

**EFFECT OF ORGANIC MULCHING ON SOIL PROPERTIES, YIELD AND
NUTRIENTS UPTAKE OF MAIZE AND GROUNDNUT UNDER RAINFED
CONDITION IN AN ALFISOL**

*Thesis submitted in part fulfillment of the requirement for the degree of
Master of Science (Agriculture) in Soil Science and Agricultural Chemistry to the Tamil
Nadu Agricultural University, Coimbatore.*

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COIMBATORE – 641003
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CERTIFICATE

This is to certify that the thesis entitled “**EFFECT OF ORGANIC MULCHING ON SOIL PROPERTIES, YIELD AND NUTRIENTS UPTAKE OF MAIZE AND GROUNDNUT UNDER RAINFED CONDITION IN AN ALFISOL**” submitted in part fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE) IN SOIL SCIENCE AND AGRICULTURAL CHEMISTRY** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Mr. N. BALAKRISHNAN**, under my supervision and guidance and that no part of the thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that work has not been published in part or full in any scientific or popular journal or magazine.

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ABSTRACT

EFFECT OF ORGANIC MULCHING ON SOIL PROPERTIES, YIELD AND NUTRIENTS UPTAKE OF MAIZE AND GROUNDNUT UNDER RAINFED CONDITION IN AN ALFISOL

By

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Field experiment was conducted at Regional Research Station, Paiyur to assess the effect of organic mulching on yield, uptake of nutrients by maize and groundnut and changes in soil physical properties and nutrient availability pattern. The treatments included maize straw at 5 and 10 t ha⁻¹, sugarcane trash at 5 and 10 t ha⁻¹, raw coirpith at 5 and 10 t ha⁻¹ and dried weed at 5 and 10 t ha⁻¹ and unmulched control, which were replicated thrice in a Randomized Block Design. Growth, yield attributes and yield, plant nutrient contents and uptake and soil hydrothermal regime and fertility status were examined at three stages of crop growth besides quality parameters of groundnut.

In maize, application of raw coir pith at 10 t ha⁻¹ had reduced the bulk density at both layers of soil. All the physical properties other than bulk density and water holding capacity were insignificantly differed with various organic mulches application. Dried weed mulch at 10 t ha⁻¹ (T₉) recorded the highest water holding capacity (11.53 %), while raw coirpith at 10 t ha⁻¹ as surface mulch consistently helped in retaining higher soil moisture content to the tune of 71.2 per cent at 0-15 cm and 41.5 per cent at 15-30 cm at harvest stage over control. Temperature of the soil at two depths was found to be lower under raw coirpith mulch at 10 t ha⁻¹ at all stages of crop growth. The different mulches

and their levels did not produce any significant impact on the pH, EC and organic carbon content of the soil. Available N, P and K status was found to be higher in dried weed mulch at 10 t ha⁻¹ with 31.7, 28.4 and 36.2 per cent increase over control. Application of raw coirpith at 10 t ha⁻¹ (T₇) increased the bacteria and fungi population by 42.0 and 42.9 per cent respectively and dried weed at 10 t ha⁻¹ (T₉) increased the actinomycetes population of the soil by 72.1 per cent at harvest stage.

Yield components were positively influenced by different mulches and their levels. Application of raw coirpith at 10 t ha⁻¹ recorded the highest dry matter production, grain test weight and cob length, ultimately resulting 73.3 per cent increased in grain yield over control. Application of different mulches and their levels showed considerable increase in nutrient content of plants analyzed. Application of sugarcane trash at 10 t ha⁻¹ recorded lower weed population and weed DMP to the tune of 53.7 and 81.5 per cent respectively as compared to unmulched control (100 %).

In groundnut, application of different organic mulches showed insignificant effect on physical properties of soil and numerical variation alone was realized. Moisture content of the soil at two depths was found to be higher in raw coirpith at 10 t ha⁻¹ with 81.5 per cent increase at 0-15 cm and 87.6 per cent increase at 15-30 cm at harvest stage over control. Temperature of the soil at two depths was again lowered by raw coirpith mulch at 10 t ha⁻¹ at all stages of crop growth.

Different mulches with their levels did not produce any significant differences in the pH, EC and organic carbon status of the soil. Available N, P and K status of soil did not show any significant increase with mulch application and however, fairly higher available nutrient status was reflected at all stages of crop growth under mulched treatments.

Application of dried weed mulch at 10 t ha⁻¹ (T₉) had increased the bacteria, fungi and actinomycetes population of the soil. Application of different mulches and their levels positively influenced the biometric characteristics and yield attributes. Dry matter production at all the three stages was found to be higher under raw coirpith mulch at 10 t ha⁻¹.

Raw coirpith at 10 t ha⁻¹ (T₇) recorded significantly higher kernel weight than the other treatments and ultimately resulting in 55.9 per cent increased pod yield over control. No significant build up of oil content, protein content and shelling percentage could be

evidenced due to mulch application. The N, P and K contents in groundnut and uptake were higher in raw coirpith mulch at 10 t ha^{-1} .

Sugarcane trash mulch at 10 t ha^{-1} had recorded much lesser weed population of only 59.0 per cent as against control (100 %). The effect of dried weed mulch at 10 t ha^{-1} in reducing the weed population was also comparable with sugarcane trash mulch.

Based on the results it could be inferred that application of raw coirpith mulch at 10 t ha^{-1} and dried weed mulch at 10 t ha^{-1} along with N, P and K could improve the yield and nutrient uptake by maize and groundnut and sustain the soil fertility with increase in microbial population and soil moisture in rainfed Alfisol.

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LIST OF ABBREVIATIONS

@	-	at the rate of
°C	-	Degree Celsius
%	-	per cent
BD	-	Bulk density
CEC	-	Cation exchange capacity
CFU	-	Colony forming unit
CD	-	Critical Difference
cm	-	centimetre
cmol (P ⁺) kg ⁻¹	-	Centimole Proton per kilogram
DAS	-	days after sowing
DMP	-	Dry matter production
dS m ⁻¹	-	Deci siemens per meter
FC	-	Field capacity
Fig	-	Figure
ha	-	hectare
K	-	Potassium
kg ha ⁻¹	-	kilogram per hectare
N	-	Nitrogen
NS	-	non significant
P	-	Phosphorus
PWP	-	permanent wilting point
r	-	Correlation co- efficient
RBD	-	Randomised block design
SEd	-	Standard error of deviation
SHC	-	Saturated hydraulic conductivity

CHAPTER I

INTRODUCTION

The rainfed agro ecosystem occupies a distinct place in Indian agriculture, as it constitutes nearly 67 per cent of the net sown area contributing 44 per cent of grain production and supporting 40 per cent population. Despite concerted efforts made in the past to improve the productivity of these areas by transferring improved technologies, gains in terms of higher yield and income are still not appreciable. In dryland areas, the environment is often more yield-limiting than even the genetic potential of the crops. Dominant features of rainfall in dryland regions are its limited amount, temporal and spatial variability and unpredictability. There are more years below the mean annual rainfall, with the degree of skewness inversely related to the amount of rainfall and the rainfall distribution is highly irregular. Rainfall intensity is extremely variable even when the amount of rainfall received is relatively low, causing substantial runoff and soil erosion. Hence, the crop management system in rainfed farming must protect the soil resource. Temperature extremes in dryland areas limit the productivity and crops are either dried or permanently injured when critical temperatures exceeded (Balak Ram, 2003).

Soils in the dryland regions of the world range from sandy, shallow, low-fertility to highly productive, medium to fine textured and deep, but the majority of dryland soils have serious problems. Soil characteristics are strongly influenced by the climate in which soils develop, and the interactions of these characteristics with current climatic conditions are a major consideration in understanding the productivity of dryland soils. Restricted biological activity resulting from a suboptimal soil environment would greatly affect the cycling and transformation of nutrients present in the organic form. Biological activity of dryland soils is much lower than the humid zones because of low organic matter levels and periods of extreme dryness. There is also evidence that the organic matter present in dryland soils is chemically and biologically less stable, because there is less biological turnover of organic matter (Wani *et al.*, 2003).

Mulching is one of the promising technologies for dryland farming and is increasingly seen in the light of integrated soil management, an essential building stone for sustainable agriculture. The use of mulch has great agro- ecological potential and it typically conserves the soil, improves the soil ecology, stabilizes and enhances crop yield and provides various environmental services (Lampkin, 1990). Application of organics,

which is an important component in organic mulching improves the soil physical, chemical and biological properties and has direct impact on moisture retention, root growth and nutrient conservation etc. Mulches conserve soil moisture, allow watering less often, keep down weeds, reduce erosion, keep plant roots cool and provide favourable microclimate. Mulch helps in conserving soil moisture loss to the tune of 10 to 25 per cent through evaporation.

In India there is a large quantity of biological and industrial organic wastes such as cattle manure (280 Mt), crop residue (273 Mt), rural compost (285 Mt), city refuse (14 Mt), sewage sludge (1 Mt), pressmud (3 Mt) and coir waste (2.4 Mt) which can be effectively recycled as nutrient sources in organic mulching system and paves way for better soil health and crop production (Subbian *et al.*, 2000). Crop residues contain substantial quantities of plant nutrients and the concentration in oven-dry tissue ranges from 0.58 to 4.0 per cent for N, 0.1 to 1.1 per cent for P, and 0.2 to 3.4 per cent for K. Nitrogen and phosphorus concentrations are generally higher in legumes than in cereals and the beneficial effects of returning crop residue as mulch on crop yield are well known. These benefits are not only due to the recycling of plant nutrients but also due to improvements in soil moisture and temperature regimes, enhancement of soil structure and erosion control. However, the use of crop residues as fertilizers is especially important to resource-poor farmers. The use of crop residues varies from region to region and depends on their calorific values, lignin content, density, palatability and nutritive value. In addition to use of crop residues as fuel and fodder, the residue of some crops is used for thatching, composting, mulching, etc. Maize straw is used to a small extent for thatching, fodder and mulch in the rural areas. The leafy residue of sugarcane is burnt in the field and also used for mulch in many crops. Coirpith is a locally available organic waste and its potential as mulch in many crops has been positively reported.

Maize and groundnut crops are preferred to farmers in the semi- arid lands of Tamil Nadu. The utilization and management of residues, especially in improved crop production under rainfed conditions may prove beneficial.

Maize (*Zea mays* L.) is one of the three most important cereals next to rice and wheat, in the world as well as India. It is one of the most versatile crops and can be grown in diverse environmental conditions and has diversified uses as human food and animal feed. It has got immense potential and is therefore called as “**miracle crop**” and also “**queen of**

cereals". This is one of the world's leading crops cultivated over an area of about 148.5 million hectares with a production of about 699.3 M.t. and productivity of 4.71 tonnes ha⁻¹ (USDA., 2007) and per capita maize grain consumption is 110.2 kg per year (Shochi Ito., 2006). In India, it occupies an area of 7.59 M.ha with the production of 14.71 M.t. and the average productivity is 1938 kg ha⁻¹ (Anonymous, 2007). In Tamil Nadu maize is cultivated in an area of 0.20 M.ha with the production of 0.24 million tonnes and an average productivity of 1189 kg ha⁻¹ (Ministry of Agriculture, Crop Report, 2006 - 07).

Groundnut (*Arachis hypogaea* L.) undisputedly enjoys the pre-eminant position in the oilseed profile of our country and is recognized as the most important commercial oil seed crop. It accounts for nearly one – third of the value of output of all oil seeds grown in our country. India has the highest area under groundnut cultivation in the world with 40 per cent of world's total area and 32 per cent of world's total production. In India it is cultivated in 8 M.ha with the production of 7.9 M.t while in Tamil Nadu it occupies an area of 1.12 M.ha and has a production of 1.85 M.t. Although this crop ranks first in terms of area, its productivity is very low (1,155 kg ha⁻¹) as compared to other groundnut growing countries. In India, Tamil Nadu ranks second in terms of both area and production but tops in productivity (1,650 kg ha⁻¹).

The above two crops have been grown under rainfed condition and the present study was contemplated with the following objectives.

- To study the effect of organic mulches on soil hydrothermal regime, moisture content, physical properties and soil nutrient availability.
- To study the effect of organic mulches on plant growth parameters, yield and weed control under maize and groundnut.
- To study the effect of organic mulches on nutrient content and uptake by crops.

CHAPTER II

REVIEW OF LITERATURE

Excessive use of chemical fertilizers and pesticides in agriculture has come in to severe criticism by the environmentally conscious group who opine that the increase in agricultural production was achieved at the cost of soil health (Mattingly, 1974; Marshall, 1977; Cooke, 1982; Arden-Clarke and Hodges, 1988). The environmental degradation because of faulty agricultural practices has set several experts to focus attention on ecologically sound, viable and sustainable farming system. There has been a series of scientific and policy conferences on this issue (Venkataraman, 1991). One such system that will help to overcome the problems of soil and environmental degradation is “**Organic Mulching**” which aims at co-operating rather than confronting with the nature (Gunjal, 1991). The available literature on organic mulching in relation to crop growth, soil fertility and crop quality are reviewed in this chapter.

2.1. Concept of organic mulching

Organic mulching practices reduce the pressure on land, water and biodiversity without adverse effects on agriculture production and nutritive value of food. Judicious use of organic mulches viz., coirpith, crop residues, etc., integrated with efficient nutrient management practices, cropping systems, conjunctive use of rain, tank and underground water, integrated pest management and conservation of genetic resources will lead to high production. Among them, soil fertility is given top attention, due to its dynamic action with various physical, chemical and biological properties. According to Lampkin (1990), the principle elements to be considered while practicing organic mulching are

- Creating a healthy soil
- Making nutrient and energy flows in the soil ecosystem
- Keeping the biological life in the cycle and
- Providing sustainable yield.

Organic mulching systems relay-upon crop rotations, crop residues, animal manures, legumes, green manures and off farm organic wastes to maintain soil productivity and tilth to supply plant nutrients and control insects and weeds (USDA, 1980).

2.2. Organic mulching and soil health

Addition of any form of organic mulches can be turned into the soil in full, adding important organic matter that enhances the health and structure of soil. Mulch enriches and protects soil, helping to provide a better growing environment for plants by retaining moisture, maintaining even soil temperatures and preventing erosion.

2.2.1. Effect of mulching on soil physical properties

The soil physical properties viz., bulk density, particle density, aggregate stability, water holding capacity, soil aeration are reported to be altered favourably by the addition of organics. Depending upon the nature of organics and the released products, the influence on physical properties varies. The organic residues that are added to the soil undergo microbial decomposition and in this process, various organic acids and other products of decay are released which act as strong binding agents in the formation of large and stable aggregates. Organic mulching improves the physical properties of the soil, decrease the bulk density and increases the water holding capacity, improves the soil aggregation, decreases vulnerability of soil to mechanical damage and increase the soil drainage. It has been well documented that addition of organics like farm and industrial wastes impart good physical soil environment for crop growth.

2.2.1.1. Effect of mulching on bulk density

Muthuvel *et al.* (1982) reported a decrease in the bulk density with increase in organic matter content due to better aggregation. Application of organics had favorable effect on the soil structural properties. Continuous addition of organic mulches brings about a favourable change in the total porosity of soils which in turn influences other physical properties. Similar were the reports of Bhatia and Shukla (1982) and Khani and More (1984).

Application of coirpith mulch to heavy black soil increased the infiltration rate and hydraulic conductivity of the soil (Mayalagu, 1983; Arunachalam, 1984). Neilsen *et al.* (1986) reported that decomposable mulches such as maize straw and sugarcane trash are generally beneficial since these materials reduced the bulk density and the soil temperature than non-mulched soils.

Hogue and Neilsen (1987) concluded that organic mulch was superior to inorganic mulch in permanent orchard vegetation because of increased organic matter, decreased bulk density and improved soil physical properties.

White (1993) reported that there was little effect of mulch treatments on soil bulk density. Bulk density was reduced from 1.3 to 1.2 Mg m⁻³ under straw mulch and it recorded lower bulk density than soil under no mulch.

2.2.1.2. Effect of mulching on infiltration rate, water holding capacity, total porosity and hydraulic conductivity

Mayalagu (1983) reported that incorporation of coir waste @ 12.5 t ha⁻¹ increased the infiltration rate of water into soil from 1.68 (control) to 6.75 cm hour⁻¹. Paddy straw mulch @ 2.5 t ha⁻¹ conserved more moisture, improved water use efficiency on mustard and safflower (Sachan and Bhan, 1986).

Loganathan (1990) also observed that application of FYM and crop residue @ 2.5 and 5 t ha⁻¹ respectively improved the soil physical properties like infiltration rate, total porosity and hydraulic conductivity of red soils. Addition of organic mulches improved the physical properties like infiltration rate, total porosity and hydraulic conductivity of soil with hard pan (Loganathan, 1990). Applications of surface mulch increase the infiltration and reduce runoff thus increases soil water availability or maintain favourable water status for plant growth (Logsdon and Linden, 1992).

Brust (1993) reported that crop residue mulch improved the water infiltration into soil and despite lower bulk density of soils was found in mulched soils compared to unmulched soil. Mandal and Mahapatra (1993) reported that application of rice straw mulch at 7 t ha⁻¹ increased the dry matter accumulation and water use efficiency in lentil and linseed. Dubey and Mandal (1994) also observed that infiltration rate of the soil was greater due to the application of FYM.

Returning crop residues to the soil improves soil quality and productivity through favorable effects on soil properties (Lal and Stewart, 1995). Piccolo (1996) revealed that maintenance of soil quality encompasses a better knowledge of soil organic matter dynamics and effects of organic matter amendments on soil physical stability.

Lourdurai (1997) stated that the composted coirpith application favourably influenced certain soil physical properties viz., infiltration, hydraulic conductivity and moisture holding capacity. Price *et al.* (1998) reported that, under temperate environments, straw mulch intercepted precipitation at a typical rate of 2.6 mm d⁻¹ and the straw mulch was

estimated at 44 per cent of total rainfall. However, the net effect of mulching was small and the heat flux greatly reduced.

Carsky *et al.* (1998) reported that the presence of crop residue mulch at the soil atmosphere interface alters the entire ecology. Favorable effects of residue mulching on soil organic carbon (SOC), water retention and percent water-stable aggregates have been reported for the surface layer (Duiker and Lal, 1999).

Corn stover mulch protects the soil surface from raindrop impact, reduces evaporation, moderates soil thermal properties, enhances biological activity, increases soil organic matter content, recycles nutrients and improves the overall soil structure and quality (Wilhelm *et al.*, 2004).

2.2.1.3. Effect of mulching on soil moisture

The conservation of soil moisture is one of the major advantages of mulch farming system. Mulching protects the soil from water erosion by reducing the rain drop impact. Robinson (1988) reported that mulches have been shown to suppress weed growth, retain soil moisture, improve soil structure, and moderate soil temperatures

A partial covering of mulch residue on the soil will strongly affect the runoff dynamics and reduces the amount of runoff (Findeling *et al.*, 2003; Rees *et al.*, 1999). Straw mulch increases soil moisture storage (Ji *et al.*, 2001).

Residue reduces evaporation of soil water primarily by shading the soil surface. Sunhemp crop residues applied over the soil surface shade the soil serve as a vapour barrier against moisture losses from the soil, slows surface runoff and also increase infiltration rate.

Zhang *et al.* (2005) reported that mulching increased the leaf area index, reduced the soil evaporation rate by 40 to 50 mm and also saved plant water usage for transpiration during dry periods.

2.2.1.4. Effect of mulching on soil temperature

Straw mulch applied at 4 - 6 t ha⁻¹ was effective in improving the soil physical conditions in tropical environments (Lal, 1976) including the protection of top soil. Mulching will reduce the soil temperature for more optimal germination and root development.

Mulches increase the soil temperature since the sun's energy passes through the mulch and heat the air and soil beneath the mulch directly and then the heat is trapped by the "green house effect" (Hu *et al.*, 1995). Cooler spring time day temperature may be maintained below mulch (Riddle *et al.*, 1996), attributed to low thermal conductivity of materials.

Ghosh *et al.* (2002) reported that the wheat straw mulch increased the minimum soil temperature by 2-3 °C recorded at vegetative stage especially during the emergence for early growth periods, while it reduced the maximum soil temperature by 2–4°C during pod development stage of groundnut.

Organic mulches act as insulation by keeping the soil temperatures cool. Duppong *et al.* (2004) stated that crop residues over spread on soil surfaces decreases the soil temperature in hot season and maintain it in autumn.

2.2.1.5. Effect of mulching on soil aggregation

Smika and Greb (1975) reported that under wheat straw mulch, soil aggregation was increased by 5 per cent and fats, waxes and oils in the soil were increased by 0.019 mg g⁻¹ of soil. Soil aggregates are formed by the binding of individual soil particles by substances present in the soil. Fats, waxes and oils serve as soil aggregation binders. Soil aggregation is important for crop establishment, water infiltration and resistance to erosion and compaction and it was influenced by soil organic carbon content. High correlation between aggregate stability and soil organic matter has been reported by Chaney and Swift (1984).

The stability of aggregates is determined by the ability of the cohesive forces between the particles to withstand an applied force (Prove *et al.*, 1990). Getachew *et al.* (1997) reported that direct drilling and stubble retention had positive effects on aggregate size distribution and resistance to abrasion. Aggregation is maintained by the presence of organic matter in the soil (Lynch, 1985). Therefore, changes in soil organic matter content can lead to changes in aggregation (Paustin *et al.*, 1997).

The energy dissipation effect of organic matter helps to reduce aggregate breakdown by raindrop impact. Increased aggregation due to residue application can also be attributed to increase in the fungal and bacterial activity.

Dahiya *et al.* (2003) reported that decreased bulk density and increased insitu saturated hydraulic conductivity was due to increased aggregation from increased soil organic carbon content under mulch treatments and also observed that mulch application significantly decreased the soil electrical conductivity of 0 - 15 cm layer by 6.4 per cent as compared to the unmulched treatment. Higher leaching and lower evaporation under mulches might have contributed towards decrease in upward movement of salt from the lower soil profile under shallow water and resulted in decrease in salt accumulation.

2.2.2. Effect of mulching on soil chemical properties

In addition to improvement in fertility in terms of soil nutrients, increase in cation exchange capacity, buffering capacity etc, are also reported to be improved by the addition of organic mulches.

2.2.2.1. pH

Soil reaction is the most important chemical characteristic of the soil, which affects the nutrient availability to the crop plants. It is also a sensitive property of the soil being influenced by nature and amount of organic manure applied.

Long term effect of organic manure brought about a significant variation in soil pH. Continuous application of chemical fertilizer for seven years lowered the soil pH by 0.1 to 0.2 units, while an increase of 0.1 to 0.7 units over initial value was observed in manured treatments (Grewal *et al.*, 1981).

Srivastava *et al.* (1988) stated that the soil reaction is one of the indices of soil fertility status and were considerably improved by continuous use of FYM either alone or in combination with inorganic fertilizer. Mulch induced pH reduction resulted from the addition or retention of organic matter and organic acids produced from decomposition of plant derived materials accumulating or leaching into the soil (Himelick and Waston, 1990). The soil pH tends towards the acidic range in the early stages of crop growth with the incorporation of certain crop residues and attained neutral at later stages of crop growth (Omar Hattab, 1995).

A field experiment was carried out to study the direct and residual effect of vermicompost and inorganic fertilizers on soil chemical properties (Srikanth *et al.*, 1999). By comparing the different combinations of vermicompost with inorganic fertilizers, the

pH of soil was maintained at neutral condition in the treatment receiving vermicompost and crop residue as mulch.

2.2.2.2 Organic carbon

Soil organic carbon (SOC) is one of the important constituents of soil that determine the soil fertility and productivity. Larson *et al.* (1972) indicated that seven years of residue application had a positive effect on SOC content in the 0–10 cm layer of the soil. Hulugalle *et al.* (1986) reported that the mulch treatments had dramatic effects on soil organic matter, microbial activity and nitrogen cycling that was readily apparent after only one season. The mulches increased the organic matter content of the soil, with the yard waste mulch having the most substantial effect, increasing organic matter content by nearly 40 per cent.

Lamers and Feil (1993) reported that the crop residue application as surface mulch can play an important role in the maintenance of SOC levels and productivity through increasing recycling of mineral nutrients, increasing fertilizer use efficiency and improving soil physical and chemical properties and decreasing soil erosion.

Giller *et al.* (1997) reported that the legume residue as mulching practices that retain organic matter and the embodied nutrients in situ are required to maximize the beneficial effect of improved fallows. Such alternatives to legume removal may include mulching or legume residue incorporation into the soil. Paustian *et al.* (1997) reported that the crop residue returned to the land can increase or maintain SOC content.

Rasse *et al.* (2000) reported that the application of organic residues increase the soil organic matter (SOM) content and can affect soil physical properties. Effects of cropping systems on soil physical properties are often related to increases in soil organic matter.

According to Jacinthe *et al.* (2002), mulching experiments without vegetation cover (e.g. crops, weeds) may be a valuable approach to determine the independent contributions of surface residue mulching to soil structural development and soil organic mulching pools without the masking effects of below-ground plant biomass.

2.2.2.3. Available nitrogen

Nitrogen is a principal plant nutrient element essential for the growth and development of crops. The availability of N in soil is mainly influenced by the organic matter status of soil.

Wade and Sanchez (1983) reported that the composted yard waste and ground wood mulches had widely differing effects on nitrogen cycling. Total soil N was the highest in the yard waste treatment, while the ground wood mulch had no effect on total N. This is not surprising since the yard waste mulch has a relatively high concentration of N (1.91 %) while the ground wood contains very little (0.65 %).

Hulugalle *et al.* (1986) reported that the total nitrogen content of the fallow and cropped soils was increased by mulching. The ammoniacal and nitrate nitrogen of the fallow as well as cropped soils were augmented due to mulch at all the intervals. The favourable influence of mulching in enhancing the production of nitrate particularly in the uncropped soils was noted. It seems that mulching has favourably influenced the nitrifying bacteria.

Giller *et al.* (1997) reported that the legume residue as mulching practices that retain organic matter and the embodied nutrients in situ are required to maximise the beneficial effect of improved fallows. This legume residue mulching practices followed continuing for years improved the available nitrogen in soil.

Aggarwal *et al.* (1997) reported that the incorporation of crop residues increased soil N and P availability. Hundal *et al.* (1998) reported that the sugarcane trash mulch and *in situ* green mulch significantly increased soil available N (0-15 cm) by 7.2 and 16.5 per cent as compared to unmulched during 1997-98 and 1998-99. The results indicated that on an average the mulch treatments increased the available N by 11.9 per cent as compared to unmulched plots during the study period.

Tossah (2000) reported that the similar effects of mulches on soil N availability. The increase in N availability with crop residue as mulching material may encourage the farmers for using crop residue as mulch instead of removal of residue. Merwin *et al.* (1995) reported that hay mulch increased topsoil nitrate (NO₃), potassium (K) and magnesium (Mg) concentrations in apple leaves when compared to herbicide or synthetic mulch-treated soils.

2.2.2.4. Available phosphorus

The availability of P in soil either native or added is limited by one or more mechanism. The organic acids produced during decomposition of organic mulches influenced by soil pH, form stable complexes or chelates with cations which are responsible for P fixation and thus increasing the availability (Tiwari *et al.*, 1980).

Hulugalle *et al.* (1986) reported that the available phosphorus content in fallow and cropped soils due to mulch during second and third interval of sampling in both the trials increased. In the third sampling, it increased by 15.3 per cent in both the cases in maize trial and by 15.5 and 21.9 per cent in fallow and cropped soil in *moong* trial due to mulching. The greater phosphorus availability by mulching may be attributed to increased activity of phosphorus solubilizing bacteria and fungi in soil. The second reason may be that mulching tends to increase the downward movement of phosphorus and decreased the amount of phosphorus fixed by the soil.

Hundal *et al.* (1998) reported that the incorporation of crop residues such as green manure (*Sesbania aculeata*) increased the availability of added and native P. The increase in P availability had been described due to mineralization of green manuring material, chelation of Ca in alkaline soil and Al in acid soils and due to accumulation of organic acids produced during decomposition of green manuring materials. The information regarding effect of green manure (*Sesbania aculeata*) as mulching material on the availability of native and added P is scanty.

Adeoye (1990) reported that the application of sugarcane trash mulch (SM) and 'in situ' green mulch (IGM) significantly increased soil available P (0-15 cm) by 8.3 and 23.8 per cent as compared to unmulched plots. Aggarwal *et al.* (1997) reported that the incorporation of crop residues increased the soil N and P availability.

2.2.2.5. Available potassium

Mineralogical characters of soil, nature of weathering and various physicochemical reactions that are occurring in soil influence the K status of soil and its availability to the plant. The availability of K in soil is also influenced by the various sources of organic mulches.

Singh *et al.* (1980) reported that continuous application of composted residues had resulted in a buildup of available K in sandy loam soil. Recycling of organic wastes like maize straw and other crops residues were reported to be useful in increasing the organic carbon and other plant nutrients in the soil (Ravikumar and Krishnamoorthy, 1983).

Moldenhauer *et al.* (1994) found that crop residue mulching altering nutrient availability and fertilizer use efficiency. The retention of the crop residues as mulch affects the release, immobilization and loss of nutrients. Suresh *et al.* (1995) observed that an increase in soil available K due to application of organic manure along with biofertilizers.

Saravanan and Baskar (1997) observed that the incorporation of coirpith into the potting medium increased the available K status of the soil. Srinivasan Rao *et al.* (1997) studied the K availability and noticed that considerable increase in the potassium extracted from earth worm castes over non-ingested soils due to the application of mulches. Quansah *et al.* (1997) found that mulching may imply changes in nutrient management by altering nutrient availability and fertilizer use efficiency. Incorporation of organic substances could increase the micro-nutrient concentration in soil depending upon their supply of reducing and chelating substances.

Rees *et al.* (2002) reported that mulching at rates as low as 2.25 Mg ha⁻¹ reduced nutrient losses of NO₃-N and available P, K, Ca and Mg. Duraisami and Mani (2000) reported that the application of coirpith improved the available K and enhanced potassium uptake by maize.

2.2.3. Effect of mulching on biological properties

The beneficial soil biochemical reactions mediated by enzymes are associated with soil microbes. Favourable influence on these activities by addition of organics is documented by many workers. The most important role played by organics on soil microflora depends mainly on organic substrates. All the reactions in soil, particularly the nutrient transformation depend mainly on soil organic matter. The use of organics in any ecofriendly farming will result in favourable soil biological properties. The soil enzymes, again by soil microbes and their reactions are mainly altered by organic matter content of the soil and were better taken care of by organic mulching.

Mccalla (1965) reported that bacteria, actinomycetes, fungi, earthworm and nematode populations were greater under stubble mulch than under conventional tillage. Lynch (1985) observed that the plate counts of bacteria and biomass were the highest in mulched soil as compared to the fertilized soil.

