

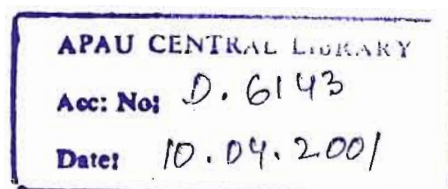
**EFFECT OF PRUNING *ALBIZIA LEBBECK* (L.)
ON YIELD AND NUTRIENT UPTAKE OF
COWPEA IN AGRI-SILIVISYSTEM**

By
MENDA GOVINDA RAO

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

MASTER OF SCIENCE IN AGRICULTURE



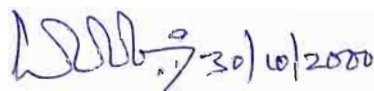
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ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
RAJENDRANAGAR, HYDERABAD - 500 030

CERTIFICATE

Mr. MENDA GOVINDA RAO has satisfactorily prosecuted the course of research and that the thesis entitled "**EFFECT OF PRUNING ALBIZIA LEBBECK (L.) ON YIELD AND NUTRIENT UPTAKE OF COWPEA IN AGRI-SILIVISYSTEM**" submitted is the result of original research work done and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for a degree of any university.

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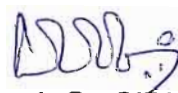
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(Dr. L.G. GIRI RAO)
Major Advisor

CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF PRUNING *ALBIZIA LEBBECK* (L.) ON YIELD AND NUTRIENT UPTAKE OF COWPEA IN AGRI-SILVISYSTEM" 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 bonafide research work carried out by Mr. MENDA GOVINDA RAO under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

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

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(Dr. L.G. GIRI RAO)

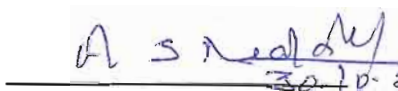
Chairman of the Advisory Committee

Thesis approved by the Student Advisory Committee

Chairman (Dr. L.G. GIRI RAO)
Senior Scientist (Agroforestry)
AICRP on Agroforestry
ANGRAU, Rajendranagar, Hyderabad-30

 30/10/2000

Member (Dr. A. SAMBASIVA REDDY)
Associate Professor
Department of Agronomy
College of Agriculture
ANGRAU, Rajendranagar, Hyderabad-30

 30/10/2000

Member (Dr. B. SREEMANNARAYANA)
Senior Scientist (Soil Science)
AICRP on Agroforestry
ANGRAU, Rajendranagar, Hyderabad-30

 29/10/2000

Member (Dr. L.M. RAO)
Associate Professor
Department of Plant Physiology
College of Agriculture
ANGRAU, Rajendranagar, Hyderabad-30



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(GOVINDA RAO M)

DECLARATION

I, **MENDA GOVINDA RAO** A hereby declare that the thesis entitled **"EFFECT OF PRUNING *ALBIZIA LEBBECK* (L.) ON YIELD AND NUTRIENT UPTAKE OF COWPEA IN AGRI-SILIVISYSTEM"** 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 any material contained in the thesis has not been published earlier in any manner.

Date :


(MENDA GOVINDA RAO)

ACRONYMS

AGR	: Absolute growth rate
BCR	: Benefit cost ratio
°C	: Degree centigrade
CGR	: Crop growth rate
cm	: centimetre
DAS	: Days after sowing
DAP	: Days after pruning
DR	: Diffusive resistance
dSm ⁻¹	: deci seimen per metre
EC	: Electrical conductivity
<i>et al</i>	: and others
g	: grams
g m ⁻² d ⁻¹	: gram per metre square per day
ha	: hectare
HI	: Harvest index
hrs	: hours
IGFRI	: Indian Grassland and Fodder Research Institute
K	: Potassium
kg ha ⁻¹	: Kilograms per hectare
LAI	: Leaf Area Index
LT	: Leaf temperature
m	: metre
mm	: millimetre
N	: nitrogen
NFTS	: Nitrogen fixing tree species
P	: Phosphorus
PAR	: Photosynthetically Active Radiation
pH	: Negative logarithm of hydrogen ion
q ha ⁻¹	: quintal per hectare
RH	: Relative humidity
Rs ha ⁻¹	: Rupees per hectare
SAT	: Semi Arid Tropics
Scm ⁻¹	: Seconds per centimetre
TR	: Transpiration rate
µg S ⁻¹ , cm ⁻²	: Microgram per second per square centimetre
µ mole s ⁻¹ m ⁻²	: micro mole per second per square metre
viz	: namely
%	: per cent

