

Treatments		Seed yield (kg ha^{-1})		Stalk yield (kg ha^{-1})		Harvest Index (%)		Oil content (%)	
		2003	2004	2003	2004	2003	2004	2003	2004
T_1	No manure	442	484	618	754	33.36	33.70	31.3	31.6
T_2	No manure + *panchagavya*	526	594	804	928	34.33	34.45	33.5	33.8
T_3	Recommended dose of fertilizer	1669	1729	2225	2284	37.52	37.70	36.2	36.4
T_4	Recommended dose of fertilizer + *panchagavya*	1696	1757	2264	2302	37.66	37.85	36.4	36.5
T_5	Farm Yard Manure	1328	1375	1838	1925	35.39	35.55	38.6	39.0
T_6	Farm Yard Manure + *panchagavya*	1546	1586	2064	2128	36.92	37.07	40.6	41.2
T_7	Vermicompost	1292	1335	1782	1875	35.14	35.62	38.4	38.8
T_8	Vermicompost + *panchagavya*	1504	1538	2005	2092	36.75	36.90	40.6	41.2
T_9	Neem leaf	1385	1418	1884	1964	35.95	35.97	38.6	39.0
T_{10}	Neem leaf + *panchagavya*	1578	1624	2108	2162	37.11	37.21	40.9	41.5
T_{11}	Poultry manure	1354	1396	1862	1942	35.63	35.81	38.4	38.6
T_{12}	Poultry manure + *panchagavya*	1552	1602	2096	2144	36.97	37.22	40.8	41.5
T_{13}	Pig manure	1305	1352	1816	1906	35.20	35.64	38.4	38.8
T_{14}	Pig manure + *panchagavya*	1528	1564	2028	2104	36.89	36.94	40.4	41.0
	SEm±	28.5	33.1	39.4	41.9	0.127	0.138	0.56	0.60
	CD (P = 0.05)	81	94	112	119	0.36	0.39	1.6	1.7

4.2.10 Stalk Yield

Stalk yield of sunflower was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.27).

The highest stalk yield of sunflower was produced with recommended dose of fertilizer + *panchagavya* spray (T_4), which was however, comparable with recommended dose of N through fertilizer (T_3) and significantly higher than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1) and the lowest stalk yield was recorded with unmanured plot (T_1).

4.2.11 Harvest Index

Harvest Index of sunflower was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.27).

The highest harvest Index of sunflower was recorded with recommended dose of fertilizer + *panchagavya* spray (T_4), which was however, comparable with recommended dose of N through fertilizer (T_3) and significantly higher than that with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments were significantly superior to no manure either with or without *panchagavya* spray (T_2 and T_1), with the lowesto harvest index of sunflower being recorded with no manure (T_1).

4.2.12 Oil Content

Oil content in the sunflower seed was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4. 27).

The highest oil content in the seed of sunflower was recorded neem leaf manure in combination with *panchagavya* spray (T_{10}), which was comparable with all other organic sources tried in combination with *panchagavya* (T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with all the organic sources without *panchagavya* (T_9, T_{11}, T_5, T_{13} and T_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over recommended dose of fertilizer either with or without *panchagavya* (T_4 and T_3), which were comparable between them and significantly higher than with no manure + *panchagavya* spray (T_2) and no manure (T_1). The oil content of sunflower seed was found to be the lowest with unmanured plot (T_1).

4.2.13 Nitrogen Uptake

Nitrogen uptake of sunflower estimated at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4. 28and 4.29).

During both the years of study, at all the crop growth stages of observation, the highest nitrogen uptake by sunflower was recorded with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which was however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13}

Table 4.28: Nitrogen uptake (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2003

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	1.0	2.2	6.9	12.2	15.6	20.4
T_2	No manure + *panchagavya*	1.4	2.8	8.4	14.8	20.8	26.5
T_3	Recommended dose of fertilizer	4.2	8.2	24.6	50.4	63.0	75.8
T_4	Recommended dose of fertilizer + *panchagavya*	4.3	8.4	25.0	50.4	63.4	76.4
T_5	Farm Yard Manure	3.0	6.5	19.8	42.5	53.4	64.6
T_6	Farm Yard Manure + *panchagavya*	3.7	7.4	22.6	46.8	59.2	70.8
T_7	Vermicompost	2.8	6.4	19.6	41.4	51.8	63.2
T_8	Vermicompost + *panchagavya*	3.6	7.2	21.8	46.2	58.2	69.4
T_9	Neem leaf	3.2	6.6	20.4	43.4	54.8	66.0
T_{10}	Neem leaf + *panchagavya*	3.8	7.6	23.2	47.8	59.6	72.2
T_{11}	Poultry manure	3.2	6.6	20.0	43.0	54.2	65.2
T_{12}	Poultry manure + *panchagavya*	3.8	7.6	23.0	47.2	59.3	71.4
T_{13}	Pig manure	3.0	6.4	19.8	42.2	52.6	63.8
T_{14}	Pig manure + *panchagavya*	3.7	7.4	22.4	46.4	58.9	70.2
	SEm±	0.11	0.18	0.42	0.85	1.06	1.13
	CD (P = 0.05)	0.3	0.5	1.2	2.4	3.0	3.2

Table 4.29: Nitrogen uptake (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2004

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	1.2	2.6	7.3	12.8	16.8	21.4
T_2	No manure + *panchagavya*	1.6	3.8	9.6	16.4	21.5	28.6
T_3	Recommended dose of fertilizer	4.5	8.5	25.0	50.4	63.6	78.4
T_4	Recommended dose of fertilizer + *panchagavya*	4.5	8.7	25.3	50.8	64.0	78.8
T_5	Farm Yard Manure	3.3	6.6	20.2	43.5	54.8	67.2
T_6	Farm Yard Manure + *panchagavya*	4.0	7.6	23.0	47.2	59.6	73.5
T_7	Vermicompost	3.2	6.5	20.0	42.8	53.6	65.6
T_8	Vermicompost + *panchagavya*	3.8	7.5	22.4	47.0	58.6	72.0
T_9	Neem leaf	3.4	6.8	21.0	44.2	55.6	68.6
T_{10}	Neem leaf + *panchagavya*	4.1	7.8	23.6	47.8	60.4	74.8
T_{11}	Poultry manure	3.3	6.8	20.6	43.8	55.2	68.0
T_{12}	Poultry manure + *panchagavya*	4.0	7.8	23.2	47.5	60.0	74.2
T_{13}	Pig manure	3.2	6.5	20.2	43.2	54.2	66.4
T_{14}	Pig manure + *panchagavya*	3.8	7.6	22.8	47.0	59.2	72.8
	SEm±	0.07	0.21	0.42	0.89	1.02	1.13
	CD (P = 0.05)	0.3	0.6	1.2	2.5	2.9	3.2

andT_7), which in turn maintained parity. The latter five treatments were significantly superior to no manure with or without *panchagavya* spray (T_2 and T_1) and the lowest nitrogen uptake was recorded with unmanured plot (T_1).

4.2.14 Phosphorus Uptake

Phosphorus uptake of sunflower estimated at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with unaltered trend during both the years of study (Table 4.30 and 4.31).

The highest phosphorus uptake of sunflower was recorded with poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}). The next highest phosphorus uptake was associated with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with neem leaf manure or vermicompost with or without *panchagavya,* (T_{10}, T_9, T_8 and T_7), which in turn was statistically superior to farm yard manure or recommended dose of fertilizer with or without *panchagavya* (T_6, T_5, T_4 and T_3). The lowest uptake of phosphorus by sunflower crop was recorded with unmanured plots with or without use of *panchagavya*.

Table 4.30: Phosphorus uptake (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2003

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	0.22	0.92	1.42	2.74	3.62	4.75
T_2	No manure + *panchagavya*	0.40	0.96	1.46	2.82	3.68	4.82
T_3	Recommended dose of fertilizer	0.92	1.18	2.38	3.54	4.72	7.80
T_4	Recommended dose of fertilizer + *panchagavya*	0.94	1.26	2.42	3.68	4.80	8.10
T_5	Farm Yard Manure	1.08	1.52	2.98	4.04	5.70	8.75
T_6	Farm Yard Manure + *panchagavya*	1.08	1.52	2.98	4.08	5.74	9.50
T_7	Vermicompost	1.10	1.55	3.00	4.16	5.82	9.54
T_8	Vermicompost + *panchagavya*	1.12	1.56	3.05	4.29	5.86	9.58
T_9	Neem leaf	1.22	1.76	3.42	4.74	6.76	10.76
T_{10}	Neem leaf + *panchagavya*	1.24	1.78	3.45	4.82	6.82	10.82
T_{11}	Poultry manure	1.36	2.22	4.24	5.80	8.68	13.28
T_{12}	Poultry manure + *panchagavya*	1.40	2.24	4.25	5.84	8.75	13.40
T_{13}	Pig manure	1.24	1.97	3.82	5.28	7.74	12.02
T_{14}	Pig manure + *panchagavya*	1.25	2.02	3.86	5.35	7.78	12.10
	SEm±	0.032	0.063	0.127	0.155	0.310	0.394
	CD (P = 0.05)	0.09	0.18	0.36	0.44	0.88	1.12

Table 4.31: Phosphorus uptake (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2004

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	0.31	0.86	1.38	2.58	3.35	5.32
T_2	No manure + *panchagavya*	0.34	0.89	1.43	2.64	3.42	5.38
T_3	Recommended dose of fertilizer	0.62	1.30	2.12	3.36	4.28	8.20
T_4	Recommended dose of fertilizer + *panchagavya*	0.65	1.34	2.18	3.48	4.42	8.26
T_5	Farm Yard Manure	0.76	1.52	2.54	3.95	5.40	9.68
T_6	Farm Yard Manure + *panchagavya*	0.76	1.52	2.60	4.04	5.42	9.76
T_7	Vermicompost	0.78	1.54	2.68	4.12	5.46	9.82
T_8	Vermicompost + *panchagavya*	0.78	1.56	2.74	4.18	5.50	9.90
T_9	Neem leaf	0.9	1.73	3.12	4.62	6.36	11.04
T_{10}	Neem leaf + *panchagavya*	0.92	1.80	3.20	4.74	6.45	11.16
T_{11}	Poultry manure	1.15	2.18	3.98	5.70	8.25	13.96
T_{12}	Poultry manure + *panchagavya*	1.17	2.19	4.07	5.77	8.39	14.10
T_{13}	Pig manure	1.03	1.98	3.56	5.18	7.32	12.40
T_{14}	Pig manure + *panchagavya*	1.04	2.01	3.62	5.26	7.38	12.70
	SEm±	0.032	0.056	0.123	0.148	0.296	0.408
	CD (P = 0.05)	0.09	0.16	0.35	0.42	0.84	1.16

4.2.15 Potassium Uptake

Potassium uptake of sunflower estimated at 15, 30, 45, 60, 75 DAS and at harvest was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.32 and 4.33).

The highest potassium uptake of sunflower was recorded with vermicompost either with or without the spray of *panchagavya* (T_8 and T_7). The next highest potassium uptake was associated with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of farm yard manure or neem leaf manure or poultry manure with or without *panchagavya,* (T_6, T_{10}, T_{12}, T_5, T_9, and T_{11}), which were comparable among them, but statistically superior to recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3). The lowest uptake of potassium by sunflower crop was recorded with unmanured plots with or without use of *panchagavya.*

4.2.16 Gross Returns

Gross returns from raising of sunflower crop were significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.34).

Table 4.32: Potassium uptake (kg ha^{-1}) of sunflower as influenced varied manurial practices and *Panchagavya* spray - 2003

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	3.2	5.8	10.8	12.8	21.8	31.5
T_2	No manure + *panchagavya*	3.5	6.2	11.4	13.2	22.6	32.6
T_3	Recommended dose of fertilizer	6.8	9.4	18.4	22.8	35.5	47.8
T_4	Recommended dose of fertilizer + *panchagavya*	7.2	9.9	19.0	23.5	36.1	48.6
T_5	Farm Yard Manure	8.6	14.5	27.8	32.0	49.2	59.6
T_6	Farm Yard Manure + *panchagavya*	8.6	14.5	28.2	32.2	49.6	60.4
T_7	Vermicompost	9.9	16.8	31.8	36.5	55.4	67.8
T_8	Vermicompost + *panchagavya*	10.0	17.0	32.0	36.8	55.9	68.4
T_9	Neem leaf	8.4	14.2	27.2	28.4	48.2	58.2
T_{10}	Neem leaf + *panchagavya*	8.5	14.2	27.5	28.6	48.4	59.0
T_{11}	Poultry manure	8.2	13.8	26.2	28.2	47.4	56.8
T_{12}	Poultry manure + *panchagavya*	8.4	14.0	26.8	28.5	47.8	57.4
T_{13}	Pig manure	9.2	15.4	29.8	34.2	52.2	63.8
T_{14}	Pig manure + *panchagavya*	9.4	15.8	30.2	34.6	52.8	64.6
	SEm±	0.14	0.28	0.49	0.63	0.81	1.06
	CD (P = 0.05)	0.4	0.8	1.4	1.8	2.3	3.0

Table 4.33: Potassium uptake (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2004

	Treatments	15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	At Harvest
T_1	No manure	3.6	8.2	12.1	16.0	23.8	34.2
T_2	No manure + *panchagavya*	3.9	8.6	12.7	16.4	24.2	34.8
T_3	Recommended dose of fertilizer	7.2	11.6	23.0	23.6	42.0	51.6
T_4	Recommended dose of fertilizer + *panchagavya*	7.8	12.0	23.4	24.0	42.8	52.5
T_5	Farm Yard Manure	9.4	13.8	27.0	31.2	49.6	60.0
T_6	Farm Yard Manure + *panchagavya*	9.4	13.8	27.0	31.6	49.8	60.6
T_7	Vermicompost	10.8	16.6	30.8	36.5	56.0	68.0
T_8	Vermicompost + *panchagavya*	11.0	17.8	33.2	37.6	56.9	68.8
T_9	Neem leaf	9.0	13.4	26.4	30.0	48.8	58.4
T_{10}	Neem leaf + *panchagavya*	9.2	13.6	26.8	30.5	49.2	59.2
T_{11}	Poultry manure	8.8	13.2	26.2	28.8	47.6	57.2
T_{12}	Poultry manure + *panchagavya*	9.0	13.4	26.2	29.4	48.2	57.8
T_{13}	Pig manure	10.0	15.0	28.6	33.8	52.6	64.0
T_{14}	Pig manure + *panchagavya*	10.2	15.4	29.2	34.5	53.2	64.5
	SEm±	0.18	0.32	0.53	0.67	0.90	1.13
	CD (P = 0.05)	0.5	0.9	1.5	1.9	2.5	3.2

The highest gross returns were realised with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however comparable with recommended dose of fertilizer (T_3) and significantly higher than with all the organic sources tried along with *panchagavya* (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with all the organic sources without the use of *panchagavya* (T_9, T_{11}, T_5, T_{13} and T_7), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest amount of gross returns were obtained with unmanured plot (T_1).

4.2.17 Net Returns

Net returns from raising of sunflower crop were significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.34).

The highest net returns were realised with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and poultry manure in combination with *panchagavya* spray (T_{12}), which were significantly higher than with neem leaf manure or farm yard manure along with *panchagavya* spray (T_{10} and T_6), which maintained significant disparity with each other and superior to Poultry manure, vermicompost or pig

Table 4.34: Economics of sunflower as influenced by varied manurial practices and *Panchagavya* spray

Treatments	Gross returns (Rs ha^{-1})		Net returns (Rs ha^{-1})		Benefit-cost ratio	
	2003	**2004**	**2003**	**2004**	**2003**	**2004**
T_1 No manure	7072	7744	2572	3244	1.57	1.72
T_2 No manure + *panchagavya*	8416	9504	3616	4704	1.75	1.98
T_3 Recommended dose of fertilizer	26704	27664	20004	20964	3.99	4.13
T_4 Recommended dose of fertilizer + *panchagavya*	27136	28112	20136	21112	3.88	4.02
T_5 Farm Yard Manure	21248	22000	14396	15148	3.10	3.21
T_6 Farm Yard Manure + *panchagavya*	24736	25376	17584	18224	3.46	3.55
T_7 Vermicompost	20672	21360	13175	13863	2.76	2.85
T_8 Vermicompost + *panchagavya*	24064	24608	16267	16811	3.09	3.16
T_9 Neem leaf	22160	22688	16060	16588	3.63	3.72
T_{10} Neem leaf + *panchagavya*	25248	25984	18848	19584	3.95	4.06
T_{11} Poultry manure	21664	22336	16536	17208	4.22	4.36
T_{12} Poultry manure + *panchagavya*	24832	25632	19404	20204	4.57	4.72
T_{13} Pig manure	20880	21632	12810	13562	2.59	2.68
T_{14} Pig manure + *panchagavya*	24448	25024	16078	16654	2.92	2.99
SEm±	419.7	452.1	276.4	290.1	0.063	0.065
CD (P = 0.05)	1192	1284	785	824	0.18	0.18

manure along with *panchagavya* and neem leaf manuring (T_{11}, T_8, T_{14} and T_9) which were comparable among them, but significantly higher than with farm yard manure (T_5) and it was in turn superior to vermicompost (T_7) and Pig manure (T_{13}), which were comparable between them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest amount of net returns were obtained with unmanured plot (T_1).

4.2.18 Benefit - cost Ratio

Benefit -cost ratio of raising of sunflower crop was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study (Table 4.34).

The highest benefit -cost ratio was recorded with poultry manure along with *panchagavya* spray (T_{12}), which was significantly superior to all other manurial practices tried either with or without the use of *panchagavya.* The next best treatment was Poultry manure alone (T_{11}), which was significantly higher than with recommended dose of N through fertilizer with or without *panchagavya* spray (T_3 and T_4)) and neem leaf manure along with *panchagavya* spray (T_{10}) which were comparable among them, but significantly higher than with neem leaf manure or farm yard manure in combination with *panchagavay* (T_9 and T_6) , which in turn were comparable and significantly higher than with farm yard manure (T_5), vermicompost or pig manure either with or without *panchagavya* spray (T_8, T_{14}, T_7 and T_{13}), which were on par and significantly superior to no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest benefit -cost ratio was recorded with unmanured plot (T_1).

4.2.19 Post harvest Soil Fertility Status

4.2.19.1 Soil organic carbon

Post harvest soil organic carbon status after sunflower crop was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study, but differed in magnitude (Table 4.35 and 4.36).

The highest status of soil organic carbon post harvest of sunflower was recorded with neem leaf manure (T_9), which was however comparable with neem leaf manure in combination with *panchagavya* (T_{10}), vermicompost or farm yard manure with or without the use of *panchagavya* (T_7, T_8, T_5 and T_6) and significantly superior to pig manure or poultry manure either with or without *panchagavya* spray (T_{13}, T_{14}, T_{11} and T_{12}), which were comparable among them. The lowest status of post harvest soil organic carbon was recorded with unmanured plot with the use of *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1) and supply of recommended dose of nitrogen through fertilizer either with or without *panchagavya* (T_4 and T_3).

4.2.19.2 Soil available nitrogen

Post harvest soil available nitrogen status after sunflower crop was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study, but differed in magnitude (Table 4.35 and 4.36).

The highest status of soil available nitrogen post harvest of sunflower was recorded with neem leaf manure (T_9), which was however, comparable with neem leaf manure in combination with *panchagavya* (T_{10}) and significantly higher than with poultry manure either with or without *panchagavya* spray (T_{11} and T_{12}), which was comparable between them and superior to vermicompost with or without the use of *panchagavya* (T_7 and T_8), which in turn was significantly higher than with pig manure or farm yard manure either with or without *panchagavya* spray ($T_{13,}$ $T_{14,}$ T_5 and T_6), which were comparable among them. Supply of recommended dose of nitrogen through fertilizer with or without *panchagavya* spray recorded significantly lesser status of soil available nitrogen than with any of the organic sources either with or without *panchagavya* spray (T_4 and T_3). The lowest status of post harvest soil available nitrogen was recorded with unmanured plot (T_1), which was however, comparable with unmanured plot with the use of *panchagavya* (T_2).

Table 4.35: Post harvest soil fertility status after sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2003

	Treatments	Organic Carbon (%)	Available Nitrogen (kg ha^{-1})	Available Phosphorus* (kg ha^{-1})	Available Potassium** (kg ha^{-1})
T_1	No manure	0.16	103.5	13.80	160.8
T_2	No manure + *panchagavya*	0.16	103.0	13.58	160.2
T_3	Recommended dose of fertilizer	0.20	118.5	31.42	204.6
T_4	Recommended dose of fertilizer + *panchagavya*	0.20	117.4	30.76	202.5
T_5	Farm Yard Manure	0.39	138.0	24.72	210.2
T_6	Farm Yard Manure + *panchagavya*	0.39	138.0	24.35	208.4
T_7	Vermicompost	0.40	144.2	27.08	232.5
T_8	Vermicompost + *panchagavya*	0.40	143.4	26.26	230.8
T_9	Neem leaf	0.42	158.2	29.74	211.2
T_{10}	Neem leaf + *panchagavya*	0.42	157.5	29.46	210.6
T_{11}	Poultry manure	0.30	148.2	34.50	206.8
T_{12}	Poultry manure + *panchagavya*	0.30	147.5	33.84	205.4
T_{13}	Pig manure	0.32	138.6	30.28	228.2
T_{14}	Pig manure + *panchagavya*	0.32	138.5	29.85	226.4
	SEm±	0.021	1.09	0.521	4.86
	CD (P = 0.05)	0.06	3.1	1.48	13.8

*** P ** K**

Table 4.36: Post harvest soil fertility status after sunflower as influenced by varied manurial practices and *Panchagavya* spray - 2004

	Treatments	Organic Carbon (%)	Available Nitrogen (kg ha^{-1})	Available Phosphorus* (kg ha^{-1})	Available Potassium** (kg ha^{-1})
T_1	No manure	0.14	84.2	10.24	132.8
T_2	No manure + *panchagavya*	0.14	84.0	10.14	132.2
T_3	Recommended dose of fertilizer	0.15	125.0	47.82	216.5
T_4	Recommended dose of fertilizer + *panchagavya*	0.15	123.0	47.24	214.8
T_5	Farm Yard Manure	0.45	173.4	28.50	225.6
T_6	Farm Yard Manure + *panchagavya*	0.45	172.6	28.16	223.8
T_7	Vermicompost	0.48	181.8	40.25	298.2
T_8	Vermicompost + *panchagavya*	0.48	180.6	38.78	295.4
T_9	Neem leaf	0.49	206.2	44.86	237.5
T_{10}	Neem leaf + *panchagavya*	0.49	204.8	43.72	235.8
T_{11}	Poultry manure	0.36	193.9	55.34	218.6
T_{12}	Poultry manure + *panchagavya*	0.36	193.1	54.75	218.2
T_{13}	Pig manure	0.36	174.8	46.52	293.2
T_{14}	Pig manure + *panchagavya*	0.36	174.0	45.98	291.4
	SEm±	0.017	1.69	0.894	6.51
	CD (P = 0.05)	0.05	4.8	2.54	18.5

*** P   ** K**

T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher LAI than that of with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which recorded the lowest LAI.

4.3.3 Dry Matter Production

Dry matter production of greengram at 15, 30, 45 DAS and at harvest was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.39).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of dry matter production of greengram, which was the highest. The next highest dry matter production was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher dry matter production than with the

4.2.19.3 Soil available phosphorus

Post harvest soil available phosphorus status after sunflower crop was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study, but differed in magnitude (Table 4. 35 and 4.36).

The highest status of soil available phosphorus post harvest of sunflower was recorded with poultry manure (T_{11}), which was comparable with poultry manure *along* with *panchagavya* (T_{12}) and significantly higher than with fertilizer or pig manure or neem leaf manure with or without *panchagavya* (T_3, T_4, T_{13}, T_{14}, T_9 and T_{10}), which were comparable among them and superior to vermicompost with or without *panchagavya,* (T_7 and T_8), which in turn were statistically superior to farm yard manure with or without *panchagavya* (T_5 and T_6). The lowest status of soil available phosphorus was recorded with unmanured plot with *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1).

4.2.19.4 Soil available potassium

Post harvest soil available potassium status after sunflower crop was significantly influenced by varied manurial practices and use of *panchagavya*, with similar trend during both the years of study, but differed in magnitude (Table 4.35 and 4.36).

The highest soil available potassium status post harvest of sunflower was recorded with vermicompost (T_7), which was however, comparable with vermicompost along *panchagavya*, pig manure with or without *panchagavya* (T_8, T_{14} and T_{13}) and significantly higher than with neem leaf manure or farm yard manure or poultry manure or fertilizer either with or without *panchagavya,* (T_9, T_{10}, T_5, T_6, T_{11}, T_{12}, T_3 and T_4), which were comparable among them. The lowest soil available potassium status was recorded with unmanured plot with *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1).

4.3 GREENGRAM (Summer, 2004 and 2005)

4.3.1 Plant Height

Plant height of greengram measured at 15, 30, 45 DAS and at harvest was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.37).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of plant height of greengram, which was the highest. The next highest plant height was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with

Table 4.37: Plant height (cm) of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	2004				2005			
		15 DAS	30 DAS	45 DAS	At Harvest	15 DAS	30 DAS	45 DAS	At Harvest
T_1	No manure	6.3	10.1	17.6	22.8	6.4	15.8	18.6	26.4
T_2	No manure + *panchagavya*	6.4	10.7	18.6	23.5	6.6	16.0	18.9	27.2
T_3	Recommended dose of fertilizer	7.0	14.2	22.4	26.2	7.5	17.4	25.8	33.5
T_4	Recommended dose of fertilizer + *panchagavya*	7.3	14.5	23.0	26.8	7.7	17.5	26.2	34.0
T_5	Farm Yard Manure	7.9	16.0	24.5	29.5	8.5	18.8	28.2	36.8
T_6	Farm Yard Manure + *panchagavya*	8.0	16.2	24.8	30.2	8.5	19.2	28.5	37.2
T_7	Vermicompost	8.2	16.5	25.2	30.8	8.6	19.5	28.8	37.5
T_8	Vermicompost + *panchagavya*	8.4	16.8	25.6	31.5	8.8	19.8	29.0	38.0
T_9	Neem leaf	9.2	18.0	27.2	34.0	9.6	21.2	31.0	40.8
T_{10}	Neem leaf + *panchagavya*	9.6	18.5	27.5	34.6	9.6	21.4	31.2	41.4
T_{11}	Poultry manure	11.2	21.8	31.0	40.4	11.5	24.4	35.4	47.6
T_{12}	Poultry manure + *panchagavya*	11.4	22.2	31.4	41.1	11.7	24.6	35.7	47.9
T_{13}	Pig manure	10.3	20.0	29.0	37.2	10.5	22.8	33.2	44.4
T_{14}	Pig manure + *panchagavya*	10.6	20.4	29.4	37.8	10.7	23.1	33.5	44.8
	SEm±	0.25	0.42	0.63	0.92	0.18	0.39	0.49	0.85
	CD (P = 0.05)	0.5	1.1	1.4	2.4	0.7	1.2	1.8	2.6

or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in taller plants than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which produced the plants of the shortest stature.

4.3.2 Leaf Area Index

Leaf area index (LAI) of greengram at 15, 30,45 DAS and at harvest was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with unaltered trend during both the years of study (Table 4.38).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of LAI of greengram, which was the highest. The next best LAI was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7,

Table 4.38: Leaf area index of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	2004				2005			
		15 DAS	30 DAS	45 DAS	At Harvest	15 DAS	30 DAS	45 DAS	At Harvest
T_1	No manure	0.10	0.36	0.95	1.14	0.11	0.40	1.02	1.23
T_2	No manure + *panchagavya*	0.11	0.38	0.95	1.22	0.11	0.40	1.04	1.32
T_3	Recommended dose of fertilizer	0.13	0.56	1.10	1.45	0.13	0.54	1.22	1.56
T_4	Recommended dose of fertilizer + *panchagavya*	0.13	0.59	1.13	1.47	0.13	0.54	1.22	1.58
T_5	Farm Yard Manure	0.15	0.74	1.34	1.71	0.15	0.68	1.40	1.82
T_6	Farm Yard Manure + *panchagavya*	0.16	0.76	1.36	1.73	0.16	0.70	1.40	1.84
T_7	Vermicompost	0.16	0.76	1.37	1.73	0.16	0.70	1.42	1.84
T_8	Vermicompost + *panchagavya*	0.16	0.78	1.38	1.78	0.16	0.80	1.42	1.86
T_9	Neem leaf	0.18	0.96	1.54	2.00	0.19	0.94	1.60	2.12
T_{10}	Neem leaf + *panchagavya*	0.18	0.98	1.55	2.03	0.19	0.94	1.60	2.14
T_{11}	Poultry manure	0.22	1.20	1.91	2.51	0.23	1.24	1.95	2.65
T_{12}	Poultry manure + *panchagavya*	0.22	1.22	1.92	2.54	0.23	1.27	1.97	2.69
T_{13}	Pig manure	0.20	1.08	1.72	2.25	0.21	1.08	1.78	2.38
T_{14}	Pig manure + *panchagavya*	0.20	1.08	1.72	2.28	0.21	1.10	1.78	2.40
	SEm±	0.004	0.028	0.049	0.070	0.004	0.046	0.056	0.081
	CD (P = 0.05)	0.01	0.08	0.14	0.20	0.01	0.13	0.16	0.23

Table 4.39: Dry matter production (kg ha^{-1}) of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	2004				2005			
		15 DAS	30 DAS	45 DAS	At Harvest	15 DAS	30 DAS	45 DAS	At Harvest
T_1	No manure	108	326	924	2014	116	342	954	2085
T_2	No manure + *panchagavya*	112	342	950	2032	120	368	982	2102
T_3	Recommended dose of fertilizer	198	468	1238	2086	202	512	1324	2175
T_4	Recommended dose of fertilizer + *panchagavya*	204	474	1267	2110	212	533	1358	2192
T_5	Farm Yard Manure	258	660	1508	2186	264	698	1624	2304
T_6	Farm Yard Manure + *panchagavya*	264	678	1524	2234	272	714	1635	2336
T_7	Vermicompost	272	692	1536	2268	280	732	1654	2368
T_8	Vermicompost + *panchagavya*	282	718	1558	2332	290	745	1672	2382
T_9	Neem leaf	306	762	1612	2532	316	808	1725	2601
T_{10}	Neem leaf + *panchagavya*	320	784	1638	2564	328	824	1764	2612
T_{11}	Poultry manure	374	878	1754	2706	386	936	1918	2792
T_{12}	Poultry manure + *panchagavya*	386	890	1785	2730	394	954	1952	2808
T_{13}	Pig manure	340	829	1691	2620	352	880	1825	2685
T_{14}	Pig manure + *panchagavya*	352	842	1706	2644	360	892	1856	2721
	SEm±	6.3	11.3	16.2	19.0	7.4	12.7	17.3	24.3
	CD (P = 0.05)	18	32	46	54	21	36	49	69

residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which produced the lowest dry matter.

4.3.4 Number of Pods Plant^{-1}

Number of pods plant^{-1} of greengram was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.40).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of number of pods plant^{-1} of greengram, which was the highest. The next highest number of pods plant^{-1} was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher number of pods plant^{-1} than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which produced the lowest number of pods plant^{-1}.

4.3.5 Number of Seeds Pod^{-1}

Number of seeds pod^{-1}of greengram was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.40).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of number of seeds pod^{-1}of greengram, which was the highest. The next highest number of seeds pod^{-1} was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), ch was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher number of seeds pod^{-1} than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which produced the lowest number of seeds pod^{-1}.

Table 4.40: Yield attributes of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

Treatments		Number of pods $plant^{-1}$		Number of seeds pod^{-1}		1000 seed weight (g)	
		2003	2004	2003	2004	2003	2004
T_1	No manure	7.0	7.2	5.2	5.5	19.4	21.8
T_2	No manure + *panchagavya*	7.2	7.5	5.6	5.8	20.8	22.5
T_3	Recommended dose of fertilizer	12.8	13.0	8.2	9.0	24.2	25.6
T_4	Recommended dose of fertilizer + *panchagavya*	13.0	13.1	8.6	9.2	24.6	26.0
T_5	Farm Yard Manure	13.8	14.0	9.4	9.8	26.2	27.5
T_6	Farm Yard Manure + *panchagavya*	14.0	14.0	9.4	9.8	26.2	27.8
T_7	Vermicompost	14.2	14.2	9.6	10.0	26.4	28.0
T_8	Vermicompost + *panchagavya*	14.4	14.2	9.6	10.0	26.6	28.0
T_9	Neem leaf	15.2	15.2	10.2	10.6	28.0	29.5
T_{10}	Neem leaf + *panchagavya*	15.4	15.6	10.2	10.6	28.2	29.8
T_{11}	Poultry manure	17.2	17.6	11.2	12.0	31.3	32.8
T_{12}	Poultry manure + *panchagavya*	17.3	17.7	11.4	12.1	31.6	33.2
T_{13}	Pig manure	16.2	16.5	10.6	11.3	29.6	31.2
T_{14}	Pig manure + *panchagavya*	16.4	16.7	10.7	11.4	30.0	31.4
	SEm±	0.25	0.28	0.14	0.18	0.42	0.46
	CD (P = 0.05)	0.7	0.8	0.4	0.5	1.2	1.3

4.3.6 Thousand Seed Weight

Thousand seed weight of greengram was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.40).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of thousand seed weight of greengram, which was the highest. The next highest thousand seed weight was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher thousand seed weight than with the residual effect of non manuring to previous crops with or without *panchagavya,* (T_2 and T_1), which produced the lowest thousand seed weight.

4.3.7 Seed Yield

Seed yield of greengram was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.41).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of seed yield of greengram, which was the highest. The next best seed yield was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher seed yield of greengram than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which produced the lowest seed yield.

Table 4.41: Yield (kg ha^{-1}), harvest index and Protein content (%) of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	Seed Yield		Haulm Yield		Harvest Index		Protein Content	
		2004	2005	2004	2005	2004	2005	2004	2005
T_1	No manure	380	396	954	992	18.87	18.99	14.8	15.2
T_2	No manure + *panchagavya*	392	412	972	1016	19.29	19.60	14.8	15.2
T_3	Recommended dose of fertilizer	442	462	1204	1268	21.19	21.24	16.5	16.6
T_4	Recommended dose of fertilizer + *panchagavya*	454	476	1225	1294	21.52	21.72	16.5	16.8
T_5	Farm Yard Manure	502	526	1388	1456	22.96	22.83	20.4	20.5
T_6	Farm Yard Manure + *panchagavya*	526	542	1415	1485	23.55	23.20	20.4	20.5
T_7	Vermicompost	546	568	1438	1518	24.07	23.99	20.6	20.8
T_8	Vermicompost + *panchagavya*	568	584	1482	1532	24.36	24.52	20.6	20.8
T_9	Neem leaf	652	672	1586	1648	25.75	25.84	20.6	20.8
T_{10}	Neem leaf + *panchagavya*	665	684	1612	1685	25.94	26.19	21.0	21.4
T_{11}	Poultry manure	784	812	1954	2058	28.97	29.08	21.2	21.6
T_{12}	Poultry manure + *panchagavya*	792	824	1986	2092	29.01	29.34	21.2	21.8
T_{13}	Pig manure	724	742	1825	1872	27.63	27.64	21.0	21.4
T_{14}	Pig manure + *panchagavya*	732	758	1852	1904	27.69	27.86	21.2	21.6
	SEm±	14.8	17.3	33.8	40.1	0.338	0.381	0.28	0.32
	CD (P = 0.05)	42	49	96	114	0.96	1.08	0.8	0.9

4.3.8 Haulm Yield

Haulm yield of greengram was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.41).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of haulm yield of greengram, which was the highest. The next highest haulm yield was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher haulm yield than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which produced the lowest haulm yield.

4.3.9 Harvest Index

Harvest index of greengram was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.41).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of harvest index of greengram, which was the highest. The next highest harvest index was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher harvest index of greengram than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which resulted in the lowest harvest index.

4.3.10 Protein Content of Seed

Protein content of greengram seed was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.41).

Residual effect of various organic manures either with or without the spray of *panchagavya* applied to previous crops of maize and sunflower was comparable, in respect of protein content of the seed, which was significantly higher than with the residual effect of application of recommended dose of fertilizer with or without *panchagavya*, which was statistically superior to the protein content of seed recorded with residual effect of non manuring to previous crops with or without *panchagavya*, which resulted in the lowest protein content of the seed of greengram.

4.3.11 Nitrogen Uptake

Nitrogen uptake of greengram estimated at 15, 30, 45 DAS and at harvest was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.42).

Table 4.42: Nitrogen uptake (kg ha^{-1}) of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	2004				2005			
		15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
T_1	No manure	1.0	7.6	10.2	17.2	1.1	8.2	10.5	17.6
T_2	No manure + *panchagavya*	1.1	7.9	10.4	18.6	1.3	8.4	10.8	19.2
T_3	Recommended dose of fertilizer	1.4	9.0	12.6	31.8	1.6	10.1	12.6	33.8
T_4	Recommended dose of fertilizer + *panchagavya*	1.5	9.4	13.1	32.9	1.7	10.2	13.2	35.6
T_5	Farm Yard Manure	2.0	12.8	22.5	55.0	2.0	12.8	21.6	54.5
T_6	Farm Yard Manure + *panchagavya*	2.2	13.2	23.3	57.0	2.3	13.5	22.2	55.9
T_7	Vermicompost	2.0	12.5	22.2	54.4	2.0	12.8	21.4	54.2
T_8	Vermicompost + *panchagavya*	2.1	13.0	22.8	56.0	2.2	13.0	21.8	55.0
T_9	Neem leaf	2.0	12.4	21.8	54.0	2.0	12.5	21.2	53.6
T_{10}	Neem leaf + *panchagavya*	2.1	12.8	22.5	55.2	2.2	13.0	21.6	54.8
T_{11}	Poultry manure	2.0	12.4	22.0	54.2	2.0	12.6	21.4	54.0
T_{12}	Poultry manure + *panchagavya*	2.1	13.0	22.8	55.8	2.2	13.0	21.8	54.8
T_{13}	Pig manure	2.0	12.5	22.2	54.6	2.0	12.8	21.5	54.5
T_{14}	Pig manure + *panchagavya*	2.2	13.2	23.2	56.4	2.3	13.2	21.9	55.2
	SEm±	0.06	0.28	0.56	1.55	0.07	0.28	0.49	1.41
	CD (P = 0.05)	0.2	0.8	1.6	4.4	0.2	0.8	1.4	4.0

Residual effect of various organic manures either with or without the spray of *panchagavya* applied to previous crops of maize and sunflower was comparable, in respect of the nitrogen uptake, which was significantly higher than with the residual effect of application of recommended dose of fertilizer with or without *panchagavya*, which was statistically superior to the nitrogen uptake recorded with residual effect of non manuring to previous crops with or without *panchagavya*, which resulted in the lowest nitrogen uptake.

4.3.12 Phosphorus Uptake

Phosphorus uptake of greengram estimated at 15, 30, 45 DAS and at harvest was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.43).

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of phosphorus uptake of greengram, which was the highest. The next highest phosphorus uptake was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically

Table 4.43: Phosphorus uptake (kg ha^{-1}) of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

Treatments		2004				2005			
		15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
T_1	No manure	0.12	0.28	1.42	2.74	0.14	0.27	1.53	3.64
T_2	No manure + *panchagavya*	0.13	0.29	1.48	2.82	0.15	0.30	1.56	3.82
T_3	Recommended dose of fertilizer	0.17	0.52	1.79	3.68	0.18	0.60	1.90	4.86
T_4	Recommended dose of fertilizer + *panchagavya*	0.20	0.54	1.87	3.72	0.20	0.62	1.96	4.98
T_5	Farm Yard Manure	0.30	0.84	2.30	5.22	0.31	0.90	2.52	6.52
T_6	Farm Yard Manure + *panchagavya*	0.30	0.84	2.30	5.25	0.32	0.90	2.52	6.54
T_7	Vermicompost	0.30	0.86	2.32	5.28	0.32	0.92	2.54	6.58
T_8	Vermicompost + *panchagavya*	0.30	0.86	2.32	5.28	0.32	0.92	2.54	6.58
T_9	Neem leaf	0.32	0.94	2.56	7.78	0.34	1.04	2.80	7.02
T_{10}	Neem leaf + *panchagavya*	0.32	0.95	2.58	7.80	0.34	1.04	2.82	7.08
T_{11}	Poultry manure	0.38	1.11	3.12	8.83	0.39	1.21	3.34	8.02
T_{12}	Poultry manure + *panchagavya*	0.38	1.13	3.19	8.90	0.39	1.22	3.37	8.10
T_{13}	Pig manure	0.35	1.03	2.83	8.30	0.36	1.12	3.08	7.52
T_{14}	Pig manure + *panchagavya*	0.35	1.03	2.86	8.32	0.36	1.12	3.08	7.56
	SEm±	0.004	0.021	0.081	0.169	0.004	0.025	0.085	0.148
	CD (P = 0.05)	0.01	0.06	0.23	0.48	0.01	0.07	0.24	0.42

superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher phosphorus uptake of greengram than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which recorded the lowest phosphorus uptake.

4.3.13 Potassium Uptake

Potassium uptake of greengram estimated at 15, 30, 45 DAS and at harvest was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.44).

Residual effect of vermicompost either with or without the spray of *panchagavya* (T_8 and T_7) applied to previous crops of maize and sunflower was comparable, in respect of potassium uptake of greengram, which was the highest. The next higher potassium uptake was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of farm yard manure or neem leaf manure or poultry manure with or without *panchagavya,* (T_6, T_{10}, T_{12}, T_5, T_9, and T_{11}), but comparable among them. Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to

Table 4. 44: Potassium uptake (kg ha^{-1}) of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	2004				2005			
		15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
T_1	No manure	2.0	5.7	8.2	9.8	2.4	6.2	7.4	10.6
T_2	No manure + *panchagavya*	2.2	6.1	8.6	10.2	2.6	6.5	7.8	11.2
T_3	Recommended dose of fertilizer	3.0	7.5	11.5	13.8	3.6	7.4	11.6	14.6
T_4	Recommended dose of fertilizer + *panchagavya*	3.1	7.6	11.8	14.2	3.8	7.6	12.0	15.0
T_5	Farm Yard Manure	4.6	8.8	14.2	16.8	4.8	9.0	14.2	19.2
T_6	Farm Yard Manure + *panchagavya*	4.6	8.8	14.2	16.8	4.9	9.0	14.3	19.2
T_7	Vermicompost	6.0	10.2	17.4	21.4	6.1	10.8	17.6	23.6
T_8	Vermicompost + *panchagavya*	6.2	10.3	17.6	21.8	6.3	11.1	17.9	24.1
T_9	Neem leaf	3.9	8.6	14.0	16.5	4.8	8.8	14.0	19.0
T_{10}	Neem leaf + *panchagavya*	3.9	8.6	14.0	16.6	4.8	8.8	14.2	19.0
T_{11}	Poultry manure	3.8	8.4	13.8	16.4	4.6	8.5	13.8	18.1
T_{12}	Poultry manure + *panchagavya*	3.9	8.5	13.8	16.4	4.6	8.6	14.0	18.6
T_{13}	Pig manure	5.3	9.5	15.8	19.0	5.4	9.8	15.8	21.2
T_{14}	Pig manure + *panchagavya*	5.3	9.5	15.8	19.4	5.6	10.0	16.0	21.6
	SEm±	0.14	0.21	0.49	0.63	0.14	0.25	0.49	0.67
	CD (P = 0.05)	0.4	0.6	1.4	1.8	0.4	0.7	1.4	1.9

preceding crops resulted in higher potassium uptake than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1), which resulted in the lowest potassium uptake.

4.3.14 Gross Returns

Gross Returns of raising of greengram crop were significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.45).

The highest gross returns were recorded with poultry manure along with *panchagavya* spray (T_{12}), which were however, comparable with poultry manure alone (T_{11}) and significantly higher than with pig manure either with or without *panchagavya* (T_{14} andT_{13}), which were superior to neem leaf manure with or without *panchagavya* (T_{10} and T_9), which in turn were significantly higher than with vermicompost or farm yard manure with or without the use of *panchagavya* (T_8, T_7, T_6 and T_5). Supply of nitrogen through fertilizer either with or without *panchagavya* (T_4 and T_3) resulted in significantly lower gross returns than with all the organic sources tried either with or without the use of *panchagavya*, but significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest amount of gross returns were realised with unmanured plot (T_1).