Organic mulch adds nutrients to soil when decomposed by microbes and help in carbon sequestration (Ning and Hu, 1990). Kamelesh Kukreja *et al.* (1991) reported that continuous application of organic mulches increased the total microbial biomass in the soil. They also reported that the enzyme dehydrogenase activity was increased with mulch treatment than the other treatments.

Karlen *et al.* (1994) reported that crop residue mulch improved soil quality in terms of organic carbon and biotic activity. Singaram and Kamalakumari (1995) concluded that activities of six soil enzymes related to carbon (amylase and cellulase) nitrogen (dehydrogenase and urease), phosphorus cycling (phosphatase and phosphorylase) and catalase were found to be maximum in the treatment that included organic manures.

Hartley *et al.* (1996) observed that sawdust mulch did not affect the size of the microbial biomass in an apple cropping system. Larsson *et al.* (1997) reported that wood chip mulch induced N deficiency in black soil while increasing the respiratory quotient but not size of the soil microbial biomass. Little is known concerning with the effects of the continuous presence of organic materials on the soil surface (i.e. mulches) on biological activity and nutrient availability in the root zone of perennial crops. Gaillard *et al.* (1999) reported that the presence of residue particles leads to strong gradients of residue-derived C, residue and soil-N, microbial biomass and enzymatic activities. The report of a crop residue mulching revealed that soil microbial biomass, respiration and dehydrogenase activity were 100 times higher than the conventional farming (Carpenter *et al.*, 2000).

Dominy and Haynes, (2002) reported that crop residue location and/or distribution pre-determines gradients in the organic matter content of the soil, in the decomposing microbial biomass and their activity

2.3. Effect of different organic mulches on growth and yield of maize, groundnut and other crops

The growth and yield of many crops are found to be improved by the addition of organics (crop residues), their quantum of application and nature of organics. The reason in most cases attributed was their influence on soil fertility. The response to organics in various crops reported to be varying, in many cases the yields were equal to that of conventional farming and in certain instances the organics gave better outputs than conventional farming. Durai (1983) reported that groundnut yield was increased from 1638 to 4123 kg ha⁻¹ by the application of coirpith mulch 10 t ha⁻¹. The studies on the response of coirpith application (20 - 60 t ha⁻¹) revealed improvement in yields of spinach, cabbage, turnip in summer and onion in winter (Ito, 1991).

Studies conducted at Barnashakti foundation, Indonesia revealed that yields of Chinese cabbage, carrot and groundnut were more under organic mulching practices as

compared to without mulching (Anonymous, 1992). Trivedi *et al.* (1994) reported that application of sugarcane trash mulch significantly increased the growth and yield parameters (in maize). Besides, the consumptive use of water was decreased by 18.4 per cent and the grain yield was increased by 15.06 per cent over control. Straw mulching @ 10 t ha⁻¹ increased the groundnut pod yield by 56 and 27 per cent respectively in two successive years.

The pod yield in groundnut was reported to have been increased significantly by 26 per cent due to mulching with groundnut shells @ 5 t ha⁻¹. The haulm yield was also increased by 17 per cent due to mulching (Yellamanda Reddy, 1995). Aruna Rajagopal *et al.* (1995) reported that application of coirwaste @ 15 t ha⁻¹ in groundnut resulted in increased plant height, leaf area index, dry matter production and higher pod yield.

2.4. Effect of mulching on nutrient content in plants

The total nutrient contents in maize and groundnut were influenced by the organic mulch application. Foss (1989) found that macadamia trees mulched with macadamia husks increased the leaf K concentrations as mulch depth increased. Gupta (1991) reported that various tree species had increased plant K concentrations when grown with a surface mulch of coirpith, a coconut by product. Marschner (1995) revealed that higher K content and uptake in mulched plots in comparison with unmulched plots. Growth of young pecan trees is substantially enhanced by mulching and increased the total nutrient concentrations (Foshee *et al.*, 1996). ‘Desirable pecan’ trees are sensitive to nutrient imbalances (Sparks, 1997), especially to nitrogen-potassium imbalance with application of organic mulching.

The higher doses of mulch increased the concentration of N in plant tissues and also the total herbage yield, which ultimately led to the increased uptake of N. The N content in the maize was also influenced due to decomposition of organic mulch (Mutuo *et al.*, 1999). A significant response to N was observed with 160 kg ha⁻¹ N in mulched plot over the same level of N in the unmulched plot.

2.5. Effect of mulching on nutrient uptake

Mulch significantly influenced the nitrogen, phosphorous and potassium uptake in maize and groundnut crops. Yastass (1971) reported that the integrated effect of moderation of hydrothermal regime and root growth was reflected in higher uptake of N, P and K in mulched plots in comparison with unmulched control. A significant response to N was observed with 160 kg ha⁻¹ N in mulched plot over the same level of N in the

unmulched plot. Using paddy straw mulch, nitrogen uptake by plants of planted and regenerated crops was increased by 33 per cent and 28.4 per cent, respectively, over the unmulched control (Mutuo *et al.*, 1999).

Duraisami and Mani (2000) reported that the enhanced uptake of phosphorous in coirpith applied plot might have been contributed by better root growth, reduced phosphorous fixation besides chelating and complexing action of organic anions and hydroxyl acids liberated from the decomposing organic mulches (Dhakshinamoorthy, 1991). With advancement of crop growth, the nitrogen, phosphorous and potassium uptake increased due to enhanced dry matter production. Duraisami and Mani (2000) reported that the application of coirpith improved the available K and enhanced potassium uptake by maize.

Ram *et al.* (2003) observed that the moderation of the hydro thermal regime with mulch treatment enhanced the root growth which would facilitate better nutrient uptake from the soil. The nutrient uptake was higher in the treatment that received crop residue as surface mulch. This might be due to higher root growth and it makes possible for the plant absorb soil water and nutrients from the soil (Mulumba and Lal, 2008).

2.6. Effect of mulching on weed control

The weeds in maize and groundnut may cause considerable yield losses depending upon the weed flora. Knowledge about the weed spectrum in maize and groundnut field is essential for the formulation of effective weed control practices.

In maize and groundnut all categories of weeds (grasses, sedges and broad leaved weeds) damage the crop. The major weed flora reported in Tamil Nadu by various workers are summarized in Table1.

Weeds remain one of the most significant agronomic problems, especially on organic forms, because weed control can only be carried out without herbicides. There is a strong interest in developing alternative methods of weed control in organic agriculture (Economou *et al.*, 2002). Mulching as weed control method is used in agriculture throughout the world (Gupta, 1991). Residue of small grains has been shown to inhibit weed emergence and growth in cropping system by allelopathy (Blum *et al.*, 1997). Since weed seed germination is affected by soil moisture and temperature, mulch not only suppresses weeds, but also maintains soil moisture at higher levels compared with unmulched soil (Edwards *et al.*, 2000).

Organic mulches are more popular in cropping systems, as they can suppress weeds, while at the same time reducing soil tillage for weed control under any tillage system implemented (Bilalis *et al.*, 2003).

Jodaugiene *et al.* (2006) reported that wood chips have longest impending effect on weed germination and the plots that have been mulched with wood chips at the beginning of summer; weed biomass was established to be 5.4 to 11.4 times lower than that in the plots without mulching. Peat straw and chopped grass provides different reducing impact on weed germination. Straw mulch has the most obvious reducing impact (3.5-14.1 times) on weed emergence.

Table 1. Common weed flora of the experimental fields of maize and groundnut

Botanical name	Common / Local name	Family	Habit
A. Grasses			
1. <i>Cynodon dactylon</i> (L) Pers	Arugampul	Poaceae	Perennial
2. <i>Dactyloctenium aegyptium</i> . Beauv	Crow foot grass	Poaceae	Annual
3. <i>Echinochloa colonum</i> (L) Link	Jungle rice	Poaceae	Annual
4. <i>Eleusine indica</i> (Linn)	Guase grass	Poaceae	Perennial
5. <i>Panicum repens</i> (Linn)	Torpedo grass	Poaceae	Perennial
B. Sedges			
1. <i>Cyperus rotundus</i> (Linn)	Purple nut sedge	Cyperaceae	Perennial
C. Broad leaved weeds			
1. <i>Abutilon theophrastis</i> Medic	Velvet leaf	Malvaceae	Perennial
2. <i>Acalypha indica</i> (Linn)	Kuppai meni	Euphorbiaceae	Annual
3. <i>Boerhaavia diffusa</i> (Linn)	Spreading-hug weed	Nactaginaceae	Annual
4. <i>Cleome viscosa</i> (Linn)	Wild mustard	Capparidaceae	Annual

5. <i>Commelina benghalensis</i> (Linn)	Kanan keera	Commelinaceae	Perennial
6. <i>Datura metal</i> (Linn)	Oomatai	Solonaceae	Annual
7. <i>Digera arvensis</i> Forsk.	Thoyya keera	Amaranthaceae	Annual
8. <i>Parthenium hystero</i> phorus L.	Carrot grass	Asteraceae	Annual
9. <i>Trianthema portulacastrum</i> (Linn)	Horse pursulane	Aizoaceae	Annual

CHAPTER III

MATERIALS AND METHODS

Field experiments were conducted during 2007 at Regional Research Station (RRS), Paiyur, Krishnagiri district, to study the influence of different organic mulch sources viz., maize straw, sugarcane trash, raw coir pith and dried weeds (before flowering) on yield and nutrient uptake of maize and groundnut and soil fertility under rainfed condition. The details of the experiments, materials used and the methods followed are detailed in this chapter.

3.1. Materials

3.1.1. Field location

Field experiments were conducted in field No. H 26 in Regional Research Station (RRS), Paiyur, Krishnagiri district. The altitude of the location is 490 m above MSL and is situated in 78°1'13'' E longitude and 12°22'36'' N latitude.

3.1.2. Climate and weather

The mean annual rainfall of RRS, Paiyur is 840 mm distributed over 51 rainy days. The annual minimum and maximum temperature are 26.2 and 33.5 °C respectively. The meteorological data viz., maximum and minimum temperatures, rainfall and relative humidity recorded in the RRS farm during the crop growth period are presented in Annexure 1.

3.1.3. Crop and variety

The crops selected for the field experiments were maize COHM-5 a hybrid and groundnut (TMV-7), a variety and bunchy type.

3.1.4. Mulches

Maize straw, sugarcane trashes, raw coirpith and dried weeds (before flowering) were collected from different sources and used in the experiments. The details of nutrient contents are presented in Table 4.

3.2. Methods

3.2.1. Experimental details

The layout plans of the maize and groundnut experiments are given in Fig.1 and 2, respectively. The experimental details are furnished below.

Particulars	Maize	Groundnut
Season	Rabi	Rabi
Variety	COHM 5	TMV 7
Date of sowing	16.09.2007	16.09.2007
Date of harvest	06.01.2008	26.12.2007

Plot size : 5 m x 4 m

Spacing : 45 cm x 20 cm for maize and 30 cm x 10 cm for groundnut

3.2.2. Treatment details

The field experiments were laid out in randomized block design with three replications. There were totally nine treatments and are detailed below

T₁- Control

T₂ - Maize straw mulch @ 5 t ha⁻¹

T₃ - Maize straw mulch @ 10 t ha⁻¹

T₄-Sugarcane trash mulch @ 5 t ha⁻¹

T₅ - Sugarcane trash mulch @ 10 t ha⁻¹

T₆ - Raw coirpith mulch @ 5 t ha⁻¹

T₇ - Raw coirpith mulch @ 10 t ha⁻¹

T₈ - Dried weeds*(before flowering) mulch @ 5 t ha⁻¹

T₉ - Dried weeds* (before flowering) mulch @ 10 t ha⁻¹

(* The names of the weeds are given in Table1)

3.2.3. Crop management

3.2.3.1. Field preparation

The field was properly ploughed with disc and cultivator ploughs. After ploughing, the field was levelled and flat beds were formed.

3.2.3.2. Seed and sowing

The maize seeds were obtained from the Department of millets, TNAU and groundnut seeds were obtained from Agricultural Extension Centre at Madukkur in Coimbatore. The recommended seed rate of 25 kg ha⁻¹ for maize and 120 kg ha⁻¹ for groundnut under rainfed condition was followed.

3.2.3.3. Gap filling and thinning

Gap filling was done at 7 DAS and thinning of plants was carried out on 15 DAS for maize and for groundnut, gap filling was done on 8 DAS to maintain uniform population per unit area.

3.2.3.4. Fertilization

The recommended doses of 60, 30, 30 kg of N, P_2O_5 and K_2O respectively were applied for maize. Half of the nitrogen in the form of urea, half of the potassium in the form of muriate of potash and full dose of phosphorus in the form of single super phosphate were applied basally. The remaining half of the nitrogen and half of the potassium were applied as top dressing on 45th day after sowing.

For groundnut, recommended doses of 10, 10, 45 kg of N, P_2O_5 and K_2O , respectively were followed. Half of the nitrogen in the form of urea, half of the potassium in the form of muriate of potash and full dose of phosphorus in the form of single super phosphate were applied basally. The remaining half of the nitrogen and half of the potassium were top dressed on 45th day after sowing.

3.2.3.5. Application of mulches

The mulches selected for the study were spread at the calculated quantities on the 10th day after sowing on the soil surface in between the rows of maize and groundnut.

3.2.4. Biometric observations

3.2.4.1. Growth and yield attributes of maize

3.2.4.1.1. Plant height

The plant height was measured from the fixed point i.e., from the ground level to the growing tip of the main stem at different stages and expressed in cm.

3.2.4.1.2. Length of the cob

The length of the cob at its maximum girth was measured. Mean for the five cobs worked out and expressed in cm.

3.2.4.1.3. Number of grain rows per cob

The number of grain rows from five cobs at final harvest was counted and average worked out and recorded.

3.2.4.1.4. Number of grains per row

The number of grains per row at final harvest was counted and recorded.

3.2.4.1.5. Hundred grain weight

A sample of one hundred grains was taken from the sample plants and the weight was recorded in gram.

3.2.4.1.6. Dry matter production (DMP)

Five plants were selected in each plot for each stage and uprooted at knee- high and tasseling stages. The samples were initially air dried in shade and later in an oven at 65°C till the samples become moisture free. Their weights were recorded on moisture free basis and computed to kg ha⁻¹.

3.2.4.2. Growth and yield attributes of groundnut

3.2.4.2.1. Number of matured pods per plant

The number of matured pods from five plants at final harvest was counted and average values recorded.

3.2.4.2.2. Number of immature pods per plant

The number of immature pods from five plants at final harvest was counted and average worked out and recorded

3.2.4.2.3. Number of pods per plant

The number of pods from five plants at final harvest was counted and average values recorded

3.2.4.2.4. Kernels test weight

A sample of one hundred kernel was taken from the sample plants and the weight was recorded in gram.

3.2.4.2.5. Dry matter production

The plants used for growth measurements at vegetative and peg initiation stages were dried at 65°C in a hot air oven, weighed and expressed in kg ha⁻¹

3.2.4.3. Observation on weeds

3.2.4.3.1. Weed count

The weed count was taken using a quadrat and was collected at three stages of crop growth, viz., for maize knee high, tasseling and harvest stages and for groundnut at vegetative, peg initiation and harvest. The weed count was expressed in number per m².

3.2.4.3.2. Weed dry matter production (DMP)

The weeds present within the randomly placed quadrat were uprooted and were collected at three stages of crop growth, viz., for maize knee high, tasseling and harvest and for groundnut at vegetative, peg initiation and harvest stages, shade dried and then dried in the hot air oven at 65°C. The dry weight of the weeds was computed and expressed in kg ha⁻¹.

3.2.4.4. Yield

The plot yield of maize (grain and stover) and groundnut (pod and haulm) were recorded and converted to hectare area.

3.2.5. Quality parameters

3.2.5.1. Kernel oil content

The oil content of the groundnut kernels from each treatment was determined using Nuclear Magnetic Resonance (NMR) analyzer and expressed in percentage.

3.2.5.2. Protein content

The total N content of kernel sample was estimated by microkjeldhal method (Humphries, 1956) and the content of N was multiplied by the factor 6.25 to obtain the protein content and expressed in per cent.

3.2.6. Collection, processing and analysis of soil and plant samples

3.2.6.1. Initial soil analysis

Composite soil sample was collected from the field prior to the application of fertilizers for assessing the initial soil characteristics. The sampling was also done at critical growth stages for the two crops. The collected sample was air dried, powdered with a wooden mallet, sieved through 2 mm sieve and stored in polythene bags for analysis. The methods adopted in the analysis of soil samples are presented in Table 2.

Table 2. Analytical methods employed in initial soil analysis

Estimation	Method	Reference
Physical Properties		
1. Textural fractions	International pipette method	Piper (1966)
2. Bulk density	Core method	Gupta and Dakshinamoorthi (1981)

Estimation		Method	Reference
3.	Particle density	Core method	Gupta and Dakshinamoorthi (1981)
4.	Water holding capacity	Pressure plate apparatus method	Richards (1954)
5.	Per cent pore space	Pressure plate apparatus method	Richards (1954)
Physico chemical properties			
1.	Soil reaction (pH)	Potentiometry : soil-water suspension of 1: 2 ratio	Jackson (1973)
2.	Electrical Conductivity (EC)	Conductometry : soil-water suspension of 1:2 ratio	Jackson (1973)
3.	Cation Exchange Capacity (CEC)	Neutral Normal ammonium acetate method	Chapman (1965)
Chemical properties			
1.	Moisture	Gravimetric method	A.O.A.C. (1962)
2.	Loss on ignition	Gravimetric method	A.O.A.C. (1962)
3.	Sesquioxides	Gravimetric method	Piper (1966)
4.	Iron and Aluminum	Volumetric method	Piper (1966)
5.	Organic Carbon	Chromic acid wet digestion method	Walkley and Black (1934)
6.	Total Nitrogen	Macrokjeldhal method	Jackson (1973)
7.	Total Phosphorus	Pemberton method	Pemberton (1945)
8.	Total Potassium	Flame photometry	Jackson (1973)
9.	Available Nitrogen	Alkaline permanganate method	Subbiah and Asija (1956)
10.	Available Phosphorus	Colorimetry method	Olsen <i>et al.</i> (1954)
11.	Available Potassium	Neutral Normal NH ₄ OAc method	Stanford and English (1949)
12.	Total Calcium	Versanate titration in HCl extract	Jackson (1973)
13.	Total Magnesium	Versanate titration in HCl extract	Jackson (1973)
14.	Exchangeable calcium	Extraction with Neutral Normal ammonium acetate	Jackson (1973)
15.	Exchangeable magnesium	Extraction with Neutral Normal ammonium acetate	Jackson (1973)

Estimation	Method	Reference
16. Available Fe, Mn, Zn and Cu	DTPA extraction Atomic Absorption Spectrophotometer	Lindsay and Norvell (1978)

3.2.6.2. Plant analysis

Plant samples were collected at the three stages of crop growth, viz., for maize 30 DAS (knee high), 60 DAS (tasseling) and 90 DAS (harvest) and for groundnut at vegetative, pegging and harvest and dried in shade then in air oven at 65°C for maize and 65°C for groundnut and ground in a Willy mill using stainless steel grinder, and stored in labelled containers for chemical analysis.

Estimation	Method	Reference
I. Plant analysis		
1. Nitrogen	Microkjeldhal method of distillation in diacid extract	Humphries (1956)
2. Phosphorus	Vanadomolybdate yellow colour method in triple acid extract	Piper (1966)
3. Potassium	Flame photometer in triple acid extract	Piper (1966)
II. Mulches		
1. Nitrogen	Microkjeldhal method in diacid extract	Humphries (1956)
2. Phosphorus	Vanadomolybdate yellow colour method in triple acid extract	Piper (1966)
3. Potassium	Flame photometer in triple acid extract	Jackson (1973)
4. Organic Carbon	Chromic acid wet digestion method	Walkley and Black (1934)

3.2.6.3. Uptake of nutrients

The content of nutrients in the plant samples was estimated using standard procedures and expressed as percentage on oven dry basis. The total uptake at different stages were worked out by multiplying the nutrient content with dry matter production and expressed in kg ha⁻¹

3.2.7. Biological Properties

3.2.7.1. Microbial count

Ten gram of soil samples were diluted serially by transferring in 250 ml Erlenmeyer flask containing 90 ml of sterile distilled water and the contents were shaken in a rotary shaker for 10 min. Using sterile pipette, 10 ml of the suspension was transferred to 90 ml of sterile water and like wise serial dilution and were continued using sterile distilled water till 10^{-3} , 10^{-4} , 10^{-5} and 10^{-6} were obtained. Aliquots of 1 ml of appropriate dilution were plated. The total bacteria were enumerated in nutrient agar, fungi in Martins Rose Bengal agar and actinomycetes in Ken Knights agar medium. The composition of the plating media are furnished below:

Nutrient agar (Rangaswami, 1966)

Glucose	-	5.0 g
Peptone	-	5.0 g
NaCl	-	5.0 g
Beef extract	-	3.0 g
Agar	-	15.0 g
Tap water	-	1000 ml
pH	-	7.0

Martin and Rose Bengal agar (Martin, 1950)

Glucose	-	10.0 g
Peptone	-	5.0 g
KH ₂ PO ₄	-	1.0 g
Rose Bengal	-	0.035 g
Agar	-	15.0 g
pH	-	6.8 – 7.0
Distilled water-		1000 ml

Three millilitres of 1 per cent solution of streptomycin sulphate prepared in sterile distilled water was added to the medium aseptically just prior to plating.

Ken Knight's agar (Allen, 1953)

Dextrose	-	1.0 g
K ₂ HPO ₄	-	0.1 g
NaNO ₃	-	0.1 g
KCl	-	0.1 g

MgSO ₄	-	0.1 g
Agar	-	5.0 g
Distilled water	-	1000 ml

The plates were incubated at room temperature (30-32°C) and counts were made after 3 days for bacteria, 3-5 days for fungi and 7 days for actinomycetes. The moisture content of soil was determined in a representative sample and the populations were expressed on oven dry basis.

3.3. Meteorological parameters

3.3.1. Soil temperature

Soil temperature was measured in each treatment at depths of 0-15 and 15-30 cm. Readings were taken with mercury in glass thermometers which were placed between the rows and soil temperature measurements were made between 12:22 hrs and 12:45 hrs.

3.4. Quantification trial for mulches

The quantity of organic mulch to be applied was derived from the trial plot of one square feet. Organic mulch with 3.2 per cent moisture content was spread to the thickness of 1 inch (2.5 cm) in the 1square feet plot and the quantity was found to be 0.56 kg. From the derived value, quantity of mulch to be applied for 1 inch (2.5 cm) thickness of 20 m² plot was calculated as 10 kg (5 t ha⁻¹). Similarly the quantity of mulch needed for 2 inches (5 cm) thickness was calculated to be 20 kg (10 t ha⁻¹).

Quantification trial for mulches was conducted and quantity of mulches were calculated using the formula suggested by Adetola Badejo *et al.* (1995)

Quantity of mulch = l x b x h

Where

l = length

b = width

h = depth of mulches

Quantity of mulch value was expressed as cubic feet and the weight was derived.

3.5. Statistical analysis

The data obtained from this investigation were subjected to statistical scrutiny to determine the effects due to treatments. Simple correlations were also worked out to determine the possible relationships as described by Panse and Sukhatme (1967).

CHAPTER IV

EXPERIMENTAL RESULTS

The results emanated from the field experiment and laboratory investigation to study the influence of different organic mulches on the yield, nutrient uptake, soil physical properties, nutrient availability and biological properties under maize and groundnut are presented in this chapter.

4.1. Initial soil analysis

4.1.1. Soil sample (Table 3)

A composite surface soil sample collected from the experimental field before the commencement of the experiment was analyzed for important physical and chemical properties. The experimental soil analysed for mechanical composition indicated that it belonged to sandy clay loam texture with 21.3 per cent clay, 14.7 per cent silt and 63.7 per cent sand. The per cent pore space was found to be 51.7. Bulk density and particle density of the soil were 1.32 and 2.81 Mg m⁻³ respectively.

The soil was slightly alkaline in reaction with a pH of 8.23 and electrical conductivity of 0.13 dSm⁻¹ and moderate CEC (18.2 C mol (P⁺) kg⁻¹). Chemical analysis for available major nutrients revealed that the soil was low in nitrogen (140.5 kg ha⁻¹), low in P (10.33 kg ha⁻¹) and high in K (385.5 kg ha⁻¹) with low organic carbon content (0.43 per cent). The available micronutrient status in Zn and Cu were at sufficiency levels and Mn and Fe were at deficiency levels.

The soil belonged to the Vannapatti series (fine, mixed and isohypothermic moderately deep, well drained, red, fine loamy, moderately structured, non-calcareous with quartz gravels present in sub soil) and grouped under soil order Alfisol (*Typic Ustropept*)

4.1.2. Organic mulches (Table 4)

The dried weeds showed relatively higher nutrient contents (0.98, 0.31 and 0.88 per cent N, P and K) as compared to raw coirpith, maize stover and sugarcane trash. The C: N ratio was found to be wider in coirpith (412:1) as compared to 45:1 in dried weeds.

A. MAIZE

4.2. Effect of organic mulches on soil physical properties

Soil samples collected at post harvest stage was subjected to the determination of physical properties such as bulk density, total porosity, capillary porosity, non capillary porosity, saturated hydraulic conductivity, field capacity, permanent wilting point and water holding capacity.

4.2.1. Bulk density (0-15 cm) (Table 5)

Application of different organic mulches had significant effect on bulk density of soil at surface. Among different treatments, the raw coir pith mulch at 10 t ha⁻¹ (T₇) and 5 t ha⁻¹ had reduced the bulk density (1.33 Mg m⁻³) and were on par but significantly varied from dried weeds at 5 t ha⁻¹ (T₈), dried weeds at 10 t ha⁻¹ (T₉) and sugarcane trash at 10 t ha⁻¹ (T₅). The treatment T₄ (sugarcane trash at 5 t ha⁻¹) moderately maintained the bulk density (1.36 Mg m⁻³) which was on par with T₂ (maize straw mulch at 5 t ha⁻¹) and T₃ (maize straw at 10 t ha⁻¹). Control recorded the highest bulk density (1.40 Mg m⁻³) which was inferior to T₂ (maize straw at 5 t ha⁻¹).

4.2.2. Bulk density (15 -30 cm) (Table 5)

Application of different organic mulches had significant effect on bulk density of soil at 15-30 cm. Among different treatments, application of raw coir pith at 10 t ha⁻¹ (T₇) had reduced the bulk density (1.42 Mg m⁻³) which was on par with raw coir pith at 5 t ha⁻¹ (T₆), dried weeds at 10 t ha⁻¹ (T₉), dried weeds at 5 t ha⁻¹ (T₈) and sugarcane trash at 10 t ha⁻¹ (T₅). The treatment T₄ (sugarcane trash at 5 t ha⁻¹) maintained higher bulk density (1.46 Mg m⁻³) which was on par with T₂ (maize straw at 5 t ha⁻¹) and T₃ (maize straw mulch at 10 t ha⁻¹). Control recorded the highest bulk density (1.49 Mg m⁻³) over other treatments. In general the bulk density was comparatively higher in 15-30 cm layer over 0-15 cm layer irrespective of treatments.

4.2.3. Saturated hydraulic conductivity (Table 6)

Saturated hydraulic conductivity of soil insignificantly varied with different organic mulches application. The lowest hydraulic conductivity was accounted (5.06 cm h⁻¹) by control (T₁), which was followed by maize straw at 5 t ha⁻¹ (T₂), maize straw mulch at 10 t ha⁻¹ (T₃) and sugarcane trash at 5 t ha⁻¹ (T₄) with values of 5.08, 5.10, 5.14 cm h⁻¹ respectively. The treatment which had received raw coir pith at 10 t ha⁻¹ (T₇) recorded (5.34 cm h⁻¹) the

highest hydraulic conductivity which was followed by sugarcane trash at 10 t ha⁻¹ (T₅), raw coir pith at 5 t ha⁻¹ (T₆), dried weeds at 5 t ha⁻¹ (T₈) and dried weeds at 10 t ha⁻¹ (T₉) with values of 5.26, 5.30, 5.30 and 5.32 cm h⁻¹ respectively. The treatments T₂, T₃ and T₄ recorded lower hydraulic conductivity of 5.08, 5.10 and 5.14 cm h⁻¹ respectively. However, it was marginally higher than control and the effect was not significant.

4.2.4. Total porosity (Table 6)

Numerically higher total porosity (44.9%) was recorded by sugarcane trash mulch at 5 t ha⁻¹ (T₄), sugarcane trash mulch at 10 t ha⁻¹ (T₅), raw coir pith at 5 t ha⁻¹ (T₆), raw coir pith at 10 t ha⁻¹ (T₇) and dried weeds at 10 t ha⁻¹ (T₉). The lowest per cent pore space (44.8 %) was recorded in control (T₁), which was followed by maize straw at 5 t ha⁻¹ (T₂), maize straw at 10 t ha⁻¹ (T₃) and dried weeds at 5 t ha⁻¹ (T₈). The application of mulches with different levels did not produce any significant impact on the total porosity of the soil.

4.2.5. Capillary porosity (Table 6)

Application of different organic mulches had insignificant performance with capillary porosity of soil. The capillary porosity ranged from 34.1 to 34.4 per cent. Higher capillary porosity of 34.4 per cent was recorded under dried weeds mulch at 10 t ha⁻¹ (T₉), raw coir pith at 5 t ha⁻¹ (T₆) and raw coir pith at 10 t ha⁻¹ (T₇).

4.2.6. Non capillary porosity (Table 6)

Non capillary porosity of soil showed marginal variations among different organic mulches tried. The non capillary porosity ranged from 12.9 to 13.2 per cent. Higher non capillary porosity of 13.2 per cent was recorded in dried weeds at 10 t ha⁻¹ (T₉) followed by dried weeds at 5 t ha⁻¹ (13.1 %). However, the effects were found to be non significant.

4.2.7. Field capacity (Table 7)

The application of different organic mulches had no significant influence on the field capacity of the soil and the values varied from 23.43 to 25.15 per cent and the value being recorded in raw coir pith at 10 t ha⁻¹ (T₇) followed by sugarcane trash at 10 t ha⁻¹ (T₅), dried weeds at 10 t ha⁻¹ (T₉), raw coir pith at 5 t ha⁻¹ (T₆) and dried weeds at 5 t ha⁻¹ (T₈). Lower field capacity of the soil was recorded in control (23.43 %).

4.2.8. Permanent wilting point (Table 7)

Permanent wilting point of the soil was not influenced significantly by different organic mulches application. The value of permanent wilting point ranged from 12.92 to 13.70 per cent and higher value being recorded by raw coir pith mulch 10 t ha^{-1} treatment which was followed by sugarcane trash at 10 t ha^{-1} (13.61 %), maize straw at 10 t ha^{-1} (T_3) (13.56 %) and sugarcane trash at 5 t ha^{-1} (13.40 %). Lowest permanent wilting point of the soil was recorded in control (12.92 %).