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ABSTRACT

Field investigation entitled "Effect of pruning *Albizia lebbbeck* (L.) on yield and nutrient uptake of cowpea in agri-silvisystem" was conducted at Agroforestry Research Division, ANGRAU, Rajendranagar, Hyderabad during *kharif*, 1999. The experiment was laid out in a randomized block design comprising of 10 treatments and replicated thrice. The different treatments included, sole cowpea (T₁), Tree without crop and without pruning (T₂), Tree with crop and without pruning (T₃), coppicing at ground level (T₄), coppicing at 30 cm (T₅), coppicing at 60 cm (T₆), Pollarding at 1.5 m (T₇), pollarding at 2.0 m (T₈), pollarding at 2.5 m (T₉) and lopping (T₁₀).

Sole cowpea (T₁) produced significantly higher seed yield of 9.56 q ha⁻¹, whereas lower seed yield of 3.02 q ha⁻¹ was with cowpea intercropped with unpruned tree (T₃). This was mainly due to significantly more number of pods per plant (8.65), seeds per pod (8.87), 1000 seed weight (81.82 g), leaf area index (1.34 and 1.20), PAR (1733 and 1681 μ mole s⁻¹ cm⁻²), dry matter production (8.97 and 15.07 g plant⁻¹) and crop growth rate (8.18 and 6.68 g g⁻¹ m⁻²) at 60 DAS and at harvesting stage, respectively.

Cowpea grown in T₁ followed by T₆ treatment and T₃ followed by T₁₀ treatment obtained maximum and minimum uptake of N,P and K. Soil pH values were greater and lower in T₁ and T₃, respectively before cropping. Similar was the

trend in T₁ and T₁₀ treatments after cropping. The treatments T₁ and T₂ were superior and inferior in soil EC values whereas in case of available N, P₂O₅ and K₂O in soil, this trend was seen in T₂ and T₁ treatments. Similarly, higher and lower soil moisture was associated with T₂ and T₃ treatments, respectively.

The treatment T₈ proved to be better in recording more number of branches per tree (7.6), girth at breast height was more in unpruned condition (T₃) than under pruned treatments. Comparatively wood and leaf biomass was higher in T₇ treatment i.e. pollarding at 1.5 m height (40.37 and 3.34 q ha⁻¹). The treatment T₆ where coppicing was done at 60 cm height, realised considerably higher gross (Rs. 11,048 ha⁻¹) and net returns (Rs. 6278 ha⁻¹) with higher benefit-cost ratio of 1.32. Positive correlation was noticed between seed yield and yield attributes, NPK uptake, dry matter production, plant height (60 and 90 DAS), PAR, TR (30, 60 DAS), LAI and CGR.

These results indicated that T₆ treatment, where coppicing was carried out at 60 cm height gave higher gross and net returns and benefit-cost ratio and considered as remunerative practice in an agri-silvisystem involving *Albizia* as tree and cowpea as an intercrop.

INTRODUCTION

CHAPTER I

INTRODUCTION

The semi-arid tropics (SAT) in India hold an important position constituting about 43 per cent of total geographical area and 64 per cent of net cultivated area occurring in diverse agro-ecological regions. It caters the needs of about 400 million human and 276 million live stock population.

The requirement of food grain by 2015 is projected as 232-235 million tonnes as against the present level of 200 million tonnes (Survey of Indian Agriculture, 2000) out of which atleast 100 million tonnes have to be produced from drylands only. The requirement of dry and green fodder by the turn of the century would be 949 and 1136 million tonnes, while the supply is expected around 367 and 595 million tonnes respectively (Hegde, 1990). According to Lal (1990), the fuel wood consumption in the country is to a tune of 235 million m³.

The shortage of fuel wood and the resultant high price have lead to the practice of burning cow dung cakes which otherwise could have been effectively utilised as a source of organic manure in increasing the food grain production. Although the forest area was estimated to be around 22.8 per cent of the total geographical area, the present productive and effective forest cover as per Satellite imagery was around 11.5 per cent of the total land area. This amounts to the per capita forest area of 0.66 ha as against the world average of 1.6 ha (Deb Roy and Gill, 1990). To overcome these deficits and avoid risk in arable cropping, proper integration of trees with field crops seems to be one of the better options.



Agroforestry is a land use system wherein trees or shrubs are grown in association with agricultural crops, pastures or livestock in which there exists both ecological and economic interactions between trees and other components. This has much to offer in checking the process of land degradation on one hand and in providing the needed products of food, fodder, fuelwood, timber etc., on the other.

