NITROGEN MANAGEMENT IN SPECIALITY CORN UNDER *PONGAMIA* + MAIZE AGRI-SILVI SYSTEM.

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B. Sc. (Ag.)

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BY

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DECLARATION

I**, C. PRATHYUSHA,** hereby declare that the thesis entitled **"NITROGEN MANAGEMENT IN SPECIALITY CORN UNDER *PONGAMIA* + MAIZE AGRI-SILVI SYSTEM"** submitted to the **Acharya N. G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place: Hyderabad **(C. PRATHYUSHA)**

Date: **I. D. No. RAM/10-01**

CERTIFICATE

Ms. C.PRATHYUSHA has satisfactorily prosecuted the course of research and that thesis entitled **"NITROGEN MANAGEMENT IN SPECIALITY CORN UNDER *PONGAMIA* + MAIZE AGRI-SILVI 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.

Date: **(Dr. S. HEMALATHA)** Place:

Chairperson

CERTIFICATE

This is to certify that the thesis entitled "**NITROGEN MANAGEMENT IN SPECIALITY CORN UNDER *PONGAMIA* + MAIZE AGRI-SILVI SYSTEM"** submitted in partial fulfilment 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 bonafied original research work carried out by **Ms. C. PRATHYUSHA** 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 assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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ABSTRACT

An experiment was carried out during *Kharif* 2011 at the Student's Farm, College of Agriculture, Rajendranagar, Hyderabad on red sandy loam soils to study the effect of nitrogen management in speciality corn under *Pongamia* + maize agri-silvi system. The Farm is geographically situated at an altitude of 542.3 m above mean sea level at 17^0 $19^{'}$ N latitude and 78^0 $28^{'}$ E longitude and falls under the Southern Telangana Agro-climatic Zone of Andhra Pradesh. The experiment was laid out in a randomized block design (factorial concept) with three replications. The treatments consists of three nitrogen levels (60, 90 and 120 kg N ha^{-1}) and three types of corn (baby corn, sweet corn and popcorn) as intercrops in *Pongamia* and one control treatment (sole *Pongamia* without maize and with no nitrogen).

The growth characters of speciality corn such as plant height, dry matter production, leaf area index were maximum with the application of 120 kg N ha^{-1} compared to other two lower doses. Whereas, silking and maturity were delayed with lower dose of N *i.e.,*60 kg N ha^{-1} of speciality corn.

All the yield attributes such as cob length, cob girth, number of cobs $plant^{-1}$, number of rows cob^{-1}, number of kernals cob^{-1} and 100 kernel weight were found maximum at 120 kg N ha^{-1} than at the remaining nitrogen levels. Whereas, cob weight (with husk) was found maximum at 120 kg ha^{-1} but was on par with 90 kg N ha^{-1}. Similarly cob yield (with husk), green fodder/stover yield, harvest index, kernel yield of popcorn and shelling percentage of popcorn were found significantly higher at 120 kg N ha^{-1} than the other two lower doses of nitrogen.

Application of 120 kg N ha^{-1} resulted in significantly higher *Pongamia* equivalent yield over 60 and 90 kg N ha^{-1}.

Post harvest soil available nitrogen was significantly higher in all the treatments than control. Maximum available N and K in soil was recorded with 120 kg N ha^{-1}. Though

available P in soil observed under 120 kg N ha^{-1} was maximum, it was statistically at par with 90 kg N ha^{-1}. The maximum nutrient uptake (N, P & K) was also registered at 120 kg ha^{-1}, which was significantly higher than 60 and 90 kg N ha^{-1}.

The different types of corn were found significantly different from each other regarding growth parameters such as plant height, days to 50 per cent silking and days to maturity. Whereas, in case of leaf area index, baby corn and pop corn were found comparable with each other in the initial stage but later at harvest sweet corn and popcorn were found on par with each other. Similarly regarding dry matter accumulation, in the initial stages, baby corn and sweet corn were found comparable with each other but later at harvest baby corn and sweet corn were found on par with each other.

Regarding the effect of types of corn on yield and yield attributes, all the three types of corn were found significantly different from each other in cob length, cob girth, cob weight (with husk), green cob yield as well as green fodder/stover yield. Whereas, sweet corn and popcorn were comparable with each other in number of cobs $plant^{-1}$ but found significantly different from baby corn.

Sweet corn gave significantly higher *Pongamia* equivalent yield than the other two types of corn. Next to this, baby corn was found to be the best as an intercrop to get higher *Pongamia* equivalent yield.

Post harvest soil available nutrients (N, P & K) were found unaffected by the different types of corn.

Sweet corn recorded significantly higher nitrogen uptake than the other two types of corn. Similarly, P & K uptake was also maximum in sweet corn but statistically on par with baby corn regarding P uptake and with popcorn regarding K uptake.

Effect of nitrogen management in speciality corn on the tree parameters of *Pongamia* was found non significant.

The interaction effect between types of corn and levels of nitrogen in case of cob yield (with husk) indicated that baby corn gave significantly higher cob yield at 120 kg N ha^{-1} over the remaining two lower doses of nitrogen. Likewise, sweet corn & popcorn also recorded higher cob yields at 120 kg N ha^{-1}which were significantly superior to both 60 and 90 kg N ha^{-1}.

The interaction effect between types of corn and levels of nitrogen on *Pongamia* equivalent yield indicated that a combination of sweet corn and 120 kg N ha^{-1} was found to be significantly superior to all the other treatments. The next best combination was sweet corn at 90 kg N ha^{-1}.

Maximum gross returns, net returns and B:C ratio from the system was obtained with the combination of sweet corn at 120 kg N ha^{-1} followed by sweet corn at 90 kg N ha^{-1}.

The results revealed that sweet corn with nutrient supplementation of 120-60-40 kg N, P_2O_5 & K_2O respectively was found to be most profitable intercrop in *Pongamia* plantations in sandy loam soils at Rajendranagar, Hyderabad.

CHAPTER-I

INTRODUCTION

Chapter I

INTRODUCTION

Arable cropping enterprise in drylands is often unremunerative on account of aberrations of monsoon. The major constraints that limit crop production in dryland areas are moisture and nutrient stress. Conservation of soil moisture and improvement of soil fertility through addition of organic materials may improve production from these lands considerably by sustaining the soil health. Hence an integrated approach of land management to utilize the natural resources more efficiently in rainfed areas is essential to meet the requirements of farmer and his live stock without deteriorating the land productivity and also generate continuous and stable income.

One of the need based alternative land use system replacing the traditional farming system is a tree based system of cropping *i.e.,* agroforestry which acts as sustainable land management system especially in dryland areas. Agroforestry systems are intermediate natural and agricultural systems and their relative status depends on several factors including the spatial and temporal arrangement of trees and crops, tree species and management, climate and soil fertility through retrival of nutrients from below the rooting zone of crops and input of nitrogen by biological N_2 fixation.

Pongamia pinnata is a multipurpose tree species (MPTS) and it is a good nitrogen fixing tree also. This tree species is sustainable under agro forestry farming system because of its fast growth and nitrogen fixation. It is the best suited tree for energy plantations. Moreover the tree prunings provide the opportunity for mulching and serve the purpose of both moisture conservation and green manuring.

Since the gestation period is high in *Pongamia* and because of wider spacing between the trees the interspaces can be effectively used for intercropping. Maize (*Zea mays L.)* is the 3rd most important cereal in the world next to rice and wheat and has the highest production potential among the cereals. In India, the production of maize is about 15.09 M.t from an area of 7.89 M.ha, with an average productivity of 1,904 kg ha^{-1} (2009-2010). In Andhra Pradesh, it is grown in an area of 0.85 M.ha with a production of 4.15 M.t and productivity of 4,073 kg ha^{-1} (CMIE, 2010).

Of the various types of maize sweet corn, baby corn and pop corn are most important. Baby corn is nothing but maize being grown for vegetable purpose. Moreover it is a short duration crop and free from pests and diseases and its nutritive value is comparable with that of several high priced vegetables. Thavaprakash *et al.* (2005) and Das *et al.* (2008) reported that 100 g of baby corn contained 89.1 per cent moisture, 0.2 per cent fat, 1.9 g protein, 8.2 mg carbohydrate, 0.06 g ash, 28.0 mg calcium, 86.0 mg phosphorous, and 11.0 mg ascorbic acid. The early harvest and sale of baby corn ears before dry spells provides higher profits and untranslocated photosynthates left in green stover becomes valuable source for nutritious green fodder to livestock giving impetus to dairy, meat and beaf production.

Sweet corn is used as a human food in soft dough stage with succulent grain and 13 to 15 per cent sugar. It is gaining popularity because of its high sugar and low starch content. Further it has been emerged as an alternative dish of urbanites *viz.*, vegetable, roasted ears, soups, corn syrup, sweeteners *etc*.

The other type *i.e.*, pop corn is very popular as snack food in many parts of the world. The use of popcorn confectionaries and popcorn products especially in amusement parks, moving picture theaters *etc.*, greatly increased the demand for popcorn products and has made a profitable outlet for those who desire to grow popcorn on a commercial scale.

Moreover the byproducts of these corn types provide good cattle feed. These are becoming popular among progressive farmers around big cities as there is very good peri-urban market for these products.

Maize is a highly nutrient exhaustive crop and responds even to higher levels of nitrogen as nitrogen is the major essential element for its productivity. Hence for improved production of these corns efficient nitrogen management is needed besides sustaining soil health.

While agroforestry systems can provide adequate N for moderate yields of cereal crops, additional fertilizer N is needed to achieve potential yields of improved crop varieties. Thus an integrated approach of using agroforestry and organic residues to supply N and inorganic fertilizers to supplement additional N is promoted.

Keeping these facts in view, a comprehensive study is therefore planned in which different levels of N are applied to maize (3 types of corns) in *Pongamia* based Agri-Silviculture system with the following objectives.

OBJECTIVES:

1. To evaluate the performance of speciality corn types as an intercrop in existing *Pongamia* plantations under rainfed conditions.
2. To study the effect of different N levels on speciality corn in Agri-Silvicultural system under rainfed conditions.
3. To workout the economics of *Pongamia* + maize Agri-Silvicultural system in relation to nitrogen management.

CHAPTER-II

REVIEW OF LITERATURE

Chapter II

REVIEW OF LITERATURE

Intercropping of agricultural crops with woody species is an age-old practice in traditional farming systems in the tropics. Food production is the major aim of subsistence farmers with most of their farmland being allocated to food crops rather than to trees and shrubs. Due to increasing population and scarcity of productive lands that cannot sustain intensive exploitation, one method that has been proposed to enhance the sustainability of agricultural production is the growing of trees in association with crops.

Alley cropping is an agroforestry system in which food crops are grown in alleys formed by hedge rows of trees or shrubs and these hedge rows are kept pruned during the rainy season. The hedge rows are usually cut to a height of about 2 m when crops are sown and kept pruned to reduce competition with crops. Work done on alley cropping in *Pongamia pinnata* was less in India and other countries. Hence literature pertaining to tree crop competition studies in agri-silvi system was presented in this chapter. Moreover, it was unable to get sizeable literature related to speciality corn. In view of the paucity of adequate literature related to speciality corn, few citations with respect to grain corn were also presented in brief to know the general scientific idea.

The available literature related to the present study has been reviewed under the following heads.

2.1 Tree crop competition studies in agri-silviculture system.

2.2 Performance of arable crops in alley cropping system.

2.3 Performance of speciality corn under the influence of graded nitrogen levels.

2.4 Economic studies in agri-silviculture system.

2.1 Tree Crop Competition Studies in Agri-Silviculture System

Agroforestry experiments involving forestry tree species *Casuarina equisetifolia* and *Leucaena leucocephala* and arable crops sunflower, sesame and groundnut resulted in significant reduction in intercrop yields primarily due to reduced light interception (Srinivasan *et al.*, 1990).

Yamoah (1991) opined that pole bean was most appropriate intercrop in six month old sesbania plantation in comparison to maize. On the other hand Tripathi and Hazra (1997) revealed that maize yields under *Hardwickia binata* were enhanced due to improved soil fertility, lower bulk density and pH.

Likewise, Khadse and Bharad (1996) reported that *Hardwickia binata* canopy reduced the mean sunlight transmission on the castor crop grown in alleys. However, higher yield was recorded from central rows with reduction in yield towards the tree.

Likewise, Rao *et al.* (2000) observed higher drymatter, crop growth rate, leaf area and leaf area index in groundnut under alley cropping with *Albizia* than in sole cropping.

Similarly, in a study conducted at Jhansi on the tree-crop interaction in *Albizia procera* and black gram and mustard agrisilvi system it was noticed that there was significant reduction in the crop yield due to the limited availability of light to the crop (Newaj *et al.*, 2003).

2.2 Performance of Arable Crops in Alley Cropping System

Studies conducted at CRIDA, Hyderabad on alley cropping with *Leucaena leucocephala* revealed significant reduction in crop yields of pigeonpea and castor (61-62%), sorghum (48%) and pearlmillet (30%). This was primarily attributed to rooting pattern of agricultural crops affecting the nutrient and moisture relations (Singh *et al.*, 1987).

Likewise, Balasubramanian (1989) reported higher grain yields of pearl millet and sorghum in *Leucaena leucocephala* alley cropping.

Chamshama *et al.* (1994) reported that in an intercropping of maize with *Faidherbia albida,* the grain yield was 90 per cent of sole maize in the first year of normal rain and corresponding year being a dry year, intercropped maize yield was 64 per cent higher than sole maize yield.

Vani (1995) conducted experiment in alley cropping with *Faidherbia albida* at Hyderabad the results revealed that plant height, dry matter production, crop growth rate, leaf area, leaf area index of castor were found significantly superior to sole crop of castor.

Likewise, the work of Madhusudhan (1997) revealed that castor had significantly higher plant height, dry matter production, crop growth rate and leaf area index when alley cropped with *Leucaena leucocephala* than the values noticed in sole castor.

The evaluation of maize production in an alley cropping system with *Calliandra calothyrsus* and *Erythrina fusa* and monoculture where trees were planted in rows of 6 m wide with spacings of 0.5, 1 and 2 m between trees and pruned twice yearly was indicated that maize crop yields in alley cropping were greater than in monoculture. (Jimenez *et al.*, 1997)

Further, Bheemaiah *et al.* (1998) observed better performance of rainfed castor alley cropped with *Leucaena leucocephala* in terms of dry matter production and crop growth rate than the sole cropping of castor.

Results of an experiment on growth and yield of maize alley cropped with *Leucaena leucocephala* and *Faidherbia albida* indicated that there was no gain in maize grain yield due to presence of *L. leucocephala* and *F. albida* (Chamshama *et al.*, 1998)

Whereas, Bisaria *et al.* (1999) conducted an experiment at Jhansi to study the effects of stand density of *Hardwickia binata* on intercrops viz., soybean and mustard. Yields of intercrops were moderate but not more than the yields obtained under sole cropping.

Suresh and Rao (1999) reported that reduction of grain and fodder yields of sorghum were minimum to the extent of 12 to 40 % with the association of nitrogen fixing trees like *Faidherbia albida, Acacia ferruginea* and *Albizia lebbeck* as compared to sole sorghum.

Studies conducted on the performance of soybean under tree species viz., *Prunus domestica*, *Morus alba* and *Punica granatum* at Solan (HP), revealed that crop yield in close proximity to tree species was minimum and the yield increased with the increase in distance from the tree (Sharma and Chauhan, 2003).

In a study on alley cropping of wheat with *Morus alba* hedge rows under rainfed conditions at Solan (HP) it was observed that adverse effect on photosynthesis, transpiration and water use efficiency of wheat was attributed to the shade effect of *Morus alba* (Thakur and Dutt, 2003).

Studies conducted on production potential of sorghum, cowpea, groundnut, dhaincha, moongbean and turmeric in alley cropping with poplar recorded significant reduction in the yield of all the test crops due to the decreased light availability to crops under poplar (Nandal and Hooda, 2005).

2.3 Performance of Speciality Corn under the Influence of Graded Nitrogen Levels:

2.3.1 Effect on Growth parameters

2.3.1.1 Baby corn

Thakur *et al.* (1997) studied the response of baby corn to different levels of nitrogen and found that growth parameters viz., plant height, leaf area and dry matter accumulation were increased with increasing levels of nitrogen application up to 150 kg N ha^{-1}.

Nitrogen fertilization had noticeable influence on crop growth and yield of baby corn. Significant increase in plant height was observed up to 120 kg N ha $^{-1}$ (Sahoo and Panda, 1999).

Thakur and Sharma (1999) reported that plant height of baby corn was found significantly increased up to 200 kg N ha^{-1}.

A field experiment conducted during rainy season at Almora, envisaged that among three levels of N tried 120 kg N ha^{-1} resulted in maximum plant height of baby corn. (Pandey *et al.*, 2000).

Sunder Singh (2001) revealed that in baby corn during summer season there was a significant increase in plant height with every increment dose of N up to 150 kg ha^{-1} where as during *kharif* season the significant difference in plant height was observed only up to 120 kg ha^{-1}.

Sunder Singh (2001) reported that in baby corn, increasing nitrogen levels recorded significant increase in dry matter production in maize up to 150 kg ha^{-1} but it was comparable with 180 kg ha^{-1} both in *kharif* and summer seasons.

Bindhani *et al.* (2007) stated that in baby corn, application of 120 kg N ha^{-1} resulted in tallest plant with maximum dry matter yield and leaf area index, which were significantly higher than those at remaining lower levels of nitrogen.

2.3.1.2 Sweet corn

Nath *et al.* (2009) observed that in sweet corn the dry matter accumulation increased significantly by enhancing the fertility level up to 90 kg N + 45 kg P_2O_5 ha^{-1}.

Jat *et al.* (2009) found that in sweet corn plant height was significantly increased with increase in level of fertilizer from 50 per cent (60:30:30 kg NPK ha^{-1}) to 100 percent RDF (120:60:60 kg NPK ha$^{-1)}$. They also reported that application of 100 per cent RDF significantly produced more dry matter (137.95 g plant^{-1}) than 75 and 50 per cent RDF.

2.3.1.3 Popcorn

Gokmen *et al.* (2001) reported that in pop corn the maximum plant height was observed with the highest dose of nitrogen *i.e.*, 250 kg ha^{-1} while lowest values were recorded at control level 0 or 50 kg N ha^{-1}.

Application of 90 kg N ha^{-1} in pop corn significantly improved dry matter per plant at harvest over 60 kg N ha^{-1}. Further increase in fertilizer dose failed to get a significant improvement. (Choudhary and Singh, 2006).

Ashok Kumar (2009) found that each successive increment in nitrogen level from 0 to 120 kg ha^{-1} markedly improved plant height as well as dry weight plant^{-1} in pop corn at New Delhi.

Konuskan *et al.* (2010) reported positive effect of increased nitrogen application on plant height of popcorn and the highest value was obtained with 240 kg N ha^{-1}.

2.3.1.4 Maize

Shanti *et al.* (1997) envisaged that in maize, among five levels of nitrogen tried, 160 kg N ha^{-1} resulted in maximum leaf area index and dry matter accumulation per plant.

Shanti *et al.* (1997) reported advancement of silking by 7.9 and 8.4 days, respectively due to 120 and 160 kg N ha^{-1} in comparison with the crop in no nitrogen treatment (control). Earlier appearance of silks (60.6 to 56.2 days) was also observed with increase in nitrogen level from 80 to 160 kg ha^{-1} by Muniswamy *et al.* (2007).

Increase in LAI (2.6 to 4.9) of maize with increase in nitrogen level from 0 to 240 kg ha^{-1} was also reported by Kumar and Bangarwa (1997) at Hisar during winter season in sandy loam soil. Similar response to increased level of nitrogen on LAI was reported by Shivay *et al.* (1999) from Pantnagar, Muniswamy *et al.* (2007) from Bangalore and Suryavanshi *et al.* (2008) from Parbhani.