Table 4.45: Economics of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

Treatments		Gross returns (Rs ha^{-1})		Net returns (Rs ha^{-1})		Benefit-cost ratio	
		2004	2005	2004	2005	2004	2005
T_1	No manure	7600	7920	3800	4120	2.00	2.08
T_2	No manure + *panchagavya*	7840	8240	4040	4440	2.06	2.17
T_3	Recommended dose of fertilizer	8840	9240	5040	5440	2.33	2.43
T_4	Recommended dose of fertilizer + *panchagavya*	9080	9520	5280	5720	2.39	2.51
T_5	Farm Yard Manure	10040	10520	6240	6720	2.64	2.77
T_6	Farm Yard Manure + *panchagavya*	10520	10840	6720	7040	2.77	2.85
T_7	Vermicompost	10920	11360	7120	7560	2.87	2.99
T_8	Vermicompost + *panchagavya*	11360	11680	7560	7880	2.99	3.07
T_9	Neem leaf	13040	13440	9240	9640	3.43	3.54
T_{10}	Neem leaf + *panchagavya*	13300	13680	9500	9880	3.50	3.60
T_{11}	Poultry manure	15680	16240	11880	12440	4.13	4.27
T_{12}	Poultry manure + *panchagavya*	15840	16480	12040	12680	4.17	4.34
T_{13}	Pig manure	14480	14840	10680	11040	3.81	3.91
T_{14}	Pig manure + *panchagavya*	14640	15160	10840	11360	3.85	3.99
	SEm±	276.1	283.8	229.6	244.7	0.049	0.053
	CD (P = 0.05)	784	806	652	695	0.14	0.15

4.3.15 Net returns

Net Returns of raising of greengram crop were significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.45).

The highest net returns were recorded with poultry manure along with *panchagavya* spray (T_{12}), which were however, comparable with poultry manure alone (T_{11}) and significantly higher than with pig manure either with or without *panchagavya* (T_{14} andT_{13}), which were superior to neem leaf manure with or without *panchagavya* (T_{10} and T_9), which in turn were significantly higher than with vermicompost or farm yard manure with or without the use of *panchagavya* (T_8, T_7, T_6 and T_5). Supply of nitrogen through fertilizer either with or without *panchagavya* (T_4 and T_3) resulted in significantly lower net returns than with all the organic sources tried either with or without the use of *panchagavya*, but significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest amount of net returns were realised with unmanured plot (T_1).

4.3.16 Benefit – cost ratio

Benefit-cost ratio of raising of greengram crop was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study (Table 4.45).

The highest benefit -cost ratio was recorded with poultry manure along with *panchagavya* spray (T_{12}), which was however, comparable with poultry manure alone (T_{11}) and significantly higher than with pig manure either with or without *panchagavya* (T_{14} andT_{13}), which was superior to neem leaf manure with or without *panchagavya* (T_{10} and T_9), which in turn was significantly higher than with vermicompost or farm yard manure with or without the use of *panchagavya* (T_8, T_7, T_6 and T_5). Supply of nitrogen through fertilizer either with or without *panchagavya* (T_4 and T_3) resulted in significantly lesser benefit -cost ratio than with all the organic sources tried either with or without the use of *panchagavya*, but significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest benefit -cost ratio was recorded with unmanured plot (T_1).

4.3.17 Post harvest Soil Fertility Status

4.3.17.1 Soil organic carbon

Post harvest soil organic carbon status after greengram crop was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study, but differed in magnitude (Table 4.46 and 4.47).

The highest status of soil organic carbon post harvest of greengram was recorded with neem leaf manure (T_9), which was however comparable with neem leaf manure in combination with *panchagavya* (T_{10}), vermicompost or farm yard manure with or without the use of *panchagavya* (T_7, T_8, T_5 and T_6) and significantly superior to pig manure or poultry manure either with or without *panchagavya* spray (T_{13}, T_{14}, T_{11} and T_{12}), which were comparable among them. The lowest status of post harvest soil organic carbon was recorded with unmanured plot with the use of *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1) and supply of recommended dose of nitrogen through fertilizer either with or without *panchagavya* (T_4 and T_3).

4.3.17.2 Soil available nitrogen

Post harvest soil available nitrogen status of greengram crop was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study, but differed in magnitude (Table 4.46 and 4.47).

The highest status of soil available nitrogen post harvest of greengram was recorded with neem leaf manure (T_9), which was however, comparable with neem leaf manure in combination with *panchagavya* (T_{10}) and significantly higher than with poultry manure either with or without

Table 4.46: Post harvest soil fertility status after greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower - 2004

Treatments		Organic Carbon (%)	Available Nitrogen (kg ha^{-1})	Available Phosphorus* (kg ha^{-1})	Available Potassium** (kg ha^{-1})
T_1	No manure	0.21	117.5	12.72	143.2
T_2	No manure + *panchagavya*	0.21	117.5	12.70	139.8
T_3	Recommended dose of fertilizer	0.23	142.2	25.15	180.5
T_4	Recommended dose of fertilizer + *panchagavya*	0.23	142.2	24.52	178.2
T_5	Farm Yard Manure	0.42	163.6	18.54	196.8
T_6	Farm Yard Manure + *panchagavya*	0.42	162.8	18.28	196.8
T_7	Vermicompost	0.45	172.5	20.60	208.3
T_8	Vermicompost + *panchagavya*	0.45	171.2	20.26	205.4
T_9	Neem leaf	0.46	188.2	22.82	200.8
T_{10}	Neem leaf + *panchagavya*	0.46	187.6	22.45	198.2
T_{11}	Poultry manure	0.34	177.4	28.26	194.5
T_{12}	Poultry manure + *panchagavya*	0.34	176.5	27.84	194.2
T_{13}	Pig manure	0.34	169.2	24.45	205.3
T_{14}	Pig manure + *panchagavya*	0.34	168.5	23.88	204.5
	SEm±	0.022	1.13	0.359	1.24
	CD (P = 0.05)	0.06	3.2	1.02	3.5

*** P ** ** K**

Table 4.47: Post harvest soil fertility status after greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower - 2005

	Treatments	Organic Carbon (%)	Available Nitrogen (kg ha^{-1})	Available Phosphorus* (kg ha^{-1})	Available Potassium** (kg ha^{-1})
T_1	No manure	0.18	100.6	8.23	120.6
T_2	No manure + *panchagavya*	0.18	100.2	8.18	118.2
T_3	Recommended dose of fertilizer	0.20	150.5	41.40	205.8
T_4	Recommended dose of fertilizer + *panchagavya*	0.20	149.7	40.44	204.2
T_5	Farm Yard Manure	0.48	193.1	22.88	214.4
T_6	Farm Yard Manure + *panchagavya*	0.48	191.2	22.43	212.8
T_7	Vermicompost	0.50	210.5	27.92	267.3
T_8	Vermicompost + *panchagavya*	0.50	209.6	27.64	264.2
T_9	Neem leaf	0.52	245.2	33.63	218.2
T_{10}	Neem leaf + *panchagavya*	0.52	244.1	33.04	216.8
T_{11}	Poultry manure	0.40	224.7	48.06	207.2
T_{12}	Poultry manure + *panchagavya*	0.40	223.8	47.04	206.8
T_{13}	Pig manure	0.40	208.1	39.16	262.5
T_{14}	Pig manure + *panchagavya*	0.40	205.9	38.21	263.8
	SEm±	0.018	1.62	0.873	1.83
	CD (P = 0.05)	0.05	4.6	2.48	5.2

* P ** K

panchagavya spray (T_{11} and T_{12}), which was comparable between them and superior to vermicompost or pig manure with or without *panchagavya* (T_7, T_8 T_{13} and T_{14}), which in turn was significantly higher than with farm yard manure either with or without *panchagavya* spray (T_5 and T_6). Supply of recommended dose of nitrogen through fertilizer with or without *panchagavya* spray recorded significantly lesser status of soil available nitrogen than with any of the organic sources either with or without *panchagavya* spray (T_4 and T_3). The lowest status of post harvest soil available nitrogen was recorded with unmanured plot (T_1), which was however, comparable with unmanured plot with the use of *panchagavya* (T_2).

4.3.17.3 Soil available phosphorus

Post harvest soil available phosphorus status of greengram crop was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study, but differed in magnitude (Table 4.46 and 4.47).

The highest status of soil available phosphorus post harvest of sunflower was recorded with poultry manure (T_{11}), which was comparable with poultry manure *along* with *panchagavya* (T_{12}) and significantly higher than with fertilizer or pig manure with or without *panchagavya* (T_3, T_4, T_{13}

and T_{14}), which were comparable among them and superior to neem leaf manure with or without *panchagavya* (T_9 and T_{10}), which were significantly higher than with vermicompost with or without *panchagavya,* (T_7 and T_8), which in turn were statistically superior to farm yard manure with or without *panchagavya* (T_5 and T_6). The lowest status of soil available phosphorus was recorded with unmanured plot with *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1).

4.3.17.4 *Soil available potassium*

Post harvest soil available potassium status of greengram crop was significantly influenced by the residual effect of varied manurial practices and use of *panchagavya* to both the preceding crops of maize and sunflower, with similar trend during both the years of study, but differed in magnitude (Table 4.46 and 4.47).

The highest soil available potassium status post harvest of greengram was recorded with poultry manure (T_7), which was however, comparable with poultry manure along with *panchagavya*, pig manure with or without *panchagavya* (T_8, T_{14} and T_{13}) and significantly higher than with neem leaf manure or farm yard manure or poultry manure either with or without *panchagavya,* (T_9, T_{10}, T_5, T_6, T_{11} and T_{12}), which were comparable among them and significantly higher than with fertilizer either with or without *panchagavya* (, T_3 and T_4). The lowest soil available potassium status was recorded with unmanured plot with *panchagavya* (T_2), which was however, comparable with unmanured plot (T_1).

4.4 CROPPING SYSTEM AS A WHOLE

Performance of the maize – sunflower – greengram cropping system as a whole (as influenced by varied manurial practices and the use of *panchagavya* to maize and sunflower crops and the residual effect on the succeeding greengram crop) was assessed based on productivity (total biomass production and total economic yield), economics (gross returns, net returns and benefit-cost ratio) and soil fertility (dynamics of soil organic carbon, soil available nitrogen, phosphorus and potassium) and the results are presented on the cropping system basis. In the following sections (4.4.1 to 4.4.5), it is implied that varied manurial practices with or without the use of *panchagavya* were imposed to only maize and sunflower.

4.4.1 Total Biomass Production of the Cropping System (Table 4.48)

During both years of study, the highest biomass production by the cropping system was produced with recommended dose of nitrogen supplied through fertilizer along with the spray of *panchagavya*, which was however comparable with fertilizer alone and significantly higher than with pig manure or farm yard manure or vermicompost in combination with application of *panchagavya*, which were comparable among them, but

Table 4.48 : *Total biomass production and economic yield* of the cropping system as a whole as influenced by varied manurial practices and Panchagavya spray*

Treatments		Biomass production (kg ha^{-1})		Economic Yield (kg ha^{-1})	
		2003-2004	2004-2005	2003-2004	2004-2005
T_1	No manure	7091	7385	3412	3613
T_2	No manure + *panchagavya*	7889	8308	3857	4160
T_3	Recommended dose of fertilizer	18380	18977	9639	10045
T_4	Recommended dose of fertilizer + *panchagavya*	18573	19216	9797	10229
T_5	Farm Yard Manure	16019	16236	8230	8471
T_6	Farm Yard Manure + *panchagavya*	17546	17900	9278	9550
T_7	Vermicompost	15746	16061	8168	8435
T_8	Vermicompost + *panchagavya*	17250	17646	9177	9460
T_9	Neem leaf	15177	15245	8359	8520
T_{10}	Neem leaf + *panchagavya*	15681	15760	8955	9146
T_{11}	Poultry manure	15469	15555	8795	9008
T_{12}	Poultry manure + *panchagavya*	16007	16054	9408	9634
T_{13}	Pig manure	16291	16490	8860	9096
T_{14}	Pig manure + *panchagavya*	17767	18137	9855	10155
	SEm±	206.3	226.1	75.3	100.7
	CD (P = 0.05)	586	642	214	286

***Maize equivalent yield**

significantly higher than with poultry manure or neem leaf manure along with *panchagavya* spray or pig manure or farm yard manure or vermicompost or poultry manure or neem leaf manure, which were in parity among them and significantly higher than with p*anchagavya* spray alone (T_2). The lowest biomass production by the cropping system was recorded with no manuring to any of the three crops.

4.4.2 Total Economic Yield of the Cropping System (Table 4.48)

During both years of study, the highest economic yield (maize grain equivalent yield) by the cropping system was produced with recommended dose of nitrogen supplied through fertilizer along with the spray of *Panchagavya*, which was however, comparable with pig manure in combination with *panchagavya* or fertilizer alone. The next best manurial practices were poultry manure or farm yard manure or vermicompost in combination with *panchagavya,* which were in parity among them and significantly higher than with neem leaf manure with *panchagavya* or pig manure or poultry manure, which were comparable among them. The latter three manurial practices were significantly superior to application of neem leaf manure or farm yard manure or vermicompost, which were on par and significantly higher than with *panchagavya* spray alone (T_2). The lowest economic yield by the cropping system was produced with no manuring to any of the three crops.

4.4.3 Economics of the Cropping System (Table 4.49 and 4.50)

4.4.3.1 Gross returns from the cropping system

During both years of study, the highest gross returns from the cropping system were realised with recommended dose of nitrogen supplied through fertilizer along with the spray of *panchagavya*, which were however, comparable with pig manure in combination with *panchagavya* or fertilizer alone. The next best manurial practices were poultry manure or farm yard manure or vermicompost in combination with *panchagavya,* which were in parity among them and significantly higher than with neem leaf manure with *panchagavya* or pig manure or poultry manure, which were comparable among them. The latter three manurial practices were significantly superior to application of neem leaf manure or farm yard manure or vermicompost, which were on par and significantly higher than with p*anchagavya* spray alone (T_2). Gross returns from the cropping system were the lowest with no manuring to any of the three crops.

4.4.3.2 Net returns from the cropping system

During both years of study, the highest net returns from the cropping system were realised with recommended dose of nitrogen supplied through fertilizer along with spray of *panchagavya* , which were

Table 4. 49: Economics of the cropping system as a whole as influenced by varied manurial practices and *Panchagavya* spray – 2003-2004

Treatments		Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit-cost Ratio
T_1	No manure	21478	6398	1.42
T_2	No manure + *panchagavya*	24357	8677	1.55
T_3	Recommended dose of fertilizer	61193	37913	2.63
T_4	Recommended dose of fertilizer + *panchagavya*	62438	38558	2.61
T_5	Farm Yard Manure	52277	31317	2.49
T_6	Farm Yard Manure + *panchagavya*	58849	37289	2.73
T_7	Vermicompost	51838	29261	2.30
T_8	Vermicompost + *panchagavya*	58196	35019	2.51
T_9	Neem leaf	52679	33599	2.76
T_{10}	Neem leaf + *panchagavya*	56321	36641	2.86
T_{11}	Poultry manure	55374	38722	3.33
T_{12}	Poultry manure + *panchagavya*	59076	41824	3.42
T_{13}	Pig manure	56002	31997	2.33
T_{14}	Pig manure + *panchagavya*	62265	37660	2.53
	SEm±	574.6	241.2	0.042
	CD (P = 0.05)	1632	685	0.12

Table 4. 50: Economics of the cropping system as a whole as influenced by varied manurial practices and *Panchagavya* spray – 2004-2005

	Treatments	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit-cost Ratio
T_1	No manure	22769	7689	1.51
T_2	No manure + *panchagavya*	26254	10574	1.67
T_3	Recommended dose of fertilizer	63798	40518	2.74
T_4	Recommended dose of fertilizer + *panchagavya*	64934	41054	2.72
T_5	Farm Yard Manure	53790	32830	2.57
T_6	Farm Yard Manure + *panchagavya*	60616	39056	2.81
T_7	Vermicompost	53506	30929	2.37
T_8	Vermicompost + *panchagavya*	59979	36802	2.59
T_9	Neem leaf	53686	34606	2.81
T_{10}	Neem leaf + *panchagavya*	57460	37780	2.92
T_{11}	Poultry manure	56665	40013	3.40
T_{12}	Poultry manure + *panchagavya*	60492	43240	3.51
T_{13}	Pig manure	57501	33496	2.40
T_{14}	Pig manure + *panchagavya*	64199	39594	2.61
	SEm±	617.6	264.8	0.049
	CD (P = 0.05)	1754	752	0.14

however, comparable with recommended dose of fertilizer and poultry manure in combination with *panchagavya* spray , which were significantly higher than with neem leaf manure or farm yard manure along with *panchagavya* spray, which maintained significant disparity with each other and superior to Poultry manure, vermicompost or pig manure along with *panchagavya* and neem leaf manuring, which were comparable among them, but significantly higher than with farm yard manure and it was in turn superior to vermicompost and Pig manure, which were comparable between them and significantly higher than with no manuring with or without *panchagavya* spray. The lowest amount of net returns from the cropping system were obtained with no manuring to any of the three crops.

4.4.3.3 Benefit-cost ratio of the cropping system

During both the years of study, the highest benefit -cost ratio of the cropping system was recorded with poultry manure along with *panchagavya* spray, which was significantly superior to all other manurial practices tried either with or without the use of *panchagavya.* The next best treatment was Poultry manure alone, which was significantly higher than with neem leaf manure or farm yard manure or fertilizer with or without *panchagavya* spray and vermicompost or pig manure along with *panchagavya*, which were comparable among them, but significantly higher than with pig manure or vermicompost without *panchagavya,* which were on par and significantly superior to no manuring with or without *panchagavya* spray. The lowest benefit -cost ratio of the cropping system was recorded with no manuring to any of the three crops.

4.4.4 Dynamics of Soil Fertility in the Cropping System

The pre-experimental and post harvest fertility of the soil (organic carbon, available nitrogen, available phosphorus and available potassium) after each of the three crops (maize, sunflower and greengram) was estimated during both the years of study, to assess the change in soil fertility status due to raising of the cropping system with varied manurial practices with or without the use of *panchagavya.* Since there was considerable time gap between the termination of first annual cycle and commencement of second annual cycle of the cropping system, pre-experimental sampling of soil was done (prior to incorporation of organic manures to respective plots as per treatments) from all the replicated plots before commencing the second annual cycle of the cropping system, analysed for the all the above mentioned four soil fertility parameters and presented as pre-experimental values (mean of three replications) treatment wise. This was done keeping in view of the possible decomposition as well as mineralization of soil organic matter during the gap period of two annual cycles of cropping system.

4.4.4.1 Soil organic carbon (Table 4.51 and 4.52)

Soil organic carbon status in the cropping system was found gradually built up compared to the pre-experimental level, with all the three crops raised in annual cycle, with the application of organic manures either with or without the use of *panchagavya*. Among the organic sources tried, neem leaf manure, vermicompost and farmyard manure added more organic carbon to the soil than with pig manure and poultry manure. Use of *panchagavya* along with any of the organic sources did not exert any measurable positive influence on the soil organic carbon status compared to the respective organic sources tried without the spray of *panchagavya*. Fertilizer application either with or without *panchagavya* could just maintain the status of soil organic carbon, with neither improving nor declining at the end of the cropping cycle with greengram. Unmanured plots with or without *panchagavya* resulted in reduction of the level of soil organic carbon. The trend of dynamics of soil organic carbon in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was marginal difference in the pre-experimental status of soil organic carbon between two annual cycles of the cropping system.

Table 4.51 : Dynamics of soil organic carbon (%) in the cropping system as influenced by varied manurial practices and *Panchagavya* spray - 2003 - 2004

Treatments		Pre - experimental	Post harvest of maize	Post harvest of sunflower	Post harvest of greengram
T_1	No manure	0.23	0.18	0.16	0.21
T_2	No manure + *panchagavya*	0.23	0.18	0.16	0.21
T_3	Recommended dose of fertilizer	0.23	0.21	0.20	0.23
T_4	Recommended dose of fertilizer + *panchagavya*	0.23	0.21	0.20	0.23
T_5	Farm Yard Manure	0.23	0.35	0.39	0.42
T_6	Farm Yard Manure + *panchagavya*	0.23	0.35	0.39	0.42
T_7	Vermicompost	0.23	0.36	0.40	0.45
T_8	Vermicompost + *panchagavya*	0.23	0.36	0.40	0.45
T_9	Neem leaf	0.23	0.38	0.42	0.46
T_{10}	Neem leaf + *panchagavya*	0.23	0.38	0.42	0.46
T_{11}	Poultry manure	0.23	0.28	0.30	0.34
T_{12}	Poultry manure + *panchagavya*	0.23	0.28	0.30	0.34
T_{13}	Pig manure	0.23	0.30	0.32	0.34
T_{14}	Pig manure + *panchagavya*	0.23	0.30	0.32	0.34

Table 4.52 : Dynamics of soil organic carbon (%) in the cropping system as influenced by varied manurial practices and *Panchagavya* spray - 2004 - 2005

Treatments		Pre - experimental	Post harvest of maize	Post harvest of sunflower	Post harvest of greengram
T_1	No manure	0.19	0.16	0.14	0.18
T_2	No manure + *panchagavya*	0.19	0.16	0.14	0.18
T_3	Recommended dose of fertilizer	0.20	0.18	0.15	0.20
T_4	Recommended dose of fertilizer + *panchagavya*	0.20	0.18	0.15	0.20
T_5	Farm Yard Manure	0.40	0.42	0.45	0.48
T_6	Farm Yard Manure + *panchagavya*	0.40	0.42	0.45	0.48
T_7	Vermicompost	0.42	0.45	0.48	0.50
T_8	Vermicompost + *panchagavya*	0.42	0.45	0.48	0.50
T_9	Neem leaf	0.44	0.46	0.49	0.52
T_{10}	Neem leaf + *panchagavya*	0.44	0.46	0.49	0.52
T_{11}	Poultry manure	0.32	0.34	0.36	0.40
T_{12}	Poultry manure + *panchagavya*	0.32	0.34	0.36	0.40
T_{13}	Pig manure	0.32	0.35	0.36	0.40
T_{14}	Pig manure + *panchagavya*	0.32	0.35	0.36	0.40

4.4.4.2 Soil available nitrogen (Table 4.53 and 4.54)

Soil available nitrogen status in the cropping system was found gradually built up compared to the pre-experimental level, with all the three crops raised in annual cycle, with the application of organic manures either with or without the use of *panchagavya*. Among the organic sources tried, neem leaf manure, poultry manure and vermicompost replenished more available nitrogen to the soil than with pig manure and farmyard manure. Use of *panchagavya* along with any of the organic sources did not exert any measurable positive influence on the soil available nitrogen status compared to the respective organic sources tried without the spray of *panchagavya*. Fertilizer application either with or without *panchagavya* could slightly improve the status of soil available nitrogen at the end of the cropping cycle with greengram, which was however, substantially lesser than with any of the organic sources. Unmanured plots with or without *panchagavya* resulted in depletion of the soil available nitrogen. The trend of dynamics of soil available nitrogen in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was considerable difference in the pre-experimental status of soil available nitrogen between two annual cycles of the cropping system.

Table 4.53 : Dynamics of soil available nitrogen (kg ha^{-1}) in the cropping system as influenced by varied manurial practices and *Panchagavya* spray - 2003 - 2004

Treatments		Pre - experimental	Post harvest of maize	Post harvest of sunflower	Post harvest of greengram
T_1	No manure	135.6	108.2	103.5	117.5
T_2	No manure + *panchagavya*	135.6	107.5	103.0	117.5
T_3	Recommended dose of fertilizer	135.6	128.4	118.5	142.2
T_4	Recommended dose of fertilizer + *panchagavya*	135.6	127.2	117.4	142.2
T_5	Farm Yard Manure	135.6	141.2	138.0	163.6
T_6	Farm Yard Manure + *panchagavya*	135.6	140.5	138.0	152.8
T_7	Vermicompost	135.6	150.4	144.2	172.5
T_8	Vermicompost + *panchagavya*	135.6	148.8	143.4	171.2
T_9	Neem leaf	135.6	158.6	158.2	138.2
T_{10}	Neem leaf + *panchagavya*	135.6	158.2	157.5	187.6
T_{11}	Poultry manure	135.6	155.2	148.2	177.4
T_{12}	Poultry manure + *panchagavya*	135.6	154.6	147.5	176.5
T_{13}	Pig manure	135.6	142.5	138.6	169.2
T_{14}	Pig manure + *panchagavya*	135.6	141.8	138.5	168.5

Table 4.54 : **Dynamics of soil available nitrogen (kg ha^{-1}) in the cropping system as influenced by varied manurial practices and *Panchagavya* spray - 2004 - 2005**

Treatments		Pre - experimental	Post harvest of maize	Post harvest of sunflower	Post harvest of greengram
T_1	No manure	119.8	90.4	84.2	100.6
T_2	No manure + *panchagavya*	120.2	90.1	84.0	100.2
T_3	Recommended dose of fertilizer	145.8	136.8	125.0	150.5
T_4	Recommended dose of fertilizer + *panchagavya*	145.2	134.9	123.0	149.7
T_5	Farm Yard Manure	166.4	178.2	173.4	193.1
T_6	Farm Yard Manure + *panchagavya*	165.5	175.6	172.6	191.2
T_7	Vermicompost	175.8	190.9	181.8	210.5
T_8	Vermicompost + *panchagavya*	174.6	189.8	180.6	209.6
T_9	Neem leaf	194.5	215.9	206.2	245.2
T_{10}	Neem leaf + *panchagavya*	194.0	214.8	204.8	244.1
T_{11}	Poultry manure	185.2	202.6	193.9	224.7
T_{12}	Poultry manure + *panchagavya*	184.6	201.7	193.1	223.8
T_{13}	Pig manure	175.8	181.2	174.8	208.1
T_{14}	Pig manure + *panchagavya*	174.4	180.6	174.0	205.9

4.4.4.3 Soil available phosphorus (Table 4.55 and 4.56)

Soil available phosphorus status in the cropping system was found built up at the end of annual cropping cycle compared to the pre-experimental level, with the application of organic manures as well as fertilizer either with or without the use of *panchagavya*. The build up of soil available phosphorus status with varied manurial practices was in the descending order of poultry manure, fertilizer, pig manure, neem leaf manure, vermicompost and farmyard manure. The former three sources enriched the soil available phosphorus to a greater extent than the latter three sources. Use of *panchagavya* along with any of the manurial sources did not exert any measurable positive influence on the soil available phosphorus status compared to the respective organic sources tried without the spray of *panchagavya*. Unmanured plots with or without *panchagavya* resulted in depletion of the soil available phosphorus. The trend of dynamics of soil available phosphorus in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was considerable difference in the pre-experimental status of soil available phosphorus between two annual cycles of the cropping system.

Table 4.55 : Dynamics of soil available Phosphorus* (kg ha^{-1}) in the cropping system as influenced by varied manurial practices and *Panchagavya* spray - 2003 - 2004

Treatments		Pre - experimental	Post harvest of maize	Post harvest of sunflower	Post harvest of greengram
T_1	No manure	17.63	15.24	13.80	12.72
T_2	No manure + *panchagavya*	17.63	15.06	13.58	12.70
T_3	Recommended dose of fertilizer	17.63	38.28	31.42	25.15
T_4	Recommended dose of fertilizer + *panchagavya*	17.63	37.65	30.76	24.52
T_5	Farm Yard Manure	17.63	30.42	24.72	18.54
T_6	Farm Yard Manure + *panchagavya*	17.63	29.75	24.35	18.28
T_7	Vermicompost	17.63	33.04	27.08	20.60
T_8	Vermicompost + *panchagavya*	17.63	32.86	26.26	20.26
T_9	Neem leaf	17.63	36.20	29.74	22.82
T_{10}	Neem leaf + *panchagavya*	17.63	35.92	29.46	22.45
T_{11}	Poultry manure	17.63	41.86	34.50	28.26
T_{12}	Poultry manure + *panchagavya*	17.63	41.54	33.84	27.84
T_{13}	Pig manure	17.63	36.84	30.28	24.45
T_{14}	Pig manure + *panchagavya*	17.63	36.40	29.85	23.88

***Phosphorus (P)**

Table 4.56 : Dynamics of soil available Phosphorus* (kg ha^{-1}) in the cropping system as influenced by varied manurial Practices and *Panchagavya* spray - 2004 - 2005

Treatments		Pre - experimental	Post harvest of maize	Post harvest of sunflower	Post harvest of greengram
T_1	No manure	13.80	11.85	10.24	8.23
T_2	No manure + *panchagavya*	13.80	11.72	10.14	8.18
T_3	Recommended dose of fertilizer	26.75	55.54	47.82	41.40
T_4	Recommended dose of fertilizer + *panchagavya*	26.52	55.12	47.24	40.44
T_5	Farm Yard Manure	20.70	35.94	28.50	22.88
T_6	Farm Yard Manure + *panchagavya*	20.42	35.70	28.16	22.43
T_7	Vermicompost	22.50	41.34	40.25	27.92
T_8	Vermicompost + *panchagavya*	22.38	40.54	38.78	27.64
T_9	Neem leaf	24.25	48.28	44.86	33.63
T_{10}	Neem leaf + *panchagavya*	24.08	47.65	43.72	33.04
T_{11}	Poultry manure	30.12	63.24	55.34	48.06
T_{12}	Poultry manure + *panchagavya*	29.96	62.85	54.75	47.04
T_{13}	Pig manure	26.54	53.92	46.52	39.16
T_{14}	Pig manure + *panchagavya*	26.35	50.98	45.98	38.21

***Phosphorus (P)**

4.4.4.4 Soil available potassium (Table 4.57 and 4.58)

Soil available potassium status in the cropping system was found built up at the end of annual cropping cycle compared to the pre-experimental level, with the application of organic manures as well as fertilizer either with or without the use of *panchagavya*. The build up of soil available potassium status with varied manurial practices was in the descending order of vermicompost, pig manure, neem leaf manure, farmyard manure, poultry manure and fertilizer. The former four sources enriched the soil available potassium status to a greater extent than the latter two sources. Use of *panchagavya* along with any of the manurial sources did not exert any measurable positive influence on the soil available potassium status compared to the respective organic sources tried without the spray of *panchagavya*. Unmanured plots with or without *panchagavya* resulted in depletion of the soil available potassium. The trend of dynamics of soil available potassium in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was considerable difference in the pre-experimental status of soil available potassium between two annual cycles of the cropping system.

Table 4.57 : Dynamics of soil available Potassium* (kg ha^{-1})) in the cropping system as influenced by varied manurial practices and *Panchagavya* spray - 2003 - 2004

Treatments		Pre - experimental	Post harvest of maize	Post harvest of sunflower	Post harvest of greengram
T_1	No manure	176.5	167.2	160.8	143.2
T_2	No manure + *panchagavya*	176.5	167.0	160.2	139.8
T_3	Recommended dose of fertilizer	176.5	228.2	204.6	180.5
T_4	Recommended dose of fertilizer + *panchagavya*	176.5	225.8	202.5	178.2
T_5	Farm Yard Manure	176.5	234.2	210.2	196.8
T_6	Farm Yard Manure + *panchagavya*	176.5	230.8	208.4	196.8
T_7	Vermicompost	176.5	254.8	232.5	208.3
T_8	Vermicompost + *panchagavya*	176.5	251.5	230.8	205.4
T_9	Neem leaf	176.5	236.4	211.2	200.8
T_{10}	Neem leaf + *panchagavya*	176.5	234.5	210.6	198.2
T_{11}	Poultry manure	176.5	229.5	206.8	194.5
T_{12}	Poultry manure + *panchagavya*	176.5	228.4	205.4	194.2
T_{13}	Pig manure	176.5	248.6	228.2	205.3
T_{14}	Pig manure + *panchagavya*	176.5	245.4	226.4	204.5

***Potassium (K)**

Table 4.58 : Dynamics of soil available Potassium* (kg ha^{-1})) in the cropping system as influenced by varied manurial practices and *Panchagavya* spray - 2004 - 2005

Treatments		Pre - experimental	Post harvest of maize	Post harvest of sunflower	Post harvest of greengram
T_1	No manure	158.8	142.6	132.8	120.6
T_2	No manure + *panchagavya*	156.2	140.8	132.2	118.2
T_3	Recommended dose of fertilizer	202.5	280.5	216.5	205.8
T_4	Recommended dose of fertilizer + *panchagavya*	200.4	276.4	214.8	204.2
T_5	Farm Yard Manure	206.4	292.4	225.6	214.4
T_6	Farm Yard Manure + *panchagavya*	208.2	288.2	223.8	212.8
T_7	Vermicompost	225.4	318.4	298.2	267.3
T_8	Vermicompost + *panchagavya*	222.8	315.8	295.4	264.2
T_9	Neem leaf	204.5	298.2	237.5	218.2
T_{10}	Neem leaf + *panchagavya*	205.2	295.8	235.8	216.8
T_{11}	Poultry manure	201.2	286.5	218.6	207.2
T_{12}	Poultry manure + *panchagavya*	200.5	282.8	218.2	206.8
T_{13}	Pig manure	225.4	312.4	293.2	262.5
T_{14}	Pig manure + *panchagavya*	224.3	309.5	291.4	263.8

***Potassium (K)**

4.4.5 Soil Available Nutrient Balance in the Cropping System

The yearly balance sheet of soil available nitrogen, phosphorus and potassium in the cropping system under different manurial practices tried was worked out for both the annual cycles of study, duly considering the quantities of thee major nutrients applied to maize and sunflower crops and uptake of the respective nutrients by all the three crops of the cropping system. The change in the soil available nutrient status after completion of each of the annual cycles of the cropping system was compared with initial status of respective nutrients, to understand the actual dynamics of soil available major nutrients due raising of different crops under different manurial practices with and without the use of *panchagavya*.

4.4.5.1 Soil available nitrogen balance in the cropping system

The balance of available nitrogen in the soil (Table 4.59 and 4.60) under the influence of diversified manurial practices adopted to first two crops of the cropping system followed similar trend during both the annual cycles, differing only in the magnitude of change. The balance of soil available nitrogen was positive with all the manurial practices tried, except in unmanured plots either with or without the use of *panchagavya*, where the balance was negative. Organic sources resulted in higher positive balance than with fertilizer, which could maintain only marginal balance on

Table 4. 59 : Balance sheet of soil available nitrogen (kg ha^{-1}) in maize-sunflower-greengram cropping system, 2003 - 2004

Manurial practices	Pre-experimental soil available nitrogen	Nitrogen applied				Nitrogen uptake				Post harvest soil available nitrogen in soil	Change in available nitrogen status of soil Net gain or loss
		Maize	Sunflower	greengram	Total to the system	Maize	Sunflower	greengram	Total by the system		
T_1	135.6	0	0	0	0	38.5	20.4	17.2	76.1	117.5	- 18.1
T_2	135.6	0	0	0	0	40.4	26.5	18.6	85.5	117.5	- 18.1
T_3	135.6	120	80	0	200	102.4	75.8	31.8	210.0	142.2	+ 6.6
T_4	135.6	120	80	0	200	103.5	76.4	32.9	212.8	142.2	+ 6.6
T_5	135.6	120	80	0	200	83.2	64.6	55.0	202.8	163.6	+ 28.0
T_6	135.6	120	80	0	200	93.8	70.8	57.0	221.6	162.8	+ 27.2
T_7	135.6	120	80	0	200	81.2	63.2	54.4	198.8	172.5	+ 36.9
T_8	135.6	120	80	0	200	91.8	69.4	56.0	217.2	171.2	+ 35.6
T_9	135.6	120	80	0	200	69.5	66.0	54.0	189.5	188.2	+ 52.6
T_{10}	135.6	120	80	0	200	70.6	72.2	55.2	198.0	187.6	+ 52.0
T_{11}	135.6	120	80	0	200	71.2	65.2	54.2	190.6	177.4	+ 41.8
T_{12}	135.6	120	80	0	200	72.6	71.4	55.8	199.8	176.5	+ 40.9
T_{13}	135.6	120	80	0	200	82.5	63.8	54.6	200.9	169.2	+ 33.6
T_{14}	135.6	120	80	0	200	92.6	70.2	56.4	219.2	168.5	+ 32.9

Table 4.60 : Balance sheet of soil available nitrogen (kg ha^{-1}) in maize-sunflower-greengram cropping system, 2004 - 2005

Manurial practices	Pre-experimental soil available nitrogen	Nitrogen applied				Nitrogen uptake				Post harvest soil available nitrogen in soil	Change in available nitrogen status of soil Net gain or loss
		Maize	Sunflower	greengram	Total to the system	Maize	Sunflower	greengram	Total by the system		
T_1	119.8	0	0	0	0	39.4	21.4	17.6	78.4	100.6	- 19.2
T_2	120.2	0	0	0	0	41.2	28.6	19.2	89.0	100.2	- 20.0
T_3	145.8	120	80	0	200	105.6	78.4	33.8	217.8	150.5	+ 4.7
T_4	145.2	120	80	0	200	106.9	78.8	35.6	221.3	149.7	+ 4.5
T_5	166.4	120	80	0	200	86.2	67.2	54.5	207.9	193.1	+ 26.7
T_6	165.5	120	80	0	200	96.8	73.5	55.9	226.2	191.2	+ 25.7
T_7	175.8	120	80	0	200	84.8	65.6	54.2	204.6	210.5	+ 34.7
T_8	174.6	120	80	0	200	94.8	72.0	55.0	221.8	209.6	+ 35.0
T_9	194.5	120	80	0	200	73.6	68.6	53.6	195.8	245.2	+ 50.7
T_{10}	194.0	120	80	0	200	74.5	74.8	54.8	204.1	244.1	+ 50.1
T_{11}	185.2	120	80	0	200	75.2	68.0	54.0	197.2	224.7	+ 39.5
T_{12}	184.6	120	80	0	200	76.0	74.2	54.8	205.0	223.8	+ 39.2
T_{13}	175.8	120	80	0	200	85.6	66.4	54.5	206.5	208.1	+ 32.3
T_{14}	174.4	120	80	0	200	95.4	72.8	55.2	223.4	205.9	+ 31.5

positive side. Irrespective of manurial sources, use of *panchagavya* did not exert any noticeable effect in upgrading the soil nitrogen balance. The highest positive balance of soil available nitrogen was associated with neem leaf manure, which was followed by poultry manure, vermicompost and pig manure, while the lowest positive balance was recorded with farm yard manure.

4.4.5.2 *Soil available phosphorus balance in the cropping system*

The balance of available phosphorus in the soil (Table 4.61 and 4.62) under the influence of different manurial practices adopted to first two crops of the cropping system followed similar trend during both the annual cycles, differing only in the magnitude of change of a large extent. The balance of soil available phosphorus was positive with all the manurial practices tried, except in unmanured plots either with or without the use of *panchagavya*, where the balance was negative. Irrespective of manurial sources, use of *panchagavya* did not exert any noticeable effect in upgrading the soil phosphorus balance. The highest positive balance of soil available phosphorus was associated with poultry manure, which was followed by fertilizer, pig manure, neem leaf manure and vermicompost, while the lowest positive balance was recorded with farm yard manure.

Table 4.61 : Balance sheet of soil available Phosphorus(kg ha^{-1}) in maize-sunflower-greengram cropping system, 2003 - 2004

Manurial practices	Pre-experimental soil available phosphorus	Phosphorus applied				Phosphorus uptake				Post harvest soil available phosphorus in soil	Change in available phosphorus status of soil Net gain or loss
		Maize	Sunflower	greengram	Total to the system	Maize	Sunflower	greengram	Total by the system		
T_1	17.63	0.00	0.00	0.00	0.00	10.80	4.70	2.74	18.24	12.72	- 4.91
T_2	17.63	0.00	0.00	0.00	0.00	10.86	4.75	2.82	18.43	12.70	- 4.93
T_3	17.63	25.80	21.50	0.00	47.30	19.40	8.85	3.68	31.93	25.15	+ 7.52
T_4	17.63	25.80	21.50	0.00	47.30	19.46	9.02	3.72	32.20	24.52	+ 6.89
T_5	17.63	35.29	23.52	0.00	58.81	19.56	9.16	5.22	33.94	18.54	+ 0.91
T_6	17.63	35.29	23.52	0.00	58.81	19.62	9.28	5.25	34.15	18.28	+ 0.65
T_7	17.63	50.00	33.33	0.00	83.33	20.92	10.46	5.28	36.66	20.60	+ 2.97
T_8	17.63	50.00	33.33	0.00	83.33	20.95	10.62	5.28	36.85	20.26	+ 2.63
T_9	17.63	62.22	41.47	0.00	103.69	21.06	10.76	7.02	38.84	22.82	+ 5.19
T_{10}	17.63	62.22	41.47	0.00	103.69	21.14	10.82	7.08	39.04	22.45	+ 4.82
T_{11}	17.63	94.48	62.98	0.00	157.46	23.86	13.28	8.02	45.16	28.26	+ 10.63
T_{12}	17.63	94.48	62.98	0.00	157.46	24.00	13.40	8.10	45.50	27.84	+ 10.21
T_{13}	17.63	74.99	49.99	0.00	124.98	22.48	12.02	7.52	42.02	24.45	+ 6.82
T_{14}	17.63	74.99	49.99	0.00	124.98	22.54	12.10	7.56	42.20	23.88	+ 6.25

*** Phosphorus**

Table 4.62: Balance sheet of soil available phosphorus* (kg ha^{-1}) in maize-sunflower-greengram cropping system, 2004 - 2005

Manurial practices	Pre-experimental soil available phosphorus	Phosphorus applied				Phosphorus uptake				Post harvest soil available phosphorus in soil	Change in available phosphorus status of soil Net gain or loss
		Maize	Sunflower	greengram	Total to the system	Maize	Sunflower	greengram	Total by the system		
T_1	13.80	0.00	0.00	0.00	0.00	11.30	5.32	3.64	20.26	8.23	- 5.57
T_2	13.80	0.00	0.00	0.00	0.00	11.54	5.38	3.82	20.74	8.18	- 5.62
T_3	26.75	25.80	21.50	0.00	47.30	20.08	9.12	4.86	34.06	41.40	+ 14.65
T_4	26.52	25.80	21.50	0.00	47.30	20.24	9.28	4.98	34.50	40.44	+ 13.92
T_5	20.70	35.29	23.52	0.00	58.81	20.42	9.42	6.52	36.36	22.88	+ 2.18
T_6	20.42	35.29	23.52	0.00	58.81	20.48	9.58	6.54	36.60	22.43	+ 2.01
T_7	22.50	50.00	33.33	0.00	83.33	21.85	10.76	6.58	39.19	27.92	+ 5.42
T_8	22.38	50.00	33.33	0.00	83.33	22.06	10.94	6.58	39.58	27.64	+ 5.26
T_9	24.25	62.22	41.47	0.00	103.69	22.18	11.04	7.78	41.00	33.63	+ 9.38
T_{10}	24.08	62.22	41.47	0.00	103.69	22.20	11.16	7.80	41.16	33.04	+ 8.96
T_{11}	30.12	94.48	62.98	0.00	157.46	25.60	13.96	8.83	48.39	48.06	+ 17.94
T_{12}	29.96	94.48	62.98	0.00	157.46	25.70	14.10	8.90	48.70	47.04	+ 17.08
T_{13}	26.54	74.99	49.99	0.00	124.98	24.00	12.40	8.30	44.70	39.16	+ 12.62
T_{14}	26.35	74.99	49.99	0.00	124.98	24.10	12.70	8.32	45.12	38.21	+ 11.86

*** Phosphorus**

4.4.5.3 *Soil available potassium balance in the cropping system*

The balance of available potassium in the soil (Table 4.63 and 4.64) under the influence of different manurial practices adopted to first two crops of the cropping system followed similar trend during both the annual cycles, differing only in the magnitude of change. The balance of soil available potassium was positive with all the manurial practices tried, except in unmanured plots either with or without the use of *panchagavya*, where the balance was negative. Irrespective of manurial sources, use of *panchagavya* did not exert any noticeable effect in upgrading the soil potassium balance. The highest positive balance of soil available potassium was associated with vermicompost, which was followed by pig manure, neem leaf manure, farmyard manure and poultry manure, while the lowest positive balance was recorded with fertilizer.

