STUDIES ON FODDER MAIZE AND LEGUME INTERCROPPING SYSTEM

BY

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B.Sc. (Ag.)

THESIS SUBMITTED TO THE
ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE

(AGRONOMY)

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2012

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Ms. PRASANTHI K. has satisfactorily prosecuted the course of research and that thesis entitled **"Studies on fodder maize and legume intercropping system"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

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This is to certify that the thesis entitled **"STUDIES ON FODDER MAIZE AND LEGUME INTERCROPPING SYSTEM"** submitted in partial fulfillment of the requirements for the degree of **'Master of Science in Agriculture'** of the Acharya N. G. Ranga Agricultural University, Hyderabad is a record of the bonafide original research work carried out by **Ms. Prasanthi K.** under our guidance and supervision.

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

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ACKNOWLEDGEMENT

Accomplishment of this thesis is the result of benevolence of Almighty, love of my parents, guidance by my teachers and help of my friends.

*I am privileged to grab this opportunity to express my deep and heartfelt gratitude and veneration to my Major Advisor and Chairman of the Advisory Committee **Dr.B. Venkateswaralu,** Professor, Dept. of Agronomy, Agricultural College, and Bapatla for his impeccable and highly informative advice and guidance and for his munificence showered on me and incessant encouragement during the course of study.*

*I sincerely extend my profound gratitude to **Dr. K. Chandrasekhar**, Associate Professor, member of my Advisory Committee for his sustained encouragement, constant support and valuable suggestions offered during my post graduation study and co-operation during submission of thesis.*

*I express my deep sense of gratitude to **Dr. P. R, K. Prasad,** Professor, Soil Science & Agricultural Chemistry, member of my Advisory Committee who showed expeditious co-operation during the whole course of my research work.*

*I avail this opportunity with humbleness to sincerely thank to **Dr. G. Subbaiah**, Professor and Head of the Department of Agronomy for the kind co-operation and guidance throughout my post graduation programme.*

*I cordially offer my indebted remarks to **Dr. Ch. Pulla Rao** , **Dr. K. Sudhakar Babu** and **Dr. Mujeeb Khan,** Professors, **Dr. K. Mosha**, Associate Professor and **Dr.Srinivasalu, Sri P. Venkata Rao** , Assistant Professor, Department of Agronomy for their constant encouragement and valuable suggestions, timely help and co-operation during the course of the study.*

*I fervently express my immense respect and thanks to **Dr. M. Martin Luther**, Principal Scientist and Head, Agricultural college Farm, Bapatla, **Smt.S. Prathibha** and **Smt. M.Sree Rekha** , Farm Managers for keeping abreast of me and providing their valuable help when ever needed, during the period of my investigation.*

I owe my special thanks to the teaching staff of all the departments in the Agricultural College, Bapatla for extending their co-operation and support in my course and research work.

It's my privilege to express my heartful feelings towards my parents Sri ***Appu*** *and* ***Smt. Kamakshi,*** *my beloved brother* ***Unni*** *and sister* ***Pradheepa*** *for their everlasting love, unmatchable encouragement, needy inspiration and moral support that moulded me into the present position.*

The help rendered by the Non-Teaching Staff of Department of Agronomy is greatly acknowledged.

I place my sincere thanks to my friends ***Vaisu, Rushi, Naji, Niveditha , Little, Punniya*** *and* ***Ammu*** *for always being there beside me in difficult times during my course of study and giving constant motivation.*

*I express sincere thanks to my colleagues**, Reddy, Krupa, Indu, Pritvi, Madhu, Neelamber,Sudha*** *and* ***Praveena,*** *for their constant help through out my PG study.*

I equally owe my sense of gratitude to my seniors and my junior friends ***Thirumala rao, Sameer, Sai ramesh, Kalyani, Jyothi, Mercy,Padmavathi, Thriveni, Vidhya,Ammaji mam, Padmaja mam, Rama, Manasa, Sujatha, Sangamithra, Gowtham, Sreeram, Sandeep, Gos, Nileesh, Chandrasekhar*** *and* ***Nileesh*** *who helped me a lot in my research work.*

Any omission in this brief acknowledgement doesn't mean lack of gratitude.

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LIST OF SYMBOLS AND ABBREVIATIONS

a.i.	:	Active ingradient
et al.	:	And others
@	:	At the rate of
Cm	:	Centimetre (s)
CV	:	Coefficient of Variation
CD (p = 0.05)	:	Critical Difference at 5 per cent probability
DAS	:	Days After Sowing
dS m^{-1}	:	Deci Seimens per metre
^{o}C	:	Degree Celsius
EC	:	Electrical Conductivity
etc.,	:	Etcetera
Fig.	:	Figure
g	:	Gram (s)
IGFRI	:	Indian Grassland and Fodder Research
ICRISAT	:	International Crops Research Institute for Semi Arid Tropics
kg ha^{-1}	:	Kilogram per hectare
Km	:	Kilometre
l ha^{-1}	:	Litres per hectare
Max	:	Maximum
M	:	Metre
Ml	:	Millilitre
Min	:	Minimum
Viz .,	:	Namely
N	:	Nitrogen
NS	:	Non - significant
No.	:	Number
%	:	Per cent
ha^{-1}	:	Per hectare
P	:	Phosphorus
P_2O_5	:	Phosphorus penta oxide
K	:	Potassium

K_2O	:	Potassium oxide
pH	:	Potential of hydrogen ion concentration
PRE	:	Pre-emergence application
RBD	:	Randomized Block Design
RH	:	Relative Humidity
Rs	:	Rupees
SSP	:	Single super phosphate
m^2	:	Square metre
SEm ±	:	Standard Error of Mean
i.e.	:	That is
T	:	Tonne (s)

ABSTRACT

Name of the Author	:	**PRASANTHI K.**
Title of the thesis	:	**Studies on fodder maize and legume intercropping system**
Degree to which it is submitted	:	Master of Science in Agriculture
Faculty	:	Agriculture
Department	:	**AGRONOMY**
Chairperson	:	**Dr. B.VENKATESWARALU**
College	:	Agricultural College, Bapatla
University	:	Acharya N. G. Ranga Agricultural University
Year of submission	:	2012

A field experiment entitiled "Studies on fodder maize and legume intercropping system" was conducted during *kharif*, 2011 on sandy clay loam soils of Agricultural College Farm, Bapatla to study the possibility of intercropping of fodder maize with various fodder legumes to realize high quantity and quality of fodder. The experiment was laid out in a randomized block design with ten treatments replicated thrice. The treatments consisted of T_1- Sole crop of Fodder maize; T_2 - Sole crop of Cowpea; T_3 - Sole crop of Pillipesara; T_4 - Sole crop of Clusterbean; T_5 - Maize + Cowpea mixed intercropping; T_6 - Maize + Pillipesara mixed intercropping; T_7 - Maize + Clusterbean mixed intercropping; T_8 - Maize in paired rows + 2 rows of cowpea; T_9 - Maize in paired rows + 2 rows of Pillipeasara and T_{10} - Maize in paired rows + 2 rows of Clusterbean.

Growth parameters recorded in the study *viz.*, plant height, number of leaves and drymatter accumulation of maize were not significantly influenced by different treatments. However, the total highest drymatter accumulation (9205 kg ha^{-1}) was recorded with fodder maize in pairs + cowpea and the lowest drymatter accumulation (1907 kg ha^{-1}) was recorded in sole pillipesara.

The highest total green and dry fodder yields (50.1 and 14.2 t ha^{-1}) were recorded in maize in pairs + cowpea intercropping and the lowest, green and dry fodder were observed in sole pillipesara treatment (14.7 and 3.4 t ha^{-1}).

The increased crude protein, nitrogen and chlorophyll contents (7.81 %, 1.25 % and 2.98 mg g^{-1}) were observed in maize pairs + cowpea intercropping and significantly lowest values (6.38 %, 1.02% and 2.2 mg g^{-1}) were recorded in sole maize. The highest total crude protein yield (865 kg ha^{-1}) was recorded in maize pairs + cowpea intercropping. The highest crude fibre content of fodder maize (30.74 %) was recorded in sole maize and lowest (28.25 %) was recorded in maize pairs + cowpea intercropping. However the total highest crude fibre yield (2515 kg ha^{-1}) was recorded in maize pairs + cowpea intercropping, it was comparable with sole maize.

Total nitrogen uptake was the highest (138 kg ha^{-1}) with fodder maize intercropped with cowpea in paired rows and the lowest nitrogen uptake was recorded in sole pillipesara (49 kg ha^{-1}). Based on the analysis of the post-harvest soil samples, residual available nitrogen was significantly affected by treatments with the highest observed in sole cowpea and the lowest in sole fodder maize plots.

The highest gross return (Rs. 28,448), net return (Rs.14,783) and returns per rupees investment (2.1) were recorded with maize in pairs + cowpea intercropping and the lowest values were obtained in sole pillipesara (Rs.11,000, Rs.1,785 and 1.10 respectively).

The current investigation revealed that sowing fodder maize in paired rows with cowpea as intercrop was advantageous which resulted in higher total green fodder with better quality without reduction in monetary return.

Chapter I

INTRODUCTION

India ranks first in milk production, but Indian dairy is a classic example of production by masses rather than mass production. The nation's milk supply comes from millions of small producers, dispersed throughout the rural areas. These farmers maintain, on an average, a herd of only two to three milch animals, comprising of cows or buffaloes and the livestock productivity is low, providing limited resource returns. Further, the consumption of milk on a per capita basis is still below the recommendations of World Health Organization. The availability of milk per head per day in the country in only 178 g against the norm of 250 g. Compared to productivity in other parts of the world, India's livestock sector offers considerable scope for enhancement. Our cattle and buffalo produce less than 1,000 kg of milk per lactation as compared to 4,500 kg in Europe, more than 7,000 kg in the United States and 10,000 kg in Israel (ICAR, 2009). The low productivity of livestock is a matter of concern. This is mainly due to inadequate supplies of quality fodder.

At present the country faces a net deficit of 63% green fodder, 24 % dry crop residue as a result crude protein and total digestible nutrients (TDN) deficiency has been to the tune of 28 and 24 % which needs to be bridged to achieve the goal of white revolution (ICAR, 2009). The situation is further aggravated due to increasing growth of livestock particularly that of genetically upgraded animals. The available forages are poor in quality, being deficient in available energy, protein and minerals. To compensate for the low productivity of the livestock, farmers maintain a large herd of animals, which adds to the pressure on land and fodder resources.

India supports nearly 15 % of the world livestock population and 16 % human population with a 2.4 % of world geographical area (Directorate of Economics and Statistics, 2011). The heavy livestock pressure on the limited land resources in the country calls for increasing the fodder production. The area under cultivated fodder is 8.33 million ha (3.9 % of total geographical area) which is not going to increase tangibly, rather it may decreases due to competition with the other agriculture crops and mounting pressure and preferential need for food crops. So, the only alternative to meet the fodder requirement is to increase the yield of fodder per unit area per unit time. This can be achieved by intercropping of high yielding varieties and hybrids of cereal fodders with legumes. The importance of intercropping in farming practices has long been recognized in India (Reddy *et al.*, 2004). Usually yield advantage occurs under intercropping system because the component crops differ in such a way that when they are grown in combination they are able to complement each other and make better overall use of resources, than when grown separately.

Maize is an ideal forage crop possessing quick growth habit, high yielding ability, palatability, and nutritiousness and can be fed to the cattle at any stage of growth, as there is no problem of hydrocyanic acid or oxalic acid poisoning to cattle. Hence, it is widely known as “ready- made fodder crop”. The green fodder of maize has also been reported to have lactogenic properties and hence, is specially suited for milch cattle (Valk, 1994).

Even though, maize provides adequate fodder, there is need to improve its quality by mixing suitable fodder legume without reduction in its forage yield. Inclusion of legumes along with cereals has been reported to improve the forage quality since legumes are rich in protein (Sharma *et al.*, 2008). It is well established fact that livestock feed should contain enough protein to maintain their health, according to an estimate the minimum protein content of 5-6 % is essential in the maintenance ration and 14 % for productive purposes. The mixed sowing of legumes with cereals not only improves the quality of fodder but also enhances the soil fertility by fixing atmospheric nitrogen (Ahamad *et al.*, 2007). The type of intercrop and spatial arrangement in intercropping has an important effect on the balance of competition between component crops and their productivity.

The information on forage production potential and nutritive value as affected by method of sowing and the type of legume intercrop in maize is lacking in Krishna agro-climatic region. Keeping this in view, a field investigation was carried out at Agricultural College Farm, Bapatla with the following objectives,

i. To find out the effect of sowing method on fodder yield and quality of maize.

ii. To find out a suitable intercrop in fodder maize at different methods of sowing.

iii. To work out the economics of the system.

Chapter II

REVIEW OF LITERATURE

Livestock production is the backbone of Indian agriculture and source of employment in rural areas for centuries. This sector has been the primary source of energy for agricultural operations and major sources of animal protein to masses. Our whole system of rural economy has revolved around livestock production. India is house to 15 per cent world cattle population and 16 per cent of human population to be sustained and progressed on 2 per cent of total geographical areas. The present context of shortage of nutritious forage with heavy pressure on arable land for grain and commercial crops, it is not possible to increase the area under forage crops (Nyamagonda *et al*., 2002). Hence the availability of adequate and quality forage has the most critical bearing on the livestock health. The production potential of livestock is quite poor in India due to shortage of quality forage. Incorporation of suitable protein rich leguminous crop with maize would improve the feed quality. Growing of Africantall maize with forage legumes and feeding together of such mixed forage to the livestock would result in improving animal health and livestock products due to balanced diet at low input cost with efficient utilization of growth resources.

The growth pattern when two forage species are intercropped may be different from that in a monocrop. Interspecies competition is mediated through competition for soil, water, available nutrient and solar radiation although other factors such as temperature fluctuation, pest infestation, and agro-management practices are equally important. Crops grown together frequently compete for essential growth factors differently. Direct and indirect effects of mutual shading in an intercropping system on forage quality, morphological development and forage yield have been reported. These differences may result from species variation, length of shading period, change in leaf to stem ratio or environmental conditions.

The present study was initiated to determine the suitable intercrop in fodder maize at different method of sowing and also to find out the effect of sowing methods on fodder yield and quality of maize. In this chapter, an attempt has been made to present a review on the aspects under the following heads.

2.1 Intercropping.

2.2 Effect of planting technique on the performance of fodder maize.

2.3 Effect of legume intercropping on performance of fodder maize.

2.4 Effect of base crop on performance of legume intercrop.

2.5 Economics.

2.1 INTERCROPPING

Intercropping is an age old practice of growing simultaneously two or more crops on the same piece of land. It is mainly practiced to cover the risk of failure of one of the crops due to vagaries of weather or pest and disease incidence (Ayyangar and Aiyer, 1942 & Singh and Katyal, 1966).

Intercropping is traditionally a low input agricultural system and an important characteristic of many developing countries. It can provide yield advantages compared to sole cropping. A major cause of yield advantages is the better use of growth resources in intercropping systems.

When legumes are used as intercrops, they provide beneficial effect on soil fertility by fixing atmospheric nitrogen. Best utilization of nutrients, moisture, space and solar energy is possible through mixed or intercropping system of cultivation (Ayyer, 1967).

Yield advantages in intercropping systems are mainly because of differential use of growth resources by component crops. The main way for complementarity to occur is when the growth pattern of component crops differs in time. The yield advantages in intercropping system are associated with full use of environmental resources overtime (Willey, 1979). The examples of successful cereal-legume intercropping combinations are finger millet + pigeon pea (Ramamoorthy *et al*., 2004), sorghum + cowpea (Singh *et al.,* 2005), pearlmillet + cowpea, pearlmillet + greengram (Ram *et al*., 2005), sugarcane + lenti, sugarcane + rajmash (Rana *et al*., 2006), wheat + fababean (Gooding *et al*., 2007), maize + cowpea, maize + soybean (Anilkumar and Thakur, 2009), maize + greengram (Sheoran *et al*., 2009), maize + horsegram (Kumar *et al.*, 2010), oats + lentil (Singh *et al*., 2011).

2.1.1 Competition and Resource Utilization in Intercropping

Donald (1963) opined that intercropping system involves two or more crop species with the assumption that they could exploit the natural resources better than monocropping system. If the two species grown together are mutually beneficial, then there is co-operation.On the contrary, competition results when they tend to be mutually harmful and this competition is mainly for water, light and nutrients. The relationship for co-operation and competition are density dependent. At low densities, there is co-operation and finally active competition comes into play as the density increases.

The factors for which competition may occur among plants are water, nutrients, light, oxygen and carbon dioxide. Water, nutrients and light are the factors most commonly deficient but in case of those plants, which have rapid photosynthesis, carbon dioxide is also depleted by most competing plants under intercropped situation.Competition is purely a physical process. When an immediate supply of any one of the said growth factor falls below the combined demand of base crop and component crop plants, competition occur.

In intercropping usually the yield advantage occurs because component crop differ in their use of growth resources in such a way that when they are grown in combination, they are able to complement each other and so make better overall use of resources than when grown separately. In terms of competition this means that, in some way the component crops are not complementing for exactly the same overall resources and thus intercrop competition arises. Maximizing intercrop advantage is therefore matter of maximizing the degree of complementarity between the components and minimizing the intercrop competition. On the basis, intercropping advantages are more likely to occur when the component crops are very different (Willey *et al*., 1976 and Rao and Willey, 1980).

A thorough understanding of competition for a certain resource requires knowledge of the size of the pool from which the competing species of plants are obtaining resources, how the resource is shared between the plants and how the presence of one plant alter the supply to other and how the altered supply of the resource influences the growth, reproduction and survival of the plants (Newman, 1983).

Narwal *et al.* (1988) indicated that mixed or intercropping of cereal and legumes reduce the drymatter accumulation in plant due to overcrowding and competition for growth resources *viz*., space, sunlight, moisture and nutrients, whereas, the yield advantage under mixed or intercropping is as a result of increased plant population and reduced competition for space owing to differences in plant height of the component crop.

Tripathi (1989) stated that intercropping of botanically diverse forage species like cereals and legumes appears to be one of the feasible approaches for increasing the herbage yield, utilization of land more efficiently, improving the forage quality and providing stable forage production.

Petrie and Hall (1992) concluded that, the plants grown as intercrops were somehow isolated from each other even though their root systems were overlapped. Competition for light, nutrient, water etc. was not occurring in intercropping system. Similarly, better overall use of resources and nitrogen fixation from legumes in cereal + legume intercropping was revealed by Tripathi *et al*. (1997), Obou *et al*. (1998, Pandita *et al.* (1998), Guptha *et al.*(2001), Lakshmi *et al.* (2003), Reddy *et al.* (2004) and Singh *et al.* (2005).

2.1.1.1 Solar radiation

In intercropping, light is to be instantaneously intercepted for realizing maximum yields. Low availability of light for any component crop in the mixture reduces the photosynthetic rate, crop growth and development.

Plant morphological characters such as leaf size, orientation, etc are determining the efficiency of light interception and Kasanaga and Monsi (1954) reported the better utilization of high light intensities by the crop canopy with greater vertical distribution of leaves.

Competition for light may occur whenever one plant casts a shadow on another, or, within a plant, when one leaf shades another leaf. It occur in almost all crops and is absent only for newly emerged crop seedling, where there may be no competition of any kind. Solar radiation is the factor governing the ultimate yield of any particular genotype or community. If water and nutrients are available in adequate supply, so that competition for these factor ceases, then light becomes the sole limiting factor for production (Donald, 1963).

Light energy is instantaneously available, and it must be instantaneously intercepted, or it will be lost as a source of energy for photosynthesis. It follows that the successful plant is not necessarily the plant with more foliage, but the plant which has its foliage in an advantageous position relative to the foliage of its competitors for light interception. A cereal crop may suppress a weed or under sown fodder plant not because it is potentially or actually more leafy, but because it is taller and has foliage so displayed to intercept the light and leave its more dwarf competitor in relative darkness (Donald, 1963).

In a study on intercropping of maize with nine different tropical legumes in the rain-forest zone of the Western state of Nigeria at Ibdan, Agboola and Fayemi (1971) observed reduced legume yields as the legumes were significantly suppressed by maize.

Willey (1979) from his extensive review on intercropping in sorghum/pigeonpea and pearlmillet/groundnut systems illustrated the temporal and spatial complementarity and magnitude of yield advantage that can be achieved in intercropping compared with sole cropping. The concept of considering environmental resource use in terms of resource capture and resource conversion efficiency was outlined and is then used to examine the resources of light, water, and nutrients. He concluded that, if there is to be better use of light, this probably has to be achieved through more efficient use of light rather than greater light interception.

Ezumah and Ikeorgu (1993) observed suppressed cowpea growth, reduced green biomass due to shading by corn in intercropping of corn with cowpea. Similarly suppressed cowpea growth due to shading by corn in intercropping with cowpea was reported by Ramanakumar and Bhanumurthy (2001). Cowpea when intercropped with corn was completely deprived of resources and solar radiation.

Mohan (2003) reported that 1:2 row proportions of maize + legumes recorded higher light absorption than 1:1 row proportion.

Solanki *et al.* (2011) in their trial on maize based intercropping system at College of Agriculture, Rajasthan, observed that the PAR interception was recorded more in maize + blackgram and maize + greengram intercropping treatment than sole maize.

2.1.1.2 Nutrient

Legumes as intercrops fix nitrogen during growth and benefit the associated non-legume crop. The transfer of nitrogen from legume to cereal may occur through three path ways *viz.,* i) from root and root nodules ii) from washing intact leaves and iii) fall or senescence of leaves. Some legumes release more nitrogen from roots and root nodules, while some other release more by leaf fall (Virtanen *et al.*, 1937).

Lai and Lawton (1962) observed that in maize and fieldbean mixed system, maize competed vigorously and absorbed more phosphorus. They attributed the reason for this effect as the maize roots penetrated the less extensive root system of fieldbean to obtain phosphorus fertilizer banded close to later crop.

Competition presumably may occur for any nutrient added for plant growth. In a situation where there is finite supply of readily available nutrients, the competitive success of any plant is governed by number of individuals depend on the supply and relative rates by which they take up the nutrients. An alternate situation is one in which nutrient is present in a range of physical and chemical forms and the competitive ability of different species may be determined by their capacity to make use of these forms (Donald, 1963).

Component crops in intercropping may make better use of nutrients and water because of differences in rooting system thereby they may exploit from different soil layers. Thus in combination, they may exploit a greater total volume of soil (Trenbath, 1974).

Economy in the use of nitrogen in parallel cropping of graminaceous and leguminous forage species could be due to fixation of nitrogen by the legumes and its utilization by the cereal/grass component (Tripathi, 1989).

Singh and Ahuja (1990) reported that, cowpea besides supplying nutritionally rich fodder, increased the yield of sorghum by making some extra nitrogen available to sorghum during the summer/rainy season under dryland conditions at IARI, New Delhi.

Legumes are widely used as food, fodder, shade, fuel, timber green manure and as cover crops. Legumes have the potential for self-sufficiency for nitrogen, the nutrient most limiting to productivity by symbiotically fixing the atmospheric nitrogen. In fixing atmospheric nitrogen, legumes contribute to soil nitrogen content of the soil either as sole crops in rotation, or as intercrops. In such systems legumes may either increase the soil nitrogen status through fixation, excretion, or in the absence of effective nitrogen fixing system, compete for nitrogen. The quantity of nitrogen fixed by the legume component in cereal legume intercropping depends on the species, morphology, and density of the legume in the mixture, the type of management on the competitive abilities of the component crops (Palaniappan and Sivaraman, 1996).

Adhikari *et al.* (2005) in an experiment consisting intercropping of maize + groundnut in different row proportions reported that maize + groundnut in 2:2 row proportion resulted in higher uptake of NPK than maize + groundnut in 1:1 row proportion.

2.1.1.3 Water

Water shortage is the major factor limiting plant growth, even when soil fertility and temperature are favorable. Although water is a major raw material in photosynthesis, less than one per cent of the water taken up by the roots is used to produce food.

Better water use efficiency was probably a common cause of yield advantage in semiarid tropical areas, because water was basically the most limiting resource (Norman, 1975).

Adiku *et al*. (1995) reported that intercropping of maize with cowpea extract more water from common reservoir because, each crop had its own rooting depth and extraction potential, thus competition for water was simulated.

Balyan (1997) stated that moisture retention capacity of the soil was higher under intercropping system. It might be due to increased crop canopy and crop residues and resulted in reduced evaporation rate, thus increased the water content.