Bangarwa and Gaur (1998) reported that increase in N dose from 40 to 120 kg ha^{-1} significantly increased the plant height from 132.16 to 139.84 cm in silty clay loam soils at Akola.

Bangarwa and Gaur (1998) reported significant response up to 120 kg nitrogen ha^{-1} in dry matter production of maize. Suryavanshi *et al.* (2008) also observed significant response of maize to N application up to 150 kg ha^{-1} and increased the dry matter production over 100 kg nitrogen ha^{-1}.

On silty clay loam soils of Pantnagar (Tarai), significant increase in plant height and dry matter accumulation was recorded with each successive increase in the level of nitrogen application from 0 to 120 kg N ha^{-1} in maize (Shivay and Singh, 2000).

Mishra *et al.* (2001) reported that in eastern Uttar Pradesh, among the three levels of nitrogen tried viz., 0, 75, and 150 kg N ha^{-1}, 150 kg N ha^{-1} recorded maximum leaf area index in winter maize.

Vadivel *et al.* (2001) observed that with increase in nitrogen levels from 0 to 60 kg N ha^{-1}, the plant height, leaf area index and dry matter of maize increased significantly.

Mohamoud and Sharnappa (2002) recorded maximum leaf area index of maize crop with 150 kg N ha^{-1}.

The result of the experiment conducted by Muniswamy *et al.* (2007) at Bangalore during *kharif* season indicated that plant height of maize increased (151.3 to 175.2 cm) significantly with each increment of nitrogen from 80 to 160 kg ha^{-1}.

Ashok Kumar *et al.* (2008) observed that in maize, growth parameters were found to be the highest with the application of 120 kg nitrogen through urea and 30 kg nitrogen through poultry manure per hectare.

Suryavanshi *et al.* (2008) reported that application of 150 kg nitrogen ha^{-1} was found significantly effective over 50 and 100 kg nitrogen ha^{-1} in increasing plant height of maize from 149.20 cm to 185.61 cm in black soil during *kharif* season at Parbhani.

2.3.2 Effect on Yield attributes:

2.3.2.1 Baby corn

Application of 120 kg N ha^{-1} resulted in the maximum weight of baby corn without husk compared to other levels of N tried viz., 0, 20, 40, 60, 80 and 100 kg N ha^{-1} (Sahoo and Panda, 1997).

Thakur *et al.* (1997) noticed increased number of baby corn cobs per plant with 200 kg N ha^{-1} compared to no nitrogen on alfisols of Bajura, Kullu valley, Himachal Pradesh.

Thakur *et al*. (1997) demonstrated that baby corn weight with and without husk was found increased significantly with successive increase in N levels up to 100 kg N ha^{-1}.

Length of baby corn, weight of ear and number of ears per plant were found to be the highest with 120 kg N ha^{-1} (Sahoo and Panda, 1999).

Thakur and Sharma (1999) registered higher number of baby corn cobs per plant and length of baby corn with 200 kg N ha^{-1} as compared to 100 kg N ha^{-1}.

Contrary to this, significant differences were not observed in the weight of cob when nitrogen was applied at 100, 150 and 200 kg ha^{-1} to baby corn. (Thakur and Sharma, 1999).

Pandey *et al.* (2000) reported that the number of baby corn cobs per plant and cob weight were highest with 120 kg N ha^{-1} than at 60 and 90 kg Nha^{-1} but did not observe any significant difference in the length of baby corn with increased levels of nitrogen from 60 to 120 kg N ha^{-1}.

Bindhani *et al.* (2007) observed that in baby corn a significant increase in baby corns/plant, their fresh weight, length and girth were also recorded up to 120 kg N ha^{-1}.

Singh *et al.* (2010) reported that significant increase in baby corn weight, cobs per plant, baby corn girth was observed with the application of 180 + 38.7 + 74.7 kg N+P+K ha^{-1} compared to 60 + 12.9 + 24.9 kg N + P + K ha^{-1}.

2.3.2.2 Sweet corn

Raja (2001) reported that increase in nitrogen levels from 0 to 120 kg N ha^{-1} significantly increased the cob length as well as cob girth of sweet corn.

Sahoo and Mahapatra (2004) concluded that in an experiment conducted in sweet corn at Jashipur, increase in levels of nitrogen from 60 to 120 kg ha^{-1} increased the number of cobs per hectare, length and weight of cob.

Kar *et al.* (2006) recorded that increased nitrogen application from 20 kg N ha^{-1} to 80 Kg N ha^{-1} significantly increased the cob length from 14.6 cm to 17.5 cm and cob girth from 13.8 cm to 16.7 cm.

Nath *et al.* (2009) reported that in sweet corn an increase of 11.6% and 16.9% in cob length and cob girth were recorded when the fertility level was raised from 50 to 70 kg N ha^{-1} and an application of 110 kg N ha^{-1} accounted for significant increase (10.1%) over 70 kg N ha^{-1} in cob girth.

2.3.2.3 Popcorn

Gokmen *et al.* (2001) observed that in popcorn, the kernel number per ear increased by about 6% as nitrogen increased from zero to 250 kg N ha^{-1} and also stated that maximum cob length was obtained from 250 kg N ha^{-1}.

Oktem and Oktem (2005) revealed that cob length increased from 16.42 cm at 150 kg N ha^{-1} to 20. 88 cm at 350 kg N ha^{-1}. They also concluded that cob girth was increased with application of N up to 250 kg ha^{-1}, beyond the level of 250 kg ha^{-1} there was no significant increase.

Ashok Kumar (2009) observed that in pop corn maximum values of yield attributes viz., cob girth, cob length, grains ear^{-1} and shelling percentage were recorded with the application of 120 kg N ha^{-1}.

Cob weight increased with increase in nitrogen application and the heaviest cobs were obtained at 240 kg N ha^{-1}. (Konuskan *et al.,* 2010).

2.3.2.4 Maize

Shanti *et al*. (1997) observed that application of 160 kg N ha^{-1} recorded the highest number of cobs per plant in maize which was however, statistically on par with that of 120 kg N ha^{-1} and significantly superior to other N levels (0, 40 and 80 kg N ha^{-1}).

Application of 160 kg N ha^{-1} in maize significantly increased the number of cobs per plant (1.62 to 2.12) as compared to 80 kg N ha^{-1} (Muniswamy *et al.,* 2007).

Ashok Kumar *et al.* (2008) revealed that in maize, highest values for all the yield parameters like number of cobs per plant, length of cob, no of grains per cob and test weight were obtained with the application of 30 kg N through poultry manure in addition to 120 kg N through urea.

Bhat *et al.* (2008) reported that maximum values for cobs per plant (1.46), grain rows per cob (16.13), grains per row (44.60), grains per cob (718.01), test weight (205 g) were obtained with nitrogen at 150 kg ha^{-1} supplied through urea and azotobacter followed by treatments with nitrogen at the same rate but through urea and poultry manure.

2.3.3 Effect on Cob/ Grain Yield:

2.3.3.1 Baby corn

Sahoo and Panda (1997) recorded the maximum baby corn yield with 120 kg N ha^{-1} both winter and wet seasons.

Sahoo and Panda (1999) observed increased baby corn yield with increased levels of nitrogen from 80 to 160 kg ha^{-1} and the increase was more during winter than in wet season.

Thakur and Sharma (1999) found significant increase in baby corn yield with increase in applied nitrogen dose from 100 to 200 kg ha^{-1} in a field experiment carried out during rainy season at Bajaura.

Baby corn yield recorded with 120 kg N ha^{-1} was found to be significantly higher than that with 60 and 90 kg N ha^{-1} (Pandey *et al.,* 2000)

Application of 120 kg N ha^{-1} in baby corn resulted in the highest baby corn yield, which was 28.6, 52.2 and 178.7% higher than that of 80, 40 kg N ha^{-1} and the no nitrogen respectively. (Bindhani *et al.*, 2007).

Significant increase in baby cob and corn yield were observed with the application of 180 kg N ha^{-1} compared to 60 kg N ha^{-1}. (Singh *et al.*, 2010).

2.3.3.2 Sweet corn

Kang *et al.* (1985) noticed that 100 kg N ha^{-1} was optimum for maximum cob yield of sweet corn and the increase in green cob yield beyond 120 kg N ha^{-1} was not appreciable.

Mullins *et al.* (1999) opined that application of 112 kg N ha^{-1} was sufficient for sweet corn, where as Akthar and Silva (1999) obtained maximum weight of green cobs with 150 kg N ha^{-1} which was on par with 120 kg N ha^{-1}.

Raja (2001) revealed that application of increasing doses of nitrogen significantly increased the number of primes from 50,376 at control to 65,639 at 120 kg ha^{-1}.

Sahoo and Mahapatra (2004) observed that increase in levels of nitrogen, increased green cob yield from 8.88 t ha^{-1} (60 kg ha^{-1}) to 10.53 t ha^{-1} (180 kg ha^{-1}).

Kar *et al.* (2006) noticed that green cob yield of sweet corn was significantly increased with increase in nitrogen from 0 to 80 kg ha^{-1}.

Sahoo and Mahapatra (2007) reported that a plant population of 83,300 per hectare & fertility level of 120 kg N^{-1} ha with P_2O_5 and K_2O at 26.2 kg ha^{-1} and 50 kg ha^{-1} respectively should be adopted to obtain the maximum green cob yield and net profit from sweet corn.

In a field experiment conducted during *Kharif* season at Pune, it was reported that application of 100 per cent RDF (120:60:60 kg NPK ha^{-1}) recorded maximum cob yield (8.84 t ha^{-1}). (Jat *et al.*, 2009).

2.3.3.3 Popcorn

Choudhary and Singh (2006) reported that application of 90 + 45 kg N and P_2O_5 ha^{-1} in pop corn significantly improved grain yield over 60 + 30 kg N and P_2O_5 ha^{-1}. Further increase in fertilizer dose failed to get a significant improvement.

Ashok Kumar (2009) found that successive increase in levels of nitrogen from 0 to 120 kg ha^{-1} recorded markedly higher green cob yield amounting 119.6, 200.0 and 222.4 %

with application of 40, 80 and 120 ha^{-1} respectively over control.

2.3.3.4 Maize

Rao and Padmaja (1994) reported that yield of sweet corn, pop corn and hybrid maize increased significantly up to 150 kg N ha^{-1}.

Kumar and Singh (2002) revealed that grain yield in Maize increased significantly with increasing levels of nitrogen (0 – 150kg ha^{-1}) and highest was obtained at 150kg ha^{-1}.

2.3.4 Effect on Stover Yield

2.3.4.1 Baby corn

Thakur and Sharma (1999) reported significant increase in green forage yield of baby corn with increase in nitrogen dose from 100 to 200 kg ha^{-1}.

2.3.4.2 Sweet corn

Sahoo and Mahapatra (2007) reported that in sweet corn, application of 120 kg nitrogen ha^{-1} resulted in higher stover yield than with other nitrogen levels.

2.3.4.3 Popcorn

Significantly higher stover yield was obtained with increase in fertilizer dose from 60 + 30 kg N and P_2O_5 ha^{-1} to 90 + 45 kg N and P_2O_5 ha^{-1} and further increase did not result any significant response in pop corn. (Choudhary and Singh, 2006 & 2007).

Increase in nitrogen levels in pop corn enhanced the green fodder yield to the tune of 97.6, 157.8 and 185.5 % with the application of 40, 80 and 120 kg ha^{-1} over control. (Ashok Kumar, 2009).

2.3.4.4 Maize

Gaur (1991) reported higher stover yield at 60 kg ‘N’ ha^{-1}. However. Venugopal and Shiva Shankar (1991) found that application of 160 kg N ha^{-1} gave significantly higher stover yield (7326 kg ha^{-1}) as compared to no nitrogen (1817 kg ha^{-1}) in maize.

Gaur *et al.* (1992) reported significantly higher stover yield due to 120 kg N ha^{-1}at Udaipur during rabi season in vertisols. Another study made by Selvaraju and Iruthayaraj (1994) revealed that 175 kg N ha^{-1} increased the stover yield significantly over 75 kg N ha^{-1}.

Kumpavat and Rathore (1995) reported maximum stover yield due to application of 120 kg ha^{-1}. There was linear increase in stover yield due to increase in N level from 62.5 to 250 kg ha^{-1} (Kuruvila and Iruthayaraj, 1996).

Bangarwa and Gaur (1998) reported higher stover yield (48.72 q) at 120 kg N ha^{-1}. Similar response to higher 'N' levels was reported by Ameta and Dhakar (2000), Kar *et al.* (2006) and Suryavanshi *et al.* (2008).

2.3.5 Effect on Nutrient Uptake:

The nitrogen concentration (%) in grain and stover of maize at harvest was increased with increase in levels of nitrogen from 50 to 100 kg ha^{-1} (Roy and Thripathi, 1987).

Baskaran *et al.* (1992) revealed that the N-uptake by maize exhibited a positive trend with increased levels of nitrogen application at all stages of crop growth. Application of 202.5 kg N ha^{-1} recorded highest N-uptake by shoot and grain.

N-uptake by grain (64 to 89 kg ha^{-1}) and stover (46 to 61 kg ha^{-1}) increased significantly with increase in N-levels from 80 to 120 kg ha^{-1} (Gaur *et al.*, 1992).

Increasing the nitrogen dose up to 90 kg ha^{-1} increased the nitrogen and phosphorus uptake by grain and fodder maize (Singh *et al.*, 1992).

Najundappa *et al*. (1994) found that increased nitrogen uptake by grain was increased up to 150 kg nitrogen ha^{-1}, which was found at par with 225 kg nitrogen ha^{-1}.

Application of 175 kg N ha^{-1} significantly increased the N-uptake as compared to lower levels (Selvaraju and Iruthayaraj, 1994).

Singh *et al.* (2000) found significant increase in nitrogen uptake with successive increment of nitrogen up to 100 kg ha^{-1}, beyond which the increase was only marginal up to 200 kg ha^{-1}.

Kumaresan (2001) revealed that the application of 100 per cent recommended dose of nitrogen and phosphorus in maize resulted in significant increase of nitrogen and phosphorus uptake, but did not influence the potassium uptake compared to 50 per cent recommended dose of nitrogen and phosphorus or control .

Parmar and Sharma (2001) reported that the nitrogen uptake in maize increased to a considerable extent with nitrogen application up to 120 kg ha^{-1}. Ashok Kumar (2008) also reported the similar findings in popcorn.

Sofi *et al*. (2004) observed that the highest uptake of nutrients in maize with the application of 160 kg nitrogen and 80 kg potassium ha^{-1}.

Sutaliya and Singh (2005) recorded that uptake of nitrogen, phosphorus and potassium was distinctly higher with application of 180-90-60 kg nitrogen, phosphorus and potassium ha^{-1} than with 120-60-40 or 60-30-20 kg nitrogen, phosphorus and potassium ha^{-1}.

Kar *et al.* (2006) revealed that uptake of N in grain and stover increased significantly with successive increase in nitrogen. It ranged between 20.41 kg in control to 91.11 kg ha^{-1} at 80 kg N application.

Application of 120-26.2-50 kg nitrogen, phosphorus and potassium ha^{-1} to sweet corn resulted in significant increase in nitrogen, phosphorus and potassium uptake compared to other levels tried (Sahoo and Mahapatra, 2007).

Bindhani *et al.* (2007) reported that the nitrogen content both in baby corn and green fodder increased significantly with increasing N levels up to 120 kg ha^{-1}.

Nitrogen application also enhanced nitrogen uptake up to 120 kg ha^{-1} (Ashok Kumar, 2009).

2.3.6 Effect on Economics of Speciality corn:

Thakur and Sharma (1999) concluded that the application of nitrogen @ 150 and 200 kg ha^{-1} gave 29.2 and 37.6 per cent higher net returns, respectively over 100 kg N ha^{-1} and the net returns per rupee invested increased with increased levels of nitrogen application. However, this increase was maximum with increased nitrogen application from 100 to 200 kg ha^{-1}.

Pandey *et al.* (2000) found that application of 120 kg N ha^{-1} gave significantly higher net returns of 27.3 and 8.6 per cent over 60 and 90 kg N ha^{-1}, respectively and the benefit : cost ratio was also found to be the highest with 120 kg N ha^{-1}.

Significant increase in net monetary returns (Rs 10,685) was recorded by Ameta and Dhakar (2000) with 150 kg N ha^{-1} over 60 kg N ha^{-1} (Rs 8,572) in maize.

Sharma *et al.* (2000) reported that application of 120 kg nitrogen ha^{-1} resulted in higher net returns than with lower levels.

Sahoo and Mahapatra (2004) observed significant higher net profit (Rs 20,700 ha^{-1}) due to 180 kg N ha^{-1} over 60 kg N ha^{-1} (Rs 15,300 ha^{-1}).

Kar *et al.* (2006) reported that application of nitrogen from 0 to 80 kg ha^{-1} gave significantly higher net returns (Rs 32,086 to Rs 61,532 ha^{-1}) and benefit: cost ratio (1.73 to 3.76) of sweet corn during *kharif* season in sandy loam soils of Bhubaneshwar.

Bindhani *et al.* (2007) concluded that in baby corn net returns and benefit : cost ratio were highest with 120 kg N ha^{-1}, which resulted in significant increase of 289.2, 69.8 and 39.15 per cent in net returns and 235.2, 57.7 and 34.1 per cent in benefit : cost ratio compared to that of the no nitrogen, 40 and 80 kg N ha^{-1} respectively.

Suryavanshi *et al.* (2008) reported significantly higher gross returns, net monetary returns and benefit: cost ratio with 150 kg nitrogen ha^{-1} as compared to either 50 and 100 kg nitrogen ha^{-1}.

There was marked improvement in net returns with each successive increase in nitrogen level from 0 to 120 kg ha^{-1}. The maximum net returns of Rs. 49.57 thousands ha^{-1} was noticed with 120 kg N ha^{-1}, which was 560.9, 64.5 and 10.0 % higher over 0, 40 and 80 kg N ha^{-1}. The net returns rupee^{-1} invested was also enhanced with higher nitrogen levels, but significant improvement was found up to 80 kg N ha^{-1} (Ashok Kumar, 2009).

2.4 Economic Studies in Agri-Silviculture System

Malviya and Patel (1989) reported from the experiment conducted at Saurashtra that crop yields of groundnut, greengram and blackgram with *Leucaena leucocephala* were remunerative when compared to their respective sole crops.

Similarly, Singh *et al.* (1989) reported that gross returns were higher in alley cropped systems. Alley cropped sorghum yielded twice the income of sole sorghum whereas the alley cropped pigeonpea yielded almost seven times the income over the sole pigeonpea.

Vani (1995) from the study conducted at Hyderabad reported that higher net returns and benefit-cost ratio obtained from castor alley cropped in *Faidherbia albida* than sole cropped castor.

Subrahmanyam *et al.* (1996) reported that sunflower and castor gave higher monetary returns under intercropping in young plantations of *Dalbergia sisso* when compared to sole cropping situation.

Bheemaiah *et al.* (1998) observed that sunflower intercropped with guava + curry leaf showed higher gross returns, net returns and benefit cost ratio than sole cropped sunflower.

Sharma *et al.* (2010) conducted an experiment at Dharwad on shallow black soils to study the effect of integrated nutrient management on pigeonpea based intercropping system and revealed that application of 50% RDF + vermicompost @ 2.5 t ha^{-1} recorded significantly higher pigeonpea yield, gross returns and net returns over the other integrated nutrient management practices.

CHAPTER-III

MATERIAL AND METHODS

Chapter III

MATERIAL AND METHODS

The details of the material used and methods followed during the course of the present experimentation are described in this chapter.