4.2.9. Water holding capacity (Table 7)

The water holding capacity of soil was conspicuously increased with various mulch treatments. Among the different mulches, application of dried weeds at 10 t ha^{-1} (T_9) recorded the highest water holding capacity (11.53 %) which was found to be on par with T_6 , T_5 , T_7 and T_8 and were significantly superior over rest of the treatments. The lowest water holding capacity (10.12 %) was registered in sugarcane trash mulch at 5 t ha^{-1} (T_4) which was on par with T_2 , T_3 and T_1 .

4.2.10. Moisture content (0-15 cm) (Table 8)

Moisture content of the soil (0-15 cm) under maize ranged from 11.09 to 18.97, 12.56 to 19.04 and 10.54 to 18.14 per cent at knee-high, tasseling and harvest stages respectively. Significantly higher moisture content was observed under raw coir pith mulch at 10 t ha^{-1} which was found to be on par with maize straw at 10 t ha^{-1} , sugarcane trash at 5 t ha^{-1} , sugarcane trash at 10 t ha^{-1} , raw coir pith at 5 t ha^{-1} , dried weeds at 5 t ha^{-1} and dried weeds at 10 t ha^{-1} treatments at early stages of crop growth. At harvest stage, the moisture content under raw coirpith mulch at 10 t ha^{-1} treatment (18.14 %) was on par with maize straw at 10 t ha^{-1} (15.76 %), sugarcane trash at 5 t ha^{-1} (15.98 %), sugarcane trash at 10 t ha^{-1} (16.87 %), raw coir pith at 5 t ha^{-1} (17.78 %), dried weeds at 5 t ha^{-1} (17.67 %) and dried weeds at 10 t ha^{-1} (17.98 %). Moisture content of soil under different mulches with varying levels were significantly higher than that of control which recorded lower values at all the three stages. The moisture content at harvest was found to be generally lower as compared to other stages irrespective of treatments.

4.2.11. Moisture content (15-30 cm) (Table 9)

Moisture content of the soil (15-30) under maize ranged between 17.40 to 28.80, 20.31 to 30.77 and 18.34 to 25.85 per cent at knee - high, tasseling and harvest stages respectively. Significantly higher value was observed in raw coir pith mulch at 10 t ha^{-1}

treatment which was on par with dried weeds at 10 t ha⁻¹ at knee high stage of maize. At tasseling and harvest stages, the moisture content recorded by raw coir pith at 10 t ha⁻¹ (30.77 and 25.85 % respectively) was on par with maize straw at 10 t ha⁻¹ (22.87 and 19.58 % respectively), sugarcane trash at 5 t ha⁻¹ (24.53 and 19.95 % respectively), sugarcane trash at 10 t ha⁻¹ (25.67, 20.72 per cent respectively), raw coir pith at 5 t ha⁻¹ (27.87 and 21.54 % respectively), dried weeds at 5 t ha⁻¹ (26.87, 23.78 % respectively) and dried weeds at 10 t ha⁻¹ (27.80 and 24.45 % respectively). Moisture content of sub surface soil under different mulches with different levels was significantly higher than the control irrespective of stages. Comparing the two layers, the 15-30 cm layer registered higher values over 0-15 cm layer irrespective of treatments and stages.

4.2.12. Soil Temperature (0-15 cm) (Table 10)

Temperature of the soil (0-15 cm) under maize ranged between 24.4 and 28, 25.50 and 28.5 and 24.8 and 29.1 °C at knee - high, tasseling and harvest stages respectively. Significantly lower temperature was observed in raw coir pith at 10 t ha⁻¹ (T₇) treatment which was on par with maize straw at 10 t ha⁻¹(T₃), sugarcane trash mulch at 5 t ha⁻¹(T₄), sugarcane trash at 10 t ha⁻¹(T₅), raw coir pith at 5 t ha⁻¹(T₆), dried weeds mulch at 5 t ha⁻¹(T₈) and dried weeds at 10 t ha⁻¹(T₉) at the early two stages of crop growth. At harvest stage, the temperature recorded by raw coir pith at 10 t ha⁻¹ (24.8 °C) was on par with maize straw at 10 t ha⁻¹ (27.3 °C), sugarcane trash at 10 t ha⁻¹ (26.9 °C), sugarcane trash at 5 t ha⁻¹ (25.2 °C), raw coir pith at 5 t ha⁻¹ (25.2 °C), dried weeds at 5 t ha⁻¹ (25.3 °C) and dried weeds at 10 t ha⁻¹ (25.1 °C). Temperature recorded under different mulches with varying levels was significantly lower than the temperature in the control at all the three stages.

4.2.13. Soil Temperature (15-30 cm) (Table 11)

Temperature of the soil (15-30 cm) ranged from 24.0 to 28.4, 25.2 to 28.1 and 24.3 to 29.0 °C at knee - high, tasseling and harvest stages respectively. Significantly lower temperature was observed in raw coir pith at 10 t ha⁻¹ treatment which was found to be on par with sugarcane trash at 10 t ha⁻¹, raw coir pith at 5 t ha⁻¹, dried weeds at 5 t ha⁻¹ and dried weeds at 10 t ha⁻¹ at knee high stage of crop growth. At harvest stage the temperature under raw coir pith mulch at 10 t ha⁻¹ (24.3°C) was on par with maize straw at 10 t ha⁻¹ (26.0 °C), sugarcane trash at 5 t ha⁻¹ (26.4 °C), sugarcane trash at 10 t ha⁻¹ (25.2 °C), raw coir pith at 5 t ha⁻¹ (24.9 °C), dried weeds at 5 t ha⁻¹ (27.6 °C) and dried weeds mulch at 10 t ha⁻¹ (25.2 °C). Temperature of the soil under different mulches with different levels was significantly

lower than that of control treatment irrespective of the stages. Comparing the two layers, the 15-30 cm layer registered lower values compared 0-15 cm layer irrespective of treatments and stages.

4.3. Effect of organic mulches on soil fertility status

4.3.1. pH (Table 12)

The pH status ranged from 8.22 to 8.24. Marginally lower pH of 8.21 was recorded in raw coir pith at 10 t ha⁻¹ (T₇) treatment. The application of different mulches with different levels did not produce any significant impact on the pH of the soil.

4.3.2. EC (Table 12)

The EC of the soil ranged from 0.12 to 0.13 dSm⁻¹. Lower EC of 0.12 dSm⁻¹ was recorded by maize straw mulch at 5 and 10 t ha⁻¹, dried weeds (5 and 10 t ha⁻¹) followed by sugarcane trash mulch at 5 and 10 t ha⁻¹. The various mulches and their levels did not produce any significant impact on the EC of the soil.

4.3.3. Organic carbon (Table 12)

The organic carbon status ranged between 0.44 and 0.52 per cent. Higher organic carbon of 0.52 per cent was recorded under dried weeds mulch at 10 t ha⁻¹ (T₉), followed by sugarcane trash at 5 t ha⁻¹, sugarcane trash at 10 t ha⁻¹ and dried weeds at 5 t ha⁻¹ with values of 0.5, 0.51 and 0.51 per cent respectively. The mulches and their different levels did not produce any significant variation on the organic carbon status of the soil in the short span of maize growth.

4.3.4. Available nitrogen (Table 13)

Progressive decline in available nitrogen with the advancement of crop growth was observed. Available nitrogen status ranged from 121.4 to 151.3, 111.2 to 146.5 and 104.9 to 138.3 kg ha⁻¹ at knee - high, tasseling and post harvest stages respectively. At all stages of crop growth, significantly higher available nitrogen was recorded under the dried weeds mulch at 10 t ha⁻¹ (151.3, 146.5 and 138.3 kg ha⁻¹ at knee - high, tasseling and post harvest stages, respectively) which was on par with the raw coir pith at 5 t ha⁻¹, raw coir pith at 10 t ha⁻¹ and dried weeds at 5 t ha⁻¹ treatments as against the lowest available nitrogen recorded by control. Among the different stages, higher available soil nitrogen was recorded in the knee - high stage, followed by tasseling and post harvest stages.

In the post harvest stage, higher available nitrogen of 138.3 kg ha^{-1} was recorded in the dried weeds at 10 t ha^{-1} (T_9) which was on par with the raw coir pith at 10 t ha^{-1} , dried weeds at 5 t ha^{-1} and raw coir pith at 5 t ha^{-1} treatments (130.8 , 130.3 and 121.9 kg ha^{-1} respectively). Treatments T_5 to T_9 have showed a build up in the available nitrogen status at the knee high stage as compared to the initial value of 140.5 kg ha^{-1} . While in the other mulched treatments depletion in the available nitrogen could be observed. Comparison of stages revealed that there was a constant depletion right through the crop growth irrespective of treatments and levels.

4.3.5. Available phosphorus (Table 14)

Available phosphorus showed a decreasing trend with the advancement of crop growth. Available phosphorus ranged from 9.71 to 11.32 , 8.41 to 10.62 , 7.34 to 9.43 kg ha^{-1} at knee - high, tasseling and post harvest stages respectively. At all stages of crop growth, dried weeds mulch at 10 t ha^{-1} (T_9) registered higher phosphorus availability followed by raw coir pith at 10 t ha^{-1} (T_7), sugarcane trash at 10 t ha^{-1} (T_5) and dried weeds at 5 t ha^{-1} (T_8) treatments. The lower availability of phosphorus was accounted by control irrespective of stages. However, the treatments failed to produce any significant influence. The application of mulches at different levels also did not produce any significant impact on the available phosphorus status.

4.3.6. Available potassium (Table 15)

Regarding the soil available potassium, significant and strong variations could be observed with treatments. The mean soil potassium ranged from 311.2 to 398.5 , 296.5 to 391.5 and 281.8 to 384.2 kg ha^{-1} at knee - high, tasseling and post harvest stages respectively. The treatments exerted significant influence on the available potassium with higher value being observed under dried weeds at 10 t ha^{-1} which was on par with raw coir pith at 5 t ha^{-1} , raw coir pith at 10 t ha^{-1} and dried weeds at 5 t ha^{-1} treatments at knee-high and tasseling stages. At post harvest stage, the available potassium registered by dried weeds mulch at 10 t ha^{-1} (384.2 kg ha^{-1}) was again on par with raw coir pith at 5 t ha^{-1} , raw coir pith at 10 t ha^{-1} and dried weeds at 5 t ha^{-1} (338.7 , 347.2 , 342.0 kg ha^{-1} respectively). With advancement of crop growth the mining of potassium was observed as reflected from the value of 281.8 kg ha^{-1} even after fertilization as against the initial value of 385.1 kg ha^{-1} in control.

4.4. Effect of organic mulches on soil biological properties

4.4.1. Bacteria (Table 16)

Generally the organic mulch application had conspicuously increased the microbial population. The various organic mulches application had significantly influenced the microbial buildup of soil. Bacterial population of the soil under maize ranged from 35.7 to 55.0, 47.7 to 60.3 and 34.0 to 48.3 CFU g⁻¹ at knee - high, tasseling and harvest stages respectively. The highest bacterial population was associated with the application of raw coir pith at 10 t ha⁻¹ (T₇) which was significantly superior (55.0, 60.3 and 48.3 CFU g⁻¹ at the three stages respectively) over sugarcane trash mulch at 10 t ha⁻¹ (47.7, 54.0 and 48.3 CFU g⁻¹ at the three stages respectively), raw coir pith at 5 t ha⁻¹ (49.7, 56.7 and 55.0 CFU g⁻¹ respectively), dried weeds at 10 t ha⁻¹ (35.7, 47.7 and 48.3 CFU g⁻¹ respectively) and dried weeds at 5 t ha⁻¹ (47.3, 56.0 and 42.7 CFU g⁻¹ respectively) and control (T₁) (35.7, 47.7 and 48.3 CFU g⁻¹ respectively).

4.4.2. Fungi (Table 16)

Application different organic mulches significantly increased the fungal population. Fungi population of the soil ranged between 20.0 to 24.7, 22.3 to 29.3 and 17.7 to 25.3 CFU g⁻¹ at knee - high, tasseling and harvest stages respectively. The treatment T₇ recorded the highest population (24.7, 29.3 and 25.3 CFU g⁻¹ at knee - high, tasseling and harvest stages respectively) followed by T₆ (24.7, 29.0 and 24.3 CFU g⁻¹ at knee - high, tasseling and harvest stages respectively) which was on par with T₄, T₅, T₈ and T₉. The lowest fungal population of 20.0, 22.3 and 25.3 CFU g⁻¹ at knee - high, tasseling and harvest stages respectively was observed in control (T₁). Application of different mulches considerably increased the fungi population at different stages of crop growth. There was an increase in fungal population during tasseling stage over knee high and it decreased during post harvest stage with the advancement of maize growth irrespective of treatments.

4.4.3. Actinomycetes (Table 16)

Actinomycetes population gradually increased from knee - high to harvesting stage. Application of dried weeds at 10 t ha⁻¹ (T₉) (10.12, 10.68, 11.12 CFU g⁻¹ at knee - high, tasseling and harvest stages respectively) accounted significantly the highest population which was superior over dried weeds at 5 t ha⁻¹ (9.26, 9.84, 10.84 CFU g⁻¹ at the three stages respectively). The superiority of other treatments was in the order of dried weeds mulch at 5 t ha⁻¹ (9.26, 9.84 and 10.84 CFU g⁻¹), raw coirpith at 10 t ha⁻¹ (8.88, 9.12 and 10.46 CFU g⁻¹), raw coirpith at 5 t ha⁻¹ (7.84, 8.86 and 9.34 CFU g⁻¹), sugarcane trash and maize

straw. The lowest population was noticed in control (4.12, 5.56 and 6.46 CFU g⁻¹ at knee-high, tasseling and harvest stages respectively).

4.5. Growth characters

4.5.1. Plant height (Table 17)

Plant height which represents the time trend of growth was recorded at different phenophases of maize. Significant differences in plant height could be observed with application of different mulches. The plant height of maize ranged between 80.3 to 99.7, 181.9 to 254.9 and 193.2 to 261.5 cm at knee-high, tasseling and harvest stages respectively. Maximum plant height was observed in raw coir pith at 10 t ha⁻¹ treatment which was on par with dried weeds and sugarcane trash mulch and these treatments were significantly superior over maize straw and control at knee high stage. At tasseling stage, again raw coir pith mulch at 10 t ha⁻¹ showed its superiority with maximum plant height of 254.9 cm over other treatments. At harvest stage, the raw coir pith at 10 t ha⁻¹ treatment registered higher value of 261.5 cm and was on par with dried weeds at 5 t ha⁻¹ treatment (241.9 cm) and there two were significantly superior over other mulches and their levels and control (192.2 cm).

4.6. Yield parameters and Yield

4.6.1. Yield parameters

4.6.1.1. Cob length (Table 18)

The cob length of maize ranged from 15.8 to 17.9 cm. The raw coir pith mulch at 10 t ha⁻¹ recorded 17.9 cm followed by sugarcane trash mulch at 10 t ha⁻¹ (17.8 cm), maize straw at 10 t ha⁻¹ (17.5 cm) and dried weeds at 10 t ha⁻¹ (17.3 cm) and were on par. The treatments of maize straw at 5 t ha⁻¹ (16.9 cm), raw coir pith at 5 t ha⁻¹ (16.3 cm) and dried weeds at 5 t ha⁻¹ (17.1 cm) were on par. All the treatments except T₄ and T₆ were significantly superior over control.

4.6.1.2. Number of grain rows per cob (Table 18)

The number of grain rows cob⁻¹ of maize ranged from 13.3 to 14.7. The number of grain rows cob⁻¹ was maximum in raw coir pith at 10 t ha⁻¹ (14.7) and sugarcane trash at 10 t ha⁻¹ (14.7) followed by maize straw at 10 t ha⁻¹ (14.1) and maize straw at 5 t ha⁻¹ (13.9). The lower number of grain rows cob⁻¹ was recorded in the control (13.3). However, the

application of various mulches with different levels failed to produce any significant variations in the number of grain rows cob⁻¹.

4.6.1.3. Number of grains per row (Table 18)

The number of grains row⁻¹ of maize ranged from 28.7 to 35.0. The number of grains row⁻¹ was higher in raw coir pith at 10 t ha⁻¹ (35) followed by maize straw at 10 t ha⁻¹ (33.7) and raw coir pith at 5 t ha⁻¹ (33.3). The lowest number of grains row⁻¹ was recorded by the control (28.7). The application of various mulches and their levels did not produce any significant differences on the number of grains row⁻¹.

4.6.1.4. Hundred grain weight (Table 18)

The hundred grain weight of maize ranged from 21.7 to 26.0 g. Hundred grain weight was the highest in raw coir pith at 10 t ha⁻¹ (26.0 g) followed by sugarcane trash mulch at 5 t ha⁻¹ (25.3 g), sugarcane trash mulch at 10 t ha⁻¹ (25.0 g) and dried weeds at 10 t ha⁻¹ (24.7 g) and were on par. The other treatments viz., maize straw at 10 t ha⁻¹ (24.3 g), raw coir pith at 5 t ha⁻¹ (24.4 g) and dried weeds at 5 t ha⁻¹ (24.0 g) treatments were on par. The lowest grain test weight of 21.7 g was recorded in the control (T₁) and this treatment was on par with maize straw mulch at 5 t ha⁻¹ (22.7 g) and these two were inferior to all other treatments.

4.6.2. Yield

4.6.2.1. Dry matter production (Table 19)

Dry matter production which represents the time trend of growth was recorded at different phenophases of maize. Significant difference in dry matter production was observed with application of different mulches. The dry matter production of maize ranged from 2575 to 3540, 7146 to 8152 and 7664 to 11771 kg ha⁻¹ at knee-high, tasseling and harvest stages respectively. Significantly higher dry matter production was observed in raw coir pith at 10 t ha⁻¹ mulch which was found to be on par with dried weeds at 10 t ha⁻¹ and dried weeds at 5 t ha⁻¹ at all stages of crop growth. The dry matter production increased with advancement of crop growth and maximum being attained at harvest stage irrespective of mulches and their levels. At all the stages the no mulch control showed lowest values.

4.6.2.2. Grain (Table 19)

Grain yield of maize ranged from 2647 to 4588 kg ha⁻¹. Among the treatments, raw coir pith mulch at 10 t ha⁻¹ (T₇) registered higher maize grain yield of 4588 kg ha⁻¹ followed by

dried weeds mulch at 10 t ha⁻¹ (4472 kg ha⁻¹), dried weeds at 5 t ha⁻¹ (4452 kg ha⁻¹) but were on par with each other and significantly superior over other treatments. The yield increase being 73.0, 68.9 and 68.0 per cent for the above said treatments over control. The grain yield in the remaining treatments follows the order of raw coir pith at 5 t ha⁻¹ (4207 kg ha⁻¹), sugarcane trash at 10 t ha⁻¹ (4170 kg ha⁻¹), sugarcane trash at 5 t ha⁻¹ (3947 kg ha⁻¹), maize straw mulch at 10 t ha⁻¹ (3635 kg ha⁻¹) and maize straw mulch at 5 t ha⁻¹ (3292 kg ha⁻¹). The yield increase in these treatments varied between 24.3 and 58.9 per cent over control. All the mulches and their levels registered significantly higher yields as compared to control which recorded the lowest yield of 2647 kg ha⁻¹.

4.6.2.3. Stover (Table 19)

Stover yield of maize under various mulches ranged between 5017 and 7183 kg ha⁻¹. The stover yield followed a similar trend as that of grain yield. The treatment of raw coir pith mulch at 10 t ha⁻¹ out yielded all other treatments with the highest stover yield of 7183 kg ha⁻¹ with yield increase of 30.1 per cent over control. This was followed by dried weeds mulch at 10 t ha⁻¹ (6967 kg ha⁻¹) and was on par with the focus treatment T₇. These two treatments were significantly superior over other mulches and their levels. The stover yield in the remaining treatments ranged between 5733 kg ha⁻¹ (maize straw mulch at 5 t ha⁻¹) and 6850 kg ha⁻¹ (raw coir pith at 5 t ha⁻¹). The yield increase ranged from 14.2 to 36.5 per cent over control for these treatments.

4.7. Nutrient content and uptake

4.7.1. Nitrogen content and uptake

4.7.1. 1. Nitrogen content (Table 20)

Nitrogen content in maize ranged between 1.06 to 1.26, 1.01 to 1.27 and 2.18 to 2.60 per cent at knee - high, tasseling and harvest stages respectively. The higher nitrogen content was observed in raw coir pith mulch at 10 t ha⁻¹ which was significantly superior over dried weeds at 10 t ha⁻¹, dried weeds at 5 t ha⁻¹ and other treatments at tasseling stages of crop growth. At harvest stage, the nitrogen content registered by raw coir pith mulch at 10 t ha⁻¹ treatment (2.60 %) was on par with dried weeds at 10 t ha⁻¹ (2.57 %) and significantly superior over other treatments. In the above two stages, all the mulches and their levels showed their superiority over control. However, the treatments failed to produce any significant influence on nitrogen content at knee – high stage.

4.7.1. 2. Nitrogen uptake (Table 20)

Nitrogen uptake in maize ranged between 27.3 to 44.6, 72.4 to 108.1 and 82.1 to 149.6 kg ha⁻¹ at knee - high, tasseling and harvest stages respectively. Higher nitrogen uptake was observed under raw coir pith mulch at 10 t ha⁻¹ treatment which was significantly superior over dried weeds at 10 t ha⁻¹, raw coir pith at 5 t ha⁻¹ and dried weeds at 5 t ha⁻¹ and other treatments at knee- high and tasseling stages of crop growth. At harvest stage also, higher total nitrogen uptake was registered by raw coir pith mulch at 10 t ha⁻¹ (149.6 kg ha⁻¹) which was on par with dried weeds mulch at 10 t ha⁻¹ (143.2 kg ha⁻¹), but was significantly superior to dried weeds mulch at 5 t ha⁻¹ (138.5 kg ha⁻¹), raw coir pith at 5 t ha⁻¹ (137.0 kg ha⁻¹) and these were significantly superior over other treatments. All the mulches and their levels registered their superiority over control.

4.7.2. Phosphorus content and uptake

4.7.2.1. Phosphorus content (Table 21)

Phosphorus content in maize ranged between 0.17 to 0.33, 0.17 to 0.29 and 0.39 to 0.74 per cent at knee - high, tasseling and harvest stages respectively. Higher phosphorus content was observed by raw coir pith at 10 t ha⁻¹ which was on par with dried weeds at 10 t ha⁻¹, raw coir pith at 5 t ha⁻¹ and dried weeds at 5 t ha⁻¹ treatments at knee high and tasseling stages of crop. At harvest stage, the total phosphorus content registered by raw coir pith mulch at 10 t ha⁻¹ (0.74 %) was on par with dried weeds at 10 t ha⁻¹ (0.71 %) but was significantly superior over other treatments. In the above stages, all the mulches and their levels showed their superiority over control.

4.7.2.2. Phosphorus uptake (Table 21)

Phosphorus uptake in maize ranged between 4.38 to 11.68, 12.15 to 24.68 and 14.35 to 41.22 kg ha⁻¹ at knee - high, tasseling and harvest stages respectively. Higher phosphorus uptake was observed in raw coir pith at 10 t ha⁻¹ treatment which was on par with dried weeds mulch at 10 t ha⁻¹ at knee high and tasseling stages. At harvest stage also, the total phosphorus uptake registered under raw coir pith mulch at 10 t ha⁻¹ treatment (41.22 kg ha⁻¹) was on par with dried weeds at 10 t ha⁻¹ (38.49 kg ha⁻¹) and significantly superior over other treatments. All the mulches and their levels registered their superiority over control.

4.7.3. Potassium content and uptake

4.7.3.1. Potassium content (Table 22)

Potassium content in maize ranged from 1.04 to 1.32, 1.03 to 1.33 and 1.73 to 1.95 per cent at knee - high, tasseling and harvest stages respectively. Among the treatments, higher potassium content was observed in raw coir pith at 10 t ha⁻¹ which was on par with dried weeds at 10 t ha⁻¹, dried weeds at 5 t ha⁻¹ and raw coir pith at 5 t ha⁻¹ treatments at knee high and tasseling stages. At harvest stage, the total potassium content registered by raw coir pith at 10 t ha⁻¹ treatment (1.95 %) was on par with dried weeds at 10 t ha⁻¹ (1.92 %) but significantly superior over other treatments. All the mulch treatments and their levels registered their supremacy over control by registering higher values.

4.7.3.2. Potassium uptake (Table 22)

Potassium uptake in maize ranged from 26.8 to 46.7, 73.6 to 113.2 and 76.8 to 125.3 kg ha⁻¹ at knee - high, tasseling and harvest stages respectively. Among the mulches, raw coir pith at 10 t ha⁻¹ registered higher value but was on par with dried weeds at 10 t ha⁻¹ and dried weeds at 5 t ha⁻¹ treatments at knee high and tasseling stages of crop growth. At harvest stage the total potassium uptake registered by raw coir pith treatment (125.3 kg ha⁻¹) was on par with dried weeds at 10 t ha⁻¹ (120.0 kg ha⁻¹) and significantly superior over other treatments. All the mulch treatments and their levels showed their superiority over control.

4.7.4. Nutrient content and uptake of maize grain

4.7.4.1. Nitrogen content (Table 23)

Nitrogen content in maize grain ranged between 1.17 to 1.43 per cent. Among the treatments, higher nitrogen content of 1.43 per cent was recorded by raw coir pith mulch at 10 t ha⁻¹ which was on par with the dried weeds at 10 t ha⁻¹ (1.41 %). The nitrogen content in raw coir pith at 5 t ha⁻¹ and dried weeds at 5 t ha⁻¹ (1.40 and 1.39 % respectively) treatments were on par but were significantly superior over sugarcane trash and maize straw mulches at the two levels tried. The nitrogen content in maize grain under various mulches with different levels were significantly higher than the nitrogen content recorded by the control.

4.7.4. 2. Nitrogen uptake (Table 23)

Nitrogen uptake in maize grain ranged between 31.0 to 65.6 kg ha⁻¹. The uptake was higher in the raw coir pith at 10 t ha⁻¹ (65.6 kg ha⁻¹), which was on par with dried weeds at 10 t ha⁻¹ and dried weeds at 5 t ha⁻¹ treatments (63.1 and 61.9 kg ha⁻¹ respectively). The nitrogen uptake of grain in the remaining treatments ranged between 39.8 kg ha⁻¹ (maize straw at 5 t ha⁻¹) and 58.9 kg ha⁻¹ (raw coir pith at 5 t ha⁻¹). All the mulch treatments and their levels registered their superiority over control.

4.7.4.3. Phosphorus content (Table 23)

Phosphorus content of maize grain ranged between 0.22 and 0.46 per cent, the highest being in raw coir pith at 10 t ha⁻¹ (0.46 %) and this was on par with dried weeds mulch at 10 t ha⁻¹ (0.44 %) which in turn was on par with T₈ and T₆. The phosphorus content in the grain was found to be much lower under remaining mulch treatments and no mulch control (0.22 %).

4.7.4. 4. Phosphorus uptake (Table 23)

Phosphorus uptake of maize grain ranged from 5.82 to 21.10 kg ha⁻¹, the highest being in the treatment of raw coir pith at 10 t ha⁻¹ followed by dried weeds at 10 t ha⁻¹ (19.68 kg ha⁻¹) and dried weeds at 5 t ha⁻¹ (18.25 kg ha⁻¹). The phosphorus uptake in the grain was lower under no mulch control (5.82 kg ha⁻¹) than under various mulche treatments.

4.7.4.5. Potassium content (Table 23)

Potassium content under various mulch treatments ranged from 0.42 to 0.57 per cent. Higher potassium content was recorded in the treatment of raw coir pith at 10 t ha⁻¹ (0.57 %) and was significantly superior over raw coir pith at 5 t ha⁻¹ (0.54 %) and dried weeds at 10 t ha⁻¹ (0.55 %) and other treatments. Even though sugarcane trash and maize straw recorded lower content than coirpith and dried weed mulch, they were significantly superior to control by registering higher potassium content.

4.7.4.6. Potassium uptake (Table 23)

Uptake of potassium in maize grain ranged from 11.1 to 26.2 kg ha⁻¹ under different treatments. The uptake of potassium raw coir pith at 10 t ha⁻¹ (59.0 kg ha⁻¹) and dried weeds at 10 t ha⁻¹ treatment (26.2 kg ha⁻¹) were higher recording higher on par potassium uptake values as compared to other mulches and their levels. Sugarcane trash mulch at both levels were significantly superior over maize straw at the two levels tried. In general all the mulches accounted for higher grain potassium uptake than control which registered the lowest uptake of 11.1 kg ha⁻¹ in grain.

4.7.5. Nutrient content and uptake of maize stover

4.7.5.1. Nitrogen content (Table 24)

Nitrogen content in maize stover ranged from 1.02 to 1.17 per cent and the higher value being observed under the raw coir pith at 10 t ha⁻¹ (1.17 %). This was on par with dried weeds at 10 t ha⁻¹ (1.15 %) which in turn was on par with raw coir pith at 5 t ha⁻¹ (1.14 %) and

dried weeds at 5 t ha⁻¹ (1.14 %) treatments. The other mulches viz., sugarcane trash and maize straw at both levels recorded lower nitrogen content as compared to above treatments. The control registered the nitrogen content of 1.02 per cent and was on par with maize straw mulch at 5 t ha⁻¹ (1.03 %).

4.7.5. 2. Nitrogen uptake (Table 24)

Nitrogen uptake in maize stover ranged between 51.2 to 84.0 kg ha⁻¹ under various mulch treatments. Higher nitrogen uptake in stover was noticed under the raw coir pith at 10 t ha⁻¹ (84.4 kg ha⁻¹), which was on par with dried weeds at 10 t ha⁻¹ treatment (80.1 kg ha⁻¹) which in turn was on par with raw coirpith at 5 t ha⁻¹ (78.1 kg ha⁻¹). The stover N uptake in the remaining treatments ranged from 59.0 kg ha⁻¹ (maize straw at 5 t ha⁻¹) to 75.0 kg ha⁻¹ (sugarcane trash mulch at 10 t ha⁻¹). The control (no mulch) recorded the lowest stover nitrogen uptake of 51.2 kg ha⁻¹ and was inferior to all other treatments.

4.7.5.3. Phosphorus content (Table 24)

Phosphorus content in maize stover ranged between 0.17 per cent (no mulch) treatments to 0.28 per cent under raw coir pith mulch at 10 t ha⁻¹. This was on par with dried weeds at 10 t ha⁻¹ (0.27 %). These two treatments were significantly superior over all other mulches and their levels. The control registered the lowest phosphorus content of 0.17 per cent.