2.2 EFFECT OF PLANTING TECHNIQUE ON THE PERFORMANCE OF FODDER MAIZE

There is certain amount of evidence from cereal crops to suggest that changes in spatial arrangement have some yield advantages. The extent to which shift in planting pattern may influence the yield of a crop is clearly dependent on the plant species (Willey and Heath, 1969).

Paired row technique is suitable for intercropping. In such systems, the two rows of the principal crop were sown close together and the large space is left before the next paired rows, the space can be intercropped. This system prevents main crop shading and therefore improves companion crop development (Anonymous, 1972).

The technique of paired row planting with required plant population of main crop has been developed to harness the maximum yield advantage from an intercropping (Tarhalkar and Rao 1979, Waghmare and Singh, 1982).

Results of three year study on grass- legume systems conducted at Central Arid Zone Research Institute, Jodhpur showed non-significant differences in the yields of Buffel grass for regular and paired row planting geometrics (Singh and Singh, 1987).

A field experiment was conducted during two *kharif* seasons at Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar on a sandy loam soil to study the effect of cereal-legume intercropping system on green fodder yield, quality of maize and also to find out suitable and compatible planting pattern of legume fodders as component crop. It was observed that among intercrop combinations, 2:2 ratio (30/90 cm pairs) of maize : cowpea was found to be the best in respect of green fodder yield, net return and benefit cost ratio (Mohapatra and Pradhan, 1992).

Khot *et al.* (1992) conducted a field experiment at the forage crop research institute, Rahuri, Maharashtra on a medium black soil and found that green forage yield and dry matter yield were significantly affected by planting system whereas, differences were not significant in crude protein yield due to planting systems.

Kumbhar *et al*. (1994) reported that alternate row sowing of sorghum with cowpea at full seed rate gave higher green and dry fodder production than any other treatment in rainfed vertisols.

A field experiment conducted at Palampur during *kharif* season revealed that planting geometry significantly affected the green and dry forage yield of maize. Green and dry fodder obtained from the 60 cm row spacing intercropped with legumes was qualitatively better than that obtained from 30 cm rows of sole maize (Sood and Sharma, 1996).

Verma *et al*. (1997) observed that paired row system of intercropping produced significantly higher yields of fresh herbage, dry matter, crude protein, digestible dry matter and productivity index and was followed by skip row and normal row intercropping in fodder sorghum at the Livestock Research Centre, G. B Pant University. The higher yield in paired row intercropping might be due to better utilization of environmental resources and the availability of ample space between paired rows.

Krishna *et al*. (1998) reported that green and dry fodder yields of maize + cowpea mixed cropping at 30 cm (24.36 and 4.32 tons ha^{-1}) and 45 cm (20.30 and 3.27 tons ha^{-1}) were significantly higher over maize alone on clay loam soils of Rudrur, Andhra Pradesh.

Ayub *et al.* (1998) conducted a field experiment on sandy clay loam soil to find out response of forage maize cultivars to two different method of sowing. Plant population was significantly higher under line sowing where as fodder yield and all other yield parameters studied were not significantly affected by sowing methods.

In a field experiment at Indian Agricultural Research Institute, New Delhi, paired row planting (30 cm/90 cm) of sorghum intercropped with fodder guar recorded higher grain and stover yield of sorghum and sorghum equivalent yield over alternate row planting and monocropping (Singh and Balyan, 2000).

Kumar and Prasad (2003) reported that sowing of forage maize and cowpea in 2:2 paired rows with proportionate seed rate gave the maximum green forage (37.6 t), dry matter, and crude protein. It is also accounted from the maximum net return along with monetary advantage. The paired rows were also found biologically more sustainable as these gave the maximum land equivalent ratio at Ranchi during rainy season.

A field experiment was conducted to study growth and forage yield response of maize- legume mixed cropping to different sowing techniques. The maximum mixed forage yield (55.75 t ha^{-1}) was obtained when cowpea intercropped with maize in alternate 1:1 row (Asifiqbal *et al.*, 2006).

The highest grain yield of maize was recorded with soybean intercropping at 1:1 row ratio and was on a par with 2:2 row ratios. The highest mean maize equivalent yield was recorded under 2:2 row ratio (Meena *et al.*, 2006).

The maximum mixed forage dry matter and green fodder yield of 24.5 and 68.8 t ha^{-1} were recorded in planting pattern of 45 cm spaced double row stripes (15/45 cm). Of the different planting patterns 15/45 cm proved to be feasible, adoptable, and more productive with high quality nutritious forage (Ahamad *et al.*, 2007)

Sharma *et al*. (2008) reported that intercropping of maize and cowpea in the row proportion at 2:2 recorded significantly higher total green fodder yield (43.2 tons ha^{-1}), dry matter (9.6 tons ha^{-1}), crude protein yield (1.1 t ha^{-1}) as well as net returns and benefit cost ratio on sandy loam soils of Sabour, Bihar during summer season.

Ram (2008) conducted a field experiment in sandy loam soils for five consecutive years to find out the productivity and quality of pasture as influenced by planting pattern at IGFRI Jhansi. Intercropping of grasses with legumes in 1:1 row ratio at 50 cm distance produced significantly higher green forage (22 t ha^{-1}), dry matter (5.4 t ha^{-1}) and crude protein yields (370.41 kg ha^{-1}) as compared to 1:2 row ratio at 75 cm distance.

2.3 EFFECT OF LEGUME INTERCROPPING ON PERFORMANCE OF FORAGE MAIZE

An intercrop is generally grown to make best use of interspace which is not fully utilized by main crop in early growth periods. The intercrop may reduce or increase the yield of main crop, depending upon the species and spatial arrangement of component crops. Several benefits are attributed to legume intercropping, such as efficient and uniform utilization of nutrient elements from different soil depths, maintenance and buildup of soil fertility and possibility of higher profit as compared to monoculture.

2.3.1 Growth Parameters

In field experimentation with maize and sorghum intercropped with beans, cowpea, and pigeonpea, Enyi (1973) reported that maize intercropped with beans and cowpea resulted in reduced maize plant height. He observed increase in sorghum plant height by intercropping with pigieonpea. Leaf area indices of both maize and sorghum were lower when intercropped with beans and cowpea indicating more adverse influence of these intercrops on the base crop. Further, he opinioned that pigeonpea was less hazardous intercrop with either maize or sorghum.

El-shamma and Ali (1976) observed the highest leaf to stem ratio in oat-horsegram mixture in their three year intercropping trials of berseem, horsegram, barley and oat for fodder purpose.

The productivity per unit area was increased considerably when cereal crops (maize/sorghum) were intercropped with short duration legume like greengram and soybean (Rajat De *et al*., 1978).

At Coimbatore, during rainy season the results of a field experiment indicated that the dry matter production in sorghum increased significantly when intercropped with blackgram, cowpea and fieldbean as compared to pure stand of sorghum (Ravichandran and Palaniappan, 1979).

Mafra *et al*. (1979) recorded 32% yield reduction in corn and 56% yield reduction in sorghum when beans was intercropped, as beans was highly aggressive and caused difficulty in harvesting of the base crop. Further, they reported that the cowpea was a more successful intercrop with cereals due to its capacity of symbiotic nitrogen fixation.

Natarajan and Willey (1979) reported an increase in drymatter accumulation by fodder sorghum when intercropped with cowpea and fieldbean. However, blackgram intercropping registered lower drymatter accumulation of sorghum crop.

Chouhan and Dungarwal (1980) observed that, companion cropping of maize with legumes like cowpea and clusterbean for fodder resulted in significant increase in production of animal feed units like total drymatter (30.91 g plant $^{-1}$) as compared to growing maize alone.

Faris *et al*. (1983) stated that plant height of sorghum remained unaffected due to intercropping combinations.

Hegde (1983) in his field experiment at Bangalore noticed taller plants and more number of leaves in sorghum when it was intercropped with soybean, clusterbean, and fieldbean in paired row planting as compared to sole sorghum during all the growth stages.

The field studies conducted at Dharwad by Shahapurkar (1985) indicated a non-significant effect due to intercropping of legumes in maize.

Rameshbabu *et al.* (1994) worked on fodder maize +cowpea intercropping on clay soils of Dharward, Karnataka during rainy season and observed that fodder maize + cowpea (at higher seed rate) resulted in taller plants, more drymatter production and higher per day productivity. They also observed that when cowpea was mixed at lower seed rates, it was suppressed by the vigorously growing fodder maize. The highest maize drymatter yield was obtained when mixed with blacksoya (9.79 t ha^{-1}). Cowpea mixture was the next best mixture in total drymatter yield (9.15 t ha^{-1}) during *kharif* season on black clay soils of Dharward.

The green matter of fodder legumes intercropped with maize (1:1) was 11.74, 12.28, 14.00, 3.08, 4.08 and 8.08 t ha^{-1} with cowpea, sunnhemp, dhaincha, blackgram, greengram and clusterbean, respectively (Gangwar and Sharma, 1994).

Field studies conducted at UAS, Dharwad by Chittapur *et al.* (1994) have shown that the fresh weight of legume intercropped for fodder with maize varied significantly. The highest phytomass (17.11 t ha^{-1}) was recorded with cowpea in 1:2 ratio followed by dhaincha (10.11t ha^{-1}), horsegram (9.1 t ha^{-1}), soybean (7.24 t ha^{-1}), sunnhemp (6.16 t ha^{-1}) and black soya (5.09 t ha^{-1}) at 70 days after sowing.

Kandiannan and Rangaswamy (1995) observed that, growth components like plant height, LAI and drymatter production of sorghum was significantly influenced by the production technologies in sorghum mixed with cowpea under rainfed conditions. However, Barik and Tiwari (1996) on medium black soils of Anjora during *kharif* season observed a non-significant difference in corn and sweet sudan intercropping with cowpea during all stages of growth.

Sood and Sharma (1996) opined that maize grown at 60 cm row spacing and intercropped with cowpea, velvet bean and soybean registered an increase of 22.03, 28.99, and 12.39 per cent of drymatter respectively over sole crop of maize grown at 60 cm spacing during *kharif* season on silty clay loams of Palampur.

Barik and Tiwari (1996) conducted a field trial on clay loamy soils of College of Veterinary Science and Animal Husbandry, Anjora during *kharif* season and found that the height of maize plants was not significantly influenced at different stages of growth when compared between sole crop and intercropping treatments.

Srinivasaraju *et al.* (1997) reported the minimum drymatter content in maize and cowpea intercropping compared to maize sole crop during winter season on clay loam soils of Amberpet (Andhra Pradesh).

Verma *et al.* (1997) on silty loam soils of Pantnagar observed higher drymatter production when sorghum was intercropped with cowpea over sole sorghum.

Singh *et al.* (2000) observed that maize + pea intercropping gave significantly more drymatter than sole maize and maize + lentil, respectively on sandy loam soils of Lakhaoti.

Patel and Rajagopal (2001) reported the highest drymatter yield when maize +cowpea was sown in a planting pattern of 5:2 and this was statistically comparable with 4:2 pattern during *kharif* season on clay loam soils of Anjora (Chhattisgarh).

Ramanakumar and Bhanumurthy (2001) observed the minimum drymatter content with intercropping system of maize and cowpea during kharif and summer seasons on sandy loam soils of Ranjendranagar (Andhra Pradesh).

Rana *et al.* (2001) observed that plant height and leaf area index of maize crop in maize + legume intercropping system were significantly better in intercropping system compared to sole maize.

In a field experiment conducted at G. B. Pant University of Agriculture & Technology, Shivay *et al.* (2001) reported that maize + legume intercropping system had no significant effect on growth and yield parameters of maize. However, grain yield, maize equivalent yield and net returns were significantly increased due to intercropping. The highest grain yield of maize was recorded in maize + urdbean system, whereas the highest maize grain equivalent yield was recorded with maize + soybean.

Tripathi *et al.* (2002) conducted a field experiment at Research farm of Central Arid Zone Research Institute, Jodhpur and stated that introduction of legume as an intercrop in the grass resulted significant increase in drymatter yield.

Lakshmi *et al.* (2003) reported non- significant differences in plant height of maize in sole cropping and intercropping treatments during summer season at College of Agriculture, Vellayani, Kerala.

Purushotham *et al.* (2003) conducted a field experiment at Zonal Research Station, Konehally, on effect of seed rate and fertility levels in sole and mixed cropping of fodder maize and cowpea and reported that the growth parameters like plant height, number of green leaves/plant of sole crop of maize did not differ with mixed cropping.

Gangaiah (2004) observed that when maize, sorghum, pearlmillet were intercropped with cowpea and horsegram, plant height, leaf number, and leaf to stem ratio of cereal were not influenced by intercropping on medium black soils of Regional Research Station, Dharwad.

Sunilkumar *et al.* (2005) reported higher drymatter yield (83 q ha^{-1}) when maize + cowpea was sown in 2:2 row proportion at Indian Grassland and Fodder Research Institute, Jhansi. The increase in drymatter yield in the intercropping system might be owing to better utilization of space and light interception coupled with nutrient contribution of leguminous fodder to cereal.

Ahamad *et al.* (2007) observed the maximum plant height, more number of leaves/plant in case of sole crop of forage sorghum as compared to intercropping treatments and concluded that this might be due to more penetration of light, circulation of light, and comparatively more nutritional area available to sole crop under competition free environment.

Eskandari and Ghanbari (2009) reported that intercropping systems had a significant effect on forage dry weight, where dry matter was increased by intercropping as compared with maize and cowpea sole crops. It was related with a higher consumption of environmental resources such as PAR and soil moisture by intercropping.

2.3.2 Yield

The increase in overall yield of green and dry fodder in the intercropping might be owing to the nutrient sparing effect of leguminous fodder. It is well evident that the atmospheric nitrogen fixed by bacteria in the root nodules of leguminous fodder imparts nitrogen enrichment to non-leguminous fodder grown in combination, thereby increasing the yield of forage.

2.3.2.1 Green fodder yield

Singh *et al.* (1980) reported increased maize yield when intercropped with cowpea with 1:2 ratio of maize : cowpea. But at 1:3 ratio, the green fodder yield of maize was significantly reduced on alluvial sandy loam soils of Delhi.

James and Robert (1983) conducted an experiment involving intercropping of maize with cowpea and soybean. They observed that the intercropping resulted in greater productivity per unit land area than monocultures of the intercrop components.

Subramanian and Govindaswamy (1985) reported that, green forage yield of (sorghum + soybean) mixture (45.9 t ha^{-1}) was the highest when sorghum was mixed with soybean than growing alone.

Tripathi (1989) stated that mixed cropping of Sorghum or maize or pearlmillet with cowpea resulted in increased herbage yields compared to their sole cropping.

From relative analysis due to maize-legume intercropping, it was observed that there was a decline in yield of legumes on an average by 37 per cent, whereas that of maize was reduced by 14.5 per cent in light textured soils of Hazaribagh (Bihar) during *kharif* season (Sarkar and Shit, 1990).

In a trial at Jhansi, sorghum in association with cowpea recorded the higher green forage (49.3 t ha^{-1}) and drymatter yield (10.2 t ha^{-1}) as compared to pure stand of sorghum (Gill and Verma, 1993).

Rameshbabu *et al.* (1994) observed that maize fodder yield was significantly reduced when grown along with dolichos and horsegram compared to maize alone. On the other hand, blacksoya, cowpea, kidneybean, clusterbean and greengram did not cause any reduction in the maize fodder yields during *kharif* season on black clayey soils of Dharwad.

Barik and Tiwari (1996) reported that among the different intercropping combinations, sweetsudan + cowpea gave higher green fodder yield than maize + cowpea on medium black soils of Anjora during *kharif* season.

Bezbaruah and Thakuria (1996) reported that, teosinte when mixed with cowpea in 100:50 seed proportion mixture resulted in significant increase in the mixed green forage yield (42.3 t ha^{-1}) over sole teosinte (34.6 t ha^{-1}).

Choubey *et al.* (1997) reported that teosinte and cowpea intercropping in 2:1 row ratio produced higher forage yield of mixture (52.6 t ha^{-1}) over other row proportions.

Srinivasraju *et al.* (1997) observed an increase in green fodder yield in maize and cowpea intercropping than maize alone during *winter* season on clay loam soils of Amberpet, A.P.

Verma *et al.* (1997) on silty loam soils of Pantnagar observed higher green fodder yields when sorghum was intercropped with cowpea over sorghum sole cropping.

Inclusion of legume component in the cereal-legume association increased the green forage yield up to 35 to 45 per cent over monocrops due to reduced intercrop competition and better use of resources (Tripathi *et al*., 1997, Obuo *et al*., 1998 and Pandita *et al*., 1998).

Krishna *et al.* (1998) opined that higher green fodder yield of maize + cowpea mixed cropping at 30 cm (24.36 t ha^{-1}) and 45 cm (20.30 t ha^{-1}) were significantly higher over maize sole crop (16.1 t ha^{-1}) on clay loam soils of Rudrur during *kharif* season.

Pandey *et al.* (1998) observed that maize as sole crop gave significantly higher green fodder yield compared to maize + cowpea intercropping during *kharif* season on sandy clay loams of Jagdalpur.

Ramanakumar and Bhanumurthy (2001) reported that intercropping system of maize and cowpea in 2:1 ratio produced higher green fodder yield, (42 t ha^{-1}) during *kharif* 1998 and (30.6 t ha^{-1}) during summer 1999, on sandy loam soils of Rajendranagar, A.P.

Nyamagonda *et al.* (2002) found that performance of maize-legume combination was better than pure stand and the results showed that maize when mixed with fieldbean in 100:50 population resulted higher green forage yield (73.43 t ha^{-1}).

Kumar and Prasad (2003) reported that sowing of maize and cowpea both in the paired rows (2:2) with proportionate seed rates produced the maximum green forage (37.6 t ha^{-1}) at Ranchi (Jharkhand).

Gangaiah (2004) reported that intercropping maize + cowpea resulted in highest green fodder production on medium black soils of Dharwad (Karnataka).

Reddy *et al.* (2004) observed that, maize and cowpea sown at 4:1 ratio resulted in higher green fodder yield during *kharif* season 2000 and 2001 at Ranjendranagar, Hyderabad (Andhra Pradesh).

Singh *et al.* (2005) reported that intercrop combination of sorghum + cowpea in 2:1 ratio resulted in the maximum green fodder yield during summer season 2002 on sandy loam soils of Hissar.

Sunilkumar *et al.* (2005) reported that higher total green fodder yield (33.8 t ha^{-1}) was obtained from intercropping of maize and cowpea in the row proportion of 2:2 in *kharif* season at Indian Grassland and Fodder Research Institute, Jhansi.

Sharma *et al.* (2008) reported that significantly higher green fodder yield was observed in intercrop combination of maize + cowpea in 2:2 row ratio (43.2 t ha^{-1}).

Dahmardeh *et al*. (2009) stated that the highest green fodder yield (65.7 t ha^{-1}) was recorded with intercropping of maize and cowpea in ratio of 100:100.

Surve *et al.* (2011) conducted a field experiment on clayey soil of Navsari (Gujarat) during summer season to assess the forage production potential of sorghum, maize and cowpea under sole and intercropping systems and they found that the highest green fodder yields (50.62 t ha^{-1}, 38.61 t ha^{-1}) were obtained from sorghum + cowpea (2:1) and maize + cowpea (2:1) respectively as compared to their respective sole crop (39.76 t ha^{-1} and 30.04 t ha^{-1}).

2.3.2.2 Dry fodder yield

According to Rameshbabu *et al.* (1994), maize Africantall when mixed with high seed rate of cowpea resulted in significant increase in the dry forage yield (15.23 t ha^{-1}) during *kharif* season on black clayey soils of Dharwad.

Barik and Tiwari (1996) reported that among the different intercropping combinations, sweetsudan + cowpea gave higher dryfodder yield over maize+ cowpea on medium black soils of Anjora during *kharif* season.

Sood and Sharma (1996) opined that maize grown at 60 cm row spacing and intercropped with cowpea, velvetbean, and soybean registered an increase of 22.03, 28.99, and 12.39 per cent dry forage respectively over sole crop of maize grown at 60 cm spacing during *kharif* season on silty clay loams of Palampur.

Srinivasaraju *et al.* (1997) observed an increase in dry fodder yield in maize and cowpea intercropping than maize alone during winter season on clay loam soils of Amberpet, A.P.

Pandey *et al.* (1998) concluded that maize as sole crop gave significantly higher dry fodder yield compared to maize + cowpea intercropping during *kharif* season on sandy clay loam of Jagdalpur.

Krishna *et al.* (1998) observed that dry fodder yield of maize + cowpea mixed cropping at 30 cm (4.32 t ha^{-1}) and 45 cm (3.27 t ha^{-1}) were significantly higher over sole maize on clay loam soils of Rudrur during *kharif* season.

Patel and Rajgopal (2001) reported the highest dry forage yield when maize + cowpea was sown in planting pattern of 5:2 and this planting pattern was statistically at par with 4:2 row ratio during *kharif* season on clay loams of Chhattisgarh.

Gangaiah (2004) reported that intercropping maize + cowpea resulted in the highest dry fodder production on medium black soils of Dharwad (Karnataka). However, Reddy et al. (2004) observed that higher dry fodder yield with sole maize (15.2 t ha^{-1}) as compared to intercropping of maize and cowpea in 2:2 row ratio(14.6 t ha^{-1}).

Surve *et al.* (2011) found higher dry fodder yield in sorghum + cowpea (17.41 t ha^{-1}) and maize +cowpea (14.08 t ha^{-1}) intercropping treatments as compared to their sole cropping (14.16 and 11.62 t ha^{-1} respectively) in clayey soils of Navsari (Gujarat) during summer.

2.3.3 Forage Quality

Forage quality can be defined as the extent to which forage has the potential to produce a desired animal response. Growing of fodder crops in mixture with legumes enhanced fodder palatability and digestibility (Chaudhary and Husain, 1985).

2.3.3.1 Crude protein content and yield

Chauhan and Dungarwal (1980) observed that companion cropping of maize with legumes like cowpea and clusterbean for fodder resulted in significant increase in yield and forage quality parameters namely crude protein, crude fibre, nitrogen free extract, crude fat and mineral matter by 67.02, 22.03, 25.64, 53.48 and 66.35 per cent, respectively compared to maize alone.

Paul *et al.* (1981) reported that forage grass in association with forage legumes resulted in higher crude protein yield and *in vitro* drymatter digestibility.

Mercy and Mohamed (1984) observed that the different legumes *viz.*, cowpea, velvet bean, blackgram didn’t show any significant effect on the crude protein yield of maize and also stated that among the crop associations, the maximum total crude protein yield was obtained from maize-velvetbean association.

The quality of the fodder increased in the mixed crop of sorghum and soybean as compared to the pure crops of sorghum alone or soybean alone (Subramaniyan and Govindaswamy, 1985).

Angadi and Gumaste (1989) reported that, maize grown in combination with blacksoya resulted in higher total crude protein (997 kg $ha^{-1)}$, phosphorus (35.15 kg ha^{-1}) and calcium (110.43 kg ha^{-1}) yield over sole maize.

Tripathi (1989) reported that association of cereal and leguminous forage not only maintained the level of herbage production (1.02 t ha^{-1}) but also doubled the crude protein yield.

Manoharan and Subramanian (1993) reported that, sorghum intercropped with cowpea in 2:1 ratio was superior with respect to crude protein yield (460 kg ha^{-1}) due to additional legume component of cowpea in the mixed forage.

Ramchandra *et al.* (1993) reported that, maize in association with cowpea gave higher crude protein content (11.52%) over sole maize (10.18 %).

Jayanthi *et al.* (1994) reported that, sorghum intercropped with cowpea at 1:1 ratio resulted in higher crude protein yield (472 kg $ha^{-1)}$ as compared to sole sorghum (268.4 kg ha^{-1})

Rameshbabu *et al.* (1994) reported higher crude protein yield of mixture (1340 kg ha^{-1}) when Africantall maize was mixed with cowpea and also stated that crude protein yield of maize was the highest when maize mixed with blacksoya and cowpea was the next best mixture during *kharif* season on black clayey soils of Dharward (Karnataka).

Sood and Sharma (1996) recorded higher *invitro* drymatter digestibility in fodder maize in the treatments having legumes as intercrops during *kharif* season on silty clay loams of Palampur (Himachal Pradesh).

Higher total crude protein yield was obtained from Intercropping of sorghum with cowpea in 2:2 row ratio (9.26 q ha^{-1}) than sole sorghum (4.31 q ha^{-1}) and sole cowpea (8.93 q ha^{-1}) (Mishra *et al.*, 1997).

Srinivasraju *et al.* (1997) reported the highest crude protein (13.8 %) and minimum crude fibre content in maize and cowpea intercropping than maize alone during winter season on clay loam soils of Amberpet (Andhra Pradesh).