3.1 Location of the Experimental Site

The experiment entitled “Nitrogen management in Speciality Corn under *Pongamia* + Maize Agri-Silvi system.” was conducted during *Kharif* 2011 on sandy loam soils at students’ farm, College of Agriculture, Rajendranagar, Hyderabad which is geographically situated at $17^0 19^1$ N latitude, $78^0 28^1$ E longitude and at an altitude of 542.3 m above mean sea level, covered under Southern Telangana agro climatic zone of Andhra Pradesh.

3.2 Weather during the Crop Period

The weekly mean meteorological data recorded at Meteorological Observatory, Agricultural Research Institute, Rajendranagar, Hyderabad during the crop growth period *i.e.,* from 07.07.2011 to 26.10.2011 are presented in Appendix-I and illustrated in Figure 3.1.

The weekly mean maximum temperature during the crop growth period ranged from 27.7^{o}C to 32.9^{o}C with an average of 30.9^{o}C, while the weekly mean minimum temperature ranged from 19.9^{o}C to 23.3^{o}C with an average of 22.0^{o}C.

A total rainfall of 466.1 mm was received in 29 rainy days. The weekly mean sunshine hours varied from 1.5 to 8.2 with an average of 5.1 hours per day, and mean evaporation ranged from 2.7 to 5.2 mm with an average of 3.7 mm per day. The mean wind speed ranged from 1.9 to 14.8 km hr^{-1} with an average of 7.4 km hr^{-1}.

3.3 Soil Characteristics of the Experimental Site

Before commencement of the field experimentation, random soil samples were collected from 0 to 30 cm depth, shade dried and passed through 2 mm sieve to make a composite sample which was later analyzed for its physico-chemical properties by following standard procedures (Table 3.1).

Table 3.1. Physico-chemical properties of the experimental soil before cropping

Particulars	Value	Method employed
A. MECHANICAL ANALYSIS		
Coarse sand (%)	34.3	Bouyoucos hydrometer (Piper, 1966)
Fine sand (%)	36.8	
Silt (%)	16.2	
Clay (%)	12.7	
Soil texture	Sandy loam	
B. CHEMICAL ANALYSIS		
Soil pH (1:2 soil suspension)	7.2	pH meter (Jackson, 1967)
E.C (d Sm^{-1} at 25^0C)	0.11	Solubridge method (Jackson, 1967)
Organic carbon (%)	0.52	Wet digestion method (Walkley and Black, 1934)
Available’ N’ (kg ha^{-1})	121.4	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available ‘P’ (kg ha^{-1})	48.2	Olsen’s method (Olsen *et al.*, 1954)
Available’ K’ (kg ha^{-1})	343.8	Flame photometry (Jackson, 1967)

The results of physico-chemical analysis revealed that the soil was red sandy loam in texture and neutral in soil reaction, low in organic carbon and available nitrogen and medium in available phosphorous and potassium.

3.4 Cropping History of Experimental Field

Details regarding the cropping pattern adopted in the preceding years in the experimental field *i.e.,* in the existing *Pongmia* plantation (6 years old) are given below.

Year	*Kharif*	*Rabi*
2008-09	Castor	Fallow
2009-10	Castor	Fallow
2010-11	Castor	Fallow
Present Investigation	Speciality corn	Fallow

The spacing between the trees is 6 m x 6 m.

3.5 Experimental Details

The field experiment consisted of Agroforestry model *i.e., Pongamia* + maize Agri-Silvi system.

3.5.1 Experimental Material

3.5.1.1 Tree Component: *Pongamia pinnata* belongs to the family Fabaceae. Common names include Indian Beech, Honge, Pongam and kanuga in Telugu. Recently it was moved to the genus *Millettia*. The tree is well suited to intense heat and sunlight and its dense network of lateral roots and its thick, long taproot make it drought-tolerant. The dense shade it provides slows the evaporation of surface water and its root nodules promote nitrogen fixation, a symbiotic process by which gaseous nitrogen (N_2) from the air is converted into ammonium (NH_4^+, a form of nitrogen available to the plant).

Oil made from the seeds, known as honge oil, is an important asset of this tree and has been used as lamp oil, in soap making, and as a lubricant for thousands of years. The seed oil has been found to be useful in diesel generators and, along with *Jatropha*, it is being explored in hundreds of projects throughout India and in the world as feedstock for biodiesel. There is also research indicating that *P. pinnata* can be used as a natural insecticide.

3.5.1.2 Crop Component: Three types of speciality corn *i.e.*, baby corn, sweet corn, popcorn were selected as intercrops in the Agri-Silvi system.

3.5.1.3 Varietal Characters: Baby corn test variety under study was **"**VL Baby Corn1". It is a composite variety developed at VPKAS, Almora in 2005. It usually has a long plant with high ear placement, medium ear length without husk, conico-cylindrical ear shape with medium number of rows. It is an extra early maturity variety. The average yield of the variety is 12-13 q ha^{-1}(without husk).

"Win Orange Sweet Corn" is a sweet corn composite developed at winter nursery, DMR in 2005. It is medium maturing with large cob size and moderately dented seed. It has a light green leaf, heavy tassel, complete husk which extends beyond tip and shriveled sugary dent.

The test variety in popcorn was "Amber popcorn". It is a composite variety developed by number of cycles of mass selection from open pollinated population of an original stock, evolved from six popcorn inbreds. This population was improved by repeated mass selection for adoptability, popping expansion and disease tolerance. The variety was released during 1981 from Acharya N. G. Ranga Agricultural University. It attains a height of 160 – 180 cm with green stems and dark green leaves. Most of the plants shows pinkish coloured silk, but few have pale yellow. Cobs are shorter in length(14-15cm) and smaller in girth (11-12 cm) with tappering end. Kernels are small and orange in color. It is resistant to leaf blight and shoot borer and matures within 95 – 100 days. (Department of Agriculture and Co-operation, 1985).

3.5.2 Treatment Details

T_1-*Pongamia* + Baby corn with N@60kg ha^{-1}

T_2- *Pongamia* + Baby corn with N@90kg ha^{-1}

T_3- *Pongamia* + Baby corn with N@120kg ha^{-1}

T_4- *Pongamia* + Sweet corn with N@60kg ha^{-1}

T_5- *Pongamia* + Sweet corn with N@90kg ha^{-1}

T_6- *Pongamia* + Sweet corn with N@120kg ha^{-1}

T_7- *Pongamia* + Pop corn with N@60kg ha^{-1}

T_8- *Pongamia* + Pop corn with N@90kg ha^{-1}

T_9- *Pongamia* + Pop corn with N@120kg ha^{-1}

T_{10}- Sole *Pongamia* without maize and nitrogen

3.5.3 Design and Layout

The experiment was laid out in Randomized block design with three replications and nine treatments. The layout plan is given in the Figure 3.2 .

Design	:	Randomized Block Design with factorial concept
Replications	:	Three
Plot size	:	6×6 m = 36 m^2

3.6 Cultivation details

3.6.1 Preparatory Cultivation

The experimental field was prepared by working with a tractor drawn cultivator, followed by bullock drawn blade harrow in order to obtain fine tilth. The field was finally levelled with wooden plank and the plots were laid out as per the layout plan.

3.6.2 Seeds and Sowing

Seeds of speciality corn were sown by hand dibbling on 7th July, 2011 at a spacing of 50 cm x 15 cm for baby corn, 60 cm x 25 cm for both sweet corn and pop corn. Gap filling and thinning were done simultaneously 10 days after sowing.

3.6.3 Fertilizers

The requisite amount of nitrogen was applied through urea as per the treatments. The nitrogen was applied in three equal splits, first dose as basal and the remaining doses at knee-high and tasseling stages. Whereas uniform dose of 60 kg P_2O_5 and 40 kg K_2O per hectare were applied through single superphosphate and muriate of potash respectively as basal dose to all the experimental plots.

3.6.4 Weeding and Earthing up

Atrazine @ 2 kg a.i. ha^{-1} was sprayed as pre-emergence herbicide immediately after sowing of the crop. Hand weeding both within and between the lines of the crop was done once during the crop growth period at 30 DAS. Hoeing with push hoe was also done in all the plots for earthing up of soil after weeding operation.

3.6.5 Plant Protection

The insecticide endosulfan @ 2ml l^{-1} of water was sprayed on 18.07.2011 to control stem borer.

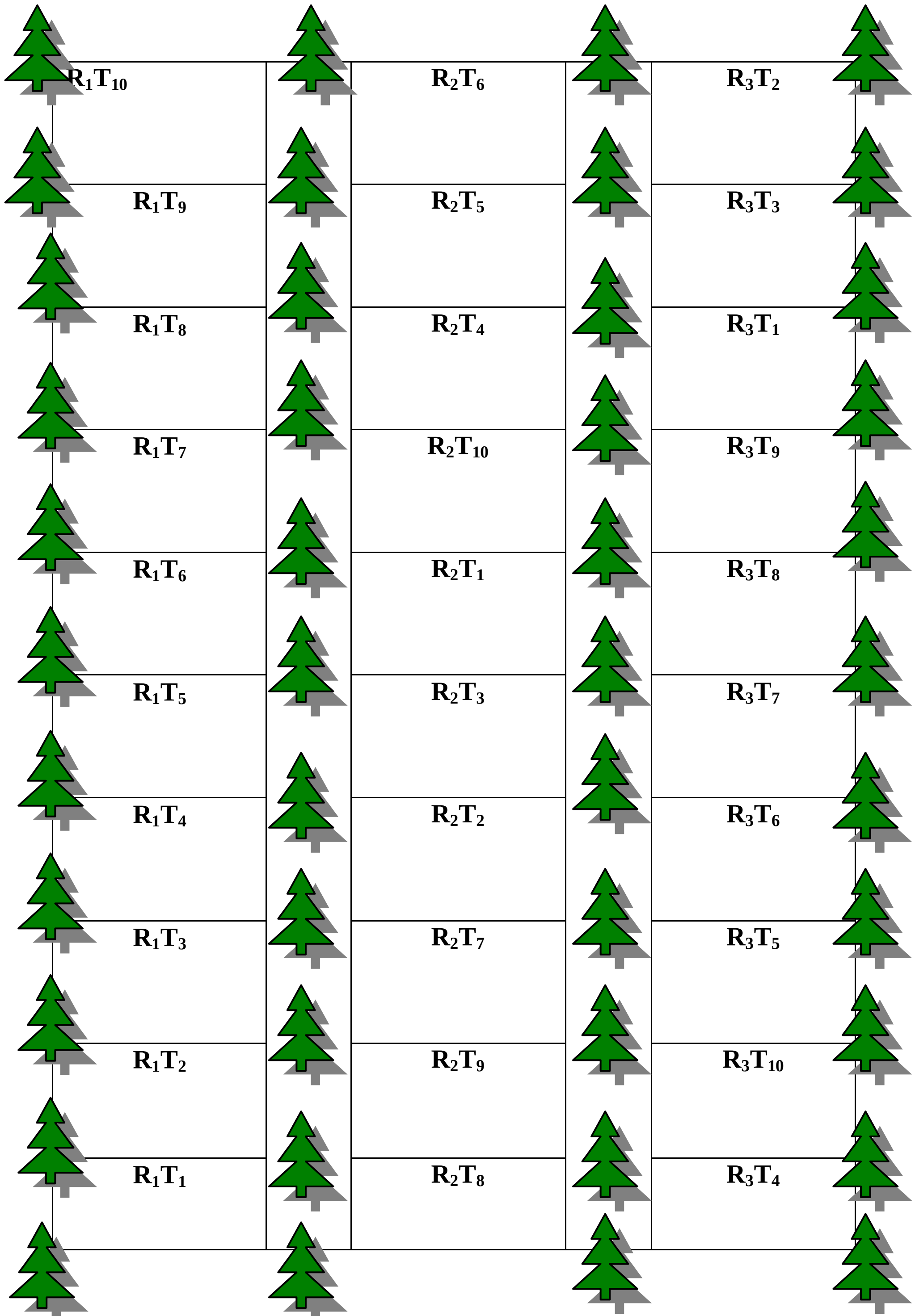

Figure 3.2. Lay-out plan.

Plate 3.1. ***Pongamia*** **plantation with speciality corn (three types of corn) as Intercrops.**

Plate 3.2. Experimental field with label indicating all the details of the experiment.

3.6.6 Harvesting

Baby corn cobs were harvested immediately just after 1-3 days after the silk emergence. The harvesting period was last for about 15 days. Soon after the harvest the cobs were sold out on the same day.

Sweet corn cobs were harvested by observing maturity symptoms like green cobs of full size with tight husk, dry brown silks, smooth and plumpy kernels which exude milky liquid when punctured with thumb nail. Sweet corn cobs were also sold out soon after the harvest.

In popcorn, harvesting was done when the sheath of cobs were completely dried. These popcorn cobs were shade dried after dehusking and kernels were shelled separately plot wise.

In all the plots the border rows were harvested first, later the crop from net plot was harvested.

3.7 Pre - Harvest Observations/ Growth Attributes

Five plants of corn were selected in each treatment plot for non destructive sampling by tagging to record the plant height. Similarly at each sampling interval, five plants were selected at random for destructive sampling to record the observations like leaf area and dry matter production.

Since there was an acute difference in the duration (days) of crop growth subperiods between three types of corn, interpretation of data (plant height, leaf area index and dry matter accumulation) was done by designating the crop growth subperiods as knee high stage, pre tasseling (10^{th} leaf stage), cob development stage and at harvest as shown below.

Type of corn	**Days after sowing**			
	knee high stage	pre tasseling (10^{th} leaf stage)	cob development stage	At harvest
Baby corn	20	35	45	60
Sweet corn	25	45	70	85
popcorn	25	45	70	105

3.7.1 Plant Height

Plant height was measured from the base to the tip of the top most leaf at initial stages and up to the tip of the tassel at later stages and at harvest from the tagged plants and the mean value was expressed in cm.

3.7.2 Leaf Area Index (LAI)

Leaf area index was calculated at three different stages of crop growth as mentioned above and at harvest by using the following formula as proposed by Williams (1946).

$$\text{Leaf Area Index} = \frac{\text{Leaf area of the plant (m}^2\text{)}}{\text{Ground area covered (m}^2\text{)}}$$

3.7.3 Dry Matter Production

Dry matter production was recorded at three different stages of crop growth as mentioned above and at harvest from destructive sampling. Five plants were taken and the plants were shade dried and later oven dried at 80^0C to constant weight and the weight was recorded. The mean values were worked out for single plant and the mean dry matter was expressed in grams per plant.

3.7.4 Days to 50 per cent Silking

The number of days taken from date of sowing to the stage when 50 percent of the plants in the net plot showed extrusion of silks was counted and given as days to 50 per cent silking.

3.7.5 Days to Maturity

The number of days taken from date of sowing to the stage of physiological maturity was counted and given as days to maturity.

Baby corn crop was considered mature when just 1-3 cm of silk emergence was seen.

Sweet corn was considered mature when green cobs are of full size with tight husk, dry brown silks, smooth and plumpy kernals which exude milky liquid when punctured with thumb nail.

Physiological maturity in popcorn was evidenced by the formation of a black polyphenol layer at the base of the kernels.

3.7.6 Soil Analysis

Soil samples were collected before sowing of the crop from each net plot area for determination of soil available nitrogen (Subbaiah and Asija, 1956), phosphorus by Olsen's method (Olsen *et al.* 1954) and potassium (Jackson, 1967).

3.8 Post - Harvest Observations

3.8.1 Number of Cobs Plant^{-1}

Total number of green cobs from the earmarked five plants were counted at harvest and expressed as average number of cobs per plant$^{-1.}$

3.8.2 Cob Length

The cob length (dehusked) from selected five plants was measured from base to tip of the cob and the mean was computed as green cob length in centimeter.

3.8.3 Cob Girth

The cob girth (dehusked) from selected five plants was measured at centre of the cob and the mean was expressed as cob girth in centimeter.

3.8.4 Cob Weight with Husk

The green cobs with husk from five labelled plants were weighed and the average weight was expressed in gram plant^{-1}.

3.8.5 Number of Kernel Rows Cob^{-1}

The total number of kernel rows from the five fresh cobs (dehusked) of sweet corn and popcorn was counted and the average was expressed as number of kernel rows cob^{-1} for sweet corn and popcorn.

3.8.6 Number of Kernels Row^{-1}

The number of kernels row^{-1} from the five cobs of sweet corn and popcorn was counted and the average was expressed as number of kernels row^{-1}.

3.8.7 Hundred seed weight

One hundred seeds were selected randomly from the shelled out samples of sweet corn and popcorn and weight was recorded and expressed in grams.

3.8.8 Shelling Percentage

After obtaining cob dry weight as well as shelled grain weight in each plot of popcorn, shelling percentage was calculated as follows.

$$\text{Shelling percentage} = \frac{\text{Grain weight}}{\text{Cob weight}} \times 100$$

3.8.9 Green Cob Yield with Husk

The green cobs (with husk) harvested from each plot separately were weighed and expressed in kg ha^{-1}.

3.8.10 Grain Yield

The grain weight from each experimental plot of pop corn including the sample plants was recorded separately and grain yield per hectare was calculated and expressed in kilograms per hectare.

3.8.11 Green Fodder/Stover Yield

After cutting of green cobs, the left over plants were immediately cut to the base and the green fodder from each experimental plot of baby corn and sweet corn was recorded separately and green fodder yield per hectare was calculated and expressed in kilograms per hectare.

The stover weight from each experimental plot of popcorn including that of sample plants was recorded after drying and stover yield per hectare was calculated and expressed in kilograms per hectare.

3.8.12 Harvest Index

Harvest index (HI) was calculated by the following formula and expressed in percentage (Singh and Stoskopf, 1971)

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (Green cob yield/grain yield in kg ha}^{-1})}{\begin{array}{c}\text{Biological yield}\\ \text{(Green cob yield/grain yield + green fodder/stover yield in kg ha}^{-1})\end{array}} \times 100$$

3.9 *Pongamia* equivalent yield

The total yield of intercropping system was expressed as *Pongamia* equivalent yield based on price of the each produce. The *Pongamia* equivalent yield was calculated using the following formula.

$$\text{EY of } \textit{Pongamia} = \frac{\text{yield of } \textit{Pongamia} \text{ X price of } \textit{Pongamia}}{\text{Price of } \textit{Pongamia}}$$

$$\text{EY of speciality corn} = \frac{\text{yield of speciality corn type X price of speciality corn type}}{\text{Price of } \textit{Pongamia}}$$

$$\text{EY of system (kg ha}^{-1}\text{ of } \textit{Pongamia}\text{)} = \text{EY of } \textit{Pongamia} + \text{EY of speciality corn}$$

3.10 Nitrogen Response

The cob yield/grain yield harvested from net plots was used to calculate the nitrogen response using the following formula.

$$\text{Nitrogen response} = \frac{\text{cob yield/grain yield (kg ha}^{-1}\text{)}}{\text{Amount of nitrogen applied (kg ha}^{-1}\text{)}}$$

3.11 Nutrient Uptake

Plant samples collected for dry matter estimation at harvest were ground in to fine powder and used for chemical analysis. Plant nitrogen content was estimated by microkjeldhal method (Jackson, 1973), plant potash content was estimated by Flame photometry (Jackson, 1967) and phosphorus was estimated by vanado molybdo phosphoric method. Contents of samples were multiplied with respective dry matter weights to obtain the uptake of respective nutrients and expressed in kg ha^{-1}. At harvest, samples of grain and stover were analyzed separately and multiplied with respective dry weights of grain and stover, which were summed up to obtain uptake of respective nutrients at harvest.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Total dry matter (kg ha}^{-1}\text{)} \times \text{Nutrient content (\%)}}{100}$$

3.12 Post-Harvest Soil Analysis

Post-harvest soil samples were drawn from each net plot immediately after the harvest of the crop and analyzed for available nitrogen (Subbiah and Asija, 1956), available phosphorus (Olsen *et al*. 1954) and available potassium (Jackson, 1967).