Table 4.63 : Balance sheet of soil available Potassium* (kg ha^{-1}) in maize-sunflower-greengram cropping system, 2003 - 2004

Manurial practices	Pre-experimental soil available potassium	Potassium applied				Potassium uptake				Post harvest soil available potassium in soil	Change in available potassium status of soil Net gain or loss
		Maize	Sunflower	greengram	Total to the system	Maize	Sunflower	greengram	Total by the system		
T_1	176.5	0.00	0.00	0.00	0.00	69.2	32.6	9.8	111.6	143.2	- 33.3
T_2	176.5	0.00	0.00	0.00	0.00	71.5	47.8	10.2	129.5	139.8	- 36.7
T_3	176.5	33.20	24.90	0.00	58.10	132.4	48.6	13.8	194.8	180.5	+ 4.0
T_4	176.5	33.20	24.90	0.00	58.10	134.2	59.6	14.2	208.0	178.2	+ 1.7
T_5	176.5	88.23	58.23	0.00	146.46	151.8	60.4	16.8	229.0	196.8	+ 20.3
T_6	176.5	88.23	58.23	0.00	146.46	153.6	67.8	16.8	238.2	196.8	+ 20.3
T_7	176.5	150.00	99.99	0.00	249.99	170.8	68.4	21.4	260.6	208.3	+ 31.8
T_8	176.5	150.00	99.99	0.00	249.99	172.1	58.2	21.8	252.1	205.4	+ 28.9
T_9	176.5	77.77	51.84	0.00	129.61	151.2	59.0	16.5	226.7	200.8	+ 24.3
T_{10}	176.5	77.77	51.84	0.00	129.61	152.5	56.8	16.6	225.9	198.2	+ 21.7
T_{11}	176.5	66.13	44.08	0.00	110.21	149.8	57.4	16.4	223.6	194.5	+ 18.0
T_{12}	176.5	66.13	44.08	0.00	110.21	150.5	63.8	16.4	230.7	194.2	+ 17.7
T_{13}	176.5	128.57	85.71	0.00	214.28	161.8	64.6	19.0	245.4	205.3	+ 28.8
T_{14}	176.5	128.57	85.71	0.00	214.28	162.5	62.6	19.4	244.5	204.5	+ 28.0

***Potassium (K)**

Table 4.64 : Balance sheet of soil available Potassium* (kg ha^{-1}) in maize-sunflower-greengram cropping system, 2004 - 2005

Manurial practices	Pre-experimental soil available potassium	Potassium applied				Potassium uptake				Post harvest soil available potassium in soil	Change in available potassium status of soil Net gain or loss
		Maize	Sunflower	greengram	Total to the system	Maize	Sunflower	greengram	Total by the system		
T_1	158.8	0.00	0.00	0.00	0.00	71.8	34.2	10.6	116.6	120.6	- 38.2
T_2	156.2	0.00	0.00	0.00	0.00	73.4	34.8	11.2	119.4	118.2	- 38.0
T_3	202.5	33.20	24.90	0.00	58.10	106.3	51.6	14.6	172.5	205.8	+ 3.3
T_4	200.4	33.20	24.90	0.00	58.10	107.9	52.5	15.0	175.4	204.2	+ 3.8
T_5	206.4	88.23	58.23	0.00	146.46	154.9	60.0	19.2	234.1	214.4	+ 8.0
T_6	208.2	88.23	58.23	0.00	146.46	157.8	60.6	19.2	237.6	212.8	+ 4.6
T_7	225.4	150.00	99.99	0.00	249.99	175.8	68.0	23.6	267.4	267.3	+ 41.9
T_8	222.8	150.00	99.99	0.00	249.99	177.0	68.8	24.1	269.9	264.2	+ 41.4
T_9	204.5	77.77	51.84	0.00	129.61	153.8	58.4	19.0	231.2	218.2	+ 13.7
T_{10}	205.2	77.77	51.84	0.00	129.61	156.5	59.2	19.0	234.7	216.8	+ 11.6
T_{11}	201.2	66.13	44.08	0.00	110.21	153.2	57.2	18.1	228.5	207.2	+ 6.0
T_{12}	200.5	66.13	44.08	0.00	110.21	155.8	57.8	18.6	232.2	206.8	+ 6.3
T_{13}	225.4	128.57	85.71	0.00	214.28	166.5	64.0	21.2	251.7	262.5	+ 37.1
T_{14}	224.3	128.57	85.71	0.00	214.28	167.4	64.5	21.6	253.5	263.8	+ 39.5

***Potassium (K)**

Discussion

CHAPTER V

DISCUSSION

Field experiments were conducted for two consecutive years (2003-04 and 2004-05) at the wetland farm of Tirupati campus of Acharya N.G. Ranga Agricultural University, Andhra Pradesh, with a view to study the prospects of organic farming practices for sustainable productivity of maize - sunflower - greengram cropping system. The experimental results presented in the preceding chapter are discussed here under to elucidate the findings.

5.1 WEATHER

Weather during the cropping cycle, 2003-2004 and 2004-2005 was congenial for optimum performance of maize, sunflower as well as greengram crops. During the crop growth period of maize and sunflower, weather was congenial for optimum performance of crops under study and weather parameters did not deviate much from the decennial mean of the location of study and as such, weather did not constrain the optimal performance of the crops under different treatments. However, there was a little fluctuation in the yield levels of maize, sunflower and greengram crops between the two years of investigation, but the fluctuation was not so large as to demand pooled analysis.

5.2 JUSTIFICATION OF TREATMENTS

The experiment was laid out in randomized block design with three replications. The same layout was followed during both the years of study in order to draw inferences more accurately and also to trace out any accrued residual effects. There were fourteen treatments of different manurial practices applied to maize and sunflower crops. Later greengram crop was raised as a residual crop without any treatmental imposition, to trace out the magnitude of carry over effect.

Manurial practices were formulated with different sources *viz.,* farm yard manure, vermicompost, neem leaf, poultry manure and pig manure and recommended dose of fertilizer along with or without *panchagavya.*

Except the treatments of no manure with or without *panchagavya* (T_2 and T_1), the quantity of nitrogen supplied to maize and sunflower crops through different sources was on equal nitrogen basis and the quantity applied was as per the recommendation made to the region by RARS, Tirupati. The treatment no manure (T_1) was considered as benchmark for ascertaining the performance of other treatments while, the treatment of no manure and *panchagavya* spray alone (T_2) was inducted to study the exclusive contribution from *panchagavya*. To find out the discount in yield due to the application of various organic sources, recommended dose of N, P and K through fertilizers was imposed as a treatment (T_3) and another treatment tried was recommended dose of N, P and K through fertilizers in combination with *panchagavya* spray (T_4).

A cropping system must be location specific and acceptability of the cropping system depends on its efficient utilization of available resources, suitability to climatic conditions and the output of the cropping system must cater the needs of the farmers. The cropping system chosen for the present study has been proved efficient in terms of productivity and remunerative economic returns in the experimental domain.

5.3 RESPONSE OF MAIZE TO VARIED MANURIAL PRACTICES

The tallest plants with largest leaf area and highest dry matter accrual (Fig. 5.1), with the highest number of grain rows cob^{-1} and number of grains row^{-1} of cob and longest cobs with largest girth and highest weight, highest grain weight, highest yield (grain as well as stover), highest harvest index of maize and the quality parameters of grain (protein content, starch content and amino acid content) (Fig. 5.3 to 5.6) were produced with recommended dose of fertilizer.

It is obvious that with the recommended dose of fertilizer, any crop would perform at its best, because of adequate and balanced nutrient supply to the crop at the right time of requirement. Accordingly, the maize crop under comfortable nutrition could produce the growth parameters of

Fig 5.1: Stage-wise dry matter production (kg ha^{-1}) of maize as influenced by varied manurial practices and *panchagavya* spray

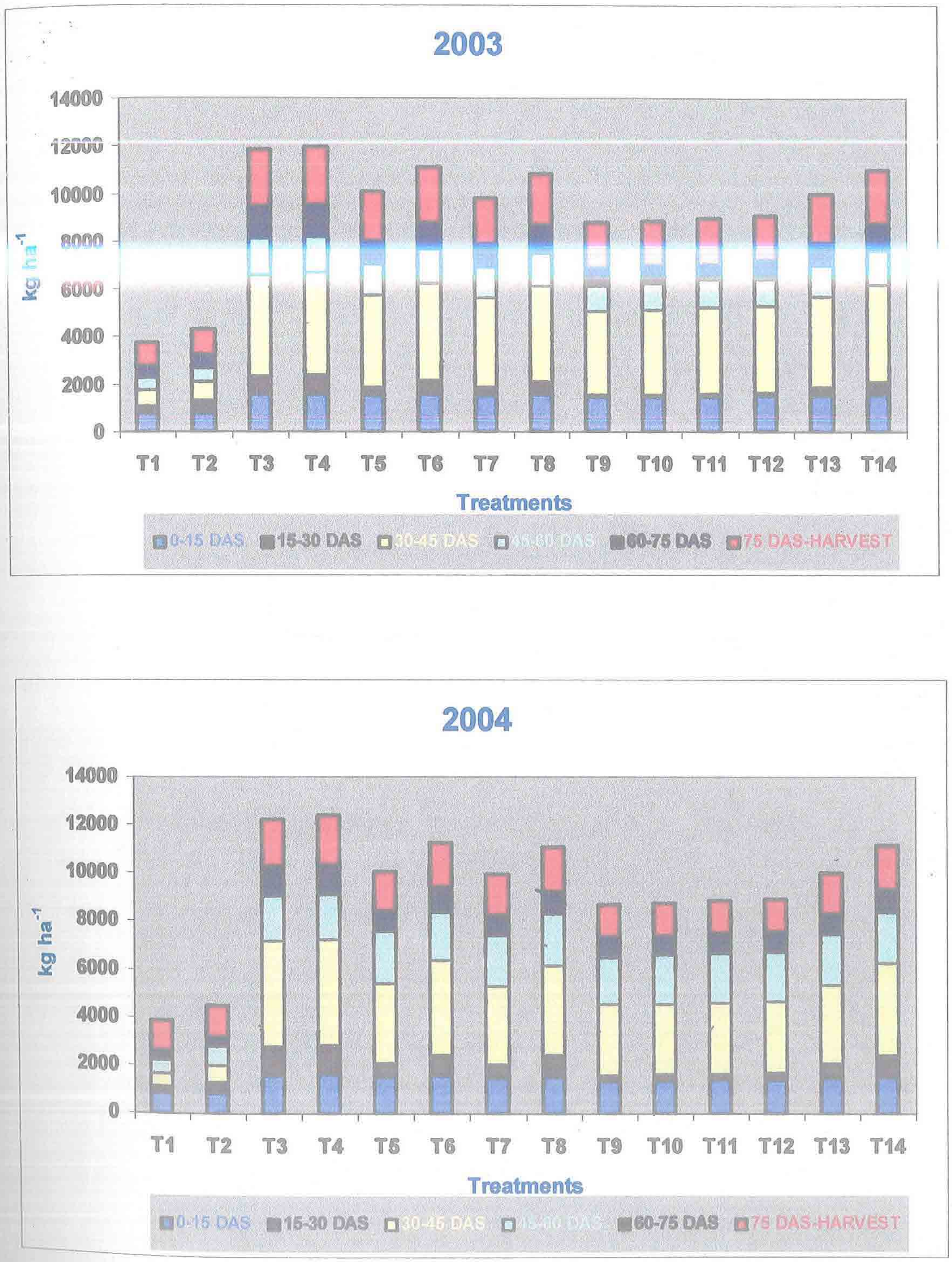
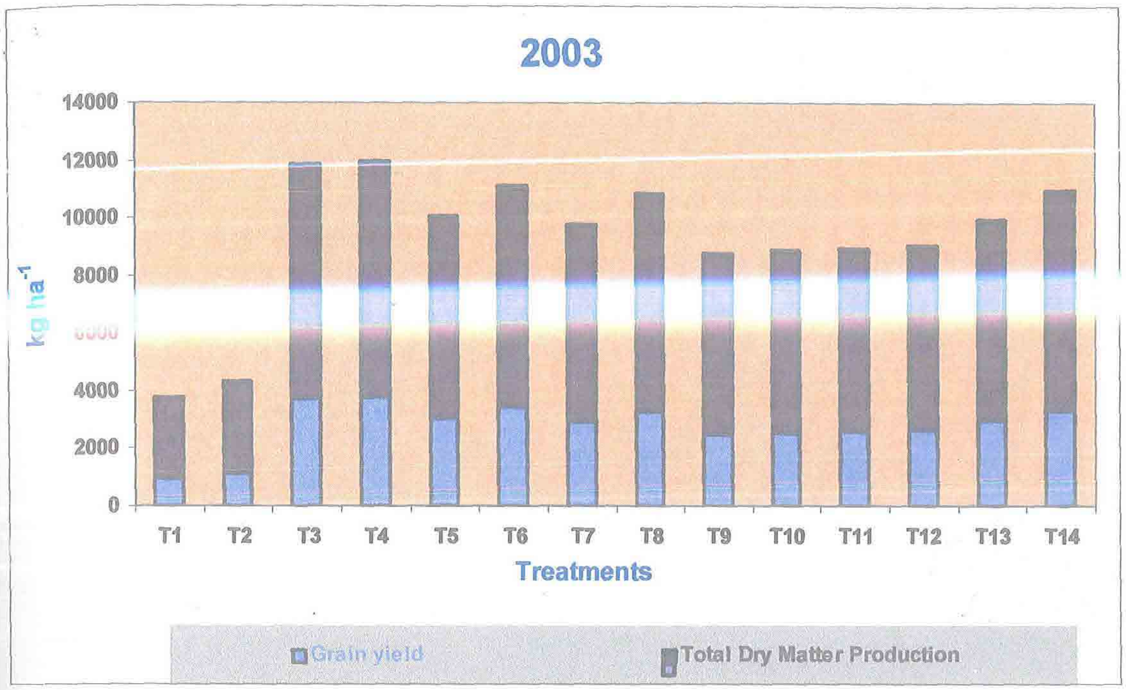


Fig 5.2: Total dry matter production (kg ha^{-1}) and grain yield of maize as influenced by varied manurial practices and *panchagavya* spray



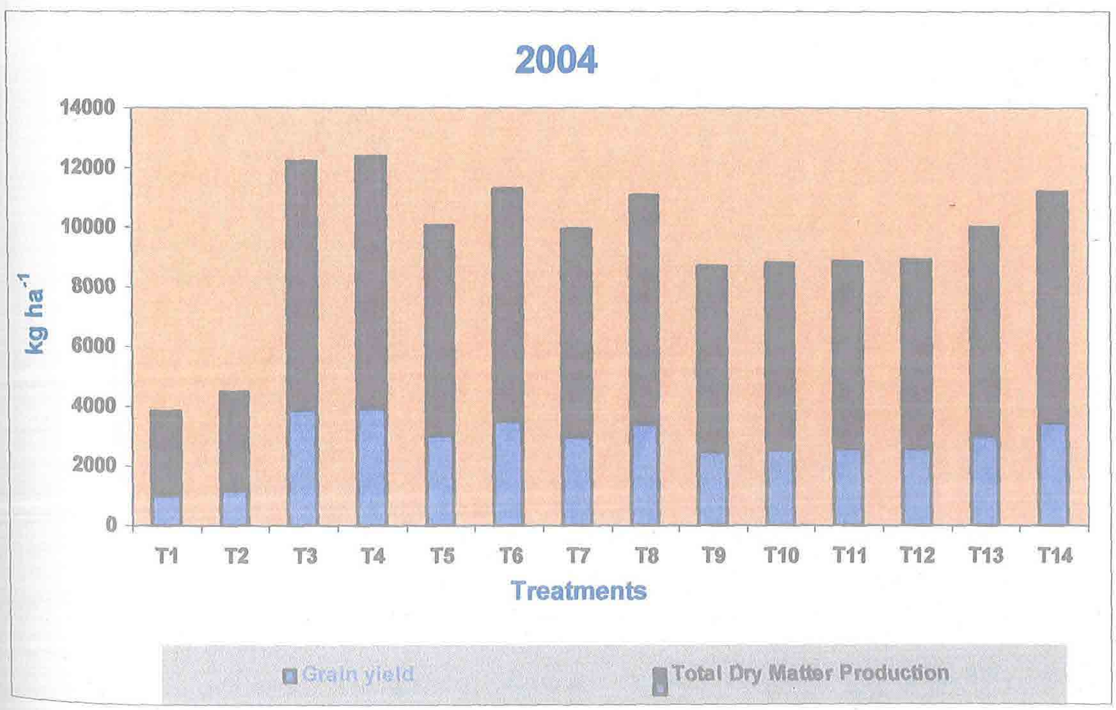
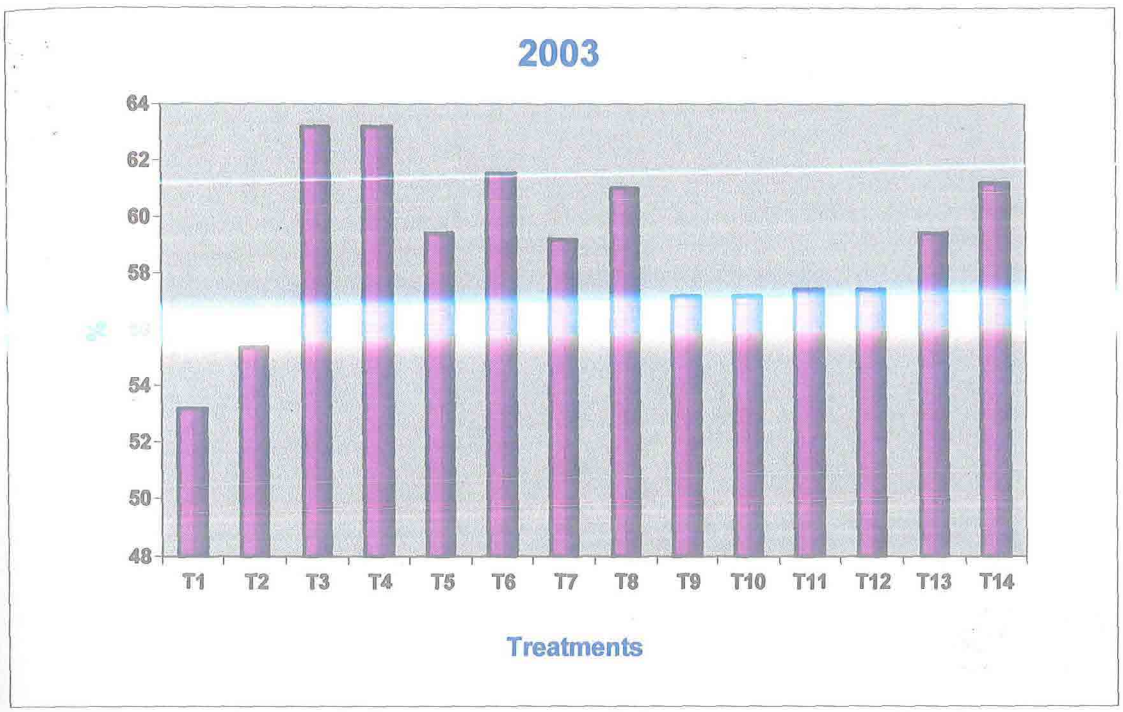


Fig 5.4: Starch content (%) of maize grain as influenced by varied manurial practices and *panchagavya* spray



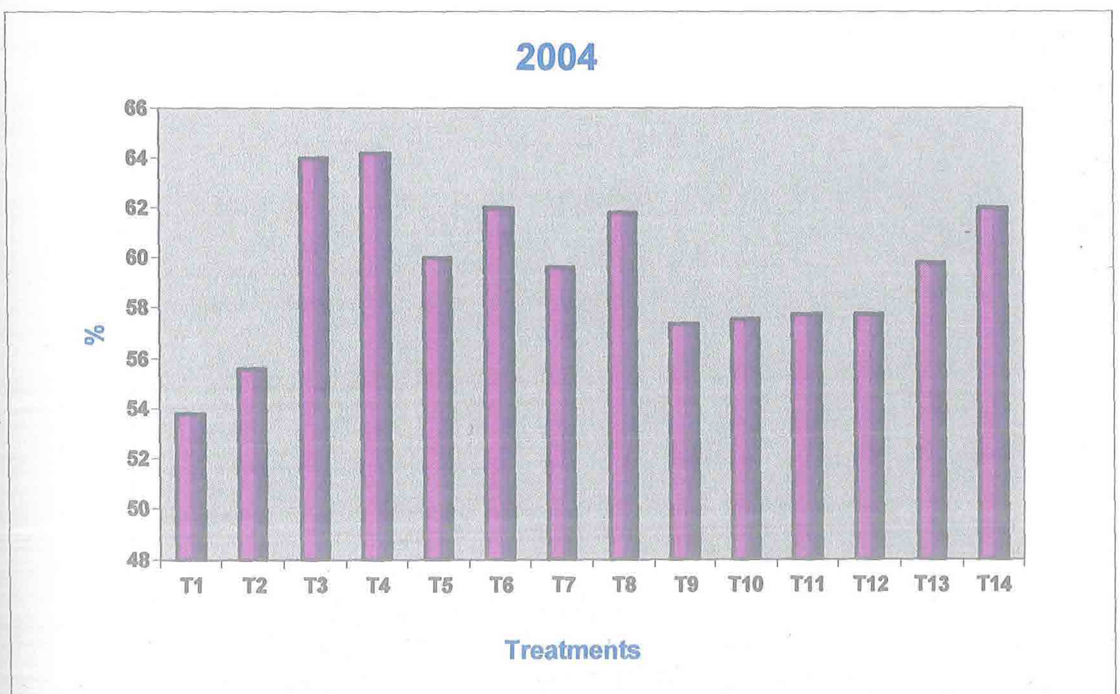
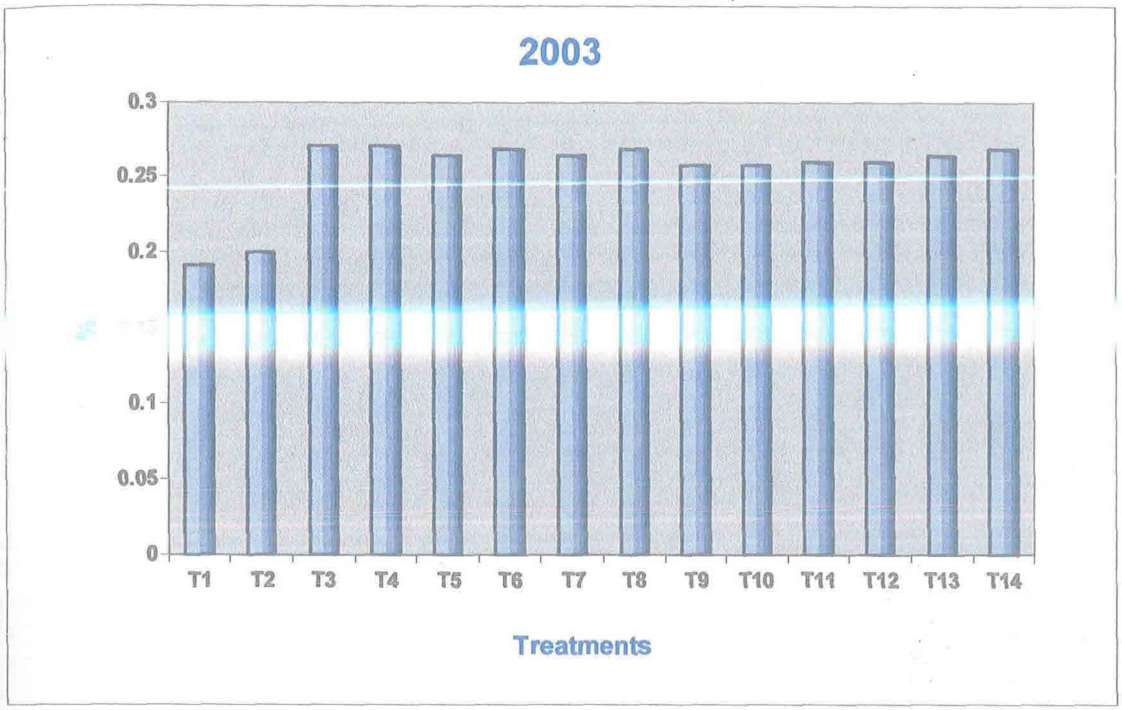


Fig 5.5: Lysine content (%) of maize grain as influenced by varied manurial practices and *panchagavya* spray



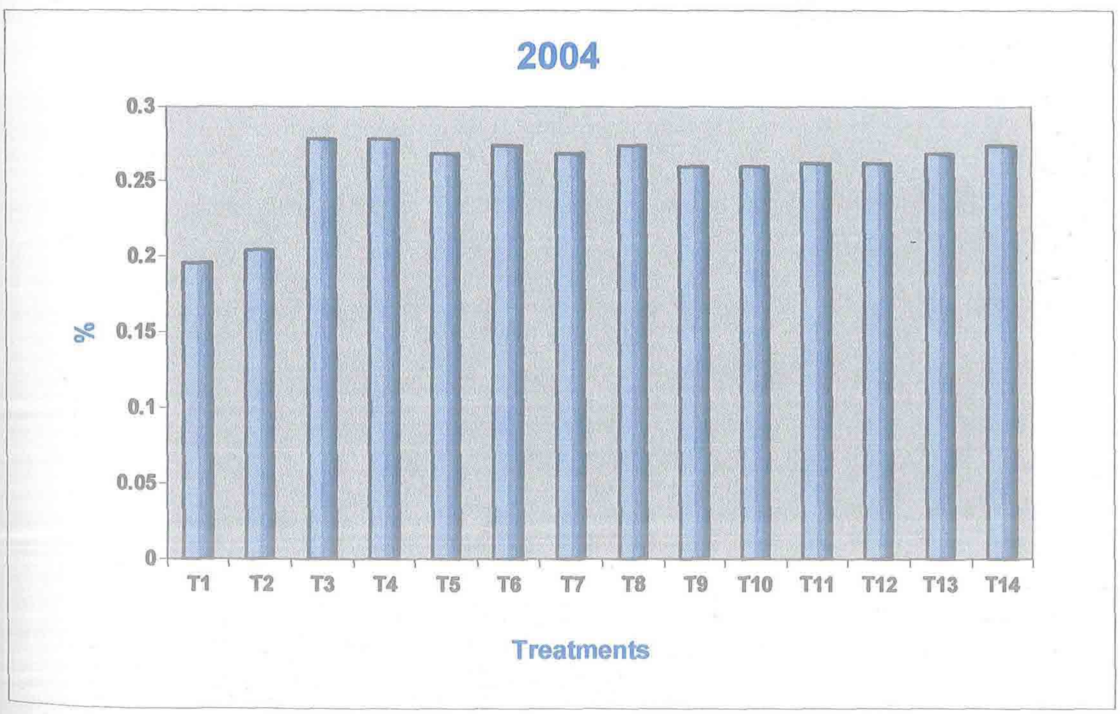
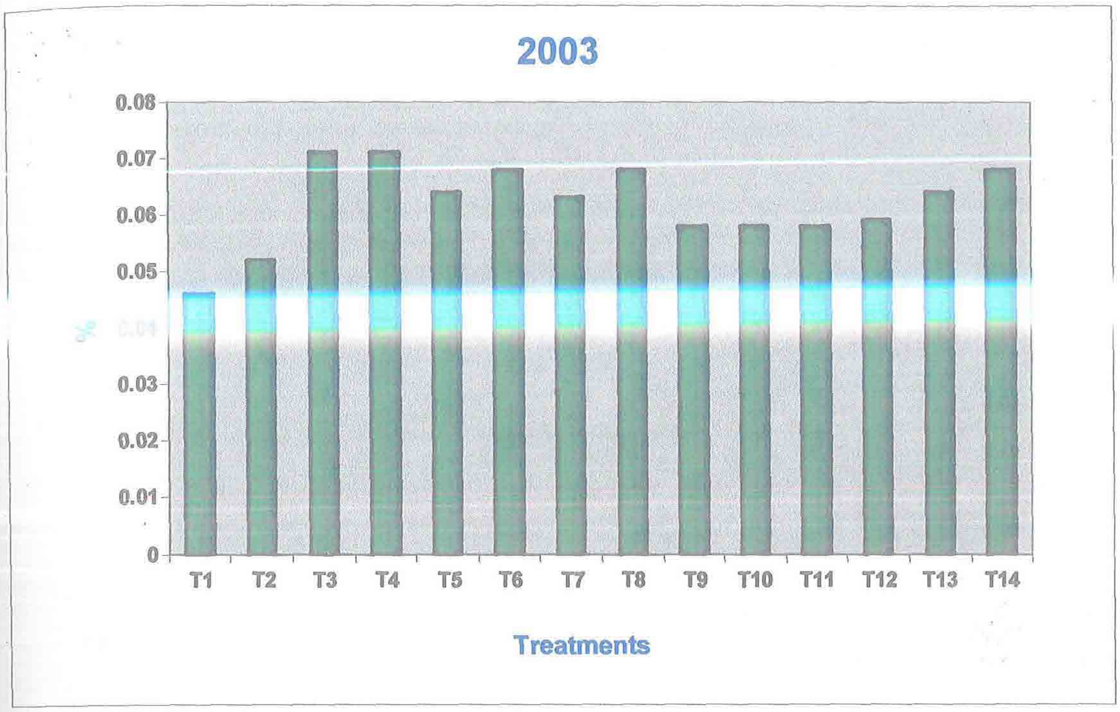
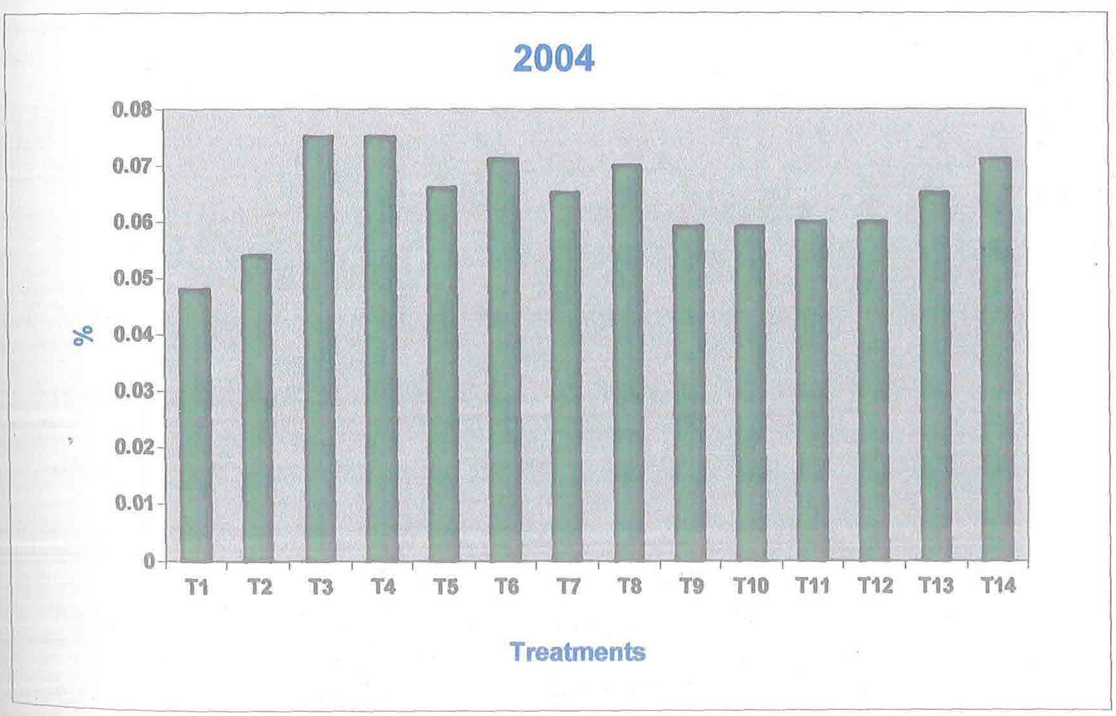


Fig 5.6: Tryptophan content (%) of maize grain as influenced by varied manurial practices and *panchagavya* spray

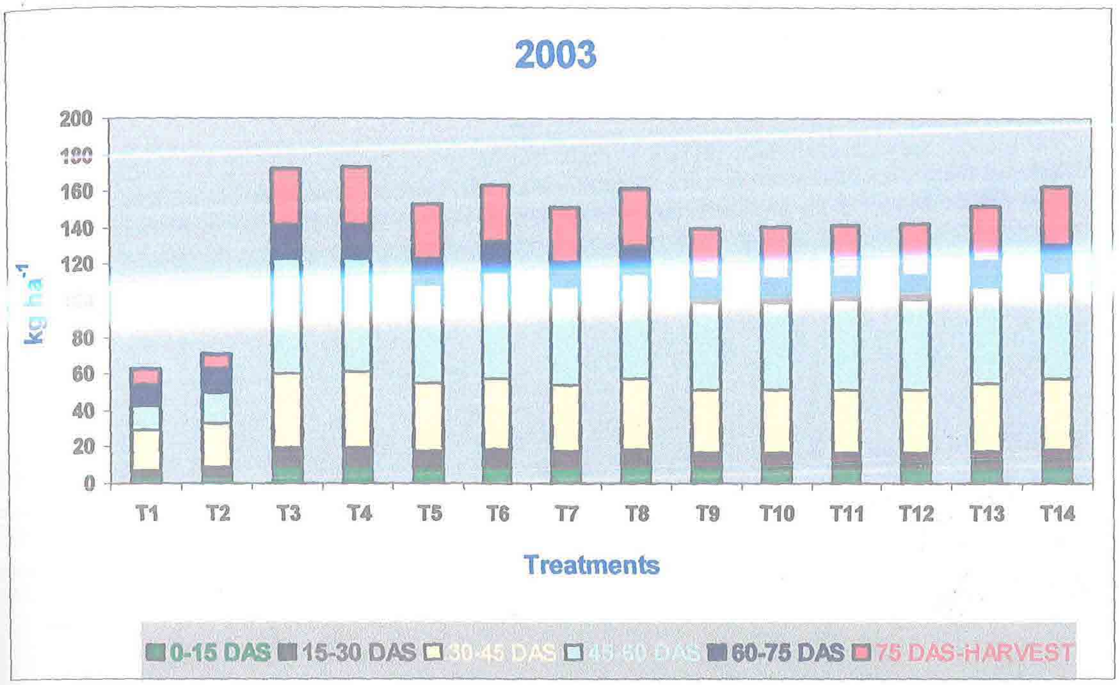




the highest stature, which could accrue huge quantity of biomass and partitioned a large fraction of assimilates to the sink (Fig.5.2), thus resulting in better yield structure as displayed by all the yield attributes of the largest stature, which could result in the highest economic yield as well as the by-product. Quality parameters of maize grain were found to be the highest with the above mentioned manurial practice. Balanced nutrition and higher nitrogen uptake would have resulted in higher amino acid, protein and starch content in the maize grain. Similar findings were reported earlier by Parthipan and Prem sekhar (2002).

The highest nitrogen uptake of maize (Fig. 5.7) was registered with recommended dose of fertilizer, while the highest phosphorus uptake (Fig. 5.8) was recorded with poultry manure and the highest potassium uptake (Fig. 5.9) was recorded with vermicompost. Under recommended level of nitrogen supply, N would be taken up by the crop uninterruptedly, since it was applied in suitable number of splits to match the physiological needs of the crop, resulting greater absorption compared to the organic source of N applied totally as basal. Higher uptake of N by sunflower crop with recommended dose of fertilizer than with organic sources, even on equal nutrient basis was reported by several earlier researchers. The highest P uptake by sunflower crop was recorded with poultry manure and the highest K uptake was associated with vermicompost. This was due to higher levels of P and K in the corresponding organic manures, which

Fig 5.7: Stage-wise nitrogen uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *panchagavya* spray



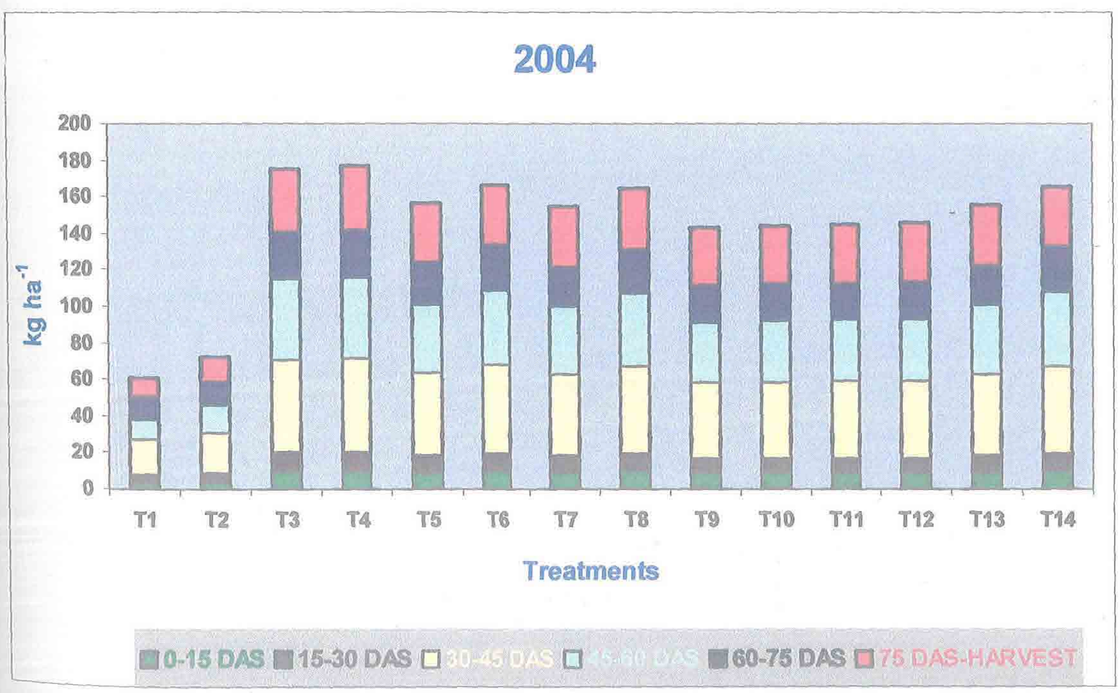
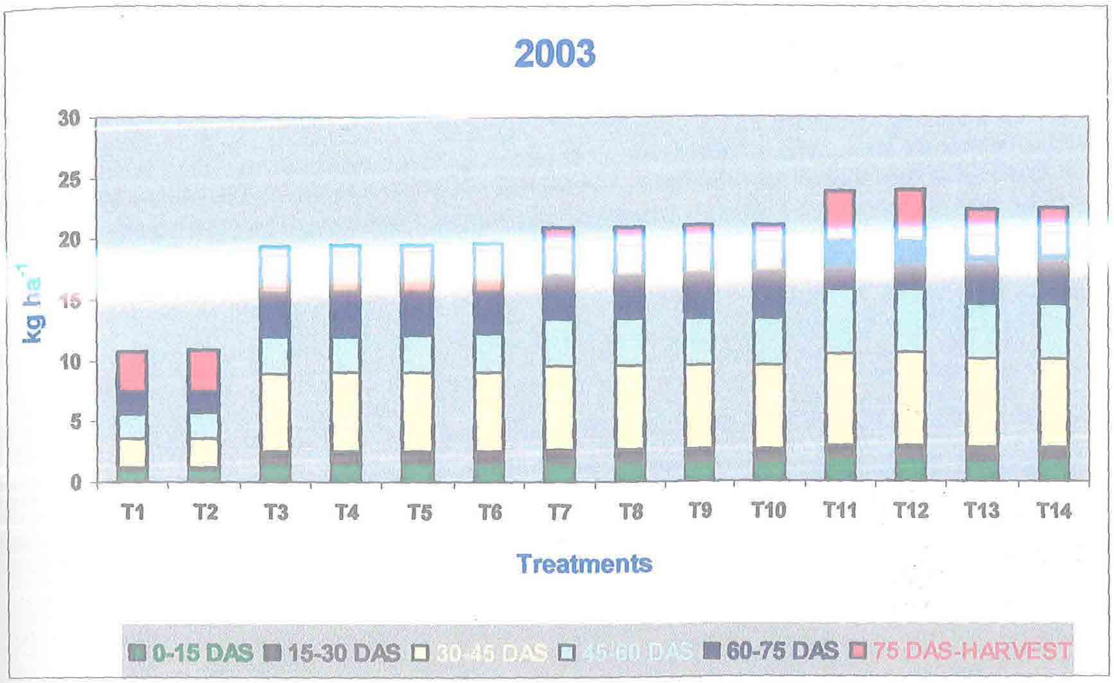


Fig 5.8: Stage-wise phosphorus uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *panchagavya* spray



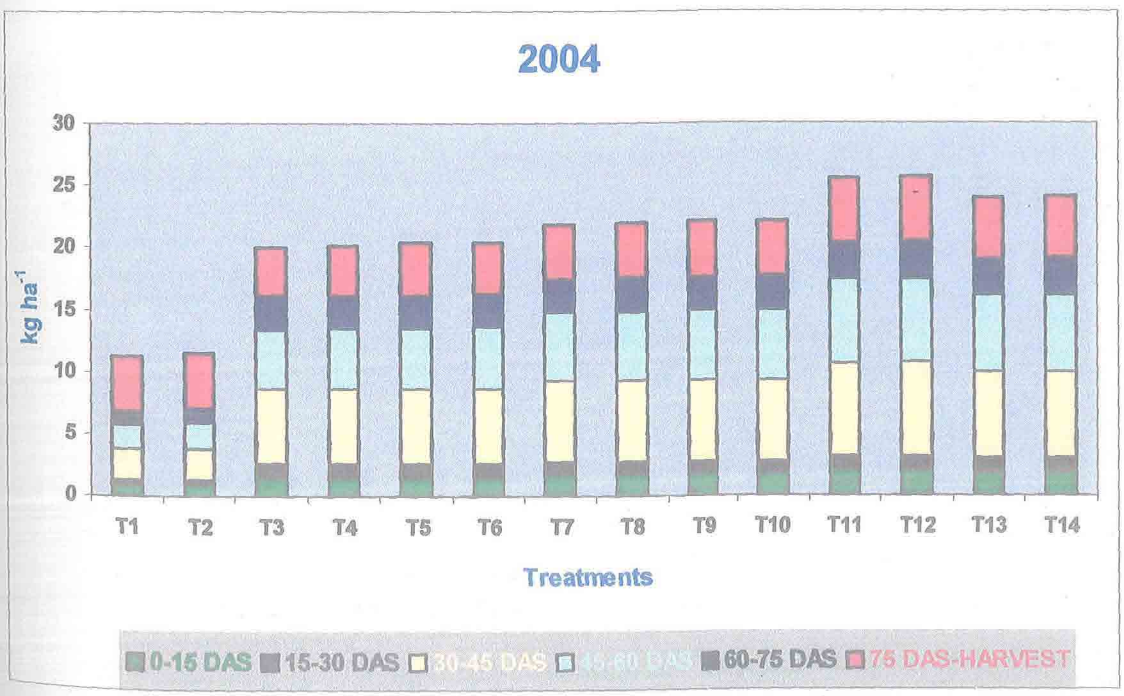
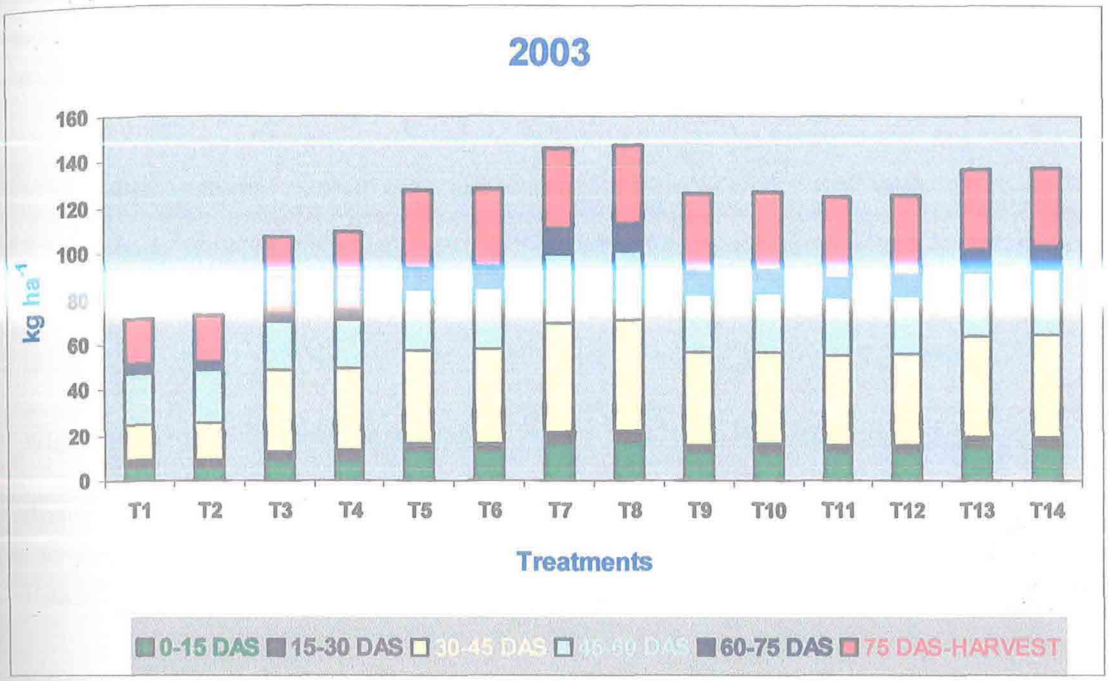
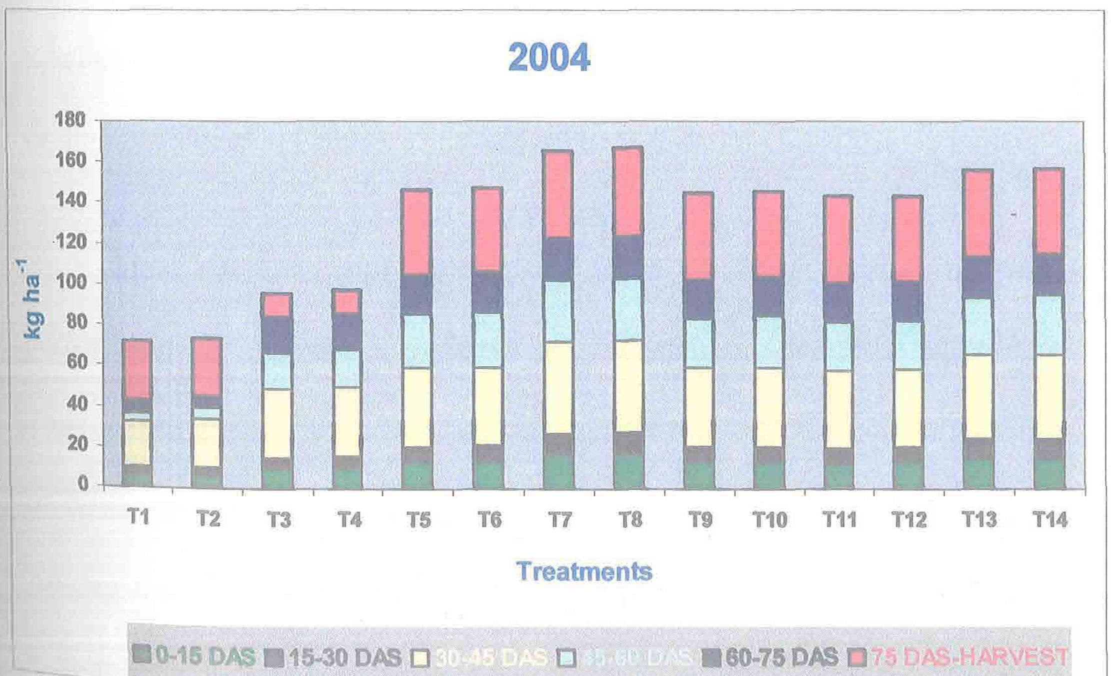