Inclusion of legume component in the cereal-legume association increased the crude protein yield from 40 to 81 per cent over monocrops due to nitrogen fixation from legumes (Tripathi *et al.*, 1997; Pandita *et al.*, 1998 and Obuo *et al.*, 1998).

Verma *et al.* (1997) observed higher crude protein yields in sorghum and cowpea intercropping during rainy season on silty loam soils of Pantnagar.

Krishna *et al.* (1998) observed that mixed cropping of fodder maize and cowpea gave significantly higher crude protein per cent up to 180 kg N ha^{-1} on clay loam soils of Rudrur, Andhra Pradesh during *kharif* season.

Pandey *et al.* (1998) registered the maximum crude protein yield in maize + cowpea intercropping (738.1 kg ha^{-1}), followed by maize + ricebean intercropping (725.1 kg ha^{-1}). However, these differences were not significant during *kharif* season on sandy clay loam soils of Jagdalpur.

Thippeswamy (1999) observed that higher total crude protein (812 kg ha^{-1}), crude fibre (3820 kg ha^{-1}), total nitrogen free extract (5665 kg ha^{-1}), total carbohydrate (9473 kg ha^{-1}) yields were observed in sorghum in association with fieldbean intercropping system at 2:1 row proportion than sole crops.

Sunilkumar *et al.* (2000) concluded that total crude protein yield of maize and fieldbean mixture (1336 kg ha^{-1}) was higher in 100:50 proportions with superior palatability (96.23%). Similarly, total yield of crude fibre, ether extract, total ash and nitrogen free extract were higher in 100:50 seed proportion mixtures of maize and legumes over sole crops and other proportions.

Ramanakumar and Bhanumurthy (2001) observed that intercropping system of maize and cowpea in 2:1 ratio was found to be better for higher crude protein content and yield of component crops. Crude fibre was the minimum in fodder maize intercropping with cowpea during *kharif* and summer seasons on sandy loam soils of Ranjendranagar, Andhra Pradesh.

Kumar and Prasad (2003) reported that sowing of maize and cowpea both in paired rows (2:2) produced the maximum crude protein yield (850 kg ha^{-1}) during rainy season at Ranchi (Bihar).

Rajshekhar *et al.* (2004) reported that significantly higher crude protein (180.43 kg ha^{-1}) and crude fibre (263.79 kg ha^{-1}) yields of intercropped lucerne were recorded with 60 × 30 cm maize spacing over paired row planting and it was on a par with 90 × 20 cm spacing.

Sunilkumar *et al.* (2005) reported significantly higher total crude protein yield with maize + cowpea (2:2) than other treatments. The results indicated superiority of 35.5 and 68.9 per cent in crude protein yield with maize + cowpea (2:2) compared to sole stands of maize and cowpea, respectively.

Verma *et al.* (2005) observed higher crude protein and crude fibre with maize and cowpea cross sowing with full seed rate of both the crops during summer season of 1998 at Udaipur (Rajasthan).

Sharma *et al.* (2008) reported that maize + cowpea (2:2) intercropping pattern recorded with the highest crude protein yield (1.10 t ha^{-1}) followed by maize + ricebean (2:2).

Eskandari and Ghanbari (2009) reported that intercropping systems had a significant effect on forage maize quality in terms of crude protein and they found that it was improved due to more availability of nitrogen for maize in intercropping compared with its sole crop

2.3.3.2 Crude fibre content and yield

Mercy and Mohamed (1984) reported that the crude fibre yield of maize was significantly influenced by the legumes and the association with blackgram resulted in higher crude fibre yield of maize while the least was recorded with cowpea.

Srinivasaraju *et al.* (1997) reported the minimum crude fibre content in maize and cowpea intercropping than maize alone during winter season on clay loam soils of Amberpet.

Ramanakumar and Bhanumurthy (2001) observed that crude fibre was the minimum in fodder maize with intercropping system of fodder maize and cowpea during *kharif* and *summer* seasons on sandy loam soils of Ranjendranagar, A.P.

2.3.4 Nutrient Content and Uptake

Inclusion of a legume with cereal intercropping restores the soil fertility as it lessens the depletion of soil N, P and K compared to sole cropping of cereals. In general, higher uptake of N, P and K was associated with higher fodder yield and higher composition of N, P and K.

Srininivasraju *et al.* (1997) reported that cowpea intercropping with maize resulted in higher N, P and K uptake of the system and a less depletion of soil N, P and K than sole cropping during *winter* season on clay loam soils of Amberpet, A.P.

Singh *et al.* (2000) observed that maize + pea intercropping accumulated more nitrogen in fodder maize than sole maize and maize + lentil respectively on sandy loam soils of Lakhaoti.

Ramanakumar and Bhanumurthy (2001) revealed that intercropping of maize and cowpea resulted in more N, P and K uptake of the system than sole cropping on sandy loam soils of Ranjendranagar during *kharif* and *summer* season

Singh *et al.* (2008) conducted a field experiment on clay loam soils of Regional Research Station, Wadura (Jammu and Kashmir) on maize based intercropping system and they found that total N, P and K uptake of the system was significantly superior in intercropping system to sole cropping and the highest uptake reported in maize + soybean intercropping. Intercropping increased available soil N and decreased both soil P and K compared to initial and available N, P and K content after sole maize. They also reported that available soil N, P and K content varied with the kind of intercrops and maize +soybean followed by maize+ cowpea system recorded the highest available soil N, P and K among various intercropping system.

2.4 EFFECT OF BASE CROP ON PERFORMANCE OF LEGUME INTERCROP

Morris and Genter (1962) reported that the yields obtained by the intercrop (soybean) in maize were about the same as would be expected when planted alone.

Intercropped legumes in maize based intercropping systems were suppressed and yielded less because of shade caused by maize (Agboola and Fayemi, 1971).

Dalal (1977) found that the yield of maize was reduced when it was planted with soybean in the same row, but the grain yield of soybean was further reduced when it was planted with maize in alternate pairs of rows.

During rainy season in black soils a field experiment was conducted by Gumaste (1981) at University of Agricultural Sciences, Dharwad. Paired row sowing of sorghum helped to get higher yield of intercropped lucerne (198.96 q ha^{-1}) than the lucerne sown in between normal planted sorghum (142.93 q ha^{-1}).

Paired rows of sorghum with two rows of legume intercrops (greengram, blackgram and cowpea) in 90 cm spacing resulted in maximum yield of all intercrops (Singh, 1981).

Chowdhury and Bose (1983) noticed the lower yield of intercropped soybean in maize than that of sole crop. The combined grain yield of the two crops in an intercropping system was more than the individual components.

Among different fodder legumes namely cowpea, sesbania, clusterbean, dolichos, soybean and sunnhemp intercropped with grain sorghum, sunnhemp resulted in higher green forage yield (13.86 t ha^{-1}) followed by dolichos and cowpea (Anon., 1984).

Khot *et al.* (1992) found that common sesban or swamp pea or sunhemp in 2:1 row ratios or in seed mixture in maize proved advantageous over the traditional system of maize + cowpea without affecting the total yield.

Intercropping of cowpea in maize, sorghum and pearlmillet suppressed the cowpea biomass compared to monocrop (Blade *et al.,* 1992).

Intercropping of maize with cowpea significantly affected the yield of cowpea, which decreased from an average of 0.48 to 0.23 tons per hectare as maize population increased from 20,000 to 80,000 plants per hectare (Cardoso, *et al*., 1994).

Niranjan *et al.* (1994) reported that among different fodder crops, intercropping of cowpea and sunhemp resulted in the highest green fodder and the lowest was recorded in sorghum + sesbania intercropping systems.

Sharma *et al.* (1994) found that blackgram was the most compatible legume intercrop in maize than horsegram.

Gangwar and Sharma (1994) stated that among different fodder legumes namely cowpea, clusterbean, sanhemp, blackgram, greengram, prickly sesban intercropped with maize, prickly sesban was the most compatible legume intercrop in maize.

Zewdu and Asregid (2001) reported that the growth and yield of the under sown forage legumes were lower in contrast to sole forage planting and *Vicia villosa* was the highest yielding forage legume species compared to other when under sown in maize.

A row proportion of 1:2 resulted in significantly higher total green forage yield (52.16 q ha^{-1}) over1:1 row ratio in maize-lucerne intercropping system (Rajshekhar *et al.*, 2004).

2.5 ECONOMICS

Maize grown with cowpea in 2:2 ratio resulted in the highest net returns (Rs. 4,026 ha^{-1}) and benefit cost ratio (1.87) during the *kharif* season of 1989 and 1990 at Bhubaneswar (Mohapatra and Pradhan (1992)).

Bai and Pillai (1993) obtained higher profit by growing sorghum in combination with velvetbean (Rs.3,475 ha^{-1}) than the sole sorghum (Rs.2,180 ha^{-1}).

In an experiment conducted at Bangalore, Ramachandra *et al.* (1993) reported that, the maximum net returns from maize and cowpea intercropping (Rs. 4,865 ha^{-1}) system than sole cropping of maize (Rs.3,310 ha^{-1})

Jayanthi *et al.*(1994) reported that fodder sorghum intercropped with cowpea at 1:1 ratio resulted in comparatively higher net returns (Rs.3,340 ha^{-1}) over sole sorghum (Rs. 2,600 ha^{-1}).

Barik and Tiwari (1996) reported that intercrop combination of maize + cowpea gave higher gross monetary returns than sole crop of maize on medium black soils of Anjora during *kharif* season.

Bezbaruah and Thakuria (1996) reported that growing of teosinte and cowpea in 100:50 proportion gave higher net returns (Rs. 6,585 ha^{-1}) as compared to other proportions.

Srinivasaraju *et al.* (1997) observed that among intercropping treatments, Africantall + cowpea intercropping gave significantly higher net returns of Rs.8,580 ha^{-1} compared to Africantall alone (Rs. 7,200 ha^{-1}) during winter season on clay loam soils of Hyderabad (Andhra Pradesh).

Patel and Rajagopal (2001) reported that the highest net returns (Rs. 12,786 ha^{-1}) were obtained when maize + cowpea were sown in planting pattern of 5:2 and this planting pattern was statistically at par with 4:2 row ratio during the *kharif* season at Anjora.

Ramanakumar and Bhanumurthy (2001) reported that intercropping cowpea with maize (Africantall) gave the highest monetary return (Rs. 8,580 ha^{-1}) and found markedly superior to the return obtained by growing Africantall alone (Rs. 7,200 ha^{-1}) on sandy loam soils of Ranjendranagar (Andhra Pradesh) during *kharif* and summer seasons.

Kumar and Prasad (2003) reported that sowing of maize and cowpea both in paired rows (2:2) accounted for the maximum net return (Rs. 24,540 ha^{-1}), along with monetary advantage (Rs. 7,740 ha^{-1}) during rainy season at Ranchi.

Singh *et al.* (2005) reported that sorghum + cowpea (2:1) was the most profitable combination which gave the highest net profit (Rs. 12, 990 ha^{-1}) and benefit cost ratio (1.97) during summer season at Hissar (Haryana).

Sunilkumar *et al.* (2005) reported that intercropping of maize and cowpea in the row proportion of 2:2 resulted significantly higher gross return (Rs. 15, 236 ha^{-1}), net return (Rs. 8,346 ha^{-1}) and benefit cost ratio (2.21) during the *kharif* season of 1999, 2000 and 2001 at Indian Grassland and Fodder Reasearch Institute, Jhansi.

In a field trial conducted in clayey soils of Parbhani, Baig *et al.* (2007) found that the maize + soybean (3:3) resulted the highest net monetary return (19,277) followed by maize + cowpea 3:3 row ratio (18,320) during *kharif* season.

Sharma *et al.* (2008) reported that the intercropping of maize and cowpea in the row proportion of 2:2 gave the maximum net returns (Rs 16,104 ha^{-1}) and benefit cost ratio (1.84), followed by maize + ricebean in row proportion 2:2 (Rs 15,319 ha^{-1} and 1.71, respectively).

Chapter III

MATERIAL AND METHODS

A field experiment entitled "**Studies on fodder maize and legume intercropping system**" was conducted at Agricultural college farm, Bapatla, during *kharif*, 2011. The material used and methodology followed during the investigation are presented in this chapter.

3.1 EXPERIMENTAL SITE

The experiment was conducted in field number 36A of Southern Block, Agricultural College Farm, Bapatla of Acharya N.G. Ranga Agricultural University. The experimental site is located at an altitude of 5.49 m above the mean sea level, 15^0 54' N latitude, $80^0$25' E longitude and about 7 km away from the coast of Bay of Bengal in the Krishna Agro Climatic Zone of Andhra Pradesh, India.

3.2 WEATHER DURING THE CROP PERIOD

The weather data recorded during the crop growth period (02.08.2011 to 02.10. 2011) are presented in Table 3.1 and depicted in Figure 3.1 and 3.2.

The weekly mean maximum and minimum temperatures during the crop period ranged from 31.5^0C to 37.0^0C and 24.1^0C to 27.0^0C, respectively, while the average maximum and minimum temperatures during the crop growth period were 34.6^0C and 25.3^0C, respectively. The weekly mean relative humidity ranged between 57.1 to 83.0 per cent with an average of 73.2 per cent. A total of 370.2 mm rainfall was received in 20 rainy days during the crop period.

3.3 EXPERIMENTAL SOIL

Initial soil samples were collected from 0 to 30 cm depth at random from the experimental field, one week prior to starting of field preparation and a composite sample was analyzed for physical and physico-chemical properties (Table 3.2).The results of the soil analysis revealed that the experimental soil was sandy clay loam in texture, slightly alkaline in reaction (p^H 7.6), medium in organic carbon (0.5%), low in available nitrogen (175 kg ha^{-1}), and high in available phosphorus (33.9 kg ha^{-1}) and potassium (532.5 kg ha^{-1}).

3.4 CROPPING HISTORY OF THE EXPERIMENTAL FIELD

The cropping history of the experimental field for the three consecutive preceding years is given below.

Year	*Kharif*	*Rabi*
2008-09	Pigeonpea	Fallow
2009-10	Dhaincha	Fallow
2010-11	Dhaincha	Fallow
2011-12	Present experiment	

3.5 EXPERIMENTAL DETAILS

3.5.1 Experimental Design and Layout

The experiment was laid out in a Randomized Block Design with 10 treatments and replicated three times (Fig. 3.3).

Crop	Variety	Seed rate (kg ha^{-1})
Fodder maize	Africantall	50
Cowpea	EC-4216	30
Clusterbean	Bundel guar-2	40
Pillipesara	Local	25

3.5.2 Treatments

The experiment consisted of ten treatments as detailed below

T_1 : Sole crop of Fodder maize

T_2 : Sole crop of Cowpea

T_3 : Sole crop of Pillipesara

T_4 : Sole crop of Clusterbean

T_5 : Maize + Cowpea

T_6 : Maize + Pillipesara

T_7 : Maize + Clusterbean

T_8 : Maize in paired rows + 2 rows of cowpea

T_9 : Maize in paired rows + 2 rows of Pillipeasara

T_{10} : Maize in paired rows + 2 rows of Clusterbean

3.5.3 Varietal Description

3.5.3.1 Fodder maize (African tall)

It is a tall annual, growing to height of 220-600 cm. Leaf blades are 30-150 cm long and 5 to 15 cm wide and this variety is ready for harvesting in 60-70 days after sowing. The green and dry fodder yields ranges from 29.0 to 60.0 t ha^{-1} and 8.0 to 12.0 t ha^{-1} respectively.

3.5.3.2 Cowpea (EC-4216)

It is a semi-erect, fast growing and high yielding fodder variety suitable for cultivation all over the country. It can be harvested for fodder in 60-70 days and yields 35-40 t ha^{-1} of green fodder with 17.5-19.0 per cent crude protein and tolerant to many pests and diseases.

3.5.3.3 Clusterbean (Bundel guar-2)

It is a high yielding fodder variety suitable for cultivation in all the guar growing areas of India. It yields 22-35 t ha^{-1} green fodder in 60-70 DAS.

3.5.3.4 Pillipesara(local)

It is a popular fodder crop in delta areas of Andhra Pradesh. It is ready for harvest at 50% flowering in 60-70 DAS and it gives 15-20 t ha^{-1} green fodder yield.

3.6 CULTIVATION DETAILS

Details of cultivation practices are presented here under. The detailed calendar of operations, however, is presented in appendix-1.

3.6.1 Field Preparation

The experimental field was treated with a non-selective systemic herbicide, Glyphosate @ 12ml L^{-1} along with 10 g of urea for the control of weeds. Fifteen days after spraying of the herbicide, the field was ploughed with tractor drawn M.B Plough till a fine tilth was obtained and stubbles were removed. The field was laid out into plots as per experimental design (Fig. 3.3) using manual labour for leveling within the plots.

3.6.2 Seeds and Sowing

Healthy and well matured bold seeds of fodder maize, cowpea, clusterbean, and pillipesara were selected. Sowing was done on 02.08.2011 in furrows opened to a depth of 5 cm. Fodder maize and fodder legume sole crops were sown at 45 cm x 10 cm whereas in paired row planting 30 cm between rows in a pair and 60 cm between two pairs was followed. In mixed cropping seeds of fodder maize and legume mixed and sown in lines spaced at 45 cm.

3.6.3 Gap filling and thinning

Gap filling and thinning of overcrowded seedling was done 8 days after sowing in order to maintain the plant population as per the treatments.

3.6.4 Fertilizers

A uniform dose of nitrogen, phosphorous and potassium was applied as per the recommendation @120 kg N, 50 kg P_2O_5 and 40 kg K_2O ha^{-1}through urea, single superphosphate (SSP) and muriate of potash (MOP) respectively, to all the plots. Entire quantity of phosphorus and potassium was applied as basal whereas nitrogen was applied in two equal splits, one at the time of sowing and another at 30 days after sowing.

3.6.5 Weed control

Pre-plant application of non-selective, translocative herbicide, Glyphosate was applied before the preparation of main field. A pre-emergence herbicide, pendimethalin (1.25 kg a.i. ha^{-1}) also sprayed after sowing to keep the experimental plots weed free.

3.6.6 Plant protection measures

Phorate granules were applied @ 1.5 kg ha^{-1} in sand mix to protect the crop against pest attack. Incidence of sucking pests like aphids, thrips was noticed on cowpea, which was controlled by spraying Dimethoate @ 2 ml L^{-1} and imidacloprid (0.006%).

3.6.7 Irrigation

The crop received irrigation 2- 3 times at later stages of crop growth.

3.6.8 Harvesting

The crops were harvested on 05.10.2011 i.e. after 60 DAS. The border rows were harvested first and crop from the net plot area was harvested for recording green fodder yield.

3.7 BIOMETRIC OBSERVATIONS

Observations on fodder maize and legumes were recorded at 20, 40 and 60 DAS. For recording non-destructive observations, ten plants were selected at random in the net plot and labeled. For destructive sampling, plants were collected from 50 cm row length for both main and intercrops in the destructive sampling area of the plot.

3.7.1 Pre-harvest Observations

3.7.1.1 Plant height at 20, 40 and 60 DAS

Plant height was recorded from five randomly selected plants in the net plot area. The plant height in maize was measured from ground level to tip of the top most leaf before tasseling and upto tip of the tassel after tasseling. In case of legumes, the plant height was taken from ground level to tip of terminal growing point.

3.7.1.2 Number of leaves plant^{-1} at 20, 40 and 60 DAS

The actual number of leaves on all the observational plants was counted and expressed as number of leaves per plant after arriving at the average values.

3.7.1.3 Drymatter Accumulation at 20, 40 and 60 DAS

Dry matter production was recorded at 20 days interval, starting from 20 DAS separately for fodder maize and intercropped legumes. At each sampling, plants in 50 cm row length in second row from left side of the plot were harvested by leaving 5 cm stubbles, and dried in shade for 48 hours. Further the samples were kept in a hot air oven at 60 °C till a constant weight was recorded. Drymatter yield was expressed crop wise and combined total drymatter accumulation in kg ha^{-1}.

3.7.2 Post-harvest Observations

3.7.2.1 Green fodder yield

In recording the green fodder yield, plants in the boarder rows were harvested first. Fodder maize and legumes from net plot area were harvested separately by leaving 5 cm stubbles from ground surface and weighed. Green fodder yield of maize and intercrops was weighed separately and total green fodder was expressed in t ha^{-1}.

3.7.2.2 Dry fodder yield

The green fodder from the net plot area was dried in sun on the threshing floor till 15 % moisture level and the dry fodder yield was recorded and expressed in t ha^{-1}.

3.7.3 Chemical Analysis

3.7.3.1 Nitrogen content in plant

The dry plant samples collected separately viz., fodder maize, cowpea, clusterbean, and pillipesara at 20, 40 and 60 DAS were oven dried, powdered, and analysed for nitrogen by Modified micro-kjeldahl method (Jackson, 1973).

3.7.3.2 Crude protein content and yield

The nitrogen content in the plant material during 20, 40 and 60 DAS was multiplied with factor 6.25 to get protein content (Doubetz and Wells, 1968). Crude protein yield was calculated by multiplying crude protein per cent with drymatter yield of respective treatment.

3.7.3.3 Crude fibre content and yield

The crude fibre content was estimated by acid-alkali digestion method (Mahadevan, 1965). Crude fibre yield was calculated by multiplying crude fibre per cent with drymatter yield of respective treatment.

3.7.3.4 Total ash content

The total ash content was estimated by dry ashing method (Piper, 1966).

3.7.3.5 Chlorophyll content in plant

The chlorophyll content in the fresh leaves was estimated colorimetrically by dimethyl sulphoxide (DSMO) method as described by Hiscox and Stan (1979).

3.7.3.6 Nitrogen uptake

The nitrogen uptake at different growth stages (20, 40 and 60 DAS) was calculated by multiplying the nitrogen content of the plant with drymatter yield of respective treatment.

3.7.3.7 Residual Soil N P K content

Nitrogen, phosphorous and potassium status of the soil after the crop harvest was estimated separately in each treatmental plot as per the methods described by Subbiah and Asija (1956) for nitrogen, Olsen's method for phosphorus by Olsen *et al.* (1954) and flame photometer method by Jackson (1973) for potassium.

3.8 ECONOMICS

For each treatment, gross returns, net returns and returns per rupee of investment were calculated by considering prevailing input cost an output prices.

Gross returns = Value of the product in Rupees

Net returns = Gross returns - Total cost of cultivation

$$\text{Returns per rupee of investment} = \frac{\text{Gross return}}{\text{Total cost of cultivation}} \times 100$$

3.9 STATASTICAL ANALYSIS

The data obtained on pre and post-harvest observations are analyzed statistically using Fisher's method of analysis of variance as suggested by Panse and Sukhatme (1978) for Randomized Block Design. Statistical significance was tested by 'F' value at P=0.05 level of significance. The results depicted by tables and figures wherever necessary.