4.7.5. 4. Phosphorus uptake (Table 24)

Uptake of phosphorus in maize stover was significantly influenced by the various mulches. Uptake of phosphorus ranged from 8.53 to 20.11 kg ha⁻¹ under different mulch treatments. Higher phosphorus uptake of 20.11 kg ha⁻¹ was observed under raw coir pith at 10 t ha⁻¹ treatments and was found to be on par with dried weeds at 10 t ha⁻¹ (18.81 kg ha⁻¹). The stover phosphorus uptake in the remaining treatments ranged from 10.89 kg ha⁻¹ (maize straw at 5 t ha⁻¹) to 17.13 kg ha⁻¹ (raw coirpith at 5 t ha⁻¹). The control (no mulch) recorded the lowest stover uptake of 8.53 kg ha⁻¹ and was inferior to all other treatments.

4.7.5.5. Potassium content (Table 24)

Potassium content in maize stover ranged from 1.31 to 1.38 per cent. Significantly higher K content was recorded in the treatment by raw coir pith at 10 t ha⁻¹ (1.38 %) was on par with dried weeds at 10 t ha⁻¹ (1.37 %), dried weeds at 5 t ha⁻¹ (1.34 %) and raw coir pith

at 5 t ha⁻¹ (1.34 %). K content in the stover was significantly lower under absolute control (1.31 %) than under different mulches treatments.

4.7.5. 6. Potassium uptake (Table 24)

The potassium uptake varied from 65.7 and 99.1 kg ha⁻¹ in stover and the differences due to treatments were found to be significant. Higher potassium uptake was recorded in the treatment raw coir pith mulch at 10 t ha⁻¹ (99.1 kg ha⁻¹) which was on par with dried weeds at 10 t ha⁻¹ (95.4 kg ha⁻¹). The stover potassium uptake in the remaining treatments ranged from 76.8 kg ha⁻¹ (maize straw at 5 t ha⁻¹) to 91.8 kg ha⁻¹ (raw coir pith at 5 t ha⁻¹). The control (no mulch) recorded the lowest stover uptake of 65.7 kg ha⁻¹ and was inferior to all other treatments.

4.7.6. Effect of different organic mulches on weed control

4.7.6.1. Weed flora

The weed flora observed in the experimental field during the course of study consisted of grasses, sedges, and broad leaved weeds. The major weeds were *Cynodon dactylon*, *Dactyloctenium aegyptium* in grasses, *Cyperus rotundus* in sedges, *Digera arvensis*, *Parthenium hysterophorus*, *Trianthema portulacastrum*, *Datura metal* and *Acalypha indica* among broad leaved weeds.

4.7.6.2. Total weed population (Table 25)

The total weed population was significantly reduced by the various mulching practices. The general appraisal revealed that the increased levels of mulching material decreased the total weed population. The application of sugarcane trash at 10 t ha⁻¹ significantly reduced the total weed population by recording (45.2, 58.0 and 53.6 per cent at knee - high, tasseling and harvest stages respectively). At all the stages sugarcane trash mulch at 10 t ha⁻¹ recorded the least total weed population which was followed by raw coir pith at 10 t ha⁻¹, raw coir pith at 5 t ha⁻¹, dried weeds at 10 t ha⁻¹ and dried weeds at 5 t ha⁻¹ and these treatments were on par. The highest weed population was observed in the control treatment T₁ (197.2, 169.6 and 202.4 Nos. per m² at knee high, tasseling and harvest stages respectively) (without mulching) at all the stages. Among the stages, the weed population increased from knee high to tasseling and decreased towards harvest in coirpith and weed mulch treatments. Comparison of various mulches revealed that the superiority was in the order of sugarcane trash, coirpith, weed mulch and maize straw.

4.7.6.3. Weed dry matter production (Table 26)

The dry matter production was observed to be decreased with crop growth. The mean dry matter production of weeds ranged from 108.6 to 134.8, 98.5 to 127.5 and 95.2 to 116.8 kg ha⁻¹ at knee - high, tasseling and harvest stages respectively. Dried weeds mulch at 10 t ha⁻¹ recorded the lowest weed dry matter production of 98.5 and 95.2 kg ha⁻¹ respectively at the tasseling and harvest stages. It was followed by sugarcane trash mulch at 10 t ha⁻¹ and sugarcane trash mulch at 5 t ha⁻¹ treatments. However at the knee-high stage sugarcane trash mulch at accounted for lower weed dry matter but was on par with dried weeds mulch. The control (without mulch) recorded the highest weed dry matter production of 134.8, 127.4 and 116.8 kg ha⁻¹ at knee - high, tasseling and harvest stages respectively

4.8. Correlation studies (Table 27 and 28)

The relationship between the soil available N, P and K, organic carbon, physical and biological properties of the soil were assessed through correlations.

The chemical parameters viz., available N, P and K of soil had positive significant correlation with the physical and biological properties of soil and negative significant correlation with bulk density and soil temperature. The relationship studies had clearly indicated that the bulk density was negatively related to water holding capacity. It is obvious that the soil organic carbon and mineralization of nutrients were closely interrelated and had a profound influence on biomass yield.

The biological properties viz., bacteria, fungi and actinomycetes of soil had positive significant correlation with the nutrient availability of soil and negative significant correlation with water holding capacity and soil temperature.

The relationship had clearly indicated that the physical properties of soil had positive significant correlation with the chemical and biological properties of soil except bulk density and soil temperature. The bulk density had negative significant correlation with all chemical and biological properties of soil. Soil temperature had negative significant correlation with all chemical and biological properties of soil. Temperature was not significantly influenced by surface soil moisture at all stages of crop growth. The N, P and K uptake at the three growth stages exhibited significant positive correlation with the grain yield of maize.

B. GROUNDNUT

4.9. Effect of organic mulches on soil physical properties

Soil samples collected at post harvest stage of groundnut was subjected to the determination of physical properties such as bulk density, total porosity, capillary porosity, non capillary porosity, saturated hydraulic conductivity, field capacity, permanent wilting point and water holding capacity.

4.9.1. Bulk density (0-15 cm) (Table 29)

Application of different organic mulches had insignificant influence on bulk density of soil at surface. Among different mulches, the treatment of raw coir pith at 10 t ha⁻¹ (T₇) marginally reduced the bulk density (1.31 Mg m⁻³) which was followed by dried weeds at 10 t ha⁻¹ (T₉), raw coir pith at 5 t ha⁻¹ (T₆) and dried weeds at 5 t ha⁻¹ (T₈). The treatment T₅ (sugarcane trash at 10 t ha⁻¹) maintained the bulk density (1.34 Mg m⁻³) as that of T₃ (maize straw at 5 t ha⁻¹) and T₄ (sugarcane trash at 10 t ha⁻¹). Control recorded higher bulk density (1.37 Mg m⁻³) which was followed by T₂ (maize straw at 5 t ha⁻¹).

4.9.2. Bulk density (15 -30 cm) (Table 29)

Application of different organic mulches did not show any significant effect on bulk density of soil at 15-30 cm. Among different treatments, dried weeds mulch at 10 t ha⁻¹ (T₉) registered lower bulk density (1.43 Mg m⁻³) which was followed by raw coir pith mulch at 5 and 10 t ha⁻¹ (T₆ and T₇), dried weeds at 5 t ha⁻¹ (T₈) and sugarcane trash at 5 and 10 t ha⁻¹ (T₄ and T₅). Control recorded higher bulk density (1.52 Mg m⁻³) as compared to other treatments. The application of mulches with different levels did not produce any significant impact on the bulk density of the soil. Comparing the two layers, 15 – 30 cm showed higher values over 0 – 15 cm layer irrespective of mulches and their levels.

4.9.3. Saturated Hydraulic Conductivity (Table 30)

Saturated hydraulic conductivity of soil varied numerically with different organic mulches application. The lowest hydraulic conductivity (5.19 cm h⁻¹) was accounted by control (T₁), followed by maize straw at 5 t ha⁻¹ (T₂), maize straw at 10 t ha⁻¹ (T₃) and sugarcane trash at 5 t ha⁻¹ (T₄). The treatment of raw coir pith mulch at 10 t ha⁻¹ (T₇) recorded higher hydraulic conductivity of 5.42 cm h⁻¹ which was followed by dried weeds

at 10 t ha⁻¹ (T₉), dried weeds at 5 t ha⁻¹ (T₈) and raw coir pith at 5 t ha⁻¹ (T₆). The treatment T₂, T₃ and T₄ recorded low hydraulic conductivity of 5.20, 5.21 and 5.23 cm h⁻¹ respectively and were higher than control. However, the variation among the mulches and their levels failed to attain the level of significance.

4.9.4. Total porosity (Table 30)

Among the different treatments, marginally higher total porosity (44.8%) was recorded under dried weeds at 10 t ha⁻¹ (T₉), raw coir pith at 10 t ha⁻¹ (T₇), raw coir pith at 5 t ha⁻¹ (T₆) and dried weeds at 5 t ha⁻¹ (T₈). Lower per cent porosity (44.2 %) was recorded in control (T₁) and maize straw at 5 t ha⁻¹ (T₂). Maize straw at 10 t ha⁻¹ (T₃) and sugarcane trash at 5 t ha⁻¹ (T₄) recorded numerically higher value over control. The application of mulches with different levels failed to produce any significant impact in the total porosity of the soil.

4.9.5. Capillary porosity (Table 30)

Application of different organic mulches did not produce any significant influence on capillary porosity of soil. The capillary porosity of the soil ranged from 32.6 to 32.8 per cent with marginally higher value (32.8 %) being recorded in raw coir pith at 10 t ha⁻¹ and dried weeds at 10 t ha⁻¹.

4.9.6. Non capillary porosity (Table 30)

Non capillary porosity of soil did not vary significantly with different organic mulches application. The non capillary porosity of the soil ranged from 12.8 to 13.1 per cent. Numerically higher value of 13.1 per cent was recorded in dried weeds mulch at 10 t ha⁻¹ (T₉) and raw coir pith at 10 t ha⁻¹ (T₇).

4.9.7. Field capacity (Table 31)

The application of different organic mulches did not produce any significant differences in field capacity of the soil. The values ranged from 24.10 to 24.92 per cent and the higher value being recorded under sugarcane trash mulch at 10 t ha⁻¹ (T₅) followed by raw coir pith at 10 t ha⁻¹ (T₇) and dried weeds at 10 t ha⁻¹ (T₉). Lower field capacity of the soil was recorded in control.

4.9.8. Permanent wilting point (Table 31)

Permanent wilting point of the soil showed non significant variations with different organic mulches. The values ranged from 13.06 to 13.64 per cent. Marginally higher value of 13.64 per cent was recorded by maize straw at 10 t ha⁻¹ treatment followed by sugarcane trash at 10 t ha⁻¹ and raw coir pith at 10 t ha⁻¹. Lower permanent wilting point was recorded in control (13.06 %).

4.9.9. Water holding capacity (Table 31)

Application of different organic mulches had shown insignificant performance with water holding capacity of soil. The water holding capacity ranged from 10.72 to 11.65 per cent, the maximum being in T₉ followed by T₅, T₇, T₈, T₆ and T₄. The lowest water holding capacity (10.72 %) was registered under maize straw mulch at 10 t ha⁻¹.

4.9.10. Moisture content (0-15 cm) (Table 32)

Moisture content of the soil (0-15 cm) under groundnut ranged from 10.44 to 17.81, 11.30 to 21.20 and 10.74 to 19.57 per cent at vegetative, peg initiation and harvest stages respectively. Significantly higher moisture content was observed under raw coir pith mulch at 10 t ha⁻¹ which was followed by dried weeds at 10 t ha⁻¹, dried weeds at 5 t ha⁻¹ and raw coir pith at 5 t ha⁻¹ at vegetative and peg initiation stages of crop growth. At harvest stage, again the raw coir pith at 10 t ha⁻¹ treatment (19.57 %) was on par with dried weeds at 10 t ha⁻¹ (17.36 %). Moisture content under different mulches with different levels was significantly higher than no mulch treatment (control) irrespective of the stages.

4.9.11. Moisture content (15-30 cm) (Table 33)

Moisture content of the soil at 15-30 cm ranged between 12.69 and 20.98, 13.60 and 21.50 and 11.54 and 22.54 per cent at vegetative, peg initiation and harvest stages respectively. Higher moisture content was observed in raw coir pith mulch at 10 t ha⁻¹ treatment which was on par with dried weeds at 10 t ha⁻¹ and raw coir pith at 5 t ha⁻¹ at vegetative and peg initiation. At harvest stage, raw coir pith at 10 t ha⁻¹ showed its superiority over all other treatments and their levels by registering the highest value of 22.54 per cent. Sugarcane trash and maize straw mulches registered comparatively higher values over control and however were on par with control (12.01 %). The moisture content was found to increase at peg initiation and decrease there after irrespective of treatments.

4.9.12. Soil Temperature (0-15 cm) (Table 34)

Temperature of the soil (0-15 cm) under groundnut ranged from 24.1 to 29.3, 25.1 to 29.3 and 25.1 to 29.1 °C at vegetative, peg initiation and harvest stages respectively. Significantly lower temperature was observed in raw coir pith at 10 t ha⁻¹ treatment which was found to be on par with maize straw at 10 t ha⁻¹, sugarcane trash at 5 t ha⁻¹, sugarcane trash at 10 t ha⁻¹, raw coir pith at 5 t ha⁻¹, dried weeds at 10 and 5 t ha⁻¹ treatments at vegetative and peg initiation stages. At harvest stage, the temperature recorded by dried weeds mulch at 5 t ha⁻¹ (25.3 °C) was on par with sugarcane trash at 5 t ha⁻¹ (25.2 °C), sugarcane trash at 10 t ha⁻¹ (25.1 °C), raw coir pith at 5 t ha⁻¹ (25.2 °C), and dried weeds at 10 t ha⁻¹ (25.2 °C) and raw coir pith at 10 t ha⁻¹ (25.1 °C). Maize straw mulch at the two levels recorded higher temperature than the above treatments. Control registered the highest temperature over mulched treatments irrespective of stages.

4.9.13. Soil Temperature (15-30 cm) (Table 35)

Temperature of the soil at 15-30 cm layer ranged from 24.5 to 29.0, 24.1 to 29.1 and 24.5 to 29.2 °C at vegetative, peg initiation and harvest stages respectively. Significantly lower temperature was observed in raw coir pith at 10 t ha⁻¹ treatment which was on par with sugarcane trash at 10 t ha⁻¹ at vegetative stage. At peg initiation stage, the raw coir pith mulch at 10 t ha⁻¹ again showed its superiority over the other mulches by registering lower temperature of 24.1 °C. At harvest stage, the temperature under raw coir pith at 10 t ha⁻¹ treatment (24.5 °C) was on par with sugarcane trash at 10 t ha⁻¹ (24.8 °C) and significantly superior over raw coir pith at 5 t ha⁻¹ (25.3 °C), dried weeds at 5 t ha⁻¹ (26.9 °C) and dried weeds at 10 t ha⁻¹ (25.2 °C). Temperature of the soil under different mulches and their levels was significantly lower than the temperature of the soil under control (no mulch).

4.10. Effect on soil fertility status

4.10.1. pH (Table 36)

The pH of soil ranged from 8.17 to 8.18. The different mulches and their levels did not produce any significant variation in soil pH at harvest stage of groundnut crop.

4.10.2. EC (Table 36)

The EC of the soil ranged from 0.12 to 0.13 dSm⁻¹. The various organic mulches and their levels failed to produce any significant influence on the EC of the soil under groundnut crop at post harvest stage.

4.10.3. Organic carbon (Table 36)

The organic carbon status ranged between 0.43 and 0.53 per cent. Higher organic carbon content of 0.53 per cent was recorded by dried weeds mulch at 10 t ha⁻¹, followed by the sugarcane trash mulch at 10 t ha⁻¹, sugarcane trash mulch at 5 t ha⁻¹ and dried weeds at 5 t ha⁻¹ treatments (0.52, 0.51 and 0.51 and 0.51 per cent respectively). The application of mulches and their levels did not produce any impact on the organic carbon status of the soil.

4.10.4. Available nitrogen (Table 37)

Available nitrogen status of the soil ranged from 160.4 to 165.8, 173.3 to 176.3 and 165.3 to 167.8 kg ha⁻¹ at vegetative, peg initiation and post harvest stages respectively. At all stages of crop growth the available N status was found to be non significantly higher in dried weeds at 10 t ha⁻¹ treatment followed by dried weeds at 5 t ha⁻¹ sugarcane trash mulch and maize straw mulch treatments at early two stages. In the post harvest stage also marginally higher available nitrogen of 167.8 kg ha⁻¹ was recorded in the dried weeds at 10 t ha⁻¹ treatment followed by the dried weeds at 5 t ha⁻¹, coirpith and sugarcane trash mulches. All the treatments recorded a marginal build up in the available nitrogen when compared to the initial value of 140.2 kg ha⁻¹ at all the three stages. Comparison of stages revealed an increase of N in the peg initiation and a decrease there after towards post harvest stage.

4.10.5. Available phosphorus (Table 38)

Available phosphorus status of the soil ranged from 11.21 to 12.30, 12.12 to 12.63 and 11.53 to 11.95 kg ha⁻¹ at vegetative, peg initiation and post harvest stages respectively. At all stages of crop growth, the available P status was found to be non significantly higher in dried weeds at 10 t ha⁻¹ treatment followed by raw coir pith at 10 t ha⁻¹, dried weeds at 5 t ha⁻¹ and sugarcane trash at 10 t ha⁻¹. In the post harvest stage, again higher phosphorus availability of 11.95 kg ha⁻¹ was recorded in the dried weeds at 10 t ha⁻¹ treatment followed by dried weeds at 5 t ha⁻¹. The application of mulches with different levels did not produce any impact in the available phosphorus status of the soil in any of the three stages studied under groundnut. There was a marginal increase in available P at peg initiation over vegetative stage and a decline was observed there after towards harvest.

4.9.6. Available potassium (Table 39)

Available potassium status of the soil ranged from 407.8 to 410.9, 421.5 to 424.2, 414.2 to 417.3 kg ha⁻¹ at vegetative, peg initiation and post harvest stages respectively. At

all stages of crop growth the available K status was found to be marginally higher in dried weeds at 10 t ha⁻¹ treatment followed by dried weeds at 5 t ha⁻¹ and raw coir pith at 10 t ha⁻¹. The application of mulches with and their levels did not produce any impact in the available potassium status of the soil. However at all the stages the no mulch control recorded lower values.

4.10. Effect of organic mulches on soil biological properties

4.10.1. Bacteria (Table 40)

Generally the organic mulch application had conspicuously increased the microbial population. Different organic mulches had significantly varied the microbial buildup of soil. Bacterial population of the soil under groundnut ranged from 38.0 to 54.67, 40.33 to 60.33 and 43.67 to 56.67 CFU g⁻¹ at vegetative, peg initiation and harvest stages, respectively. The highest bacterial population was associated with the application of dried weeds at 10 t ha⁻¹ (T₉) which was significantly higher as compared to other mulches and their levels and control (38.0, 40.33 and 43.67 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively). Sugarcane trash mulch at 10 t ha⁻¹ (51.3, 52.6, 51.2 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively), raw coir pith at 10 t ha⁻¹ (52.3, 52.0, 52.1 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively) and dried weeds at 5 t ha⁻¹ (49.0, 53.6, 54.6 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively) have also showed their positive influence towards the buildup of bacteria under groundnut as observed from their higher values over control (T₁).

4.10.2. Fungi (Table 40)

Application of different organic mulches had significantly increased the fungal population. Fungi population of the soil under groundnut ranged between 19.3 and 22.3, 22.3 and 30.3 and 16.3 and 23.7 CFU g⁻¹ at vegetative, peg initiation and harvest stages, respectively. The treatment T₉ recorded the highest population (22.3, 30.3 and 23.7 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively) followed by T₅ (22.1, 25.7, 23.3 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively). The lowest fungal population (19.3, 22.3, 16.3 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively) was observed in control (T₁). Application of different treatments considerably increased the fungi population under different stages of crop growth. The values in comparison of three stages indicated an increase at peg initiation and than a decrease towards the harvest stage.

4.10.3. Actinomycetes (Table 40)

Actinomycetes population gradually increased from vegetative to harvesting stage. Application of dried weeds at 10 t ha⁻¹(T₉) (9.82, 10.36, 11.45 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively) accounted for higher population and was on par with dried weeds at 5 t ha⁻¹(9.54, 10.14, 10.84 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively), raw coir pith at 10 t ha⁻¹(9.15, 9.39, 10.15 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively) and raw coir pith at 5 t ha⁻¹(7.84, 8.86, 9.06 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively) than control (T₁). Sugarcane trash and maize straw mulches showed lower actinomycetes population than the above treatments but were significantly superior over control (4.24, 5.73, 6.27 CFU g⁻¹ at vegetative, peg initiation and harvest stages respectively).

4.11. Growth characters

4.11.1. Plant height (Table 41)

Plant height which represents the time trend of growth was recorded at different phenophases of groundnut. A significant difference in plant height was observed with application of different mulches. The plant height of groundnut ranged from 20.36 to 34.56, 40.76 to 44.35 and 43.24 to 52.46 cm at vegetative, peg initiation and harvest stages respectively. Significantly maximum plant height was observed in raw coir pith at 10 t ha⁻¹ treatment which was found to be on par with dried weeds at 10 t ha⁻¹ at all stages of crop growth. The plant height increased with advancement of crop growth and maximum being attained at harvest stage irrespective of mulches and their levels. At all the stages the no mulch control showed lower plant height values.

4.12. Yield parameters and Yield

4.12.1. Yield parameters

4.12.1.1. Total number of pods per plant (Table 42)

The total number of pods per plant of groundnut ranged from 13.8 to 18.47. Raw coir pith at 10 t ha⁻¹ treatment registered higher number of 18.47 pods plant⁻¹ which was found to be on par with raw coir pith at 5 t ha⁻¹ (18.33 pods plant⁻¹). These two treatments were significantly superior over dried weeds at 5 t ha⁻¹ (17.47 pods plant⁻¹) and dried weeds at 10 t ha⁻¹ (17.53 pods plant⁻¹). Remaining mulch treatments (sugarcane trash and maize straw) were inferior to the above treatments by registering lower values. The control recorded lower number of pods (13.80 pods plant⁻¹) but however on par with maize straw mulch.

4.12.1.2. Number of matured pods per plant (Table 42)

The number of matured pods per plant of groundnut ranged from 9.40 to 17.37. The raw coir pith at 10 t ha⁻¹ treatment accounted for higher number of pods (17.37 pods plant⁻¹) and was significantly superior over raw coir pith at 5 t ha⁻¹ (16.73 pods plant⁻¹), dried weeds at 5 t ha⁻¹ (15.80 pods plant⁻¹) and dried weeds at 10 t ha⁻¹ (16.00 pods plant⁻¹). Sugarcane trash and maize straw mulches were found to record lower number of pods as compared to the above treatments but were significantly superior over control which recorded the lowest number of pods (9.40 pods plant⁻¹).

4.12.1.3. Number of immature pods per plant (Table 42)

The number of immature pods per plant of groundnut ranged from 1.10 to 4.40. The treatments of raw coir pith at 10 t ha⁻¹ recorded lower number of immature pods (1.10 pods plant⁻¹) but was par with sugarcane trash at 10 t ha⁻¹ (1.60 pods plant⁻¹) raw coir pith at 5 t ha⁻¹ (1.60 pods plant⁻¹), dried weeds at 5 t ha⁻¹ (1.60 pods plant⁻¹) and dried weeds at 10 t ha⁻¹ (1.53 pods plant⁻¹). The numbers of immature pods were significantly higher in sugarcane trash mulch at 5 t ha⁻¹ (2.93 pods plant⁻¹), maize straw mulch at 5 and 10 t ha⁻¹ and was on par with each other. Control accounted for the highest number (4.40 pods plant⁻¹) of immature pods per plant and was on par with T₂ and T₃.

4.12.1.4. Hundred kernel weight (Table 42)

The hundred kernel weight of groundnut ranged from 21.83 to 25.92 g. Higher kernel weight of groundnut was observed in raw coir pith at 10 t ha⁻¹ (25.92 g) treatment which was on par with dried weeds at 10 t ha⁻¹ (25.24 g) which in turn was on par with dried weeds mulch at 5 t ha⁻¹ (24.90 g) and raw coir pith at 5 t ha⁻¹ (24.56 g). The above sets of treatments were significantly superior over sugarcane trash and maize straw mulches (22.51 to 23.58 g). The control (no mulch) treatment was found to be inferior by registering minimum kernel weight (21.83 g).

4.12.2. Yield

4.12.2.1. Dry matter production (Table 43)

Dry matter production which represents the time trend of biomass was recorded at different phenophases of groundnut. A significant difference in dry matter production was observed with application of different mulches. The dry matter production of groundnut ranged from 2300 to 2948, 3454 to 4874 and 4355 to 7252 kg ha⁻¹ at vegetative, peg initiation and harvest stages respectively. Higher dry matter production was observed in raw coir pith at 10 t ha⁻¹

¹ treatment which was found to be on par with dried weeds at 10 t ha⁻¹ and dried weeds mulch at 5 t ha⁻¹ at all stages of crop growth. The dry matter production increased with advancement of crop growth and maximum being attained at harvest stage irrespective of mulches and their levels. At all the stages the no mulch control showed lowest values.

4.12.2.2. Pod yield (Table 43)

Pod yield of groundnut ranged from 1708 to 2663 kg ha⁻¹. The raw coir pith mulch at 10 t ha⁻¹ registered higher pod yield of 2663 kg ha⁻¹ and was on par with dried weeds at 10 t ha⁻¹ with 2600 kg ha⁻¹ and raw coir pith at 5 t ha⁻¹ (2565 kg ha⁻¹). The yield increase was 55.9, 52.2 and 50.1 per cent respectively over control. The above treatments were significantly superior over other mulches and control. The maize straw and sugarcane trash mulches recorded lower yield values ranging from 1768 to 2355 kg ha⁻¹ and were found inferior to coirpith and dried weed mulch and their levels. The yield increase in maize straw and sugarcane trash mulches ranged between 3.5 and 37.8 per cent over control. The no mulch (control) treatment recorded on par. Grain yield in sugarcane trash at 10 t ha⁻¹ (2355 kg ha⁻¹), and dried weeds at 5 t ha⁻¹ (2530 kg ha⁻¹) treatments were on par. Raw coir pith at 10 t ha⁻¹ and dried weeds at 10 t ha⁻¹ treatments have recorded 55.9, 52.2 per cent increase in yield over absolute control.

4.12.2.3. Haulm yield (Table 43)

Haulm yield of groundnut ranged from 2352 to 3073 kg ha⁻¹. Significantly higher haulm yield of 3073 kg ha⁻¹ was recorded by the raw coir pith mulch at 10 t ha⁻¹ which was followed by dried weeds at 10 t ha⁻¹ (2939 kg ha⁻¹) and 5 t ha⁻¹ (2936 kg ha⁻¹), raw coir pith at 5 t ha⁻¹ (2911 kg ha⁻¹). The yield increase being 29.1, 24.9, 24.8 and 23.7 percent over control. The above treatments were found to be significantly superior over sugarcane trash at 10 t ha⁻¹ (2684 kg ha⁻¹), sugarcane trash at 5 t ha⁻¹ (2774 kg ha⁻¹) and maize straw at 10 t ha⁻¹ (2612 kg ha⁻¹) treatments. The lowest haulm yield of 2352 kg ha⁻¹ was recorded in the control (no mulch) and however it was on par with maize straw mulch (5 t ha⁻¹) with haulm yield of 2533 kg ha⁻¹.

4.13. Effect of treatments on quality parameters of ground nut

4.13.1. Oil Content (Table 44)

Application of different organic mulches showed non significant increase in the oil content of groundnut kernel. The oil content ranged from 40.2 to 47.9 per cent. Higher oil content of 47.9 per cent was recorded by raw coir pith at 10 t ha⁻¹ followed by raw coir pith

at 5 t ha⁻¹, dried weeds at 10 t ha⁻¹ and dried weeds at 5 t ha⁻¹. Oil content of kernel in the remaining treatments ranged from 41.8 to 44.5 per cent. The control recorded the lowest oil content of 40.2 per cent and compared to all other mulched treatments.

4.13.2. Protein content (Table 44)

The application of different organic mulches had insignificantly increased the protein content of groundnut and values ranged from 15.7 to 22.6 per cent. The higher protein content was recorded by raw coir pith at 10 t ha⁻¹ (T₇) followed by dried weeds at 10 t ha⁻¹ (T₉), dried weeds at 5 t ha⁻¹ (T₈) and raw coir pith at 5 t ha⁻¹ (T₆). The protein content in the remaining mulched treatments ranged between 16.2 (maize straw at 5 t ha⁻¹) and 18.7 per cent (sugarcane trash at 10 t ha⁻¹). Lower protein content of 15.7 per cent was observed under no mulch (T₁).

4.13.3. Shelling percentage (Table 44)

The application of different organic mulches had insignificantly influenced the shelling per cent of groundnut and values ranged from 65.5 to 77.8 per cent. The higher shelling per cent was recorded by raw coir pith at 10 t ha⁻¹ (T₇) followed by dried weeds at 10 t ha⁻¹ (T₉), dried weeds at 5 t ha⁻¹ (T₈) and raw coir pith at 5 t ha⁻¹ (T₆). The shelling per cent in the remaining mulches ranged between 67.5 (maize straw at 5 t ha⁻¹) and 70.6 (sugarcane trash at 10 t ha⁻¹). The lowest shelling per cent of 65.5 percent was observed under no mulch (T₁).

4.14. Nutrient Content and uptake

4.14.1. Nitrogen content and uptake

4.14.1.1. Nitrogen content (Table 45)

Nitrogen content in groundnut ranged from 2.03 to 2.54, 1.72 to 2.26 and 4.24 to 5.87 per cent at vegetative, peg initiation and harvest stages respectively. Higher nitrogen content was recorded by raw coir pith mulch at 10 t ha⁻¹ treatment which was found to be on par with sugarcane trash at 10 t ha⁻¹, raw coir pith at 5 t ha⁻¹, dried weeds at 5 t ha⁻¹ and dried weeds at 10 t ha⁻¹ treatments at the two early stages of crop growth. At harvest stage, the nitrogen content under raw coir pith at 10 t ha⁻¹ (5.87 %) was on par with raw coir pith at 5 t ha⁻¹ treatment (5.40 %) and dried weeds at 10 t ha⁻¹ (5.66 %). The nitrogen content in groundnut under different mulches with different levels was significantly higher than the nitrogen content of control (no mulch).

4.14.1.2. Nitrogen uptake (Table 45)

Nitrogen uptake in groundnut ranged from 46.7 to 74.9, 59.4 to 110.2 and 71.5 to 149.3 kg ha⁻¹ at vegetative, peg initiation and harvest stages respectively. Significantly higher nitrogen uptake was observed by raw coir pith at 10 t ha⁻¹ and was found to be on par with dried weeds at 10 t ha⁻¹ treatment at vegetative and peg initiation stages of groundnut growth. At harvest stage also the nitrogen uptake of raw coir pith at 10 t ha⁻¹ treatment (149.3) was on par with dried weeds mulch at 10 t ha⁻¹ (140.4 kg ha⁻¹). The different mulches and their levels exhibited significantly higher nitrogen uptake over control irrespective of the stages.