Trees constitute a very important component in life support systems in semi-arid areas. Arable crops grown in these regions cover the land generally for about three to four months only. Rainfall received during the uncropped period in alfisols can be effectively utilised by the perennial vegetation. In addition, these soils are generally deficient in plant nutrients, particularly nitrogen. Hence land use system which includes a perennial component, preferably a legume, would be the most appropriate proposition in such regions. Agroforestry system involving nitrogen fixing tree species (NFTS) helps in building soil fertility through leaf litter fall, fixation of atmospheric nitrogen and in recycling the nutrients from lower soil layers to surface soil. Cowpea (*Vigna unguiculata* walp) among legume crops, assumed predominant position in the rainfed regions of SAT (Vandenbeldt, 1990), Thus, there is need to study the association of such crops along with promising NFTS like *Albizia lebbeck* (L.) Benth.

Albizia lebbeck is the one such NFTS, capable of fixing atmospheric nitrogen, having 20.2 per cent of crude protein, 3.2 per cent nitrogen in leaf and giving 36 t ha⁻¹ of green leaf material (Chakravarty *et al.*, 1978) and having good coppicing and pollarding ability (Sreemannarayana *et al.*, 1994a)

Agri-silviculture is the conscious and deliberate use of land for the concurrent production of agricultural and tree crops. The productivity of arable crops under agri-silvisystem during the first year was not affected by trees but later the crop productivity decreased year after year due to shade and other factors. However, the effect can be minimised to certain extent by adopting pruning techniques which will allow interception of sufficient radiation to crops for efficient photosynthesis. Tree canopy could be managed through various pruning practices such as lopping, pollarding and coppicing. The yield of crops whether the tree or arable crops are dependent on the radiant energy which they intercept. Since the information with reference to pruning effect on different field crops when grown along with multipurpose tree species is not available, the present studies were contemplated with the following objectives.

1. To evaluate cowpea performance under different pruning practices.
2. To study the nutrient uptake of cowpea in relation to pruning practices
3. To study comparative soil moisture status in different treatments.
4. To study the growth pattern of stumps in different treatments.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1 CONCEPT OF AGROFORESTRY

Agroforestry by its virtue is both an integrative and interactive discipline. It covers the domains of traditional production oriented agronomy and forestry. Its scientific premises and principles are based on various disciplines viz., soil science, plant physiology and others that are basis to all land use systems.

The International Council for Research in Agroforestry (ICRAF) at Nairobi, Kenya undertook a global inventory of existing agroforestry systems and practices. The definition of agroforestry as coined by ICRAF was "It is an interdisciplinary approach to different systems of land use based on crop production, forestry, animal husbandry including pastures, aquaculture, fisheries and land resource management etc. (ICRAF, 1983). Several other definitions were advocated by authors suggested on agroforestry and research. Bene *et al.* (1977) opined that agroforestry as a sustainable management system for land that increases overall production combined with agricultural crops, tree crops and forest plants and/or animals simultaneously or sequentially and applied management practices that were compatible with the cultural patterns of local population.

Agroforestry is a sustainable land management system which increases the overall productivity of land, production of crops (including tree crops) and forest plants and/or animals simultaneously in the same unit of land while applying management practices that are compatible with cultural practices of local population (King and Chandler, 1978).

According to Lundgren (1982) "Agroforestry is a collective name for land use system and technologies in which woody perennial including trees, shrubs, bamboos etc. are deliberately combined on the same land management unit with herbaceous crops and/or animals either in same form of spatial arrangement or temporal sequence. In agroforestry system, there are both ecological and economical interactions amongst different components". Nair (1984) defined agroforestry as a land use system that involves deliberate introduction or mixture of trees or other woody perennials in crops / animal production to derive benefit from the resultant ecological and economic interactions.

2.2 PERFORMANCE OF ANNUAL CROPS UNDER TREES

2.2.1 Seed yield

The nitrogen fixing tree species (NFTS) play a vital role in agroforestry because of their ability to fix atmospheric nitrogen and benefit the associated crops, as their nitrogen requirement was met partially by trees. About 640 leguminous tree species were identified to fix nitrogen (Haliday and Nakao, 1982). It was found that the yield of green gram and cluster bean were minimum under unlopped situation with 8 year old *Holoptelea integrifolia* spaced at 5 x 5 m (Paroda and Muthan, 1979).