Table 3.1 Weekly meteorological data during the crop period (02.08.2011 to 05.10.2011)

Standard week	Date and Month	Mean temperature ^0C		Mean RH (%)	Rain fall (mm)	No. of rainy days
		Max. (^0C)	Min. (^0C)			
31	30th July - 05th Aug	34.4	24.8	68.7	36.3	3
32	06th Aug. - 12th Aug.	37.0	27.0	57.1	0.70	0
33	13th Aug. - 19th Aug.	35.1	26.0	77.4	49.6	3
34	20th Aug. - 26th Aug.	31.5	24.8	83.0	66.8	3
35	27th Aug.- 02th Sept.	33.6	24.9	76.0	11.2	3
36	03th Sept. - 09th Sept.	34.8	26.2	67.4	3.00	0
37	10th Sept. - 16th Sept.	34.8	24.7	78.7	89.6	4
38	17th Sept. - 23th Sept	35.0	25.6	73.4	2.60	0
39	24th Sept. - 30th Sept	34.9	24.5	79.4	78.2	3
40	01th Oct. - 07th Oct.	34.9	24.1	71.0	32.2	1
Total				**-**	**370.2**	**20**
Mean		**34.6**	**25.3**	**73.2**		

Table 3.2 Physical and Physico-chemical properties of the experimental soil

Property	Value	Method adopted
I) Physical components		
Sand (%)	77.7	Bouyoucos hydrometer method (Piper, 1966)
Silt (%)	8.0	
Clay (%)	14.3	
Textural class	**Sandy Clay Loam**	
II) Physico-chemical properties		
P^H (1:2.5 soil water suspension)	7.6	Glass electrode method (Jackson, 1973)
Ec (1:2.5 soil water suspension dSm^{-1} at 25^oC)	0.2	EC bridge (Richards, 1954)
III) Chemical properties		
Organic Carbon (%)	0.50	Walkely and Black's modified method (Walkley and Black, 1934)
Available Nitrogen (kg ha^{-1})	175	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	33.9	Olsen's method (Olsen *et al.*, 1954)
Available K_2O (kg ha^{-1})	532.5	Neutral normal ammonium acetate method (Jackson, 1973)

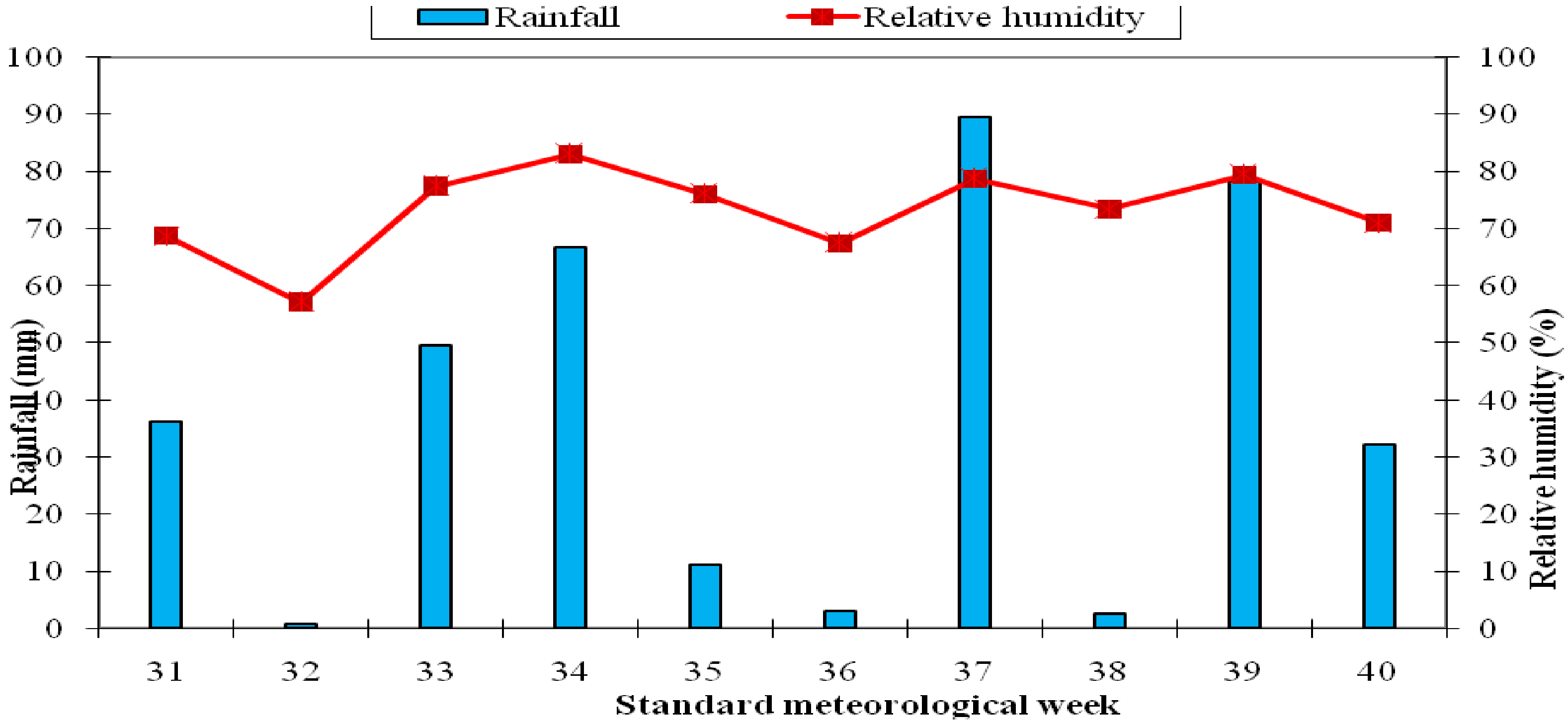


Fig.3.2 Weekly mean relative humidity (%) and rainfall data during the crop growth period (02.08.2011 to 05.10.2011)

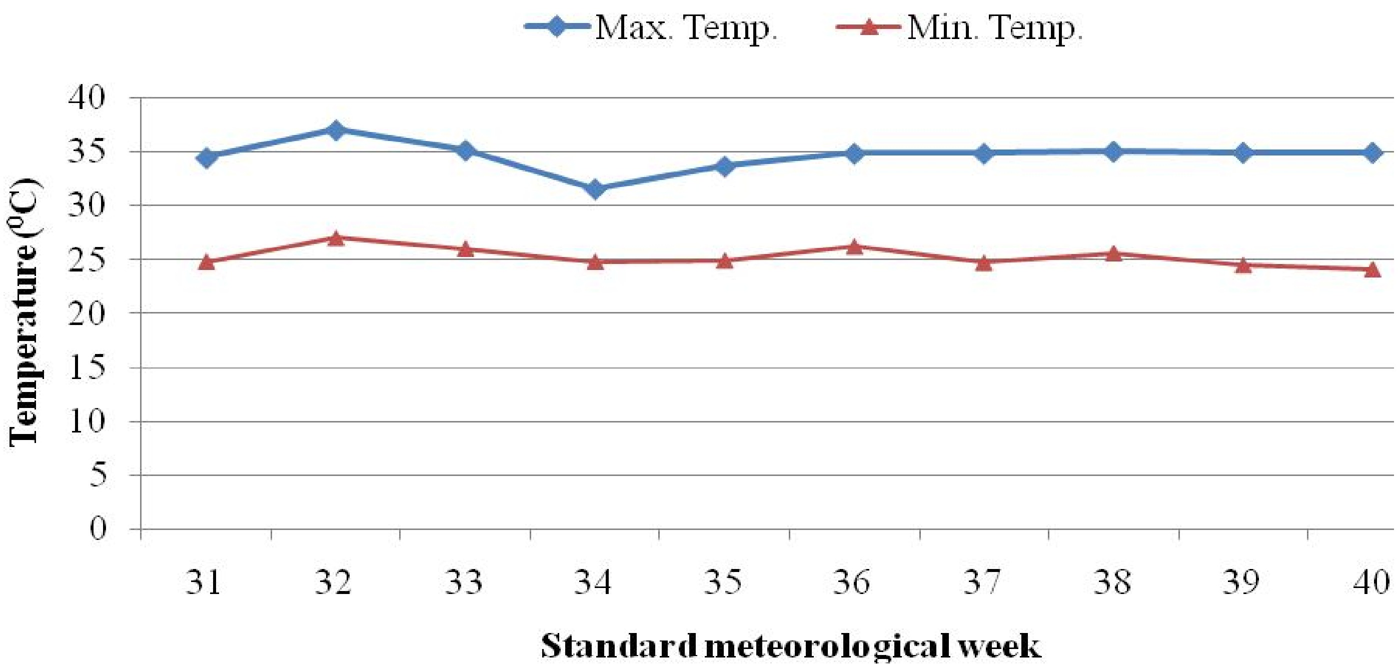


Fig.3.1 Weekly Mean temperature (°C) during the crop growth period (02.08.2011 to 05.10.2011)

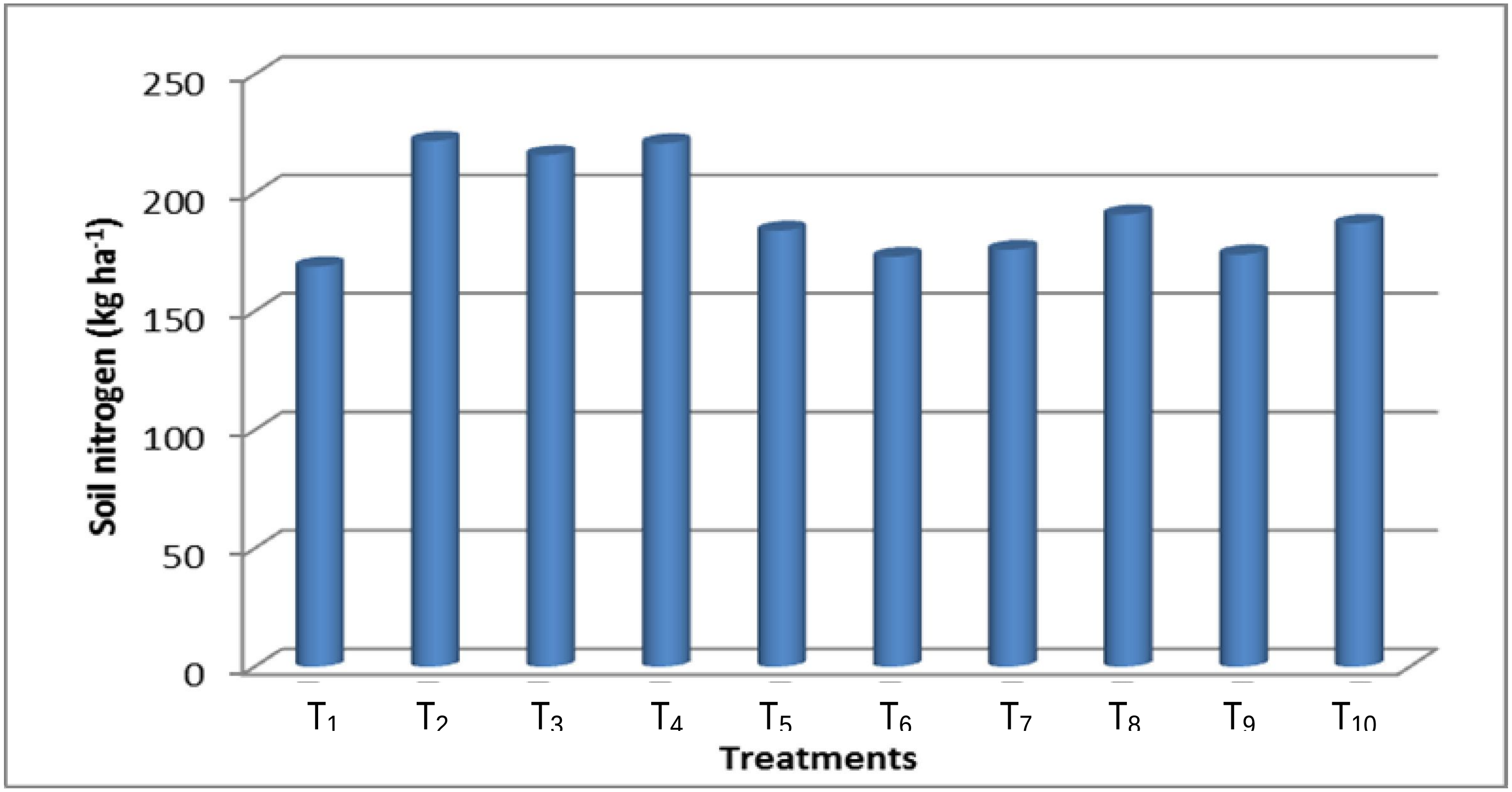
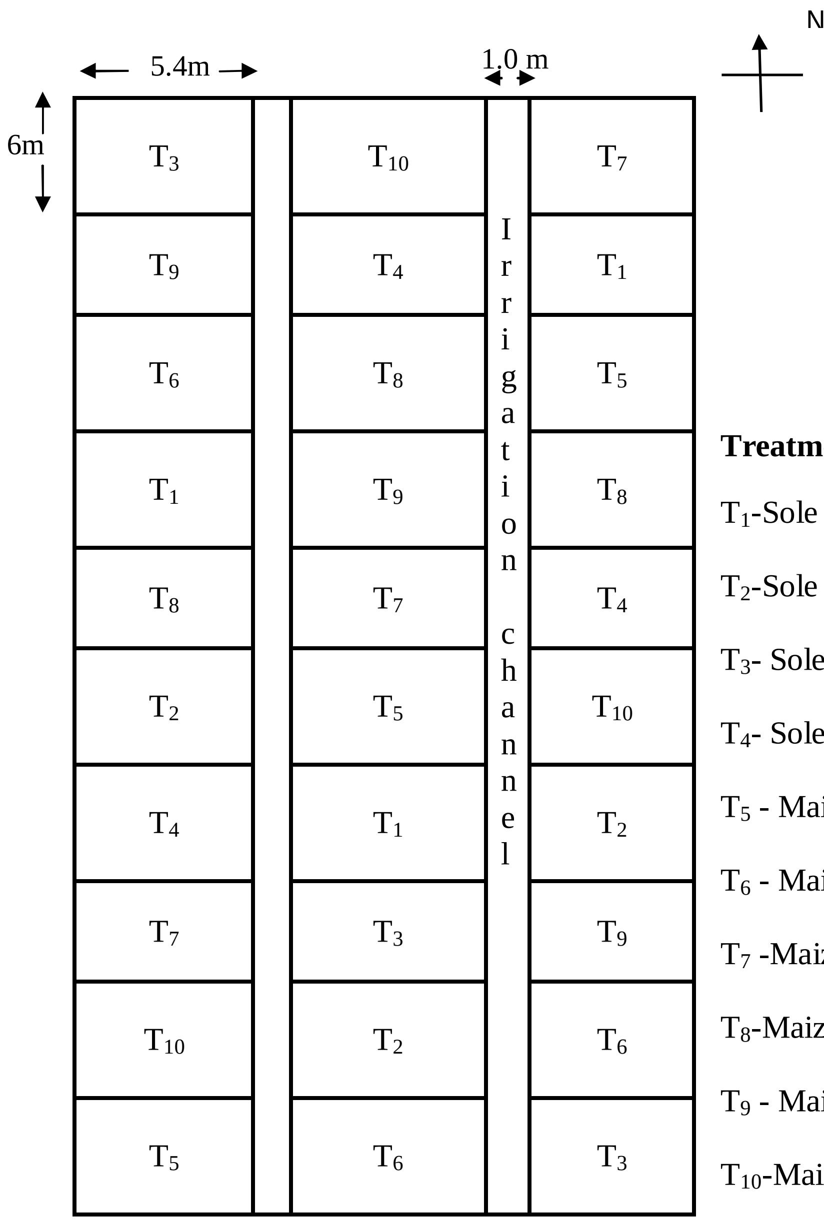


Fig.4.10 :Residual Available Nitrogen status (kg ha^{-1}) of the experimental field after harvest as influenced by different treatments.



Design	:	Randomized block design
Replications	:	3
Season	:	*kharif*, 2011
Gross plot size	:	5.4 m x 6.0 m
Net plot size	:	3.6 m x 5.0 m

Treatments

T_1-Sole crop of Maize

T_2-Sole crop of Cowpea

T_3- Sole crop of Pillipesara

T_4- Sole crop of Clusterbean

T_5 - Maize + Cowpea

T_6 - Maize + Pillipesara

T_7 -Maize + Clusterbean

T_8-Maize in paired rows + 2 rows of Cowpea

T_9 - Maize in paired rows + 2 rows of Pillipesara

T_{10}-Maize in paired rows + 2 rows of Clusterbean

Fig.3.3 Field Layout Plan of the Experiment

Chapter IV

RESULTS AND DISCUSSION

Quality forage production plays an important role in dairy industry. Availability of green forage to animals is the key to success of dairy enterprises and it is difficult to maintain the health and milk production of the livestock without supply of the green fodder. Fodder and feeds are the major inputs in animal production especially in milch animals, which account for about 60 to 70 per cent of total cost of milk production. The present availability of green fodder is about 513 million tonnes projecting a deficit of 53 percent and that of dry fodder is around 400 million tonnes as against the requirement of 676 millions tonnes (Surve and Arvadia, 2012). Intercropping has been recognised as a beneficial system of crop production as well as one of the potent means of better utilization of resources and higher fodder production per unit area per unit time. Cereal- based forages have the potential to supply large amounts of energy rich forages for animal diets. Unfortunately, they often contain less crude protein and for desirable levels of milk or meat production these diets require some protein supplementation. Inclusion of legumes along with cereals has been reported to improve the forage quality since legumes are rich in protein. There are numerous advantageous of intercropping a cereal *i.e.* non-legume fodder crop with legume crop, such as improved herbage quality, increased biomass production and economic use of fertilizers besides efficient utilization of land and minimizing the risk due to aberrant weather.

Information on forage production potential and nutritive value of fodder maize in intercropping with different legumes is meagre in Krishna agro climatic zone. So a field experiment was conducted during *kharif*, 2011 on coastal sandy loam soils of the Agricultural College Farm, Bapatla campus of the Acharya N.G. Ranga Agricultural University to study the performance of fodder maize intercropped with different legumes. The data collected on various growth parameters, yield attributes, yield as well as quality parameters of the fodder maize and legumes are statistically analysed and experimental findings are being discussed hereunder to evolve cause and effect relationship, substantiating the outcome in the light of current available literature.

4.1 WEATHER CONDITIONS AND SOIL

The weather conditions prevailed during the crop growth period were normal (Table 3.1). During the crop growth period, a total rainfall of 370 mm was received in 20 rainy days. The average maximum and minimum temperatures were 34.6^{0}C and 25.3^{0}C, respectively. The weekly mean relative humidity was 73 per cent. As a whole, the climatic conditions were favourable for the cultivation of fodder maize along with different legume intercrops.

The crop was grown on sandy clay loam soils, which was medium in organic carbon low in available nitrogen and high in available phosphorus and potassium. (Table 3.2)

4.2 GROWTH CHARACTERS

4.2.1 Plant Height

The data on fodder maize height at 20, 40 & 60 DAS are presented in table 4.1. A glance at the data reveals that plant height increased at a rapid rate from 20 to 40 DAS and the rate of increase decreased afterwards. It was also evident from the data that the method of sowing and different legume intercrops didn’t have any significant influence on the plant height of maize. Even though the differences were non-significant, taller maize plants were observed in sole cropping as compared to intercropping treatments. The maximum plant height of 239 cm and the lowest of 227 cm were observed at 60 DAS in sole maize and maize inter cropped with clusterbean, respectively.

Growth by cell division and enlargement occur in specialized tissues known as meristems. Apical meristem generates new cells in the tip of roots or shoots, resulting in increased height or length. An apical bud contains massed meristem and has a self-generating hormone supply. Very often crop management practices are designed to control formation of massed meristem (Gardner *et al*., 1988). This phenomenon might have operated in the present study also.

When plants were grown in association (intercropping), interaction between the species occur. Competition is a kind of interference. It occurs when i) two plants draw a requirement (*e.g.* light, nutrient) from the same limited pool. ii) the supply of this requirement to at least one of the plants is reduced by the presence of the other, and iii) the reduced supply influence the growth of the plant, and hence the negative interaction between two individuals or populations (Vandermeer, 1989). This negative interaction between fodder maize and legumes might have resulted in lower height of maize in intercropped treatments. Similar result was reported by Rameshbabu *et al*. (1994) and Gangaiah (2004). Likewise, in intercropped studies dwarf plants than the sole crop was also reported by Enyi (1973) and Nyamagonda *et al*. (2002).

The maximum plant height in case of sole crop was attributed to penetration of light, circulation of air and comparatively more nutritional area available to sole crop under competition free environment. While, decrease in plant height in intercropped situation, was ascribed to the fast growth of intercrops at an early growth stage and competition offered by intercrop for different environmental resources which suppressed growth of the companion crop. The current results are in accordance with the findings of Faris *et al.* (1983), Shahapurkar (1985), Shivay *et al.* (2001), Purushotham *et al.* (2003) and Gangaiah (2004).

4.2.2 Number of Leaves Plant $^{-1}$

The data on number of leaves per plant of maize at 20, 40 and 60 DAS are presented in Table 4.2. The data indicated that, different treatments tried in the experiment could equally influence the number of leaves per plant. The number of leaves per plant increased with age of the crop. The lowest and the highest numbers of leaves per plant were recorded at 20 DAS and 60 DAS, respectively. At 60 DAS, the least number of leaves (10) were registered in maize intercropped with pillipesara and clusterbean treatments where as the highest number (11.3) were found in sole maize treatment.

Leaf serves as the major photosynthetic organ of higher plants. The large, flat external surface of the leaf allows for maximum light interception per unit volume and minimizes the distance CO_2 must travel from leaf surface to chloroplast. The photosynthetic activity of crop plants depends upon the size and number of leaves (Kirankumar *et al.,* 2008). The rate of leaf appearance varies with environment but remains more or less constant under constant conditions (Patel and Cooper, 1961).Similar results of non-significant influence of intercropping treatments on the leaf number of cereal were also reported by Shahapurkar (1985), Shivay *et al.* (2001), Purushotham *et al.*(2003) and Gangaiah (2004).

4.2.3 Drymatter Accumulation

Drymatter is the expression of development of different morphological components like stem and number of leaves. The data pertaining to drymatter accumulation of fodder maize and intercrops (cowpea, clusterbean and pillipesara) individually and combined drymatter at 20, 40 and 60 DAS are furnished in Table 4.3 and depicted in Fig. 4.1, 4.2 and 4.3. A perusal of the data indicated that the drymatter accumulation increased with the increase in the age of the crops. There was a continuous increase in drymattter accumulation with advanced age of the crop up to harvest. Among the different crops, maize produced higher drymatter than legume intercrops at all the stages of growth. Taller plants and thick stems might have contributed for increased drymatter accumulation in maize.

The lowest drymatter accumulation was observed at 20 DAS and the highest was at 60 DAS. Drymatter accumulation was very slow during first 20 DAS probably due to poor root system and slow growth and thereafter it increased rapidly (Kumar and Purohit, 1996). These logarithmic increases in growth can’t continue definitely, because crop matures and growth ceases.

Drymatter accumulation of maize individually was non- significant in different treatments at 20, 40 and 60 DAS. Even though the differences were non -significant, maize plants in sole crop recorded with higher drymatter accumulation (1739, 4635, 7622 kg ha^{-1} at 20, 40 and 60 DAS, respectively) and this might be due to less interspace competition, lack of inter-specific competition and increased habitat population. The lowest drymatter accumulation by maize (1519, 4142 and 6904 kg ha^{-1} at 20, 40 and 60 DAS, respectively) was recorded when it was mixed with cowpea fodder. The performance of maize was better in terms of its drymatter accumulation when it was sown in pairs and the legume fodders were sown in between the pairs which might be due to the availability of more space and less competition.

The data on drymatter accumulations by legume (cowpea, pillipesara, clusterbean) indicated significant influence of various treatments at 20, 40 and 60 DAS. Higher drymatter accumulation was recorded with sole crops of cowpea, clusterbean, and pillipesara fodders over their respective intercropped stands at all the growth stages. Among the different sole fodder legumes, cowpea registered the highest drymatter accumulation at 20, 40 and 60 DAS (540, 1621 and 2701 kg ha^{-1} respectively) while the lowest drymatter accumulation was recorded by pillipesara in T_6 treatment (14, 43 and 72 kg ha^{-1} at 20, 40 and 60 DAS respectively). Cowpea is superior to other legumes because it tolerates both drought and shade. Reductions of drymatter in legumes was observed in mixed intercropping compared to row intercropping in between the fodder maize pairs. The reduction in legume drymatter in mixed cropping might be due to increased population pressure and inter-specific competition. Further, maize competed with associated legumes by means of mutual shading. Intercropping of cereal with legume has resulted in a significant reduction in yield of legume, while the yield of cereal remains unaffected. This reduction in fodder production of legume was possibly due to shading by cereal component and competition for soil resources (Gangaiah, 2004).

Legume fodders intercropped within the pairs of maize recorded better performance with lower reduction in drymatter. This might be due to better utilization of environmental resources and the availability of ample space between paired rows (Verma *et al.*, 1997). Among different legume intercrops, cowpea (340, 1019 and 1699 kg ha^{-1} at 20, 40 and 60 DAS) performance was the best followed by clusterbean (250, 750 and 1161 kg ha^{-1} at 20, 40 and 60 DAS) . The lowest drymatter (30, 91 and 151 kg ha^{-1} at 20, 40 and 60 DAS) was recorded by pillipesara.

Total drymatter also increased with the advanced age of the fodder crops. At 20 DAS, all the treatments performed uniformly and indicated a non significant difference. More total drymatter accumulation (1981 kg ha^{-1}) was in maize pairs + cowpea intercropping (T_8) followed by maize pairs + clusterbean (1873 kg ha^{-1}). The lowest total drymatter (1584 kg ha^{-1}) was recorded in maize + pillipesara mixed intercropping (T_6). As the crops were in young, root system might have not been fully developed to absorb nutrients, which is essential for drymatter accumulation.