Fig 5.9: Stage-wise potassium uptake (kg ha^{-1}) of maize as influenced by varied manurial practices and *panchagavya* spray



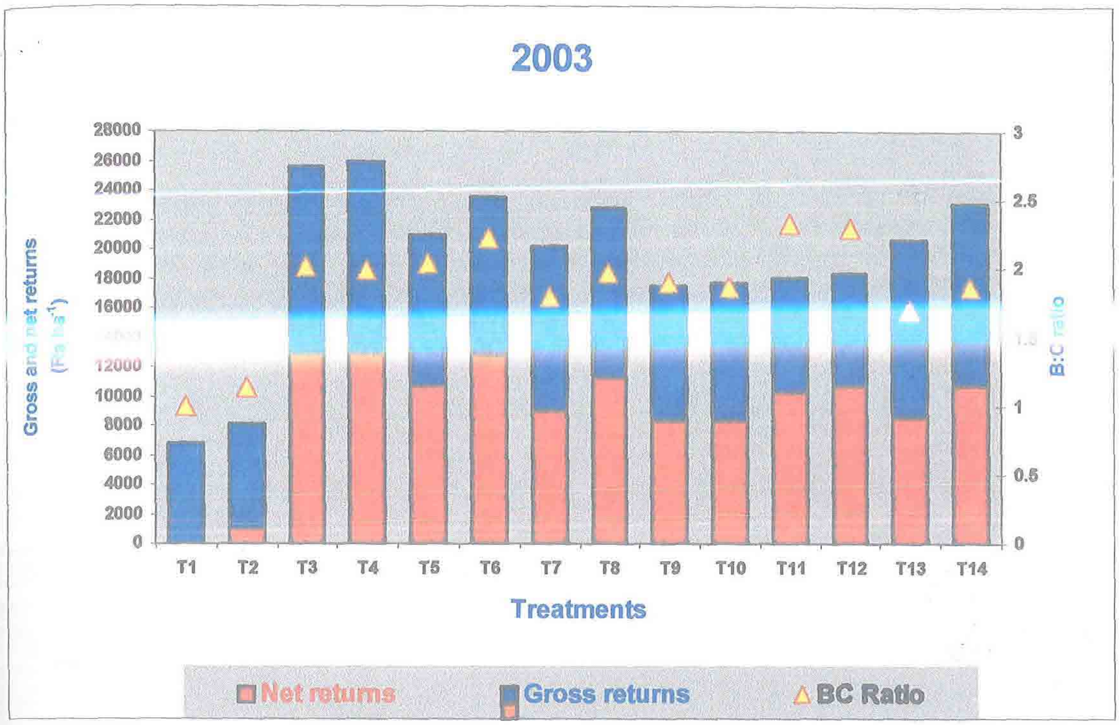


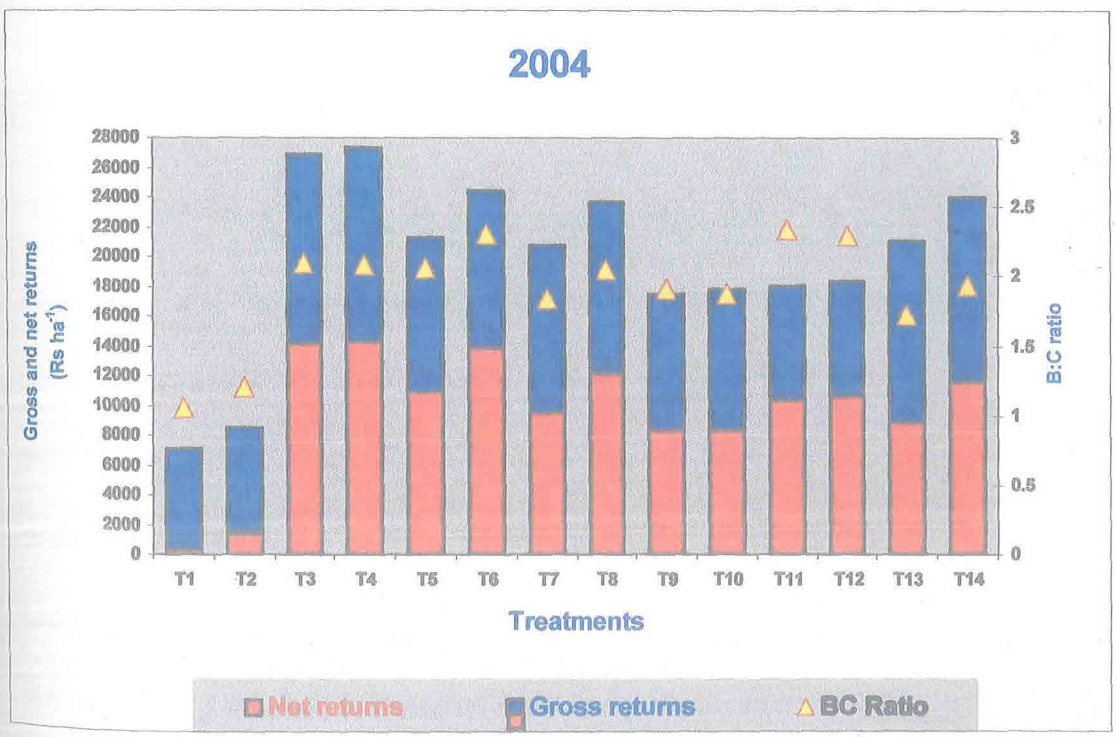
happened to be due to the application of all manures and fertilizer on equal N basis (Table 3. 2 and 3.3). The results of the present study are in accordance with those of Bhiday (1994), Lam *et al.* (1997) and Dosani *et al.* (1999).

The highest gross and net returns from maize crop were realized with the recommended dose of fertizer, while the benefit-cost ratio (B-C ratio) was the highest with the application of poultry manure (Fig. 5.10). Highest economic yield and stover yield was resulted with recommended dose of fertizer, obviously resulting in higher economic returns. Reasonably higher yield resulting in higher gross returns and relatively cheaper cost of poultry manure has resulted in higher B-C ratio. The outcome from the present investigation corroborates with the findings of Sundararaman *et al.* (2001), with respect to gross and net returns and the findings of Beaulah (2001), with respect to B-C ratio.

Since the main aim of the study is on the scope organic farming, performance of crops with different organic manures has to be examined. Thus, keeping the best performance of maize crop with recommended dose of fertilizer apart, comparison was made among different organics tried. Among the organic manures tried on maize crop, farm yard manure, pig manure and vermicompost, which resulted in equal performance, were found better than poultry manure and neem leaf manure. The former three

Fig 5.10: Gross returns, Net returns (Rs ha^{-1}) and B-C Ratio of maize as influenced by varied manurial practices and *panchagavya* spray





organic sources could produce growth parameters and yield attributes of higher stature, resulting in higher yield, nitrogen uptake, quality parameters of grain and gross returns than with the two latter sources. Among different organics, the highest net returns were realized with farmyard manure, while they were the lowest with neem leaf manure.

Major nutrient balance would be different with different organic sources applied on equal nitrogen basis, since concentration of nutrients varied with them. The preference of crops differ with the source of organics applied, depending upon its nutritional requirement. Further, the mineralization pattern and release of nutrients into the soil solution differs. Since, each crop would likely to have its own preference, in the present study, maize has performed better with farm yard manure or pig manure or vermicompost than with poultry manure or neem leaf manure.

The present investigation revealed that if organic farming is desired, one can go for the choice of organic sources to maize, depending upon the abundant availability locally and cheaper cost among the sources, which would result in expected performance of a given crop. The outcome of the present investigation is in consonance with those of Bhiday (1994), Gorodonii *et al.* (1994), Ramamurthy and Shivashankar (1995), Rameshwar and Singh (1998) and Marinari *et al.* (2000).

Growth parameters, yield attributes, yield, nutrient uptake, quality parameters of grain and economic returns were at their lowest with non-manuring of maize through any source. It is obvious that modern genotypes of crops would under perform in the absence of adequate nutrient supply, since they are responsive only to the applied nutrients and the same thing happened in the present study.

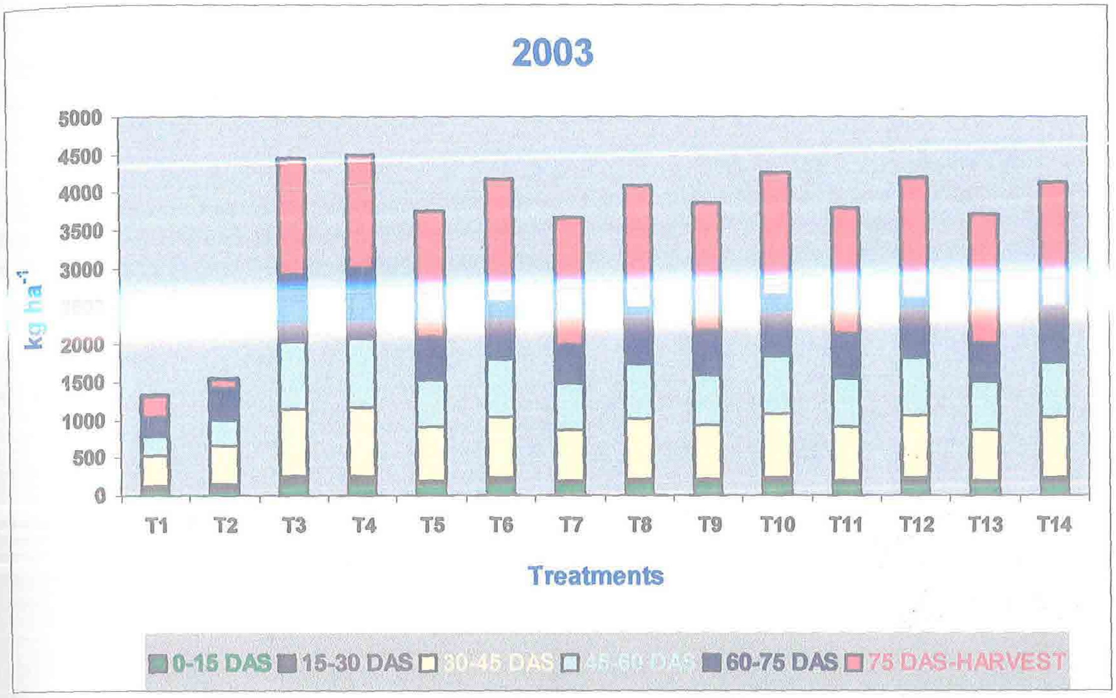
Maize crop has flowered and matured at the earliest with no manure, while the flowering and maturity was found most delayed with recommended dose of fertilizer, which matured significantly later than the organic sources. However, all organic sources had abrust similar effect on maturity. Under adequate nutrition of **N** and its availability to the crop continuously, the vegetative phase will be extended and it is opposite with non-supply of **N.** Exactly that was what happened in the present study. Numerous research reports revealed the same phenomenon in several crops, including maize.

5.4 RESPONSE OF SUNFLOWER TO VARIED MANURIAL PRACTICES

The tallest plants with largest leaf area and highest dry matter accrual (Fig.5.11), with the largest head diameter, highest number of total and filled seeds head^{-1} (Fig.5.12) and highest grain weight, highest yield (seed as well as stalk), highest harvest index of sunflower were produced with recommended dose of fertilizer. With the recommended dose of fertilizer, any crop would perform at its best, because of adequate and balanced nutrient supply to the crop at the right time of requirement. Accordingly, the sunflower crop under comfortable nutrition could produce the growth parameters of the highest stature, which could accrue huge quantity of biomass and partitioned a sizeable quantity of assimilates to the sink. Thus resulting in better yield structure as exhibited by all the yield attributes of the largest stature, which could result in the highest yield (Fig.5.13). The results of present investigation are in accordance with those of Devi Dayal *et al.* (1999).

The highest oil content in the seed of sunflower (Fig. 5.14) was recorded with neem leaf manure, which was comparable with all other organic sources tried. For biosynthesis of oil in oilseed crops, sulphur is required in adequate quantities. Organic manures possess large quantities of secondary and micronutrients, besides the major nutrients. Thus the large quantities of sulphur present in organics applied would have

Fig 5.11: Stage-wise dry matter production (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *panchagavya* spray



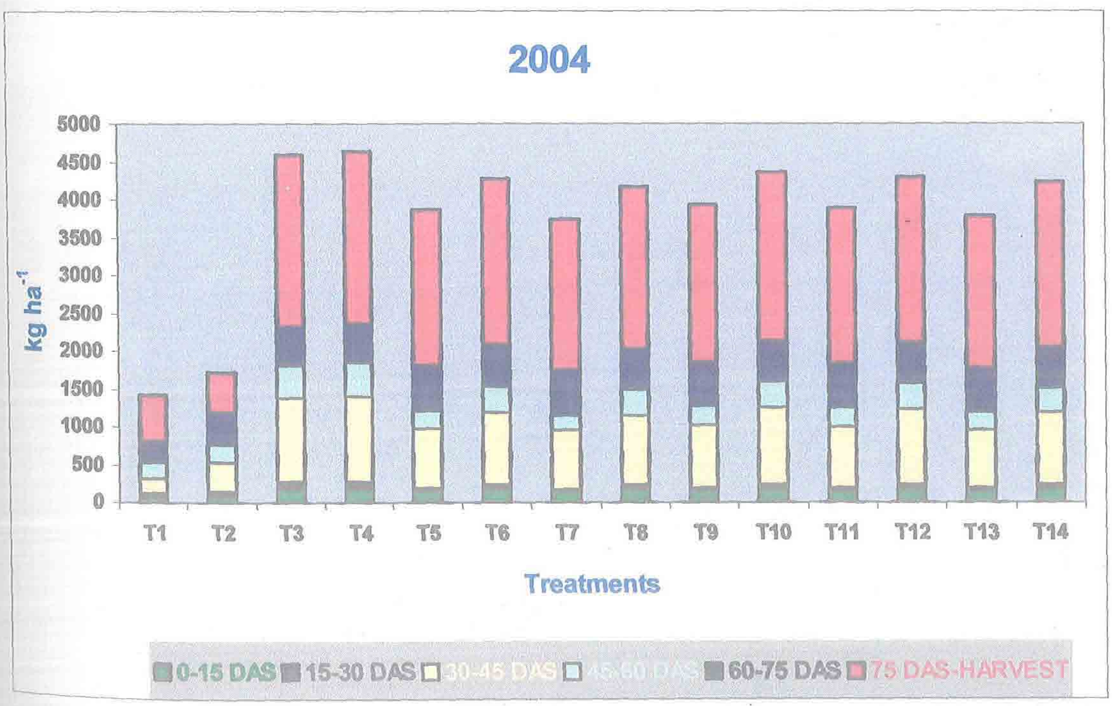
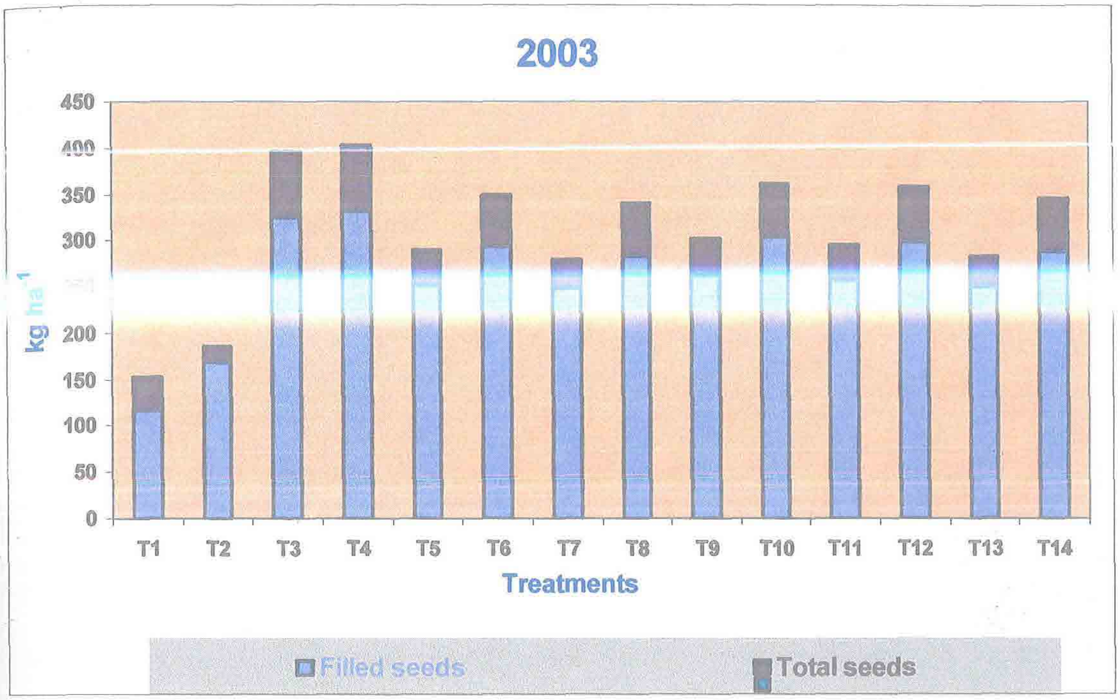


Fig 5.12: Total seeds and Filled seeds head^{-1} of sunflower as influenced by varied manurial practices and *panchagavya* spray



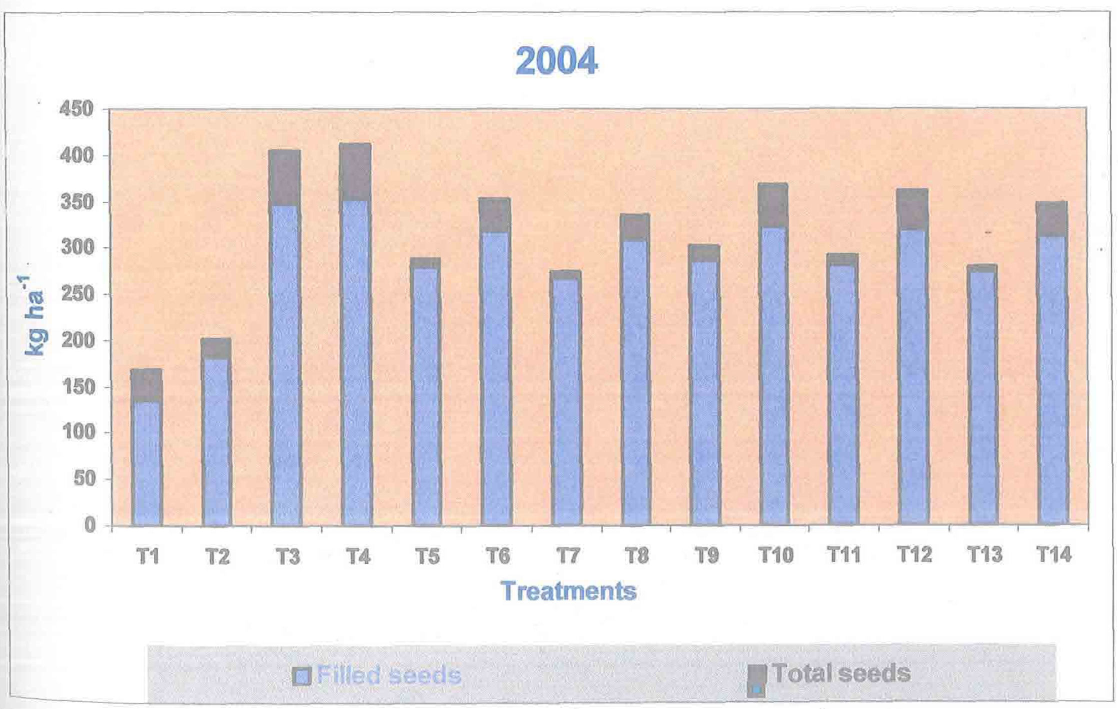
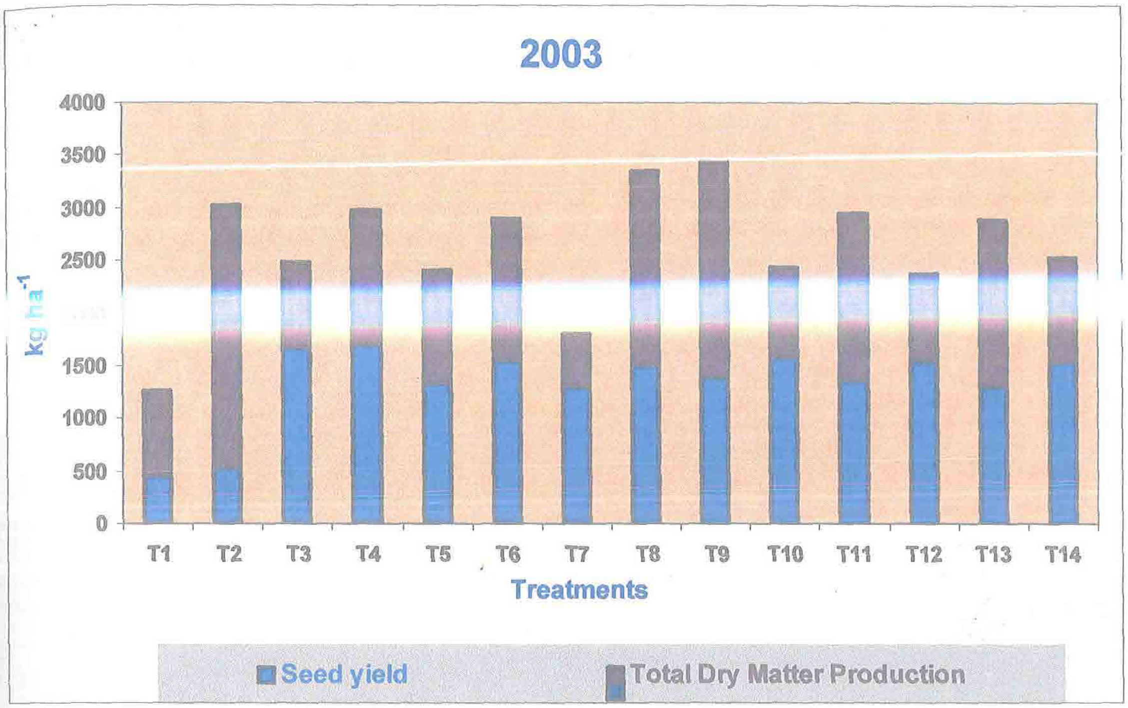


Fig 5.13: Total dry matter production and seed yield (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *panchagavya* spray



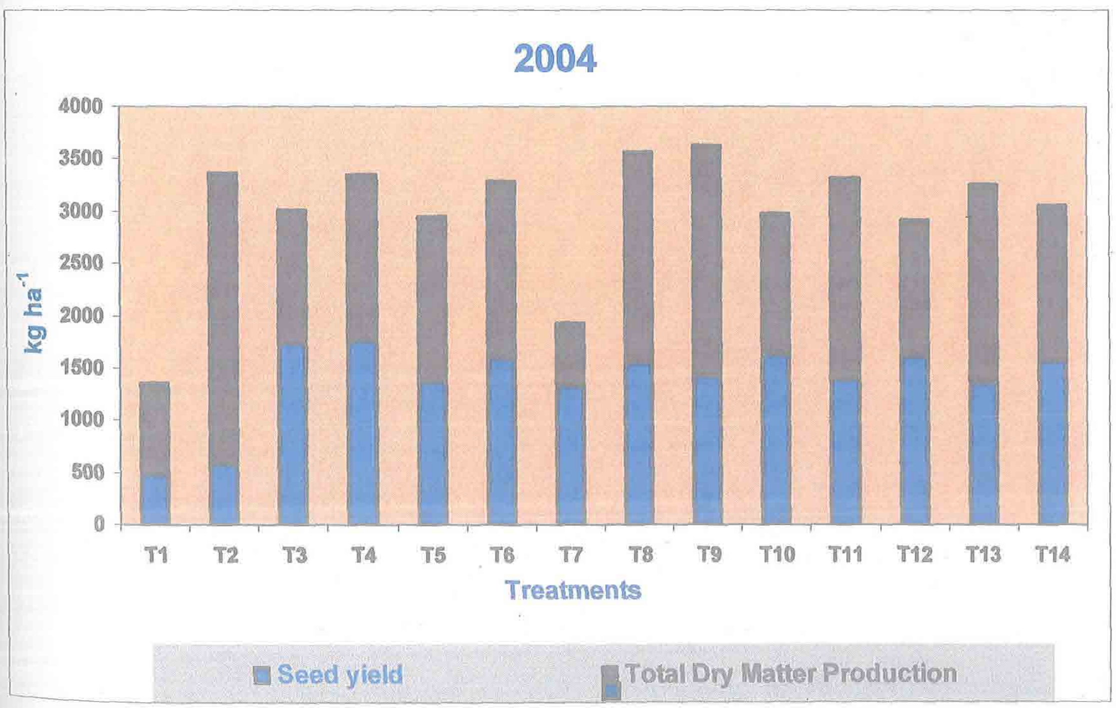
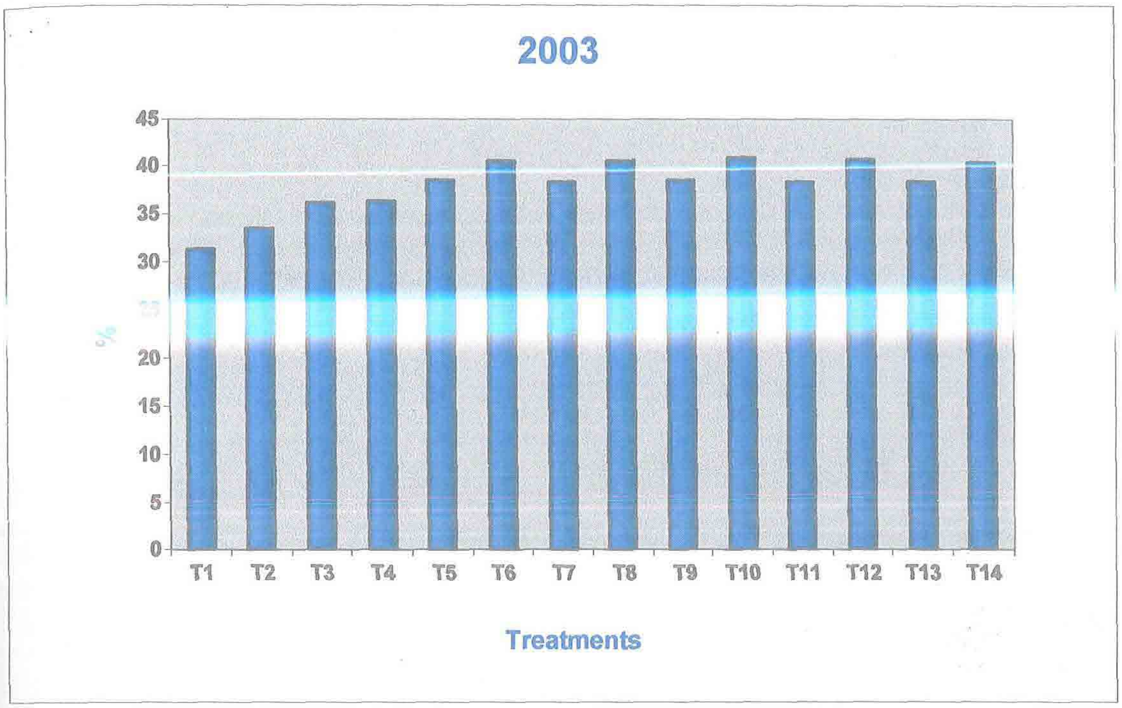
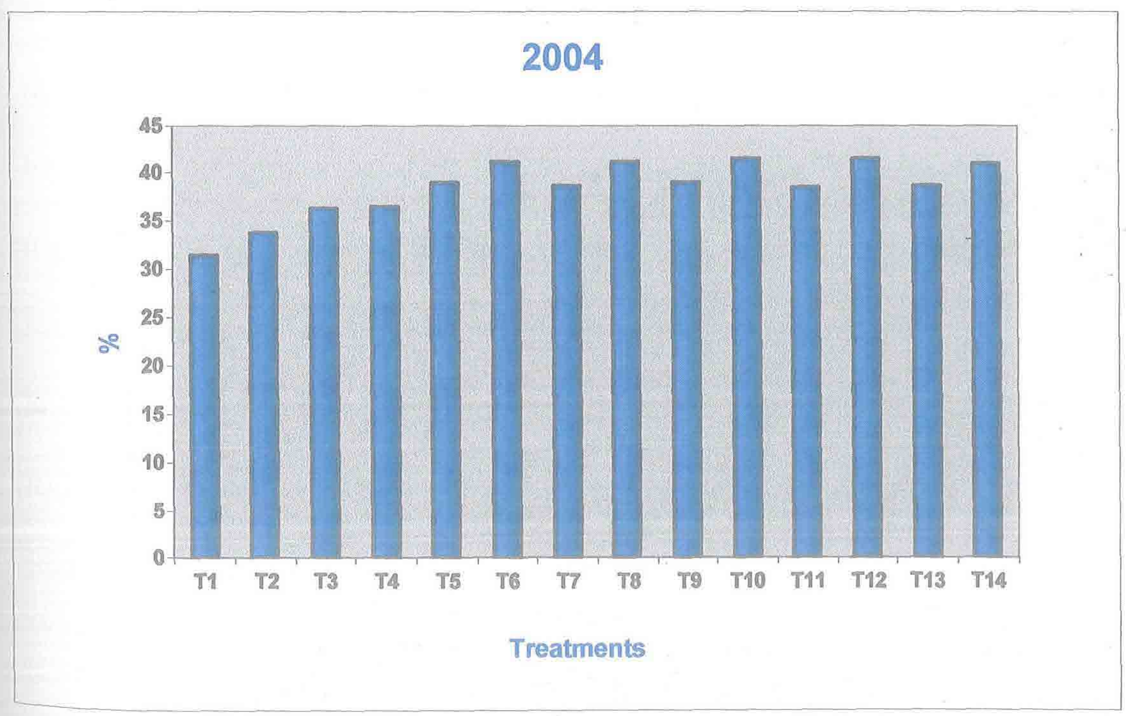


Fig 5.14: Oil content (%) of sunflower seed as influenced by varied manurial practices and *panchagavya* spray



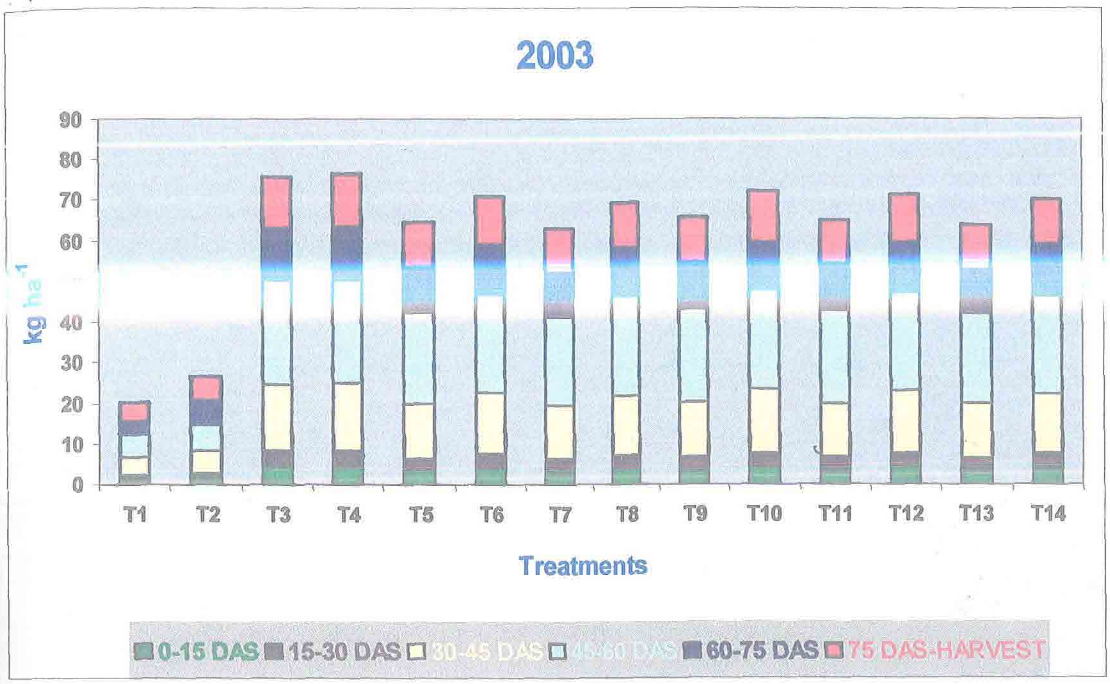


manifested in higher oil content in sunflower seed. Similar findings were reported by Somasundaram (2003).

The highest nitrogen uptake of sunflower (Fig. 5.15) was registered with recommended dose of fertilizer, while that of phosphorus uptake (Fig. 5.16) was highest with poultry manure. The potassium uptake (Fig. 5.17) was highest with vermicompost. Under recommended level of nitrogen supply, N would be taken up by the crop uninterruptedly, since it was applied in suitable number of splits to match the physiological needs of the crop, resulting greater absorption compared to the organic source of N applied totally as basal. Higher uptake of N by sunflower crop with recommended dose of fertilizer than with organic sources, even on equal nutrient basis was reported by several earlier researchers. The highest P uptake by sunflower crop was recorded with poultry manure and the highest K uptake was associated with vermicompost. This was due to higher levels of P and K in the corresponding organic manures, which happened to be due to the application of all manures and fertilizer on equal N basis (Table 3.2 and 3.3). These results are in agreement with those of Raju *et al.* (1991), Bhiday (1994), Ramamurthy and Shivashankar (1997), Sharanappa and Shivaraj (1997) and Lam *et al.* (1997).

The highest gross and net returns from maize crop were realized with the recommended dose of fertizer, while the B-C ratio was the highest

Fig 5.15: Stage-wise nitrogen uptake (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *panchagavya* spray



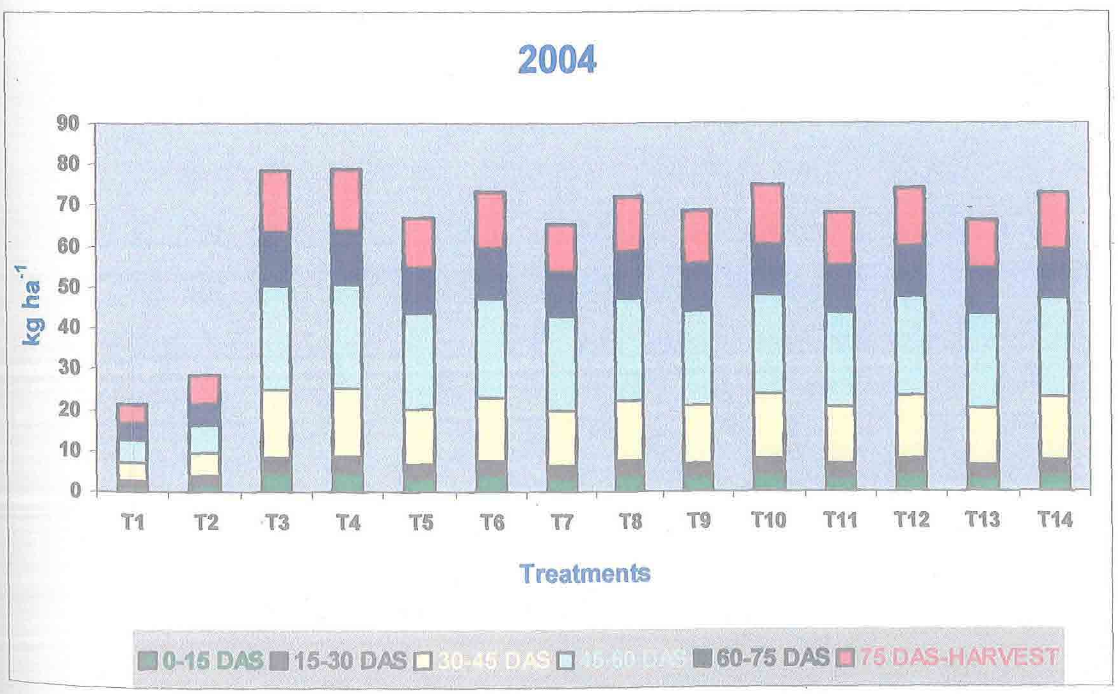
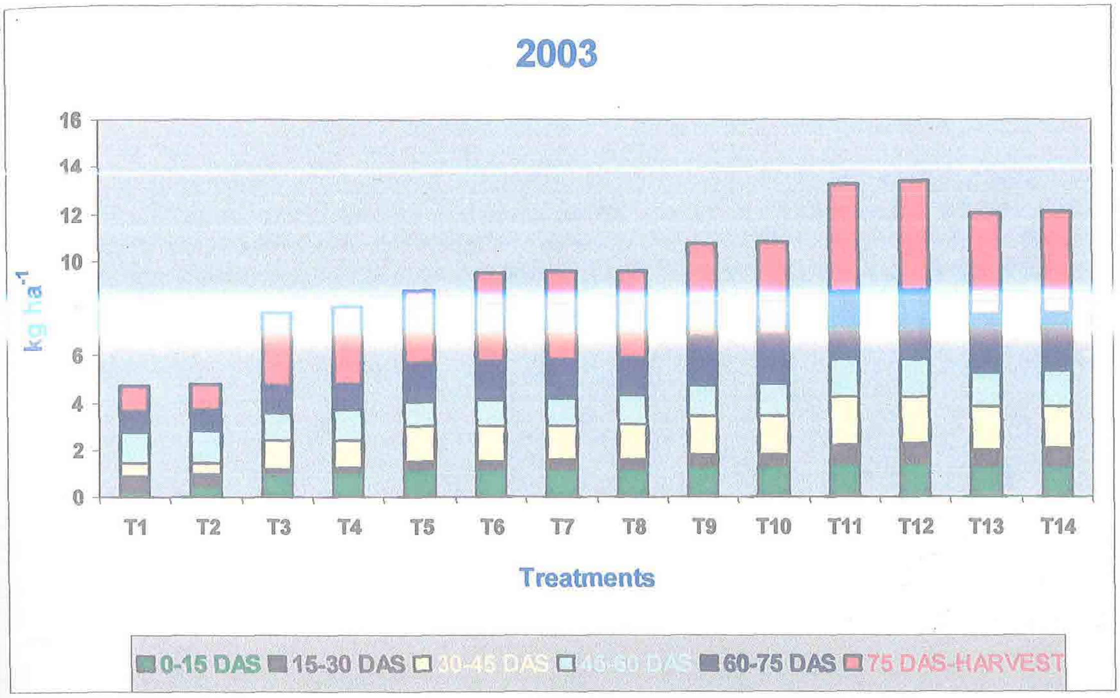


Fig 5.16: Stage wise phosphorus uptake (kg ha⁻¹) of sunflower as influenced by varied manurial practices and *panchagavya* spray