3.13 Tree Parameters

3.13.1 Tree Height

The tree height was measured by using the altimeter and expressed in meter (m).

3.13.2 Canopy Spread

The spread of the branches from the centre of the bole was measured towards east and west directions of the tree. The tree spread on both sides was added and expressed in meter (m).

3.13.3 Pod Yield of Tree

The matured pods fallen from the tree and which were present on the tree were collected. The collected pods were dried and then weighed. The pod yield of tree was expressed in kg plant^{-1}.

3.14 Economics

3.14.1 Gross Monetary Returns from the System

Total gross monetary returns from the system was calculated by adding the estimated returns from the trees in the system (Appendix-IV) and gross monetary returns obtained from the crop under intercropping situation.

3.14.2 Net Monetary Returns from the System

Total net monetary returns from the system were calculated by subtracting the cost of cultivation of the system from the total gross monetary returns obtained from the system. Regarding the cost of cultivation of *Pongamia*, costs incurred in the establishment of Pongamia was spread over these six years and recurrent expenses of present year were taken in to consideration.

3.14.3 Benefit Cost Ratio

Benefit-Cost ratio was calculated by using the following formula.

$$\text{Benefit-Cost ratio} = \frac{\text{Net returns (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

3.15 Statistical Analysis

The data on the observations made were analyzed statistically by applying the technique of analysis of variance for randomized block design with factorial concept and significance was tested by F-test (Snedecor and Cochran, 1967). Critical difference for examining treatment means for their significance was calculated at 5 per cent level of probability. Standard error of mean and critical difference on interaction is presented only where ever there is significant difference among the treatments.

CHAPTER-IV

RESULTS AND DISCUSSION

Chapter IV

RESULTS AND DISCUSSION

The results and discussion of the field experiment entitled “Nitrogen management in speciality corn under *Pongamia* + maize Agri-silvi system” conducted during *Kharif* 2011 at Student’s Farm, College of Agriculture, Rajendranagar, Hyderabad are presented in this chapter under appropriate headings. Expeimental data was statistically analyzed under various heads and subheads, furnished in two way tables and illustrated through figures wherever necessary. The three different types of corn included in the study contains many variations among themselves regarding genetic makeup, crop duration and their potentials for different growth and yield characteristics. Hence the type of corns were not discussed in terms of superiority and were discussed as how markedly they differed from each other in case of growth and yield attributes. However, the profitable corn to be grown as an intercrop in *Pongamia* was concluded based on *Pongamia* equivalent yield and economics of the system.

4.1 Growth Parameters of speciality corn

4.1.1 Plant Height of Speciality Corn (cm)

Data pertaining to plant height of speciality corn as influenced by different levels of nitrogen at different growth stages was analysed statistically and presented in Tables (4.1 to 4.4) and and illustrated in Fig (4.1).

There was a gradual increase in the plant height of speciality corn from knee high stage to harvest. Application of 120 kg N ha^{-1} recorded maximum plant height at all the stages but was at par with 90 kg N ha^{-1} in the initial stages and significantly superior to both 60 and 90 kg N ha^{-1} at later stages. The minimum plant height was registered with the nitrogen level of 60 kg ha^{-1} at all the growth stages. The increase in plant height of speciality corn due to higher dose of nitrogen (120 kg N ha^{-1}) was 12.5 per cent compared to 60 kg N ha^{-1} at harvest (Table 4.4) . The increase in plant height with increased levels of nitrogen might be attributed to the fact that higher nitrogen levels induce cell division and maintain higher auxin levels, which inturn stimulate cell elongation along the main axis leading to better elongation of internodes and finally resulted in conspicuous increase in plant height. Similar results of increase in plant height with increasing nitrogen levels have been reported by Pandey *et al.* (2000), Muniswamy *et al.* (2007), Suryavanshi *et al.* (2008) and Ashok Kumar (2009).

Regarding the effect of types of corn on plant height, all the three types of corn are significantly different from each other at all the stages of crop growth (137.7, 200.2 & 180.8 cm in baby corn, sweet corn and popcorn respectively at harvest) (Table 4.4) owing to the difference in their genetic makeup. Similar variation in plant height due to difference in their genetic makeup was reported by Ashok (2006) and Idikut *et al.* (2009)

The interaction effect due to nitrogen levels and types of corn on plant height was found to be non significant.

4.1.2 Leaf Area Index

Data pertaining to leaf area index of speciality corn as influenced by different levels of nitrogen at different growth stages was analysed statistically and presented in Tables (4.5 to 4.8) and illustrated in Fig(4.2)

The leaf area index of speciality corn tended to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels at all the growth stages. The maximum leaf area index was recorded with 120 kg N ha^{-1}, while the minimum was registered with 60 kg N ha^{-1} at all stages. The increase in leaf area index of speciality corn due to higher dose of nitrogen (120 kg N ha^{-1}) was 67.24 per cent compared to 60 kg N ha^{-1} at harvest (Table 4.8). Increase in LAI with increase in nitrogen levels was evident due to the favourable effect of nitrogen on cell division and enlargement, resulting in production of more number of leaves as well as greater expansion of the individual leaf, thereby consistent increase in leaf area per unit area. The present findings are in confirmity with those of Mishra *et al.* (2001) and Mohammoud and Sharanappa (2002).

In the initial stage, baby corn and pop corn were found comparable with each other (0.47 & 0.46 respectively) (Table 4.5) but later at harvest sweet corn and popcorn were found on par with each other (2.49 for both sweet corn & popcorn) (Table 4.8).

The interaction effect due to nitrogen levels and types of corn on leaf area index was found significant at cob development and at harvest (Tables 4.7 & 4.8). Application of 120 kg N ha^{-1} recorded significantly higher leaf area index in all the three types of corn (2.79, 2.98, 2.98 in baby corn, sweet corn and popcorn respectively at harvest) compared to remaining two lower doses. Significantly lower leaf area index was recorded at 60 kg N ha^{-1} in all the types of corn.

4.1.3 Dry Matter Production of Speciality Corn (kg ha^{-1})

Data pertaining to dry matter production of speciality corn as influenced by different levels of nitrogen at different growth stages was analysed statistically and presented in Tables (4.9 to 4.12) and illustrated in Fig (4.3).

An insight into the data on dry matter accumulation, it was observed that dry matter progressively increased with the crop age. Maximum dry matter accumulation was recorded at 120 kg N ha^{-1} at all the stages but was at par with 90 kg N ha^{-1} in the initial stage and found significantly superior to both 60 and 90 kg N ha^{-1} at later stages. Significantly lower dry matter accumulation was recorded at 60 kg N ha^{-1} at all the stages of crop growth. The increase in drymatter accumulation of speciality corn due to higher dose of nitrogen (120 kg N ha^{-1}) was 22.4 per cent compared to 60 kg N ha^{-1} at harvest (Table 4.12). Adequate supply of nitrogen might have helped the baby corn plants to increase their growth and plant height due to the favourable effect on cell enlargement and production of larger leaves. This in turn might have eventually resulted in higher photosynthetic efficiency and thereby accumulated higher quantity of dry matter. Enhanced dry matter production with adequate supply of nitrogen, as evidenced in this investigation corroborates the findings of Bindhani *et al.* (2007) and Ashok kumar (2009).

In the initial stages, baby corn and sweet corn were found comparable with each other (561.1 & 564.3 kg ha^{-1} respectively) (Table 4.9) but later at harvest baby corn and sweet corn were found on par with each other (6645.1 and 6504.8 kg ha^{-1} respectively) (Table 4.12).

The interaction effect due to nitrogen levels and types of corn on dry matter accumulation was found significant at pre tasseling stage. In baby corn dry matter accumulation tended to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels. Whereas, in sweet corn and popcorn application of 120 kg N ha^{-1} resulted in maximum dry matter accumulation but found at par with 90 kg N ha^{-1}.

4.1.4 Days to 50% Silking

Days to 50% silking recorded in speciality corn (three types of corn) under different levels of nitrogen fertilization was analysed statistically and presented in Table (4.13)

Lower dose of nitrogen (60 kg ha^{-1}) took significantly more number of days to 50 % silking when compared to 120 kg N ha^{-1} but was at par with 90 kg N ha^{-1}. The earlier silking in speciality corn was observed with higher nitrogen level *i.e.*, 120 kg N ha^{-1}. Prolonged silking at low level of nitrogen might be due to insufficient quantity of nitrogen available to the crop. Similar results were recorded by Kalyani (2011).

Regarding the effect of types of corn on days to 50 % silking, all the three types of corn were significantly different from each other (44.7, 59.8 & 67.0 days in baby corn, sweet corn and popcorn respectively). This variation among the types of corn was mainly due to difference in the duration of the types of corn.

The interaction effect between the types of corn and levels of nitrogen was not significant on days to 50% silking in speciality corn.

4.1.5 Days to Maturity

The data pertaining to days to maturity in speciality corn (three types of corn) as influenced by different levels of nitrogen application was analysed statistically and presented in Table (4.13)

Application of 60 kg N ha^{-1} registered longer days to maturity in speciality corn, which was however comparable with the nitrogen level 90 kg ha^{-1} and was significantly superior to that of 120 kg N ha^{-1}. However, the early maturity was recorded at higher level of nitrogen *i.e.*, 120 kg N ha^{-1}.

Regarding the effect of types of corn on days to maturity, all the three types of corn are significantly different from each other (44.7, 83.2 & 103.1 days in baby corn, sweet corn and popcorn respectively). This variation among the types of corn was mainly due to difference in the duration of the types of corn.

The interaction effect between types of corn and levels of nitrogen was not significant on days to maturity in speciality corn.

4.2 Post Harvest Observations of Speciality Corn

4.2.1 Cob Length (cm)

The cob length of speciality corn (three types of corn) recorded under different levels of nitrogen was analysed statistically and presented in Table (4.14).The results revealed that cob length was significantly influenced by the levels of nitrogen in three types of corn.

Cob length of speciality corn tended to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels. Maximum cob length was recorded at 120 kg N ha^{-1} (13.86 cm), while the minimum was with 60 kg N ha^{-1} (11.58 cm). Better crop growth coupled with early tasseling and silking, enabled the crop to have more number of days for accumulating the assimilates to sink through longer period of translocation and this would have resulted in higher cob length. The results as evidenced in the present study are in conformity with the findings of Singh *et al.* (2000), Bindhani *et al.* (2007) and Ashok kumar (2009).

All the three types of corn differed significantly from each other with respect to cob length (7.10, 16.52 & 14.60 cm in baby, sweet and popcorns respectively) due to the variation in their genetic makeup. Significant variation in cob length owing to genetic differences was reported by Ashok (2006) and Huseyin *et al*. (2003).

Regarding the interaction effect, it was indicated that in baby corn maximum cob length was obtained with the application of 90 kg N ha^{-1}(7.97 cm), which was significantly superior to 60 kg N ha^{-1}(6.05 cm) but it was on par with that of 120 kg N ha^{-1}(7.30 cm). Whereas, the other two types *i.e.*, sweet corn and popcorn were found with the maximum cob length at 120 kg N ha^{-1}(18.00 & 16.26 cm respectively) as compared to the other two lower levels of nitrogen, 60 and 90 kg ha^{-1}. The minimum cob length was noticed with 60 kg N ha^{-1} in all the types of corn (6.05, 15.30 & 13.40 cm in baby corn, sweet corn and popcorn respectively). The results suggest that in case of baby corn, application of 90 kg N ha^{-1} is sufficient to achieve maximum cob length. Whereas, for the other two types 120 kg N ha^{-1} is required to obtain maximum cob length.

4.2.2 Cob Girth (cm)

The data pertaining to cob girth of speciality corn (three types of corn) as influenced by different levels of nitrogen was analysed statistically and presented in Table (4.14).

Among the three nitrogen levels tried, the highest girth of cob was noticed with nitrogen level of 120 kg ha^{-1} (9.87 cm), which was significantly higher than 60 and 90 kg N ha^{-1}.The next best treatment in promoting cob girth was 90 kg N ha^{-1} (9.11 cm), which was at par with 60 kg N ha^{-1} (8.92 cm). Higher level of biomass accrual and efficient translocation of photosynthates to the reproductive parts was due to supply of adequate nitrogen. Significantly thinner cobs were obtained with nitrogen level of 60 kg ha^{-1}and this might be due to non-availability of sufficient quantity of assimilates to sink. Similar observations were also reported by Bindhani *et al.*, (2007) and Ashok kumar (2009).

All the three types of corn are significantly different from each other with respect to cob girth (4.26, 13.59 & 10.05 cm in baby, sweet and popcorns respectively) due to their genetic differences among themselves and due to the variations in their potentialities for different growth and yield characteristics.

The interaction effect between types of corn and levels of nitrogen indicated that in sweet corn, maximum cob girth was registered with nitrogen application of 120 kg ha^{-1} (14.96 cm) which was significantly superior to rest of the nitrogen levels tried. However, significant differences in cob girth was not noticed with increasing levels of nitrogen in baby corn and popcorn. The present experimental results suggest that application of 120 kg ha^{-1} is recommended to get higher cob girth in sweet corn. Whereas, in baby corn and popcorn, 60 kg ha^{-1} is sufficient to get maximum cob girth.

4.2.3 Number of Cobs Plant^{-1}

Data pertaining to number of cobs plant^{-1} of speciality corn as influenced by different levels of nitrogen was analysed statistically and presented in Table (4.15).

Increasing levels of nitrogen supply *i.e.,* from 60 to 120 kg N ha^{-1} progressively enhanced the number of cobs plant^{-1} in speciality corn. Application of nitrogen at 120 kg N ha^{-1} (1.59) recorded significantly higher number of cobs plant^{-1} than the rest of the nitrogen levels tried. The minimum number of cobs plant^{-1} was recorded with nitrogen level of 60 kg ha^{-1} (1.32). Higher number of cobs plant^{-1} at 120 kg N ha^{-1} might be presumably due to the higher level of biomass accrual and efficient translocation of metabolites to the sink. These results corroborate with the findings of Raja (2001), Nagaraj *et al*. (2004), Sahoo and Mahapatra (2004) and Sutaliya and Singh (2005).

Regarding the effect of types of corn on number of cobs plant^{-1}, baby corn (2.13) was found significantly different from other two types of corn which were however comparable with each other (1.10 & 1.12 in sweet corn and popcorn respectively). This difference in different types of corn might be due to the genetic differences among themselves and due to the variations in their potentialities for different growth and yield characteristics.

The interaction effect between types of corn and levels of nitrogen was not significant on number of cobs plant^{-1}in speciality corn.

4.2.4 Cob Weight with Husk (g cob^{-1})

Cob weight with husk recorded in speciality corn (three types of corn) under different levels of nitrogen fertilization was analysed statistically and presented in Table (4.15)

The increase in the level of nitrogen from 60 to 120 kg ha^{-1} also progressively increased the cob weight with husk. Application of nitrogen at 120 kg ha^{-1} recorded significantly heavier cobs (68.0 g) compared to 60 kg N ha^{-1} but it was found at par with 90 kg N ha^{-1}. The increase in cob weight with husk of speciality corn due to heavy dose (120 kg N ha^{-1}) compared to 60 kg N ha^{-1} was 9.85 per cent. This evidently proved that increased availability of nitrogen to crop at higher levels resulted in better corn and grain development and greater production of photosynthates and their efficient translocation for development of reproductive parts. Similar results were reported by Sahoo and Mahapatra (2004), Kar *et al.* (2006), Muniswamy *et al.* (2007), Suryavanshi *et al.* (2008) and Ashok Kumar (2009).

Regarding the effect of types of corn on cob weight with husk, all the three types of corn are significantly different from each other (17.2, 113.4 & 62 g in baby corn, sweet corn and popcorn respectively) due to the differences in fresh weight and dry weight of the cobs and due to the differences in their potentialities for different growth & yield characteristics.

The interaction effect between types of corn and levels of nitrogen was not significant on cob weight with husk in speciality corn.

4.2.5 Number of Kernel Rows Cob^{-1}

The data pertaining to number of kernel rows cob^{-1} in speciality corn (sweet corn and popcorn) as influenced by different levels of nitrogen application was not analysed statistically and presented in Table (4.16).

Increase in nitrogen levels from 60 kg ha^{-1} to 120 kg ha^{-1} resulted in a gradual increase in the number of kernel rows cob^{-1} in both the types of corn *i.e.,* sweet corn and popcorn. The maximum number of kernel rows cob^{-1} was recorded with the nitrogen level of 120 kg ha^{-1} (14.4 & 14.6 in sweet corn and popcorn respectively) while the minimum number of kernel rows cob^{-1} was registered with nitrogen level of 60 kg ha^{-1}(11.3 & 12.0 in sweet corn and popcorn respectively). The increase in kernels rows cob^{-1} of sweet corn and popcorn due to high dose of nitrogen *i.e.,* 120 kg N ha^{-1}compared to 60 kg N ha^{-1} was 27.4 and 21.6 per cent respectively. The elevated stature of yield attributes might be presumably due to higher accumulation of dry matter in plants under favourable nitrogen nutrition. These results are in confirmity with those of Ashok Kumar (2009) and Kumar and Ahlawat (2004).

4.2.6 Number of Kernels Row^{-1}

The data pertaining to number of kernels row^{-1} in speciality corn (sweet corn and popcorn) as influenced by different levels of nitrogen application was not analysed statistically and presented in Table (4.16).

Number of kernels row^{-1} of speciality corn also tend to increase gradually with increased levels of nitrogen from 60 to 120 kg N ha^{-1}. Application of 120 kg N ha^{-1} recorded maximum number of kernels row^{-1} compared to remaining two lower doses in both types of corn, sweet corn (36.5) and popcorn (34.1). Whereas, they were minimum with 60 kg N ha^{-1} (29.9 & 31.3 in sweet corn and popcorn respectively). The increase in number of kernels row^{-1} of speciality corn due to heavier dose (120 kg N ha^{-1}) compared to 60 kg N ha^{-1} was 22.0 and 9.0 per cent in sweet corn and popcorn respectively. This evidently proved that increased availability of nitrogen to crop at higher levels resulted in increased grain filling, that gave more kernels row^{-1} due to efficient translocation of photosynthates for development of reproductive parts. Similar results were reported by Sahoo and Mahapatra (2004), Kar *et al.* (2006), Muniswamy *et al.* (2007), Suryavanshi *et al.* (2008) and Ashok Kumar (2009).

4.2.7 Hundred Grain Weight (g)

The data pertaining to hundred grain weight in speciality corn (sweet corn and popcorn) as influenced by different levels of nitrogen application was not analysed statistically and presented in Table (4.16).

The maximum hundred grain weight was noticed with nitrogen level of 120 kg ha^{-1} (13.0 g), which was significantly higher than the other nitrogen levels. The higher level of nutrition might have improved source – sink relationship with better translocation of photosynthates to grain formation. The minimum hundred grain weight was registered with nitrogen level 60 kg ha^{-1} (12.1 g). The results corroborate the findings of Choudhary and Singh (2006).

4.2.8 Shelling Percentage of Popcorn (%)

Data pertaining to shelling percentage of popcorn as influenced by different levels of nitrogen fertilization was presented in Table (4.18).

Shelling percentage of popcorn also tended to increase progressively with increase in the level of nitrogen from 60 to 120 kg ha^{-1}. Supply of nitrogen at 120 kg ha^{-1}(40.9%) resulted in the higher shelling percentage of popcorn compared to both 60 and 90 kg N ha^{-1} (39.7 & 40.2% respectively)$^{.}$ The next best nitrogen level in recording higher shelling percentage was 90 kg ha^{-1}. These results are in accordance with those of Ashok Kumar (2009).

4.2.9 Cob Yield (kg ha^{-1})

Data pertaining to cob yield (with husk) of speciality corn as influenced by different levels of nitrogen was analysed statistically and presented in Table (4.17) and shown in Figure (4.4).