At 40 DAS, significantly the highest total drymatter accumulation (5495 kg ha^{-1}) was recorded with maize pairs intercropped with cowpea (T_8) over all other treatments except maize pairs + clusterbean *i.e.* T_{10} (5270 kg ha^{-1}). The sole maize *i.e.* T_1 (4635 kg ha^{-1}) and maize pairs + clusterbean were statistically comparable. Treatments $T_{1,}$ T_9, T_7, T_5 and T_6 were comparable.

At 60 DAS, significantly the highest total drymatter of 9205 kg ha^{-1} was recorded with maize pairs + cowpea (T_8) followed by 8694 kg ha^{-1} in maize pairs + clusterbean (T_{10} treatments). The lowest total drymatter accumulation (7205 kg ha^{-1}) was recorded in maize + pillipesara mixed cropping and this was statistically comparable with total drymatter accumulation (7622 kg ha^{-1}) in maize sole cropping. As a whole, the total drymatter production recorded was higher in maize pairs + cowpea followed by maize in pairs + clusterbean. This might be due to better utilization of space and light interception coupled with nutrient contribution of legume fodder to cereal (Sunilkumar *et al.*, 2005). Intercropping offered more plants per unit area and efficient utilization of environmental and soil resources which might have resulted in higher drymatter accumulation. These findings are in agreement with reports of Natarajan and Willey (1979), Chohan and Dungarwal (1980), Rameshbabu *et al.* (1994), Patel and Rajagopal (2001), Kumar and Prasad (2003), Sunilkumar *et al.* (2005) and Eskandari and Ghanbari (2009).

4.3 YIELD (t ha^{-1})

The total biomass is the economic yield in fodder crops. The stage of harvest plays a vital role in influencing the quality and quantity of fodder. The data on green and dry fodder yields of maize, legume intercrops individually and total yield in intercropping systems are furnished in table 4.4 and depicted in Fig. 4.2.1 and 4.2.2. A perusal of the data in table 4.4 revealed that the total green and dry fodder yield was significantly influenced by different treatments whereas; the individual maize yield recorded was non –significant.

4.3.1 Green Fodder Yield

All the treatment tried in the experiment could influence uniformly the green fodder yield of Africantall maize (table 4.4). Even though the differences were non-significant, higher green fodder yield (40 t ha^{-1}) was registered with sole maize fodder followed by maize pairs + pillipesara and maize pairs + clusterbean (38 t ha^{-1}). The lower green fodder yield was observed with maize + cowpea mixed intercropping treatment (T_5).

Yield is the accumulation of drymatter over time. How efficiently the crop utilizes solar radiation and how long it can efficiently maintain utilization results in the final drymatter yield of the crop (Gardner *et al.*, 1988). Further, yield is the result of crop canopy efficiency in intercropping and utilization of the solar radiation available during the growing season. The primary plant organs intercepting solar radiation are the leaves. In the current study, the non-significant differences in terms of plant height, number of leaves per plant, drymatter accumulation in maize during the various growth stages could be the possible reason to register the non significant green fodder yields of maize in various treatments. Greater competitive ability of the cereal to exploit resources in association with some legumes has been reported by many researchers. Barik *et al.* (2006) reported that the advantages accrued from the intercropping system evident from competitive function are due to better utilization of growth resources under cereal-legume intercropping system. Hauggaard –Nielsen *et al.* (2001) revealed that legumes in intercrops are greatly affected and oppressed by the cereal component. Aynehband and Behrooz (2011) also reported the non-significant differences in forage yields of cereal component in cereal + legume intercropped system. Gangaiah (2004) reported non significant differences in fodder yield of cereal component in cereal + legume cropping system at Dharwad, Karnataka.

Data presented in Table 4.4 on green fodder yield of legume fodders indicated that green fodder yield of legume fodders was significantly influenced by the treatments at all growth stages. The data indicated that all legumes when sown in sole situation, performed better. It was also evident from the data that the legume fodders registered better yields when they were intercropped in maize fodder pairs over mixed intercropping with fodder maize. The highest legume fodder was recorded in sole cowpea with 20.8 t ha^{-1}. Significantly the lowest green fodder yield was recorded by pillipesara (0.6 t ha^{-1}) in T_6 treatment. Performance of leguminous fodder was in the order of cowpea, clusterbean and pillipesara in sole situation, maize pairs + legumes and maize + legume mixed intercropping.

Total fodder yield of maize + legume mixture was a true indicator of real output in response to the treatment combinations under study. The data presented in Table 4.4 indicated that, total fodder yield recorded was higher under intercropped situation compared to sole crops of either fodder maize or fodder legumes. However, intercropping of all the legumes in between maize pairs registered higher total fodder yield over mixed intercropping of fodder maize and fodder legumes. The highest mixed fodder yield was obtained from cowpea seeded in paired rows of maize *i.e.* T_8 (50.1 t ha^{-1}) followed by T_{10} treatment (46.9 t ha^{-1}) *i.e.* maize pairs + clusterbean intercropping. Contrarily the lowest mixed fodder yield (36.6 t ha^{-1}) was recorded for maize + pillipesara mixed intercropping treatment. T_8 treatments (maize pairs + cowpea) resulted in 25 and 30 per cent higher fodder yield over T_1 (sole maize) and T_6 treatments, (fodder maize + cowpea mixed intercrop) respectively.

On the whole, cowpea yielded significantly higher green fodder yield than clusterbean followed by pillipesara irrespective to sowing technique. These results are in line with findings of Mohapathra & Pradhan (1992) and Asifiqbal (2006) who reported that cowpea was a better intercrop out of various legumes under their study because of its good quality fodder.

In general forage yield of the component crops, viz., maize cowpea, pillipesara and clusterbean in intercropping decreased in comparison to their respective sole stands. The higher yield in sole stands might be due to limited disturbance of the habitat and interactional competition in the sole cropping environment. Under sole cropping the crops didn't experience inter-specific competition as in case of intercropping treatments. These results are in conformity with the findings of Ayenhbad and Behrooz (2011). But this decrease was compensated by contribution of both components in total intercrop yield. The increase in total green fodder in intercropping system might be owing to better utilization of space and light interception along with nutrient contribution of leguminous fodder to cereal. These results are in line with findings of Singh *et al*. (1980), Tripathi (1989), Rameshbabu *et al.*(1994), Bezbaruah and Thakuria (1996), Srinivasaraju *et al.* (1997), Verma *et al.* (1997), Nyamagonda (2002) Sunilkumar *et al*. (2005), Sharma (2008) and Surve *et al.*(2011).

4.3.2. Dry Fodder Yield (t ha^{-1})

The data on dry fodder are presented in table 4.4 and depicted in Fig.4.2.2 The data indicated non significant effect of different treatments in terms of dry fodder yield in maize. However, the treatments could significantly influence individually by fodder legumes and total dry fodder.

Even though the dry fodder yield of fodder maize was uninfluenced, relatively higher yield (11.9 t ha^{-1}) was registered in sole maize treatment and the lowest in fodder maize when mixed with cowpea (10.4 t ha^{-1}). Maize is an aggressive crop in general and African tall fodder maize in particular is having vigorously growing habit with long stem with more leafiness. This vigorous growth associated with tall plants, more number of leaves and higher drymatter accumulation might be the reason for relatively higher dry fodder yield in sole fodder maize which has the privilege to use the natural resources such as land, light, water and space.

Legume crops are known for their slow growth in the initial days. The stature of legume was lower during the first phase of growth in legumes. These legumes in intercropped situation with aggressively growing African tall fodder maize fail to compete and couldn't show any significant influence. Further, similar non significant differences in plant height, number of leaves, drymatter accumulation and green fodder yields might be the reason for the non significant differences in dry fodder of maize. Added to this Ayenhband and Behrooz (2011) reported that the maize has a crowding coefficient of more than 1 and results in vigorous growth. Similar non significant differences in dry fodder yield of maize were earlier reported by Rameshbabu *et al.* (1994), Patel and Rajgopal (2001), and Gangaiah (2004).

Data presented in table 4.4 indicated that, dry fodder yield of legume was significantly influenced by different treatments tried. Performance of the leguminous fodders in the sole cropped situation was followed by intercropping them in fodder maize pairs. The least performance could be observed when legumes were mixed intercropped with fodder maize. Significantly the highest dry fodder yield (4.8 t ha^{-1}) was recorded in cowpea sole crop and was statistically comparable with sole clusterbean (4.5 t ha^{-1}). Significantly the lowest dry fodder yield 0.1 t ha^{-1} and 0.3 t $ha^{\mathbf{-1}}$ was recorded by pillipesara mixed intercrop and paired intercropping respectively.

The sole crop of legumes showed significantly higher dry fodder yield over intercropping treatments, which might be due to lack of interspecies competition in pure stands. Legume fodders intercropped within the pairs of maize recorded better performance with lower reduction in dry fodder yield as compared to mixed rows. This might be due to lesser competition in between maize and legumes in wider interspaces between paired rows resulted in higher legume dry fodder yield. These results are in line with findings of Ravichandran and Palaniappan (1979). Significantly the lowest dry fodder yield in mixed rows might be due to shading and competition effect of maize plants on associated legumes (Pandita, 1998). Verma *et al.* (1997) also reported that in mixed intercropping, closer spacing between maize and legume enhanced competition leading to suppression of legume component. This might be the possible reason for the lowest legume dry fodder yield in mixed intercropping treatments.

Significantly the highest total dry fodder yield was obtained from T_8 treatment (14.2 t ha^{-1}) and was statistically comparable with that of T_{10} treatment (13.4 t ha^{-1}). The lowest total dry fodder yield (3.4 t ha^{-1}) was recorded in T_3 treatment *i.e.* sole pillipesara. Among intercropping system, lowest dry fodder yield was recorded with T_6 (10.8 t ha^{-1}) but this was statistically comparable with T_1, T_9, T_5 and T_7.

Total dry fodder yield was the highest (14.2 t ha^{-1}) under maize in pairs + cowpea intercropping system followed by maize in pairs + clusterbean intercropping (13.4 t ha^{-1}). It is reasonable to suggest that, two species of contrasting habit, with respect to branching, leaf distribution, height, root distribution, mineral uptake or other morphological or physiological characters, will together be able to exploit the total environment more effectively over monoculture, and will thereby give increased overall yield (Donald, 1963). Hence fodder maize intercropped with cowpea in T_8 treatment could result in the higher dry fodder yield. Similar results of increased fodder yields of fodder maize intercropped with cowpea was also reported by Mohapathra and Pradhan (1992), Ramanakumar and Bhanumurthy (2001), Patel and Rajgopal (2001), Kumar and Prasad (2003), Ganaiah (2004), Reddy *et al*. (2004), Rambabu *et al.*(2004) and Sunilkumar *et al.* (2005).

4.4 FODDER QUALITY

Fodder quality is a broader term that not only includes nutritive value but also fodder intake. In practice, performance of grazing animals reflects the forage quality. The higher the content and digestibility of the nutrients, better is the quality of the forage. The higher nutrient status and more digestibility is in younger herbage, because it contains the lowest amount of structural carbohydrates (cellulose, hemicelluloses) and lignin. As a fodder crop matures, its digestibility, rate of digestion and CP content declines.

4.4.1 Crude Protein Content (%)

Proteins together with energy are the most important nutrients for livestock as they support rumen microbes that in turn degrade forage. True proteins make up 60-80% of the total plant nitrogen (N), with soluble protein and a small portion of fiber-bound N making up the remainder. Forage protein concentrations vary considerably depending on species, soil fertility, and plant maturity. Crude protein is measured indirectly by determining the amount of N in the forage plant and multiplying that value by 6.25. The assumption is that N constitutes about 16% of tissue protein in the forage (100/16= 6.25). Crude protein concentration varies with forage type: Legumes (12-25%) > Cool-Season grasses (8-23%) > Warm-Season grasses (5 – 18%).

Data pertaining to crude protein content (%) in fodder maize and fodder intercrops at 20, 40 and 60 DAS are furnished in table 4.5 and depicted in Fig 4.3.1 and 4.3.2. A glance at the data revealed that crude protein content of fodder maize, cowpea, pillipesara and clusterbean decreased with the age and the highest crude protein content (%) of fodder maize (10.98), cowpea (19.6), pillipesara (18.85) and clusterbean (19.0) were recorded at 20 DAS. The data also indicated the significant influence of treatments on crude protein content of fodder maize alone but not on the crude protein content of fodder legumes.

Higher crude protein content was recorded both fodder maize and fodder legumes at 20 DAS but there were no significant differences in between the treatments. Even though treatments were non significant, higher crude protein content was recorded by sole maize (10.98 %) as compared to other intercropping treatments.

At 40 DAS, crude protein content of maize alone was significantly influenced by various treatments. Significantly the highest crude protein content of maize (9.08 %) was recorded in maize pairs + cowpea intercropping (T_8) and this treatment was statistically comparable to T_{10} *i.e.* maize pairs + clusterbean intercropping (8.56 %). Significantly, the lowest crude protein content of fodder maize was recorded in sole maize (7.58 %). Treatments T_9, T_5, $T_{7,}$ T_6 and T_1 were comparable with each other. Similar response to different treatments was also observed during 60 DAS. Significantly the highest 7.81 per cent crude protein was registered when cowpea was intercropped in between the pairs of maize. The lowest of 6.27 per cent crude protein in fodder maize was found when maize and pillipesara seed was mixed and sown in lines *i.e.* T_6 treatment which was statistically comparable with T_1.

The improvement of quality of maize in fodder maize pairs + cowpea might possibly the result of fixation of higher amount of nitrogen either by direct excretion from the legume nodule root system or by decomposition of nodule and root debris. These findings are in conformity with the result obtained by Singh *et al.* (1983). Ravichandran and Palaniappan (1979) reported that in the wider row spacing, the legume intercrops were able to grow better, fixing greater amount of atmospheric N, some part of which might have become available to cereal crop. This might be the possible reason for obtaining higher crude protein content of maize in paired rows. Similar results of high crude protein in fodder maize when intercropped with legumes was earlier reported by Chouhan and Dungarwal (1980**),** Paul *et al.* (1981), Tripathi (1989) , Sood and Sharma (1996) , Verma *et al.* (1997) Ram (2008) and Eskandari and Ghanbari (2009).

4.4.2 Crude Protein Yield (kg ha^{-1})

Crude protein yield is the product of crude protein per cent and drymatter yield. So change in crude protein per cent and drymatter accumulation causes change in the crude protein yield.

The data on crude protein yield of maize and intercrops individually and their combined yield at 20, 40 and 60 DAS are furnished in Table 4.6 and depicted in Fig.4.4 (1, 2 & 3). In the present investigation, crude protein yield of maize and intercrops individually and in mixture was significantly influenced by different treatments at various stages of observation.

At 20 DAS, crude protein yield of maize was the highest in sole maize treatment (191 kg ha^{-1}) and statistically similar to other treatments. But the data indicated that crude protein yield of legumes was significantly influenced by various treatments. Significantly the highest crude protein yield of legume was recorded with sole cowpea (106 kg ha^{-1}) followed by sole clusterbean (105 kg ha^{-1}). The lowest crude protein yield (3 kg ha^{-1}) was recorded with pillipesara in T_6 *i.e.* maize + pillipesara mixed intercropping. Total crude protein content was significantly influenced by treatments. Significantly, the highest total crude protein yield (240 kg ha^{-1}) was recorded in maize in pairs + cowpea intercropping (T_8) and this was on a par with T_{10} *i.e.*maize pairs + clusterbean intercropping (212 kg ha^{-1}). The lowest total crude protein yield was recorded with sole pillipesara was recorded (72 kg ha^{-1}).

At 40 DAS, the crude protein yield of maize was significantly influenced by various treatments. Higher crude protein yield (521 kg ha^{-1}) was recorded with sole maize over other treatments. The lowest crude protein yield of maize (416 kg ha^{-1}) was recorded in T_5 *i.e.* maize+ cowpea mixed intercropping Among legumes, the highest crude protein yield was recorded in sole cowpea followed by sole clusterbean (282 kg ha^{-1} and 273 kg ha^{-1} respectively). The lowest crude protein yield (7 kg ha^{-1}) was recorded in pillipesara in T_6 *i.e.* maize+ pillipesara mixed intercropping. The total crude protein yield was significantly influenced by various treatments and significantly, the highest crude protein yield (653 kg ha^{-1}) was recorded in T_8 treatment (maize in pair + cowpea intercropping) over all other treatments except T_{10} treatment. Significantly the lowest crude protein yield (189 kg ha^{-1}) was registered in T_3 treatment, *i.e.* sole pillipesara. The highest crude protein yield of cowpea might be due to higher crude protein content and higher dry matter accumulation.

At 60 DAS, fodder maize sown in paired rows + cowpea resulted in the highest crude protein yield (582 kg $ha^{-1)}$ followed by T_{10} treatment *i.e.* maize in pairs + clusterbean intercropping (560 kg ha^{-1}). Among legume intercrops, higher crude protein yield was recorded with cowpea (454 kg ha^{-1}) followed by clusterbean (425 kg ha^{-1}) in T_2 and T_4 treatments. Significantly, the highest total crude protein yield (865 kg ha^{-1}) was recorded in T_8 treatment (maize in pairs + cowpea intercropping) over all other treatments except T_{10} treatment (752 kg ha^{-1}). Significantly the lowest crude protein yield (307 kg ha^{-1}) was registered in T_3 treatment, *i.e*. sole pillipesara.

In the present investigation, crude protein yield of maize and intercrops individually and jointly was significantly influenced by different treatments at various stages of observation. At 20 and 40 DAS, the highest crude protein yield was recorded with sole fodder maize over rest of the treatments. The highest drymatter yield in sole maize could be the reason for higher crude protein yield. Paired intercropping of fodder maize + cowpea resulted the highest crude protein yield due to the highest crude protein content in the legume component and higher total drymatter yield of fodder maize at the time of harvest. Mohapatra and Pradhan (1992), Ramanakumar and Bhanumurthy (2001), Kumar and Prasad (2003), Sunilkumar *et al.* (2005), and Sharma *et al.* (2008) too reported the similar high crude protein yield in maize + cowpea paired intercropping.

4.4.3 Crude Fibre Content (%)

All plants are composed of cells having fibrous cell walls for support and protection. Contained within the cells are several soluble compounds, most of which are highly digestible. Since cell wall material is the primary constituent of forages, one of the main objectives of forage analysis is to characterize the cell wall fibre. Plant fibre has three major components viz., cellulose, hemi cellulose, and lignin. Cellulose and hemi cellulose are digestible to some extent by ruminants. Ruminants can convert these fibre components to energy because the rumen provides the correct environment for bacteria and other microorganisms that actually break down the fibre. Lignin is indigestible, and thus cannot be used by ruminants for energy.

The data on crude fibre content (%) of maize and legume intercrops individually at 20, 40 and 60 DAS are presented in Table 4.7 and depicted in fig 4.5 (1 & 2). Data indicated that there was a marked increase in crude fibre content (%) from 20 to 60 DAS. This increase in crude fibre content with increase in age could be ascribed to the accumulation of structural material such as hemi cellulose, cellulose, lignin, silica etc. These results are in accordance with findings of Sullivan (1962) and Ranjhan (1980).

Crude fibre content of maize was significantly influenced by the different treatments. Significantly, the highest crude fibre content was observed in sole fodder maize at 20, 40 and 60 DAS, *i.e.* 23.24, 28.44 and 30.74 per cent respectively. This might be due to higher drymatter accumulation of maize in sole cropping treatment as compared to intercropping treatments. The photosynthate during its partitioning might have been stored as cell wall contents, which might be the possible reason for higher crude fibre content in sole maize. Lower crude fibre per cent values were recorded in fodder maize when it was intercropped with legumes viz., cowpea, clusterbean and pillipesara at all sampling stages. Maize grown along with legumes might have availed better nitrogen nutrition. This higher nitrogen under intercropped situation could have made the maize more succulent. Negative correlation between nitrogen and crude fibre content was reported by Raskar (1978) and Rambabu *et al*. (2004). Similar low crude fibre content values in maize fodder under legume intercropping was earlier reported by Srinivasraju *et al.* (1997) and Ramanakumar and Bhanumurthy (2001).

Data on crude fibre content of legumes indicated that comparatively the lowest crude fibre per cent *i.e*. 16.38 %, 19.48 % and 21.6 % was registered in pillipesara at 20, 40 and 60 DAS respectively. Pillipesara fodder developed profused branching and more leaf matter among all the three intercrops and was highly succulent. This high succulence and more leafiness of pillipesara could be the possible reason for low fibre content in pillipesara. Relatively higher crude fibre value 19.12 %, 22.21 % and 24.33 % were recorded in clusterbean in T_7 treatment at 20, 40 and 60 DAS respectively. Similar higher crude fibre content values in clusterbean among different legumes were earlier reported by Kirankumar *et al.* (2008).

4.4.4 Crude Fibre Yield (kg ha^{-1})

Crude fibre yield is the product of crude fibre content and drymatter accumulation. Crude fibre yield was significantly influenced by different treatments.

Data pertaining to crude fibre yield of maize and intercrops and total yield at 20, 40 and 60 DAS furnished in table 4.8 and depicted in Fig.4.6 (1 & 2) indicated that crude fibre yield increased with advanced age of the crops. It further indicated the significant impact of the treatment in crude fibre yield in legumes and total crude fibre yield (fodder maize along with legumes) but not the crude fibre yield of fodder maize alone.

Among the legumes, crude fibre yield (kg ha^{-1}) was significantly the highest in cowpea followed by clusterbean at various stages of observation. Significantly the lowest was recorded with pillipesara fodder. Higher crude fibre yield 100, 351 and 642 kg ha^{-1} was registered in cowpea at 20, 40 and 60 DAS respectively. The lowest, 62, 221 and 409 kg ha^{-1} crude fibre yield was recorded in pillipesara fodder at 20, 40 and 60 DAS, respectively.

The higher total crude fibre yield, 416, 1384 and 2515 kg ha^{-1} was found in T_8 treatment *i.e.* maize in pairs + cowpea intercropping during 20, 40 and 60 DAS respectively, but this treatment was statistically comparable with crude fibre yield of sole maize fodder (404, 1318 and 2428 kg ha^{-1} at 20, 40 and 60 DAS respectively). The lowest total crude fibre yield was recorded in sole pillipesara treatments (62, 221 and 409 kg ha^{-1}during 20, 40 and 60 DAS respectively). High crude fibre content along with high drymatter accumulation in maize and lower crude fibre content with low drymatter accumulation in pillipesara were responsible for the current results.

Cellwall is made up of a porous matrix of cellulose. The most minute units are some extremely delicate thread like bodies called micro fibrils which are grouped together in to large bundles and anastomose to form a three dimensional with an interfibrillar system of micro-capillaries. The fibrils are the aggregrates, referred to as miscelle of a large number of long chain-like cellulose molecules arranged among the longer axis of fibril. Colloidal pectic compounds and other non-cellulotic substances fill up the micro-capillaries of the anastmosing system. Such cell wall contents could be more in maize in comparison with legume fodder. Rambabu *et al.* (2004) and Singh *et al.* (2005) also reported similar high crude fibre in cereal fodders.

4.4.5 Total Ash Content (%)

Data pertaining to total ash content at 20, 40 and 60 DAS are furnished in table 4.9. A glance at the data indicated that total ash content of maize and other legume crops decreased with the age of crops. The data also indicated the influence of the different treatments on total ash content which was non-significant at 20, 40 and 60 DAS. The highest total ash content (%) in fodder maize (13.93%), cowpea (19.3 %), pillipesara (19.08 %) and clusterbean (18.73 %) were obtained at 20 DAS. The lowest total ash content in fodder maize (10.22%), cowpea (15.88 %), pillipesara (15.96 %) and clusterbean (15.66 %)

were obtained at 60 DAS. Decrease in ash concentration with maturity could results from dilution of minerals as crop matures and agree with findings of Dahmardeh *et al.* (2009). Similar non significant impact of intercropping treatments on total ash content was earlier reported by Krishna *et al.* (1997).

4.4.6 Chlorophyll Content (%)

Leaf chlorophyll content provides important information about photosynthetic activity of plant and is related to nitrogen content of the plant. Chlorophyll content of higher plants consist of different types of chlorophyll molecule *i.e.* chlorophyll ‘a’, chlorophyll ‘b’ with slightly difference in their molecular structure.