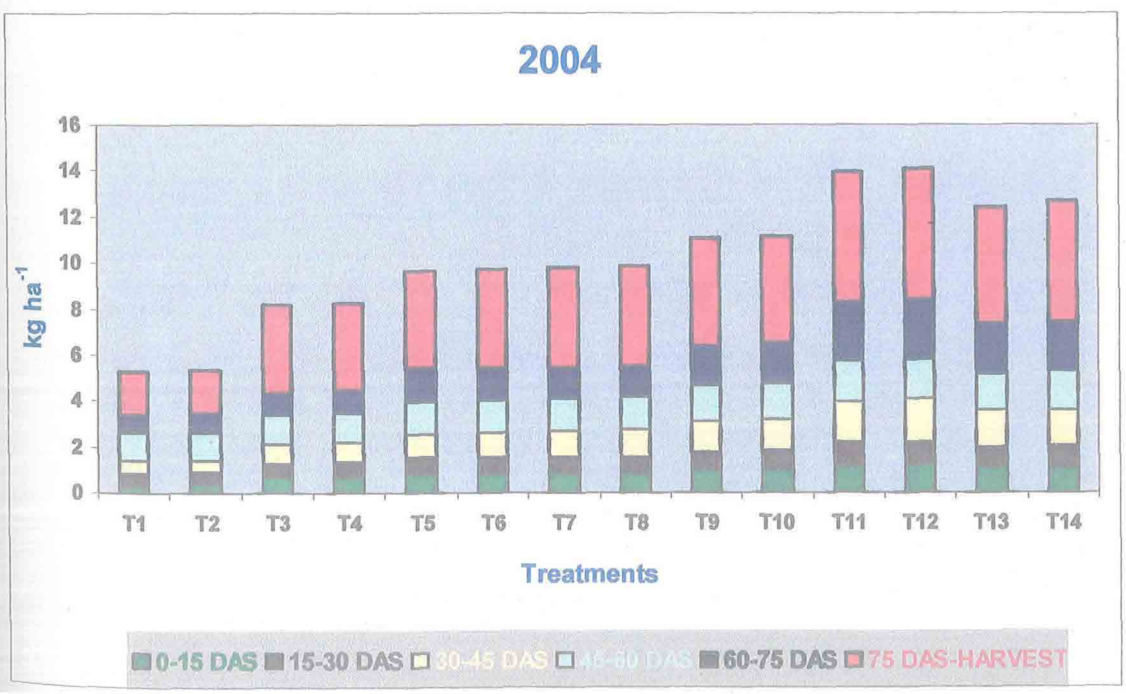
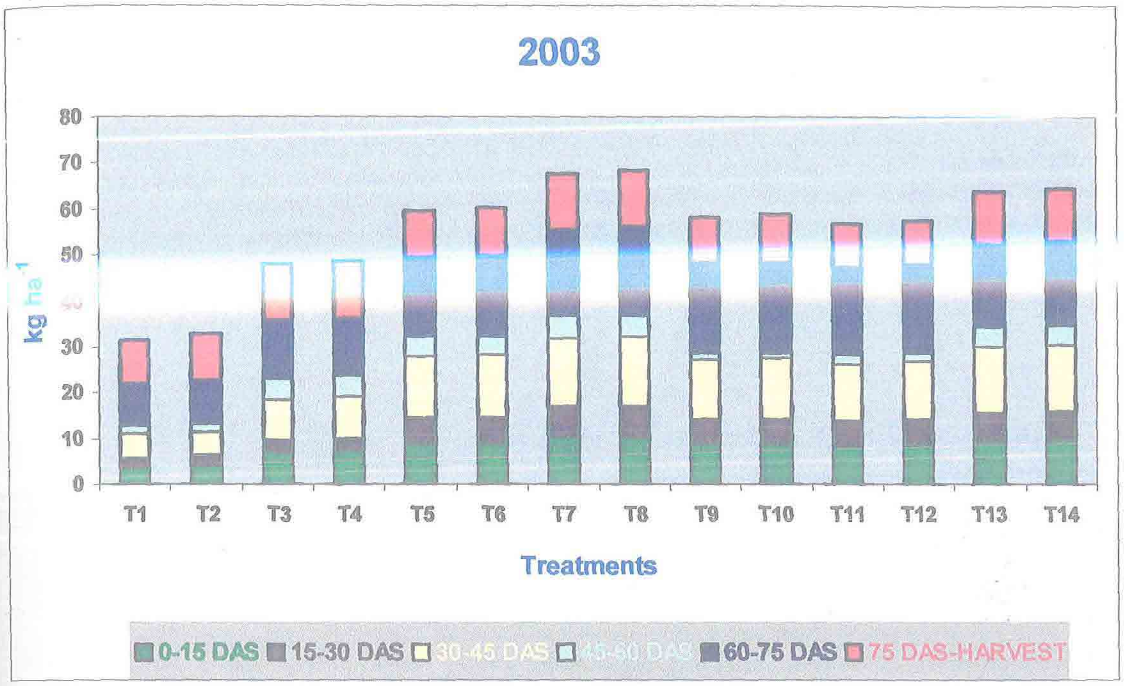
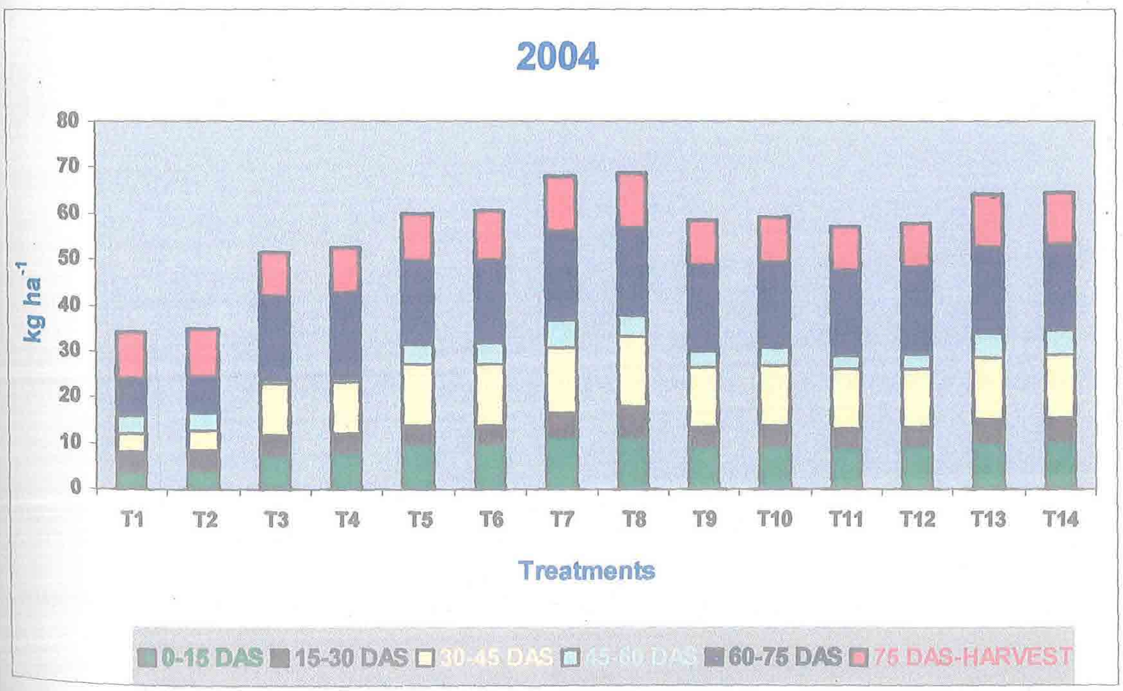


Fig.5.17: Stage-wise potassium uptake (kg ha^{-1}) of sunflower as influenced by varied manurial practices and *panchagavya* spray



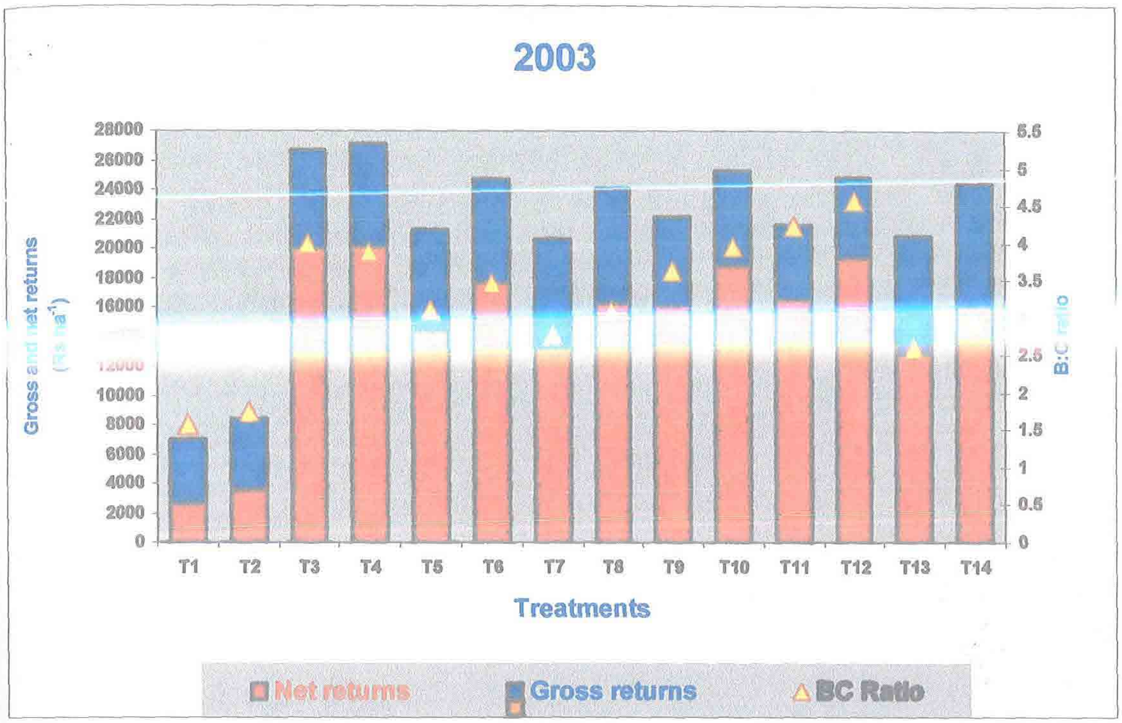


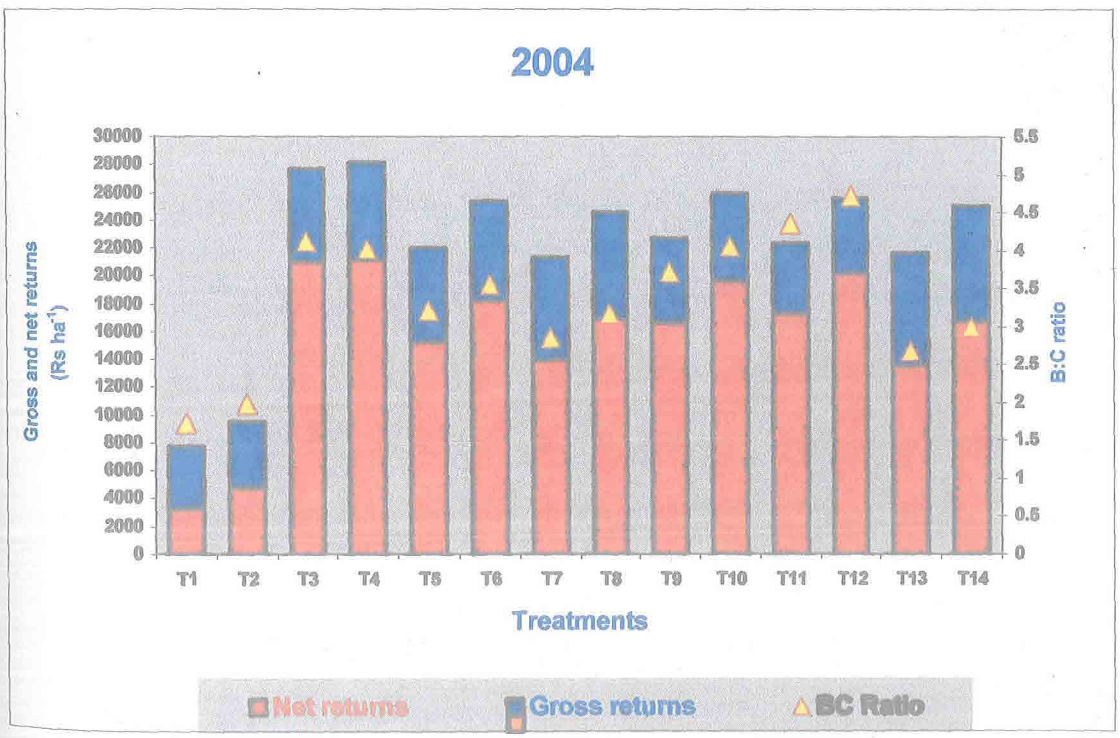
with the application of poultry manure (Fig. 5.18). The highest seed yield of sunflower obtained with recommended dose of fertilizer, obviously resulted in higher economic returns. Reasonably higher yield resulting in higher gross returns and relatively cheaper cost of poultry manure has resulted in higher B-C ratio. The outcome from the present investigation corroborates with the findings of Natarajan (2002), Parrot and Marsdon (2002) and Somasundaram (2002).

All the five organic manures tried on sunflower crop have resulted in equal performance in terms of yield and economic returns. The results have revealed that sunflower crop could respond to various organic manures in similar way and hence, one can go for the choice of organic sources to sunflower, depending upon the abundant availability locally and cheaper cost. The outcome of the present investigation corroborates with the findings of (Murugappan *et al.,* 2001), Franki *et al.* (2004) and Latha *et al.* (2002).

Growth parameters, yield attributes, yield, nutrient uptake, oil content of the seed and economic returns were at their lowest with non-manuring of sunflower through any source. It is obvious that modern genotypes of crops would under perform in the absence of adequate nutrient supply, since they are responsive only to the applied nutrients and the same thing happened in the present study.

Fig 5.18: Gross returns, Net returns (Rs ha^{-1}) and B-C Ratio of sunflower as influenced by varied manurial practices and *panchagavya* spray





Sunflower crop has flowered and matured at the earliest with no manure, while the flowering and maturity was found most delayed with recommended dose of fertilizer, which took significantly more number of days than with all the organic sources of manuring which were comparable among them. Under adequate nutrition of **N** and its availability to the crop continuously, the vegetative phase will be extended and it is opposite with non-supply of **N.** Exactly that was what happened in the present study. Widely published research evidence is available to support the same phenomenon in several crops, including sunflower.

5.5 EFFECT OF *PANCHAGAVYA* ON PRODUCTIVITY AND QUALITY OF MAIZE AND SUNFLOWER

Panchagavya was applied as foliar spray to maize and sunflower crops (as per the treatments) at fortnightly intervals starting from 15 DAS to 15 days before harvest. *Panchagavya* was known to contain plant growth stimulants, which can enhance the biological efficiency of crops and the quality of the produce (Pathak and Ram, 2002). It contains macro and micronutrients, besides several groups of beneficial microorganisms (Table 3.4). The effect of *panchagavya* on the productivity and quality of the economic produce of maize and sunflower is deduced here under. *Panchagavya* has exerted variable influence on different parameters of the two crops on which it was applied.

Growth parameters, yield attributes, yield, nitrogen uptake, grain quality parameters, harvest index and gross as well as net returns of maize were found to be the highest with recommended dose of fertilizer along with spray of *panchagavya,* but all of them were statistically comparable with recommended dose of fertilizer alone, indicating the fact that foliar application of *panchagavya* could not exert any pronounced effect in combination with recommended dose of fertilizer, probably because of adequate and balanced nutrient supply to meet the crop's requirement, resulting in exploiting the maximum possible performance of maize crop under the domain of experimentation. The difference in grain yield of maize with recommended dose of fertilizer along with spray of *panchagavya* and recommended dose of fertilizer alone was mere 1.6 per cent (mean of two years). Beyond a certain level, each crop under a given set of environmental conditions will have a biological ceiling to elevate its performance, in spite of supplementation with any beneficial additives. This fact in crop production can be substantiated with the analogy of non-responsiveness of *Rhizobium* inoculation to leguminous crops raised on soils of adequate available nitrogen status. Thus the response of maize to foliar application of *panchagavya* over and above the recommended dose of fertilizer was not perceptible.

The effect of foliar application of *panchagavya* along with farmyard manure or pig manure or vermicompost was found considerable on all the above mentioned parameters of maize compared to their individual application of the respective manures alone, while with poultry manure and neem leaf, the additional beneficial effect was not perceptible, as in the case of fertilizer. The grain yield difference of maize with farmyard manure, pig manure, vermicompost, poultry manure and neem leaf in combination with foliar application of *panchagavya* over their individual application alone was to the tune of 13.8, 13.0, 12.9, 1.8 and 1.4 per cent, respectively (mean of two years). Crude protein content of maize grain was found improved to a tune of 2.0 to 11.0 per cent with the use of *panchagavya* in combination with different manures applied. The above results indicate that for maize crop, combination of foliar application of *panchagavya* would be fruitful only with certain organic manures and fruitless with others. Similar results were reported by Somasundaram (2003) from Tamil Nadu.

Growth parameters, yield attributes, yield, nitrogen uptake, oil content of the seed, harvest index and gross as well as net returns of sunflower were found to be the highest with recommended dose of fertilizer along with spray of *panchagavya,* but all of them were statistically comparable with recommended dose of fertilizer alone, indicating the fact that foliar application of *panchagavya* could not exerted any pronounced effect in combination with recommended dose of fertilizer. The difference in seed yield of sunflower with recommended dose of fertilizer along with spray of *panchagavya* and recommended dose of fertilizer alone was mere 1.7 per cent (mean of two years). The substantiation for this has been detailed in Para. 2 of this same section.

The effect of foliar application of *panchagavya* along with different organic manures to sunflower crop was totally contrasting with maize. The effect of combination of *panchagavya* and organic manures was striking on the performance of sunflower. All the five organic manures tried on sunflower crop in combination with foliar application of *panchagavya* have resulted in considerably better performance over their individual application without the combination of *panchagavya*. The seed yield difference of sunflower with farmyard manure, pig manure, vermicompost, poultry manure and neem leaf in combination with foliar application of *panchagavya* over their individual application alone was to the tune of 15.5, 16.5, 15.7, 15.0 and 14.5 per cent, respectively (mean of two years).

These results indicate that for sunflower crop, combination of foliar application of *panchagavya* would be fruitful with all the organic manures.

Somasundaram (2003) from Tamil Nadu has reported similar results as from the present study. The contrasting results between maize and sunflower with respect to response of the crops to combination of *panchagavya* and organic manures indicate that such response differs with the crop. The above statement is an oversimplification and indepth studies on this aspect are to be made, to establish the facts with accurate scientific support.

Oil content of sunflower seed was found improved considerably with foliar application of *panchagavya* in combination with any of the organic manures tried over their individual application. The increase in oil content with the use of *panchagavya* ranged from 5.2 to 8.0 per cent with different manures. As indicated earlier, *panchagavya* is known to contain certain plant growth stimulants, which can improve the biological efficiency and quality of certain crops (Pathak and Ram, 2002). Thus, the oil content of sunflower seed might have been improved due to beneficial effect on biosynthesis of oil. These results are in accordance with those of Somasundaram (2003).

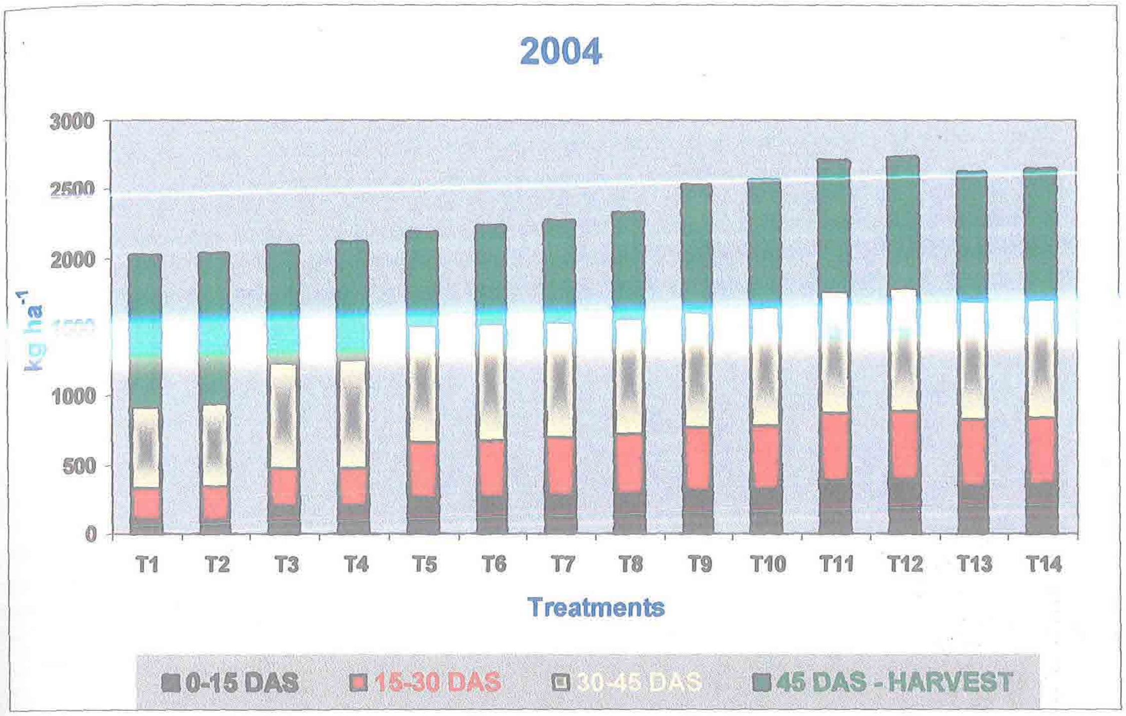
It was clearly found from this study that foliar application of *panchagavya* alone to maize and sunflower crops could not exert any beneficial effect either on the productivity or quality and this was just comparable with non-manuring to the two crops through any source. This amply indicates that foliar application of *panchagavya* alone to crops can not meet the nutritional requirement of the crops and *panchagavya* can be used as a supplement or additive, whenever organic sources are applied to the crops. Further, *panchagavya* acts as a top dressing to supplement the nutrient requirement of crop. Hence, it can be tried out higher levels of organic sources and high carbon contents of soils also.

5.6 RESIDUAL EFFECT OF VARIED MANURIAL PRACTICES TO MAIZE AND SUNFLOWER ON SUCCEEDING GREENGRAM

It is customary in India, to include short duration pulse crops in high intensive cropping systems, since they are known to sustain with the residual fertility of soil resulting from heavily manured preceding crops of the cropping system, besides enriching the soil with moderate quantities of nitrogen. In the present study, greengram crop was raised succeeding sunflower, without imposing any treatments, with the aim to find out the carry over effect of varied manurial practices adopted to preceding maize and sunflower crops.

The tallest plants with largest leaf area and highest dry matter accrual (Fig 5.19), with the highest number of pods plant^{-1}and number of seeds pod^{-1} as well as thousand seed weight, highest yield (Fig 5.20), highest harvest index, highest protein content of seed (Fig 5.21), highest nutrient uptake (Fig 5.22 to 5.24) and economic returns (Fig 5.25) of greengram were recorded with the residual effect of poultry manure applied to previous crops of maize and sunflower. Application of recommended dose of fertilizer to both the preceding crops could not extend any carry over effect on greengram, as could be noticed from the all the above mentioned parameters of greengram, which were significantly lesser than with any of the five organic manures applied to two preceding crops. Greengram being a legume, it responds to the supply of phosphorus

Fig 5.19: Stage-wise dry matter production (kg ha^{-1}) of green gram as influenced by the residual effect of varied manurial practices and *panchagavya* spray to preceding crops of maize and sunflower



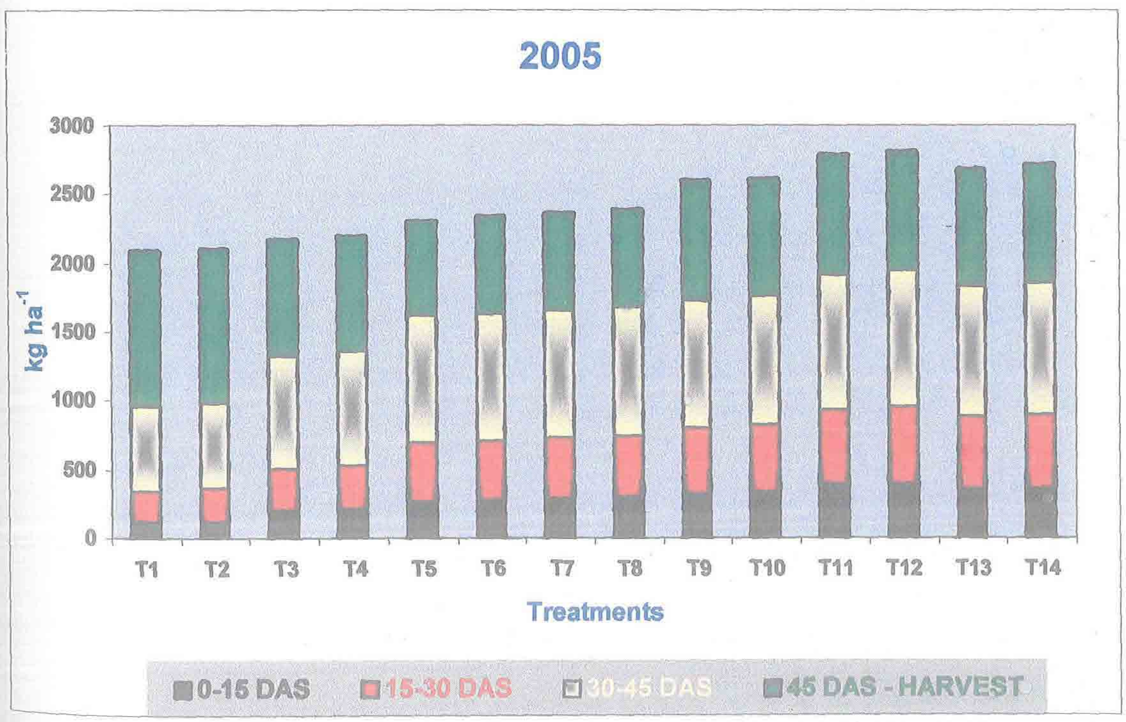
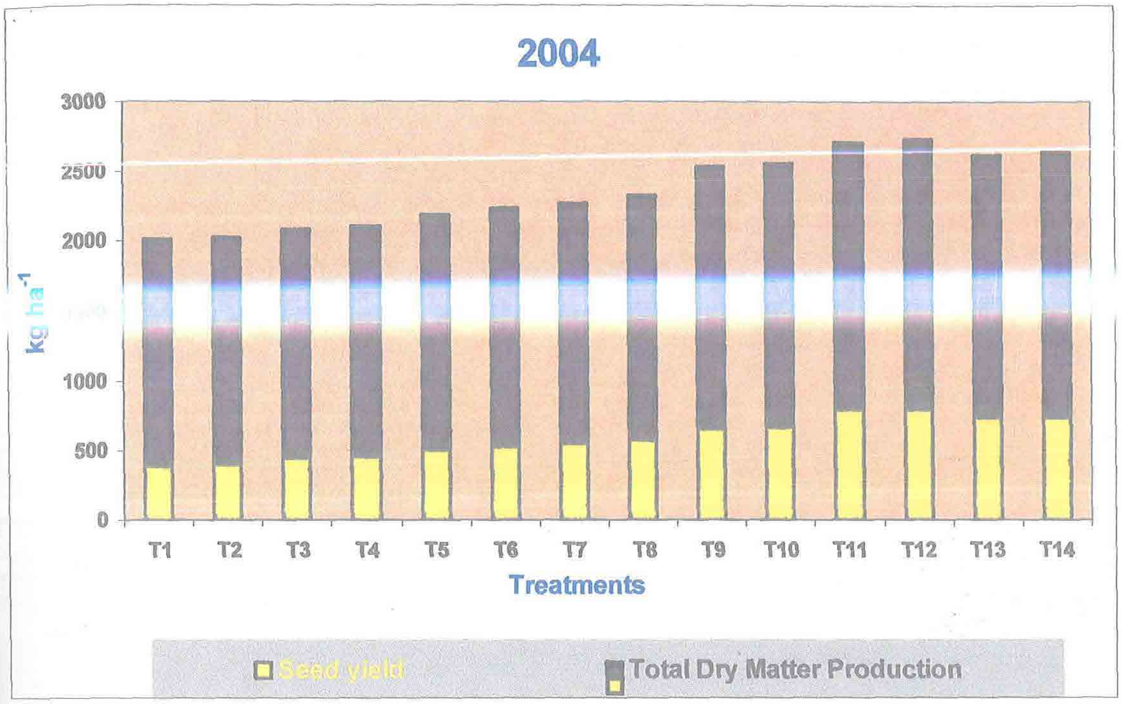


Fig 5.20: Total dry matter production and seed yield (kg ha^{-1}) of green gram as influenced by the residual effect of varied manurial practices and *panchagavya* spray to preceding crops of maize and sunflower



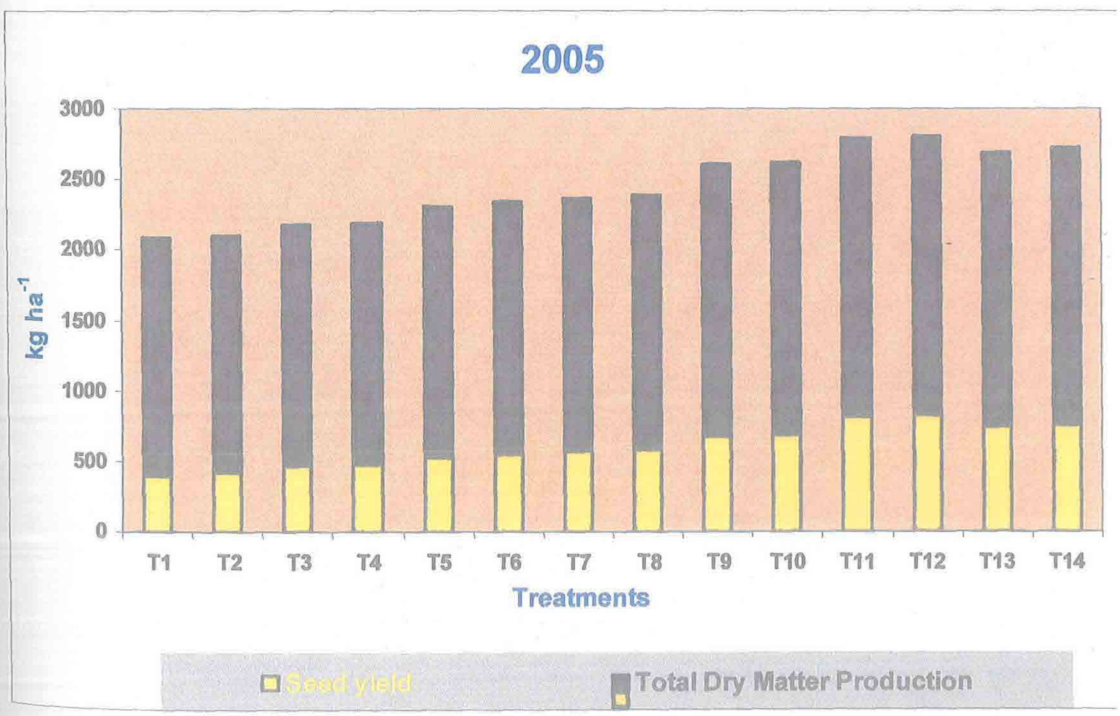
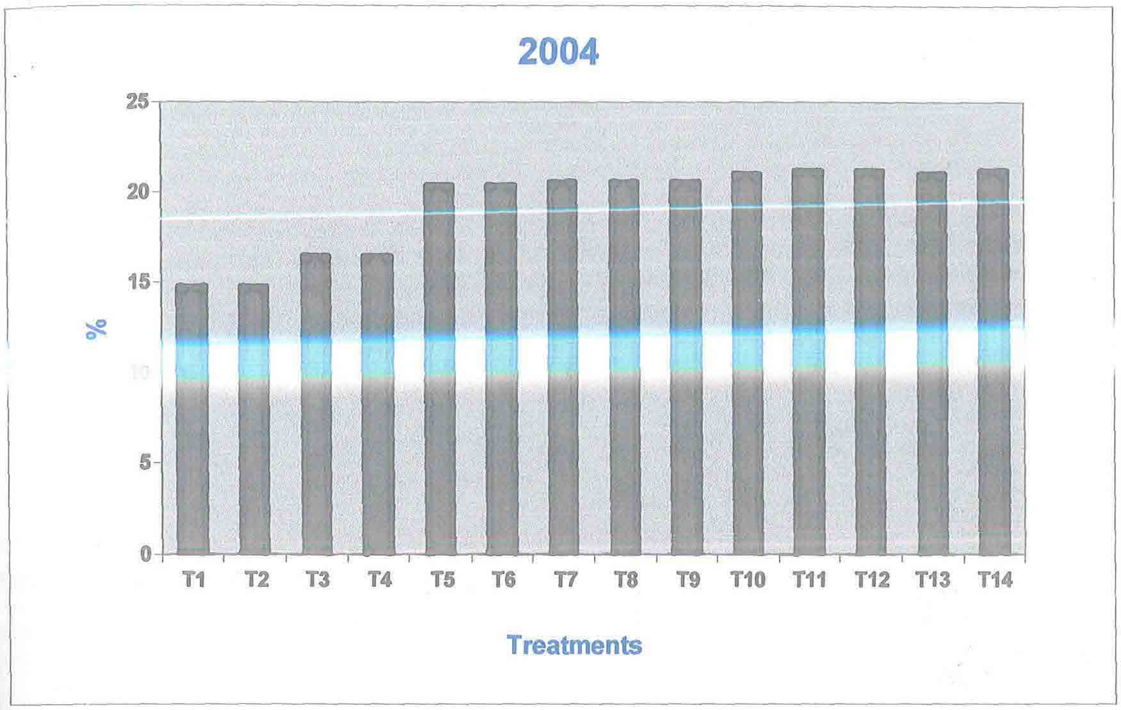


Fig 5.21: Protein content (%) of green gram seed as influenced by the residual effect of varied manurial practices and *panchagavya* spray to preceding crops of maize and sunflower



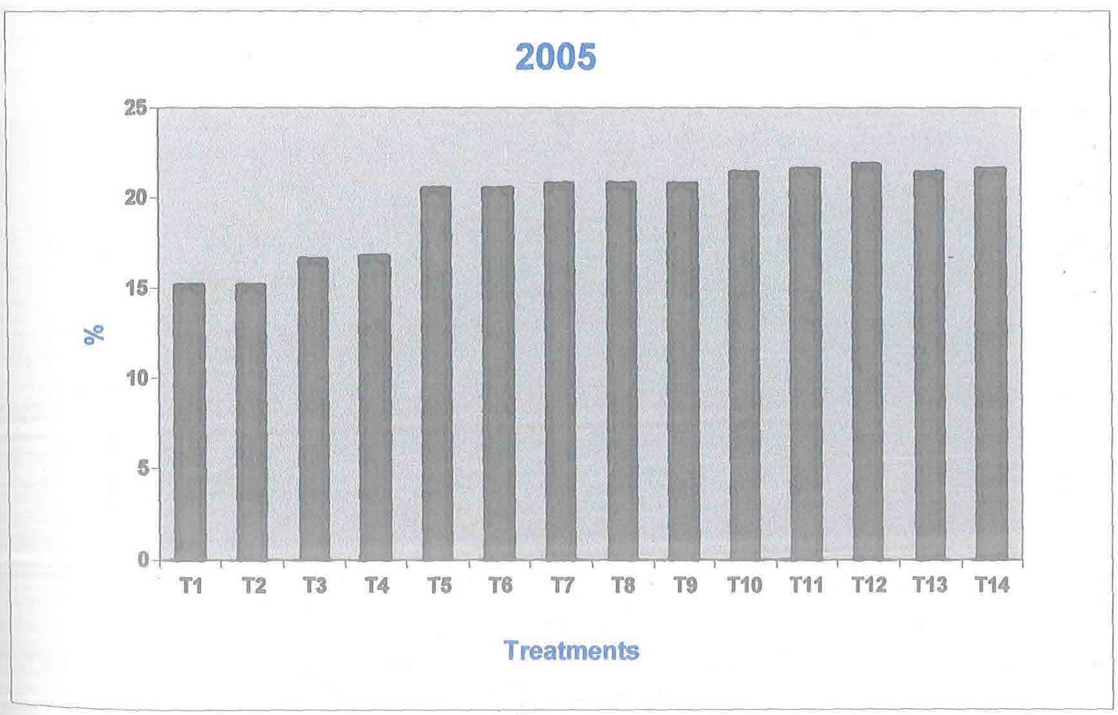
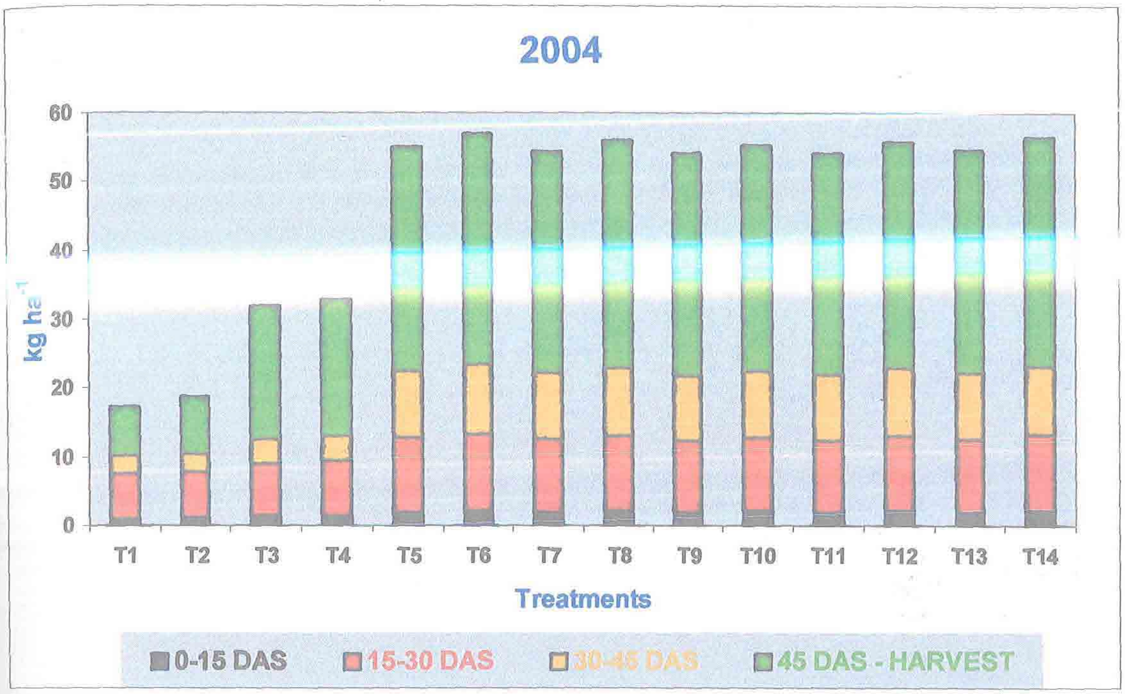


Fig 5.22: Stage-wise nitrogen uptake (kg ha^{-1}) of green gram as influenced by the residual effect of varied manurial practices and *panchagavya* spray to preceding crops of maize and sunflower



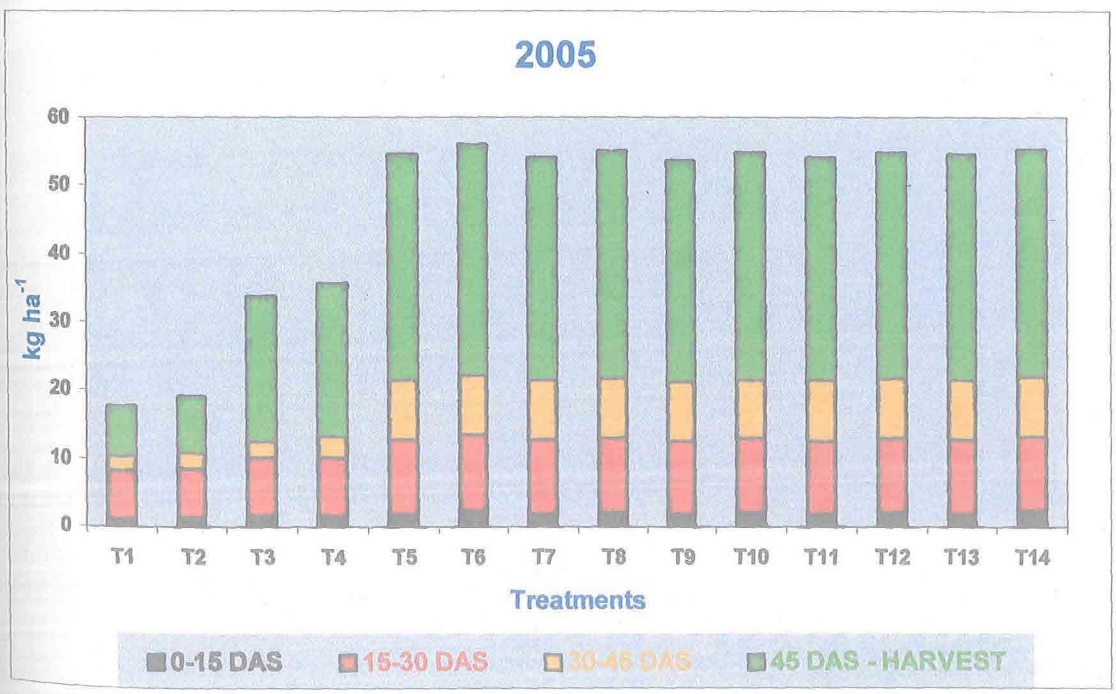


Fig 5.23: Stage-wise phosphorus uptake (kg ha^{-1}) of green gram as influenced by the residual effect of varied manurial practices and *panchagavya* spray to preceding crops of maize and sunflower

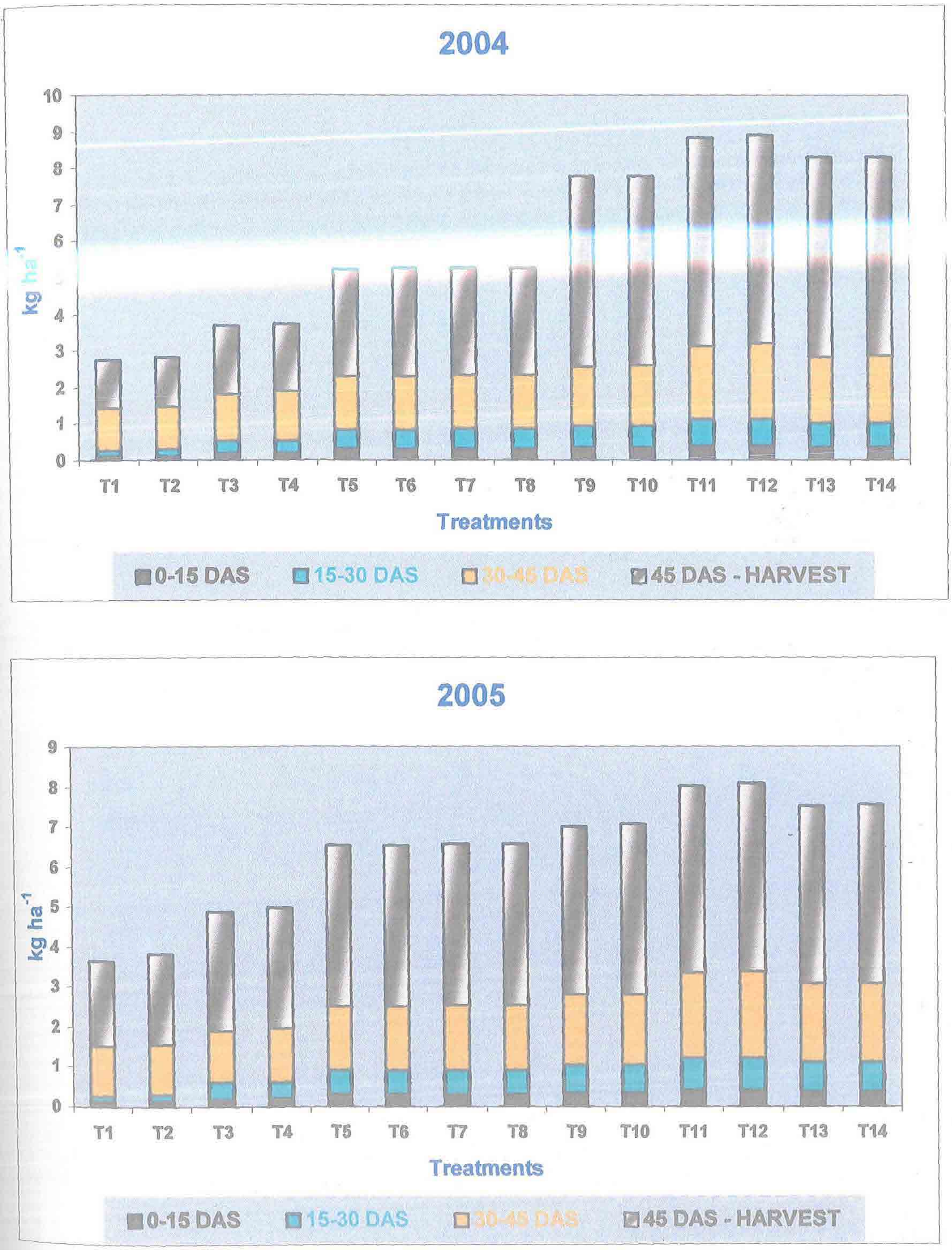
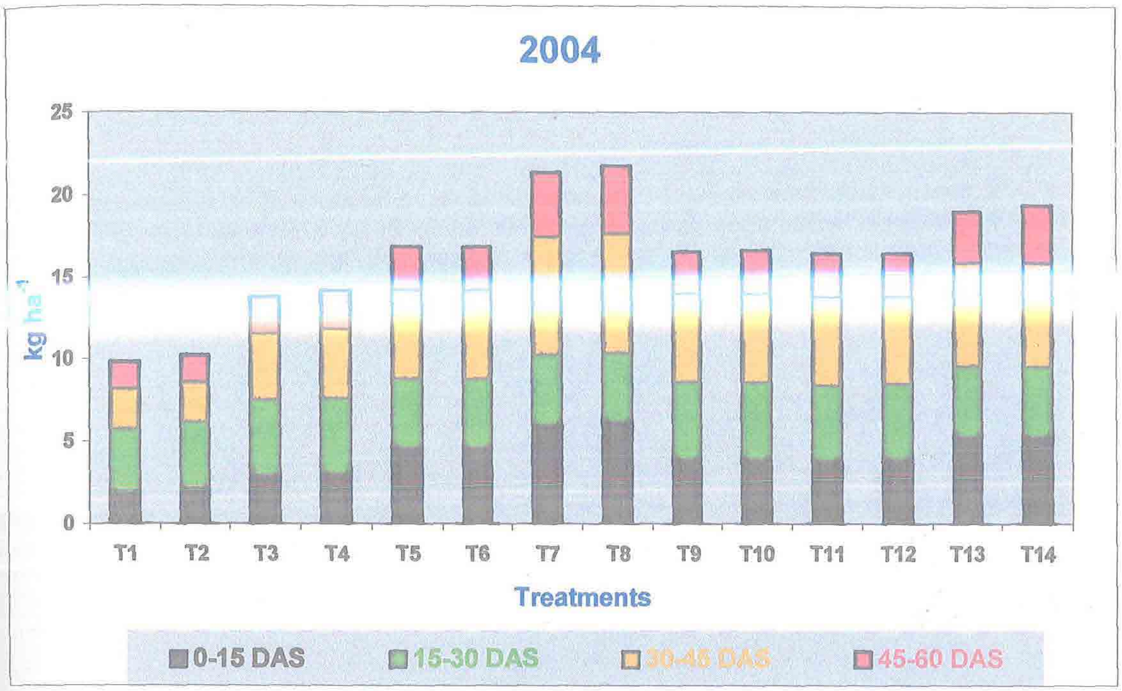