Cob yield (with husk) of speciality corn tended to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels. The maximum cob yield was recorded with 120 kg N ha^{-1} (5366.6 kg ha^{-1}), while the minimum cob yield was with 60 kg N ha^{-1}(4294.4 kg ha^{-1}). The increase in cob yield (with husk) of speciality corn due to higher dose of nitrogen (120 kg N ha^{-1}) was 30.5 per cent compared to 60 kg N ha^{-1}. The higher cob yield at higher level of nitrogen supply was mainly due to more number of cobs plant^{-1} and length of the cob coupled with higher cob weight. Adequate nitrogen nutrition has promoted growth stature as well as the enhanced yield structure of speciality corn, resulting in higher cob yield. The present investigation confirms the documented evidence of Pandey *et al.* (2000), Kar *et al.* (2006), Muniswamy *et al.* (2007) and Suryavanshi *et al.* (2008).

Regarding the effect of types of corn on cob yield (with husk), all the three types of corn are significantly different from each other (4109.1, 7010.6 & 3393.8 kg ha^{-1}in baby corn, sweet corn and popcorn respectively) owing to the difference in their genetic makeup. Genotypic differences in yield are in conformity with the findings of Huseyin *et al*. (2003) and Ashok (2006).

The interaction effect between types of corn and levels of nitrogen indicated that baby corn gave significantly higher cob yield under the application of 120 kg N ha^{-1} (4675.5 kg ha^{-1}) over remaining two lower doses of nitrogen. Sweet corn & popcorn also recorded higher cob yields at 120 kg N ha^{-1}(7557.2 & 3867.1 kg ha^{-1}) which were significantly superior to both 60 kg and 90 kg N ha^{-1}. The results suggest that in speciality corn (three types), application of 120 kg N ha^{-1} is required to achieve maximum cob yield.

4.2.10 Kernel Yield of Popcorn (kg ha^{-1})

Data pertaining to kernal yield of popcorn as influenced by different levels of nitrogen fertilization was presented in Table (4.18) and shown in Figure (4.5).

The increase in the level of nitrogen from 60 to 120 kg ha^{-1} also progressively increased the kernal yield of popcorn. Application of nitrogen at 120 kg ha^{-1} recorded maximum kernel yield (2656.3 kg ha^{-1}) when compared to remaining lower doses of nitrogen. While, minimum kernel yield was observed at 60 kg N ha^{-1} (1994.9 kg ha^{-1}). The highest kernel yield obtained with the higher level of nitrogen 120 kg ha^{-1} might be due to adequate availability of nitrogen to the crop, which results in production of sufficient quantity of photosynthates coupled with better partitioning to the sink. These results are in conformity with those of Sahoo and Mahapatra (2005), Choudhary and Singh (2006) and Ashok kumar (2009).

4.2.11 Green Fodder/Stover Yield (kg ha^{-1})

Data pertaining to green fodder/stover yield of speciality corn as influenced by different levels of nitrogen at different growth stages was analysed statistically and presented in Table (4.19) and shown in Figure (4.6).

Supply of nitrogen at 120 kg ha^{-1} (8082.5 kg ha^{-1}) resulted in significantly higher green fodder/stover yield than the rest of the two nitrogen levels tried which were on par with each other. The maximum green fodder/stover yield with the nitrogen level of 120kg ha^{-1} could be attributed to the better vegetative growth, which in turn enhanced dry matter production. Significantly lower green fodder/stover yield was obtained with 60kg N ha^{-1}. These results are in accordance with those of Raja *et al.* (2000) Pandey *et al.* (2000), Bindhani *et al.* (2007) and Ashok kumar (2008).

Regarding the effect of types of corn on stover yield, all the three types of corn are significantly different from each other (10.8, 8.4 & 3.3 t ha^{-1} in baby corn, sweet corn and popcorn respectively) owing to the difference in their genetic makeup. Genotypic differences in yield are in conformity with the findings of Huseyin *et al*. (2003) and Ashok (2006).

The interaction effect between types of corn and levels of nitrogen was not significant on green fodder/stover yield in speciality corn.

4.2.12 Harvest Index (%)

Data pertaining to harvest index of speciality corn as influenced by different levels of nitrogen was analysed statistically and presented in Table (4.20).

Increasing levels of nitrogen supply progressively enhanced the harvest index of speciality corn to the maximum level of nitrogen tried. Application of nitrogen at 120 kg ha^{-1} (38.7%) recorded significantly higher harvest index than with rest of the nitrogen levels tried. The minimum harvest index was recorded with nitrogen level of 60 kg ha^{-1} (36.0%).

Regarding the effect of types of corn on harvest index, all the three types of corn are significantly different from each other (26.9, 44.6 and 40.6% in baby corn, sweet corn and popcorn respectively) due to the genetic differences among themselves and due to the differences in their potentialities for different growth and yield characteristics.

The interaction effect between types of corn and levels of nitrogen was not significant on harvest index in speciality corn.

4.3 *Pongamia* Eqvivalent Yield (kg ha^{-1})

Data pertaining to *Pongamia* eqvivalent yield as influenced by different levels of nitrogen in speciality corn was analysed statistically and presented in Table (4.21) and shown in Figure (4.7).

All the treatments showed significantly higher *Pongamia* eqvivalent yield than control (sole *Pongamia* without maize) (1085.8 kg ha^{-1}). *Pongamia* eqvivalent yield tended to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels. The maximum *Pongamia* eqvivalent yield was recorded with 120 kg N ha^{-1} (8012.1 kg ha^{-1}), while it was minimum with 60 kg N ha^{-1} (6480.5 kg ha^{-1}). The increase in eqvivalent yield due to higher dose (120 kg N ha^{-1}) compared to 60 kg N ha^{-1} was 23.6 per cent. This was mainly due to higher yields of speciality corn types as intercrops at higher levels of nitrogen.

Among the different types of corn sweet corn has recorded significantly higher *Pongamia* equivalent yield (8031.8 kg ha^{-1}) compared to baby corn (7148.8 kg ha^{-1}) and popcorn (6777.1 kg ha^{-1}) which in turn had a significant disparity between them.

The interaction effect between types of corn and levels of nitrogen indicated that a combination of sweet corn at 120 kg N ha^{-1} (8562.7 kg ha^{-1}) was found to be significantly superior over all other treatments. The next best combination was sweet corn at 90 kg N ha^{-1} (8145.6 kg ha^{-1}). Significantly lower *Pongamia* eqvivalent yield was obtained with popcorn at 60 kg N ha^{-1}(5984.4 kg ha^{-1}).

4.4 Tree Parameters of *Pongamia*

The *Pongamia* plantation in which our experiment was taken up was studied. Depending on the soil fertility gradient, plant type, growing conditions the trees vary in their growth and development and some of the tree parameters were recorded and presented in the Table (4.22).

4.4.1 Tree Height (m)

In general *Pongamia* tree grows to a height of 5 m to 8 m. In our experimental site the trees were laid out in four rows and eleven trees in a row. The spacing between the trees is 6 m x 6 m. The height of trees varied from 4.62 m to 5.66 m. The average height of all the trees in the system is about 5.09 m. This difference in the height helped us to study the effect of tree on the crop.

The effect of nitrogen levels, types of corn and interaction on the tree height of *Pongamia* was not significant. It was analysed statistically and presented in Table (4.22).

4.4.2 Canopy Spread (m)

The trees in the system differed in the spread of the branches and canopy. The canopy spread is measured by the length of the branches from the main stem in E-W direction. The canopy spread varied from a minimum of 4.04 m to 4.71 m. The average canopy spread of each tree was 4.42 m.

The effect of nitrogen levels, types of corn and interaction on the canopy spread of *Pongamia* was not significant. It was analysed statistically and presented in Table (4.22).

4.4.3 Pod Yield of Tree (kg tree^{-1})

The pod yield varied from 3.26 kg to 4.41 kg and the average yield per tree was 3.68 kg. The effect of nitrogen levels, types of corn and interaction on the tree yield of *Pongamia* was not significant. It was analysed statistically and presented in Table (4.22).

4.5 Nutrient uptake by the crop

4.5.1 Nitrogen Uptake:

Data pertaining to nitrogen uptake by speciality corn as influenced by different levels of nitrogen at harvest was analysed statistically and presented in Table (4.23) and shown in Figure (4.8).

Nitrogen uptake by speciality corn tended to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels. Maximum nitrogen uptake was recorded with 120 kg N ha^{-1} (76.1 kg ha^{-1}), while the minimum was with 60 kg N ha^{-1} (59.7 kg ha^{-1}). With the comfortable nitrogen nutrition, crop might have developed larger rhizosphere exploring more volume of soil and extracting larger quantity of nitrogen and transporting to planosphere, thus enhancing the nutrient content in the vegetative parts and translocating considerable fraction to the cobs. The similar findings have also been reported by Sutaliya and Singh (2005), Kar *et al.* (2006), Sahoo and Mahapatra (2007) and Ashok Kumar (2009).

Regarding the effect of types of corn on nitrogen uptake, sweet corn (71.0 kg ha^{-1}) recorded significantly higher nitrogen uptake than the rest of the corn types which were comparable with each other (66.5 and 65.7 kg ha^{-1} in baby corn and popcorn respectively) . This variation in different types of corns might be due to the genetic differences among themselves and due to the differences in their potentialities for different growth & yield characteristics.

The interaction effect between types of corn and levels of nitrogen was not significant on nitrogen uptake by speciality corn.

4.5.2 Phosphorus Uptake

Data pertaining to phosphorous uptake by speciality corn as influenced by different levels of nitrogen at harvest was analysed statistically and presented in Table (4.23) and shown in Figure (4.8).

Phosphorous uptake by speciality corn tended to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels. Maximum phosphorous uptake was recorded with 120 kg N ha^{-1} (27.6 kg ha^{-1}), while the minimum was with 60 kg N ha^{-1} (21.4 kg ha^{-1}). The higher phosphorous uptake at higher level of nitrogen was mainly attributed to the higher dry matter production at that level of nitrogen. These results are in accordance with those of Singh *et al.* (2010) and Kalyani (2011).

Regarding the effect of types of corn on phosphorous uptake, sweet corn was found significantly superior over the rest of corn types which were statistically on par with each other (24.3, 26.4 & 22.8 kg ha^{-1} in baby corn, sweet corn and popcorn respectively).

The interaction effect between types of corn and levels of nitrogen was not significant on phosphorous uptake by speciality corn.

4.5.3 Potassium Uptake

Data pertaining to potassium uptake by speciality corn as influenced by different levels of nitrogen at harvest was analysed statistically and presented in Table (4.23) and shown in Figure (4.8).

Increasing levels of nitrogen supply from 60 to 120 kg ha^{-1} progressively enhanced the potassium uptake by speciality corn. Application of nitrogen at 120 kg ha^{-1} (107.2 kg ha^{-1}) recorded significantly higher potassium uptake than the other two nitrogen levels tried which in turn had significant disparity between them. This might be due to the efficient absorption of mineral nutrients coupled with higher dry matter production under higher nitrogen levels. Similar results have also been reported by Spandana (2010) and Kalyani (2011).

Regarding the effect of types of corn on phosphorous uptake, sweet corn and baby corn were found significantly different from each other. Whereas, the rest of corn type combinations were found comparable with each other in potassium uptake by the crop (92.1, 102.9 & 95.3 kg ha^{-1} in baby corn, sweet corn and popcorn respectively).

The interaction effect between types of corn and levels of nitrogen was not significant on potassium uptake by speciality corn.

4.6 Nitrogen Respose

Data pertaining to nitrogen response by speciality corn as influenced by different levels of nitrogen was presented in Table (4.24).

The nitrogen response decreased gradually with increase in levels of nitrogen from 60 to 120 kg N ha^{-1} in all the types of corn. The maximum nitrogen response was observed with 60 kg ha^{-1} (56.45 & 106.36 kg of cob per kg of nitrogen applied in baby corn and sweet corn respectively and 22.13 kg of grain per kg of nitrogen applied in popcorn). Whereas, minimum nitrogen response was resulted with 120 kg ha^{-1}. Similar results were reported by Spandana (2010).

4.7 Post Harvest Soil Fertility Status

Data pertaining to post harvest soil fertility status as influenced by different levels of nitrogen application was analysed statistically and presented in Table (4.25)

All the treatments showed significantly higher available nitrogen than control. The maximum post harvest soil available nitrogen was recorded with the nitrogen level 120 kg ha^{-1}(144.9 kg ha^{-1}), which was significantly higher than with other nitrogen levels studied. The next best nitrogen level was 90 kg ha^{-1} followed by 60 kg ha^{-1} and both of them were comparable between each other. Considerable quantity of nitrogen left over in the soil, might have remained in the soil after meeting the maximum requirement of the crop at higher levels of nitrogen applied. Similar results were also reported by Kumaresan (2001), Anil Kumar *et al.*, (2002) and Kalyani (2011).

All the treatments showed significantly higher available phosphorous and potassium than control. Application of nitrogen at 120 kg ha^{-1} (43.7 kg ha^{-1}) recorded significantly maximum post harvest soil available phosphorous compared to 60 kg N ha^{-1} but it was found at par with 90 kg N ha^{-1}. Whereas, available potassium in soil tend to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels. These results are in accordance with those of Sunitha (2007), Spandana (2010) and Kalyani (2011).

The effect of types of corn on post harvest soil fertility status was found to be non significant.

The interaction effect between types of corn and levels of nitrogen was also found non significant on post harvest soil fertility status.

4.8 Economics

The economics of *Pongamia* + maize (speciality corn types) agri-silvi system recorded under different levels of nitrogen was presented in Table (4.26) and illustrated in Fig(4.9)

4.8.1 Gross Returns

The gross returns (Rs. ha^{-1}) increased considerably with increased levels of nitrogen (60 to 120 kg N ha^{-1}) in all the types of corn. Among the treatments, gross returns were maximum in T_6 (*Pongamia* + sweet corn at 120 kg N ha^{-1}) (Rs. 87418) followed by T_5 (*Pongamia* + sweet corn at 90 kg N ha^{-1}) (Rs. 83108). Minimum gross returns were recorded in T_{10} (sole *Pongamia* without maize) (Rs.10858). Higher gross returns in T_6 can be attributed mainly due to maximum green cob as well as green fodder yields at higher level of nitrogen application. Similar results were also reported by Ashok Kumar (2008).

4.8.2 Net Returns

The net returns (Rs. ha^{-1}) also increased with increased levels of nitrogen from 60 to 120 kg N ha^{-1} in all the types of corn. Maximum net returns were recorded in T_6 (*Pongamia* + sweet corn at 120 kg N ha^{-1}) (Rs. 64917) followed by T_5 (*Pongamia* + sweet corn at 90 kg N ha^{-1}) (Rs. 60999). Whereas, minimum gross returns were obtained in T_{10} (sole *Pongamia* without maize) (Rs.6358). This was mainly due to maximum cob yield obtained under higher nitrogen nutrition. These results are in accordance with those of Ashok Kumar (2008).

4.8.3 Benefit-Cost Ratio

The maximum B: C ratio (2.88) was obtained with T_6 (*Pongamia* + sweet corn at 120 kg N ha^{-1}) (2.88) followed by T_5 (*Pongamia* + sweet corn at 90 kg N ha^{-1}) (2.75). Minimum B: C ratio was recorded in T_{10} (sole *Pongamia* without maize) (1.41). Similar results were also reported by Ashok Kumar (2008) and Kalyani (2011).

CHAPTER-V

SUMMARY AND CONCLUSIONS

Chapter V

SUMMARY AND CONCLUSIONS

Arable cropping enterprise in drylands is often unremunerative on account of aberrations in monsoon. The major constraints that limit crop production in dryland areas are moisture and nutrient stress. Conservation of soil moisture and improvement of soil fertility through addition of organic materials may improve production from these lands considerably by sustaining the soil health. Hence an integrated approach of land management to utilize the natural resources more efficiently in rainfed areas is essential to meet the requirements of farmer and his live stock without deteriorating the land productivity and also generate continuous and stable income.

One of the need based alternative land use system replacing the traditional farming system is a tree based system of cropping *i.e.*, agroforestry which acts as sustainable land management system especially in dryland areas.

So an experiment was carried out during *Kharif* 2011 at the Student's Farm, College of Agriculture, Rajendranagar, Hyderabad on red sandy loam soils to study the effect of different nitrogen levels on speciality corn under *Pongamia* + maize agrisilvi system. The Farm is geographically situated at an altitude of 542.3 m above mean sea level at 17^0 $19^'$ N latitude and 78^0 $28^'$ E longitude and falls under the Southern Telangana Agro-climatic Zone of Andhra Pradesh. The experiment was laid out in a randomized block design (factorial concept) with three replications. The treatments consists of three nitrogen levels (60, 90 and 120 kg N ha^{-1}) and three types of corn (baby corn, sweet corn and popcorn) as intercrops in *Pongamia* and one control treatment (sole *Pongamia* without maize and with no nitrogen).

The objectives of the experiment were as follows.

1. To evaluate the performance of speciality corn types as an intercrop in existing *Pongamia* plantations under rainfed conditions.
2. To study the effect of different N levels on speciality corn in Agri-Silvicultural system under rainfed conditions.
3. To workout the economics of *Pongamia* + maize Agri-Silvicultural system in relation to

nitrogen management.

The salient findings are summarized below:

- A total rainfall of 466.1 mm was received in 29 rainy days during the crop growth period. The distribution of rainfall was uniform and sufficient for better crop growth. Hence, the crop was grown successfully without any supplementary irrigation.
- Among the growth characters, plant height and dry matter accumulation increased due to increased level of nitrogen application from 60 to 120 kg ha^{-1} at all the stages of crop growth but in the initial stages 90 & 120 kg N ha^{-1} were comparable with each other. At later stages, significantly taller plants with maximum dry matter accumulation were recorded at 120 kg N ha^{-1}. Whereas, leaf area index tended to increase with increased levels of nitrogen from 60 to 120 kg N ha^{-1}, with significant disparity between any two successive levels at all the growth stages. Further, early silking and maturity was observed in all corns at higher dose of N *i.e.*, 120 kg N ha^{-1}.
- All the yield attributes such as cob length, cob girth, number of cobs $plant^{-1}$, number of rows cob^{-1}, number of kernels cob^{-1} and 100 kernel weight were found maximum at higher level of 120 kg N ha^{-1} when compared to lower doses. Whereas, in case of cob weight (with husk) application of nitrogen at 120 kg ha^{-1} recorded significantly heavier cobs compared to 60 kg N ha^{-1} but it was found at par with 90 kg N ha^{-1}. Similarly cob yield (with husk), green fodder yield, harvest index, kernel yield of popcorn and shelling percentage of popcorn were found significantly higher at 120 kg N ha^{-1} than the other two lower doses of nitrogen.
- Regarding the *Pongamia* equivalent yields application of 120 kg N ha^{-1} resulted in significantly higher equivalent yield of *Pongamia* when compared to over 60 and 90 kg N ha^{-1}.
- Post harvest soil available nitrogen was significantly higher in all the treatments than control. However, maximum available nitrogen and potassium in soil was noticed at 120 kg N ha^{-1} which was significantly higher than the other nitrogen levels studied . Whereas, available phosphorous registered was maximum at 120 kg N ha^{-1} but was statistically at par with 90 kg N ha^{-1}.