The data on chlorophyll content (chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll) of fodder maize and legumes as influenced by different treatments at harvest are presented in table 4.10 and depicted in fig. 4.7 (1 &2). Chlorophyll content of fodder maize was significantly influenced by different treatments. Significantly the highest chlorophyll contents, *i.e.* chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll (1.45 mg g^{-1} , 1.52 mg g^{-1} and 2.98 mg g^{-1} respectively) were observed in T_8 treatment *i.e.* maize in pairs + cowpea cropping followed by T_{10} with chlorophyll ‘a’, chlorophyll ‘b’ and total chlorophyll contents of 1.39, 1.42 and 2.80 mg g^{-1} respectively. Significantly the lowest chlorophyll contents, chlorophyll ‘a’: 1.05 mg g^{-1}, chlorophyll ‘b’: 1.16 mg g^{-1} and total chlorophyll: 2.21 mg g^{-1} was observed in sole maize.

Data on chlorophyll ‘a’ and ‘b’ contents in legumes indicated that all the treatments were statistically on a par with each other. However, higher chlorophyll contents was recorded with cowpea *i.e.* chlorophyll ‘a’ (1.65 mg g^{-1}) and chlorophyll ‘b’ (1.68 mg g^{-1}) compared to other legumes. Total chlorophyll in various legumes was significantly influenced by different treatments tried. The highest total chlorophyll, 3.30 mg g^{-1} was observed in T_2 treatment *i.e.* sole cowpea. The chlorophyll content in T_2 was statistically comparable with that of T_8, T_4, T_{10} and T_3 treatments. The lowest total chlorophyll, 2.82 mg g^{-1} was registered in T_6 treatment where in pillipesara was mixed with fodder maize. However $T_{6,}$ T_7, T_9 and T_5 treatments were comparable with each other in respect of chlorophyll content.

Leguminous fodders in sole situation recorded with higher total chlorophyll compared to intercropped situation. Under intercropped situation maize fodder by virtue of its faster and vigorous growth might have dominated and utilized the resources more efficiently and suppressed the legume fodders. These legumes which were not exposed to sun fully due to shading by fodder maize and reduced nutrient utilization particularly nitrogen might have resulted in lower total chlorophyll. Environmental factors such as light, CO_2, temperature, water status and mineral status directly affect leaf photosynthesis rate by influencing either light reaction or carboxylation system of chloroplast (Gardner *et al.*, 1988). This phenomenon might have operated in the present study.

The higher chlorophyll content of fodder maize in T_8 and T_9 treatment might be due to higher nitrogen contribution by legume component to cereal through paired intercropping. Various workers reported the nitrogen transfer of legume to cereal in intercropping situation. Saeid and Darbandi (2011), Vanyine *et al.* (2012) reported positive relation between nitrogen and chlorophyll content in fodder maize.

4.5 NUTRIENT UPTAKE

4.5.1 Nitrogen Content (%)

The relevant data on nitrogen content in fodder maize and legume intercrops individually at 20, 40 and 60 DAS are presented in table 4.11 and depicted in Fig.4.8 (1 & 2). It is evident from the data that nitrogen content of maize, cowpea, pillipesara and clusterbean decreased from 20 DAS to 60 DAS. Nitrogen content in fodder maize was significantly influenced by various treatments at 40 and 60 DAS, but not at 20 DAS.

Even though the differences were non significant at 20 DAS, higher (1.76 per cent) nitrogen was observed in sole maize and lower (1.59 per cent) was registered in maize when intercropped with clusterbean. Higher nitrogen content in sole maize might be due to lack of interspecific competition and more availability of nutrients, thereby more uptake and concentration of nitrogen in tissue increased.

At 40 and 60 DAS, 1.45 and 1.25 per cent nitrogen respectively was observed in fodder maize when cowpea was intercropped in between fodder maize paired rows, *i.e.* T_8 treatment followed by T_{10} treatment, but T_8 and T_{10} treatments were statistically comparable. The treatments T_1, T_6, T_7 and T_9 were also statistically on a par with each other. At 40 and 60 DAS, significantly the highest nitrogen content of maize was recorded (1.45 and 1.25 per cent) in T_8 treatment *i.e.* maize in pairs + cowpea intercropping followed by maize in pairs + clusterbean intercropping. This might be due to more legume population in paired rows, which might have helped to fix more nitrogen and the enhanced nutrient sparing capacity of legume to cereal component. The system of intercropping is an important factor which affects the quantity of nitrogen fixed by legumes. The differences in the depth of rooting lateral root spread and root densities were some of the factors that affect competition between the component crops in an intercropping system for nutrients. The cereal component, maize in this experiment usually was taller, has a faster growing rate with more extensive root system, particularly a larger mass of fine roots and is competitive for soil nitrogen. This forces the legume component, cowpea to fix nitrogen from the atmosphere and there by more nitrogen availability to cereal crop (Eskandari and Ghanbari, 2009).

The nitrogen content in fodder legumes was not influenced by various treatments at any stages of observation. Even though, the differences were non significant, the highest nitrogen content was recorded in cowpea (3.14, 2.78 and 2.69 per cent at 20, 40 and 60 DAS respectively) followed by clusterbean (3.04, 2.75 and 2.66 per cent at 20, 40 and 60 DAS respectively) and pillipesara (3.02, 2.64 and 2.58 per cent at 20, 40 and 60 DAS respectively). Similar reports were also reported by Ahamad *et al.* (2007).

4.5.2 Nitrogen Uptake (kg ha^{-1})

Nitrogen uptake of a crop is the product of nitrogen content in plant and its drymatter accumulation. The data on nitrogen uptake by fodder maize and legumes (cowpea, clusterbean and pillipesara) individually and their combined uptake at 20, 40 and 60 DAS are furnished in table 4.12 and depicted in Fig. 4.9

(1, 2 & 3). Nitrogen uptake by fodder maize and legumes individually and their total uptake gradually increased from 20 DAS upto harvest and significantly influenced by different treatments at different sampling stages.

At 20 DAS, nitrogen uptake by fodder maize was found non-significant among different treatments. However, the nitrogen uptake by legume and total uptake (maize + legume) was significantly influenced by different treatments. Nitrogen uptake by legume fodders under sole cropping was higher over their respective uptake under intercropped situation. Significantly the highest uptake was observed under T_2 treatment *i.e.* sole cowpea (17.0 kg ha^{-1}) and was statistically comparable with T_4 treatment with 16.7 kg ha^{-1} of nitrogen uptake. Significantly the lowest nitrogen uptake (0.4 kg ha^{-1}) by legume was observed in pillipesara under T_6 treatment *i.e.* maize + pillipesara. This lower nitrogen uptake in pillipeasara was due to the lower drymatter accumulation under intercropped situation. The highest total uptake (38.4 kg ha^{-1}) was recorded with T_8 treatment (maize in pairs + cowpea intercropping) and this was statistically similar to T_1 and T_{10} treatments.

At 40 DAS, significantly the highest nitrogen uptake of fodder maize was recorded in T_8 (65 kg ha^{-1}) and T_{10} (64.1 kg ha^{-1}) treatments which were statistically comparable with nitrogen uptake of sole maize (57.4 kg ha^{-1}). Significantly the lowest nitrogen uptake by fodder maize (51.5 kg ha^{-1}) was recorded in T_5 treatment (maize + cowpea mixed intercropping) and this was statistically comparable to T_6 (52.5 kg ha^{-1}) and T_7 treatment (52.9 kg ha^{-1}). The data on nitrogen uptake by leguminous crops indicated that, cowpea registered the highest nitrogen uptake (45.1 kg ha^{-1}) in T_2 treatment and significantly the lowest nitrogen uptake (1.1 kg ha^{-1}) was recorded by pillipesara in T_6 treatment. Significantly the highest total nitrogen uptake (93.2 kg ha^{-1}) was found in T_8 treatment (maize in pairs + cowpea intercropping) which was comparable with that of T_{10} (maize in pairs + clusterbean intercropping). Significantly the lowest total nitrogen uptake (30.3 kg ha^{1}) was observed in T_3 treatment *i.e.* sole pillipesara.

At 60 DAS, significantly the highest nitrogen uptake of fodder maize was recorded in T_8 (93.1 kg ha^{-1}) and was statistically comparable with that of T_{10} (89.7 kg ha^{-1}) and T_5 (82.3 kg ha^{-1}) treatment. Significantly the lowest nitrogen uptake by fodder maize (74.1 kg ha^{-1}) was recorded in T_7 treatment (maize + clusterbean mixed intercropping) and was statistically comparable with that of T_1, (80.5 kg ha^{-1}) ,T_5 (82.3 kg ha^{-1}) , T_6 (78.2 kg ha $^{-1}$) and T_9 (77.6 kg ha^{-1}) treatments. The data on nitrogen uptake by leguminous crops indicated that, cowpea registered the highest nitrogen uptake (72.6 kg ha^{-1}) in T_2 treatment and significantly the lowest nitrogen uptake (1.9 kg ha^{-1}) was recorded by pillipesara in T_6 treatment. Significantly the highest total nitrogen uptake was (138.4 kg ha^{-1}) was found in T_8 treatment (maize in pairs + cowpea intercropping) and followed by nitrogen uptake of 120.3 kg ha^{-1} in T_{10} treatment *i.e.* maize in pairs + clusterbean intercropping. Significantly the lowest total nitrogen uptake (49.2 kg ha^{1}) was observed in T_3 treatment *i.e.* sole pillipesara.

The increase in nitrogen uptake in fodder maize paired rows might be due to higher drymatter accumulation. Among intercrops relatively higher nitrogen uptake was recorded by cowpea and this might be due to more nitrogen content and higher drymatter accumulation.

Total nitrogen uptake was the highest in maize in pairs + cowpea intercropping (T_8) and was on a par with maize in pairs + clusterbean paired intercropping (T_{10}) which might be due to higher total drymatter accumulation and nitrogen content. Enhanced nitrogen uptake by intercropping system was observed by several workers and has often been claimed as the basis for yield advantage from intercropping system. This might be due to better exploitation of different soil layer for nutrients (Willey, 1979) or due to phenomenon of mutual advance (Trenbath, 1974). These results are in conformity with findings of Srinivasaraju *et al.* (1997), Ramanakumar and Bhanumurthy (2001).

4.5.3 Residual available N, P_2O_5, and K_2O status (kg ha^{-1}) of the experimental field after harvest

Data on residual available nitrogen, P_2O_5 and K_2O status of the experimental field after the crop harvest are presented in table 4.13. The data indicated that the soil nitrogen alone after the harvest of the crop was significantly influenced by different treatments. This is depicted in Fig 4.10.

Available soil nitrogen after the harvest of the crop was lower (169 kg ha^{-1}) in plots where sole fodder maize was grown. The highest soil available nitrogen (222 kg ha^{-1}) was registered in T_2 treatment. Available nitrogen in T_3 and T_4 treatments were statstically comparable. The treatments T_5, T_6, T_7 and T_9 were statistically similar with regard to soil available nitrogen after the harvest of crops. Among intercropping treatments, higher residual available soil nitrogen recorded in T_8 treatment (191 kg ha^{-1}) followed by T_{10} treatment (187 kg ha^{-1}). The residual P_2O_5 and K_2O after the harvest of the crop were not significantly influenced by different treatments.

The residual available nitrogen status of the soil after the harvest of the crops in T_1 treatment was the lowest which might be the result of high exhaustive nature of fodder maize in sole cropping condition. The highest content of available soil nitrogen was recorded with T_2 treatment (sole cowpea); which might be due to more nitrogen fixation and less drymatter accumulation of legume crop. Relatively higher available soil nitrogen in T_8 and T_{10} treatments might be the results of nitrogen contribution by legume component under intercropped situation.

Srinivasaraju *et al.* (1997) reported that there was a less depletion of soil N, P, K in intercropping compared to sole cropping and suggesting for inclusion of a legume with cereal for restoration of fertility. The current results are in line with results of these scientists.

4.4 ECONOMICS

Economics (Rs. ha^{-1}) of different treatments are presented in table 4.14. The data indicated that gross and net returns and returns per rupee investment were significantly influenced by different treatments in the experiment.

The highest gross return (Rs. 28,448) was recorded with T_8 treatment (maize in pairs + cowpea intercropping) which was statistically comparable with that of T_{10} treatment (maize in pairs + clusterbean intercropping) with a gross return of Rs.25,533. Significantly the lowest gross return (Rs. 11,000) was obtained from T_3 treatment *i.e.* sole pillipesara.

The highest net return (Rs. 14,783) and returns per rupee investment (2.1) were recorded in T_8 treatment (maize in pairs + cowpea intercropping) and statistically comparable with T_{10} treatment (maize in pairs + clusterbean intercropping). This could be due to the high green fodder yield in these treatments.The lowest gross returns (Rs.11,000), net return (Rs.1,785) and returns per rupee investment (1.2) were registered in T_3 treatment *i.e.* sole pillipesara. These results are in accordance with Barik and Tiwari (1996), Srinivasraju *et al.* (1997), Patel and Rajgopal (2001); Ramanakumar and Bhanumurthy (2001).

Table 4.1. Plant height (cm) of fodder maize as influenced by different treatments

Treatments	**20 DAS**	**40 DAS**	**60 DAS**
T_1 : Sole maize	65	187	239
T_5:Maize +cowpea	56	158	229
T_6:Maize + pillipesara	60	164	230
T_7:Maize +clusterbean	55	162	227
T_8:Maize in pairs + cowpea	61	174	231
T_9:Maize in pairs + pillipesara	61	181	234
T_{10}:Maize in pairs + clusterbean	61	182	237
SEm±	4	10	15
CD (P=0.05)	NS	NS	NS
CV (%)	10	10	11

NS: Non-significant

Table 4.2. Number of leaves plant^{-1} in fodder maize as influenced by different Treatments

Treatments	20 DAS	40 DAS	60 DAS
T_1 : Sole maize	8.0	11.1	11.3
T_5:Maize +cowpea	7.2	9.5	10.3
T_6:Maize + pillipesara	7.4	9.9	10.0
T_7:Maize +clusterbean	7.3	9.4	10.0
T_8:Maize in pairs + cowpea	7.7	10.5	10.6
T_9:Maize in pairs + pillipesara	7.9	10.5	10.7
T_{10}:Maize in pairs + clusterbean	7.9	10.6	10.7
SEm±	0.4	0.5	0.6
CD (P=0.05)	NS	NS	NS
CV (%)	9.0	8.5	9.0

NS: Non-significant

Table 4.13 Residual Available Nitrogen, P_2O_5 and K_2O status (kg ha^{-1}) of the experimental field after harvest as influenced by different treatments

Treatments	N	P_2O_5	K_2O
T_1:Sole fodder maize	169	29.30	515
T_2:Sole cowpea	222	28.67	529
T_3:Sole pillipesara	216	29.33	530
T_4:Sole clusterbean	221	29.17	528
T_5:Maize +cowpea	184	28.67	526
T_6:Maize + pillipesara	173	29.00	527
T_7:Maize +clusterbean	176	28.93	527
T_8:Maize in pairs + cowpea	191	28.93	516
T_9:Maize in pairs + pillipesara	174	29.00	524
T_{10}:Maize in pairs + clusterbean	187	28.33	517
SEm±	6	0.62	10
CD(P=0.05)	18	NS	NS
CV (%)	5.4	4.4	4.3

NS: Non-significant

Table 4.14 Gross return (Rs. ha^{-1}), Net return (Rs. ha^{-1}) and Return per rupee investment as influenced by different treatments

Treatments	Gross return	Net return	Return per rupee investment
T_1:Sole fodder maize	19760	8495	1.8
T_2:Sole cowpea	15583	4968	1.5
T_3:Sole pillipesara	11000	1785	1.2
T_4:Sole clusterbean	14750	4785	1.5
T_5:Maize +cowpea	19810	6445	1.5
T_6:Maize + pillipesara	18251	5986	1.5
T_7:Maize +clusterbean	19417	6702	1.5
T_8:Maize in pairs + cowpea	28448	14783	2.1
T_9:Maize in pairs + pillipesara	19633	7068	1.6
T_{10}:Maize in pairs + clusterbean	25533	12518	2.0
SEm$\pm$	1120	782	0.09
CD(P=0.05)	3326	2322	0.3
CV (%)	10	18	10.0

Input cost

Seed		
Maize	:	Rs. 55 kg^{-1}
Cowpea	:	Rs. 70 kg^{-1}
Pillipesara	:	Rs.25 kg^{-1}
Clusterbean	:	Rs.58 kg^{-1}
Urea	:	Rs. 5.51 kg^{-1}
SSP	:	Rs. 4.5 kg^{-1}
MOP	:	Rs. 6.64 kg^{-1}
Labour charge	:	150 head^{-1}

Output cost

Maize green fodder : Rs. 0.50 kg^{-1}

Legume fodder : Rs.0.75 kg^{-1}

Table 4.3. Drymatter accumulation (kg ha^{-1}) of fodder maize and legume fodders as influenced by different treatments

Treatments	20 DAS			40 DAS			60 DAS		
	Maize	Legumes	Total	Maize	Legumes	Total	Maize	Legumes	Total
T_1:Sole fodder maize	1739	-	1739	4635	-	4635	7622	-	7622
T_2:Sole cowpea	-	540	540	-	1621	1621	-	2701	2701
T_3:Sole pillipesara	-	381	381	-	1144	1144	-	1907	1907
T_4:Sole clusterbean	-	517	517	-	1585	1585	-	2557	2557
T_5:Maize +cowpea	1519	88	1607	4142	265	4408	6904	442	7346
T_6:Maize + pillipesara	1569	14	1584	4280	43	4323	7133	72	7205
T_7:Maize +clusterbean	1555	65	1620	4240	196	4436	7067	303	7370
T_8:Maize in pairs + cowpea	1641	340	1981	4476	1019	5495	7506	1699	9205
T_9:Maize in pairs + pillipesara	1651	30	1681	4502	91	4593	7504	151	7655
T_{10}:Maize in pairs + clusterbean	1623	250	1873	4520	750	5270	7533	1161	8694
SEm±	94	17	87	259	44	236	414	79	382
CD (P=0.05)	NS	53	258	NS	131	700	NS	237	1136
CV (%)	10	12	11	10	10	11	10	11	11

Table 4.4. Green and dry fodder yield (t ha^{-1}) of maize and legume intercrops as influenced by different treatments

Treatments	Green fodder yield (t ha^{-1})			Dry fodder yield (t ha^{-1})		
	Maize	Legumes	Total	Maize	Legumes	Total
T_1:Sole fodder maize	40.0	-	40.0	11.9	-	11.9
T_2:Sole cowpea	-	20.8	20.8	-	4.8	4.78
T_3:Sole pillipesara	-	14.7	14.7	-	3.4	3.37
T_4:Sole clusterbean	-	19.7	19.7	-	4.5	4.52
T_5:Maize +cowpea	35.0	3.4	38.4	10.4	0.8	11.1
T_6:Maize + pillipesara	36.0	0.6	36.6	10.7	0.1	10.8
T_7:Maize + clusterbean	35.1	2.3	37.3	10.6	0.5	11.1
T_8:Maize in pairs + cowpea	37.0	13.1	50.1	11.2	3.0	14.2
T_9:Maize in pairs + pillipesara	38.0	1.2	39.2	11.3	0.3	11.6
T_{10}:Maize in pairs + clusterbean	38.0	8.9	46.9	11.3	2.1	13.4
SEm±	2.2	0.6	2.1	0.7	0.1	0.7
CD (P=0.05)	NS	1.8	6.2	NS	0.4	2.1
CV (%)	11.0	11.0	10.6	10.6	11.3	10.3

Table 4.5. Crude protein (%) of fodder maize and legumes as influenced by different treatments

Treatments	20 DAS		40 DAS		60 DAS	
	Maize	Legume Intercrop	Maize	Legume Intercrop	Maize	Legume Intercrop
T_1:Sole fodder maize	10.98	-	7.58	-	6.38	-
T_2:Sole cowpea	-	19.60	-	17.38	-	16.79
T_3:Sole pillipesara	-	18.85	-	16.52	-	16.13
T_4:Sole clusterbean	-	19.00	-	17.19	-	16.63
T_5:Maize +cowpea	10.03	19.13	7.77	16.71	7.46	16.48
T_6:Maize + pillipesara	10.52	18.48	7.73	16.23	6.27	15.79
T_7:Maize +clusterbean	10.04	18.96	7.77	16.88	6.58	15.85
T_8:Maize in pairs + cowpea	10.69	19.17	9.08	17.31	7.81	16.71
T_9:Maize in pairs + pillipesara	10.13	18.92	7.79	16.31	6.47	16.19
T_{10}:Maize in pairs + clusterbean	10.19	18.98	8.56	16.85	7.44	16.50
SEm±	0.28	0.48	0.22	0.44	0.21	0.50
CD (P=0.05)	NS	NS	0.69	NS	0.67	NS
CV (%)	4.75	4.47	4.89	4.14	5.49	5.43

Table 4.6. Crude protein yield (kg ha^{-1}) of fodder maize and legumes as influenced by different treatments

Treatments	20 DAS			40 DAS			60 DAS		
	Maize	Legume Intercrop	Total	Maize	Legume Intercrop	Total	Maize	Legume Intercrop	Total
T_1:Sole fodder maize	191	-	191	521	-	521	503	-	503
T_2:Sole cowpea	-	106	106	-	282	282	-	454	454
T_3:Sole pillipesara	-	72	72	-	189	189	-	307	307
T_4:Sole clusterbean	-	105	105	-	273	273	-	425	425
T_5:Maize +cowpea	152	17	169	416	44	460	515	73	587
T_6:Maize + pillipesara	165	3	168	451	7	458	489	12	500
T_7:Maize +clusterbean	156	12	168	425	33	459	463	48	512
T_8:Maize in pairs + cowpea	175	65	240	477	176	653	582	283	865
T_9:Maize in pairs + pillipesara	167	6	173	456	15	471	485	24	510
T_{10}:Maize in pairs + clusterbean	165	47	212	460	127	586	560	191	752
SEm±	12	3	11	33	9	30	23	15	29
CD(P=0.05)	NS	10	31	101	26	88	72	46	85
CV (%)	12	12	11	12	12	12	8	13	9

Table 4.7 Crude fibre (%) of fodder maize and legumes as influenced by different treatments

Treatments	20 DAS		40 DAS		60 DAS	
	Maize	Legume Intercrop	Maize	Legume Intercrop	Maize	Legume Intercrop
T_1:Sole fodder maize	23.24	-	28.44		30.74	-
T_2:Sole cowpea	-	18.50	-	21.60	-	23.72
T_3:Sole pillipesara	-	16.20	-	19.30	-	21.42
T_4:Sole clusterbean	-	18.90	-	22.00	-	24.12
T_5:Maize +cowpea	21.13	18.98	26.60	22.08	29.30	24.20
T_6:Maize + pillipesara	21.03	16.65	26.76	19.75	29.06	21.87
T_7:Maize +clusterbean	21.39	19.12	26.59	22.21	29.22	24.33
T_8:Maize in pairs + cowpea	21.40	18.66	25.94	21.76	28.25	23.88
T_9:Maize in pairs + pillipesara	21.80	16.38	26.33	19.48	28.80	21.60
T_{10}:Maize in pairs + clusterbean	21.56	18.95	26.43	22.05	28.26	24.17
SEm$\pm$	0.55	0.37	0.55	0.40	0.48	0.48
CD (P=0.05)	1.71	1.11	1.71	1.20	1.48	1.44
CV (%)	4.44	3.56	3.61	3.28	3.00	3.58

Table 4.8 Crude fibre yield (kg ha^{-1}) of fodder maize and legumes as influenced by different treatments

Treatments	20 DAS			40 DAS			60 DAS		
	Maize	Legume Intercrop	Total	Maize	Legume Intercrop	Total	Maize	Legume Intercrop	Total
T_1:Sole fodder maize	404	-	404	1318	-	1318	2428	-	2428
T_2:Sole cowpea	-	100	100	-	351	351	-	642	642
T_3:Sole pillipesara	-	62	62	-	221	221	-	409	409
T_4:Sole clusterbean	-	98	98	-	349	349	-	616	616
T_5:Maize +cowpea	321	17	337	1102	59	1161	2023	108	2130
T_6:Maize + pillipesara	333	2	336	1151	8	1159	2270	16	2286
T_7:Maize +clusterbean	334	12	347	1132	43	1175	2070	74	2144
T_8:Maize in pairs + cowpea	352	63	416	1163	222	1384	2110	405	2515
T_9:Maize in pairs + pillipesara	367	5	372	1187	18	1205	2163	33	2195
T_{10}:Maize in pairs + clusterbean	346	47	394	1199	166	1365	2133	281	2414
SEm$\pm$	24	4	25	78	12	74	130	20	120
CD (P=0.05)	NS	11	74	NS	36	222	NS	62	358
CV (%)	12	14	15	12	13	13	10	12	12