Fig 5.24: Stage-wise potassium uptake (kg ha^{-1}) of green gram as influenced by the residual effect of varied manurial practices and *panchagavya* spray to preceding crops of maize and sunflower



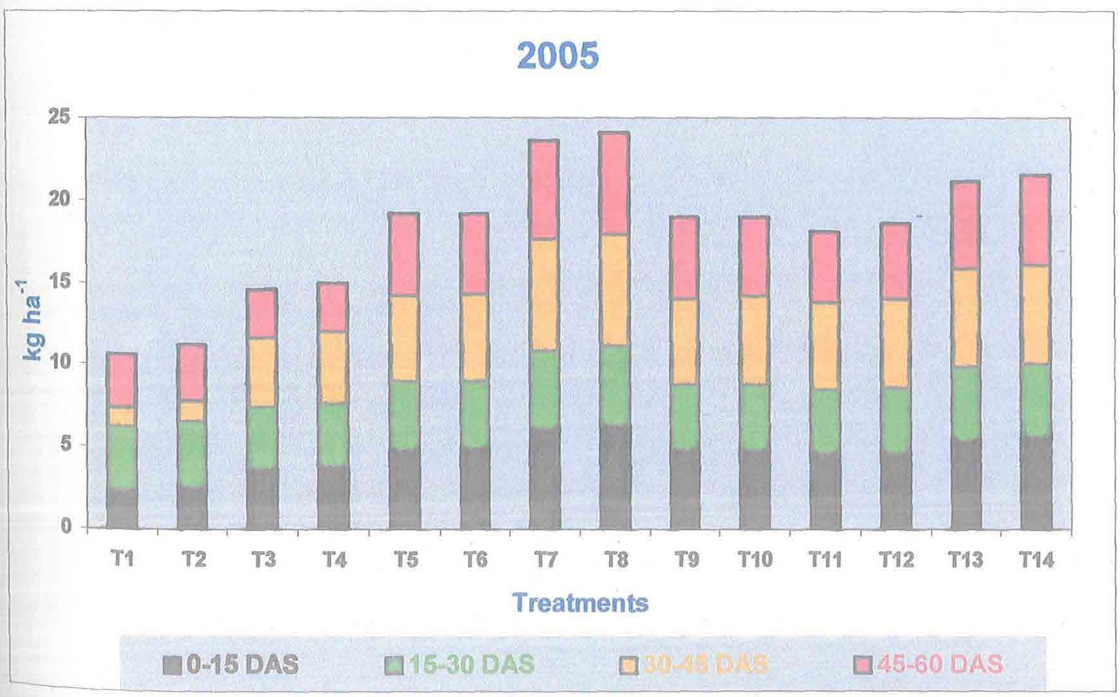
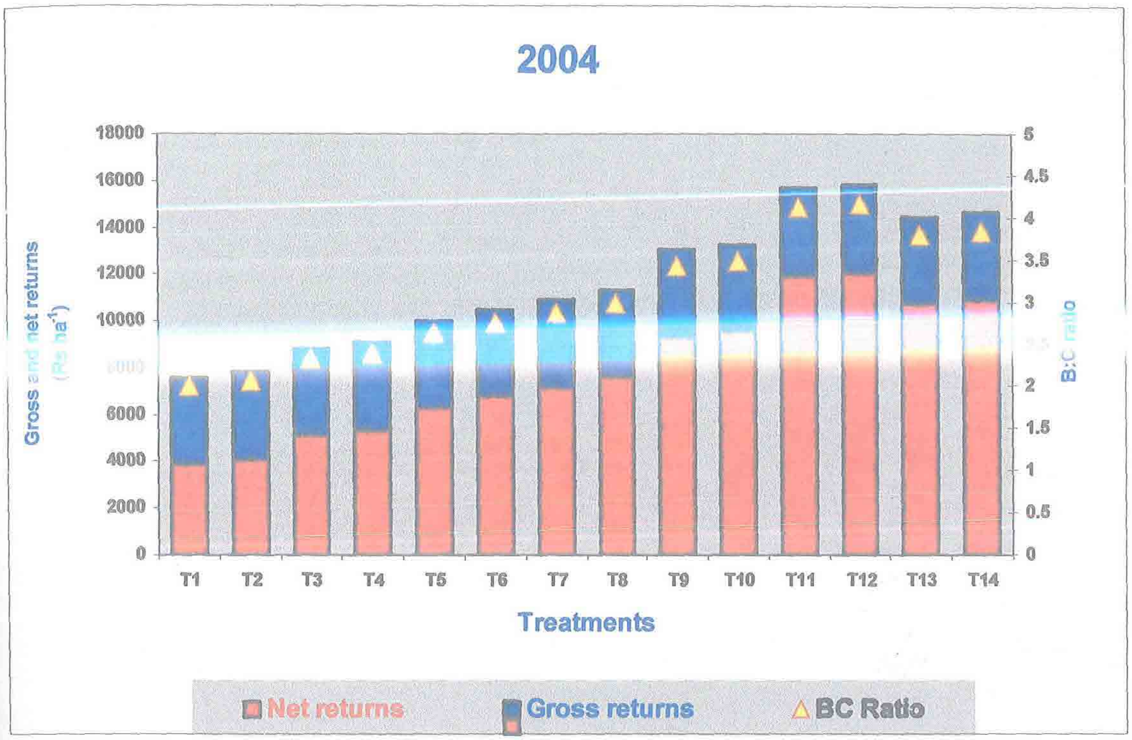
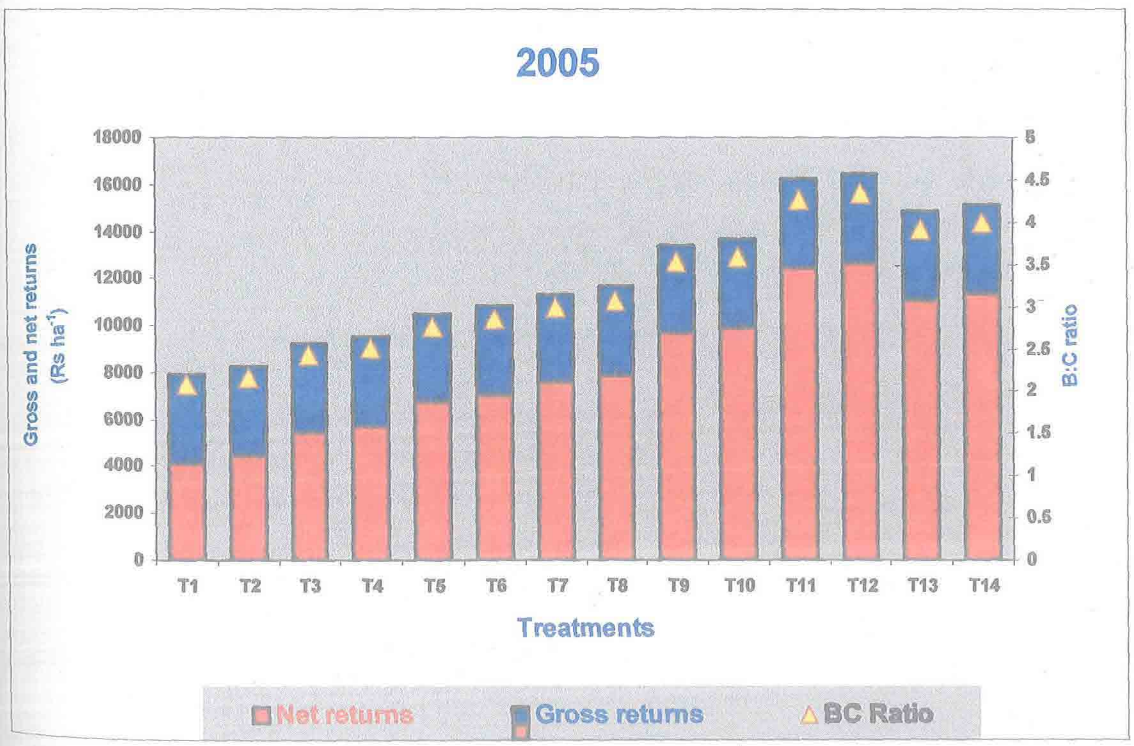


Fig 5.25: Gross returns, Net returns (Rs ha^{-1}) and B-C Ratio of green gram as influenced by the residual effect of varied manurial practices and *panchagavya* spray to preceding crops of maize and sunflower



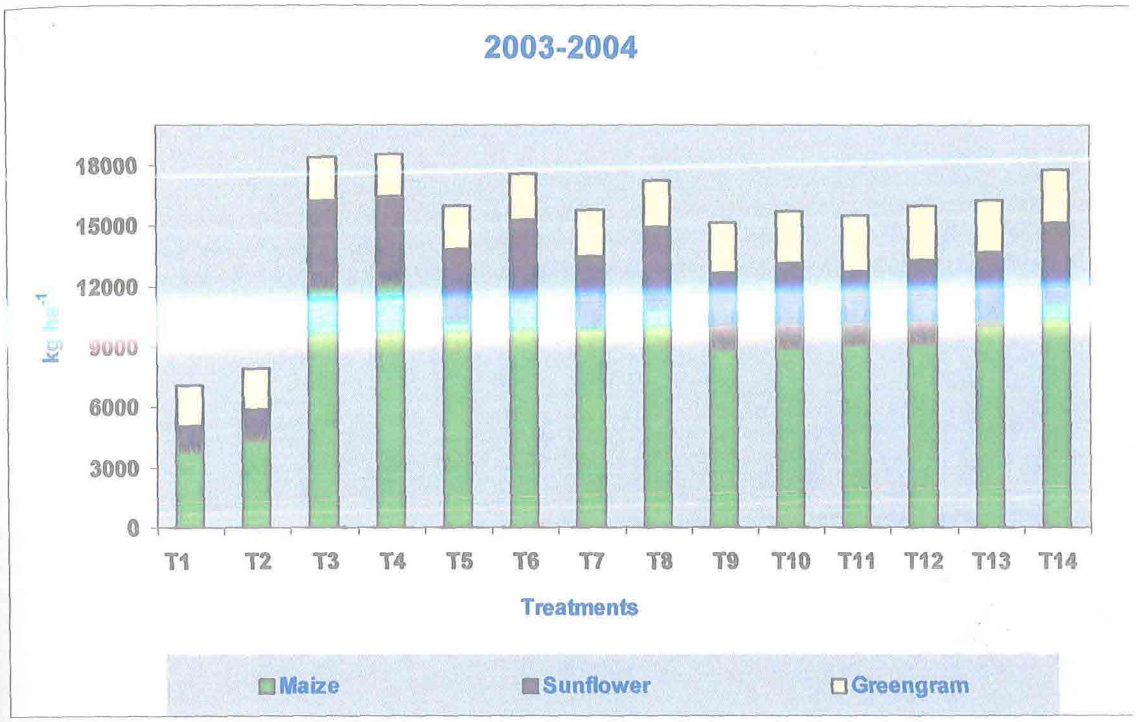


and poultry manure, which was applied to the preceding crops contained high quantity of **P**, which would have left considerable quantity **P** in the soil to be utilized by greengram, which might have triggered the growth resulting in higher yield, quality and economic returns. All the other four organic manures have resulted in nearly equal performance of greengram, but significantly superior to fertilizer, indicating that fertilizers can not leave behind residual nutrients to be used by the succeeding crop as compared to organic manures. The results of the present investigation are in agreement with those of Gaudencio *et al.* (1998) and Dash *et al.* (*2000*).

5.7 PERFORMANCE OF CROPPING SYSTEM AS A WHOLE

The performance efficiency of any cropping system would be usually be evaluated by assessing the biological efficiency as indicated by the total dry matter accrual by different crops included in the cropping system, productive efficiency as indicated by the saleable yield produced by different crops included in the cropping system and the economic efficiency as indicated by the economic returns of different crops included in the cropping system. In the present study also, the performance of the cropping system as a whole as influenced by varied manurial practices was assessed in terms of biological yield, economic yield (maize grain equivalent yield) and economic parameters.

Fig 5.26: Total Biomass Production (Kg ha^{-1}) of the cropping system as a whole as influenced by varied manurial practices and *panchagavya* spray



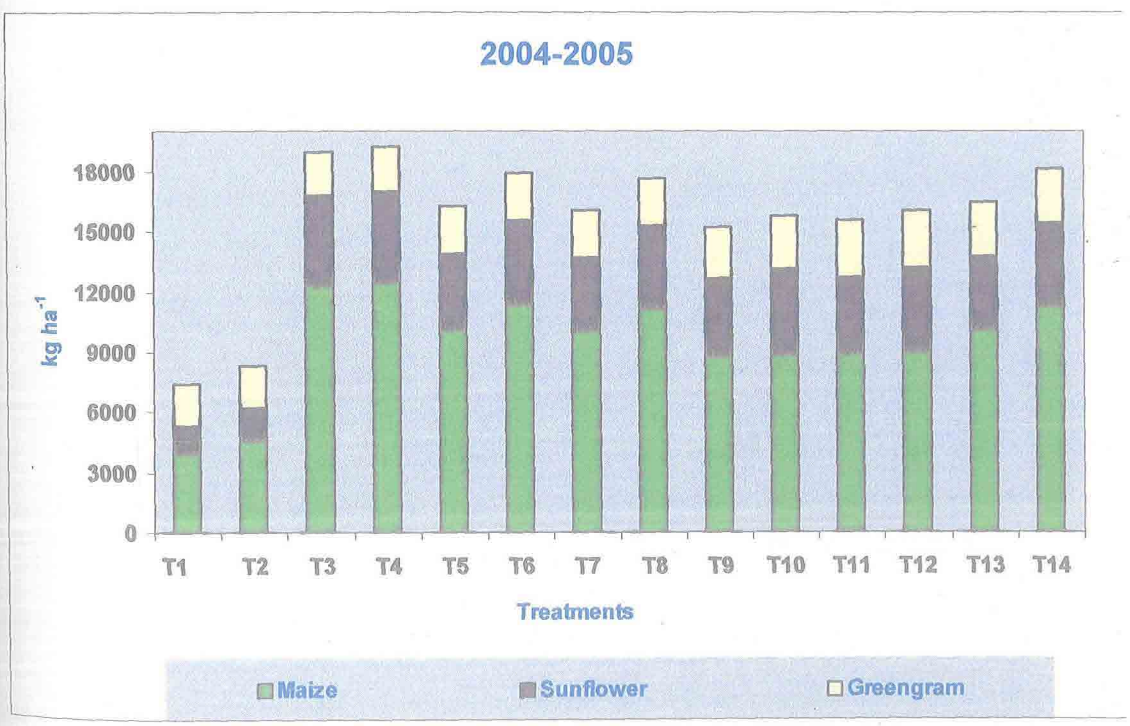
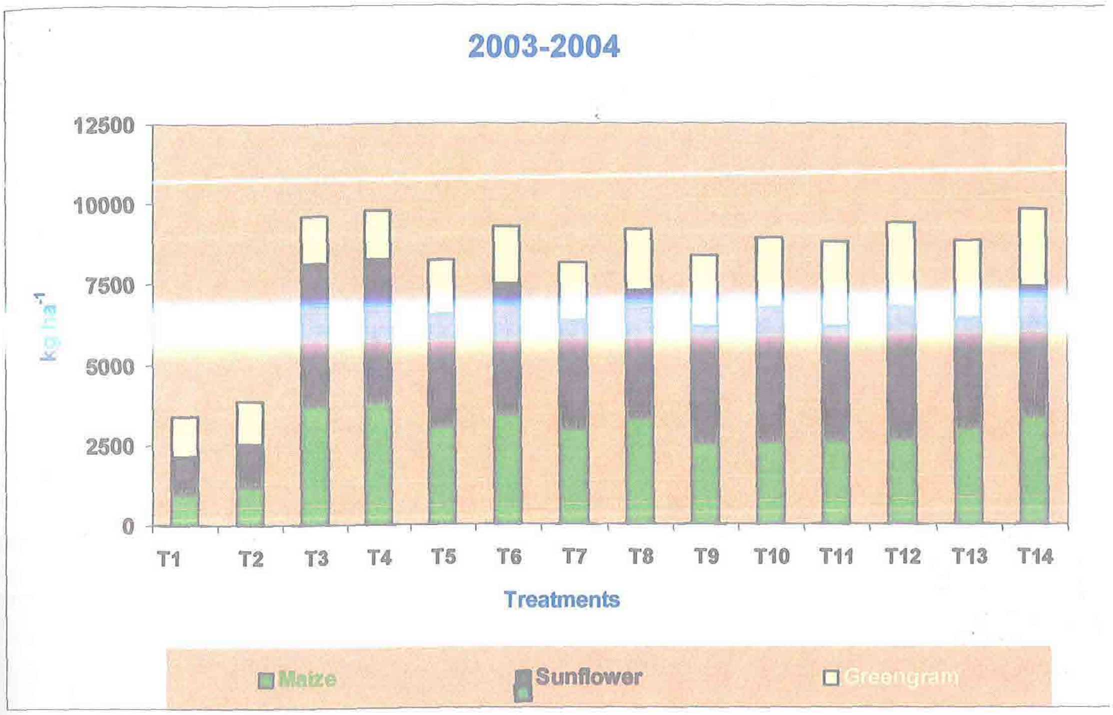
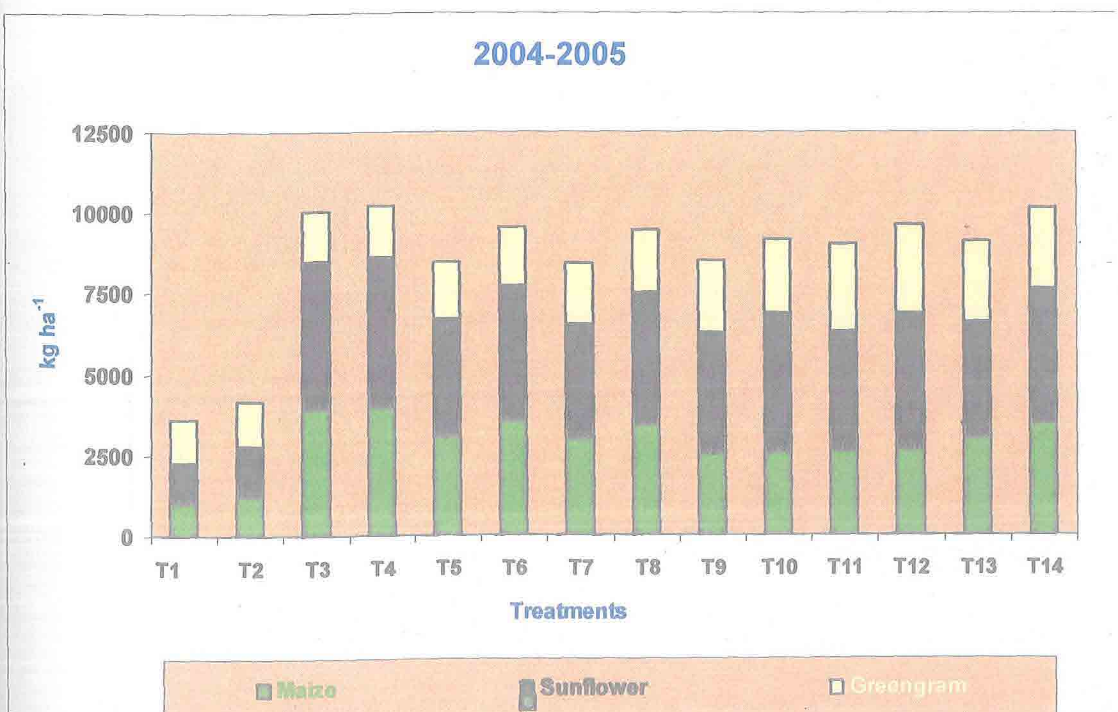


Fig 5.27: Total Economic Yield* (Kg ha^{-1}) of the cropping system as a whole as influenced by varied manurial practices and *panchagavya* spray



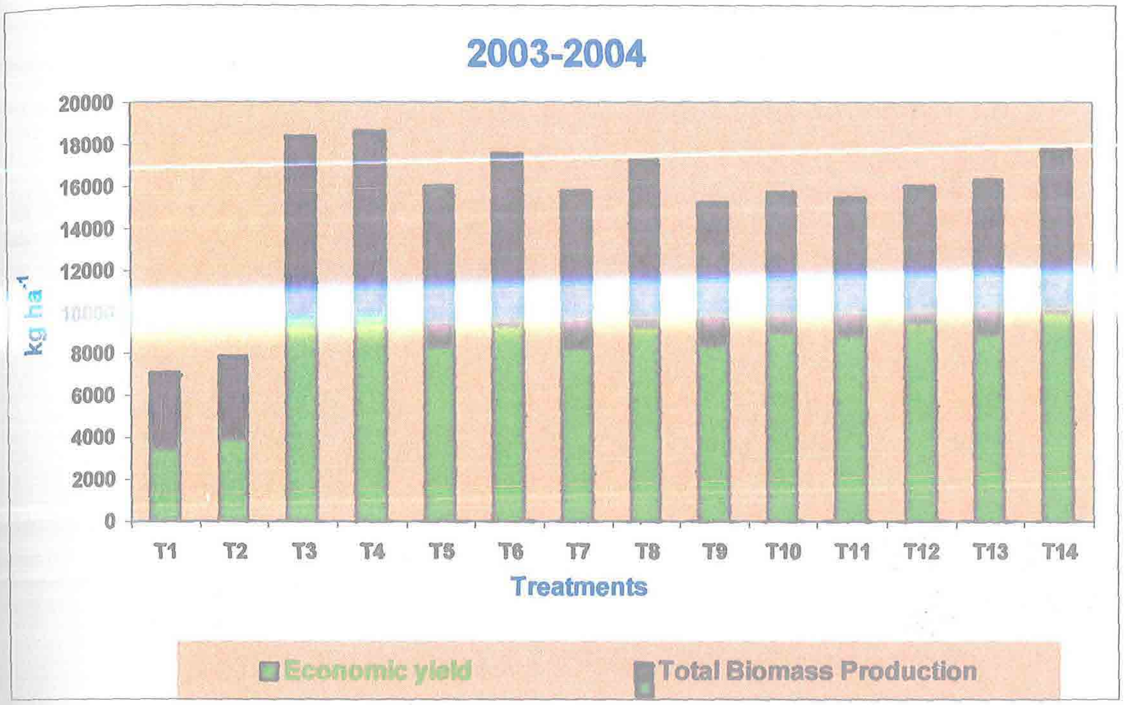


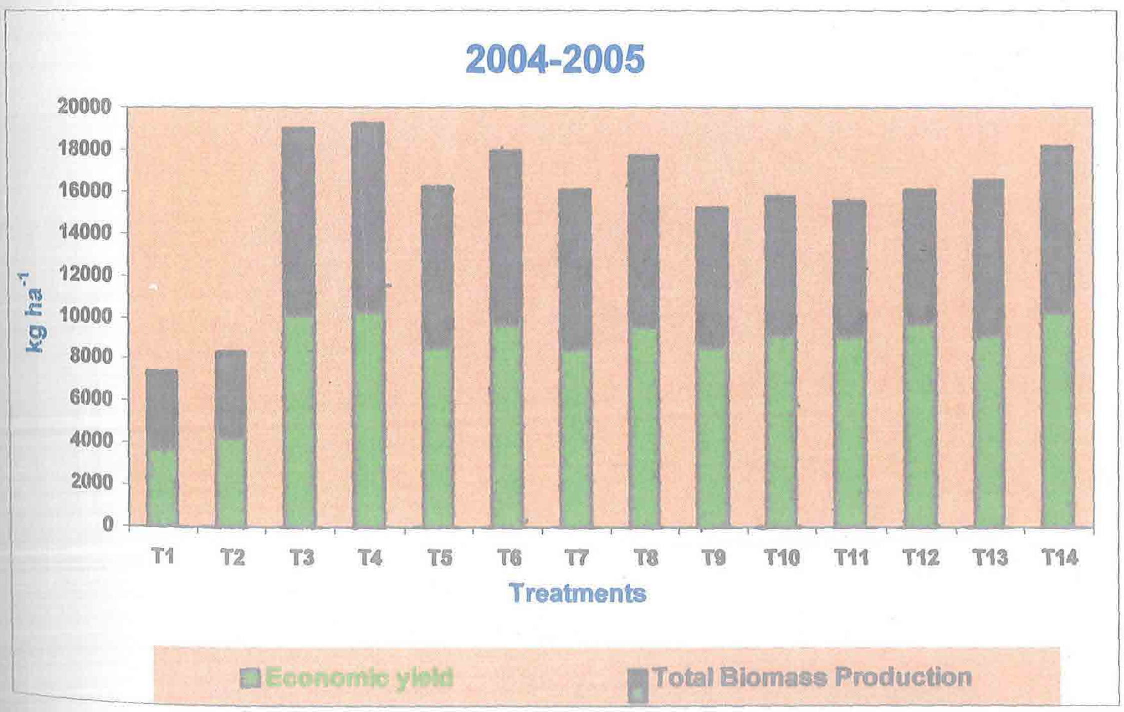
* Maize Equivalant Yield

The highest biomass production, economic yield (maize grain equivalent yield) and highest gross as well as net returns from the cropping system as a whole was registered with recommended dose of fertilizer along with the spray of *panchagavya*, which were however, comparable with recommended dose of fertilizer alone. Since the highest dry matter production (Fig. 5.26), economic yield (Fig. 5.27), gross and net returns (Fig. 5.29) from component crops of maize and sunflower were maximum with recommended dose of fertilizer along with the use of *panchagavya,* it is obvious that all the above mentioned parameters of the cropping system stood at the highest level. Keeping the manurial practice of fertilizer application aside, comparison was made among different organic manures.

Among different organic manures tried, the highest biomass production from the cropping system was registered with pig manure or farm yard manure or vermicompost in combination with application of *panchagavya,* while the highest economic yield (maize grain equivalent yield) and gross returns from the cropping system were realized with pig manure in combination with *panchagavya*. The next best manurial practices in recording higher economic yield and gross returns were poultry manure or farm yard manure or vermicompost in combination with *panchagavya* (Fig. 5.28).

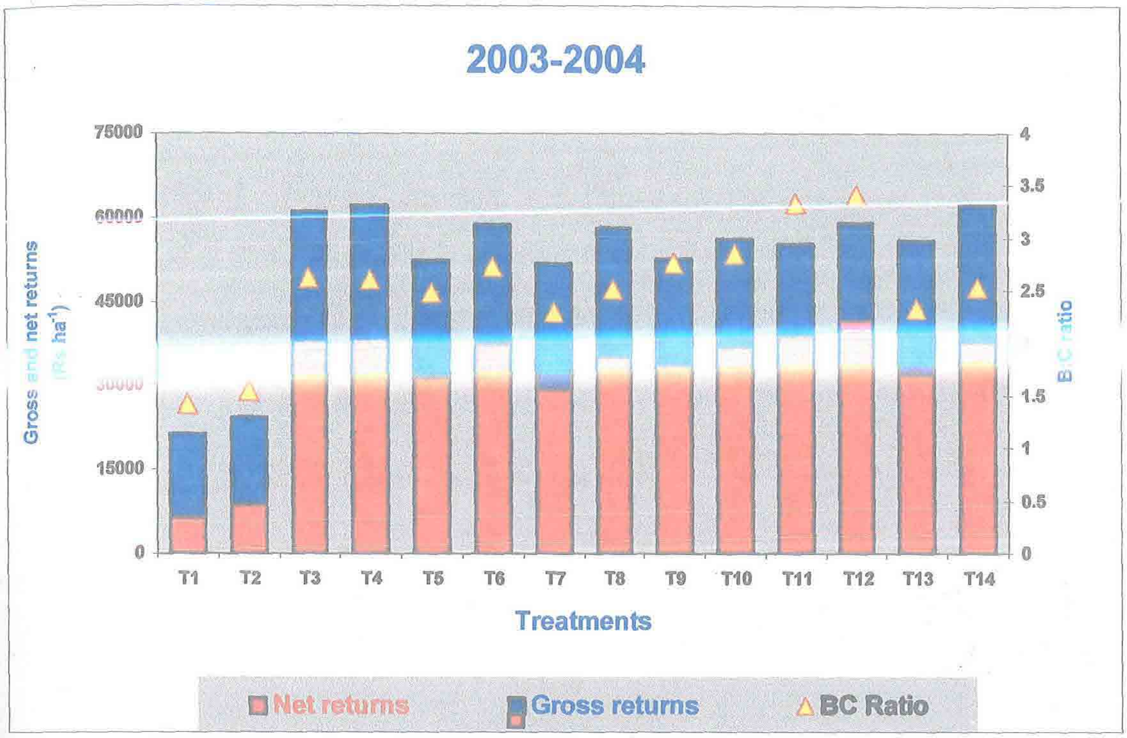
Fig 5.28: Total Biomass Production Vs Total Economic Yield*(Kg ha^{-1}) of the cropping system as influenced by varied manurial practices and *panchagavya* spray

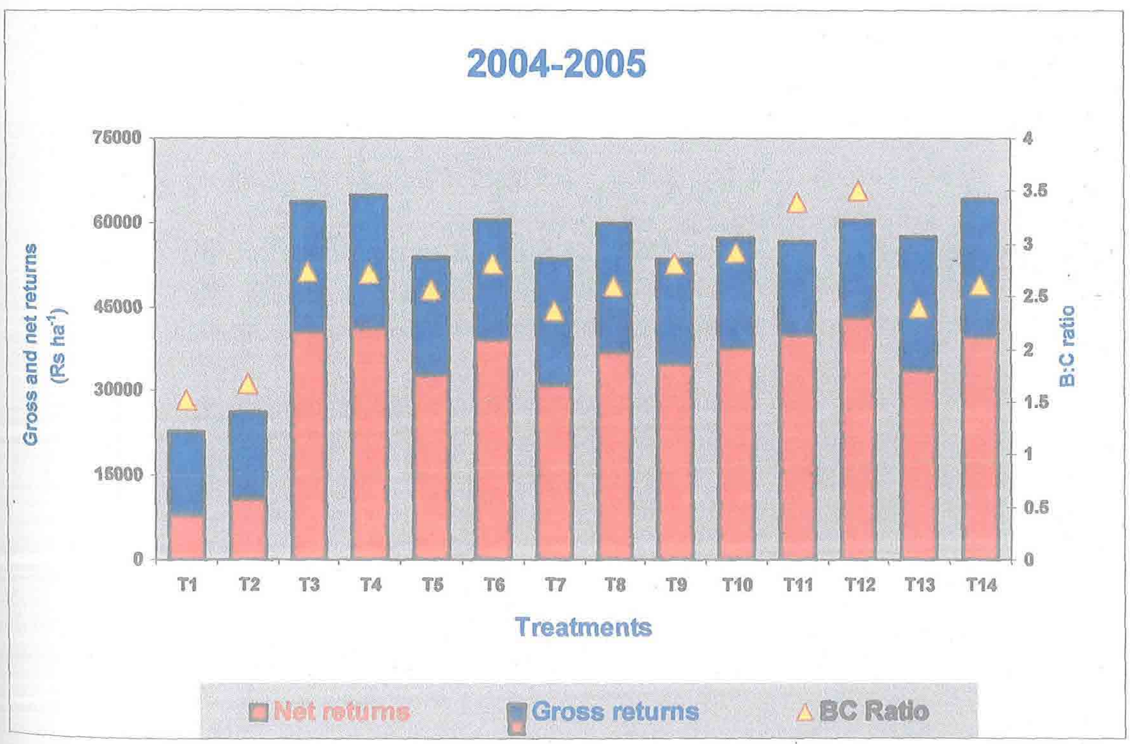




* Maize Equivalant Yield

Fig 5.29: Gross returns, Net returns (Rs ha^{-1}) and B-C Ratio of the cropping system as a whole as influenced by varied manurial practices and *panchagavya* spray





The highest net returns and benefit-cost ratio from the cropping system were realized with poultry manure in combination with *panchagavya.* All the above mentioned parameters of the cropping system are the result of sum total of the respective parameters of the three crops included in the cropping system, with different organics tried.

It could be deduced from the data of the cropping system that there was an improvement in total biomass production of the system, which was higher by 1.3 to 10.0 per cent with the use of *panchagavya* along with varied manurial sources to maize and sunflower. The maximum improvement of biomass production in the system was with the combination of *panchagavya* with farm yard manure or vermicompost, while it was minimum with fertilizer.

Needless to say, the poorest performance of the cropping system in terms of biomass production, economic yield and economic returns was associated with non-mauring through any source to any of the three crops and application of *panchagavya* alone to maize and sunflower crops could not improve the performance of the cropping system. This was the result of poor performance of individual crops involved in the cropping system with non-manuring.

5.8 DYNAMICS OF SOIL FERTILITY IN THE CROPPING SYSTEM

Dynamics of soil fertility in the cropping system, in terms of soil organic carbon, available nitrogen, available phosphorus and available potassium was monitored in all the experimental plots (treatment and replication wise) after harvest of each of the crops in both the annual cropping cycles and just before the commencement of each of the two annual cropping cycles.

Fertilizer application could just maintain the status of soil organic carbon and available nitrogen status in the cropping system, with neither improving nor declining at the end of the annual cropping cycle. While they were found gradually built up (Fig. 5.30 and 5.31) compared to the pre-experimental level, with all the three crops raised with the application of organic manures. Among the organic sources tried, neem leaf manure, vermicompost and farmyard manure added more organic carbon to the soil compared to pig manure and poultry manure, while neem leaf manure, poultry manure and vermicompost replenished more available nitrogen to the soil than with pig manure and farmyard manure. Further, the minerlization of organic manures and release pattern of nitrogen into the soil solution differs a large and accordingly, the final balances of soil organic carbon and available nitrogen would reflect source-wise. Neverthless, organics did build up the organic content as well as nutrients there by indicating the sustenance of soil productivity.

Fig 5.30: Dynamics of soil organic carbon (%) in the cropping system as influenced by varied manurial practices and *panchagavya* spray

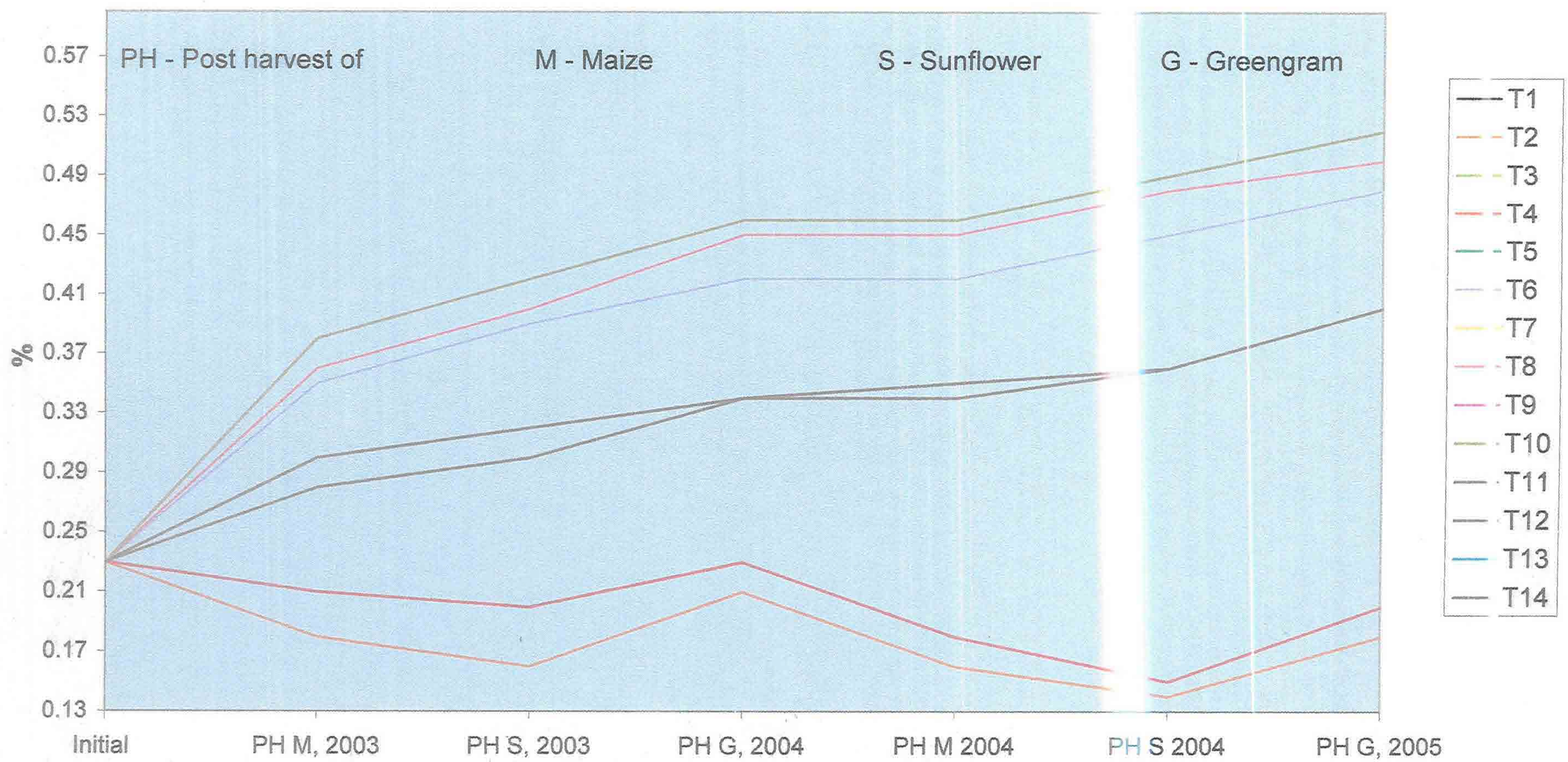
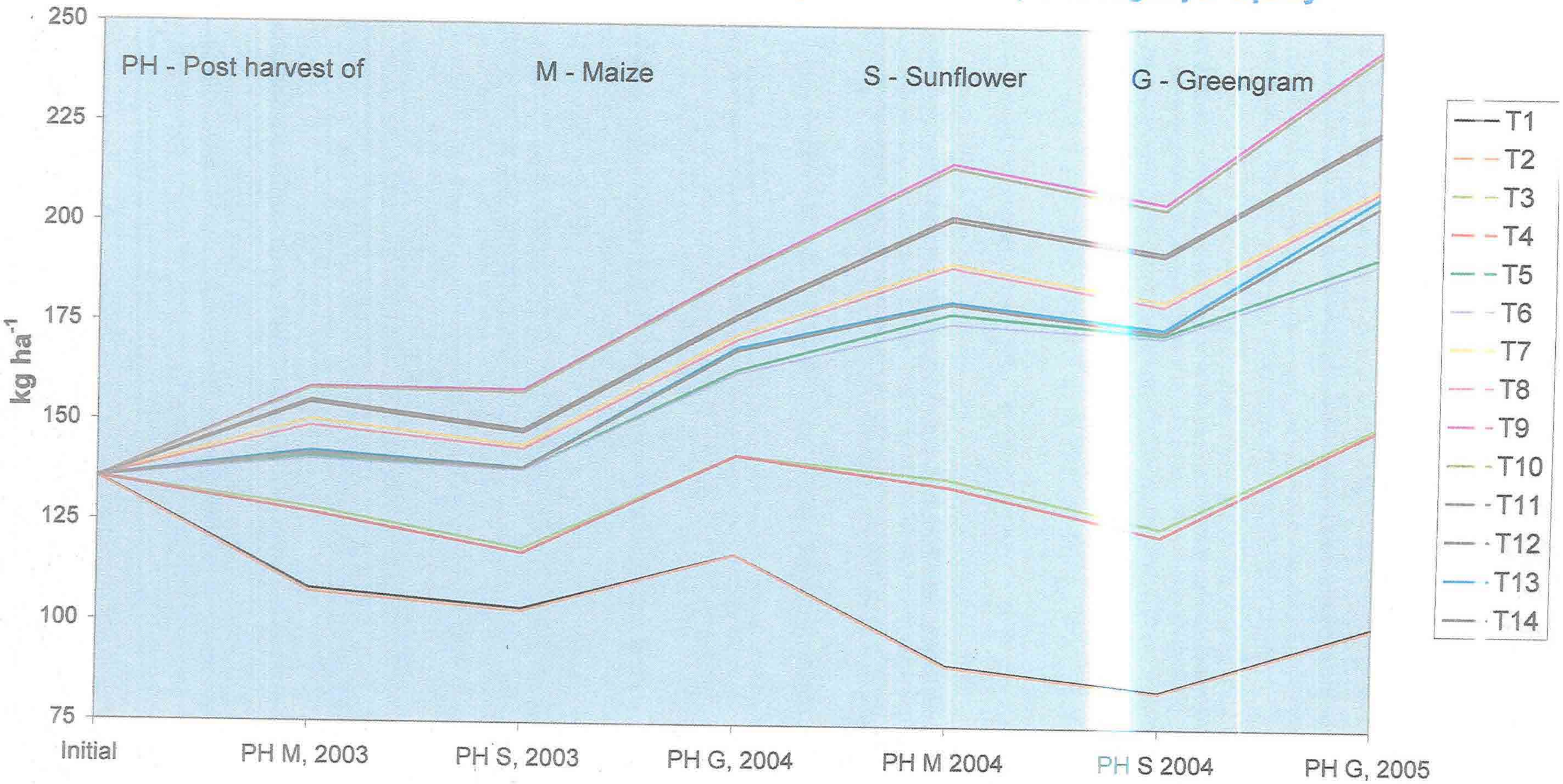


Fig 5.31: Dynamics of soil available nitrogen (kg ha^{-1}) in the cropping system as influenced by varied manurial practices and *panchagavya* spray



Soil available phosphorus (Fig. 5.32) and available potassium (Fig. 5.33) status in the cropping system was found built up at the end of annual cropping cycle compared to the pre-experimental level, with the application of organic manures as well as fertilizer. The build up of soil available phosphorus status with varied manurial practices was in the descending order of poultry manure, fertilizer, pig manure, neem leaf manure, vermicompost and farmyard manure, while the build up of soil available potassium status with varied manurial practices was in the descending order of vermicompost, pig manure, neem leaf manure, farmyard manure, poultry manure and fertilizer. The **P** and **K** content of different organic sources tried differed to a large extent and the final balances of **P** and **K** were in commensurate to their respective contents of **P** and **K** in different organic sources.