Venkateshwarlu (1980) found that castor yields were improved under the *Leucaena leucocephala*. It was reported that the *Leucaena* + maize intercropping was encouraging and yield levels were maintained at reasonable level with no additional input on sandy loam soils (Wilson and Kang, 1981). It was reported that the yield of arable crops could be increased by 56 per cent in Eastern Ethiopia

under NFTs (Peter Poschen, 1986). Similarly, increased yield of castor was recorded by integration of nitrogen fixing trees (Sankarnarayan *et al.*, 1987). It was reported that the redgram grown in association with *Albizia lebbeck* of 11-12 yrs old produced significantly higher grain yield under 50 cm deep trenching lopping as compared to deep trench and lopping and control when followed separately at Jhansi (AICRPAF, 1989).

Balasubramaniam (1989) observed higher grain yield of pearl millet and sorghum with *Leucaena*. Grain yield of maize and cowpea were reduced by 340 and 46 kg ha⁻¹ respectively in an agri-silvisystem (Lal, 1989).

Jama and Getahum (1991) noticed that the yield of maize was 24-76 per cent more under alley cropped plots as compared to sole crop. Rosecrance *et al.* (1992) reported that the maize yield decreased by 34 per cent in the row spaced 40 cm from *Sesbania* hedge. Increasing the distance away from the hedge to 60 cm and coppicing the hedge significantly improved grain yield. Grain yield decreased by only 10 per cent in the row closest to the trees.

Keshwa and Singh (1993) reported poor performance of pearl millet under *Acacia tortilis* as compared to that under *Albizia lebbeck*. Pathak (1994) reported that the cotton yield in association with *A. lebbeck* (288 kg ha⁻¹) was significantly higher than with *Sesbania sesban* (216 kg ha⁻¹). Maize grain yields were enhanced by 0.68 t ha⁻¹ when grown as intercrop between *Glyricidia* hedge as compared to sole crop at claveria (Agues *et al.*, 1994).

✓Sreemannarayana *et al.* (1994b) observed that the yield reduction was 23.8, 9.6, 3.3 and 0.08 per cent over sole crop in sunflower, redgram, jowar and

castor crops respectively in the rows adjacent to fruit trees (Tamarind and Phalsa). It was reported that the yield of sorghum was reduced by 18 per cent when sown at 0-3 m away from the tree (Tilander et al., 1995). Yield of redgram (6.35), sunflower (6.8), castor (22.3) and sorghum (12.5 q ha^{-1}) under *D.sissoo* were lower than those obtained under sole crop. Similarly, with respect to subabul also, the seed yields followed the same trend as that of under *D.sissoo* (Sreemannarayana et al., 1996). Similar trend was observed in case of *Azadirachta* and *Acacia* on yield reduction of horsegram in another agroforestry study conducted by Basavaraju and Rao (1997).

Newman et al. (1998) reported that the yield of summer maize and beans were significantly reduced when intercropped in paulownia as compared to control the yield of field crops growing in the vicinity of the *L. Leucocephala* tree was significantly reduced. It was suggested that the reduction in crop yield could be minimised by proper pruning and lopping and can be compensated by standing biomass of tree (Prasad and Prasad, 1997). It was reported that the yield of chilli, brinjal, cauliflower and okra were significantly low when grown under the shade of subabul than under normal (Shukla et al., 1997). Viswanath et al. (1997) reported higher cowpea yield where *Sesbania* was pruned at a height of 1.5 m than when they were pruned at 1.0 and 0.5 m height.

Bheemaiah et al. (1998) reported that pod yield of groundnut was higher with sole crop (2161 kg ha^{-1}) compared to intercropping (1348 kg ha^{-1}) with subabul. Grain yield of maize when intercropped with *L.leucocephala* was decreased by 383 kg ha^{-1} (Chamshama et al., 1998). It was also reported that under *F.albida* the grain yield of maize was increased by 25 kg ha^{-1} as compared to sole maize.

Duguma *et al.* (1998) reported that the grain yield of maize and cowpea was higher with increasing pruning frequency and decreasing pruning height of hedge row trees in alley cropping. It was reported that the pod yield of groundnut under alley cropping was 324 per cent more than the pod yield obtained under intercropping (Endrias Hebana, 1998). Hocking and Islam (1998) reported that pruning of roots and branches of trees significantly increased grain yield of rice by amounts proportionate to the intensity of root or top pruning.