- The highest nutrient uptake (N, P & K) was observed with nitrogen level of 120 kg ha^{-1}, which was significantly superior to 60 and 90 kg N ha^{-1}.
- The different types of corn were found significantly different from each other regarding growth parameters such as plant height, days to 50 per cent silking and days to maturity. Whereas, in case of leaf area index, baby corn and pop corn were found comparable with each other in the initial stage but later at harvest sweet corn and popcorn were found on par with each other. Similarly regarding dry matter accumulation, in the initial stages, baby corn and sweet corn were found comparable with each other but later at harvest baby corn and sweet corn were found on par with each other.
- Regarding the effect of types of corn on yield and yield attributes, all the three types of corn were found significantly different from each other in cob length, cob girth, cob weight (with husk), green cob yield as well as green fodder/stover yield. Whereas, sweet corn and popcorn were comparable with each in number of cobs $plant^{-1}$ but found significantly different from baby corn.
- Among the different types of corns, sweet corn had resulted in significantly higher *Pongamia* equivalent yield than the other two types of corn. Next to this, baby corn was found to be best as an intercrop to get higher *Pongamia* equivalent yield.
- Post harvest soil available nutrients (N, P & K) were found unaffected by the different types of corn.
- Sweet corn recorded significantly higher nitrogen uptake than baby corn and popcorn which were comparable with each other. Similarly, sweet corn recorded higher phosphorous and potassium uptake but was on par with baby corn regarding phosphorous uptake and with popcorn in case of potassium uptake.
- Effect of nitrogen management in speciality corn on the tree parameters of *Pongamia* was found non significant. The effect may be seen over a long run.
- The interaction effect between types of corn and levels of nitrogen in case of cob yield (with husk) indicated that baby corn gave significantly higher cob yield under the application of 120 kg N ha^{-1} over remaining two lower doses of nitrogen. Likewise, sweet corn & popcorn also recorded higher cob yield at 120 kg N ha^{-1} which was significantly superior to both 60 kg and 90 kg N ha^{-1}.

- The interaction effect between types of corn and levels of nitrogen on *Pongamia* equivalent yields indicated that a combination of sweet corn at 120 kg N ha^{-1} was found to be significantly superior over all other treatments. The next best combination was sweet corn at 90 kg N ha^{-1}.
- Maximum gross returns, net returns and B:C ratio was obtained with the combination of sweet corn at 120 kg N ha^{-1} followed by sweet corn at 90 kg N ha^{-1}.

From the above, it was concluded that

- Speciality corn types can be grown successfully in the alleys of six year old *Pongamia* plantation with nutrient supplementation in sandy loam soils of Southern Telangana region of Andhra Pradesh.
- Application of 120 kg N ha^{-1} was found to be better in terms of growth and yield of speciality corn.
- Among the different types of corn, sweet corn was found to be the most profitable intercrop in *Pongamia* plantations (higher *Pongamia* equivalent yield and B:C ratio).
- Maximum net returns and B:C ratio was obtained with sweet corn at 120 kg N ha^{-1} followed by sweet corn at 90 kg N ha^{-1}.

Future line of work

- For improving the yield and quality with the sustained soil productivity, the combined use of organic manures and chemical fertilizers in the *Pongamia* based alley cropping has a paramount importance for the research. It is suggested that the research work may be continued in the following areas.
- Need to study the performance of speciality corn hybrids as intercrops in *Pongamia* which may be more profitable than the varieties /composites.
- Need to study the effect of *Pongamia* on the nutrient availability in the soil and on the soil microbial growth.

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The pattern of 'Literature cited' presented above is in accordance with the guidelines for thesis presentation for Acharya N.G. Ranga Agricultural University, Hyderabad.

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APPENDICES

APPENDIX-I

Weekly Meteorological Data Recorded at ARI, Rajendranagar During 7th July 2011 to 19th October 2011

WEEK		TEMPERATURE (oC)		R.H. (%)		RAIN-	RAINY	SUN-	WIND	EVAPO-	MEAN
NO.	PERIOD	MAX.	MIN.	I	II	FALL	DAYS	SHINE	SPEED	RATION	TEMP.
						(mm)		(hrs.)	(km/hr)	(mm)	(oC)
27	02-08	31.3	22.4	91	64	89.0	4	2.5	9.1	4.5	26.9
28	09-15	30.7	22.6	84	64	38.8	2	5.6	14.5	5.2	26.7
29	16-22	31.6	23.3	82	59	15.0	1	5.2	14.8	5.0	27.4
30	23-29	30.6	21.9	93	65	48.2	4	5.2	8.3	4.3	26.2
31	30-05 AUG	29.5	22.6	87	65	10.4	1	3.2	12.1	4.6	26.1
32	06-12	31.4	23.3	90	63	1.8	0	4.9	11.1	5.0	27.3
33	13-19	31.7	23.2	89	76	11.0	2	6.2	7.7	5.2	27.4
34	20-26	30.2	22.2	95	73	106.6	3	3.5	3.7	3.5	26.2
35	27-02 SEP	27.7	22.1	89	80	61.5	5	1.5	10.0	3.4	24.9
36	03-09	29.7	22.2	90	79	30.6	2	5.2	9.1	2.7	26.0
37	10-16	31.3	22.5	89	74	0.0	0	6.2	4.1	2.9	26.9
38	17-23	30.5	22.4	83	69	12.0	1	5.0	5.8	2.8	26.4
39	24-30	31.7	20.7	88	74	3.5	1	6.5	2.9	2.9	26.2
40	01-07 OCT	32.4	20.5	89	74	8.2	1	6.8	1.9	2.7	26.4
41	08-14	32.0	21.1	91	64	28.5	2	5.5	1.9	2.7	26.5
42	15-21	32.9	19.9	90	67	1.0	0	8.2	2.0	2.8	26.4

APPENDIX– II

Cost of cultivation (Rs. ha^{-1})

Operations	Treatments								
	C_1N_1	C_1N_2	C_1N_3	C_2N_1	C_2N_2	C_2N_3	C_3N_1	C_3N_2	C_3N_3
Land preparation	3000	3000	3000	3000	3000	3000	3000	3000	3000
Seed	600	600	600	720	720	720	1080	1080	1080
Sowing	1800	1800	1800	1800	1800	1800	1800	1800	1800
Urea	783	1174	1566	783	1174	1566	783	1174	1566
SSP	2175	2175	2175	2175	2175	2175	2175	2175	2175
MOP	840	840	840	840	840	840	840	840	840
Fertilizer application	750	750	750	750	750	750	750	750	750
Earthing up	450	450	450	450	450	450	450	450	450
Gap filling & thinning	450	450	450	450	450	450	450	450	450
Plant protection	500	500	500	500	500	500	500	500	500
Weeding & Herbicide application	3200	3200	3200	3200	3200	3200	3200	3200	3200
Bird scaring	300	300	300	300	300	300	300	300	300
Harvesting	3750	3750	3750	2250	2250	2250	2250	2250	2250
Total	18658	19049	19441	17218	17609	18001	18178	18569	18961

APPENDIX- III

Calendar of operations

Operation	Date
Lay out	28-06-2011
Sowing & basal fertilizer application	07-07-2011
Herbicide (Atrazine) application	08-07-2011
Gap filling	16-07-2011
Pesticide spraying	18-07-2011
Thinning	21-07-2011
Top dressing of N in baby corn(2nd split)	27-07-2011
Weeding	29-07-2011
Top dressing of N in sweet corn and popcorn (2nd split)	01-08-2011
Top dressing of N in baby corn(3rd split)	11-08-2011
Top dressing of N in sweet corn and popcorn (3rd split)	26-08-2011
Harvesting of baby corn	20-08-2011 to 04-09-2011
Harvesting of sweet corn	29-09-2011
Harvesting of popcorn	19-10-2011

APPENDIX – IV

Estimated returns (Rs ha^{-1}) from the tree component (*Pongamia pinnata*)

Treatments	Yield (kg) per tree	Yield (kg) per hectare	Returns (Rs ha^{-1})
T_1- *Pongamia* + Baby corn with N@ 60kg ha^{-1}	3.30	914.10	9141
T_2- *Pongamia* + Baby corn with N@90kg ha^{-1}	3.70	1024.90	10249
T_3- *Pongamia* + Baby corn with N@120kg ha^{-1}	3.80	1052.60	10526
T_4- *Pongamia* + Sweet corn with N@60kg ha^{-1}	3.40	941.80	9418
T_5- *Pongamia* + Sweet corn with N@90kg ha^{-1}	3.90	1080.30	10803
T_6- *Pongamia* + Sweet corn with N@120kg ha^{-1}	3.80	1024.90	10249
T_7- *Pongamia* + Pop corn with N@60kg ha^{-1}	3.20	886.40	8864
T_8- *Pongamia* + Pop corn with N@90kg ha^{-1}	3.70	1024.90	10249
T_9- *Pongamia* + Pop corn with N@120kg ha^{-1}	3.60	997.20	9972
T_{10}- Sole *Pongamia* with out maize and nitrogen	3.92	1085.8	10858

Tree spacing: 6 m x 6 m

Number of trees per hectare: 277

Estimated cost of seed: Rs. 10 per kg

APPENDIX – V

COST OF INPUTS AND OUTPUT

INPUTS	` Kg^{-1}
Baby corn seed	33
Swet corn seed	90
Popcorn seed	90
Urea	6.0
Single super phosphate	12.6
Muriate of potash	5.8

OUTPUTS	` Kg^{-1}
Baby corn cobs (with husk)	15
Swet corn cobs (with husk)	10
Popcorn seed	15
Pongamia pods	10
Green fodder of baby corn and sweet corn	0.2

APPENDIX – VI

NPK content (%) of crop at harvest as influenced by varying nitrogen levels in three types of corn

Treatments	Nitrogen	Phosphorous	Potassium
C_1N_1	0.98	0.36	1.38
C_1N_2	0.99	0.37	1.39
C_1N_3	1.02	0.37	1.39
C_2N_1	0.98	0.37	1.45
C_2N_2	1.00	0.37	1.46
C_2N_3	1.03	0.38	1.46
C_3N_1	0.99	0.33	1.42
C_3N_2	1.01	0.35	1.48
C_3N_3	1.03	0.37	1.49

Table 4.1. Plant height (cm) of speciality corn as influenced by varying nitrogen levels and types of corn at knee high stage of crop growth

Nitrogen levels (kg ha^{-1})	Types of corn			
	Baby corn	Sweet corn	Popcorn	Mean
60	32.6	40.8	48.5	**40.6**
90	35.6	46.0	51.5	**44.3**
120	36.4	46.5	56.4	**46.4**
Mean	**34.8**	**44.4**	**52.1**	

	S.Em±	CD (p = 0.05)
Nitrogen levels (kg ha^{-1})	0.80	2.41
Types of corn	0.80	2.41
N x C	1.39	NS

Table 4.2. Plant height (cm) of speciality corn as influenced by varying nitrogen levels and types of corn at pre tasseling stage of crop growth

Nitrogen levels (kg ha^{-1})	Types of corn			
	Baby corn	Sweet corn	Popcorn	Mean
60	73.6	159.7	159.6	**130.9**
90	73.7	171.7	177.4	**140.9**
120	76.8	174.4	188.7	**146.6**
Mean	**74.7**	**168.6**	**175.2**	

	S.Em±	CD (p = 0.05)
Nitrogen levels (kg ha^{-1})	3.93	11.79
Types of corn	3.93	11.79
N x C	6.81	NS

Table 4.3. Plant height (cm) of speciality corn as influenced by varying nitrogen levels and types of corn at cob development stage of crop growth

Nitrogen levels (kg ha^{-1})	Types of corn			
	Baby corn	Sweet corn	Popcorn	Mean
60	126.1	188.1	171.1	**161.7**
90	135.4	197.3	177.9	**170.2**
120	17.2	211.3	189.3	**182.6**
Mean	**136.2**	**198.9**	**179.4**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	3.35		10.06	
Types of corn	3.35		10.06	
N x C	5.81		NS	

Table 4.4. Plant height (cm) of speciality corn as influenced by varying nitrogen levels and types of corn at harvest

Nitrogen levels (kg ha^{-1})	Types of corn			
	Baby corn	Sweet corn	Popcorn	Mean
60	127.7	189.6	172.6	**163.3**
90	137.6	198.1	179.4	**171.7**
120	148.0	212.9	190.6	**183.3**
Mean	**137.7**	**200.2**	**180.8**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	3.53		10.61	
Types of corn	3.53		10.61	
N x C	6.13		NS	

Table 4.5. Leaf area index of speciality corn as influenced by varying nitrogen levels and types of corn at knee high stage of crop growth

Nitrogen levels (kg ha^{-1})	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	0.42	0.31	0.41	**0.38**
90	0.42	0.41	0.44	**0.42**
120	0.56	0.43	0.52	**0.50**
Mean	**0.47**	**0.38**	**0.46**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	0.01		0.03	
Types of corn	0.01		0.03	
N x C	0.02		NS	

Table 4.6. Leaf area index of speciality corn as influenced by varying nitrogen levels and types of corn at pre tasseling stage of crop growth

Nitrogen levels (kg ha^{-1})	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	0.78	0.86	1.31	**0.98**
90	1.23	1.32	1.61	**1.38**
120	1.62	1.51	2.11	**1.75**
Mean	**1.21**	**1.23**	**1.68**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	0.03		0.09	
Types of corn	0.03		0.09	
N x C	0.05		NS	

Table 4.7. Leaf area index of speciality corn as influenced by varying nitrogen levels and types of corn at cob development stage of crop growth

Nitrogen levels ($kg\ ha^{-1}$)	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	1.16	2.19	2.15	**1.83**
90	2.56	2.64	2.61	**2.60**
120	2.90	3.10	3.03	**3.01**
Mean	**2.20**	**2.64**	**2.60**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels ($kg\ ha^{-1}$)	0.05		0.15	
Types of corn	0.05		0.15	
N x C	0.08		0.26	

Table 4.8. Leaf area index of speciality corn as influenced by varying nitrogen levels and types of corn at harvest

Nitrogen levels ($kg\ ha^{-1}$)	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	1.14	2.02	2.07	**1.74**
90	2.36	2.48	2.42	**2.42**
120	2.79	2.98	2.98	**2.91**
Mean	**2.09**	**2.49**	**2.49**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels ($kg\ ha^{-1}$)	0.05		0.16	
Types of corn	0.05		0.16	
N x C	0.09		0.28	

Table 4.9. Dry matter accumulation (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn at knee high stage of crop growth

Nitrogen levels (kg ha^{-1})	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	493.7	502.6	884.6	**626.9**
90	592.6	592.3	973.4	**719.4**
120	597.1	598.1	984.3	**726.5**
Mean	**561.1**	**564.3**	**947.4**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	6.17		18.52	
Types of corn	6.17		18.52	
N x C	10.70		NS	

Table 4.10. Dry matter accumulation (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn at pre tasseling stage of crop growth

Nitrogen levels (kg ha^{-1})	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	1987.6	2393.3	3164.8	**2515.5**
90	2499.5	2529.1	3376.3	**2801.6**
120	2963.2	2672.7	3492.3	**3042.7**
Mean	**2483.4**	**2532.0**	**3344.4**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	40.93		122.74	
Types of corn	40.93		122.74	
N x C	70.90		212.60	

Table 4.11. Dry matter accumulation (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn at cob development stage of crop growth

Nitrogen levels (kg ha^{-1})	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	5852.9	6076.3	5738.6	**5889.2**
90	6594.8	6834.7	6172.3	**6533.9**
120	7132.7	7586.3	6731.4	**7150.1**
Mean	**6526.8**	**6832.4**	**6214.1**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	56.04		168.02	
Types of corn	56.04		168.02	
N x C	97.06		NS	

Table 4.12. Dry matter accumulation (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn at harvest

Nitrogen levels (kg ha^{-1})	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	5962.3	6286.3	5934.5	**6061.0**
90	6692.2	7059.8	6486.3	**6746.1**
120	7280.8	7864.7	7093.7	**7413.0**
Mean	**6645.1**	**7070.2**	**6504.8**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	123.07		369.03	
Types of corn	123.07		369.03	
N x C	213.18		NS	

Table 4.13. Days to 50 % silking and Days to maturity of speciality corn as influenced by varying nitrogen levels and types of corn

Nitrogen levels (kg ha^{-1})	**Types of corn**							
	Days to 50 % silking				**Days to maturity**			
	Baby corn	Sweet corn	Popcorn	Mean	Baby corn	Sweet corn	Popcorn	Mean
60	45.6	60.6	68.0	**58.1**	45.6	84.3	103.6	**77.8**
90	45.0	60.0	66.6	**57.2**	45.0	83.3	103.3	**77.2**
120	43.6	59.0	66.3	**56.3**	43.6	82.0	102.3	**76.0**
Mean	**44.7**	**59.8**	**67.0**		**44.7**	**83.2**	**103.1**	
	S.Em±		CD (p = 0.05)		S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	0.35		1.05		0.34		1.03	
Types of corn	0.35		1.05		0.34		1.03	
N x C	0.60		NS		0.59		NS	

Table 4.14. Cob length (cm) and Cob girth (cm) of speciality corn as influenced by varying nitrogen levels and types of corn

Nitrogen levels (kg ha^{-1})	**Types of corn**							
	Cob length (cm)				**Cob girth (cm)**			
	Baby corn	Sweet corn	Popcorn	Mean	Baby corn	Sweet corn	Popcorn	Mean
60	6.05	15.30	13.40	**11.58**	3.96	12.90	9.90	**8.92**
90	7.97	16.26	14.10	**12.77**	4.33	12.92	10.10	**9.11**
120	7.30	18.00	16.30	**13.86**	4.49	14.96	10.16	**9.87**
Mean	**7.10**	**16.52**	**14.60**		**4.26**	**13.59**	**10.05**	
	S.Em±		CD (p = 0.05)		S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	0.24		0.73		0.19		0.59	
Types of corn	0.24		0.73		0.19		0.59	
N x C	0.42		1.26		0.34		1.03	

Table 4.15. Number of cobs plant^{-1} and Cob weight with husk (g cob^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn

Nitrogen levels (kg ha^{-1})	**Types of corn**							
	Number of cobs plant^{-1}				**Cob weight with husk (g cob^{-1})**			
	Baby corn	Sweet corn	Popcorn	Mean	Baby corn	Sweet corn	Popcorn	Mean
60	1.98	1.00	1.00	**1.32**	15.1	109.2	59.7	**61.3**
90	2.16	1.10	1.06	**1.44**	16.2	112.3	61.6	**63.3**
120	2.27	1.20	1.30	**1.59**	20.3	118.8	64.9	**68.0**
Mean	**2.13**	**1.10**	**1.12**		**17.2**	**113.4**	**62.0**	
	S.Em±		CD (p = 0.05)		S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	0.03		0.10		1.69		5.07	
Types of corn	0.03		0.10		1.69		5.07	
N x C	0.06		NS		2.92		NS	

Table 4.16. Number of kernel rows cob^{-1}, Number of kernels row^{-1} and 100 seed weight (g) of sweet corn and popcorn as influenced by varying nitrogen levels and types of corn

Nitrogen levels (kg ha^{-1})	Types of corn								
	Number of kernel rows cob^{-1}			**Number of kernels row^{-1}**			**100 seed weight (g)**		
	Sweet corn	Popcorn	Mean	Sweet corn	Popcorn	Mean	Sweet corn	Popcorn	Mean
60	11.3	12.0	**11.6**	29.9	31.3	**30.6**	11.2	13.1	**12.1**
90	12.4	13.3	**12.8**	32.6	32	**32.3**	11.3	13.4	**12.3**
120	14.4	14.6	**14.5**	36.5	34.1	**35.3**	12.2	13.8	**13.0**
Mean	**12.7**	**13.3**		**33.0**	**32.4**		**11.5**	**13.4**	

*Data not analysed statistically

Table 4.17. Cob yield (with husk) (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn and their interaction

Nitrogen levels (kg ha^{-1})	Types of corn			
	Baby corn	Sweet corn	Popcorn	Mean
60	3387.5	6381.8	3114.1	**4294.4**
90	4264.5	7093.0	3200.2	**4852.5**
120	4675.5	7557.2	3867.1	**5366.6**
Mean	**4109.1**	**7010.6**	**3393.8**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	70.37		210.99	
Types of corn	70.37		210.99	
N x C	121.88		365.45	

Table 4.18. Kernel yield (kg ha^{-1}) and Shelling percentage of popcorn as influenced by varying nitrogen levels