All the four soil fertility parameters were found depleted at the end of two year cropping cycles due to non-manuring to any of the crops in the cropping system during two annual cropping cycles.

The balance of soil available nitrogen, available phosphorus and available potassium was positive with all the manurial practices tried, except in unmanured plots where the balance was negative. Organic sources resulted in higher positive balance than with fertilizer, which could maintain only marginal balance on positive side.

Fig 5.32: Dynamics of soil available phosphorus (kg ha^{-1}) in the cropping system as influenced by varied manurial practices and *panchagavya* spray

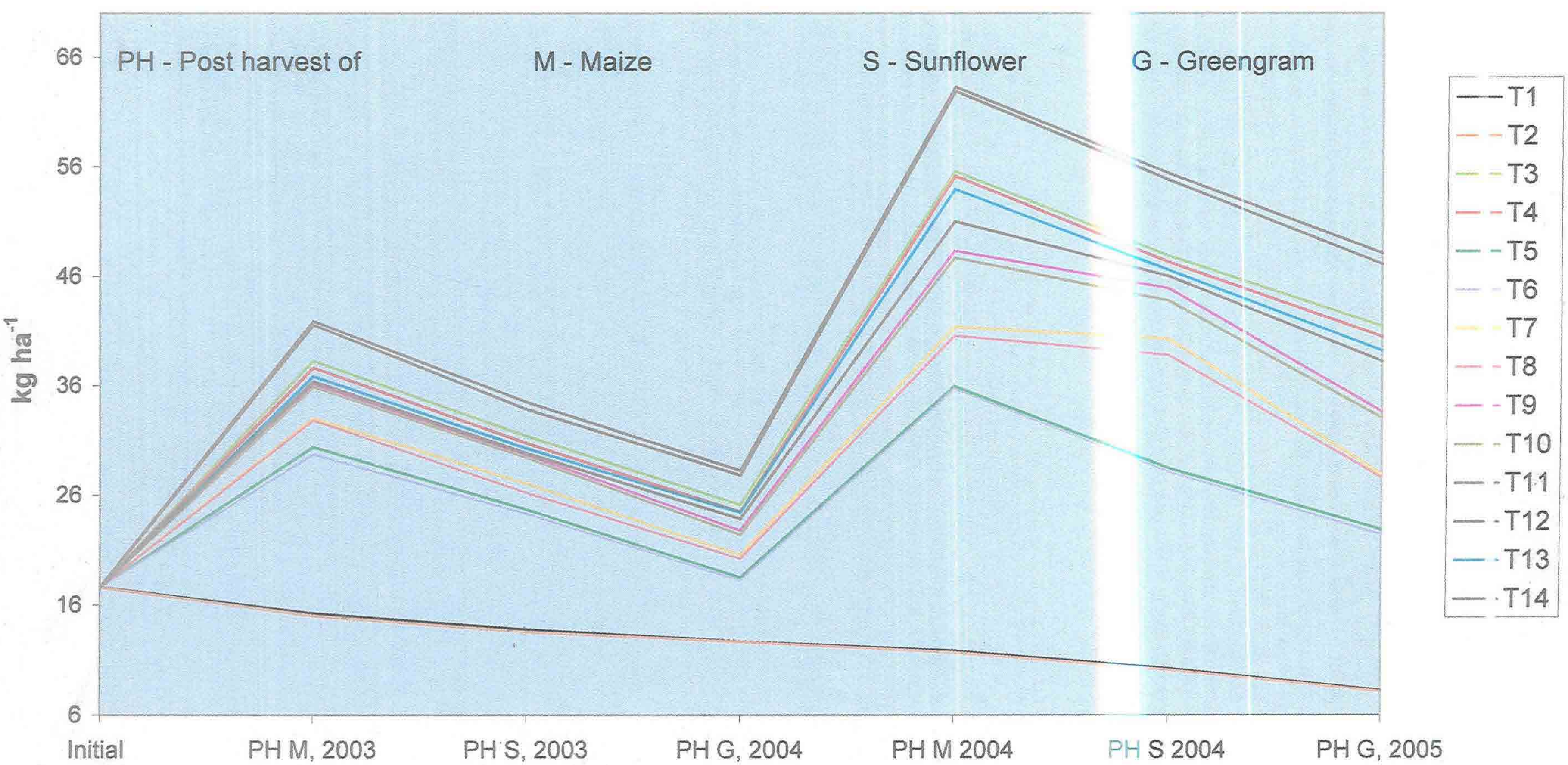
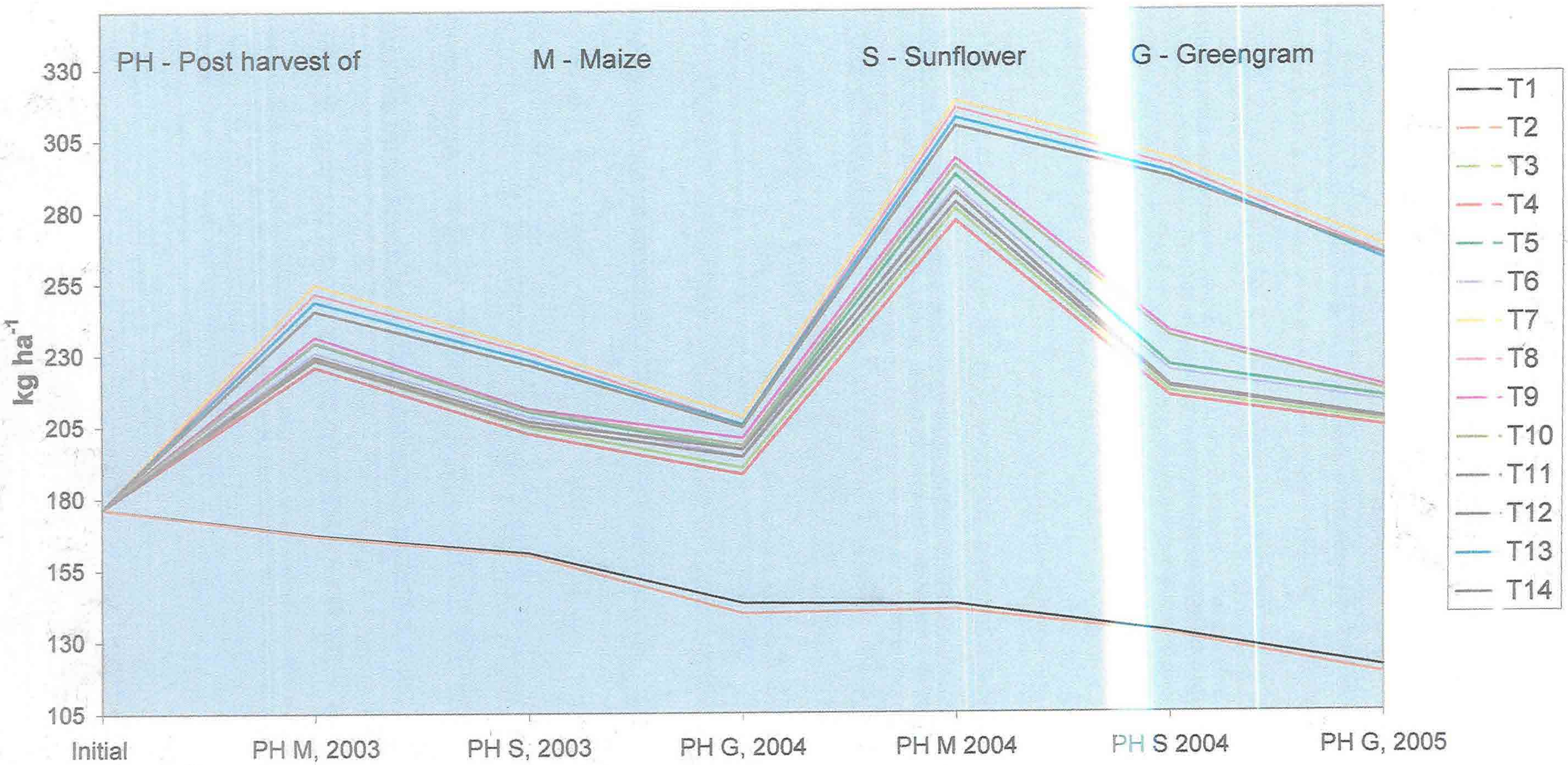


Fig 5.33: Dynamics of soil available potasium (kg ha^{-1}) in the cropping system as influenced by varied manurial practices and *panchagavya* spray



The highest positive balance of soil available nitrogen was associated with neem leaf manure, which was followed by poultry manure, vermicompost, pig manure and farm yard manure, while the lowest positive balance was recorded with fertilizer.

The highest positive balance of soil available phosphorus was associated with poultry manure, which was followed by fertilizer, pig manure, neem leaf manure and vermicompost, while the lowest positive balance was recorded with farm yard manure.

The highest positive balance of soil available potassium was associated with vermicompost, which was followed by pig manure, neem leaf manure, farmyard manure and poultry manure, while the lowest positive balance was recorded with fertilizer.

The final balance of all the three major nutrients at the end of two annual cropping cycles was considerably higher with organic sources than with fertilizer. Among the organic manures, the balance left over with respect to the major nutrients was commensurate with respective nutrient content of different organic manures and depletion pattern of nutrients due to differential uptake by different crops. While working out balance sheet of nutrients, the net gain or loss would be considered as positive or negative, which bye and large is only arbitrary and never accurate, because of several factors, the discussion of which is beyond the scope of the present study.

5.9 SCOPE AND PROSPECTS OF ORGANIC FARMING IN MAIZE - SUNFLOWER -GREENGRAM CROPPING SYSTEM

Since the main aim of the present study is to find out the prospects of raising maize – sunflower – greengram cropping system with organic manures exclusively, the performance of cropping system in terms of productivity and economic returns has to be assessed in comparison with recommended dose of nutrients supplied through fertilizers. Such comparison would give a clear picture about the discount of economic yield and net returns from the cropping system with organic manures exclusively, compared to recommended fertilizer application.

Total biomass production of the cropping system as a whole was lesser by 5.5, 6.5, 8.2, 12.6 and 17.8 percent (mean of two years), respectively with pig manure, farm yard manure, vermicompost, neem leaf manure and poultry manure compared to recommended dose of fertilizer.

Total economic yield (maize grain equivalent yield) of the cropping system as a whole was lesser by 0.9, 6.2, 6.5, 7.3 and 11.3 percent (mean of two years), respectively with pig manure, farm yard manure, poultry manure, vermicompost and neem leaf manure compared to recommended dose of fertilizer.

Net returns realized from the cropping system as a whole were lesser by 4.3, 4.8, 8.0 and 11.4 percent (mean of two years), respectively with pig manure, farm yard manure, neem leaf manure and vermicompost and compared to recommended dose of fertilizer, while the net returns with poultry manure were 7.0 per cent higher than recommended dose of fertilizer.

Perusal of the above results amply indicate that performance of the cropping system with organics exclusively did not result any considerable discount in saleable yield or net monetary returns, indicating the fact that maize – sunflower – greengram cropping system could sustain with organics exclusively. Further, the soil health would be thoroughly taken care of through addition of organic manures, which is invaluable. In the long run, the productivity and profitability of cropping system with organics would be far higher than with continuous use of fertilizers alone, since the biological wealth and organic matter status of the soil would be largely improved.

In the southern agro climatic zone of Andhra pradesh, all the organic manures tried in the present study are available in abundance. Further, sheep and goat manure is also available in large quantities. The farmers can choose any of the organic manures available in the nearest vicinity of their farms, on the relative cost-effective basis.

5.10 OVERVIEW

- Maize and sunflower crops have shown their best performance in terms of productivity and economic returns with the application of recommended dose of fertilizers in combination with *panchagavya* spray.

- Among different organics tried, farm yard manure or pig manure or vermicompost in combination with foliar application of *panchagavya* was found better in increasing the productivity, quality and economic returns of maize than the other organic manurial practices.

- All the five organic manures tried in combination with foliar application of *panchagavya* were found better in increasing the productivity, quality and economic returns of sunflower than with the use of respective organic manures alone without the use of *panchagavya*.

- Foliar application of *panchagavya* was found more spectacular on sunflower than on maize in increasing the productivity and economic returns, while the quality parameters and economic yield of both the crops were found improved with the use of *panchagavya*.

- Foliar application of *panchagavya* alone without any manurial sources could not exert any measurable positive influence either on maize or sunflower.

- Among all the manurial practices tried on maize and sunflower crops, the cumulative residual effect of poultry manure in combination with the foliar application of *panchagavya* was found the best on the performance of succeeding crop of greengram in terms of productivity, quality and economic returns.

- Among the organic manurial practices, application of pig manure in combination with spray of *panchagavya* resulted in the production of highest economic yield from the cropping system, which was closely followed by the application of poultry manure or farm yard manure or vermicompost in combination with *panchagavya* to maize and sunflower.

- Among the organic manurial practices, application of poultry manure in combination with spray of *panchagavya* to maize and sunflower has resulted in the highest net returns from the cropping system.

- Soil fertility parameters *viz.*, soil organic carbon and available nitrogen, available phosphorus and available potassium were found built up to a considerable extent with the use of organic manures to maize and sunflower.

- The study has revealed that crops included in the cropping system could sustain with any of the organic sources tried with uncountable difference among them, indicating that any source of organic manure that is cheaper and abundantly available in the farm itself or in the nearest vicinity of the farm can be used for exclusive organic farming.
- Though the performance of the maize – sunflower – greengram cropping system in terms of productivity and profitability was found to be higher with recommended dose of fertilizer than various organic manurial practices, keeping in view of sustainable soil fertility, use of organics seems to be promising, since the discount in yield and economic returns was also not so large as the farmer has to rethink.
- The study has also revealed that there is no need to apply any nutrient source to the pulse crop included in the cropping system and the crop could sustain with the carry over effect of organics applied to preceding crops and could produce reasonable yield, besides enriching the soil fertility.

5.11 FUTURE LINE OF WORK

- Recycling of residues of leguminous crops included in the cropping system has to be tried and the beneficial effects have to be brought out.

- Possibility of including green manures in the intensive cropping systems in between any of the two crops for *in-situ* green manuring has to be researched.

- Enrichment of soil physical, nutritional and biological properties due to exclusive use of organics in the cropping system has to be investigated.

- Beneficial effect of usage of organic manures on soil micronutrient status has to be studied.

- Farming system approach has to be tried to have sheep/goat penning and bio-gas slurry as on-farm and cost-effective organic sources to the crops and cropping systems.

- Collaborative research with biochemists has to be carried out to disclose the quality improvement of economic yield produced with the foliar application of *panchagavya* on crops.

- Studies on fertigation of diluted stock solution of *panchagavya* through drip irrigation for high value and wide spaced crops have to be conducted.

- Indigenous Technical Knowledge (ITK) and traditional wisdom gathered from the rural farming folk has to be combined while formulating the research programmes on organic farming to crops/cropping systems.

- Long term (5 – 6 years) organic farming studies on the same field with different crop rotations has to be carried out to prove that yield will not be discounted compared to chemical version of exploitive farming.

- Studies on various organic sources at different levels of soil carbon content is needed to unrevel the effects on crop sustainability.

Summary

CHAPTER - VI

SUMMARY

Investigations entitled **"Studies on Organic Farming in Maize - Sunflower - Greengram Cropping System"** were carried out for two consecutive years (2003-04 and 2004-05) at wetland farm of Tirupati campus (S.V.Agricultural College) of Acharya N.G Ranga Agricultural University, Andhra Pradesh. In these investigations, maize was raised during later *kharif* and sunflower during late *rabi.* Greengram was raised as residual crop in summer. The experiment was laid out in a randomized block design, replicated thrice. The same lay out was followed during both the years of study. There were fourteen treatments comprising of six different sources of nitrogen viz., farm yard manure, vermicompost, neem leaf, poultry manure, pig manure and fertilizer to supply recommended dose of nitrogen on equal nitrogen basis and one treatment of no manuring through any source. All the seven treatments were tried with or without the foliar application of *panchagavya,* thus making the total treatments to fourteen. The treatments were imposed to maize and sunflower crops, while their residual effect was studied on succeeding greengram crop without imposing any treatments. The test cultivars of maize, sunflower and greengram were DHM-103, MSFH-17 and LGG-460, respectively.

The salient findings of the influence of different manurial practices in combination with or without *panchagavya* spray on the performance of maize and sunflower and their residual effect on greengram as well on the performance of cropping system as a whole are summarised below.

The influence of varied manurial practices either with or without the use of *panchagavya* imposed on maize and sunflower and the residual effect on green gram exerted variable influence on the growth parameters, yield attributes, yield, harvest index, quality parameters, nutrient uptake, economics and the post harvest soil fertility status of the crops, but with exactly similar trend with respect to each of the parameters of each of the three crops, during both the years of study, however, differing only in magnitude.

However, all the growth parameters and nitrogen uptake of maize and sunflower at 15 DAS were comparable with all the manurial practices tried, which were significantly higher than with no manuring either with or without *panchagavya* spray.

Maize crop has flowered (tasselling and silking) and matured at the earliest with no manure either with or without *panchagavya*, which was significantly earlier than with all other manurial practices tried, while flowering (tasseling and silking) and maturity was found most delayed with recommended dose of fertilizer with or without *panchagavya* spray, which took significantly more number of days than with all other organic sources of manuring with or without *panchagavya* spray, which were however, comparable among them.

The tallest plants with largest leaf area and highest dry matter accrual, with the highest number of grain rows cob^{-1} and number of grains row^{-1} of cob and longest cobs with largest girth and highest weight, highest grain weight, highest yield (grain as well as stover), highest harvest index of maize and the quality parameters of grain (protein content, starch content amino acid content) were produced with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with farm yard manure or pig manure or vermicompost in combination with application of *panchagavya* (T_6, T_{14} and T_8), which were comparable, but significantly higher than with farm yard manure or pig manure or vermicompost (T_5, T_{13} and T_7), which maintained parity among them, but significantly higher than with poultry manure, and neem leaf manure either with or without *panchagavya* spray (T_{12}, T_{11}, T_{10} and T_9), which were comparable among them and statistically superior to non manuring with or without *panchagavya* spray (T_2 and T_1). All the above mentioned parameters of maize were at their lowest with unmanured plot (T_1).

Nitrogen uptake by maize crop under the influence of varied manurial practices and use of *panchagavya* followed the exactly similar trend to that of growth and yield, with the highest nitrogen uptake being registered with recommended dose of fertilizer along with spray of *panchagavya.*

The highest phosphorus uptake of maize was recorded with poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}). The next highest phosphorus uptake was associated with pig manure with or without *panchagavya* (T_{14} and T_{13}), which was significantly higher than with neem leaf manure or vermicompost with or without *panchagavya,* (T_{10}, T_9, T_8 and T_7), which in turn was statistically superior to farm yard manure or recommended dose of fertilizer with or without *panchagavya* (T_6, T_5, T_4 and T_3).

The highest potassium uptake of maize was recorded with vermicompost either with or without the spray of *panchagavya* (T_8 and T_7). The next highest potassium uptake was associated with pig manure with or without *panchagavya* (T_{14} and T_{13}), which was significantly higher than with farm yard manure or neem leaf manure or poultry manure with or without *panchagavya,* (T_6, T_{10}, T_{12}, T_5, T_9, and T_{11}), which were comparable among them, but statistically superior to recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3).

The lowest uptake of nitrogen, phosphorus and potassium by maize crop at different crop growth stages was recorded in unmanured plot (T_1).

Gross returns from maize crop under the influence of varied manurial practices and use of *panchagavya* followed the exactly similar trend to that of grain yield with the highest gross returns being realized with recommended dose of fertilizer along with spray of *panchagavya*

The highest net returns were realised with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and farm yard manure in combination with application of *panchagavya* (T_6), which were significantly higher than with vermicompost or pig manure in combination with *panchagavya*, farm yard manure alone and poultry manure along with *panchagavya* (T_8, T_{14}, T_5, T_{12} and T_{11}), which were comparable among them, but significantly higher than with vermicompost or pig manure alone and neem leaf manure with or without *panchagavya* (T_7, T_{13}, T_9 and T_{10}), which were comparable among them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1).

The highest benefit-cost ratio was recorded with poultry manure along with *panchagavya* spray (T_{12}), which was however, comparable with poultry manure alone (T_{11}) and farm yard manure in combination with application of *panchagavya* (T_6) and significantly higher than with all other manurial practices tried either with or without *panchagavya*, which were comparable among them, but significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1).

Gross returns, net returns and benefit-cost ratio of raising maize crop were the lowest with non-manuring through any source (T_1).

Sunflower crop has flowered and matured at the earliest with no manure either with or without *panchagavya*, which was significantly earlier than with all other manurial practices tried, while flowering and maturity were found most delayed with recommended dose of fertilizer with or without *panchagavya* spray, which took significantly more number of days than with all other organic sources of manuring with or without *panchagavya* spray, which were however, comparable among them.

The tallest plants with largest leaf area and highest dry matter accrual, with the largest head diameter, highest number of total and filled seeds head^{-1} and highest seed weight, highest yield (seed as well as stalk), highest harvest index of sunflower were produced with recommended dose of fertilizer along with *panchagavya* spray (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and significantly higher than with neem leaf manure or poultry manure or farm yard manure or pig manure or vermicompost in combination with *panchagavya* spray (T_{10}, T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with neem leaf manure, poultry manure, farm yard manure, pig manure and vermicompost (T_9, T_{11}, T_5, T_{13} and T_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over no manure + *panchagavya* spray (T_2) and no manure (T_1). All the above mentioned parameters of sunflower were at their lowest with unmanured plot (T_1).

The highest oil content in the seed of sunflower was recorded neem leaf manure in combination with *panchagavya* spray (T_{10}), which was comparable with all other organic sources tried in combination with *panchagavya* (T_{12}, T_6, T_{14} and T_8), which were comparable among them, but significantly higher than with all the organic sources without *panchagavya* (T_9, T_{11}, T_5, T_{13} andT_7), which in turn maintained parity among them. The latter five treatments maintained statistical superiority over recommended dose of fertilizer either with or without *panchagavya* (T_4 and T_3), which were comparable between them and significantly higher than with no manure + *panchagavya* spray (T_2) and no manure (T_1). The oil content of sunflower seed was found to be the lowest with unmanured plot (T_1).

Nitrogen uptake by sunflower crop under the influence of varied manurial practices and use of *panchagavya* followed the exactly similar trend to that of growth and yield, with the highest nitrogen uptake being recorded with recommended dose of fertilizer along with spray of *panchagavya*.

The highest phosphorus uptake of sunflower was recorded with poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}). The next highest phosphorus uptake was associated with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with neem leaf manure or vermicompost with or without *panchagavya,* (T_{10}, T_9, T_8 and T_7), which in turn was statistically superior to farm yard manure or recommended dose of fertilizer with or without *panchagavya* (T_6, T_5, T_4 and T_3).

The highest potassium uptake of sunflower was recorded with vermicompost either with or without the spray of *panchagavya* (T_8 and T_7). The next highest potassium uptake was associated with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of farm yard manure or neem leaf manure or poultry manure with or without *panchagavya,* (T_6, T_{10}, T_{12}, T_5, T_9, and T_{11}), which were comparable among them, but statistically superior to recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3).

The lowest uptake of nitrogen, phosphorus and potassium by sunflower crop at different crop growth stages was registered in unmanured plot (T_1).

Gross returns from sunflower crop under the influence of varied manurial practices and use of *panchagavya* followed the exactly similar trend to that of seed yield with the highest gross returns being realized with recommended dose of fertilizer along with spray of *panchagavya.*

The highest net returns were realised with recommended dose of fertilizer along with spray of *panchagavya* (T_4), which were however, comparable with recommended dose of fertilizer (T_3) and poultry manure in combination with *panchagavya* spray (T_{12}), which were significantly higher than with neem leaf manure or farm yard manure along with *panchagavya* spray (T_{10} and T_6), which maintained significant disparity with each other and superior to poultry manure, vermicompost or pig manure along with *panchagavya* and neem leaf manuring (T_{11}, T_8, T_{14} and T_9) which were comparable among them, but significantly higher than with farm yard manure (T_5) and it was in turn superior to vermicompost (T_7) and pig manure (T_{13}), which were comparable between them and significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1).

The highest benefit-cost ratio was recorded with poultry manure along with *panchagavya* spray (T_{12}), which was significantly superior to all other manurial practices tried either with or without the use of *panchagavya.* The next best treatment was poultry manure alone (T_{11}), which was significantly higher than with recommended dose of N through fertilizer with or without *panchagavya* spray (T_3 and T_4)) and neem leaf manure along with *panchagavya* spray (T_{10}) which were comparable among them, but significantly higher than with neem leaf manure or farm yard manure in combination with *panchagavay* (T_9 and T_6), which in turn were comparable and significantly higher than with farm yard manure (T_5), vermicompost or pig manure either with or without *panchagavya* spray (T_8, T_{14}, T_7 and T_{13}), which were on par and significantly superior to no manuring with or without *panchagavya* spray (T_2 and T_1).

Gross returns, net returns and benefit-cost ratio of raising sunflower crop were the lowest with non-manuring through any source (T_1).

The tallest plants with largest leaf area and highest dry matter accrual, with the highest number of pods plant^{-1}and number of seeds pod^{-1} as well as thousand seed weight, highest yield (seed as well as haulm), and highest harvest index of greengram were produced with the residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower. The next highest stature of all the above parameters was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher level of all the parameters than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1). All the above mentioned parameters of greengram were at their lowest with the residual effect of non-manuring to both the preceding crops.

Residual effect of various organic manures either with or without the spray of *panchagavya* applied to previous crops of maize and sunflower was comparable, in respect of protein content of greengram seed and nitrogen uptake by the crop, which were significantly higher than with the residual effect of application of recommended dose of fertilizer with or without *panchagavya*, which were statistically superior to those recorded with residual effect of non manuring to previous crops with or without *panchagavya*, which resulted in the lowest protein content of the seed and nitrogen uptake by greengram crop.

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of phosphorus uptake of greengram, which was the highest. The next highest phosphorus uptake was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher phosphorus uptake of greengram than with the residual effect of non manuring to previous crops with or without *panchagavya* (T_2 and T_1).

Residual effect of vermicompost either with or without the spray of *panchagavya* (T_8 and T_7) applied to previous crops of maize and sunflower was comparable, in respect of potassium uptake of greengram, which was the highest. The next higher potassium uptake was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of farm yard manure or neem leaf manure or poultry manure with or without *panchagavya,* (T_6, T_{10}, T_{12}, T_5, T_9, and T_{11}), but comparable among them. Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher potassium uptake than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1).

The lowest uptake of phosphorus and potassium by greengram crop at different crop growth stages was registered with the residual effect of non-manuring to both the preceding crops.

The highest gross and net returns as well as benefit-cost ratio from greengram crop were realized with poultry manure along with *panchagavya* spray (T_{12}), which were however, comparable with poultry manure alone (T_{11}) and significantly higher than with pig manure either with or without *panchagavya* (T_{14} andT_{13}), which were superior to neem leaf manure with or without *panchagavya* (T_{10} and T_9), which in turn were significantly higher than with vermicompost or farm yard manure with or without the use of *panchagavya* (T_8, T_7, T_6 and T_5). Supply of nitrogen through fertilizer either with or without *panchagavya* (T_4 and T_3) resulted in significantly lower economic returns than with all the organic sources tried either with or without the use of *panchagavya*, but significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest gross and net returns as well as benefit-cost ratio from greengram crop were realized with the residual effect of non-manuring to both the preceding crops.

During both years of study, the highest biomass production by the cropping system was registered with recommended dose of nitrogen supplied through fertilizer along with the spray of *panchagavya*, which was however, comparable with fertilizer alone and significantly higher than with pig manure or farm yard manure or vermicompost in combination with application of *panchagavya*, which were comparable among them, but significantly higher than with poultry manure or neem leaf manure along with *panchagavya* spray or pig manure or farm yard manure or vermicompost or poultry manure or neem leaf manure, which were in parity among them and significantly higher than with *panchagavya* spray alone (T_2). The lowest biomass production by the cropping system was recorded with no mauring to any of the three crops.

During both years of study, the highest economic yield (maize grain equivalent yield) by the cropping system was produced with recommended dose of nitrogen supplied through fertilizer along with the spray of *panchagavya*, which was however, comparable with pig manure in combination with *panchagavya* or fertilizer alone. The next best manurial practices were poultry manure or farm yard manure or vermicompost in combination with *panchagavya,* which were in parity among them and significantly higher than with neem leaf manure with *panchagavya* or pig manure or poultry manure, which were comparable among them. The latter three manurial practices were significantly superior to application of neem leaf manure or farm yard manure or vermicompost, which were on par and significantly higher than with *panchagavya* spray alone (T_2). The lowest economic yield by the cropping system was produced with no mauring to any of the three crops.

During both years of study, the highest gross returns from the cropping system were realized with recommended dose of nitrogen supplied through fertilizer along with the spray of *panchagavya*, which were however, comparable with pig manure in combination with *panchagavya* or fertilizer alone. The next best manurial practices were poultry manure or farm yard manure or vermicompost in combination with *panchagavya,* which were in parity among them and significantly higher than with neem leaf manure with *panchagavya* or pig manure or poultry manure, which were comparable among them. The latter three manurial practices were significantly superior to application of neem leaf manure or farm yard manure or vermicompost, which were on par and significantly higher than with *panchagavya* spray alone (T_2). Gross returns from the cropping system were the lowest with no mauring to any of the three crops.

During both years of study, the highest net returns from the cropping system were realized with recommended dose of nitrogen supplied through fertilizer along with spray of *panchagavya*, which were however, comparable with recommended dose of fertilizer and poultry manure in combination with *panchagavya* spray, which were significantly higher than with neem leaf manure or farm yard manure along with *panchagavya* spray, which maintained significant disparity with each other and superior to poultry manure, vermicompost or pig manure along with *panchagavya* and neem leaf manuring, which were comparable among them, but significantly higher than with farm yard manure and it was in turn superior to vermicompost and pig manure, which were comparable between them and significantly higher than with no manuring with or without *panchagavya* spray. The lowest amount of net returns from the cropping system were obtained with no mauring to any of the three crops.

During both the years of study, the highest benefit-cost ratio of the cropping system was recorded with poultry manure along with *panchagavya* spray, which was significantly superior to all other manurial practices tried either with or without the use of *panchagavya*. The next best treatment was Poultry manure alone, which was significantly higher than with neem leaf manure or farm yard manure or fertilizer with or without *panchagavya* spray and vermicompost or pig manure along with *panchagavya*, which were comparable among them, but significantly higher than with pig manure or vermicompost without *panchagavya,* which were on par and significantly superior to no manuring with or without *panchagavya* spray. The lowest benefit-cost ratio of the cropping system was recorded with no mauring to any of the three crops.

Soil organic carbon status in the cropping system was found gradually built up compared to the pre-experimental level, with all the three crops raised in annual cycle, with the application of organic manures either with or without the use of *panchagavya*. Among the organic sources tried, neem leaf manure, vermicompost and farmyard manure added more organic carbon to the soil than with pig manure and poultry manure. Use of *panchagavya* along with any of the organic sources did not exert any measurable positive influence on the soil organic carbon status compared to the respective organic sources tried without the spray of *panchagavya*. Fertilizer application either with or without *panchagavya* could just maintain the status of soil organic carbon, with neither improving nor declining at the end of the cropping cycle with greengram. Unmanured plots with or without *panchagavya* resulted in reduction of the level of soil organic carbon. The trend of dynamics of soil organic carbon in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was marginal difference in the pre-experimental status of soil organic carbon between two annual cycles of the cropping system.

Soil available nitrogen status in the cropping system was found gradually built up compared to the pre-experimental level, with all the three crops raised in annual cycle, with the application of organic manures either with or without the use of *panchagavya*. Among the organic sources tried, neem leaf manure, poultry manure and vermicompost replenished more available nitrogen to the soil than with pig manure and farmyard manure. Use of *panchagavya* along with any of the organic sources did not exert any measurable positive influence on the soil available nitrogen status compared to the respective organic sources tried without the spray of *panchagavya*. Fertilizer application either with or without *panchagavya* could slightly improve the status of soil available nitrogen at the end of the cropping cycle with greengram, which was however, substantially lesser than with any of the organic sources. Unmanured plots with or without *panchagavya* resulted in depletion of the soil available nitrogen. The trend of dynamics of soil available nitrogen in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was considerable difference in the pre-experimental status of soil available nitrogen between two annual cycles of the cropping system.

Soil available phosphorus status in the cropping system was found built up at the end of annual cropping cycle compared to the pre-experimental level, with the application of organic manures as well as fertilizer either with or without the use of *panchagavya*. The build up of soil available phosphorus status with varied manurial practices was in the descending order of poultry manure, fertilizer, pig manure, neem leaf manure, vermicompost and farmyard manure. The former three sources enriched the soil available phosphorus to a greater extent than the latter three sources. Use of *panchagavya* along with any of the manurial sources did not exert any measurable positive influence on the soil available phosphorus status compared to the respective organic sources tried without the spray of *panchagavya*. Unmanured plots with or without *panchagavya* resulted in depletion of the soil available phosphorus. The trend of dynamics of soil available phosphorus in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was considerable difference in the pre-experimental status of soil available phosphorus between two annual cycles of the cropping system.

Soil available potassium status in the cropping system was found built up at the end of annual cropping cycle compared to the pre-experimental level, with the application of organic manures as well as fertilizer either with or without the use of *panchagavya*. The build up of soil available potassium status with varied manurial practices was in the descending order of vermicompost, pig manure, neem leaf manure, farmyard manure, poultry manure and fertilizer. The former four sources enriched the soil available potassium status to a greater extent than the latter two sources. Use of *panchagavya* along with any of the manurial sources did not exert any measurable positive influence on the soil available potassium status compared to the respective organic sources tried without the spray of *panchagavya*. Unmanured plots with or without *panchagavya* resulted in depletion of the soil available potassium. The trend of dynamics of soil available potassium in the cropping system with varied manurial practices was found similar in both the annual cropping cycles. However, there was considerable difference in the pre-experimental status of soil available potassium between two annual cycles of the cropping system.

The balance of available nitrogen in the soil under the influence of diversified manurial practices adopted to first two crops of the cropping system followed similar trend during both the annual cycles, differing only in the magnitude of change. The balance of soil available nitrogen was positive with all the manurial practices tried, except in unmanured plots either with or without the use of *panchagavya*, where the balance was negative. Organic sources resulted in higher positive balance than with fertlizer, which could maintain only marginal balance on positive side. Irrespective of manurial sources, use of *panchagavya* did not exert any noticeable effect in upgrading the soil nitrogen balance. The highest positive balance of soil available nitrogen was associated with neem leaf manure, which was followed by poultry manure, vermicompost and pig manure, while the lowest positive balance was recorded with farm yard manure.

The balance of available phosphorus in the soil under the influence of different manurial practices adopted to first two crops of the cropping system followed similar trend during both the annual cycles, differing only in the magnitude of change of a large extent. The balance of soil available phosphorus was positive with all the manurial practices tried, except in unmanured plots either with or without the use of *panchagavya*, where the balance was negative. Irrespective of manurial sources, use of *panchagavya* did not exert any noticeable effect in upgrading the soil phosphorus balance. The highest positive balance of soil available phosphorus was associated with poultry manure, which was followed by fertilizer, pig manure, neem leaf manure and vermicompost, while the lowest positive balance was recorded with farm yard manure.

The balance of available potassium in the soil under the influence of different manurial practices adopted to first two crops of the cropping system followed similar trend during both the annual cycles, differing only in the magnitude of change. The balance of soil available potassium was positive with all the manurial practices tried, except in unmanured plots either with or without the use of *panchagavya*, where the balance was negative. Irrespective of manurial sources, use of *panchagavya* did not exert any noticeable effect in upgrading the soil potassium balance. The highest positive balance of soil available potassium was associated with vermicompost, which was followed by pig manure, neem leaf manure, farmyard manure and poultry manure, while the lowest positive balance was recorded with fertilizer.

The following broad conclusions to answer the objectives with which the study was setout could be drawn from the present investigation:

- Performance of maize and sunflower in terms of productivity and economic returns was found at their best with the application of recommended dose of fertilizers in combination with *panchagavya* spray.

- However, since the study was aimed at to bring out the performance evaluation of crops with varied organic manures, it was found that among different organics, farm yard manure or pig manure or vermicompost in combination with foliar application of *panchagavya* was found better in increasing the productivity, quality and economic returns of maize than the other organic manurial practices.

- All the five organic manures tried in combination with foliar application of *panchagavya* were found better in increasing the productivity, quality and economic returns of sunflower than with the use of respective organic manures alone without the use of *panchagavya*.

- Performance of maize and sunflower in terms of productivity, quality and economic returns was the poorest with non-manuring through any source to any of the two crops

- Foliar application of *panchagavya* was found more spectacular on sunflower than on maize in increasing the productivity and economic returns, while the quality parameters of economic yield of both the crops were found improved with the use of *panchagavya.*

- Foliar application of *panchagavya* alone without any manurial sources could not exert any measurable positive influence either on maize or sunflower.

- Among all the manurial practices tried on maize and sunflower crops, the cumulative residual effect of poultry manure in combination with the foliar application of *panchagavya* was found the best on the performance of succeeding crop of greengram in terms of productivity, quality and economic returns.

- The highest biomass production and economic yield (maize grain equivalent yield) by the cropping system was produced with recommended dose of fertilizer in combination with spray of *panchagavya* applied to maize and sunflower.

- However, the economic yield (maize grain equivalent yield) realized from the cropping system with recommended dose of fertilizer in combination with spray *panchagavya* was statistically similar to that with the application of pig manure in combination with spray of *panchagavya* applied to maize and sunflower, which was closely followed by poultry manure or farm yard manure or vermicompost in combination with *panchagavya*

- The highest gross and net returns from the cropping system were realized with recommended dose of fertilizer in combination with *panchagavya* applied to maize and sunflower.

- However, gross returns from the cropping system realized with recommended dose of fertilizer in combination with spray *panchagavya* were comparable with those with the application of pig manure in combination with spray *panchagavya* applied to maize and sunflower, closely followed by poultry manure or farm yard manure or vermicompost in combination with *panchagavya*.

- The net returns from the cropping system realized with recommended dose of fertilizer in combination with spray of *panchagavya* were statistically similar to those with the application of poultry manure in combination with spray of *panchagavya* applied to maize and sunflower.

- The highest benefit-cost ratio of the cropping system was recorded with the application of poultry manure in combination with spray of *panchagavya* applied to maize and sunflower.

- Performance of the cropping system in terms of productivity and economic returns was obviously the poorest with non-manuring through any source to any of the crops in the cropping system, which was statistically similar to that with foliar application of *panchagavya* alone to maize and sunflower.

- Soil fertility parameters *viz.*, soil organic carbon and available nitrogen, available phosphorus and available potassium were found built up to a considerable extent with the use of organic manures to maize and sunflower, while the application of fertilizer to maize and sunflower could just maintain the soil fertility status, with neither considerable replenishment nor deterioration.

- Soil organic carbon and available nitrogen were replenished more with neem leaf manure, poultry manure and vermicompost.

- The build up of soil available phosphorus with varied manurial practices was in the descending order of poultry manure, fertilizer, pig manure, neem leaf manure, vermicompost and farm yard manure.

- The build up of soil available potassium status with varied manurial practices was in the descending order of vermicompost, pig manure and neem leaf manure.

- Foliar application of *panchagavya* along with any of the organic sources to maize and sunflower crops did not exert any measurable positive influence on any of the four soil fertility parameters compared to the application of respective organic sources without the combination of *panchagavya* spray.

In conclusion, it can be inferred from the investigation that maize crop can be sustained with farm yard manure or pig manure or vermicompost along with foliar application of *panchagavya* and sunflower crop can be sustained with neem leaf manure or poultry manure with *panchagavya*, as pure organic additives, since they have performed nearly equal with that of recommended dose of fertilizers. In case of residual effect of organic manures on greengram, poultry manure performed better over others. Considering the cropping system as a whole, maize- sunflower - greengram cropping system can be sustained with organic manures along with combination of *panchagavya* not only in terms of productivity and economic returns, but also in terms of sustaining the soil fertility status at fairly high level. Supply of N through exclusive organic sources could nearly meet the crop demand for nutrients and performed equally with that of recommended dose of fertilizer. Foliar application of *panchagavya* seems to be promising in improving the productivity and quality of maize and sunflower crops.

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Appendices

APPENDIX – A

Standard week wise meteorological data during the crop period (First year cropping cycle 2003-2004)

Stan-dard week	Month	Date	Temperature (°C)				Mean RH (%)		Rainfall (mm)		No. of rainy days		Bright Sunshine (hrs day^{-1})		Evaporation (mm day^{-1})	
			Maximum		Minimum											
			A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
31	July - August	30-5	32.4	+0.90	25.2	+0.72	52.4	+1.22	10.2	+3.60	2	+1.5	7.8	+7.20	7.8	+0.42
32	August	6-12	38.7	+0.38	24.9	+1.34	49.0	-1.72	1.4	+7.45	1	+3.2	8.2	+2.05	7.2	+1.10
33	August	13-19	36.5	+0.74	26.4	+1.66	61.0	-6.65	20.0	+11.20	5	+3.8	7.4	+0.70	7.4	+0.84
34	August	20-26	35.9	+0.99	25.9	+0.70	50.5	-7.75	0.0	-27.57	0.0	-1.3	7.7	+1.92	7.7	+4.1
35	Aug –Sept	27-2	36.2	+2.37	26.4	+1.78	47.5	-10.85	0.0	-27.18	0.0	-1.3	7.8	+2.33	8.0	+1.16
36	September	3-9	34.8	+0.62	25.8	+1.51	62.5	+1.75	51.7	24.27	2.0	+0.5	7.0	+0.97	6.8	+0.91
37	September	10-16	32.6	-14.0	24.5	+0.13	67.0	+3.65	26.8	-13.51	2.0	-0.1	5.7	+0.13	3.7	-2.24
38	September	17-23	32.8	-1.05	24.8	+0.60	69.0	+4.70	16.2	-4.71	3.0	+1.8	6.9	+0.62	5.6	+0.20
39	September	24-30	32.3	-1.42	24.7	+0.88	61.5	-5.35	10.0	-25.89	1.0	-1.1	5.6	-0.53	4.6	-0.45
40	October	1-7	33.2	+1.13	22.5	-0.72	63.0	-7.70	1.7	-39.49	0.0	-2.4	6.8	+1.38	4.3	-0.11
41	October	8-14	33.9	+1.79	19.0	-3.92	56.5	-16.30	0.0	-33.61	0.0	-2.0	10.2	+4.56	6.5	+2.48
42	October	15-21	33.0	+0.96	22.7	+0.45	65.0	-5.35	0.5	-39.98	0.0	-2.2	8.0	+1.93	5.1	+0.78
43	October	22-28	32.3	+0.47	23.2	+1.68	73.0	+1.10	18.4	-1.55	3.0	+1.4	7.7	+0.73	4.4	-1.66
44	Oct-Nov.	29-4	29.9	-0.31	22.8	+1.53	82.0	+9.05	135.2	+70.92	5.0	+2.5	4.9	-0.55	3.4	-0.54
45	November	5-11	29.3	-0.72	23.0	+2.12	78.5	+4.25	42.2	-8.71	4.0	+1.4	4.1	-1.75	2.7	-1.05
46	November	12-18	29.3	-0.07	22.1	+1.55	81.0	+6.20	61.5	-9.08	4.0	+1.4	6.0	+6.7	3.2	-0.69
47	November	19-25	29.4	-0.27	23.1	+3.24	82.0	+7.80	118.9	+95.94	5.0	+3.2	4.7	-1.76	3.2	-0.83
48	Nov-Dec.	26-2	29.2	+0.15	22.3	+4.77	82.5	+14.40	25.4	+3.02	2.0	+1.4	5.9	-2.40	2.9	-1.38
49	December	3-9	27.7	-0.63	21.6	+3.55	85.5	+12.15	75.8	+37.17	4.0	+2.4	4.4	-1.84	2.5	-1.11
50	December	10-16	29.7	+1.68	22.7	+4.92	82.5	+10.00	8.0	-24.10	3.0	+1.9	6.3	-0.18	3.4	-0.11
51	December	17-23	29.1	+1.12	23.0	+5.17	83.5	+10.20	8.4	+0.37	1.0	+0.4	5.3	-1.64	2.9	-0.86
52	December	24-31	30.0	+1.51	20.1	+3.16	72.0	+1.60	0.0	-8.74	0.0	-0.4	9.1	+1.00	3.2	-0.97

Contd….