4.14.1.3. Phosphorus content (Table 46)

Phosphorus content in groundnut ranged between 0.23 and 0.49, 0.18 and 0.42 and 0.40 to 0.94 per cent at vegetative, peg initiation and harvest stages respectively. The phosphorus content was observed to be higher under raw coir pith at 10 t ha⁻¹ treatment (0.49 %) which was found to be on par with raw coir pith at 5 t ha⁻¹, dried weeds at 5 t ha⁻¹ and dried weeds at 10 t ha⁻¹ treatments at the vegetative stage. At peg initiation, dried weeds mulch at two levels and raw coirpith at 10 t ha⁻¹ recorded on par higher phosphorus content and were significantly superior over other mulches. At harvest stage, raw coir pith at 10 t ha⁻¹ treatment (0.94 %) was on par with dried weeds at 10 t ha⁻¹ (0.85 %), raw coir pith at 5 t ha⁻¹ (0.81 %) and dried weeds at 5 t ha⁻¹ (0.77 %). The different mulches and their levels recorded significantly higher P content over control irrespective of the stages.

4.14.1.4. Phosphorus uptake (Table 46)

Phosphorus uptake in groundnut ranged from 5.29 to 14.45, 6.22 to 20.47 and 7.93 to 26.92 kg ha⁻¹ at vegetative, peg initiation and harvest stages respectively. Higher phosphorus uptake was observed under raw coir pith at 10 t ha⁻¹ which was found to be on par with dried weeds at 10 t ha⁻¹ treatment at vegetative and peg initiation stages. At harvest stage, higher phosphorus uptake was recorded by raw coir pith at 10 t ha⁻¹ treatment (26.92 kg ha⁻¹) which was significantly superior over dried weeds at 10 t ha⁻¹ (23.49 kg ha⁻¹) and raw coir pith at 5 t ha⁻¹ (22.06 kg ha⁻¹). The different mulches and their levels recorded significantly higher phosphorus uptake over control in all the three stages.

4.14.1.5. Potassium content (Table 47)

Potassium content in groundnut ranged between 1.99 and 3.05, 2.21 and 2.78 and 3.93 and 5.58 per cent at vegetative, peg initiation and harvest stages respectively. Higher potassium content was observed by raw coir pith at 10 t ha⁻¹ treatment which was on par with raw coir pith at 5 t ha⁻¹, dried weed mulch at two levels and sugarcane trash at two levels at early two stages of crop growth. At harvest stage, the potassium content under raw coir pith mulch at 10 t ha⁻¹ (5.58 %) was on par with dried weeds at 10 t ha⁻¹ (5.43 %), raw coir pith at 5 t ha⁻¹ (5.22 %), dried weeds at 5 t ha⁻¹ (5.14 %). Potassium content of groundnut under different mulches and their levels were higher over no mulch control.

4.14.1.6. Potassium uptake (Table 47)

Potassium uptake in groundnut ranged between 45.8 to 89.9, 76.3 to 135.5 and 80.0 to 159.8 kg ha⁻¹ at vegetative, peg initiation and harvest stages respectively. Raw coir pith mulch at 10 t ha⁻¹ and dried weeds at 10 t ha⁻¹ recorded higher but on par potassium uptake values at vegetative and peg initiation stages of groundnut. At harvest stage, the potassium uptake of raw coir pith at 10 t ha⁻¹ (159.8 kg ha⁻¹) was on par with dried weeds at 10 t ha⁻¹ (150.2 kg ha⁻¹). Different mulches and their levels recorded higher potassium uptake over control.

4.15. Nutrient content and uptake in groundnut pod

4.15.1. Nitrogen content and Uptake

4.15.1. 1. Nitrogen content (Table 48)

Nitrogen content in groundnut pod ranged between 2.52 and 3.61 per cent and higher value being recorded by raw coir pith at 10 t ha⁻¹ treatment which was found to be on par with the raw coir pith at 5 t ha⁻¹, dried weeds at 5 t ha⁻¹ and dried weeds at 10 t ha⁻¹. The sugarcane trash mulch at 10 t ha⁻¹, sugarcane trash mulch at 5 t ha⁻¹ and maize straw at 10 t ha⁻¹ (2.99, 2.86, and 2.74 % respectively) treatments were on par and were inferior to T₇. The nitrogen content in groundnut pod under mulches with different levels were significantly higher than the nitrogen content in the control (no mulch). However the control was on par with the treatments T₂, T₃, T₄ and T₅.

4.15.1. 2. Nitrogen uptake (Table 48)

Nitrogen uptake in groundnut pod ranged from 43.0 to 96.1 kg ha⁻¹. Higher nitrogen uptake was noticed under the raw coir pith mulch at 10 t ha⁻¹ (96.1 kg ha⁻¹) which was on par with dried weeds at 10 t ha⁻¹ treatment (90.5 kg ha⁻¹). The nitrogen uptake in the remaining mulches treatments ranged from 45.8 to 85.8 kg ha⁻¹ and were inferior to

coirpith and dried weed mulches. The control registered lower nitrogen uptake of 43.0 kg ha⁻¹ and was on par with maize straw mulch (T₂).

4.15.2. Phosphorus content and uptake

4.15.2.1. Phosphorus content (Table 48)

Phosphorus content in groundnut pod ranged between 0.23 and 0.48 per cent. The raw coir pith at 10 t ha⁻¹ (0.48 %) treatment was found to be on par with dried weeds at 10 t ha⁻¹, raw coir pith at 5 t ha⁻¹ and sugarcane trash mulch at 10 t ha⁻¹. The phosphorus content in the maize straw mulch at both levels were significantly lower than raw coirpith and weed mulches but was superior over no mulch treatment (0.23 %).

4.15.2. 2. Phosphorus uptake (Table 48)

Phosphorus uptake in groundnut pod ranged from 3.93 to 12.78 kg ha⁻¹. Raw coir pith at 10 t ha⁻¹ (12.78 kg ha⁻¹) followed by dried weeds at 10 t ha⁻¹ (11.44 kg ha⁻¹) and raw coir pith at 5 t ha⁻¹ (11.29 kg ha⁻¹) registered at par higher uptake values over other mulches. Maize straw and sugarcane trash mulches were inferior to T₇, T₉ and T₆ treatments. The control recorded the lowest uptake of 3.93 kg ha⁻¹.

4.15.3. Potassium content and uptake

4.15.3.1. Potassium content (Table 48)

Potassium content in groundnut pod ranged from 1.97 to 2.85 per cent. Higher potassium content was recorded in the treatment of raw coir pith at 10 t ha⁻¹ (2.85 %) which was on par with raw coir pith at 5 t ha⁻¹ (2.64 %), dried weeds at 5 t ha⁻¹ (2.61 %) and dried weeds at 10 t ha⁻¹ (2.76 %). The potassium content was comparatively lower under control (0.42 %) and was on par with maize straw mulch at the two levels.

4.15.3.2. Potassium uptake (Table 48)

Uptake of potassium in groundnut pod ranged between 33.6 and 75.9 kg ha⁻¹. Uptake of potassium under raw coir pith mulch at 10 t ha⁻¹ (75.9 kg ha⁻¹) followed by dried weeds at 10 t ha⁻¹ (71.8 kg ha⁻¹) were significantly superior over other treatments. These were followed by sugarcane trash and maize straw mulches with potassium uptake values ranging from 37.7 to 61.0 kg ha⁻¹. The control registered the lowest potassium uptake and was on par with maize straw at 5 t ha⁻¹.

4.16. Nutrient content and uptake in groundnut haulm

4.16.1. Nitrogen content and Uptake

4.16.1. 1. Nitrogen content (Table 49)

Nitrogen content in groundnut haulm at harvest stage ranged between 1.21 and 1.73 per cent and higher value being recorded by raw coir pith at 10 t ha⁻¹ treatment which was found to be on par with the raw coir pith at 5 t ha⁻¹, dried weeds at 5 t ha⁻¹, dried weeds at 10 t ha⁻¹ and sugarcane trash mulch at 10 t ha⁻¹. The sugarcane trash mulch at 5 t ha⁻¹, maize straw mulch at 5 and 10 t ha⁻¹ (1.48, 1.38, and 1.42 % respectively) treatments were on par and were inferior to T₇. The nitrogen content in groundnut haulm under mulches with different levels were significantly higher than the nitrogen content in the control (no mulch). However the control was on par with the treatments T₂ and T₃.

4.16.1. 2. Nitrogen uptake (Table 49)

Nitrogen uptake in groundnut haulm ranged from 28.5 to 53.2 kg ha⁻¹. Higher nitrogen uptake was noticed under the raw coir pith mulch at 10 t ha⁻¹ (53.2 kg ha⁻¹) which was on par with dried weeds at 10 t ha⁻¹ treatment (50.0 kg ha⁻¹). The nitrogen uptake in the remaining mulches treatments ranged from 35.0 to 48.0 kg ha⁻¹ and were inferior to coirpith and dried weed mulches. The control registered lower nitrogen uptake of 28.5 kg ha⁻¹ and was on par with maize straw mulch (T₂).

4.16.2. Phosphorus content and uptake

4.16.2.1. Phosphorus content (Table 49)

Phosphorus content in groundnut haulm ranged between 0.17 and 0.46 per cent. The raw coir pith at 10 t ha⁻¹ (0.47 %) treatment was found to be on par with dried weeds at 10 t ha⁻¹. The phosphorus content in the maize straw and sugarcane trash mulch at both levels were significantly lower than raw coirpith and weed mulches but was superior over no mulch treatment (0.17 %).

4.16.2. 2. Phosphorus uptake (Table 49)

Phosphorus uptake in groundnut haulm ranged from 4.00 to 14.14 kg ha⁻¹. Raw coir pith at 10 t ha⁻¹ (14.14 kg ha⁻¹) followed by dried weeds at 10 t ha⁻¹ (12.05 kg ha⁻¹) registered at par higher uptake values over other mulches. Maize straw and sugarcane trash mulches were inferior to T₇, T₉ and T₆ treatments. The control recorded the lowest uptake of 4.00 kg ha⁻¹.

4.16.3. Potassium content and uptake

4.16.3.1. Potassium content (Table 49)

Potassium content in groundnut haulm ranged from 1.97 to 2.73 per cent. Higher potassium content was recorded in the treatment of raw coir pith at 10 t ha⁻¹ (2.73 %) which was on par with sugarcane trash mulch at 5 and 10 t ha⁻¹ (2.39 and 2.46 % respectively), raw coir pith at 5 t ha⁻¹ (2.58 %), dried weeds at 5 t ha⁻¹ (2.53 %) and dried weeds at 10 t ha⁻¹ (2.67 %). The potassium content was comparatively lower under control (1.97 %) and was on par with maize straw mulch at the two levels.

4.16.3.2. Potassium uptake (Table 49)

Uptake of potassium in groundnut haulm ranged between 46.3 and 83.9 kg ha⁻¹. Uptake of potassium under raw coir pith mulch at 10 t ha⁻¹ (83.9 kg ha⁻¹) followed by dried weeds at 10 t ha⁻¹ (78.5 kg ha⁻¹) were significantly superior over other treatments. These were followed by sugarcane trash and maize straw mulches with potassium uptake values ranging from 53.7 to 66.0 kg ha⁻¹. The control registered the lowest potassium uptake and was on par with maize straw at 5 t ha⁻¹.

4.17. Effect of organic mulches on weed control

4.17.1. Weed flora

The weed flora observed in the experimental field during the course of study consisted of grasses, sedges, and broad leaved weeds. The major weeds were *Cynodon dactylon*, *Dactyloctenium aegyptium* in grasses, *Cyperus rotundus* in sedges, *Digera arvensis*, *Parthenium hysterophorus*, *Trianthema portulacastrum*, *Datura metal* and *Acalypha indica* in broad leaved weeds.

4.17.2. Total weed population (Table 50)

The total weed population was significantly reduced by the various mulching practises. The general appraisal revealed that the increased quantity of mulching material decreased the total weed population. The application of sugarcane trash mulch at 10 t ha⁻¹ significantly reduced the total weed population at all the three stages (98.0, 97.2 and 109.2 number per m² at vegetative, peg initiation and harvest stages respectively). This was followed by maize straw at 10 t ha⁻¹, sugarcane trash mulch at 5 t ha⁻¹, dried weeds at 10 t ha⁻¹ and dried weeds at 5 t ha⁻¹ treatments. The highest weed population was observed in the control treatment (229.2, 204.8 and 185.2 number per m² at vegetative, peg initiation and harvest stages respectively) (without mulching).

4.17.3. Weed dry matter production (Table 51)

The dry matter production of weeds was recorded at vegetative, peg initiation and harvest stages of groundnut growth. Increased dry matter production was observed with advancement of crop growth. The mean dry matter production of weeds ranged from 82.9 to 113.4, 127.4 to 148.2 and 132.6 to 164.8 at vegetative, peg initiation and harvest stages respectively. At the vegetative stage maize straw mulch at 10 t ha⁻¹ followed by sugarcane trash mulch at 10 t ha⁻¹ recorded the lower weed dry matter of 82.4 and 82.9 kg ha⁻¹ respectively. However at peg initiation and harvest stages sugarcane trash mulch accounted for lower weed dry matter production of 127.4 and 132.6 kg ha⁻¹ respectively. It was followed by maize straw at 10 t ha⁻¹, sugarcane trash mulch at 5 t ha⁻¹ and dried weeds at 10 t ha⁻¹ treatments. The control (without mulching) recorded the highest weed dry matter production of 113.4, 148.2 and 164.8 kg ha⁻¹ at vegetative, peg initiation and harvest stages respectively.

4.18. Correlation studies (Table 52 and 53)

The relationship of the soil available N, P and K, organic carbon, physical and biological properties of the soil are given below.

The chemical parameters viz., available N, P and K of soil had positive significant correlation with the physical and biological properties of soil and negative significant correlation with bulk density and soil temperature. The relationship studies had clearly indicated that the bulk density was significantly related to increase soil organic carbon. It is obvious that the soil organic carbon and mineralization of nutrients were closely interrelated and had a profound influence on biomass yield and soil organic carbon.

The biological properties viz., available bacteria, fungi and actinomycetes of soil had positive significant correlation with the physical and chemical properties of soil and negative significant correlation with water holding capacity and soil temperature.

The relationship studies had clearly indicated that the physical properties of soil had positive significant correlation with the chemical and biological properties of soil except bulk density and soil temperature. The bulk density had negative significant correlation with all chemical and biological properties of soil. Soil temperature had negative significant correlation with all chemical and biological properties of soil. Temperature was

not significantly influenced by surface soil moisture at all stages of crop growth. Uptake of nutrients at different stages showed positive significant correlation with the yield.

CHAPTER V

DISCUSSION

Excessive use of chemical fertilizers and pesticides in agriculture has come into criticism by the environmentally conscious group who opine that the increase in agriculture production was achieved at the cost of soil health (Arden-Clarke and Hodges, 1988). The environmental degradation because of faulty agricultural practices has set several experts to focus attention on ecologically sound, viable and sustainable farming system. One such system that will help to overcome the problems of soil and environmental degradation is “organic mulching” which aims at co-operating rather than confronting with the nature (Gunjal, 1991).

The present study was undertaken to evaluate the effect of different mulches its effect on soil fertility and crop productivity of maize and groundnut under rainfed condition. The results obtained from this study are discussed below.

5.1. Effect of different organic mulches on soil physical properties

Application of organic mulches generally improves the soil physical conditions besides improving the nutrient availability and biological properties. Soil physical property improvement by addition of organic manure is mainly due aggregation of soil particle through which porosity, soil air, water holding capacity and bulk density are maintained at optimum level to maximize the crop yield.

5. 1. 1. Bulk density and porosity

Mulch application significantly improved the bulk density and porosity of soil. In maize, the bulk density of soil under raw coirpith mulch at 5 t ha⁻¹ and 10 t ha⁻¹ was 1.33 (0-15cm) and 1.42 (15-30 cm) Mg m⁻³ respectively and porosity was 44.9 per cent, when compared to its initial values of 1.40 and 1.47 Mg m⁻³ at 0-15 and 15-30 cm soil depth and 44.8 per cent of porosity. In groundnut, the bulk density of raw coirpith at 5 t ha⁻¹ and 10 t ha⁻¹ surface mulch applied soil was 1.31 (0-15cm) and 1.43 (15-30 cm) Mg m⁻³ respectively and porosity was 44.8 per cent, when compared to its initial bulk density value of 1.40 and 1.47 Mg m⁻³ of bulk density at 0-15 and 15-30 cm depth and 44.8 per cent of porosity. The decrease in bulk density and increased porosity was due to increased aggregation from increased soil organic carbon content under mulch. Similar findings were also expressed by Rajkannan *et al.* (2001) and Dahiya *et al.* (2003) who have reported that the presence of residues on the soil surface maintained the low bulk density.

Ghosh *et al.* (2006) reported that the soil under wheat straw mulch generate more favorable habitats for soil and surface dwelling earthworms and microorganisms (Hatfield and Steward, 1994; Unger and Jones, 1998; Acharya *et al.*, 2005) which might have contributed to low bulk density under straw mulch.

Mulumba and Lal (2008) reported that the total porosity increased with increased rate of mulch application and it was significantly lower under the no mulch treatments. Increased porosity due to mulch application was also reported by Oliveira and Mervin (2001). The increased porosity is important to crop development since it may have a direct effect on soil aeration and can enhance root growth (Sugiyanto *et al.*, 1986).

5. 1. 2. Water holding capacity and saturated hydraulic conductivity

Water holding capacity of soil, which depends on micro porosity of soil varied significantly with different organic mulches application. Among the different mulches used under the maize crop, raw coirpith at 10 t ha⁻¹ showed its superiority of 15 per cent higher water holding capacity over the control (without mulch) and in groundnut, raw coirpith at 10 t ha⁻¹ showed its superiority with 13 per cent higher water holding capacity over the control (no mulch). The increased water holding capacity may be attributed to more micro pores, which are responsible for more water retention. Further, their higher humus content, higher surface area and favourable soil aggregates would have resulted in increased water holding capacity. These results are in confirmity with the findings of Venkatesh (1995).

Saturated hydraulic conductivity, a physical property indicates the condition of soil in terms of drainage. Different organic mulches application had significant effect on saturated hydraulic conductivity of soil. In maize the highest saturated hydraulic conductivity was accounted in the treatment that has received raw coirpith at 10 t ha⁻¹ (T₇) and for groundnut also highest saturated hydraulic conductivity was accounted in the treatment of raw coirpith mulch at 10 t ha⁻¹ (T₇) and can be attributed to their higher pore space, low bulk density and favorable soil structure. These results are in accordance with the finding of Chan and Heena (1995).

5. 1. 3. Soil moisture (Fig. 3 and 4)

Soil moisture content in the surface and subsurface was affected by mulch application. Both crop residue and coirpith surface mulch consistently helped in retaining higher soil moisture content upto 30 cm soil depth than control through out the crop growth

period. Organic mulch forms a barrier at the evaporating soil surface and alters microclimate, which acts as the driving force for evaporation. The soil moisture content in both maize and groundnut ranged from 10.54 to 18.14 per cent and 10.74 to 19.57 per cent respectively at surface layer. Among the different organic mulches, application of raw coirpith at 10 t ha⁻¹ (T₇) retained more soil moisture content followed by dried weeds at 10 t ha⁻¹ (T₈), raw coirpith at 5 t ha⁻¹ and dried weeds at 5 t ha⁻¹ than the control. Due to this the soil moisture got depleted at a slower rate from the top soil layers in plots under organic mulches than the bare soil (Jalota and Prihar, 1990; Prihar *et al.*, 1996; Ji *et al.*, 2001; Pawar *et al.*, 2004). Vadi *et al.* (2005) reported that the wheat straw mulch has recorded higher soil moisture content than unmulched plot. This might be due to reduction in soil temperature (Cadavid *et al.*, 1998) as well as weed growth (Bussiere and Cellier, 1994) and increased downward movement of rain water. Mulching increased the leaf area index and there by reduced the soil evaporation rate by 40 – 50 mm and prolonged soil moisture retention. (Zhang *et al.*, 2005; Movahedi Naeni and Cook, 2000). Mulching produced greater infiltration by runoff reduction and subsequent evaporation suppression of the infiltrated water that apparently contributed to soil moisture gains (Unger, 1994) and reflected on favourable plant physiological parameters in cowpea. The increased soil water accumulation under mulching in comparison with no mulching treatment has been reported by Sharma (1998). Negative and significant relationships were also seen between soil moisture and temperature ($r = 0.910^{**}$). These 'r' values also clearly depicted the relationship between soil moisture and temperature.

5. 1. 4. Soil temperature (Fig. 5 and 6)

Soil temperature recorded at various intervals showed that, there was reduction in mulch applied treatments in the entire experimental period, when compared to ambient temperature. These results were in agreement with the findings of Gupta and Acharya (1993) and who also reported that the soil temperature was 2.9 – 4.1⁰C lower than the atmospheric temperature. The decrease in the soil temperature under vegetative mulches is partly due to their higher albedo, greater conversion of solar energy into evaporative flux and increase in diffusion path of heat transfer to the soil (Stratton and Rechcigl, 1998; Lalitha *et al.*, 2001). The mulch layer on the field surface can weaken the intensity of turbulent exchange between the atmosphere and soil water, which cause soil moisture to be prevented from evaporation, and thus reduce ineffective water consumption. However the mulch treatment

usually promotes plant growth associated with higher plant transpiration and greater soil water loss.

Regarding maize, the mulched treatments recorded lower soil temperature during early growth stages while it reduced the soil temperature at tasseling and harvest when compared to control. The lower soil temperature of mulched plots observed in the investigation were in agreement with the results of Choi and Chung (1997) who observed that thermistors placed at soil surface recorded decrease in soil temperature by 3.0 – 3.9 °C and 2.9 to 4.7 °C at 30 cm depth when compared to control. The findings of Devi Dayal *et al.* (1991) showed a decrease of 2 – 3 °C in soil temperature with wheat straw mulch under maize. The correlation between soil temperature and moisture was negative and significant at growth stage ($r = -0.918^{**}$).

In groundnut, mulch has decreased the soil temperature by 1.3 – 5.2 °C during early growth period, while it reduced the soil temperature by 0.1–1 °C during pod development stage of crop as compared to control. Similar findings were also expressed by Ghosh *et al.* (2006) who observed that the wheat straw mulch increased the soil temperature by 2 – 3 °C during early growth period, while it reduced the soil temperature by 2 – 4 °C during pod development stage of groundnut. The soil temperature in mulched treatments was lower than that in control at pod development stage and late filling stage. However the soil temperature in straw mulch applied area was lower than that in control, which is in agreement with results obtained earlier Devi Dayal *et al.* (1991). The lower soil temperature with straw mulch may be caused by the combined effects of changes in albedo and surface roughness, increased plant cover, and higher water content at the soil surface. Excessive amount of straw may lead to low soil temperature. However, Chen *et al.* (1988) argued the soil temperature with straw mulch decreased in the day and was conserved at night. Negative and significant relationships were also seen between soil moisture and temperature ($r = -0.713^{*}$). These 'r' values also clearly depicted the relationship between soil moisture and temperature.

5.2. Effect of different organic mulches on chemical properties

Addition of organic mulches viz., raw coirpith maize straw, sugarcane trash and dried weeds improved the soil physical condition. Further, in the process of decomposition nutrients are released slowly but steadily so that the released nutrients are taken by crops

without much loss from the soil system. The process of mineralisation also supplies most of the essential nutrients including micronutrients.

5. 2.1. Soil reaction (pH)

Soil reaction is the most important chemical characteristic of the soil, which affects the nutrient availability to the crop plants. It is also a sensitive property of soil being influenced by nature and amount of organic matter applied.

The experimental soil initial pH was 8.23. The treatment including dried weeds at 10 t ha⁻¹ surface mulch had recorded higher soil pH in both crops. This might be due to release of basic cations from mulch. Lal *et al.* (2000) reported that in mulch applied soil basic cations were responsible for rise in pH and after that release of organic acids played a major role in influencing soil reaction. The rise in soil pH by mulch application was also reported by Cadavid *et al.* (1998).

5. 2.2. Electrical conductivity (EC)

The electrical conductivity observed in the experimental soil at the initial sampling time was about 0.13 dS m⁻¹. The EC of the soil was decreased in mulch applied soil under both crops. The reduction in EC could be due to the leaching of salts and uptake by the crop. These results were in agreement with the findings of Dahiya *et al.* (2003), who have reported that the application of sugarcane trash mulch to sugarcane reduced the EC from 0.33 dS m⁻¹ to 0.29 dS m⁻¹. They also reported that the mulch application significantly decreased the soil EC of 10 – 15 cm layer by 6.4 per cent as compared to unmulched soil. Higher leaching and lower evaporation under mulches might have contributed towards decline in upward movement of salts from lower soil profile contributed to in salt accumulation.

5.2.3. Organic carbon

Organic carbon is an indicator of health status of soil as it influences the soil physical, chemical and biological properties and it is also the indispensable component of the soil system.

Application of different organic mulches had favourably influenced the organic carbon content of soil. The organic carbon under maize ranged from 0.44 per cent to 0.52 per cent and for groundnut it ranged from 0.43 to 0.53 per cent. Among the different organic mulches, application of dried weeds at 10 t ha⁻¹ (T₉) recorded higher organic

carbon content followed by dried weeds at 5 t ha^{-1} (T_8), sugarcane trash at 5 t ha^{-1} and sugarcane trash at 10 t ha^{-1} than the control. It might be due to higher humus content of dried weeds resulted from decomposition. The supply of nitrogen during initial period of decomposition avoided the immobilization caused by microbes in mulch treated plots. Similar results were observed by Balaji (1994) and Acharya *et al.* (1998). Tindall *et al.* (1991) also observed a buildup that in soil organic carbon of mulch applied plot due to their decomposition.

5. 2.4. Available nitrogen (Fig. 7)

The available nutrient contents of the soil varied significantly with various organic mulches application. The highest available N was recorded in dried weeds mulch at 10 t ha^{-1} (T_9) which showed 31 per cent higher available N over the control. This could be attributed to the lower C: N ratio of dried weeds which resulted in fast decomposition and release of nutrients as compared to maize stover, sugarcane trash and raw coirpith. Balaji (1994) and Venkatesh (1995) also reported similar increase in available nitrogen content of the soil due to mulch application. The high available nitrogen in surface mulch treatment is due to higher microbial biomass and activity often lead to high nitrogen mineralization and soil ammoniacal nitrogen and nitrate nitrogen concentration. Similar results were also recorded by Daisley *et al.* (1998) who observed an increase in available nitrogen content due to mineralization of native nitrogen by higher bacterial population in organic mulch treatments. Acharya *et al.* (1998) reported that available nitrogen in mulch treatment increased due to the application of nitrogen containing organic mulches.

Regarding maize, the available N of soil at knee-high stage was 151.3 kg ha^{-1} in T_9 and at harvest stage 138.3 kg ha^{-1} for maize. Such depletion in soil nitrogen due to higher N uptake of crops like maize with the progression of crop is reported in many literatures (Kuo *et al.*, 1997 and Sainju *et al.*, 2002). The transformation losses would have also contributed to the reduction in the advanced stage of crop. In contrast to maize, groundnut had available N content of soil at vegetative stage was 165.8 kg ha^{-1} and 167.8 kg ha^{-1} at harvest stage. Such maintenance of available N status under groundnut crop could be due to the N fixing capacity of the plants. Peoples *et al.*, (2001) reported similar increase in available N status of groundnut grown soil.

2.5. Available phosphorous (Fig. 8)

Application of different organic mulches significantly influenced the available phosphorus status of soil. Among the different organic mulches, application of dried weeds mulch at 10 t ha⁻¹ (T₉) recorded higher available phosphorus for both crops. The reason attributed to the increased available phosphorus in soil might be due to higher phosphorus content of dried weeds. Further, decomposition of dried weeds leads to increase in the available nitrogen which in turn increased the phosphorus status due to its synergetic effect. The organic acids released from decomposition of dried weeds could have released fixed phosphorus into the available pool. Kale *et al.* (1992) also reported an increase in soil available phosphorus with mulch application. In the present study, the available phosphorus content was decreased towards advancement of crop growth. Similar findings were also expressed by Duraisami and Mani (2000), who have reported that, irrespective of the cropping and nitrogen levels and available phosphorus decreased considerably with advancement of maize growth which might be due to crop removal.

On an average, the mulch treatments increased the available phosphorus by 16.1 per cent as compared to that of unmulched. There was increase in soil phosphorus availability with the sugarcane trash mulch. The sugarcane trash mulch and insitu green mulch increased the availability of native phosphorus by 19.3 and 4.8 per cent and of added phosphorus by 23.6 and 11.5 per cent. The organic acids produced during the decomposition of mulching materials complexed the metal cations viz., Ca, Al and Fe, thereby helping in solubilization of native phosphorus and reduction in phosphorus sorption.

5. 2. 6. Available potassium (Fig. 9)

Different organic mulches application had its own influence on availability of K in soil. The available K under maize ranged from 281.8 kg ha⁻¹ to 384.2 kg ha⁻¹ while for groundnut it ranged from 414.2 kg ha⁻¹ to 417.3 kg ha⁻¹ in post harvest soil. Among the different organic mulch combinations, application of dried weeds at 10 t ha⁻¹ (T₉) registered the highest available K, which was higher than other mulches and control. The reason attributed could be the organic and inorganic acids produced during decomposition of dried weeds which might have helped in the release of mineral bound insoluble potassium. The increased N could have also increased the K availability through its synergistic effect. Similar results were obtained by Srinivasan Rao *et al.* (1997). Lal *et al.* (2000) reported that the microorganisms and organic decomposition products affect the availability of potassium through liberation of organically bound potassium by decomposition process as

well as by solubilization of insoluble forms present in soil and minerals. Khistaria *et al.* (1994) also observed similar results when they incorporated different tree leaves in soil. The amount of potassium mineralized increased significantly and raised the available potassium pool in soil due to release of more organically bound potassium in course of decomposition of organic wastes.

Among the different stages, the available K status was the highest at knee-high stage followed by tasselling and the lowest available K was recorded at post harvest soil. The decrease in soil available K could be attributed to the uptake of K by maize crop.

Among the different stages in groundnut, the available K status was higher at harvest stage followed by peg initiation and the lower available K was recorded at vegetative stage. Cadavid *et al.* (1998) reported that the soil potassium was significantly increased due to mulching when compared to control indicating that the application of plant residues are rich in potassium.

5.3. Effect of different organic mulches on soil biological properties

Organic mulching aims to maintain soil health by increasing the soil living organisms. All chemical reactions in soil involve soil enzymes which are mainly depend on in soil microbes. The soil biological properties decide the chemical properties of soil.