Table 4.9. Total ash content (%) of fodder maize and legumes as influenced by different treatments

Treatments	20 DAS		40 DAS		60 DAS	
	Maize	Legume Intercrop	Maize	Legume Intercrop	Maize	Legume Intercrop
T_1:Sole fodder maize	13.93	-	10.86	-	10.22	-
T_2:Sole cowpea	-	19.30	-	17.94	-	15.88
T_3:Sole pillipesara	-	19.08	-	17.35	-	15.96
T_4:Sole clusterbean	-	18.73	-	17.57	-	15.66
T_5:Maize +cowpea	13.09	19.03	10.04	17.38	10.01	15.04
T_6:Maize + pillipesara	13.00	18.51	10.18	16.35	10.11	15.32
T_7:Maize +clusterbean	13.08	18.18	10.27	17.10	10.15	15.01
T_8:Maize in pairs + cowpea	13.55	19.15	10.96	17.67	10.55	15.81
T_9:Maize in pairs + pillipesara	13.07	18.96	10.63	17.01	10.51	15.35
T_{10}:Maize in pairs + clusterbean	13.13	18.30	10.51	17.35	10.40	15.42
SEm±	0.41	0.40	0.30	0.39	0.32	0.47
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	5.35	3.74	4.94	3.94	5.45	5.29

Table 4.10. Chlorophyll content (mg g^{-1}) of fodder maize and legumes as influenced by different treatments

Treatments	Chlorophyll 'a'		Chlorophyll 'b'		Total chlorophyll	
	Maize	Legume Intercrop	Maize	Legume Intercrop	Maize	Legume Intercrop
T_1:Sole fodder maize	1.05	-	1.16	-	2.21	-
T_2:Sole cowpea	-	1.62	-	1.68	-	3.30
T_3:Sole pillipesara	-	1.52	-	1.58	-	3.09
T_4:Sole clusterbean	-	1.57	-	1.60	-	3.17
T_5:Maize +cowpea	1.20	1.51	1.36	1.48	2.56	2.99
T_6:Maize + pillipesara	1.09	1.36	1.20	1.45	2.29	2.82
T_7:Maize +clusterbean	1.12	1.46	1.30	1.48	2.42	2.94
T_8:Maize in pairs + cowpea	1.45	1.65	1.52	1.54	2.98	3.20
T_9:Maize in pairs + pillipesara	1.17	1.50	1.32	1.48	2.49	2.98
T_{10}:Maize in pairs + clusterbean	1.39	1.62	1.42	1.52	2.80	3.14
SEm±	0.04	0.05	0.04	0.49	0.59	0.07
CD(P=0.05)	0.11	NS	0.14	NS	0.18	0.22
CV (%)	5.31	6.30	5.80	5.50	4.10	4.06

Table 4.11. Nitrogen content (%) of fodder maize and legumes as influenced by different treatments

Treatments	20 DAS		40 DAS		60 DAS	
	Maize	Legume Intercrop	Maize	Legume Intercrop	Maize	Legume Intercrop
T_1:Sole fodder maize	1.76	-	1.21	-	1.02	-
T_2:Sole cowpea	-	3.14	-	2.78	-	2.69
T_3:Sole pillipesara	-	3.02	-	2.64	-	2.58
T_4:Sole clusterbean	-	3.04	-	2.75	-	2.66
T_5:Maize +cowpea	1.61	3.06	1.24	2.67	1.19	2.64
T_6:Maize + pillipesara	1.68	2.96	1.24	2.60	1.00	2.53
T_7:Maize +clusterbean	1.59	3.03	1.24	2.70	1.05	2.54
T_8:Maize in pairs + cowpea	1.71	3.07	1.45	2.77	1.25	2.67
T_9:Maize in pairs + pillipesara	1.62	3.03	1.25	2.61	1.04	2.59
T_{10}:Maize in pairs + clusterbean	1.63	3.04	1.37	2.70	1.19	2.64
SEm$\pm$	0.04	0.08	0.03	0.04	0.03	0.08
CD (P=0.05)	NS	NS	0.11	NS	0.11	NS
CV (%)	4.65	4.42	4.8	3.44	5.50	5.40

Table 4.12. Nitrogen uptake (kg ha^{-1}) of fodder maize and legumes as influenced by different treatments

Treatments	20 DAS			40 DAS			60 DAS		
	Maize	Legume Intercrop	Total	Maize	Legume Intercrop	Total	Maize	Legume Intercrop	Total
T_1:Sole fodder maize	30.6	-	30.6	57.4	-	57.4	80.5	-	80.5
T_2:Sole cowpea	-	17.0	17.0	-	45.1	45.1	-	72.6	72.6
T_3:Sole pillipesara	-	11.5	11.5	-	30.3	30.3	-	49.2	49.2
T_4:Sole clusterbean	-	16.7	16.7	-	43.6	43.6	-	68.0	68.0
T_5:Maize +cowpea	24.4	2.7	27.1	51.5	7.1	58.6	82.3	11.7	94.0
T_6:Maize + pillipesara	26.5	0.4	26.9	52.5	1.1	53.6	78.2	1.9	80.1
T_7:Maize +clusterbean	24.9	2.0	26.9	52.9	5.3	58.2	74.1	7.7	81.8
T_8:Maize in pairs + cowpea	30.0	10.4	38.4	65.0	28.2	93.2	93.1	45.3	138.4
T_9:Maize in pairs + pillipesara	26.8	0.9	27.7	56.1	2.4	58.5	77.6	3.9	81.5
T_{10}:Maize in pairs + clusterbean	26.4	7.6	34.0	64.1	20.2	84.3	89.7	30.6	120.3
SEm$\pm$	1.9	0.6	1.7	2.7	1.3	3.3	3.7	2.4	4.6
CD (P=0.05)	NS	1.7	5.0	8.4	4.1	9.6	11.5	7.3	13.6
CV (%)	12.0	12.3	11.4	8.3	11.6	9.7	7.8	13.1	9.2

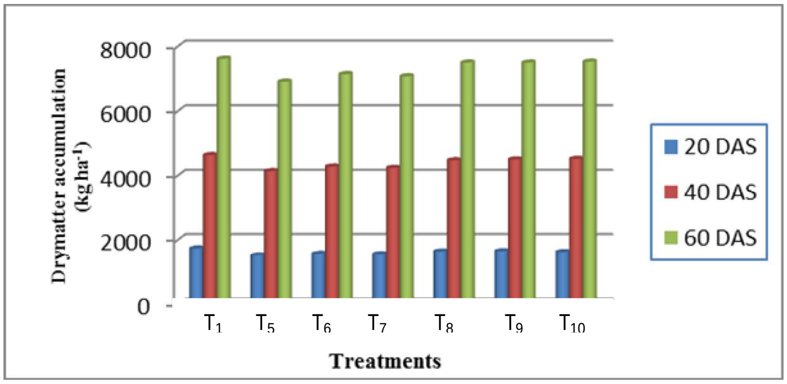


Fig 4.1.1 : Drymatter accumulation (kg ha^{-1}) of fodder maize as influenced by different treatments.

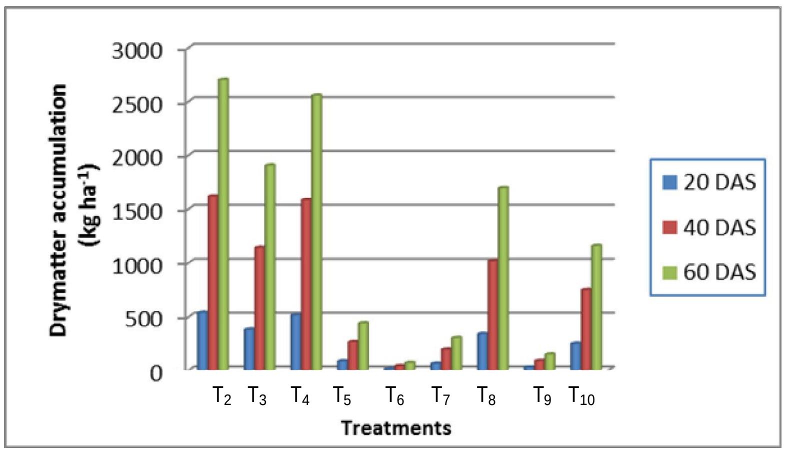


Fig 4.1.2 : Drymatter accumulation (kg ha^{-1}) of fodder legumes as influenced by different treatments.

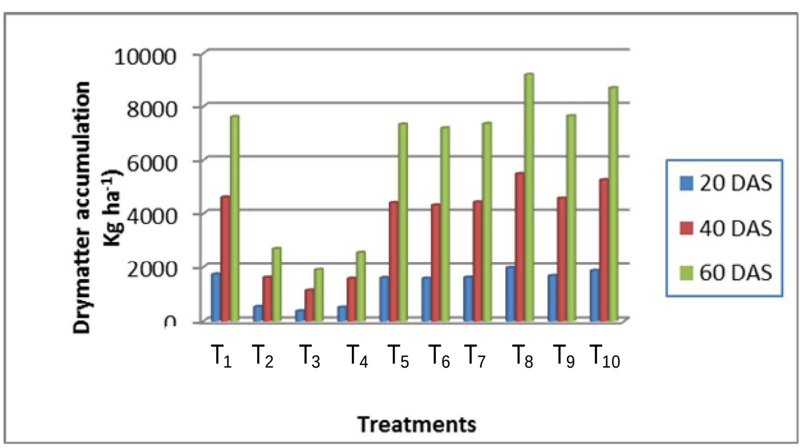


Fig 4.1.3: Total drymatter accumulation (kg ha^{-1}) of fodder maize and legume fodders as influenced by different treatments

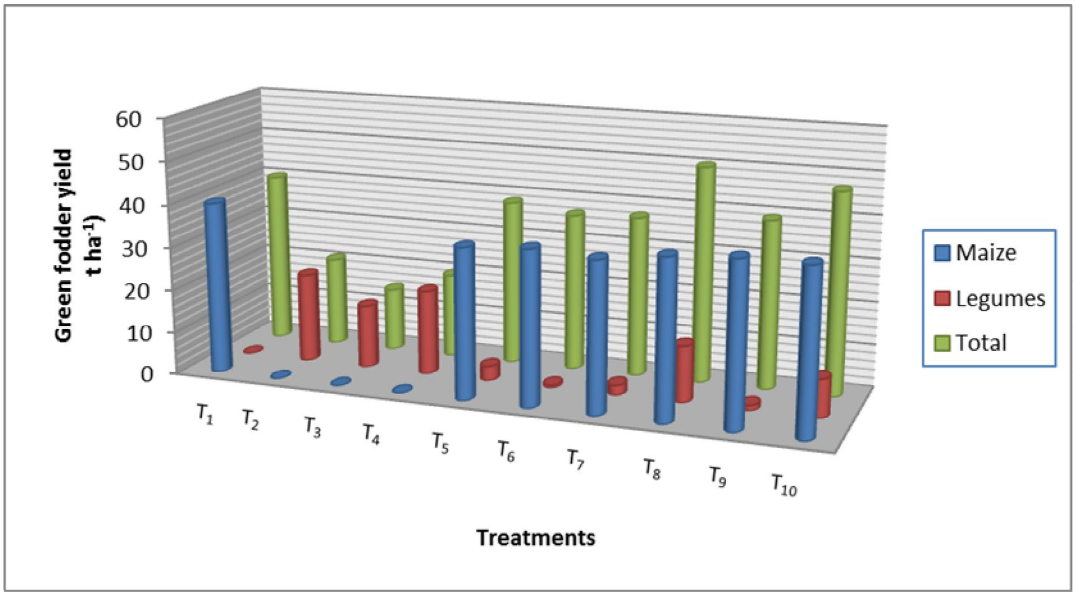


Fig 4.2.1: Green fodder yield (t ha^{-1}) of maize and legume fodders as influenced by different treatments.

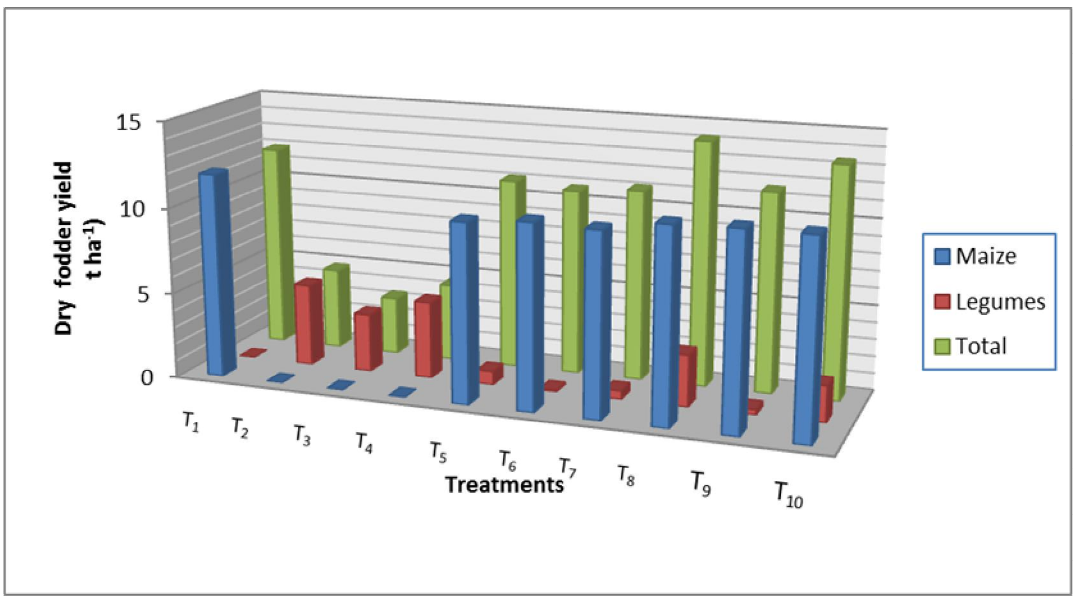


Fig 4.2.2: Dry fodder yield (t ha^{-1}) of maize and legume fodders as influenced by different treatments.

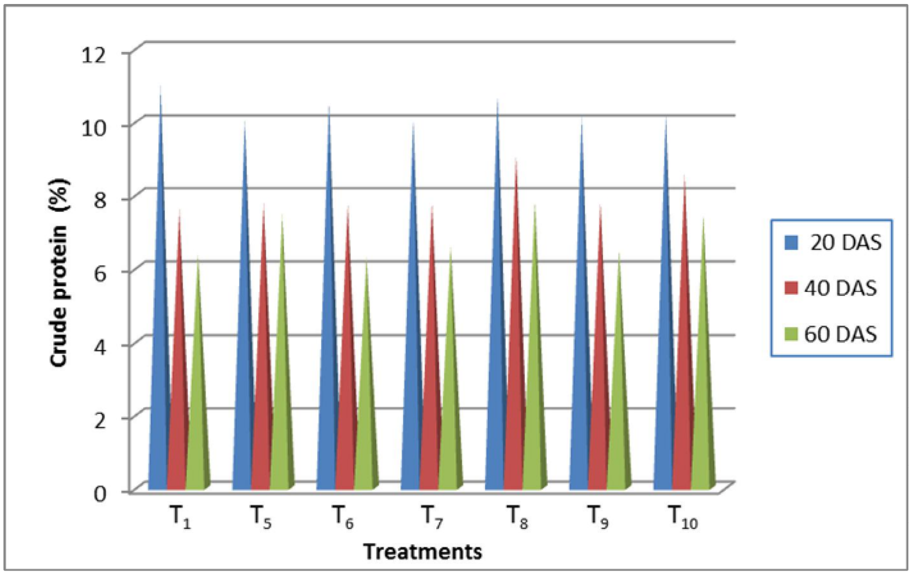


Fig 4.3.1 : Crude protein content(%) of fodder maize as influenced by different treatments.

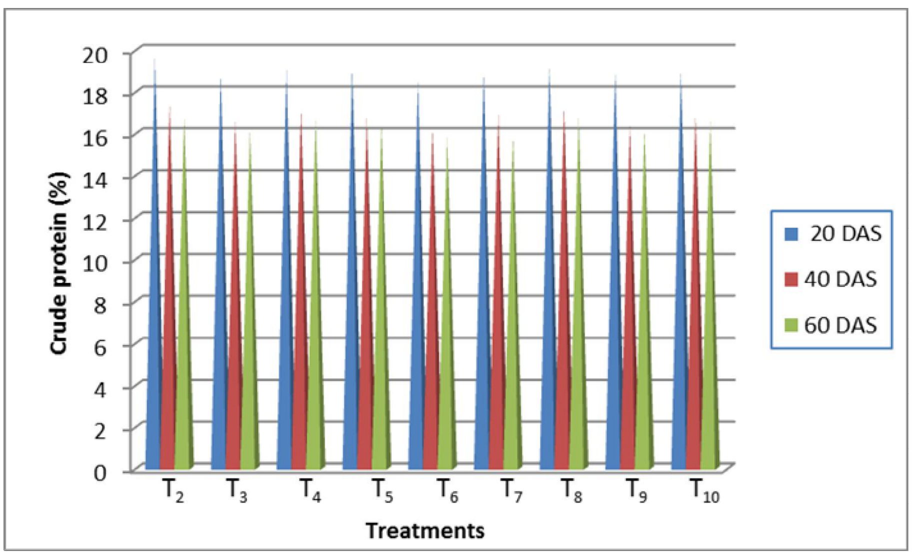


Fig 4.3.2: Crude protein content(%) of legumes as influenced by different treatments.

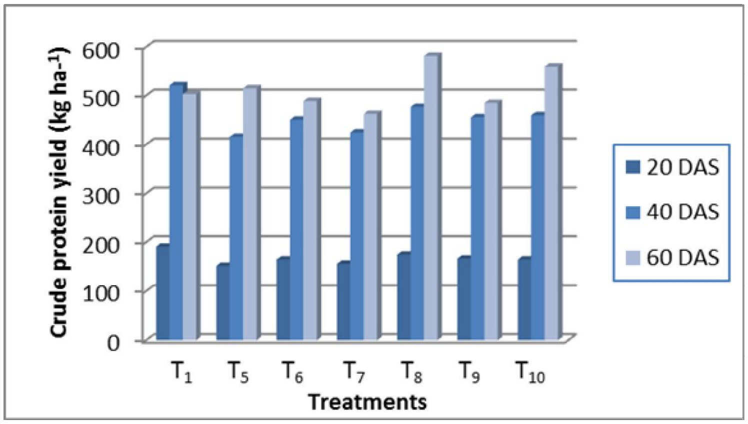


Fig 4.4.1: Crude protein yield (kg ha^{-1}) of fodder maize as influenced by different treatments.

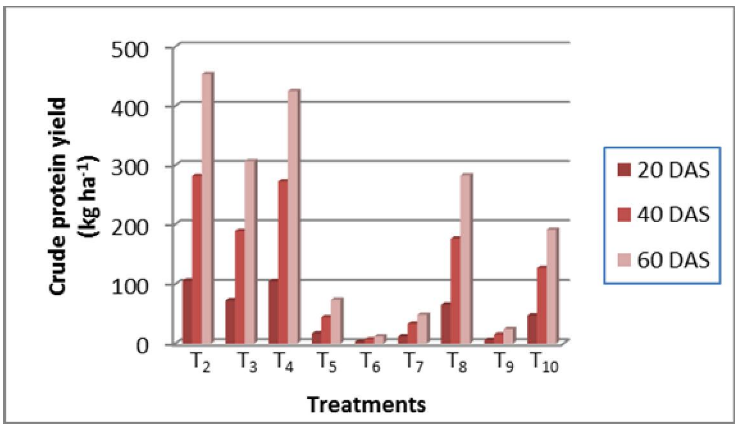


Fig 4.4.2: Crude protein yield (kg ha^{-1}) of fodder legumes as influenced by different treatments

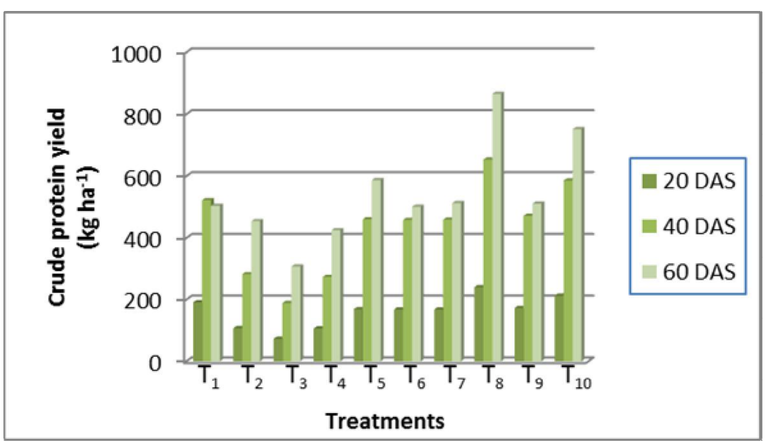


Fig 4.4.3: Total crude protein yield (kg ha^{-1}) of fodder maize and legumes as influenced by different treatments.

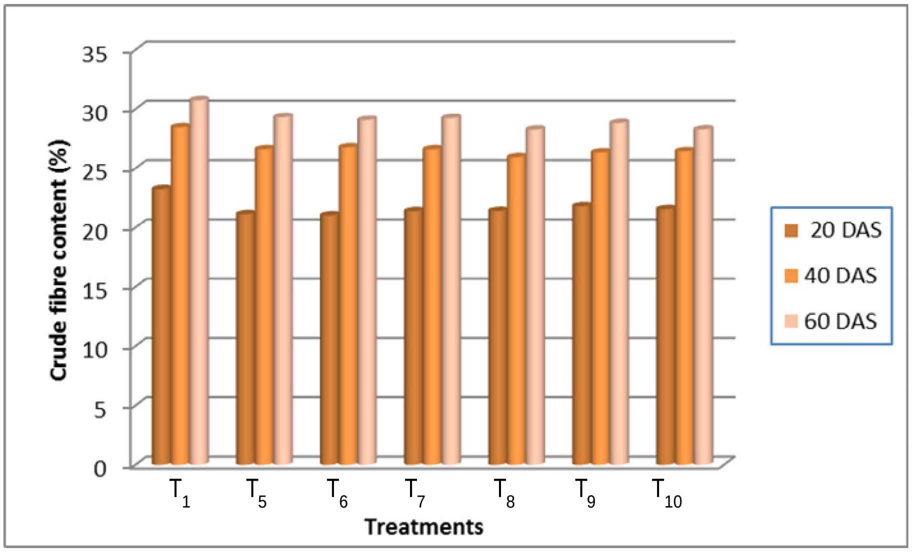


Fig 4.5.1 : Crude fibre content(%) of fodder maize as influenced by different treatments.

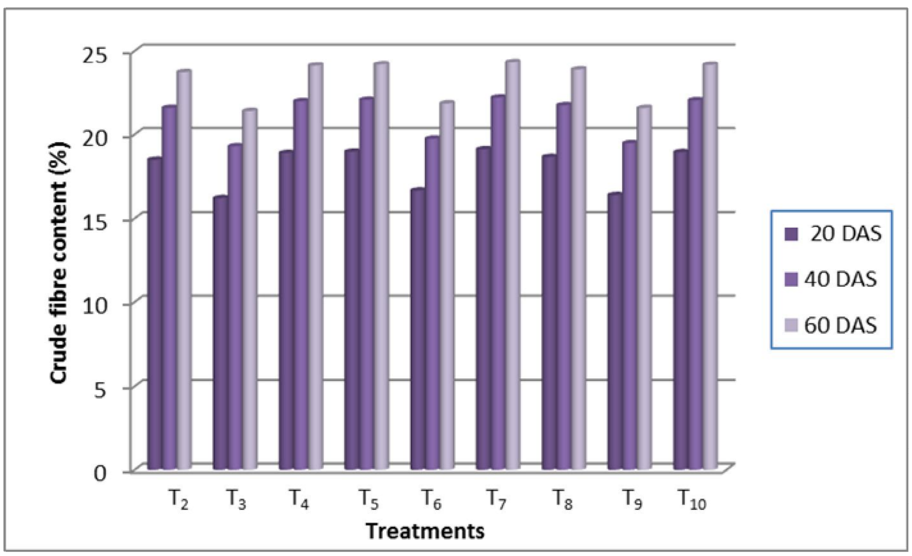


Fig 4.5.1: Crude fibre content(%) of fodder legumes as influenced by different treatments.