Treatment	**Kernel yield (kg ha^{-1})**	**Shelling percentage**
60	1994.9	39.7
90	2268.2	40.2
120	2656.3	40.9

*Data not analysed statistically

Table 4.19. Green fodder/stover yield (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn

Nitrogen levels (kg ha^{-1})	Types of corn			
	Baby corn	Sweet corn	Popcorn	Mean
60	10092.5	8147.9	3006.4	**7082.2**
90	10918.4	8259.2	3284.3	**7487.3**
120	11442.5	8953.4	3851.7	**8082.5**
Mean	**10817.8**	**8453.5**	**3380.8**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	157.35		471.79	
Types of corn	157.35		471.79	
N x C	272.53		NS	

Table 4.20. Harvest index (%) of speciality corn as influenced by varying nitrogen levels and types of corn

Nitrogen levels (kg ha^{-1})	Types of corn			
	Baby corn	Sweet corn	Popcorn	Mean
60	25.1	43.1	39.8	**36.0**
90	26.6	45.1	40.8	**37.5**
120	29.0	45.7	41.4	**38.7**
Mean	**26.9**	**44.6**	**40.6**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	0.64		1.92	
Types of corn	0.64		1.92	
N x C	1.11		NS	

Table 4.21. ***Pongamia*** **eqvivalent yields (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn and their interaction**

Nitrogen levels (kg ha^{-1})	**Types of corn**			
	Baby corn	Sweet corn	Popcorn	Mean
60	6070.0	7387.3	5984.4	**6480.5**
90	7357.8	8145.6	6892.8	**7465.1**
120	8018.7	8562.7	7455.0	**8012.1**
Mean	**7148.8**	**8031.8**	**6777.1**	
	S.Em±		CD (p = 0.05)	
Nitrogen levels (kg ha^{-1})	86.62		259.73	
Types of corn	86.62		259.73	
N x C	150.04		449.87	

Control (sole *Pongamia* without maize) – 1085.8 kg ha^{-1}

Control Vs Treatments – Sifnificant (significance was tested by F test)

Table 4.22. Tree height (m), Canopy spread (m) and Pod yield of tree (kg tree^{-1}) of *Pongamia* as influenced by varying nitrogen levels and types of corn

Treatments	Tree height (m)	Canopy spread E-W (m)	Tree yield (kg tree^{-1})
Nitrogen levels (kg ha^{-1})			
60	4.87	4.29	3.48
90	5.07	4.45	3.89
120	5.24	4.50	3.60
S.Em±	0.38	0.10	0.26
CD(p = 0.05)	NS	NS	NS
Types of corn			
Baby corn	4.75	4.54	3.75
Sweet corn	5.16	4.36	3.68
Popcorn	5.27	4.34	3.53
S.Em±	0.38	0.10	0.26
CD(p = 0.05)	NS	NS	NS
Control	**5.41**	**4.46**	**3.92**
N x C Interaction			
S.Em±	0.66	0.17	0.45
CD(P = 0.05)	NS	NS	NS
Control vs Treatments	NS	NS	NS

Table 4.23. NPK uptake (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn

Nitrogen levels (kg ha^{-1})	**Types of corn**											
	Nitrogen				**Phosphorus**				**Potassium**			
	Baby corn	Sweet corn	Popcorn	Mean	Baby corn	Sweet corn	Popcorn	Mean	Baby corn	Sweet corn	Popcorn	Mean
60	59	61.6	58.7	**59.7**	21.4	23.2	19.5	**21.4**	82.2	91.1	84.2	**85.8**
90	66	70.5	65.5	**67.4**	24.7	26.1	22.7	**24.5**	93.0	103.0	95.9	**97.3**
120	74	81.0	73.0	**76.1**	26.9	29.8	26.2	**27.6**	101.2	114.8	105.6	**107.2**
Mean	**66.5**	**71.0**	**65.7**		**24.3**	**26.4**	**22.8**		**92.1**	**102.9**	**95.3**	
	S.Em±		CD (p = 0.05)		S.Em±		CD (p = 0.05)		S.Em±		CD (P = 0.05)	
Nitrogen levels (kg ha^{-1})	1.45		4.36		0.68		2.05		2.85		8.56	
Types of corn	1.45		4.36		0.68		2.05		2.85		8.56	
N x C	2.52		NS		1.18		NS		4.94		NS	

Table 4.24 Nitrogen response of speciality corn as influenced by different levels of nitrogen

Treatment combinations	**Nitrogen response (kg of cob or kg of grain per kg of nitrogen)**
C_1N_1	56.45
C_1N_2	47.38
C_1N_3	38.96
C_2N_1	106.36
C_2N_2	78.81
C_2N_3	62.97
C_3N_1	33.24
C_3N_2	23.20
C_3N_3	22.13

C_1 – Baby corn
C_2 – Sweet corn
C_3 – Popcorn

N_1 – 60kg ha^{-1}
N_2 – 90kg ha^{-1}
N_3 – 120kg ha^{-1}

Table 4.25. Available nutrient status of soil (kg ha^{-1}) after harvest of speciality corn as influenced by varying nitrogen levels and types of corn

Nitrogen levels (kg ha^{-1})	**Types of corn**											
	Available nitrogen				**Available phosphorous**				**Available potassium**			
	Baby corn	Sweet corn	Popcorn	Mean	Baby corn	Sweet corn	Popcorn	Mean	Baby corn	Sweet corn	Popcorn	Mean
60	119.7	124.3	128.3	**124.1**	38.9	40.3	41.7	**40.3**	309.4	298.4	300.6	**302.9**
90	126.0	138.6	132.3	**132.3**	40.7	41.2	43.2	**41.7**	317.6	321.6	337.8	**325.6**
120	138.6	144.9	151.2	**144.9**	41.0	45.4	44.8	**43.7**	325.9	333.9	340.3	**333.3**
Mean	**128.1**	**135.9**	**137.2**		**40.2**	**42.3**	**43.2**		**317.6**	**317.9**	**326.2**	
	S.Em±		CD (p = 0.05)		S.Em±		CD (p = 0.05)		S.Em±		CD (P = 0.05)	
Nitrogen levels (kg ha^{-1})	4.65		9.13		1.25		2.45		6.50		12.74	
Types of corn	4.65		NS		1.25		NS		6.50		NS	
N x C	8.06		NS		2.17		NS		11.26		NS	

Control (sole *Pongamia* without maize) – 101.9 - 38.9 - 292.6 (available NPK respectively).
Control Vs Treatments – Significant (significance was tested by F test)

Table 4.26. Gross and Net returns (Rs ha^{-1}) and Benefit cost ratio of the system as influenced by nitrogen levels and types of corn

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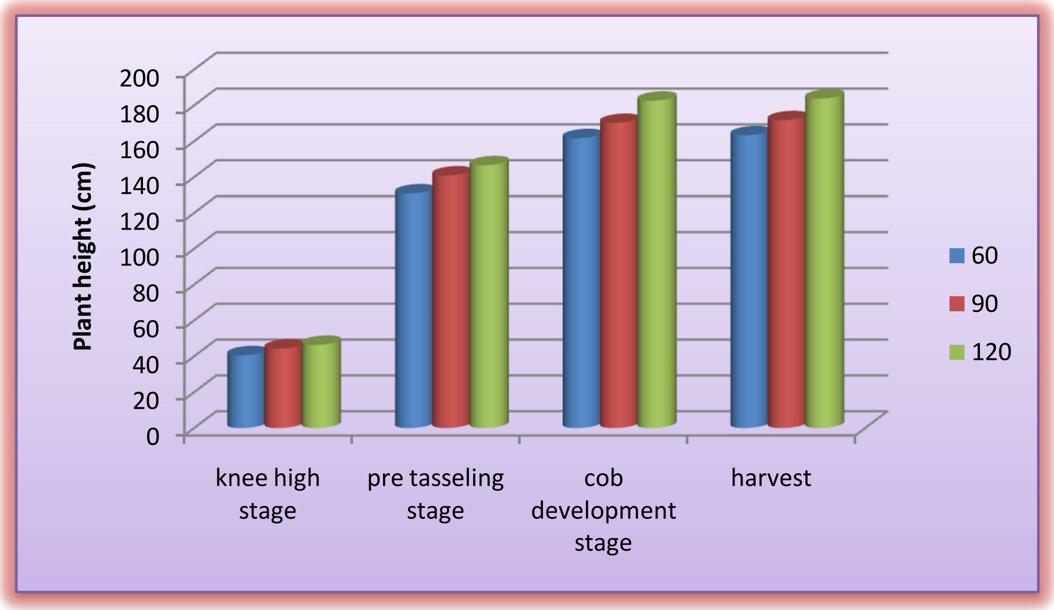
Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B: C ratio
T_1- *Pongamia* + Baby corn with N@ 60kg/ha	23158	62720	39562	1.70
T_2- *Pongamia* + Baby corn with N@90kg/ha	23549	75763	52214	2.21
T_3- *Pongamia* + Baby corn with N@120kg/ha	23941	84139	60198	2.51
T_4- *Pongamia* + Sweet corn with N@60kg/ha	21718	75503	53785	2.47
T_5- *Pongamia* + Sweet corn with N@90kg/ha	22109	83108	60999	2.75
T_6- *Pongamia* + Sweet corn with N@120kg/ha	22501	87418	64917	2.88
T_7- *Pongamia* + Pop corn with N@60kg/ha	22678	59845	37167	1.63
T_8- *Pongamia* + Pop corn with N@90kg/ha	23069	68920	45851	1.98
T_9- *Pongamia* + Pop corn with N@120kg/ha	23461	74551	51090	2.17
T_{10}- Sole *Pongamia* with out maize and nitrogen	4500	10858	6358	1.41



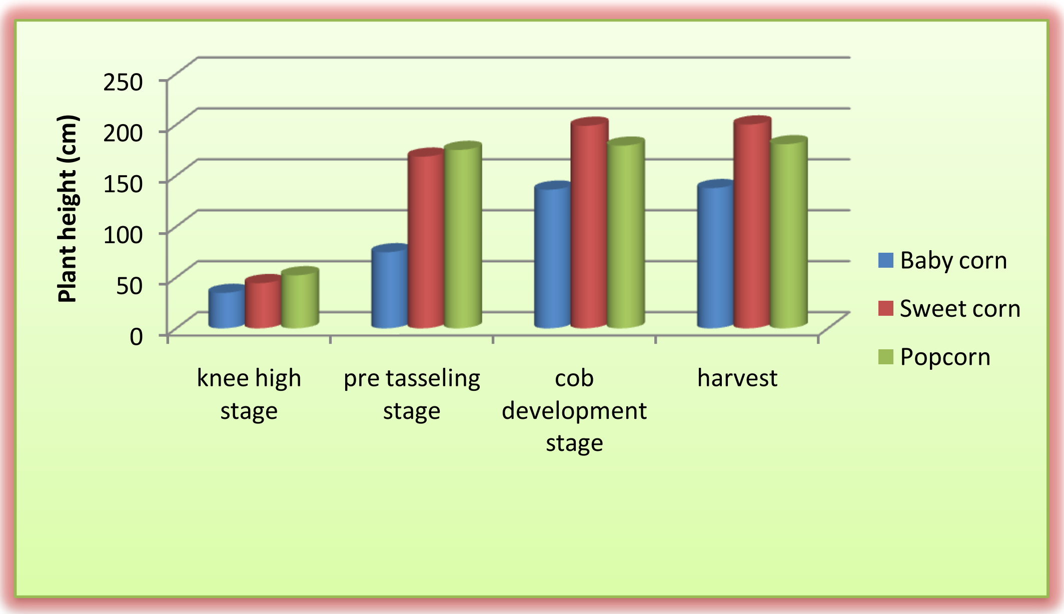
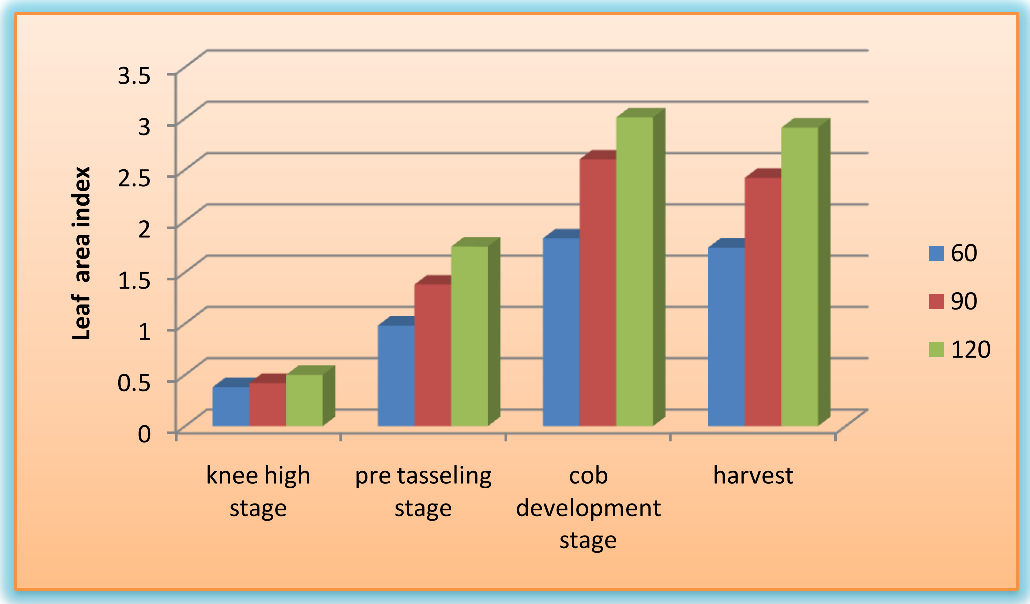


Figure 4.1. Plant height (cm) of speciality corn as influenced by varying nitrogen levels and types of corn at different stages of crop growth.



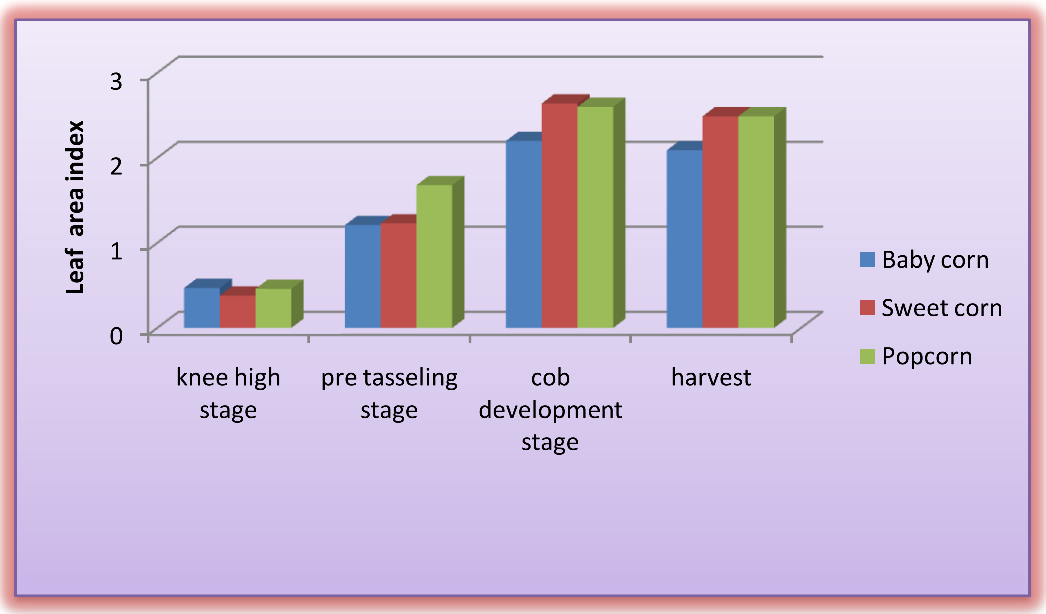


Figure 4.2. Leaf area index of speciality corn at different stages as influenced by varying nitrogen levels at different stages of crop growth.

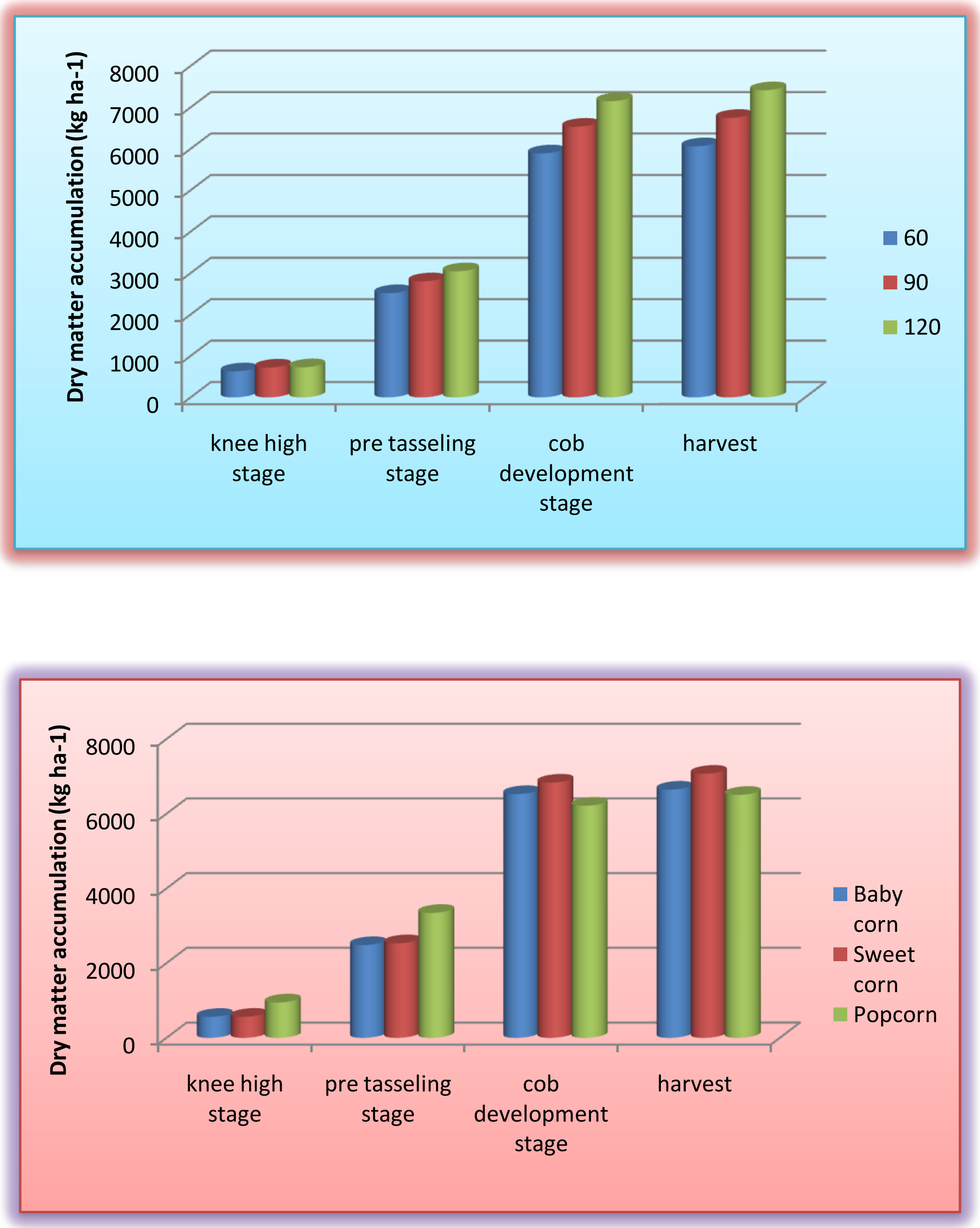


Figure 4.3. Dry matter accumulation (kg ha^{-1}) of speciality corn at different stages as influenced by varying nitrogen levels and types of corn at different stages of crop growth.