5.3.1. Microbial population

Generally, the organic mulch application had conspicuously increased the microbial population. Application of different organic mulches had significantly increased the bacterial build up of soil. The highest bacterial population was associated with the application of raw coirpith at 10 t ha⁻¹(T₇) under maize and dried weeds at 10 t ha⁻¹(T₉) under groundnut. This reason for this may be attributed to the coirpith containing higher amount of growth promoting substances, vitamins and enzymes, which in turn increased the bacterial population. In addition to that the cooler soil temperature and enhanced soil moisture would have increased the root biomass production, which resulted in higher production of root exudates increasing bacterial population in rhizosphere region. These results are in confirmity with the findings of Gunadi *et al.* (1999) and Suresh *et al.* (1995). Bacterial population gradually increased from vegetative to harvesting stage. It might be due to favourable physical and chemical environment of soil, which favoured the growth of bacterial population in the presence of crop.

Application of different organic mulches had conspicuously increased the fungal population. Among the different organic sources, raw coirpith mulch at 10 t ha^{-1} (T₇) under maize and dried weeds at 10 t ha^{-1} (T₉) under groundnut recorded maximum fungal population over the control. The reason attributed again to the favourable environment facilitated by organics. The fungal population gradually increased from vegetative to harvesting stage. The increased microbial population in mulch applied soil might be due to the presence of high organic carbon content in soil. Significant increase in microbial biomass and activity under crop residue mulch was reported by Karlen *et al.* (1994) and Dominy and Haynes (2002). This might be due to easily decomposable organic carbon in soil after additions of mulch with a moderate total C: N ratio likely contributing to the enhanced microbial biomass and activity.

Application of dried weeds at 10 t ha^{-1} (T₉) accounted for the highest population of actinomycetes while the lowest population noticed in control for both crops. The reasoning discussed under bacteria and fungi also holds good for actinomycetes. Tu *et al.* (2006) reported that the organic mulching had beneficial effects on soil microbes likely through buffering the extreme fluctuations in soil moisture and temperature.

Increased biological numbers were observed in mulch applied soil. Bacteria, fungi and actinomycetes population were higher in partially composted surface mulch applied soil in maize crop. Straw-surface mulching enhanced microbial biomass and activity and potential nitrogen supply. Such effects of mulching may originate from improvements of soil carbon and water availability. In addition to direct carbon inputs (Pinamonti, 1998; Tiquia *et al.* 2002), organic mulching also improves soil moisture through reducing evaporation from soil (Franzluebbers *et al.*, 1995), thus mitigating the disruptive effect of soil drying on microbes especially in dry season.

5.3. 2. Effect of mulching on plant growth

Plant growth parameters viz., plant height of the maize was significantly influenced by mulch application. Application of different organic mulches had considerably increased the plant height over the control. Among the different organic mulches, application of raw coirpith at 10 t ha^{-1} (T₇) registered 35.3 per cent increase in maize height and 1.21 per cent increase in groundnut plant height over the control. Ghosh *et al.* (2006) observed that the application of mulch (organic) kept the surface layer wetter for longer periods and enhanced seedling emergence. The time required for initiation of seedling emergence was

shorter under mulching than under no mulching. Similar results under wheat straw mulch was reported by Sarmah (1986) in soybean crop and Ning and Hu (1990) in maize crop.

Crop residue mulch without partial composting recorded maximum plant height, number of leaves and stem girth in maize. This might be due to better moisture conservation by mulches and higher uptake of nutrients by plants because of increased availability of nutrients in soil. Similar results were also expressed by Ghosh *et al.* (2006) with respect to maize and groundnut. Nagarajan and Wahab (2001) reported that in ragi, the application of mulch regulated more plant height, number of tillers hill⁻¹, and leaf area index as compared to control. The increase in growth components is due to adequate moisture supply in the root zone which increased the growth components. Jadhav and Jadhav (1999) reported that adequate supply of water increased cell turgidity and consequently higher meristematic activity and macronutrient uptake leading to relatively more foliage.

Tu *et al.* (2006) reported that high microbial biomass and activity in mulch applied plot often lead to high nutrient availability to crops (Zaman *et al.*, 1999 and Wang *et al.*, 2004), which results in increased plant productivity.

5. 3.3. Effect of different organic mulches on yield (Fig. 10 and 11)

Application of different organic mulches had conspicuously increased the yield of maize over the control. Among the different organic mulches, application of raw coirpith at 10 t ha⁻¹ (T₇) recorded 73 and 43 per cent higher yield of maize grain and stover followed by dried weeds at 10 t ha⁻¹ (T₉) over the control (T₁). It is worth to mention here that the addition of organic mulches was found to be better as compared to control. This could be explained as the nutrient release from the organic sources was continuous, slow and steady but in the unmulched, fertilized control the release would have been very fast subjected to transformation losses from the system. Anon, (1992) indicated that integrating the organics with fertilizers could save 25 per cent N through organic mulches. Among different organic mulches, application of dried weeds proved to be superior since the composition of raw coir pith would have supplied growth promoting substances, enzymes etc, in addition to their nutrient supply.

Yield parameters viz., matured pods; immature pods, pod yield and haulm yield of the groundnut were significantly influenced by mulch application. Application of different

organic mulches had conspicuously increased the yield of groundnut over the control. Among the different organic mulches, application of raw coirpith at 10 t ha⁻¹ (T₇) recorded 56 and 30.6 per cent higher yield of groundnut pod and haulm respectively followed by dried weeds at 10 t ha⁻¹ (T₉) over the control (T₁). Initial soil temperature was greater under control and however, during pod development stage the soil temperature recorded at 14 h under raw coirpith mulch was reduced by 2–4.2°C.

The coirpith and dried weeds consistently helped in retaining higher soil water than the control. However, between these two mulches, the raw coirpith mulch maintained higher soil water during the period of crop growth. Thus, favourable soil temperature and soil water under raw coirpith mulch during the pod development stage could be the reason for higher pod yield and harvest index of groundnut. The result of the present study is in conformity to the findings of Osuji (1990), Khistaria *et al.* (1994), Khan (2002) and Pawar *et al.* (2004). Another factor significantly contributing to higher pod yield under raw coirpith mulch is flower production and mature pod numbers. Retention of high soil water and maintaining favourable soil temperature under raw coirpith mulch through out the crop growth, especially at relatively sensitive growth stages (germination and podding) favoured greater flower numbers, mature pod numbers and pod yield per plant. Similar to raw coirpith mulch, the beneficial effect of other mulches on pod yield of groundnut was observed in the present study.

Ramakrishna *et al.* (1999) showed that the groundnut plants in straw mulched plot were generally tall, more vigorous and reached 50 per cent flowering 4 to 6 days earlier than in the unmulched plots. The more favourable soil environment under the straw mulch, resulted in increased numbers of pods plant⁻¹, pod mass, pod and haulm yield. In the process of refinement of mulch technology it was observed that the combined application of wheat straw mulch and black polythene mulch out-yielded sole application of wheat straw mulch. During early crop growth, black polythene exhibited early and maximum seedling emergence but later, particularly during pod development stage, Wheat straw mulch sustained optimum soil water and favourable soil temperature. This explains how the dual action of the combined use of organic and inorganic mulch on soil hydrothermal regimes benefits summer groundnut. It was observed that the wheat straw mulch alone and the combined use of wheat straw and black polythene mulch were equally effective in

increasing haulm yield, though the extent of increase in haulm yield was less (16–18 per cent) than the increase in pod yield (23–46 per cent) due to mulch.

Availability of higher soil moisture, enhanced infiltration of rain water by restricting the surface flow, reduced evaporation and suppression of weeds under ridges and furrows or tied ridges with mulching contributed collectively to better plant physiology and grain yield. Li *et al.* (2001) reported that the ridges and furrows technique combined with mulching maximized the utilization of rainwater in arid and semi arid areas. The favourable effect of straw mulch on yield of pearl millet was mainly due to conservation of rainwater in the soil profile.

Another possible reason for increased yield under mulches is release of macronutrient as well as micronutrients and maintenance of the optimum soil physical fertility and biological fertility so favoured plant growth, dry matter production and nutrient uptake leading to higher yield of tomato. These results are in conformity with the finding of Manonmani and Anand (2002). The positive correlation observed between available nutrients with yield was also gives lent to support this reasoning.

5.4. Effect of different organic mulches on quality parameters

Application of different organic mulches had conspicuously increased the quality parameters (shelling % and oil content of groundnut) over the control. Among the different organic mulches, application of raw coirpith at 10 t ha⁻¹ (T₇) recorded 47.9 and 77.8 per cent of groundnut oil and shelling per cent followed by dried weeds at 10 t ha⁻¹ (T₉) over the control (T₁). It is worth to mention here that the addition of organic mulches was found to be better as compared to control. The observed effects of mulching might be due to maintaining a conducive soil environment in terms of better soil moisture, lowering of soil temperature and better supply of nutrients, which ultimately favoured better growth and vegetative biomass production. The favourable effects of organic mulch application have been reported by Patra *et al.* (1993)

5.5. Effect of different organic mulches on nutrient uptake

The nutrient uptake by maize plants at knee high, tasselling and harvest stages revealed that the incorporation of different organic mulches conspicuously increased the nutrient uptake of plants.

5.4.1. Nitrogen (Fig. 12 and 13)

Application of raw coirpith at 10 t ha⁻¹(T₇) significantly increased the N uptake (149.6 kg ha⁻¹) followed by dried weeds at 10 t ha⁻¹ (143.3 kg ha⁻¹) under maize and for groundnut application of raw coirpith at 10 t ha⁻¹(T₇) significantly increased the N uptake (149.3 kg ha⁻¹) followed by dried weeds at 10 t ha⁻¹ (140.4 kg ha⁻¹). It might be due to the increased availability of N in soil accompanied by its increased absorption and dry matter production by maize. Enhanced release of N through mineralisation of organic mulches may also account for the increase in N uptake by maize plants. Subbiah (1991) and Dhanalakshmi and Pappiah (1995) have also reported similar result. Further, the increase in root growth, enhance the plant absorb soil water and nutrients from the soil (Mulumba *et al.*, 2008). Ram *et al.* (2003) observed that the moderation of the hydro thermal regime with mulch treatment enhanced root growth which would facilitate better nutrient uptake from the soil. The N uptake was increased from vegetative stage to harvesting stage of crop growth. This was attributed to advancement of crop growth resulting in increased dry matter production because uptake is a function of concentration and dry matter production.

5.4.2. Phosphorus (Fig. 14 and 15)

Application of different organic mulches significantly influenced P uptake of maize plants. Among the different treatments, raw coirpith at 10 t ha⁻¹ recorded highest P uptake (41.22 kg ha⁻¹) followed by dried weeds at 10 t ha⁻¹ (T₉) under maize and for groundnut coirpith at 10 t ha⁻¹ (T₇) recorded highest P uptake (26.92 kg ha⁻¹) followed by dried weeds at 10 t ha⁻¹ at harvest stage. This could be attributed to synergetic effect of available N on P uptake through their increased drymatter production and absorption of available P. The positive correlation between available N and P uptake also conform this reasoning. Similar results were obtained by Suresh *et al.* (1995).

The uptake of P was gradually increased from vegetative to flowering stage due to their advancement of growth, which resulted in increased dry matter production as crop growth progressed. Duraisami and Mani (2000) reported that the enhanced uptake of phosphorous in coirpith applied plot might have been contributed by better root growth, reduced phosphorous fixation besides chelating and complexing action of organic anions and hydroxyl acids liberated from the decomposing organics (Dhakshinamoorthy, 1991).

5.4.3. Potassium (Fig. 16 and 17)

Application of different organic mulches considerably influenced the K uptake of crop plants. Application of raw coirpith at 10 t ha⁻¹ accounted highest K uptake followed by dried weeds at 10 t ha⁻¹ over the control for both crops. The increased dry matter productions for the application of raw coirpith at 10 t ha⁻¹ would have ultimately resulted in more potassium uptake. Higher soil available K recorded for the treatment would have also contributed to the high K assimilation for both crops.

5.5. Effect of different organic mulches on weed population (Fig. 18 and 19)

It is apparent from the results that the sugarcane trash mulch at 10 t ha⁻¹ more effectively reduced weed number and weed dry weight than the other organic mulches. Similar observations were made by Yaduraju and Ahuja (1990), Sudha and Nanjappa (1999) and Lalitha *et al.* (2001). However, raw coirpith was not as effective as sugarcane trash in controlling weeds. Weeds are a major problem in most organic systems and the application of the organic mulching, especially the slow decomposing organic mulches reduced weed populations significantly when compared to all other treatments. The impact of sugarcane trash mulch was lower due to the more rapid decomposition, although surface application reduced the weeds to a greater extent than when incorporated. Weed dry mass showed significant differences between the treatments. The sugarcane trash gave the least weight whereas the unmulched treatment gave the highest weight. At all stages, the sugarcane trash mulch treated plots were covered with almost as many weed species as the other mulched plots. Similar results were found that Ramakrishna *et al.* (1999) and Park *et al.* (1996).

CHAPTER VI

SUMMARY AND CONCLUSIONS

A field experiment was conducted during September 2007 to January 2008 at Regional Research Station, Paiyur, Krishnagiri district, Tamil Nadu with maize hybrid COHM-5 and groundnut TMV-7, to study the effect of organic mulching on yield, uptake of maize and groundnut and changes in soil physical properties and nutrient availability pattern under rainfed condition. The treatment structure comprised of nine treatments viz., T₁- Control (without mulching), T₂- Maize straw mulch @ 5 t ha⁻¹, T₃- Maize straw mulch @ 10 t ha⁻¹, T₄- Sugarcane trash mulch @ 5 t ha⁻¹, T₅- Sugarcane trash mulch @ 10 t ha⁻¹, T₆- Raw coir pith mulch @ 5 t ha⁻¹, T₇- Raw coir pith mulch @ 10 t ha⁻¹, T₈ - Dried weeds*(Before flowering) mulch @ 5 t ha⁻¹ and T₉ - Dried weeds*(Before flowering) mulch @ 10 t ha⁻¹. The treatments were replicated thrice in Randomized Block Design.

Stage wise soil samples were collected for assessing the soil fertility status of the soil. Maize (grain and stover) and groundnut (pod and haulm) samples were collected for assessing the nutrient uptake pattern. Observations on growth parameters were and yield also recorded. The findings that emanated from this investigation are summarized below.

MAIZE

- Application of different organic mulches had significant effect on bulk density of soil at surface (0-15 cm) and sub surface (15-30 cm). Among different treatments, the treatment which received raw coir pith mulch at 10 t ha⁻¹ (T₇) had reduced the bulk density (1.33 Mg m⁻³) which was on par with raw coir pith at 5 t ha⁻¹ (T₆), dried weeds at 5 t ha⁻¹ (T₈), dried weeds at 10 t ha⁻¹ (T₉) and sugarcane trash at 10 t ha⁻¹ (T₅) over the control at both depths.
- All the physical properties viz., saturated hydraulic conductivity, total porosity, capillary porosity, non capillary porosity, field capacity and permanent wilting point of the soil was not influenced significantly varied with different organic mulches application.
- The water holding capacity of soil conspicuously increased with various mulch treatments. Among the different mulches, dried weeds at 10 t ha⁻¹ (T₇) recorded

the highest water holding capacity (11.53 %). The tune of increase was found to be 13.9 per cent over control.

- The moisture content of the soil at two depths was found to be higher under raw coirpith mulch at 10 t ha⁻¹ treatment at all stages of crop growth. The tune of increase was found to be to the tune of 71.2 per cent at 0-15 cm and 41.5 per cent at 15-30 cm at harvest stage over control.
- Temperature of the soil at two depths was found to be lower in raw coirpith at 10 t ha⁻¹ treatment at all stages of crop growth. The reduction was found to be 17.3 per cent at 0-15 cm and 19.3 per cent at 15-30 cm at harvest stage over control.
- The application of mulches with different levels did not produce any significant impact on the pH, EC and organic carbon content of the soil. However, the organic carbon status of the soil was comparatively higher in dried weeds at 10 t ha⁻¹ treatment 18.1 per cent increase over control.
- Available N, P and K status was found to be higher under dried weeds mulch at 10 t ha⁻¹ at all stages of crop growth. The tune of increase over control was found to be 31.7, 28.4 and 36.2 per cent in available N, P and K respectively.
- Generally the organic mulch application had conspicuously increased the microbial population. Different organic mulches had significantly enhanced the microbial buildup of soil. Among different treatments, the raw coirpith mulch at 10 t ha⁻¹ (T₇) had increased bacteria and fungi population by 42.0 and 42.9 per cent respectively in soil.
- Regarding actinomycetes, the treatment which received dried weeds at 10 t ha⁻¹ (T₉) had increased the population by 72.1 per cent.
- The biometric observation revealed that raw coirpith at 10 t ha⁻¹ and dried weeds at 10 t ha⁻¹ treatments recorded increased plant height, cob length, number of grain rows per cob, number of grains per row and 100 grain weight.
- Dry matter production at all stages of crop growth was found to be higher in raw coirpith at 10 t ha⁻¹ followed by dried weeds at 10 t ha⁻¹ and dried weeds mulch at 5 t ha⁻¹ and were on par.

- Grain yield of maize under raw coirpith mulch at 10 t ha⁻¹ (4488 kg ha⁻¹), dried weeds at 10 t ha⁻¹ (4472 kg ha⁻¹) and dried weeds at 5 t ha⁻¹ (4452 kg ha⁻¹) were on par. These treatments have recorded 73.3, 68.9 and 68.1 percent increase in yield over control. The same trend was observed in stover yield.
- The N, P and K contents of the maize grain and stover and uptake of these nutrients by the maize crop were significantly higher in raw coirpith mulch at 10 t ha⁻¹ and dried weeds mulch at 10 t ha⁻¹ treatments.
- Application of different organic mulches had significant effect on weed population and weed DMP in maize. Among different treatments, the sugarcane trash at 10 t ha⁻¹ (T₅) had reduced weed population and weed DMP which was on par with dried weeds at 10 t ha⁻¹ (T₉). Application of sugarcane trash at 10 t ha⁻¹ recorded the weed population and weed DMP of 53.7 and 81.5 per cent only as compared to control (100 %).

GROUNDNUT

- Application of different organic mulches had insignificant effect on physical properties of soil. The physical properties viz., bulk density, saturated hydraulic conductivity, total porosity, capillary porosity, non capillary porosity, field capacity permanent wilting point and water holding capacity of the soil marginally varied with application of different organic mulches.
- The moisture content of the soil at two depths was found to be higher under raw coirpith mulch at 10 t ha⁻¹ treatment at all stages of crop growth. The increase was found to be to the tune of 81.5 per cent at 0-15 cm and 87.6 per cent at 15-30 cm at harvest stage over control.
- Temperature of the soil at two depths was found to be lower in raw coirpith mulch at 10 t ha⁻¹ treatment at all stages of crop growth.
- The application of mulches and their levels did not produce any significant impact in the pH, EC and organic carbon status of the soil. However the organic carbon of the soil was higher in dried weeds mulch at 10 t ha⁻¹ with 23.2 per cent increase over control.

- Available N, P and K status was found to be higher in dried weeds mulch at 10 t ha⁻¹ treatment at all stages of crop growth. The tune of increase at harvest stage was 1.5 per cent for N, 3.6 per cent for P and 0.7 per cent for K over control.
- Generally the organic mulch application had conspicuously increased the microbial population. The various organic mulches had significantly increased the microbial buildup of soil. Among different mulches, the dried weeds at 10 t ha⁻¹ treatment (T₉) increased the bacteria, fungi and actinomycetes population of the soil. The increase of population at harvest stage was to the tune of 29.7, 45.3 and 82.6 per cent for bacteria, fungi and actinomycetes respectively over control.
- The biometric observation revealed that raw coirpith at 10 t ha⁻¹ treatment recorded increased plant height, total number of pods, number of matured pods per plant and 100 kernel weight and reduced the number of immature pods per plant.
- Dry matter productin at all stages of crop growth was found to be higher under raw coirpith mulch at 10 t ha⁻¹ followed by dried weeds at 10 t ha⁻¹ and dried weeds mulch at 5 t ha⁻¹ and were on par.
- Pod yield of groundnut under raw coirpith at 10 t ha⁻¹ (2663 kg ha⁻¹), dried weeds at 10 t ha⁻¹ (2600 kg ha⁻¹), dried weeds at 5 t ha⁻¹ (2530 kg ha⁻¹) and raw coirpith at 5 t ha⁻¹ (2565 kg ha⁻¹) were at par. These treatments have recorded 55.9, 52.2, 50.1 and 48.1 percent increase in yield over control. The same trend was observed for haulm yield.
- The application of mulches with different levels did not produce any significant impact in the oil content, protein content and shelling percentage groundnut. However marginal increase was observed under mulched treatments over unmulched control.
- The N, P and K contents and uptake were significantly higher under raw coirpith mulch at 10 t ha⁻¹ treatment and dried weeds at 10 t ha⁻¹ treatments.
- Application of different organic mulches had significantly reduced the weed population and weed DMP in groundnut. Among the different treatments,

sugarcane trash mulch at 10 t ha^{-1} (T_5) had reduced the weed population and weed DMP which was on par with dried weeds at 10 t ha^{-1} (T_9).

Overall, the results of the experiment conducted to study the effect of organic mulching on yield, uptake nutrients, changes in soil physical properties and nutrient availability pattern under rainfed condition at Regional Research Station, Paiyur, Krishnagiri district, Tamil Nadu with maize hybrid and groundnut revealed that the raw coirpith and dried weeds mulches at 10 t ha^{-1} along with application of N, P and K fertilizer could improve the grain and stover yield of maize, pod and haulm yield of groundnut, soil fertility status besides reducing the soil temperature, increasing soil moisture and microbial population and nutrient uptake pattern in the rainfed Alfisols.

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Table 29. Effect of treatments on bulk density (BD) of the soil at post harvest stage - Groundnut

Treatment	Bulk density (Mg m ⁻³)	
	0-15 cm	15-30 cm
T ₁	1.37	1.52
T ₂	1.36	1.52
T ₃	1.35	1.50
T ₄	1.35	1.48
T ₅	1.34	1.48
T ₆	1.33	1.44
T ₇	1.31	1.43
T ₈	1.33	1.45
T ₉	1.32	1.43
SEd	0.11	0.12
CD(P= 0.05)	NS	NS

Table 30. Effect of treatments on saturated hydraulic conductivity (SHC), total porosity, capillary porosity and non capillary porosity of the soil at post harvest stage- Groundnut

Treatment	SHC (cm hr ⁻¹)	Total porosity (per cent)	Capillary porosity (per cent)	Non capillary porosity (per cent)
T ₁	5.19	44.2	32.6	12.8
T ₂	5.20	44.3	32.6	12.8
T ₃	5.21	44.3	32.6	12.8
T ₄	5.23	44.3	32.7	12.9
T ₅	5.24	44.6	32.7	12.9
T ₆	5.33	44.6	32.7	12.9
T ₇	5.42	44.8	32.8	13.1
T ₈	5.34	44.6	32.6	12.9
T ₉	5.37	44.8	32.8	13.1
SEd	0.32	3.10	2.27	0.90
CD(P= 0.05)	NS	NS	NS	NS

Table 31. Effect of treatments on field capacity, permanent wilting point and water holding capacity of the soil at post harvest stage - Groundnut

Treatment	FC (per cent)	PWP (per cent)	WHC (per cent)
T ₁	24.10	13.06	11.04
T ₂	24.22	13.34	10.88
T ₃	24.36	13.64	10.72
T ₄	24.51	13.40	11.11
T ₅	24.92	13.49	11.43
T ₆	24.36	13.24	11.12
T ₇	24.88	13.46	11.42
T ₈	24.56	13.33	11.23
T ₉	24.82	13.17	11.65
SEd	0.73	0.41	0.47
CD(P= 0.05)	NS	NS	NS

Table 32. Effect of treatments on moisture content of the soil (per cent) at 0-15 cm at different stages of crop growth - Groundnut

Treatment	Vegetative	Peg initiation	Harvest
T ₁	10.44	11.30	10.74
T ₂	11.56	13.60	11.24
T ₃	13.45	14.40	11.96
T ₄	13.88	16.60	12.34
T ₅	14.63	17.50	12.84
T ₆	15.55	19.60	16.25
T ₇	17.81	21.20	19.57
T ₈	15.66	18.50	16.56
T ₉	16.48	20.40	17.36
SEd	1.25	1.46	1.15
CD(P= 0.05)	2.65	3.10	2.45

Table 33. Effect of treatments on moisture content of the soil (per cent) at 15-30 cm at different stages of crop growth- Groundnut

Treatment	Vegetative	Peg initiation	Harvest
T ₁	12.69	13.60	12.01
T ₂	13.51	14.70	12.24
T ₃	14.12	15.60	13.65
T ₄	15.04	16.80	13.85
T ₅	15.55	17.20	14.75
T ₆	18.01	18.30	17.46
T ₇	20.98	21.50	22.54
T ₈	17.60	17.90	17.76
T ₉	18.73	20.40	18.66
SEd	1.42	1.18	1.26
CD(P= 0.05)	3.01	3.03	2.68

Table 34. Effect of treatments on temperature of the soil (°C) at 0-15 cm at different stages of crop growth- Groundnut

Treatment	Vegetative	Peg initiation	Harvest
T ₁	29.30	29.32	29.13
T ₂	28.00	28.48	28.20
T ₃	27.83	27.56	27.30
T ₄	25.20	25.31	25.20
T ₅	27.37	26.32	25.13
T ₆	26.17	25.45	25.17
T ₇	24.10	25.12	25.07
T ₈	26.32	26.10	25.27
T ₉	25.73	26.28	25.23
SEd	0.11	0.06	0.09
CD(P= 0.05)	0.24	0.12	0.19

Table 35. Effect of treatments on temperature of the soil (°C) at 15-30 cm at different stages of crop growth - Groundnut

Treatment	Vegetative	Peg initiation	Harvest
T ₁	29.00	29.10	29.17
T ₂	27.57	27.47	27.47
T ₃	27.33	27.12	27.37
T ₄	27.17	25.18	27.17
T ₅	24.63	24.24	24.83
T ₆	25.73	24.47	25.27
T ₇	24.47	24.10	24.50
T ₈	27.70	26.78	26.93
T ₉	25.40	25.89	25.30
SEd	0.17	0.08	0.19
CD(P= 0.05)	0.38	0.20	0.40

Table 36. Effect of treatments on pH, EC and organic carbon of the soil - Groundnut

Treatment	pH	EC (dSm ⁻¹)	O.C (per cent)
T ₁	8.18	0.13	0.43
T ₂	8.17	0.13	0.47
T ₃	8.17	0.12	0.51
T ₄	8.17	0.13	0.51
T ₅	8.17	0.12	0.52
T ₆	8.18	0.13	0.47
T ₇	8.17	0.12	0.47
T ₈	8.17	0.12	0.51
T ₉	8.19	0.12	0.53
SEd	0.51	0.008	0.035
CD(P= 0.05)	NS	NS	NS

Table 37. Effect of treatments on available N status (kg ha⁻¹) of the soil at different stages of crop growth - Groundnut

Treatment	Vegetative	Peg initiation	Post harvest
T ₁	160.4	173.3	165.3
T ₂	161.4	174.1	165.9
T ₃	163.9	174.5	166.0
T ₄	164.3	174.8	166.2
T ₅	165.1	174.9	166.6
T ₆	164.9	175.3	166.7
T ₇	164.8	175.7	167.1
T ₈	165.3	175.9	167.3
T ₉	165.8	176.3	167.8
SEd	3.82	2.89	3.85
CD(P= 0.05)	NS	NS	NS

Table 38. Effect of treatments on available P status (kg ha⁻¹) of the soil at different stages of crop growth - Groundnut

Treatment	Vegetative	Peg initiation	Post harvest
T ₁	11.21	12.12	11.53
T ₂	11.24	12.15	11.55
T ₃	11.38	12.20	11.62
T ₄	11.46	12.33	11.67
T ₅	11.47	12.36	11.72
T ₆	11.73	12.42	11.77
T ₇	12.15	12.55	11.84
T ₈	11.81	12.43	11.87
T ₉	12.30	12.63	11.95
SEd	1.01	0.27	0.36
CD(P= 0.05)	NS	NS	NS

Table 39. Effect of treatments on available K status (kg ha⁻¹) of the soil at different stages of crop growth - Groundnut

Treatment	Vegetative	Peg initiation	Post harvest
T ₁	407.8	421.5	414.2
T ₂	408.2	422.1	414.4
T ₃	408.7	421.8	414.6
T ₄	408.9	422.2	414.8
T ₅	409.1	422.7	415.2
T ₆	410.1	422.9	415.9
T ₇	410.4	423.2	416.2
T ₈	410.5	423.6	416.7
T ₉	410.9	424.2	417.3
SEd	9.54	9.59	9.76
CD(P= 0.05)	NS	NS	NS

Table 40. Effect of treatments on Bacteria, Fungi and Actinomycetes population (CFU g⁻¹) of the soil at different stages of crop growth - Groundnut

Treatment	Bacteria x 10 ⁶			Fungi x 10 ⁴			Actinomycetes x 10 ²		
	Vegetative	Peg initiation	Post harvest	Vegetative	Peg initiation	Post harvest	Vegetative	Peg initiation	Post harvest
T ₁	38.00 (1.57)	40.33 (1.60)	43.67 (1.66)	19.3 (1.28)	22.3 (1.34)	16.3 (1.21)	4.24 (0.62)	5.73 (0.75)	6.27 (0.79)
T ₂	40.67 (1.60)	43.67 (1.64)	44.00 (1.64)	20.3 (1.30)	23.0 (1.36)	18.7 (1.27)	5.30 (0.72)	6.63 (0.81)	7.12 (0.89)
T ₃	44.00 (1.64)	48.67 (1.68)	47.33 (1.67)	22.0 (1.34)	23.7 (1.37)	20.3 (1.27)	6.05 (0.78)	6.77 (0.83)	8.10 (0.90)
T ₄	51.67 (1.68)	49.00 (1.69)	50.67 (1.70)	21.7 (1.33)	24.0 (1.37)	20.7 (1.30)	6.56 (0.81)	7.46 (0.87)	8.11 (0.90)
T ₅	51.33 (1.71)	52.67 (1.72)	51.24 (1.69)	22.1 (1.35)	25.7 (1.41)	23.3 (1.36)	7.12 (0.85)	7.99 (0.90)	8.98 (0.95)
T ₆	48.33 (1.71)	51.67 (1.76)	53.42 (1.74)	19.0 (1.30)	23.7 (1.46)	19.7 (1.33)	7.84 (0.89)	8.86 (0.94)	9.06 (0.95)
T ₇	52.33 (1.74)	52.00 (1.75)	52.14 (1.72)	19.3 (1.32)	24.0 (1.44)	22.7 (1.38)	9.15 (0.95)	9.39 (0.97)	10.15 (1.00)
T ₈	49.00 (1.69)	53.67 (1.72)	54.67 (1.73)	20.3 (1.27)	28.7 (1.37)	22.0 (1.29)	9.54 (0.97)	10.14 (1.00)	10.84 (1.03)
T ₉	54.67 (1.71)	60.33 (1.73)	56.67 (1.75)	22.3 (1.30)	30.3 (1.40)	23.7 (1.35)	9.82 (0.99)	10.36 (1.01)	11.45 (1.06)
SEd	0.019	0.012	0.022	0.033	0.034	0.027	0.011	0.012	0.013
CD(P= 0.05)	0.041	0.025	0.047	NS	0.072	0.058	0.023	0.025	0.026