Narain *et al.* (1998) reported severe yield reduction ranging from 21 to 92 per cent for wheat, 59-65 per cent for maize and 50 per cent for turmeric when they were grown in association with eucalyptus and *Leucaena* at Dehradun. Intercropping of maize with paulownia plantation gave 63 per cent less seed yield (207 g m^{-1}) as compared to sole maize (646 g m^{-1}). Similarly, intercropping beans produced 29 g m^{-2} less seed yield than sole beans of 79 g m^{-2} (Newman *et al.*, 1998). Osman *et al.* (1998) observed that sorghum and cowpea gave higher dry matter and LAI when grown in association with pruned trees. The yield reduction was to the tune of 61 and 74 per cent in case of sorghum and cowpea, respectively, when intercropped in unpruned trees.

Grain yield of wheat showed significant reduction with increase in pollarding height. It decreased by 11.3 per cent with increase in pollarding height from 1.5 to 3.0 m and 7.21 per cent from 3.0 m to 4.5 m at solan (AICRP AF 1997-99). It was reported that the maximum yield of cowpea was obtained in sole crop (9.7 q ha^{-1}) followed by coppicing at 60 cm (9.0 q ha^{-1}) while the lowest yield was obtained in crop + tree without pruning in *Albizia lebbbeck* Agri-silvisystem (AICRP AF, 1998-99).

Dhyani and Tripathi (1999) observed depressed yields in linseed and soybean when intercropped with *Albizia* and cherry.

Joseph *et al.* (1999) reported that during the first year of experimentation, there was no interference from *Albizia lebbbeck* on growth of sunflower. During the third year, however, maximum yield was obtained in sole crop followed by coppicing and pollarding treatments, while the maximum yield loss was recorded in tree without pruning to the tune of 27.5 per cent.

2.2.2 Growth parameters/ Biometric observations

Leihnar *et al.* (1996) reported that the crop growth rate (CGR) and leaf area index (LAI) values were significantly higher in sole maize than alley cropped maize in *Leucaena* while CGR and LAI values reached maximum at 70 and 60 DAS, respectively. Madhusudan (1997) observed significant decrease in plant height, dry matter production, CGR and LAI of castor when grown in integration with *Leucaena leucocephala* than sole castor on sandy loam soils of Hyderabad. It was reported that the morphology and specific leaf weight of maize and beans were significantly reduced when intercropped in paulownia as compared to control (Newman *et al.*, 1998). Chamshama *et al.* (1998) reported that the height of maize intercropped with *L. leucocephala* trees was decreased by 42.9 per cent. In comparison plant height under *F. albida* was enhanced by 19.7 per cent as compared to sole maize. Kanchana (1998) reported that the plant height and dry matter in groundnut when intercropped with *F. albida* was superior than sole crop. LAR in both cropping systems did not differ significantly. But leaf area and CGR were inferior in intercropping than under sole crop. It was noticed that there was 28.6 to 54.7 per cent reduction in plant height when it was grown under mango shade (Maneesh *et al.*, 1998).

2.2.3 Physiological parameters

Unlike water and nutrients, light is a source of energy that cannot be stored for later use. In situations where water and nutrients are not limiting factors, the rate of dry matter production by crop is primarily determined by the amount of solar radiation intercepted by its foliage. The amount of light intercepted by an agroforestry system depends on the amount of incident light and the fraction of light intercepted through the system to the soil surface. Shading affected understorey crops by reducing temperature, both in quantity and quality of light (Monteith *et al.*, 1989).

Hazra and Tripathi (1986) reported that the mean photosynthetically active radiation (PAR) availability under *Albizia lebbeck* to be in the order of 60-68 per cent of full radiation for the annual crops grown under these trees. Corlette *et al.* (1989) reported that the canopy temperature in alley cropped pearl millet as well as sole crop was similar in the early stage of crop growth. Light interception was reduced in the alley cropped plots compared to sole crop throughout the crop growth. It was reported that canopies of *Acacia tortilis*, *Hardwickia binata*, *Albizia lebbeck* transmitted maximum amount of PAR (55-60 %) in all the months, whereas the canopy of *L.leucocephala* transmitted only 30 per cent PAR during crop growth period of under storey crops (Misra and Bhat, 1994).