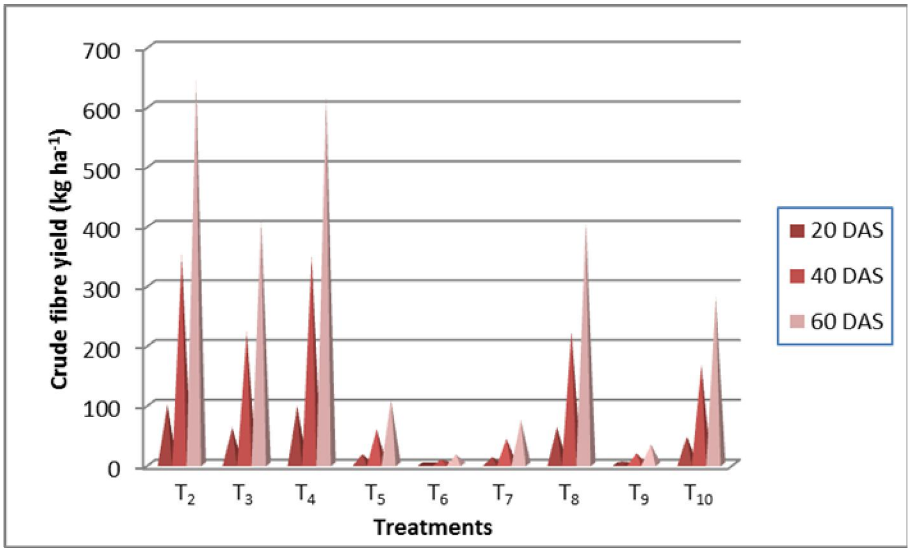


Fig 4.6.1: Crude fibre yield (kg ha^{-1}) of fodder legumes as influenced by different treatments.

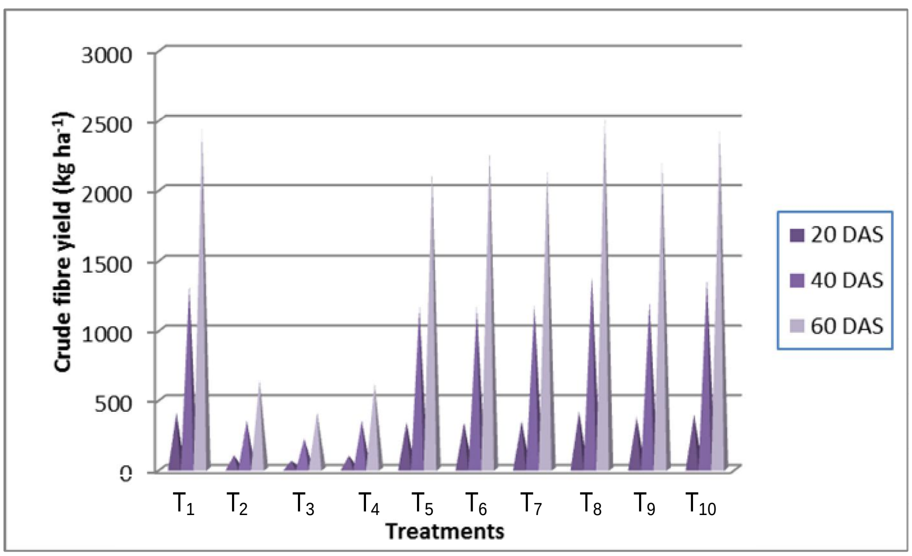


Fig 4.6.2: Total crude fibre yield (kg ha^{-1}) of fodder maize and fodder maize as influenced by different treatments.

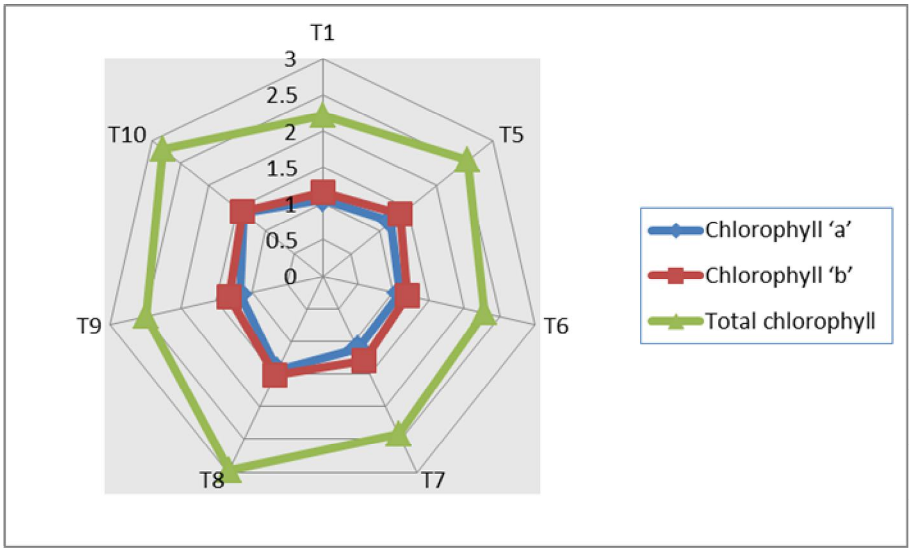


Fig 4.7.1 : Chlorophyll content (mg g^{-1}) of fodder maize as influenced by different treatments.

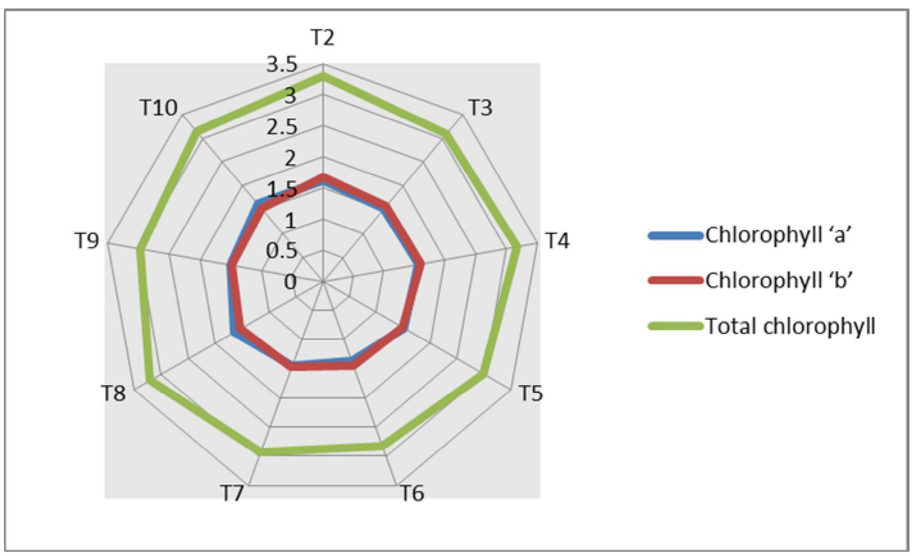


Fig 4.7.2: Chlorophyll content (mg/g) of fodder legumes as influenced by different treatments.

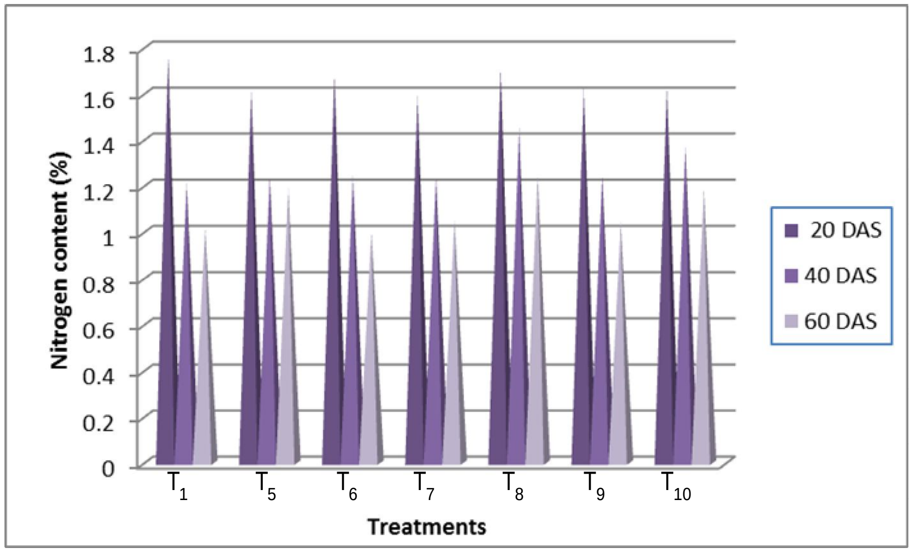


Fig 4.8.1 : Nitrogen content(%) of fodder maize as influenced by different treatments.

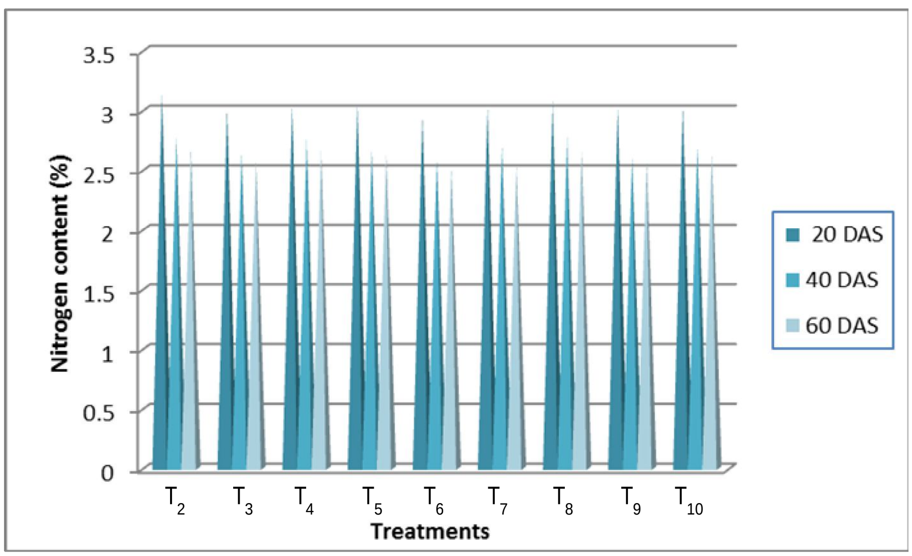


Fig 4.8.2: Nitrogen content(%) of legumes as influenced by different treatments.

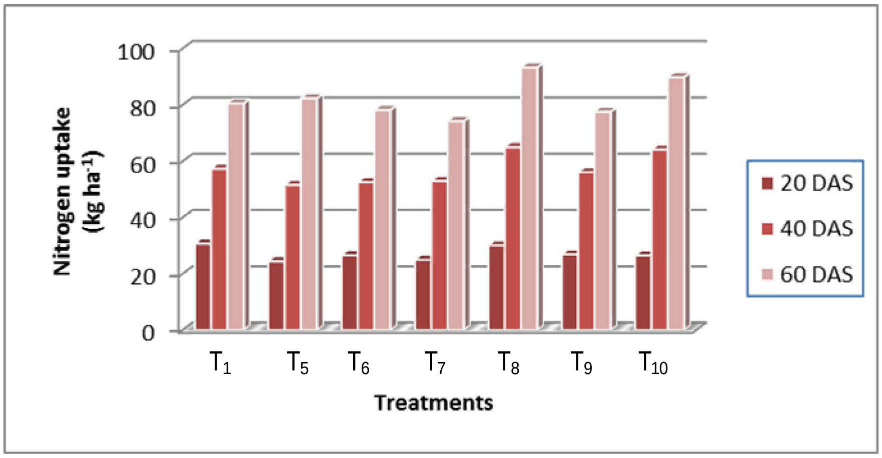


Fig 4.9.1: Nitrogen uptake (kg ha^{-1}) of fodder maize as influenced by different treatments.

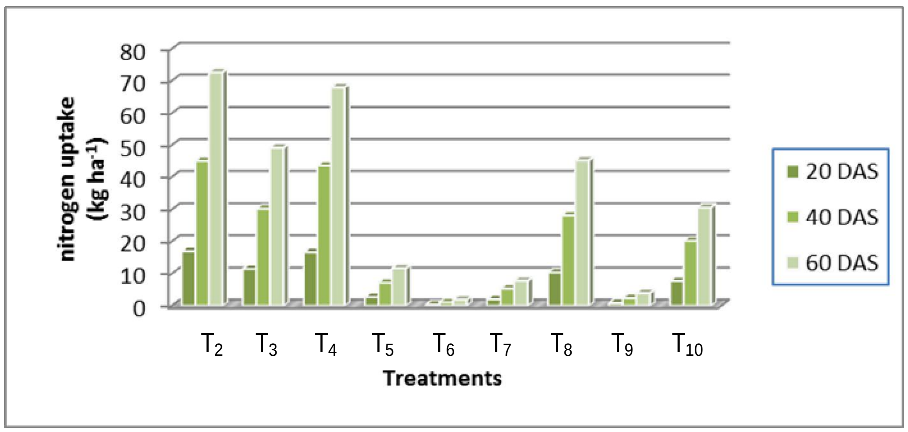


Fig 4.9.2: Nitrogen uptake (kg ha^{-1}) of fodder legumes as influenced by different treatments.

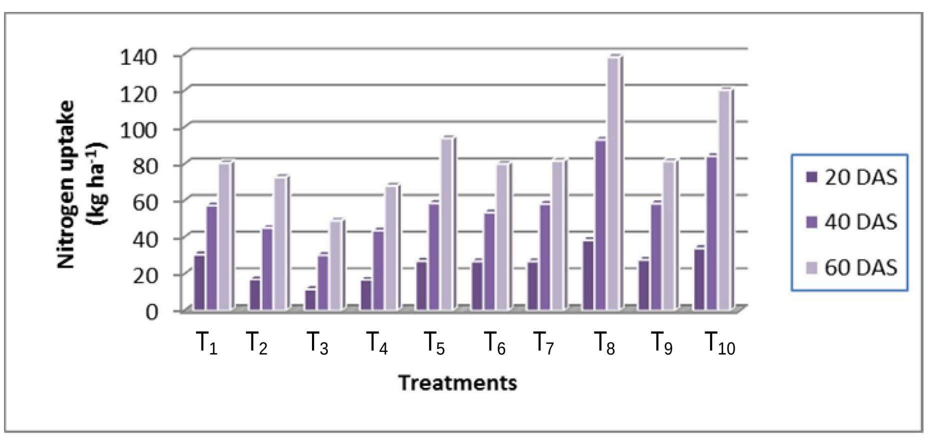


Fig 4.9.3: Total nitrogen uptake (kg ha^{-1}) of fodder maize and legume as influenced by different treatments.

Chapter V

SUMMARY AND CONCLUSIONS

One of the bottlenecks of livestock production in India is feed shortage. Although fodder is cheapest form of feed for animals but present fodder production in our country does not meet the fodder requirements in terms of both quantity and quality which consequently results in the under-nourishing of animals. Cultivation of cereal forages along with legumes in intercropping system appears to be a prospective method to get an increased quantity and nutritious fodder with an appreciable improvement in the enrichment of the soil (Patel and Rajgopal, 2001). Among cereal fodders, maize has the potential to supply large amount of energy rich forage diets and its fodder can safely be fed at all stages of growth without any danger of oxalic acid and prussic acid as incase of sorghum (Dahmardeh *et al.*, 2009). Thus there is a need to develop an appropriate fodder maize-legume intercropping system leading to higher forage production of good quality. In this context, a field experiment entitled "Studies on fodder maize and legume intercropping system" was conducted during *kharif,* 2011 at Agricultural College Farm, Bapatla on sandy clay loam soil.

The experiment was laid out in a Randomized Block Design with ten treatments replicated thrice. The treatmental details are T_1: Sole crop of Fodder maize, $T_{2:}$ Sole crop of Cowpea, $T3_{:}$ Sole crop of Pillipesara, $T_{4:}$ Sole crop of Cluster bean, $T_{5:}$ Maize + Cowpea mixed intercropping, $T_{6:}$ Maize + Pillipesara mixed intercropping, $T_{7:}$ Maize + Cluster bean mixed intercropping, $T_{8:}$ Maize in paired rows + 2 rows of cowpea $T_{9:}$ Maize in paired rows + 2 rows of Pillipeasara and $T_{10:}$ Maize in paired rows + 2 rows of Clusterbean.

Results of the experiment revealed that, growth parameters viz., plant height, number of leaves plant^{-1} and drymatter accumulation of fodder maize were uninfluenced by different treatments, whereas, legumes and total drymatter accumulation was significantly influenced by various treatments at different growth stages. Higher drymatter accumulation was recorded with sole crops of cowpea, clusterbean, and pillipesara fodders over their respective intercropped stands at all the growth stages. Among the different sole fodder legumes, the highest drymatter accumulation was registered by cowpea at 20,40 and 60 DAS (540, 1621 and 2701 kg ha^{-1} respectively) while significantly the lowest drymatter accumulation was obtained with pillipesara at all growth stages (14, 43 and 72 kg ha^{-1} at 20, 40 and 60 DAS respectively) in T_6 treatment *i.e.* mixed intercropping of maize with pillipesara. The highest total drymatter accumulation (1981, 5495 and 9205 kg ha^{-1} at 20, 40 and 60 DAS respectively) was recorded in maize pairs + cowpea (T_8) followed by T_{10} treatment *i.e*. maize pairs + clusterbean (1681, 5270 and 8694 kg ha^{-1} at 20, 40 and 60 DAS respectively). The lowest total drymatter accumulation (1584, 4323 and 7205 kg ha^{-1} at 20, 40 and 60 DAS respectively) was recorded in maize + pillipesara mixed cropping which was statistically comparable with total drymatter accumulation in maize sole cropping.

Green and dry fodder yields of fodder maize were uninfluenced by various treatments, whereas, total yield along with legume intercrop were significantly influenced. The highest legume fodder yield was recorded with sole cowpea with 20.8 t ha^{-1}. Significantly the lowest green fodder yield was recorded with pillipesara (0.6 t ha^{-1}) in T_6 treatment. The highest total green fodder yield was obtained from cowpea seeded in paired rows of maize *i.e*. T_8 treatment (50.36 t ha^{-1}) followed by T_{10} treatment (46.6 t ha^{-1}) *i.e.* maize pairs + clusterbean intercropping. Among the intercropping treatments, the lowest total green fodder yield was recorded with that of maize + pillipesara mixed intercropping treatment (36.6 t ha^{-1}). The highest dry fodder yield of legume (4.78 t ha^{-1}) was recorded in cowpea sole crop and was statistically comparable with sole clusterbean (4.52 t ha^{-1}). Significantly the lowest dry fodder yield 0.13 t ha^{-1} and 0.27 t $ha^{\mathbf{-1}}$ was recorded by pillipesara mixed intercrop and paired intercropping respectively. The highest total dry fodder yield was obtained from T_8 treatment (14.2 t ha^{-1}) and was statistically comparable with that of T_{10} treatment (13.4 t ha^{-1}).The lowest total dry fodder yield (3.4 t ha^{-1}) was recorded in T_3 treatment *i.e*. sole pillipesara.

Quality parameters like crude protein content, crude protein yield, crude fibre content and crude fibre yield were significantly influenced by different treatments whereas, total ash content was unaffected. Significantly the highest crude protein content in fodder maize (9.08 and 7.81 per cent at 40 and 60 DAS respectively) was recorded in maize pairs + cowpea intercropping (T_8 treatment). The lowest *i.e.* 6.27 per cent crude protein in fodder maize was found when maize and pillipesara seed was mixed and sown in lines *i.e.* T_6 treatment which was statistically comparable with 6.38 per cent crude protein content in sole fodder maize. Fodder maize in T_8 treatment registered with the highest crude protein yield (582 kg ha^{-1}) and it was comparable with that of T_{10} treatment *i.e.* maize in pairs + clusterbean intercropping (560 kg ha^{-1}). Among legume intercrops, higher crude protein yield (454 kg ha^{-}1) was recorded cowpea followed by clusterbean (425 kg ha^{-1}) in T_2 and T_4 treatments. The highest total crude protein yield (865 kg ha^{-1}) was recorded in T_8 treatment (maize in pairs + cowpea intercropping) and the lowest crude protein yield (307 kg ha^{-1}) was registered in T_3 treatment, *i.e.* sole pillipesara.

The highest crude fibre content (30.74 per cent) was recorded with sole fodder maize treatment and the lowest (21.4 per cent) was recorded by sole pillipesara. The higher total crude fibre yield, 416, 1384 and 2515 kg ha^{-1} was found in T_8 treatment *i.e.* maize in pairs + cowpea intercropping during 20, 40 and 60 DAS respectively but this treatment was statistically comparable with crude fibre yield of sole maize fodder (404, 1318 and 2428 kg ha^{-1} at 20, 40 and 60 DAS respectively). The lowest total crude fibre yield was recorded in sole pillipesara treatment (62, 221 and 409 kg ha^{-1}during 20, 40 and 60 DAS respectively).

The highest nitrogen content of maize was recorded (1.45 and 1.25 per cent at 40 and 60 DAS respectively) in T_8 treatment *i.e.* maize in pairs + cowpea intercropping. Significantly the highest chlorophyll contents, viz., chlorophyll ‘a’, chlorophyll ‘b’, and total chlorophyll (1.45 mg g^{-1}, 1.52 mg g^{-1} and 2.98 mg g^{-1}) were observed in T_8 treatment *i.e.* maize in pairs + cowpea cropping and the lowest was observed in sole maize.

The highest nitrogen uptake of fodder maize was recorded in T_8 (93.08 kg ha^{-1}) and was statistically comparable with that of T_{10} (89.65 kg ha^{-1}) and T_5 (82.33 kg ha^{-1}) treatment. Significantly the lowest nitrogen uptake by fodder maize (74.13 kg ha^{-1}) was recorded in T_7 treatment (maize + clusterbean mixed intercropping). Among legume fodders, the highest nitrogen uptake (72.64 kg ha^{-1}) was registered by cowpea in T_2 treatment and significantly the lowest nitrogen uptake (1.85 kg ha^{-1}) was recorded by pillipesara in T_6 treatment. The highest total nitrogen uptake was (138.43 kg ha^{-1}) was found in T_8 treatment (maize in pairs + cowpea intercropping) followed by nitrogen uptake of 120.28 kg ha^{-1} in T_{10} treatment *i.e.* maize in pairs + clusterbean intercropping. Significantly the lowest total nitrogen uptake (49.15 kg ha^{1}) was observed in T_3 treatment *i.e.* sole pillipesara.

Available soil nitrogen after the harvest of the crop was lower (169 kg ha^{-1}) in plots where sole fodder maize was grown. The highest soil available nitrogen (222 kg ha^{-1}) was registered in T_2 treatment *i.e.* sole cowpea. Relatively higher available soil nitrogen recorded in T_8 treatment (191 kg ha^{-1}) was followed by T_{10} treatment (187 kg ha^{-1}) as compared to other intercropping treatments. The residual P_2O_5 and K_2O after the harvest of the crop were not significantly influenced by different treatments.

Economics of various treatments revealed that the highest gross return, net return and return per rupee investment (Rs. 28,448, Rs. 14,783 and 2.1 respectively) were recorded with T_8 treatment (maize in pairs + cowpea intercropping).

CONCLUSIONS

Based on the results of present investigation, the following conclusions were drawn.

- Paired row planting of fodder maize intercropped with fodder legume resulted on higher fodder yield with better quality and proved to be the best method of sowing.
- Among the different fodder legumes intercropped, fodder cowpea proved to be the best suitable intercrop resulting in the highest fodder yield.
- The highest values of gross return, net return and return per rupee investment were registered under fodder maize paired rows intercropped with cowpea.

From the foregoing experimental results, farmers of Krishna zone, Andhra Pradesh may be suggested to grow fodder maize in paired rows along with two rows of cowpea as intercrops to achieve higher fodder yield with better quality which is more profitable.

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***Original not seen**

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Appendix -I

CALENDAR OF OPERATIONS

Operation	Date
Spraying of glyphosate	19.07.2011
Ploughing with MB plough	27.07.2011
Removal of stubbles & Layout of field	01.08.2011
Leveling by using manual labour	01.08.2011
Fertilizer application (basal application)	02.08.2011
Sowing	02.08.2011
Pre-emergence herbicide application (Pendimethalin)	03.08.2011
Phorate application	07.08.2011
Irrigation	08.08.2011
Gap filling	08.08.2011
Second irrigation	11.08.2011
Spraying of Dimethoate @ 2 ml L^{-1}	20.08.2011
Handweeding	30.08.2011
Fertilizer application (topdressing)	31.08.2011
Spraying of Imidachloprid (0.006 %)	09.09.2011
Irrigation	15.09.2011
Irrigation	25.09.2011
Harvesting	02.10.2011