* Values in the parenthesis are log transformed

Table 41. Effect of treatments on plant height of groundnut at different stages

Treatment	Plant height (cm)		
	Vegetative	Peg initiation	Harvest
T ₁	20.36	40.76	43.24
T ₂	24.69	40.38	45.36
T ₃	25.87	39.32	44.78
T ₄	28.54	39.36	45.28
T ₅	28.78	41.61	49.87
T ₆	30.33	38.99	48.74
T ₇	34.46	44.35	52.46
T ₈	32.35	40.03	46.64
T ₉	34.56	40.51	49.98
SEd	0.72	1.33	1.48
CD(P= 0.05)	1.48	2.81	3.12

Table 42. Effect of treatments on yield attributes of groundnut

Treatment	No. of pods per plant	No. of matured pods per plant	No. of immature pods per plant	100 kernel wt.(g)
T ₁	13.80	9.40	4.40	21.83
T ₂	14.47	10.74	3.73	22.51
T ₃	14.60	11.33	3.27	22.85
T ₄	14.60	11.67	2.93	23.54
T ₅	14.93	13.23	1.60	23.58
T ₆	18.33	16.73	1.60	24.56
T ₇	18.47	17.37	1.10	25.92
T ₈	17.47	15.87	1.60	24.90
T ₉	17.53	16.00	1.53	25.24
SEd	0.39	0.30	0.56	0.41
CD(P= 0.05)	0.83	0.63	1.20	0.86

Table 43. Effect of treatments on dry matter production, pod and haulm yield in groundnut

Treatment	Vegetative (kg ha ⁻¹)	Peg initiation (kg ha ⁻¹)	Harvest	
			Pod yield (kg ha ⁻¹)	Haulm yield (kg ha ⁻¹)
T ₁	2300	3454	1708	2352
T ₂	2415	3678	1768	2533
T ₃	2524	3782	2170	2612
T ₄	2596	3852	2337	2774
T ₅	2654	3914	2355	2684
T ₆	2728	4125	2565	2911
T ₇	2948	4874	2663	3073
T ₈	2816	4564	2530	2936
T ₉	2884	4621	2600	2939
SEd	89.8	124.3	61.7	62.5
CD (P= 0.05)	190.3	257.2	130.2	132.6

Table 44. Effect of treatments on quality parameters of groundnut

Treatment	Oil Content (per cent)	Protein content (per cent)	Shelling (per cent)
T ₁	40.2	15.7	65.5
T ₂	41.8	16.2	67.5
T ₃	42.2	17.1	68.6
T ₄	43.4	17.8	70.6
T ₅	44.5	18.7	70.6
T ₆	46.7	20.5	73.7
T ₇	47.9	22.6	77.8
T ₈	45.4	21.2	74.7
T ₉	46.7	21.8	75.7
SEd	3.84	2.24	6.20
CD (P= 0.05)	NS	NS	NS

Table 45. Effect of treatments on N content and uptake of N by groundnut at different stages

Treatment	Total N content (per cent)			N uptake (kg ha ⁻¹)		
	Vegetative	Peg initiation	Harvest	Vegetative	Peg initiation	Harvest
T ₁	2.03	1.72	4.24	46.7	59.4	71.5
T ₂	2.18	1.78	4.37	52.6	65.5	80.7
T ₃	2.29	1.83	4.57	57.8	69.2	96.5
T ₄	2.37	1.91	4.77	61.5	73.6	107.9
T ₅	2.43	1.96	4.95	64.5	76.7	112.6
T ₆	2.45	2.12	5.40	66.8	87.5	132.2
T ₇	2.54	2.26	5.87	74.9	110.2	149.3
T ₈	2.41	2.08	5.47	67.9	94.9	132.4
T ₉	2.46	2.18	5.66	70.9	100.7	140.4
SEd	0.20	0.17	0.27	2.41	4.38	7.36
CD(P= 0.05)	0.44	0.36	0.56	4.95	10.21	15.12

Table 46. Effect of treatments on P content and uptake of P by groundnut at different growth stages

Treatment	Total P content (per cent)			P uptake (kg ha ⁻¹)		
	Vegetative	Peg initiation	harvest	Vegetative	Peg initiation	Harvest
T ₁	0.23	0.18	0.40	5.29	6.22	7.93
T ₂	0.30	0.22	0.48	7.25	8.09	10.09
T ₃	0.37	0.26	0.57	9.34	9.83	13.52
T ₄	0.39	0.29	0.67	10.12	11.17	16.93
T ₅	0.43	0.33	0.75	11.41	12.92	18.75
T ₆	0.41	0.38	0.81	11.18	15.68	22.06
T ₇	0.49	0.42	0.94	14.45	20.47	26.92
T ₈	0.42	0.40	0.77	11.83	18.26	21.06
T ₉	0.48	0.42	0.85	13.84	19.41	23.49
SEd	0.007	0.028	0.027	0.31	0.51	2.56
CD(P= 0.05)	0.015	0.059	0.058	0.67	1.08	5.16

Table 47. Effect of treatments on K content and uptake of K by groundnut at different growth stages

Treatment	Total K content(per cent)			K uptake(kg ha ⁻¹)		
	Vegetative	Peg initiation	Harvest	Vegetative	Peg initiation	Harvest
T ₁	1.99	2.21	3.93	45.8	76.3	80.0
T ₂	2.26	2.28	4.24	54.6	83.9	91.4
T ₃	2.44	2.39	4.50	61.6	90.4	107.8
T ₄	2.53	2.42	4.87	65.7	93.2	124.3
T ₅	2.62	2.46	5.05	69.5	96.3	127.0
T ₆	2.68	2.53	5.22	73.1	104.4	142.8
T ₇	3.05	2.78	5.58	89.9	135.5	159.8
T ₈	2.66	2.51	5.14	74.9	114.6	140.3
T ₉	2.78	2.68	5.43	80.2	123.8	150.2
SEd	0.22	0.21	0.26	5.7	6.1	7.2
CD(P= 0.05)	0.47	0.44	0.54	11.8	12.4	15.3

Table 48. Effect of treatments on N, P and K content and uptake of groundnut pod

Treatment	Nutrient content (per cent)			Uptake of nutrients (kg ha ⁻¹)		
	N	P	K	N	P	K
T ₁	2.52	0.23	1.97	43.0	3.93	33.6
T ₂	2.59	0.27	2.13	45.8	4.77	37.7
T ₃	2.74	0.31	2.27	59.5	6.73	49.3
T ₄	2.86	0.38	2.48	66.8	8.88	58.0
T ₅	2.99	0.42	2.59	70.4	9.89	61.0
T ₆	3.28	0.44	2.64	84.1	11.29	67.7
T ₇	3.61	0.48	2.85	96.1	12.78	75.9
T ₈	3.39	0.38	2.61	85.8	9.61	66.0
T ₉	3.48	0.44	2.76	90.5	11.44	71.8
SEd	0.26	0.03	0.19	4.01	0.71	2.98
CD(P= 0.05)	0.56	0.06	0.42	8.16	1.62	6.02

Table 49. Effect of treatments on N, P and K content and uptake of groundnut haulm

Treatment	Nutrient content (per cent)			Uptake of nutrients (kg ha ⁻¹)		
	N	P	K	N	P	K
T ₁	1.21	0.17	1.97	28.5	4.00	46.3
T ₂	1.38	0.21	2.12	35.0	5.32	53.7
T ₃	1.42	0.26	2.24	37.1	6.79	58.5
T ₄	1.48	0.29	2.39	41.1	8.04	66.3
T ₅	1.57	0.33	2.46	42.1	8.86	66.0
T ₆	1.65	0.37	2.58	48.0	10.77	75.1
T ₇	1.73	0.46	2.73	53.2	14.14	83.9
T ₈	1.59	0.39	2.53	46.7	11.45	74.3
T ₉	1.70	0.41	2.67	50.0	12.05	78.5
SEd	0.11	0.027	0.19	2.21	1.07	3.73
CD(P= 0.05)	0.24	0.058	0.41	4.56	2.23	7.86

Table 50. Effect of treatments on weed population at different stages of groundnut

Treatment	Weed population (No. per m ²)		
	Vegetative	Peg initiation	Harvest
T ₁	229.2 (100)	204.8 (100)	185.2 (100)
T ₂	178.4(77.9)	130 (63.5)	112 (60.4)
T ₃	121.2(52.9)	128.8 (61.0)	119.2 (64.5)
T ₄	113.6(49.7)	126.4 (61.8)	137.2 (74.1)
T ₅	98.0(42.9)	97.2 (47.5)	109.2 (59.0)
T ₆	184(80.2)	153.6 (75.1)	136 (73.4)
T ₇	168(73.3)	138.2(67.4)	128 (69.1)
T ₈	142.4(62.2)	135.2 (67.5)	130.1 (70.2)
T ₉	138(60.3)	121.6 (66.1)	124.9 (67.4)
SEd	9.8	11.3	8.78
CD(P= 0.05)	20.1	23.2	19.4

The values in the parenthesis are per cent

Table 51. Effect of treatments on weed dry matter production (DMP) at different stages of groundnut

Treatment	Weed DMP (kg ha ⁻¹)		
	Vegetative stage	Peg initiation	Harvest
T ₁	113.4	148.2	164.8
T ₂	87.5	134.6	156.2
T ₃	82.4	128.7	148.7
T ₄	86.6	135.4	138.2
T ₅	82.9	127.4	132.6
T ₆	96.4	132.8	141.2
T ₇	91.8	128.2	138.9
T ₈	91.6	129.7	141.5
T ₉	86.4	131.4	134.2
SEd	2.04	4.05	4.37
CD(P= 0.05)	4.34	8.59	9.27

Table 53. Correlation between nutrient uptake and yield

Nitrogen uptake				Phosphorus uptake			Potassium uptake		
	Vegetative	Peg initiation	Harvest	Vegetative	Peg initiation	Harvest	Vegetative	Peg initiation	Harvest
Yield	0.949**	0.977**	0.954**	0.923**	0.926**	0.854**	0.932**	0.949**	0.907**

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level.

Fig. 3. Effect of treatments on soil moisture (%) at different layers and growth stages of maize

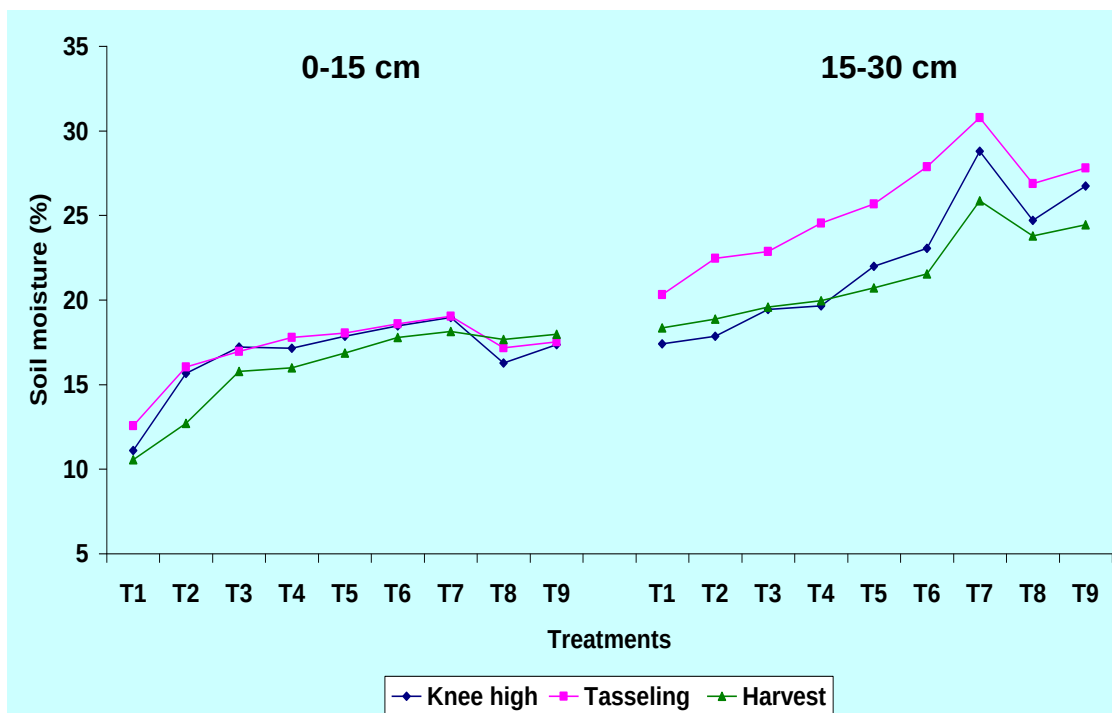


Fig. 4. Effect of treatments on soil moisture (%) at different layers and growth stages of groundnut

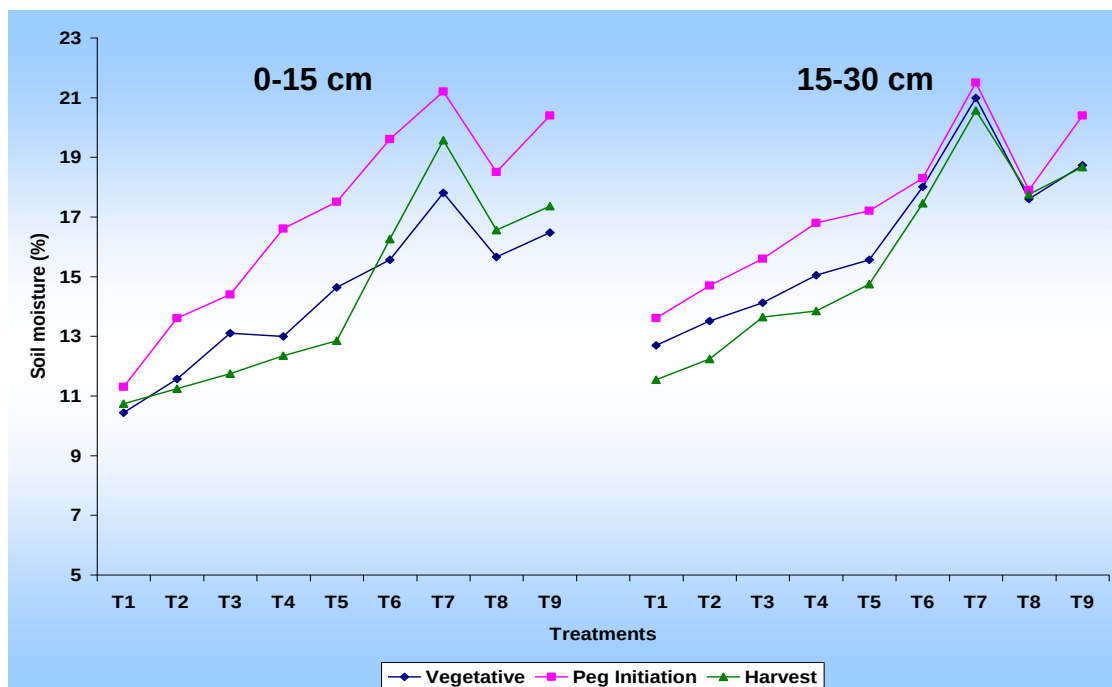


Fig. 5. Effect of treatments on soil temperature ($^{\circ}\text{C}$) at different layers and growth stages of maize

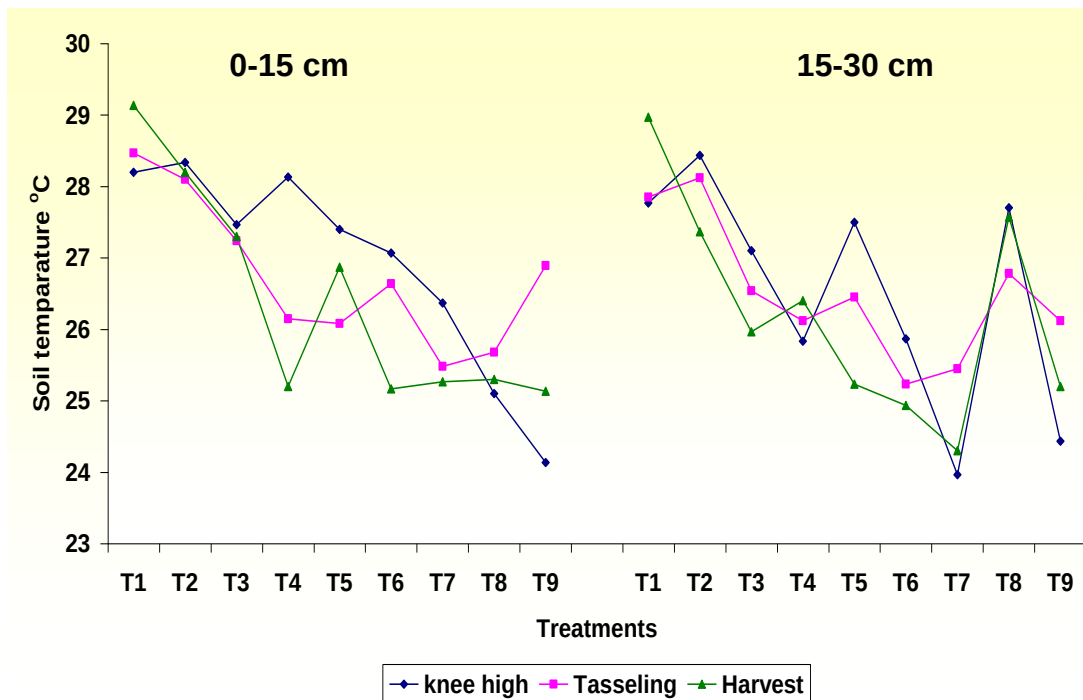


Fig. 6. Effect of treatments on soil temperature ($^{\circ}\text{C}$) at different layers and growth stages of groundnut

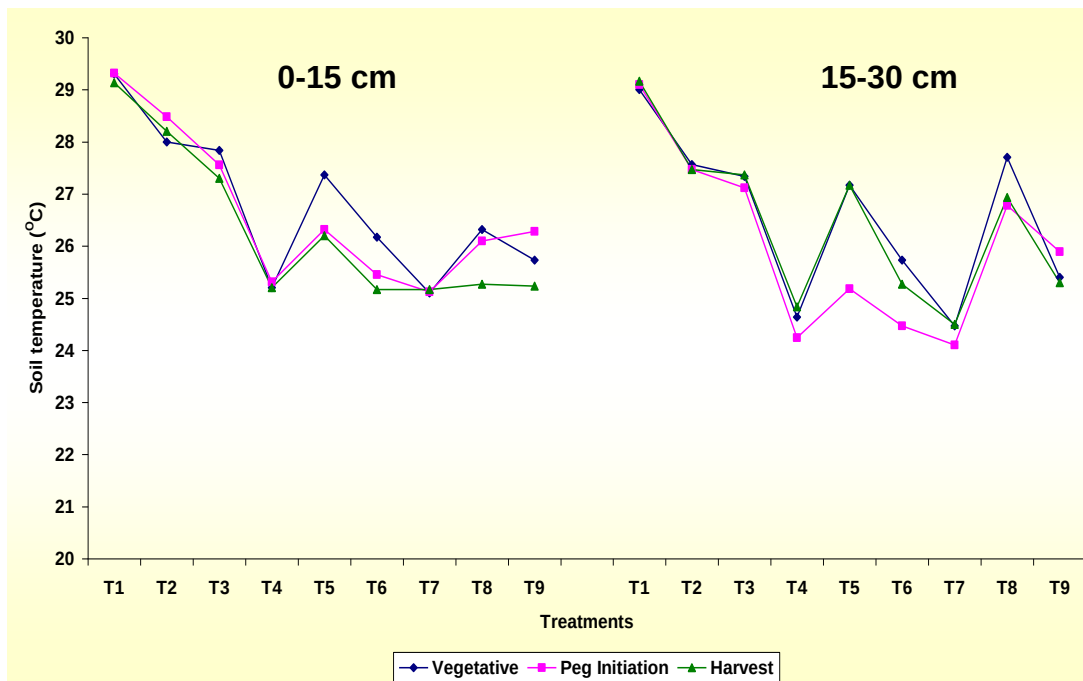


Fig. 7. Effect of treatments on soil available nitrogen (kg ha^{-1}) status at different growth stages of maize

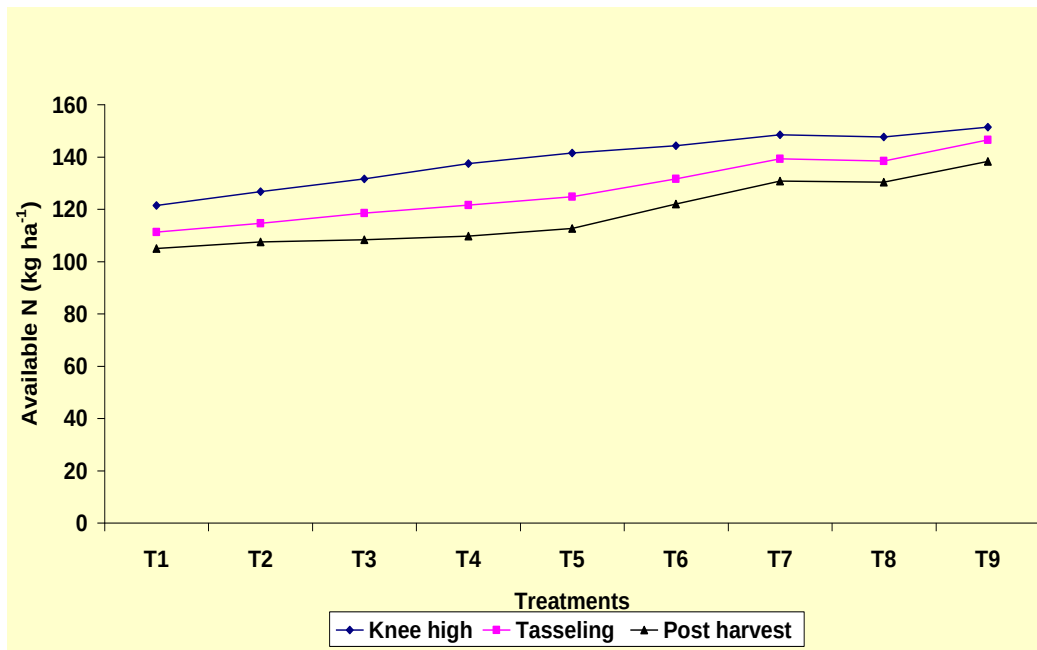


Fig. 8. Effect of treatments on soil available phosphorus (kg ha^{-1}) status at different growth stages of maize

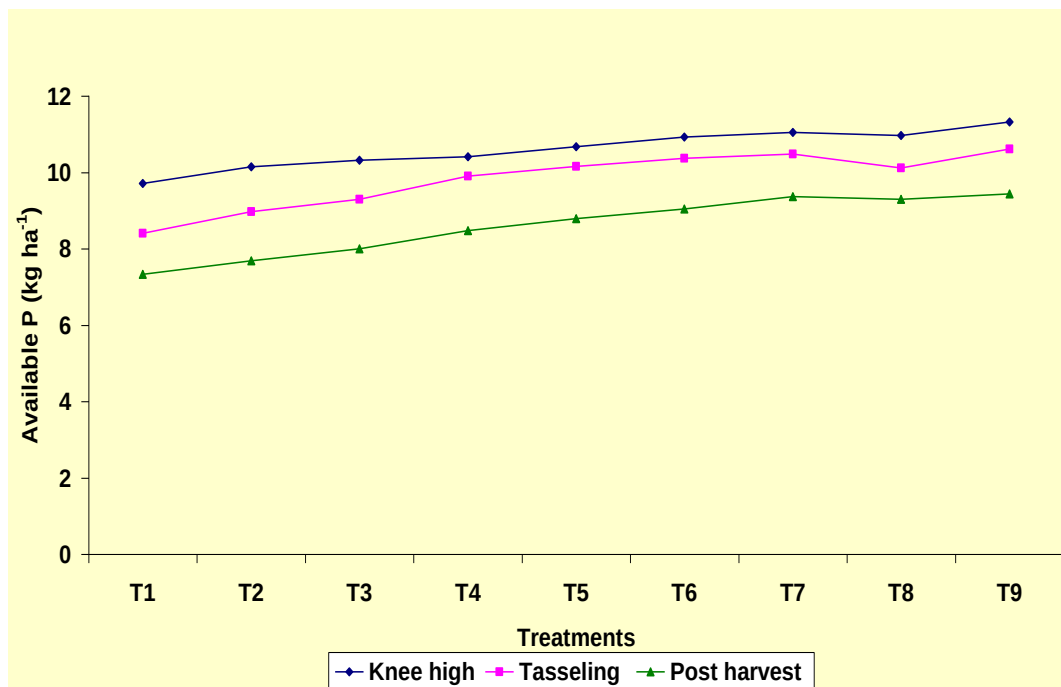


Fig. 9. Effect of treatments on soil available potassium (kg ha^{-1}) status at different growth stages of maize

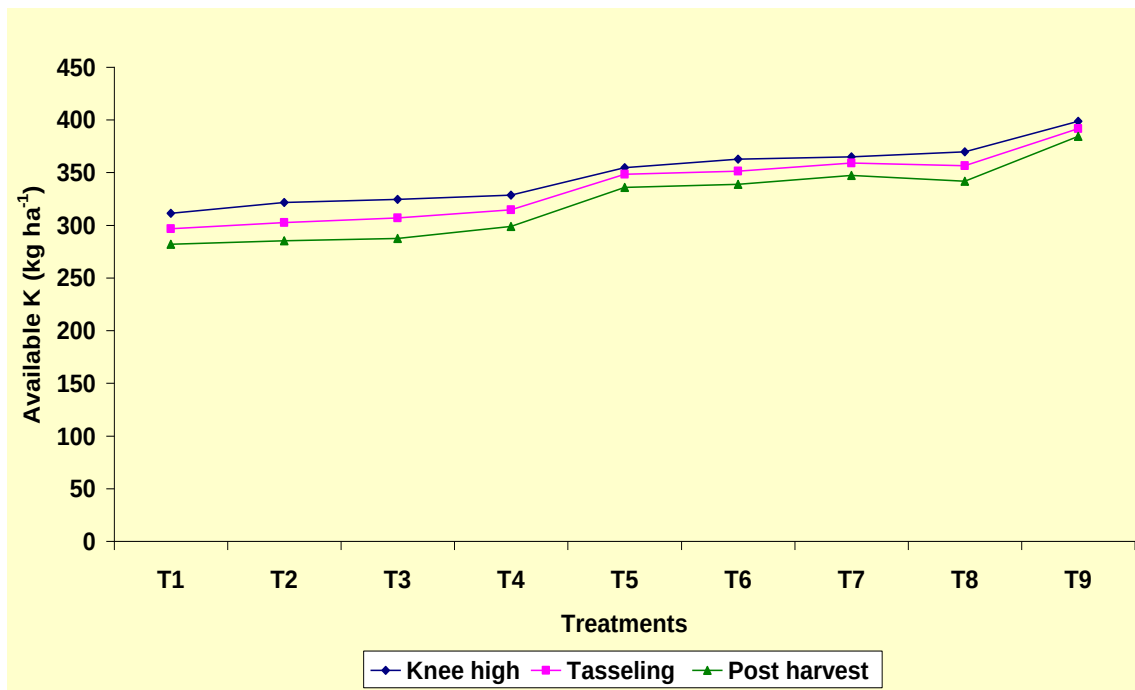


Fig. 10. Effect of treatments on grain and stover yield (kg ha⁻¹) of maize

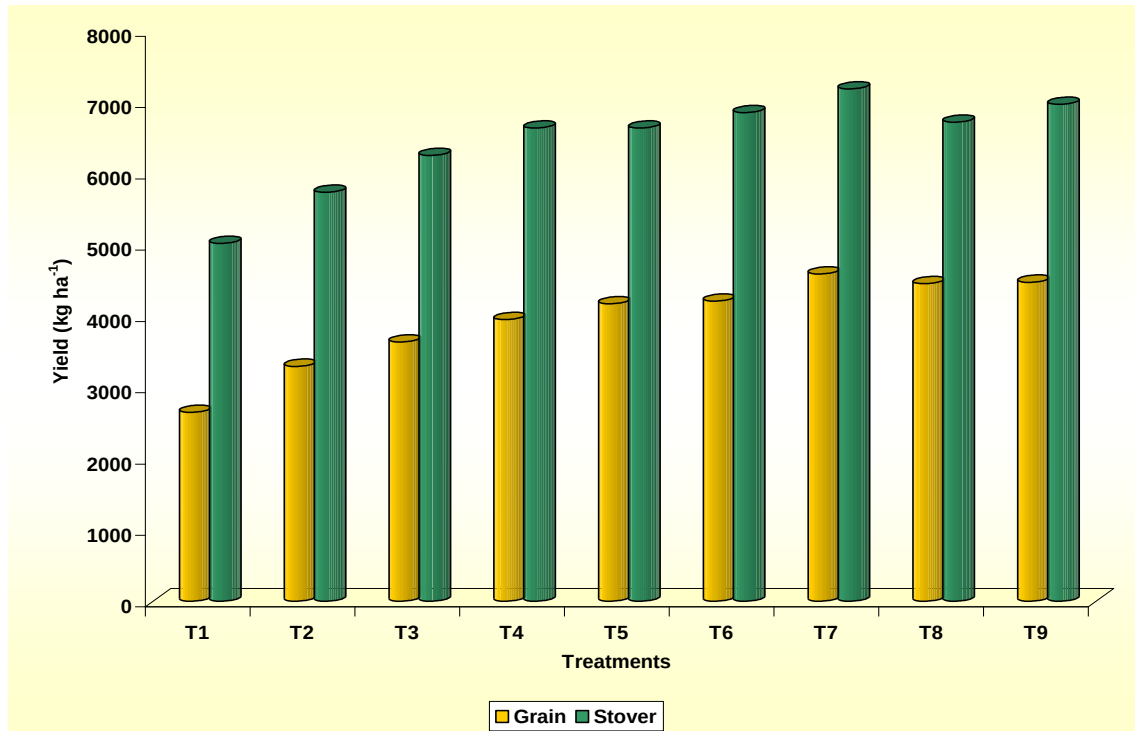


Fig. 11. Effect of treatments on pod and haulm yield (kg ha⁻¹) of groundnut

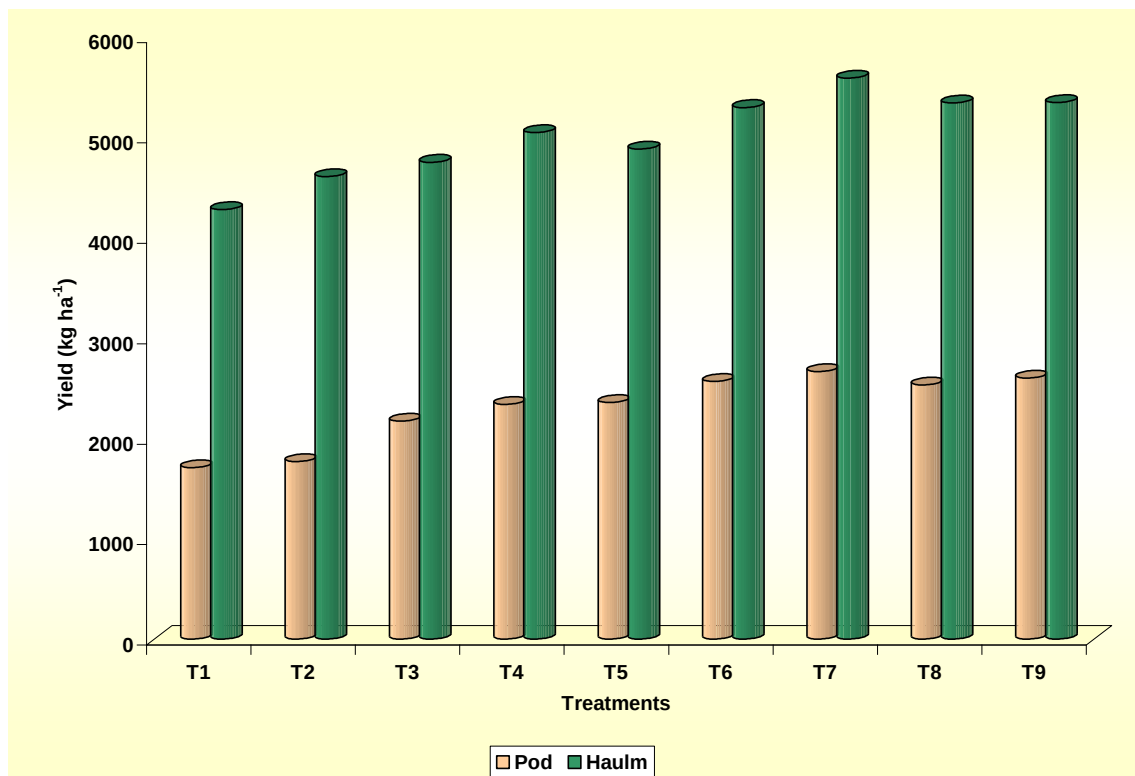


Fig. 12. Effect of treatments on nitrogen uptake (kg ha^{-1}) at different stages of maize