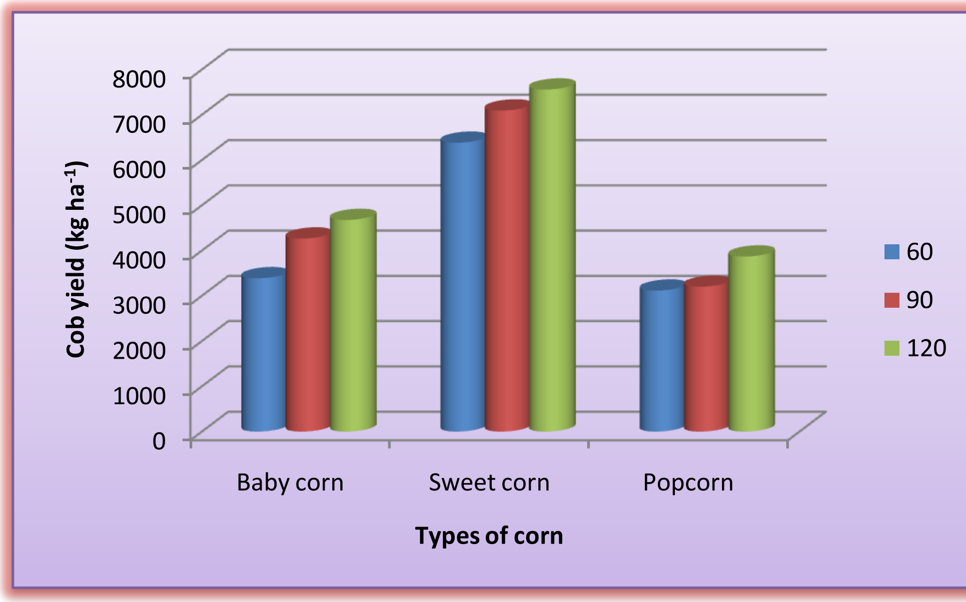


Figure 4.4. Cob yield (with husk) (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels in three types of corn.

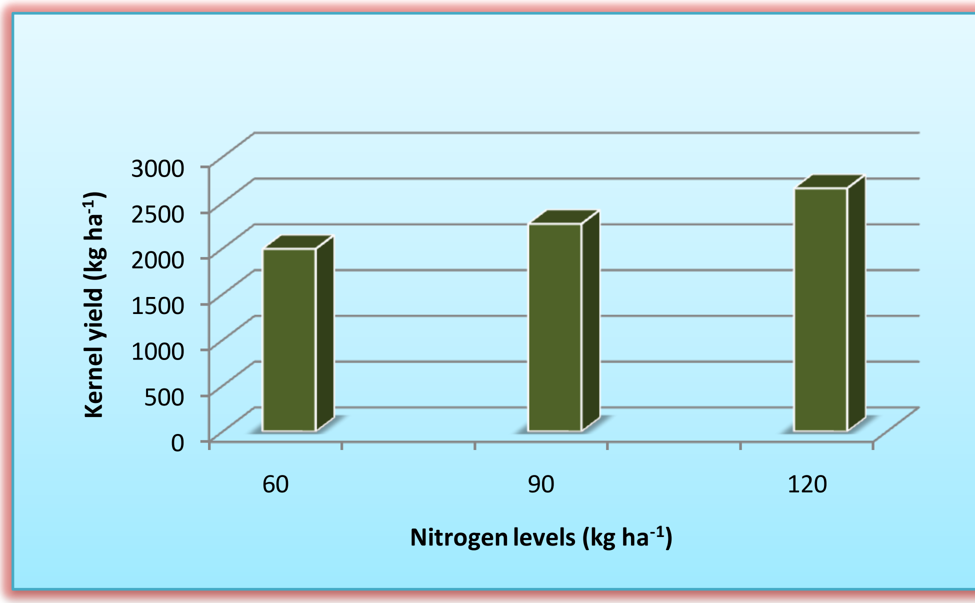


Figure 4.5. Kernel yield (kg ha^{-1}) of popcorn as influenced by varying nitrogen levels.

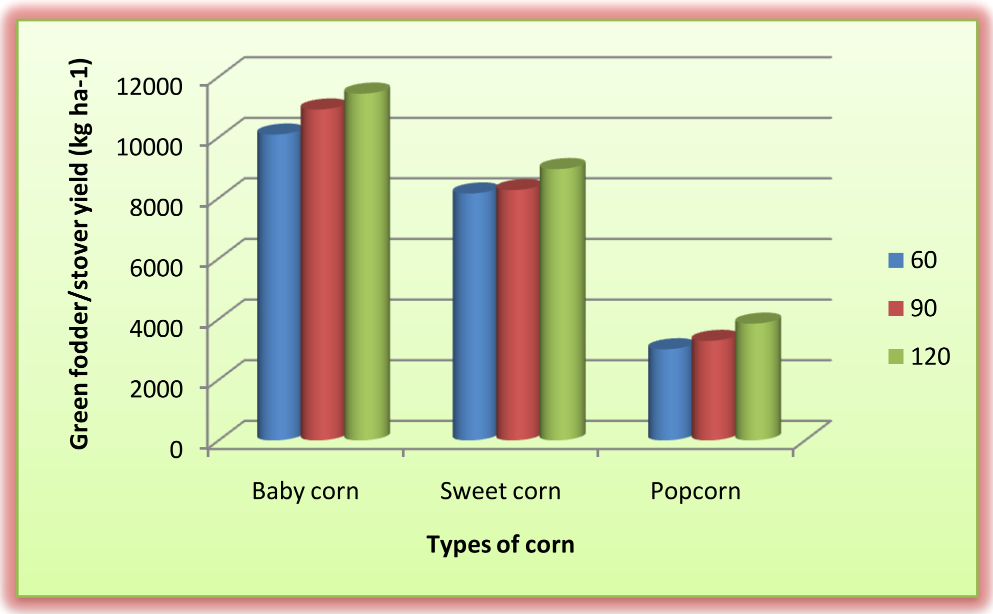


Figure 4.6. Green fodder/stover yield (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels in three types of corn.

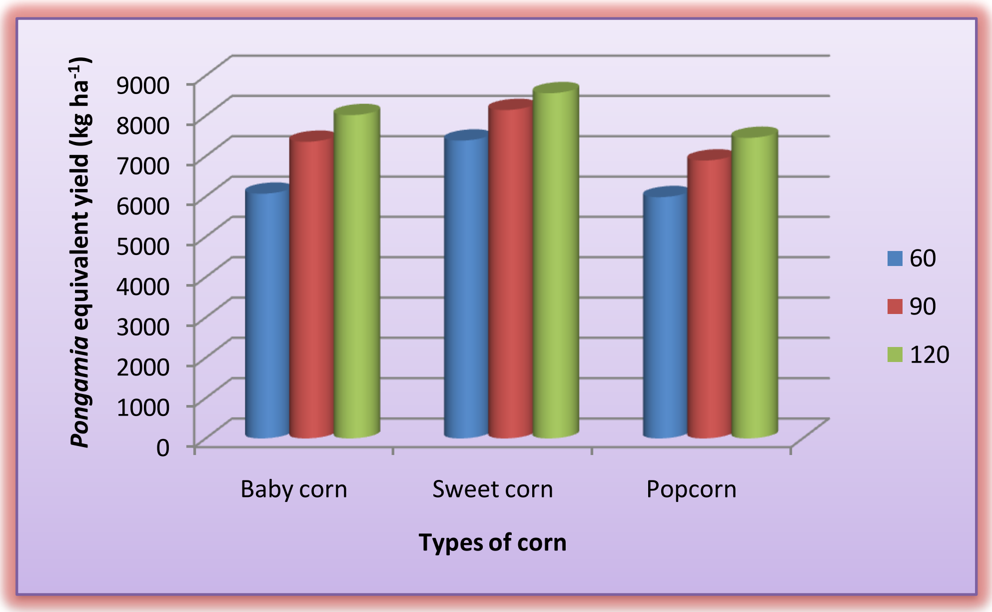


Figure 4.7. ***Pongamia*** **eqvivalent yields (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels and types of corn.**

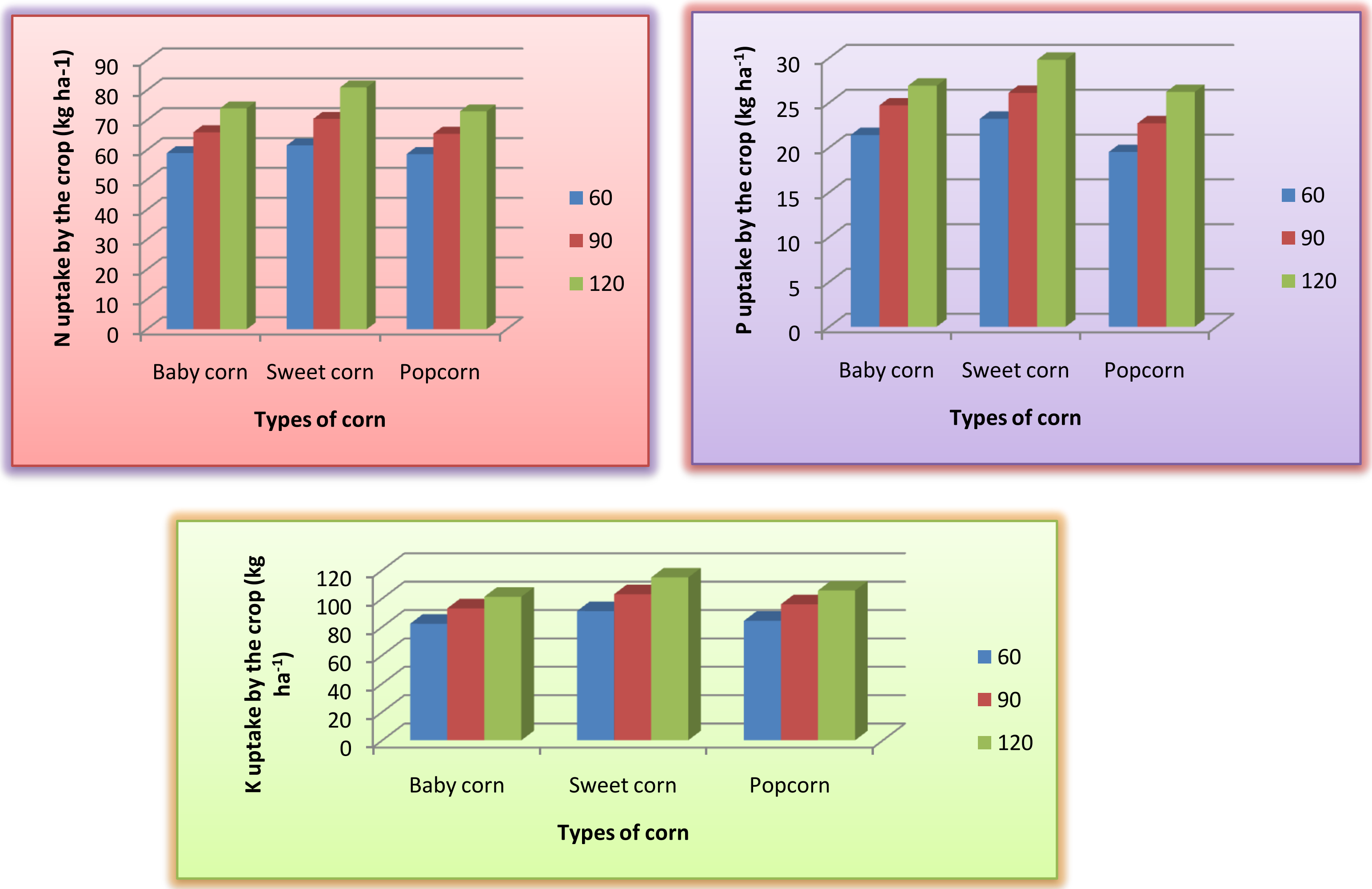


Figure 4.8. NPK uptake (kg ha^{-1}) of speciality corn as influenced by varying nitrogen levels in three types of corn.

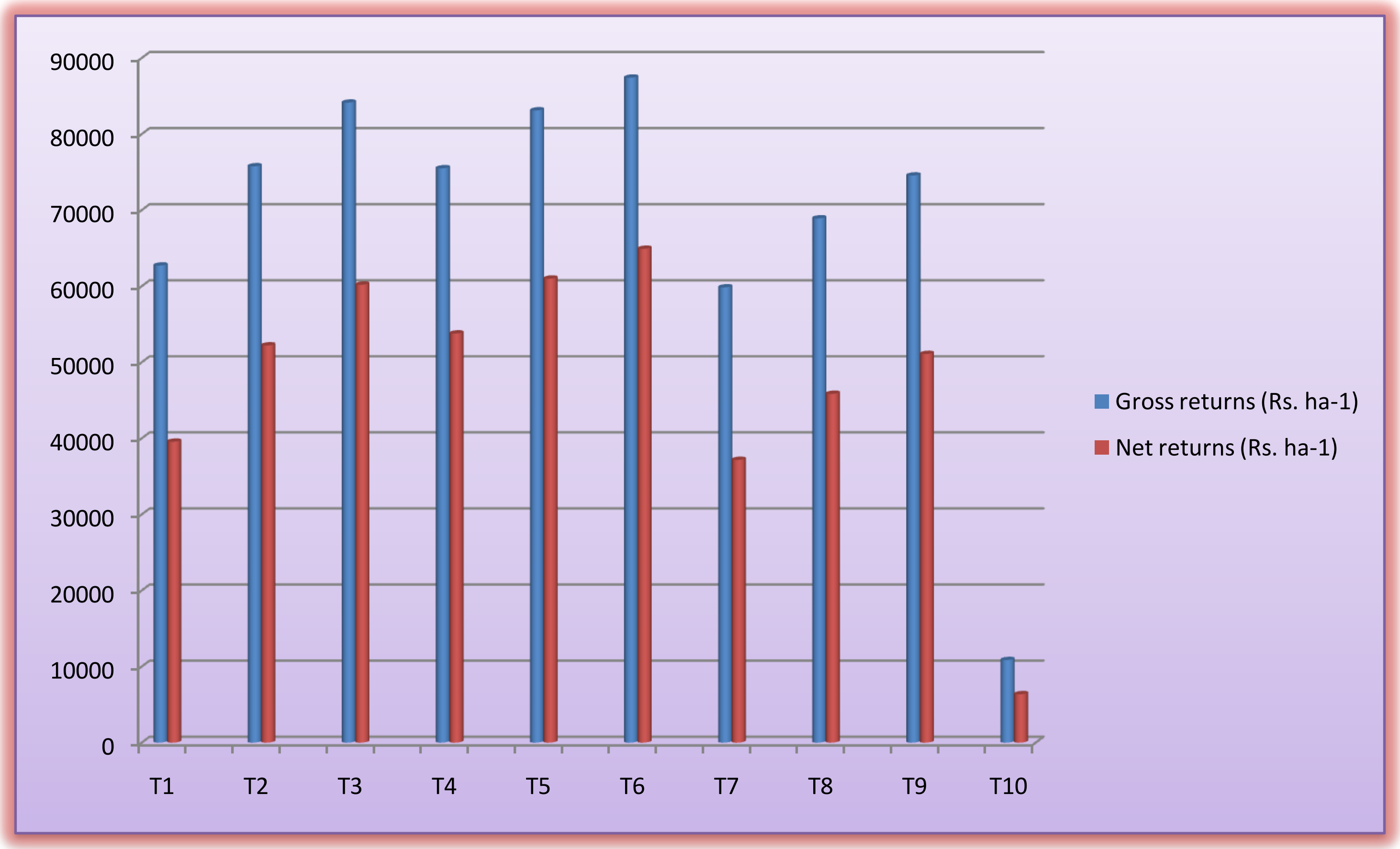


Figure 4.9. Gross and Net returns (Rs ha^{-1}) of the system as influenced by nitrogen levels and types of corn.

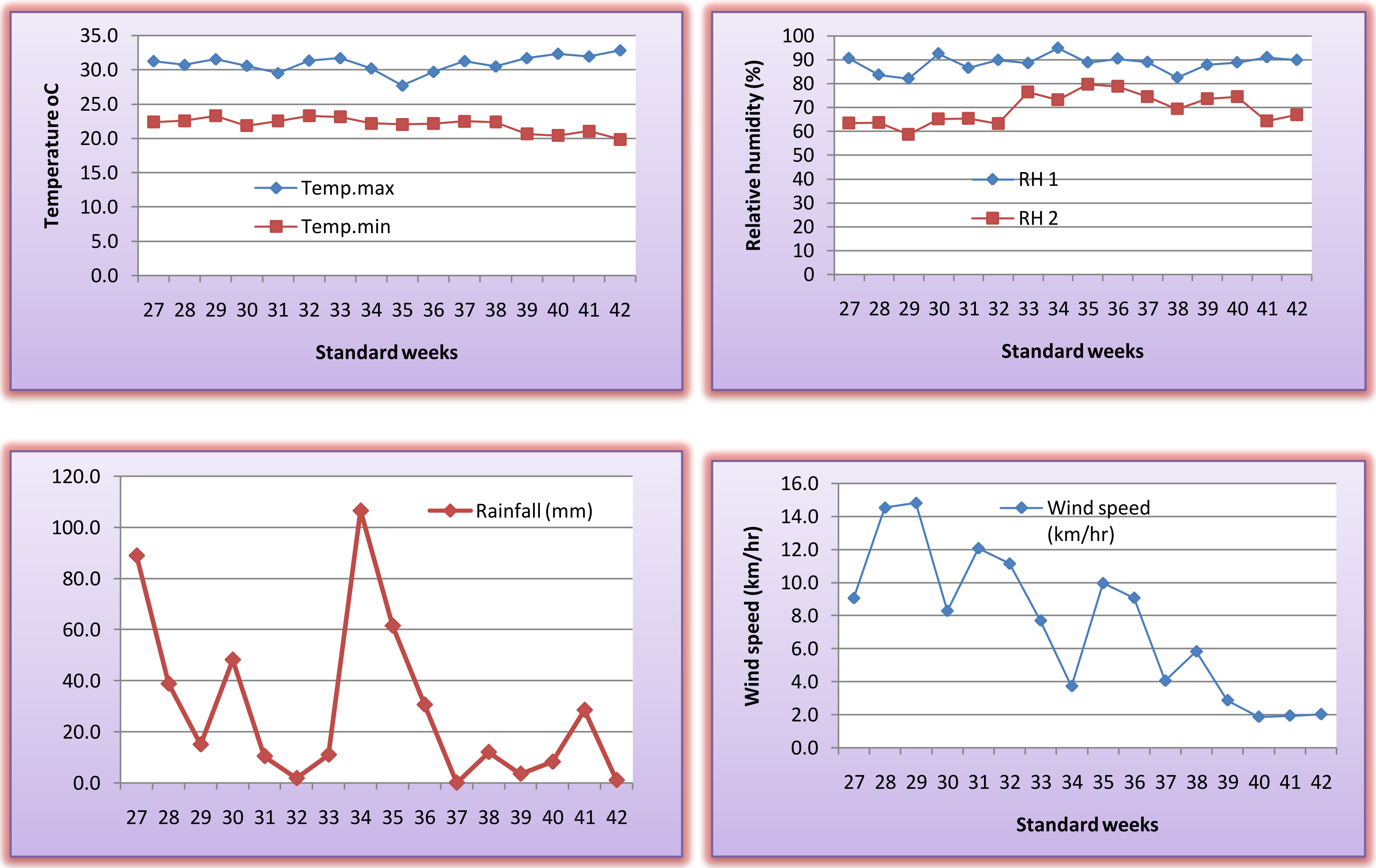


Figure 3.1. Weekly meteorological data during crop growth period (*Kharif* 2011).