1	January	1-7	29.9	+1.04	19.3	+2.62	71.5	+3.45	0.0	-1.81	0.0	-0.2	9.2	+0.90	4.0	-0.28
2	January	8-14	29.0	+1.20	16.9	+0.44	67.0	-0.60	0.0	-3.84	0.0	-0.3	9.9	+1.69	4.5	+0.46
3	January	15-21	31.4	+1.71	19.7	+3.20	64.5	-1.15	0.0	-3.86	0.0	-0.4	8.5	+0.14	3.7	-0.58
4	January	22-28	32.0	+1.84	21.6	+6.32	67.0	+3.60	0.0	0.0	0.0	0.0	8.9	-0.50	4.5	-0.43
5	Jan-Feb.	29-4	31.7	+0.73	19.2	+3.30	68.0	+7.50	0.0	0.0	0.0	0.0	10.0	+02.5	5.4	+0.21
6	February	5-11	31.7	-0.25	19.8	+2.97	67.0	+87.0	0.0	0.0	0.0	0.0	9.8	-0.02	5.0	-0.56
7	February	12-18	31.9	+1.04	16.7	-1.33	58.0	+1.20	0.0	0.0	0.0	0.0	10.2	+0.72	6.2	+0.45
8	February	19-25	34.7	+0.32	24.2	+4.47	59.0	+3.10	0.0	-0.58	0.0	0.0	9.0	-0.87	5.9	-0.17
9	Feb-March	26-3	35.1	-0.28	22.7	+3.72	59.5	+7.70	0.0	-1.16	0.0	-0.1	9.6	-0.22	5.9	-0.69
10	March	4-10	35.9	+1.20	24.2	+4.61	57.5	+6.65	0.0	-0.55	0.0	-0.1	9.0	-0.69	7.0	0.29
11	March	11-17	36.0	-1.83	23.2	+3.07	57.5	+9.00	0.0	-0.52	0.0	-0.01	9.5	-0.47	6.7	-0.22
12	March	18-24	36.4	-0.50	22.0	+0.31	51.0	+3.30	0.0	-3.80	0.0	-0.2	9.5	-0.21	7.5	-0.02
13	March	25-31	36.6	+2.40	25.0	+1.77	60.0	+8.10	0.0	-1.36	0.0	-0.2	9.2	+0.11	7.3	-0.13
14	April	1-7	37.3	+2.63	24.9	+1.31	54.5	+3.90	0.0	-11.11	0.0	-0.5	10.5	+0.72	7.6	-0.04
15	April	8-14	37.9	-0.44	25.0	+0.90	53.0	+1.20	0.0	-0.99	0.0	-0.3	10.9	+1.71	7.9	+0.23
16	April	15-21	39.7	+2.25	27.0	+1.95	565.	+5.75	0.0	-4.57	0.0	-0.3	10.7	+1.16	8.4	+0.49
17	April	23-29	38.0	-0.41	26.6	+1.26	59.0	+8.5	21.6	+204.2	2.0	-0.2	7.8	-1.92	6.9	-1.4
18	April - May	30-6	39.2	+0.46	27.1	+1.01	57.5	+6.95	0.0	-9.36	0.0	-0.8	10.8	+1.91	8.2	-0.07
19	May	7-13	37.7	-0.78	26.1	-0.14	65.0	+14.25	1.2	-28.80	0.0	-1.1	8.0	+0.28	7.1	-1.42
20	May	14-20	38.9	-0.60	26.0	-1.06	57.0	+11.40	3.3	-11.35	1.0	0.0	4.5	-3.95	5.9	-3.33
21	May	21-27	40.7	+1.89	28.0	+1.54	46.0	-2.00	6.2	-10.19	1.0	0.0	6.3	-1.90	9.1	+0.50

A - Actual DN - Deviation from normal

APPENDIX - B

Standard week wise meteorological data during the crop period (second year cropping cycle, 2004-2005)

Stan-dard week	Month	Date	Temperature (°C)				Mean RH (%)		Rainfall (mm)		No. of rainy days		Bright Sunshine (hrs day^{-1})		Evaporation (mm day^{-1})	
			Maximum		Minimum											
			A	DN	A	DN	A	DN	A	DN	A	DN	A	DN	A	DN
31	July – August	30-5	33.8	+0.85	26.2	-1.70	75.0	+1.50	14.2	+7.00	3	+1.9	4.5	-2.01	4.5	+1.50
32	August	6-12	33.0	+1.20	25.8	+1.50	68.4	-1.75	15.6	+12.2	3	+2.5	7.4	+4.80	5.8	-0.75
33	August	13-19	34.2	+0.30	25.4	+1.20	58.9	-1.02	3.2	-3.40	2	-0.11	6.8	+3.20	6.5	+1.22
34	August	20-26	35.4	+1.40	20.5	-0.85	62.5	+0.85	16.8	+1.21	3	+1.7	7.4	-1.54	6.6	-0.88
35	Aug -Sep	27-2	32.7	-1.13	24.2	-0.43	75.0	+16.7	45.8	-18.62	3.0	+1.7	4.6	-0.89	3.8	-3.02
36	September	3-9	32.5	-1.62	24.2	-0.22	78.0	+16.45	66.9	+37.20	4.0	+2.5	4.5	-1.53	4.3	-1.56
37	September	10-16	33.1	-0.49	25.1	+0.86	64.5	-0.05	4.9	-37.13	1.0	-1.2	4.6	-0.98	4.6	-0.99
38	September	17-23	33.0	-0.47	24.0	-0.23	65.0	-0.20	17.2	-2.59	2.0	+0.7	5.7	-0.46	4.4	-0.86
39	September	24-30	29.8	-3.57	23.8	+0.04	85.0	+17.90	33.7	-0.63	4.0	+1.9	2.5	-3.41	2.4	-2.42
40	October	1-7	29.6	-2.54	24.0	+0.88	85.0	+15.45	5.6	-31.87	0.0	-2.0	0.8	-4.66	1.9	-2.49
41	October	8-14	29.4	-2.79	22.9	+0.45	88.0	+17.30	63.0	+31.75	5.0	+3.3	1.1	-4.80	1.9	-2.29
42	October	15-21	26.4	-5.56	22.7	+0.59	65.0	-5.25	0.0	-39.05	0.0	-2.1	7.3	+1.02	3.8	-0.52
43	October	22-28	32.7	+0.90	22.1	+0.53	72.5	+0.15	0.0	-21.19	0.0	-1.9	5.8	-1.05	4.3	-1.65
44	Oct-Nov.	29-4	29.3	-0.91	22.1	+0.82	79.5	+3.45	140.0	+66.52	4.0	+1.3	2.8	-2.77	1.6	-2.22
45	November	5-11	27.7	-2.71	22.7	+1.74	85.0	+10.58	93.4	+42.52	4.0	+1.5	3.4	-2.32	1.6	-2.01
46	November	12-18	32.8	+3.52	20.8	+0.26	69.5	-6.40	0.0	-73.50	0.0	-2.7	7.8	+2.38	4.1	+0.27
47	November	19-25	31.4	+1.95	21.4	+1.40	75.5	-0.65	5.2	-27.32	1.0	-1.1	6.9	+0.80	3.9	-0.07
48	Nov-Dec.	26-2	30.3	+1.33	19.3	+1.27	70.0	-0.20	2.2	-22.72	0.0	-0.8	8.8	+0.96	3.6	-0.48
49	December	3-9	27.9	-0.44	20.8	+2.74	73.5	0.0	0.0	-38.63	0.0	-1.4	4.3	-2.55	3.7	+0.10
50	December	10-16	26.7	-1.39	20.0	+2.06	83.0	+10.20	172.2	+131.62	4.0	+2.9	4.7	-1.77	2.2	-1.36
51	December	17-23	28.2	+0.08	16.1	-1.59	73.0	-0.40	0.0	-6.51	0.0	-0.06	8.8	+1.63	4.0	+0.32
52	December	24-31	27.6	-1.13	16.4	-0.59	71.0	+2.10	0.0	-1.00	0.0	-0.1	6.3	-2.02	3.7	-0.43

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1	January	1-7	28.3	-0.70	16.6	-0.28	66.5	-1.50	0.8	-1.81	0.0	-0.2	8.8	+0.4	4.6	+0.3
2	January	8-14	29.3	+0.64	16.4	-0.13	65.0	-2.40	0.0	-3.84	0.0	-0.5	7.3	-0.93	4.3	+0.23
3	January	15-21	28.3	-1.49	16.3	-0.53	67.5	+2.20	0.0	-2.80	0.0	-0.3	8.6	+0.34	4.4	+0.16
4	January	22-28	29.4	-0.90	13.8	-2.05	68.0	+4.75	0.0	0.0	0.0	0.0	7.4	-1.93	4.3	-0.66
5	Jan-Feb.	29-4	31.0	+0.23	15.4	-0.90	66.5	+5.65	0.0	0.0	0.0	0.0	9.2	-0.52	5.3	+0.04
6	February	5-11	31.1	-0.81	19.4	+2.14	69.0	+9.55	0.0	0.0	0.0	0.0	7.9	-1.87	5.3	-0.17
7	February	12-18	32.0	-0.76	17.0	-0.71	64.0	+76.0	0.0	0.0	0.0	0.0	9.4	-0.12	5.5	-0.32
8	February	19-25	32.4	-1.41	16.5	-3.56	56.0	+0.20	0.0	-0.58	0.0	0.0	6.8	-2.92	5.7	-0.38
9	Feb-March	26-4	33.9	+0.77	15.3	-3.22	45.0	-6.75	0.0	-1.16	0.0	-0.1	6.2	-3.68	6.4	-0.14
10	March	5-11	36.0	+1.01	18.3	-1.56	36.5	-14.50	0.0	-0.55	0.0	-0.1	9.5	-0.08	6.9	+0.19
11	March	12-18	35.3	-0.62	18.3	-2.01	43.5	-5.75	0.0	-0.25	0.0	-0.1	9.5	-0.38	6.5	-0.32
12	March	19-25	37.6	+0.31	23.5	+1.95	53.5	+6.25	0.0	0.0	0.0	0.0	7.1	-2.66	6.1	-1.42
13	March-April	26-1	38.4	+1.17	23.3	+0.08	46.5	-6.50	0.0	-1.14	0.0	-0.2	8.7	-0.45	6.8	-0.65
14	April	2-8	32.8	-4.39	22.9	-0.76	46.0	-4.65	0.0	-11.11	0.0	-0.5	10.0	+0.15	6.6	-0.04
15	April	9-15	40.6	+2.84	26.2	+2.13	38.0	-13.75	0.0	-0.99	0.0	-0.3	8.5	-0.89	8.6	+0.95
16	April	16-22	37.4	-0.68	25.2	-0.08	50.0	-0.90	0.0	-3.33	0.0	-0.2	5.8	-3.88	7.8	-0.17
17	April	23-29	39.5	+0.92	26.6	+0.94	44.0	-6.35	0.0	-2.16	0.0	0.0	8.4	-1.23	6.7	-1.57
18	April - May	30-6	39.6	+0.69	27.0	+0.72	48.5	-1.85	18.2	+13.52	3.0	+2.5	7.2	-2.03	7.4	-0.94
19	May	7-13	38.3	+0.22	25.9	-0.15	54.0	+1.10	12.6	-17.52	2.0	+0.9	7.0	-0.55	6.8	-1.46
20	May	14-20	35.1	-4.19	25.8	-1.14	63.0	+16.10	51.9	+36.92	2.0	+0.9	5.6	-2.42	3.9	-4.89
21	May	21-27	35.9	-3.03	27.4	+0.97	58.0	+9.6	12.5	-4.51	1.0	-0.2	5.3	-2.88	6.0	-2.56

IV

APPENDIX-C

Nutrient content (%) of different organic sources

Source	N (%)	P (%)	K (%)
FYM	0.68	0.20	0.50
Vermicompost	1.20	0.50	1.50
Neem leaf (GM)	0.50	0.28	0.35
Poultry manure	2.54	2.00	1.40
Pig manure	0.56	0.35	0.60

APPENDIX-D

CALENDAR OF OPERATIONS OF THE CROPPING SYSTEM

Sl. No.	Particulars of operation	2003-2004	2004-2005
1	Primary tillage of experimental field (Plot wise during Second year of experimentation)	04.08.2003	01.08.2004
2	Secondary tillage and micro levelling of individual plots (Plot wise during Second year of experimentation)	06.08.2003	03.08.2004
3	Layout of the experimental field	07.08.2003	04.08.2004
4	Application of organic manures treatment wise	08.08.2003	05.08.2004
5	Irrigation and decomposition period	09.08.2003 to 24.08.2003	06.08.2004 to 21.08.2004
6	a) Sowing of maize and basal dressing of fertilizers b) *Panchagavya* preparation	25.8.2003	22.08.2004
7	Pre-sowing irrigation	26.8.2003	29.8.2003
8	Gap filling	01.09.2003	30.08.2004
9	Thinning	09.09.2003	06.09.2004
10	First weeding and irrigation	15.09.2003	12.09.2004
11	Irrigation	23.09.2003	20.09.2004
12	Top dressing of fertilizer (urea)	25.09.2003	22.09.2004
13	Irrigation	04.10.2003	03.10.2004
14	Second weeding	08.10.2003	05.10.2004
15	Irrigation	14.10.2003	12.10.2004
16	Top dressing of fertilizer (urea)	16.10.2003	15.10.2004
17	Irrigation	25.10.2003	26.10.2004
18	Harvesting of maize	26.11.2003	28.11.2004
19	Threshing	28.11.2003	30.11.2004

20	Ploughing within individual plots	29.11.2003	30.11.2004
21	Application of organic manures and leveling	30.11.2003	01.12.2004
22	Irrigation and decomposition period	30-11-2003 to 15.12.2003	01-12-2004 to 16.12.2004
23	Pre-sowing irrigation	16.12.2003	17.12.2004
24	a) Sowing of sunflower and basal dressing of fertilizers b) *Panchagavya* preparation	17.12.2003	18.12.2004
25	Gap filling and irrigation	27.12.2003	28.12.2004
26	Thinning	31.12.2003	01.01.2005
27	Top dressing of fertilizer and irrigation	05.01.2004	06.01.2005
28	Hand weeding	10.01.2004	11.01.2005
29	Irrigation	17.01.2004	18.01.2005
30	Hand weeding	25.01.2004	26.01.2005
31	Irrigation	28.01.2004	27.01.2005
32	Irrigation	05.02.2004	03.02.2005
33	Irrigation	16.02.2004	14.02.2005
34	Harvesting and threshing	14.03.2004	15.03.2005
35	Ploughing with in individual plots	15.03.2004	16.03.2005
36	Pre sowing irrigation	20.03.2004	20.03.2005
37	Sowing of greengram	27.03.2004	27.03.2005
38	Thinning & Irrigation	10.04.2004	9.04.2005
39	Hand weedings	11.04.2004 25.04.2004 10.05.2004	10.04.2005 23.04.2005 08.05.2005
40	Irrigation	20.05.2004	20.05.2005
41	Harvesting	27.05.2004	27.05.2005
42	Threshing of pods	30.05.2004	30.05.2005

APPENDIX-E

COST OF INPUTS AND OUTPUTS OF THE EXPERIMENT

S.No.	Particulars	Unit	Cost / Price (Rs.)
1.	Farm yard manure	kg	0.20
2.	Vermicompost	kg	0.45
3.	Neem leaf (green manure)	kg	0.10
4.	Poultry manure	kg	0.20
5.	Pig manure	kg	0.25
6.	Urea	kg	4.80
7.	Single super phosphate	kg	3.11
8.	Muriate of potash	kg	4.42
9.	Maize seed (for sowing)	kg	20.00
10.	Sunflower seed (for sowing)	kg	280.00
11.	Greengram seed (for sowing)	kg	30.00
12.	*Panchagavya*	Litre	15.00
13.	Maize grain	Kg	5.05
14.	Sunflower seed	Kg	10.00
15.	Greengram seed	kg	20.00
16.	Maize stover	tonne	450.00
17.	Sunflower stover	Kg	0.20

APPENDIX-F

COST OF CULTIVATION (Rs ha^{-1}) OF MAIZE

Treatments		Cost of cultivation excluding nutrients	Cost of organic manures	Cost of fertilizer	Total cost of cultivation
T_1	No manure	6780	-	-	6780
T_2	No manure+ *Panchagavya*	6780	300	-	7080
T_3	Recommended dose of fertilizer	6780	-	6000	12780
T_4	Recommended dose of fertilizer + *Panchagavya*	6780	300	6000	13080
T_5	Farm Yard Manure	6780	3528	-	10308
T_6	Farm Yard Manure + *Panchagavya*	6780	3828	-	10608
T_7	Vermicompost	6780	4500	-	11280
T_8	Vermicompost + *Panchagavya*	6780	4800	-	11580
T_9	Neem leaf	6780	2400	-	9180
T_{10}	Neem leaf + *Panchagavya*	6780	2700	-	9480
T_{11}	Poultry manure	6780	944	-	7724
T_{12}	Poultry manure + *Panchagavya*	6780	1244	-	8024
T_{13}	Pig manure	6780	5355	-	12135
T_{14}	Pig manure + *Panchagavya*	6780	5655	-	12435

APPENDIX-G

PARTICULARS OF COST OF CULTIVATION (Rs ha^{-1}) OF MAIZE EXCLUDING NUTRIENTS

S.No.	Item of expenditure	Cost
1.	Land preparation	900
2.	Seeds and sowing	1600
3.	After care including weeding	2300
4.	Irrigation	1200
5.	Harvesting and threshing	780
	Total	6780

APPENDIX-H

COST OF CULTIVATION (Rs ha^{-1}) OF SUNFLOWER

Treatments		Cost of cultivation excluding nutrients	Cost of organic manures	Cost of fertilizer	Total cost of cultivation
T_1	No manure	4500	-	-	4500
T_2	No manure + *Panchagavya*	4500	300	-	4800
T_3	Recommended dose of fertilizer	4500	-	2200	6700
T_4	Recommended dose of fertilizer + *Panchagavya*	4500	300	2200	7000
T_5	Farm Yard Manure	4500	2352	-	6852
T_6	Farm Yard Manure + *Panchagavya*	4500	2652	-	7152
T_7	Vermicompost	4500	2997	-	7497
T_8	Vermicompost + *Panchagavya*	4500	3297	-	7797
T_9	Neem leaf	4500	1600	-	6100
T_{10}	Neem leaf + *Panchagavya*	4500	1900	-	6400
T_{11}	Poultry manure	4500	628	-	5128
T_{12}	Poultry manure + *Panchagavya*	4500	928	-	5428
T_{13}	Pig manure	4500	3570	-	8070
T_{14}	Pig manure + *Panchagavya*	4500	3870	-	8370

APPENDIX-I

PARTICULARS OF COST OF CULTIVATION (Rs ha^{-1}) OF SUNFLOWER EXCLUDING NUTRIENTS

S.No.	Item of expenditure	Cost
1.	Land preparation	650
3.	Seeds and sowing	1050
4.	After care including weeding	1400
5.	Irrigation	550
6.	Bird scaring	500
7.	Harvesting and threshing	350
	Total	4500

APPENDIX-J

COST OF CULTIVATION (Rs ha^{-1}) OF GREENGRAM

Treatments		Cost of cultivation (Rs ha^{-1})
T_1	No manure	3800
T_2	No manure + *Panchagavya*	3800
T_3	Recommended dose of fertilizer	3800
T_4	Recommended dose of fertilizer + *Panchagavya*	3800
T_5	Farm Yard Manure	3800
T_6	Farm Yard Manure + *Panchagavya*	3800
T_7	Vermicompost	3800
T_8	Vermicompost + *Panchagavya*	3800
T_9	Neem leaf	3800
T_{10}	Neem leaf + *Panchagavya*	3800
T_{11}	Poultry manure	3800
T_{12}	Poultry manure + *Panchagavya*	3800
T_{13}	Pig manure	3800
T_{14}	Pig manure + *Panchagavya*	3800

APPENDIX-K

PARTICULARS OF COST OF CULTIVATION (Rs ha^{-1}) OF GREENGRAM

S.No.	Item of expenditure	Cost
1.	Land preparation	300
2.	Seeds and sowing	650
3.	Thinning	200
4.	Weeding	700
5.	Irrigation	750
6.	Harvesting (pod picking)	700
7.	Threshing	500
	Total	**3800**

APPENDIX-L

COST OF CULTIVATION (Rs ha^{-1}) OF THE CROPPING SYSTEM AS A WHOLE

	Treatments	Maize	Sunflower	Greengram	Cropping system as a whole
T_1	No manure	6780	4500	3800	15080
T_2	No manure + *Panchagavya*	7080	4800	3800	15680
T_3	Recommended dose of fertilizer	12780	6700	3800	23280
T_4	Recommended dose of fertilizer + *Panchagavya*	13080	7000	3800	23880
T_5	Farm Yard Manure	10308	6852	3800	20960
T_6	Farm Yard Manure + *Panchagavya*	10608	7152	3800	21560
T_7	Vermicompost	11280	7497	3800	22577
T_8	Vermicompost + *Panchagavya*	11580	7797	3800	23177
T_9	Neem leaf	9180	6100	3800	19080
T_{10}	Neem leaf + *Panchagavya*	9480	6400	3800	19680
T_{11}	Poultry manure	7724	5128	3800	16652
T_{12}	Poultry manure + *Panchagavya*	8024	5428	3800	17252
T_{13}	Pig manure	12135	8070	3800	24005
T_{14}	Pig manure + *Panchagavya*	12435	8370	3800	24605

Plates

Plate 1: Over all view of the experimental field
(Maize crop raised during late kharif)

Plate 2: Over all view of the experimental field
(Sunflower crop raised during late rabi)

Plate 3: Over all view of the experimental field
(Greengram crop raised d

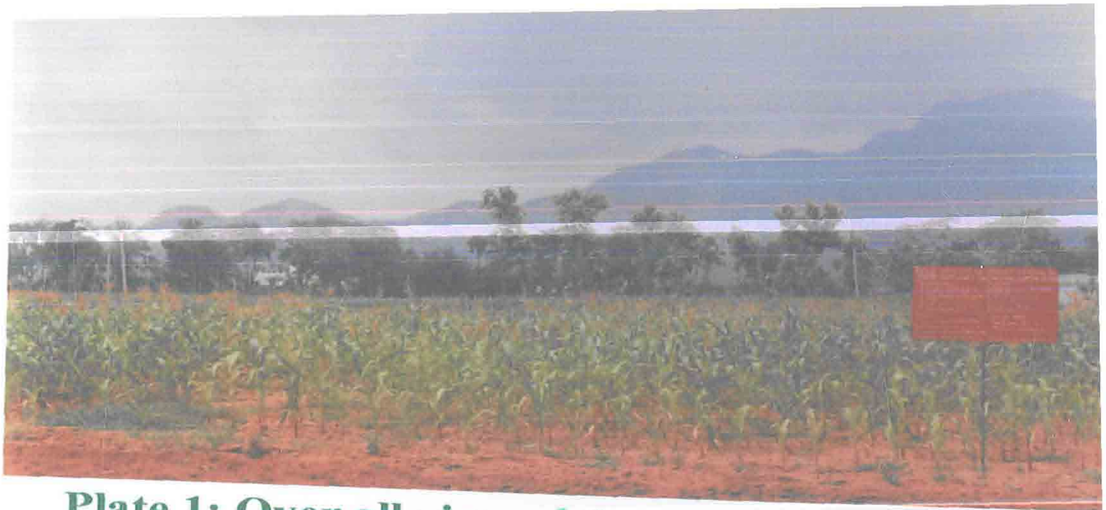

Plate 1: Over all view of the experimental field (Maize crop raised during late kharif)

Plate 2: Over all view of the experimental field (Sunflower crop raised during late rabi)

Plate 3: Over all view of the experimental field (Greengram crop raised during summer)

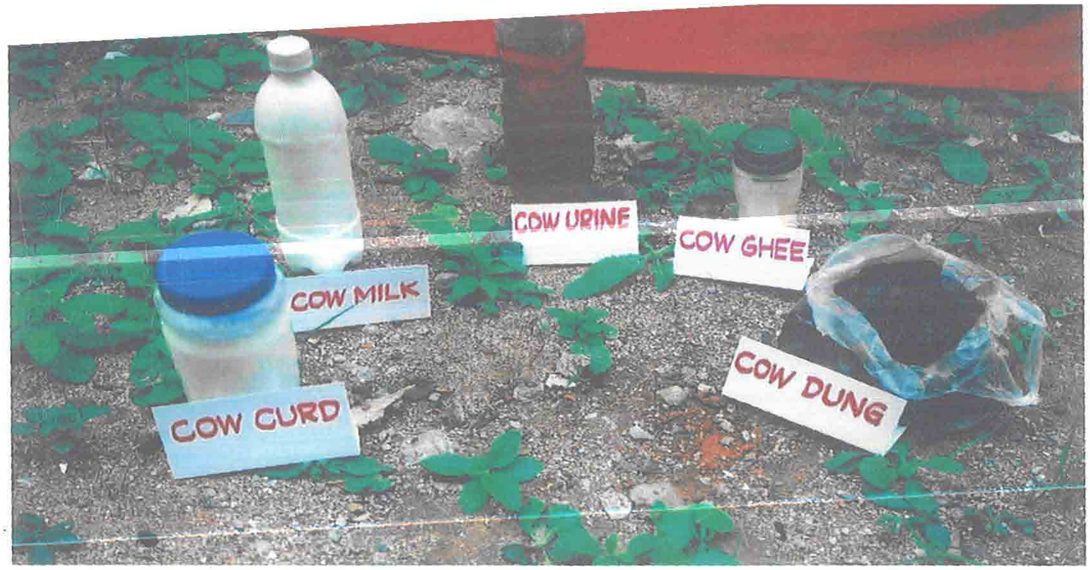

Plate 4: Components of *panchagavya* from cow's origin

Plate 5: Additives used for effective fermentation of *panchagavya*

Plate 6: Total materials used for preparation of *panchagavya*

Plate 7: Application of farm yard manure to the experimental plots

Plate 8: Application of vermicompost to the experimental plots

Plate 9: Application and incorporation of neem leaf manure to the experimental plots

Plate 10: Application of pig manure to the experimental plots

Plate 11: Application of poultry manure to the experimental plots

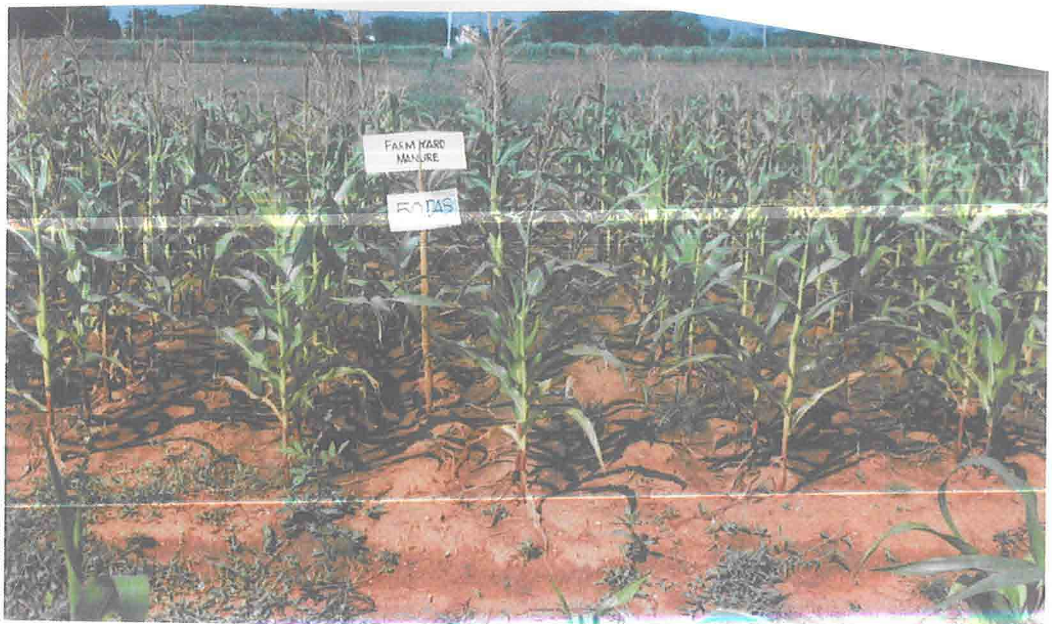

Plate 12: Stature of maize crop with the application of farm yard manure

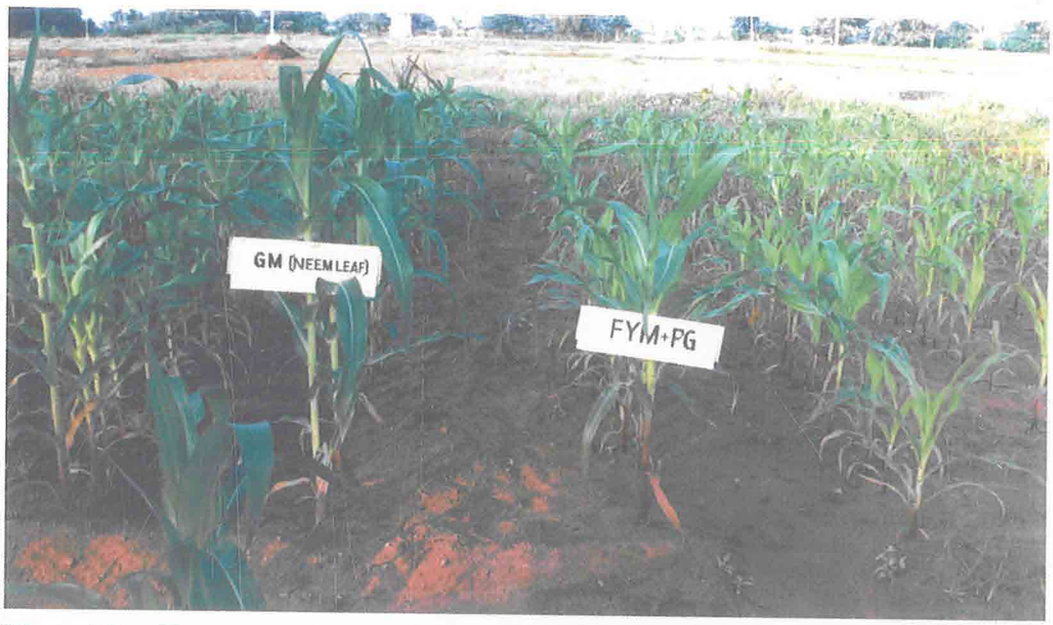

Plate 13: Comparative stature of maize crop with the application of neem leaf manure and farm yard manure along with *panchagavya*

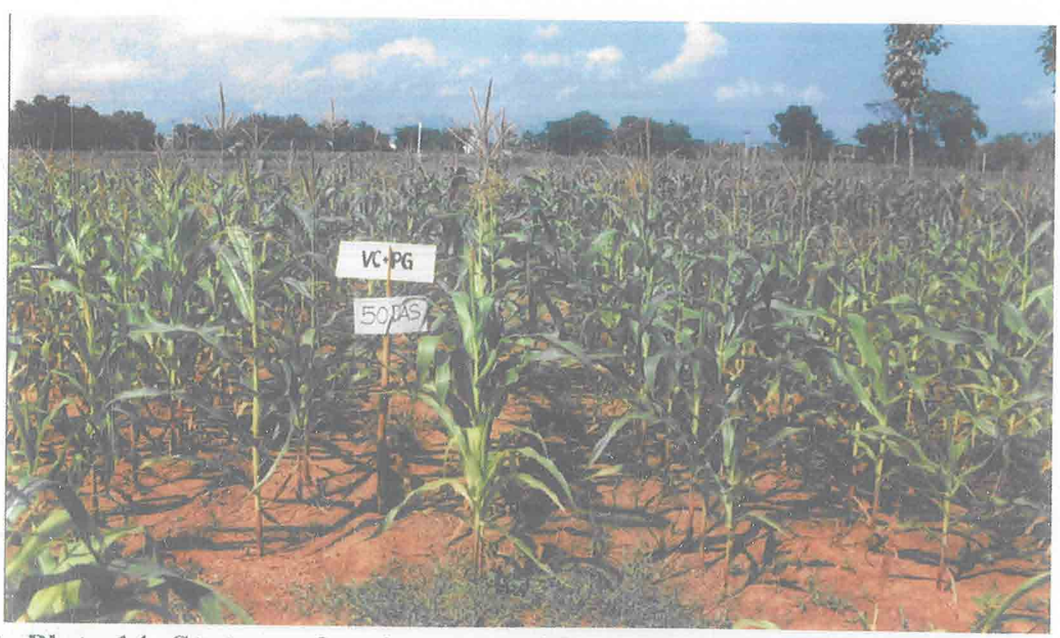

Plate 14: Stature of maize crop with application of vermicompost

Plate 12: Stature of maize crop with the application of farm yard manure

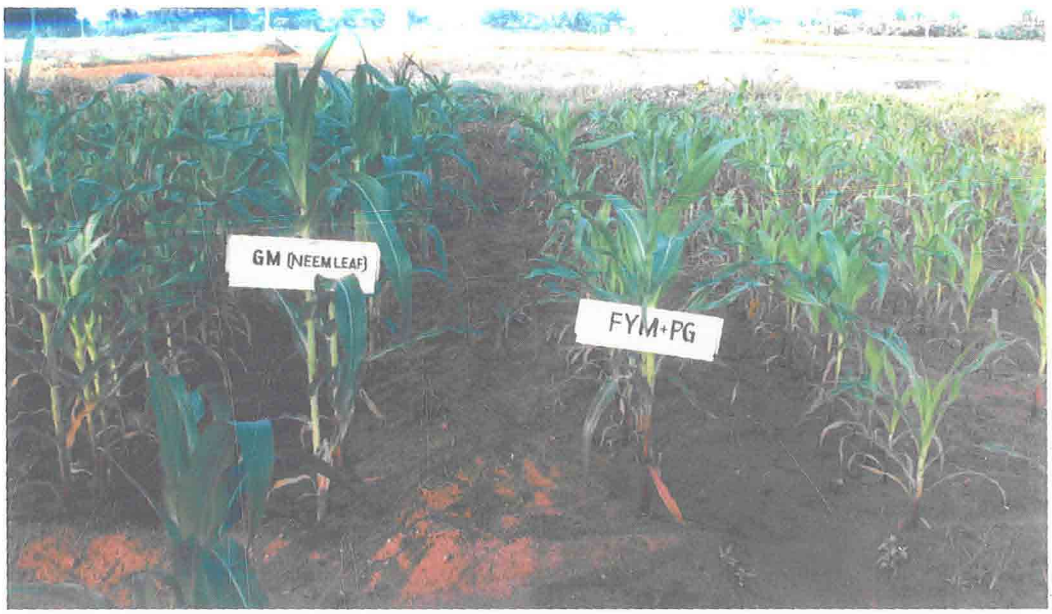

Plate 13: Comparative stature of maize crop with the application of neem leaf manure and farm yard manure along with *panchagavya*

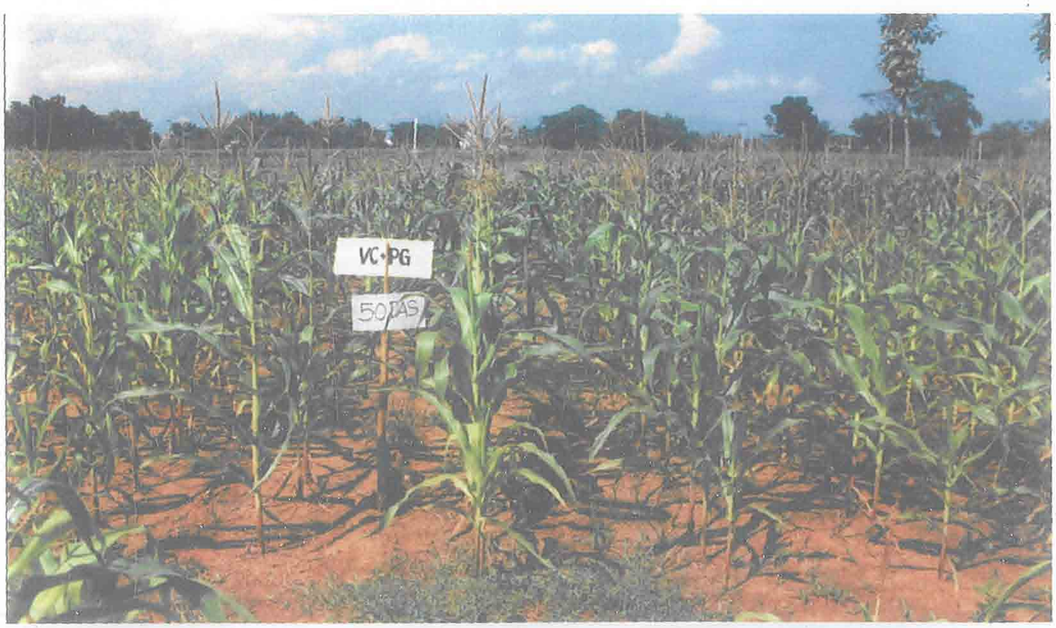

Plate 14: Stature of maize crop with application of vermicompost along with *panchagavya*

Plate 15: Stature of maize crop with the application of neem leaf manure along with *panchagavya*

Plate 16: Stature of maize crop without any manure / fertilizer or *panchagavya*

Plate 17: Comparative stature of maize crop with the application of neem leaf manure and without any manure / fertilizer

Plate 18: Stature of sunflower crop along with the matured heads ready for harvest with the application of neem leaf manure along with *panchgavya*

Plate 19: Stature of sunflower crop along with the matured heads ready for harvest with the application of recommended dose of fertilizer along with *panchgavya*

Plate 20: Stature of sunflower crop along with the matured heads ready for harvest with *panchagavya* alone (without any manure/ fertilizer)

Plate 21: Stature of sunflower crop along with the matured heads ready for harvest without any manure/ fertilizer or *panchagavya*

Plate 22: Stature of greengram crop raised with the residual effect of farm yard manure applied to preceding two crops

Plate 23: Stature of greengram crop raised with the residual effect of vermicompost applied to preceding two crops

Plate 24: Stature of greengram crop raised with the residual effect of neem leaf manure applied to preceding two crops

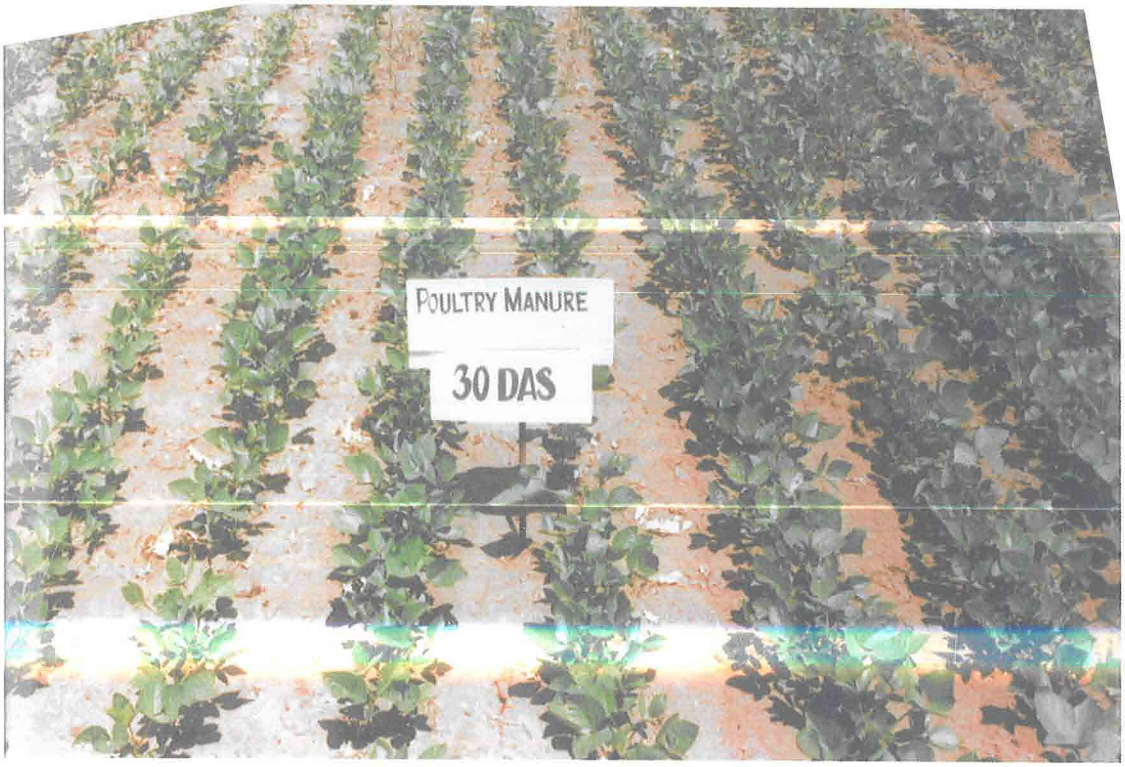

Plate 25: Stature of greengram crop raised with the residual effect of poultry manure applied to preceding two crops

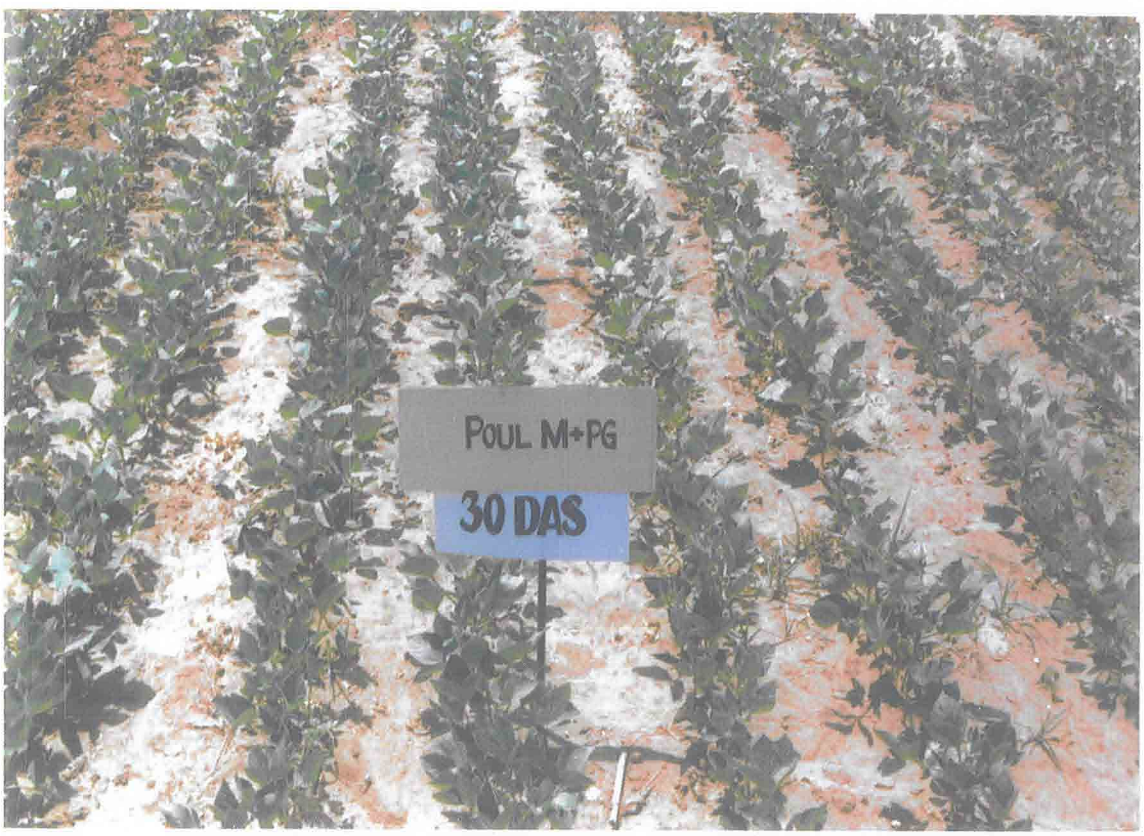

Plate 26 : Stature of greengram crop raised with the residual effect of poultry manure with *panchagavya* applied to preceding two crops