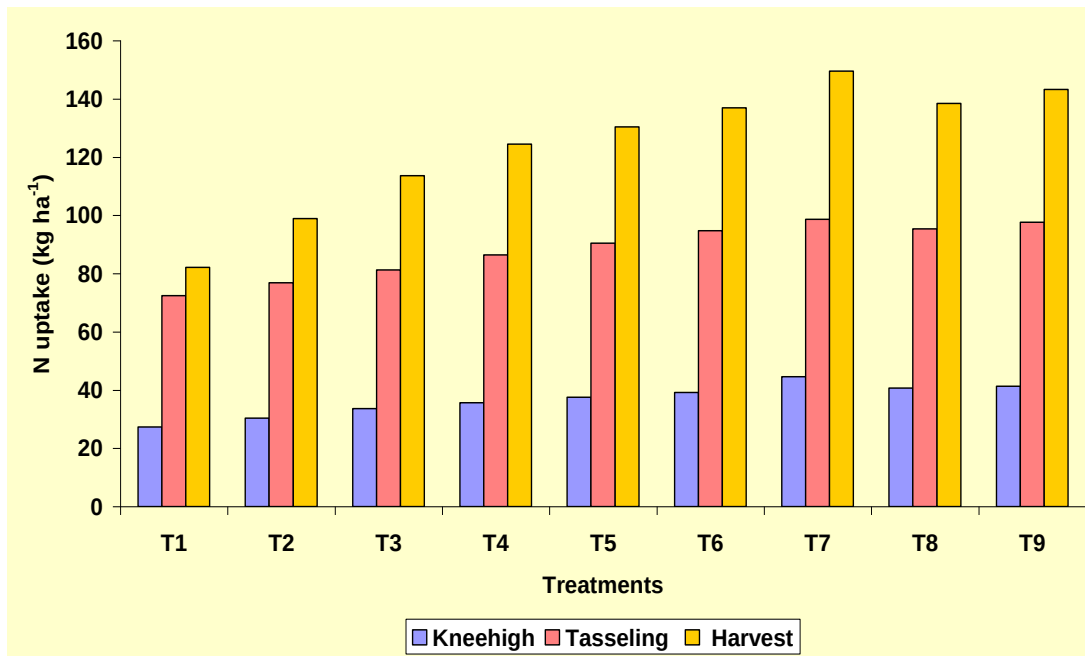


Fig. 13. Effect of treatments on nitrogen uptake (kg ha^{-1}) at different stages of groundnut

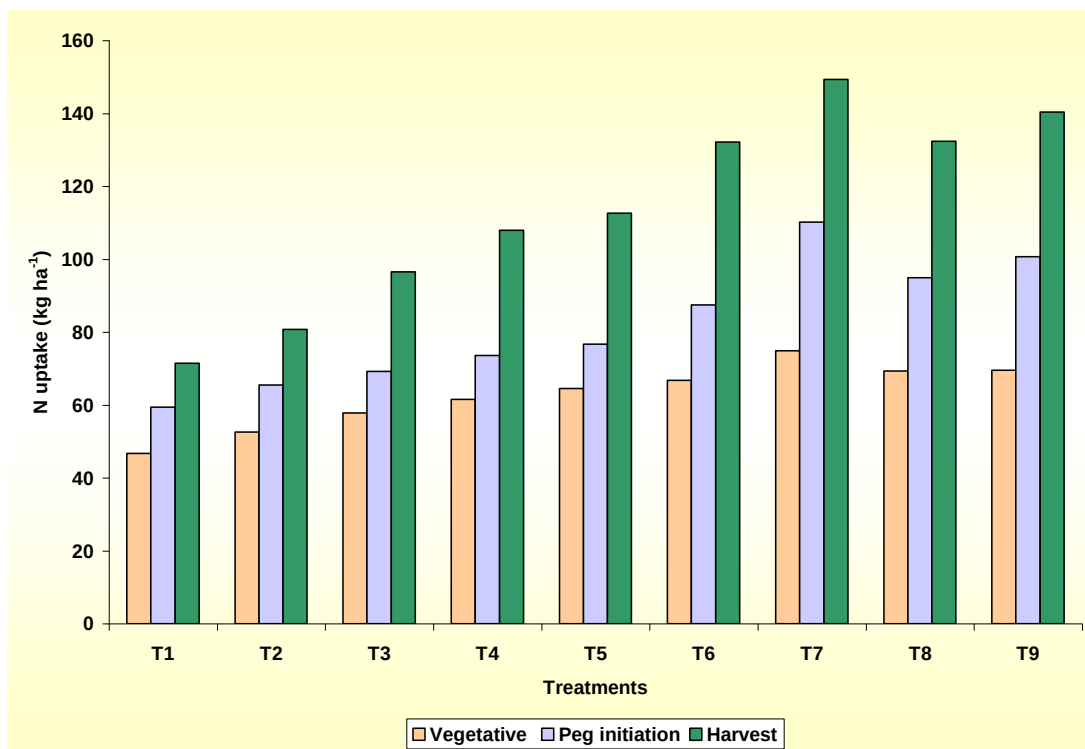


Fig. 14. Effect of treatments on phosphorus uptake (kg ha^{-1}) at different stages of maize

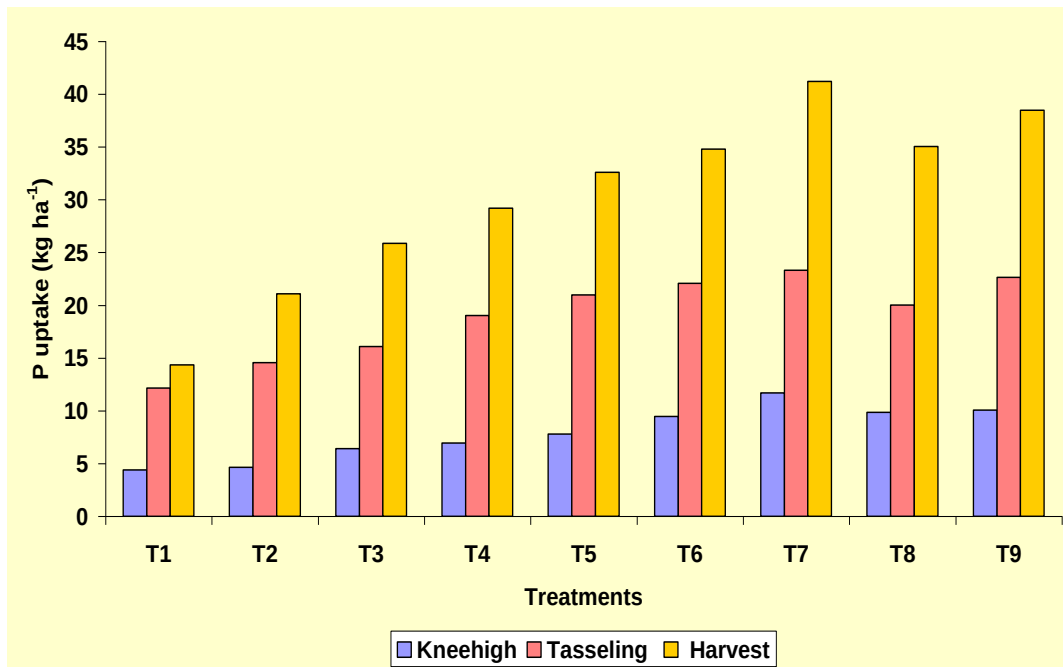


Fig. 15. Effect of treatments on phosphorus uptake (kg ha^{-1}) at different stages of groundnut

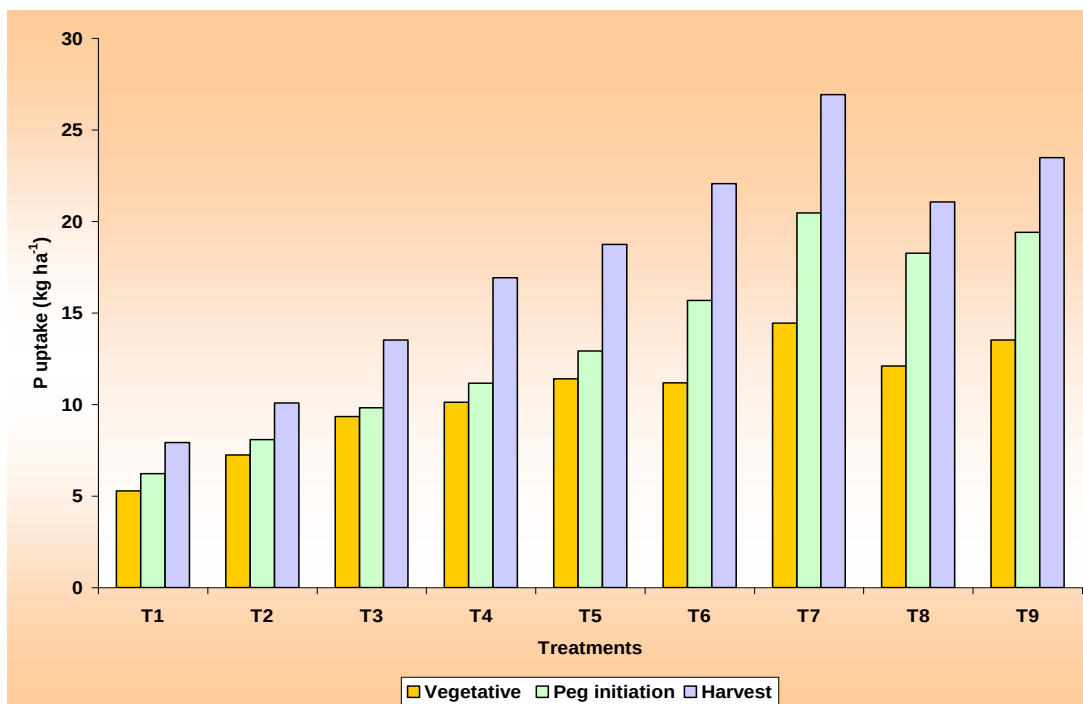


Fig. 16. Effect of treatments on potassium uptake (kg ha^{-1}) at different stages of maize

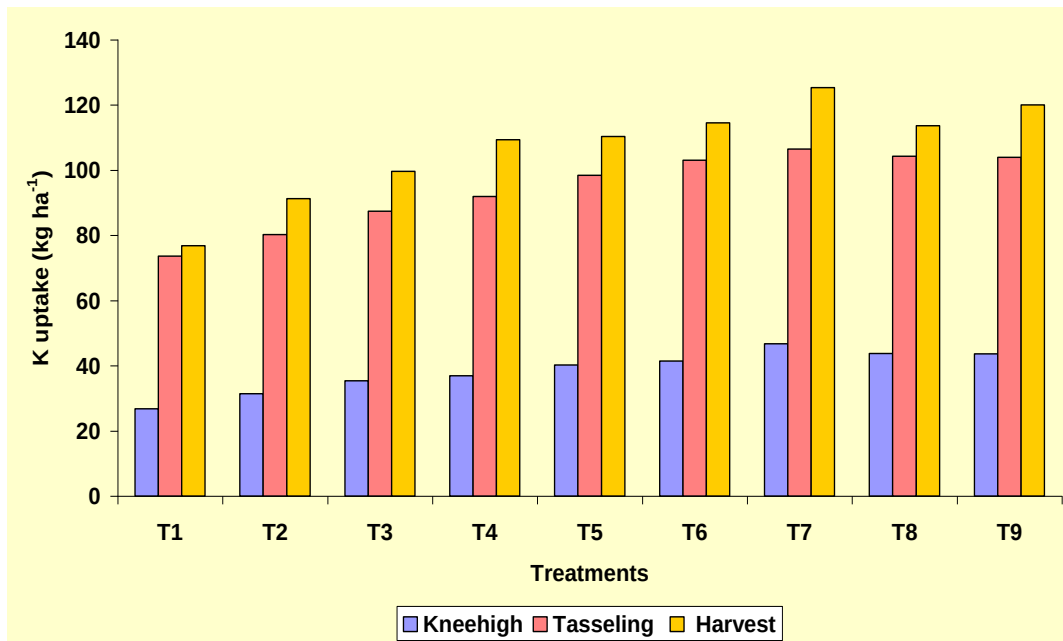


Fig. 17. Effect of treatments on potassium uptake (kg ha^{-1}) at different stages of groundnut

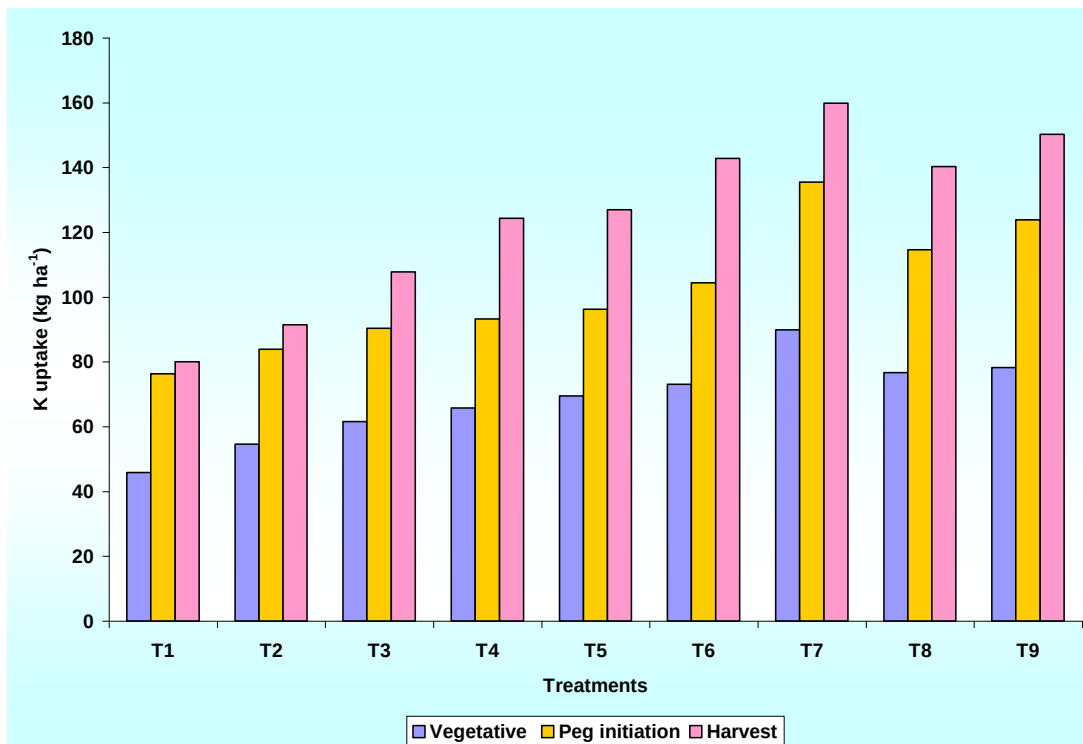


Fig. 18. Effect of treatments on per cent reduction of weed DMP at different growth stages of maize

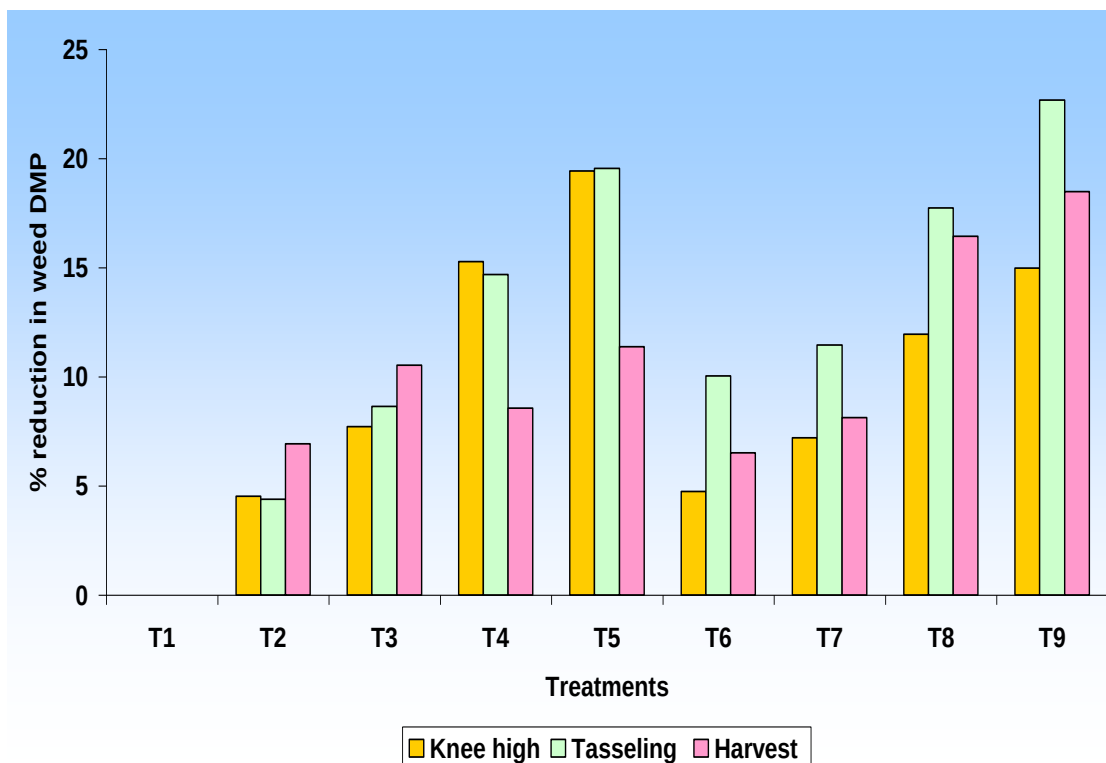
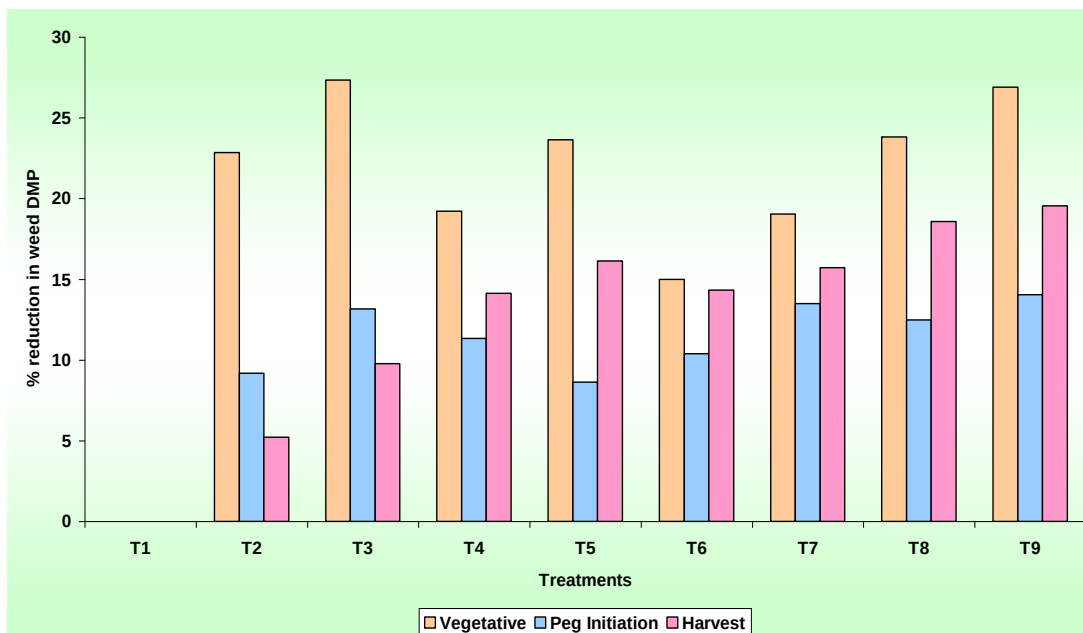


Fig. 19. Effect of treatments on per cent reduction of weed DMP at different growth stages of groundnut



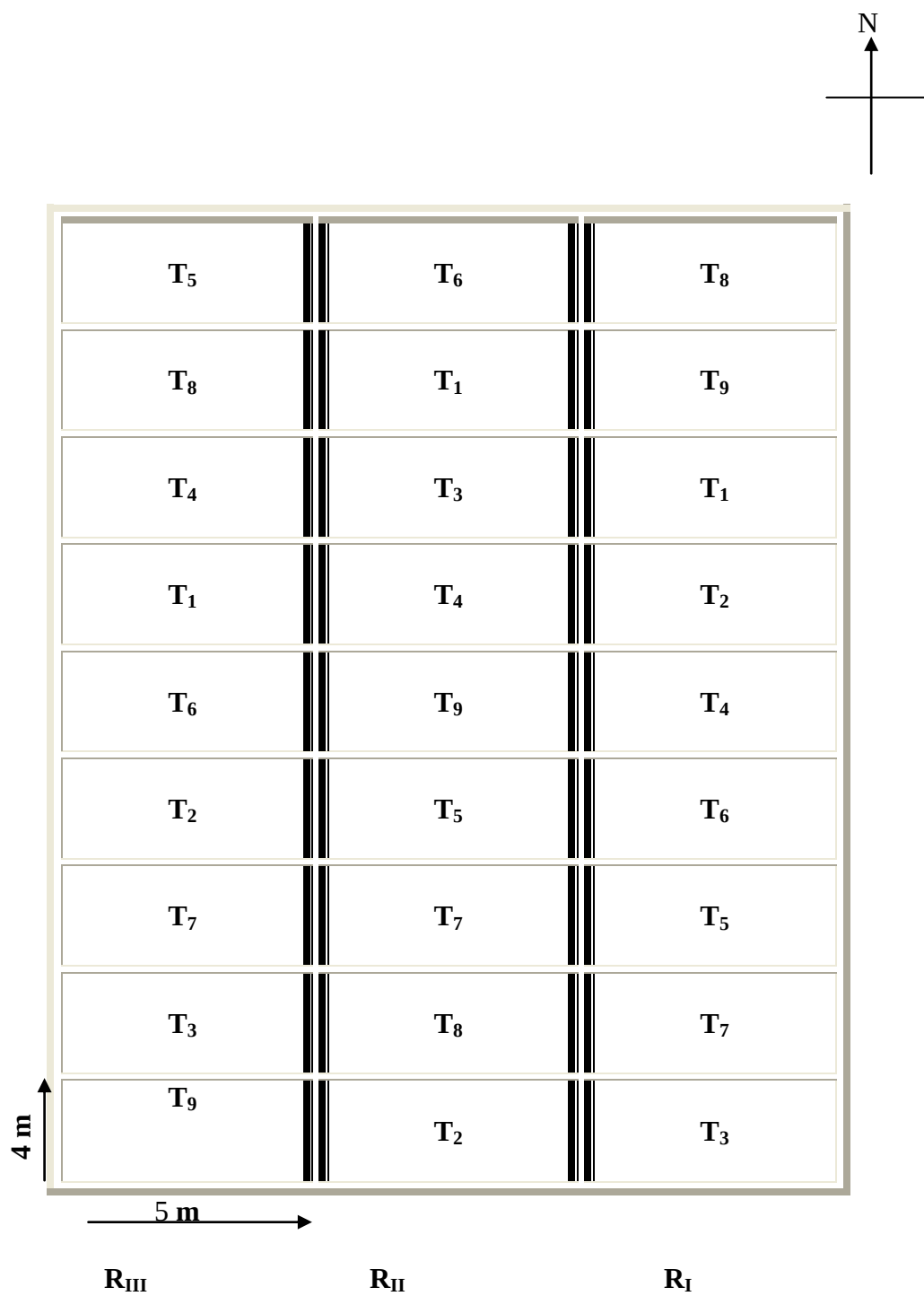


Fig. 1. Field lay out plan - Maize

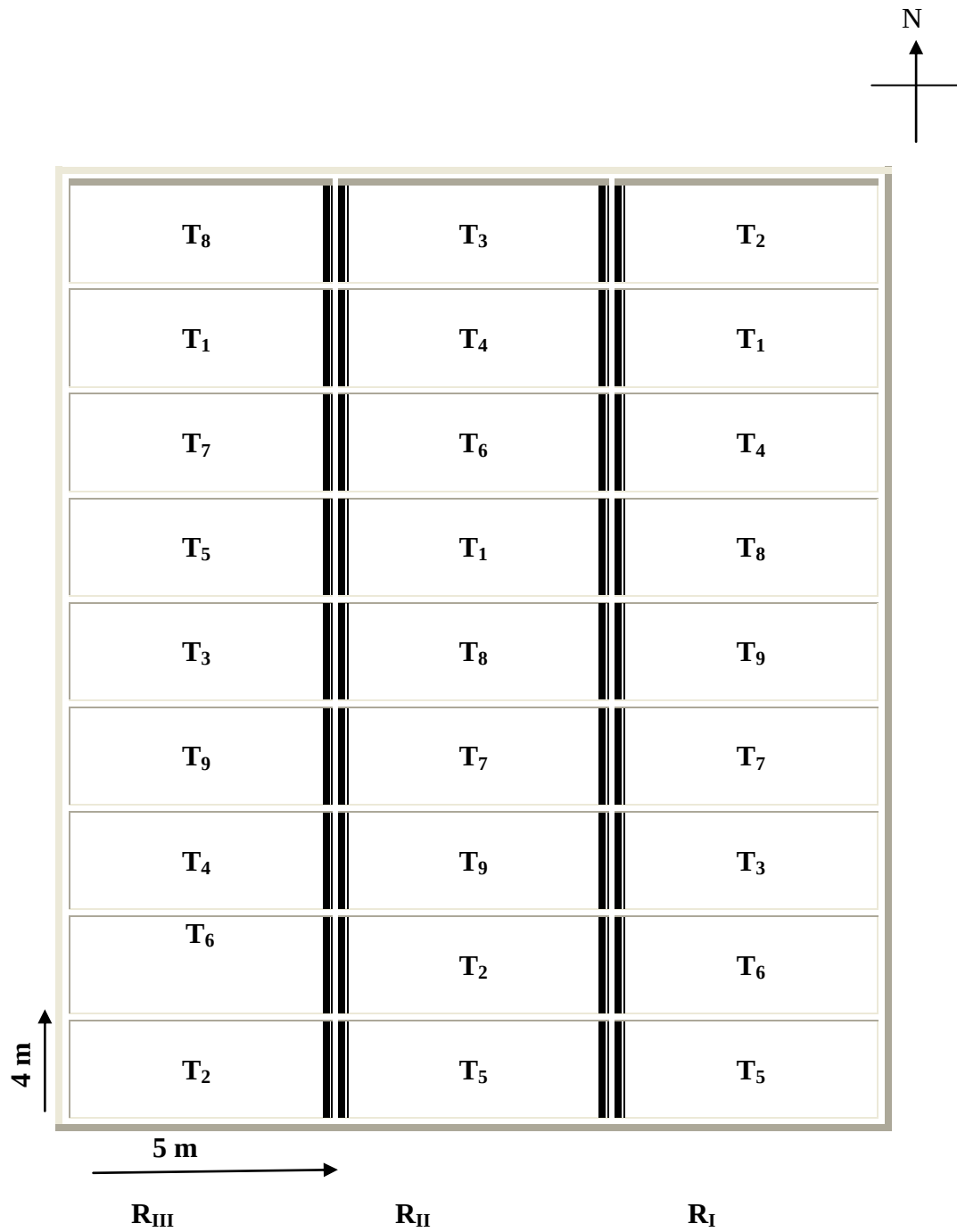


Fig.2. Field lay out plan - Groundnut



Plate 1. Field experimental view of maize



Plate 2. T₄ – Sugarcane trash @ 5 t ha⁻¹ (maize)



Plate 3. T₃ – Maize straw mulch @ 10 t ha⁻¹ (maize)



Plate 4. T₇ – Raw coirpith mulch @ 10 t ha⁻¹ (maize)



Plate 5. T₉ Dried weeds mulch @ 10 t ha⁻¹ (maize)



Plate 6. T₈ Dried weeds mulch @ 5 t ha⁻¹ (groundnut)



Plate 7. T₇ Raw coirpith mulch @ 10 t ha⁻¹ (groundnut)



Plate 8. T₅ Sugarcane trash mulch @ 10 t ha⁻¹ (groundnut)