Vani (1995) observed that with *F.albida*, castor crop situated away from tree had more transpiration rate and radiation interception but less stomatal diffusive resistance. Miah *et al.* (1995) reported low reduction in light incidence of rice and mungbean (3-10 %) in the pruned alleys and severe reduction (53- 59 %) in the unpruned alleys. Pruning improved the light availability to maize at ear height by 36 per cent and allowed 52 per cent more light to penetrate to the 15 cm height



of maize plants. Maize plants on the second row from the unpruned hedges received more light than the first row maize but this was reversed with hedge pruning, especially for light reaching the 15 cm height of maize plants (Ssekabembe *et al.*, 1997). Bheemaiah *et al.* (1998) observed that the leaf temperature and photosynthetically active radiation (PAR) values were very low under intercropping whereas the sole crop had higher PAR values in groundnut. The other parameters such as relative humidity and diffusive resistance were higher under tree canopies resulting in lower transpiration rates. Gaddanakeri *et al.* (1998) deduced that reduction in the seed yield of sunflower was due to competition for light interception when alley cropped with *L.leucocephala*.

It was noticed by Kanchana (1998) that groundnut with *F.albida* had more transpiration rate, while diffusive resistance was same but PAR, recorded was less as compared to sole cropped groundnut. Madhusudan (1997) reported that alley cropped castor had higher transpiration rate and low diffusive resistance than sole castor. Endrias Hebana (1998) reported that the leaf temperature of groundnut at 90 DAS was not influenced significantly in both alley cropping and intercropping with *A. lebbeck* but intercropping had significantly higher RH (45.41 %) over alley cropping (41.43 %) and alley cropping had higher PAR ($1663.72 \mu \text{ mole s}^{-1} \text{ cm}^{-2}$) over inter cropping ($120.20 \mu \text{ mole s}^{-1} \text{ cm}^{-2}$).

It was reported that the leaf temperature, PAR and transpiration rate were significantly decreased in *Leucaena* based agri-silvisystem over sole blackgram crop. It was also observed that the photosynthetic rate, light intensity and DR of sorghum grown under *Leucaena* were adversely affected except for the sorghum grown under pollarded plants (CRIDA, 1998-99).

2.2.4 Uptake of nutrients by crops

Hazra and Tripathi (1986) reported that nitrogen uptake by crop was increased with increasing 'N' application dose under *A.lebbeck*. It was noticed that there was reduced NPK uptake by sole maize over hedge row crops (Yamoah *et al.*, 1986).

Szott *et al.* (1991) conducted research on alley cropping with three tree species i.e., *Leucaena leucocephala*, *Erythrina* sp., *Inga dulcis* with rice at upper Amazon basin. It was reported that in all the species, treatments at the same mulch level, uptake of N and K was appreciably increased but 'P' uptake did not vary significantly from the control. Vani (1995) reported that the uptake by intercropped castor in association with *F.albida* was superior to sole castor. It was reported that the nitrogen and phosphorus uptake at harvest of associated annual crops (sorghum and cowpea) was higher and almost similar in sole crops and that under *F.albida* followed by *Acacia ferruginea* and lowest in *A.lebbeck*, while the N and P contents in the annual crops were higher under tree species compared to respective sole crop situation (Suresh, 1996). Sreemannarayana *et al.* (1996) noticed that the NPK uptake of redgram, sunflower, castor and sorghum was low in first, second and third rows but significantly higher in rows away from the trees viz., *L.leucocephala* and *Dalbergia sissoo*. Madhusudan (1997) reported that the N and K uptake of castor was significantly higher in *Leucaena* alley cropping system than sole cropping. But 'P' uptake was not significantly influenced by two cropping systems. It was noticed that the uptake of nitrogen, phosphorus and potassium in groundnut in alley cropping was 61.82, 6.46 and 54.83 kg ha⁻¹ respectively which was significantly superior to inter cropping (Endrias Hebana, 1998). In intercropping of groundnut

with *F.albida*, it was observed that there was higher uptake of NPK as compared to sole cropped groundnut (Kanchana, 1998). It was also reported that the total uptake of N and K in wheat decreased with increasing pollarding height whereas P uptake did not show any significant difference at 3.0 and 4.5 m cutting heights (AICRP AF, 1997-99).

2.3 SOIL MOISTURE STATUS AS INFLUENCED BY AGROFORESTRY SYSTEMS

Moisture, nutrients and light ^{ARE} were considered to be critical factors influencing productivity of agroforestry systems. Among the three factors, moisture assumed greater importance in areas with low and erratic rainfall, especially in semi-arid regions.

Trenbath (1974) opined that component crops in a crop mixture may exploit different soil layers. Thus in combination they may exploit a greater total volume of soil. This was considered as the cause on yield advantage in mixtures of varieties and suggested that such differences in rooting pattern could occur because of the mutual avoidance of different root systems.

Sanchez (1976) observed that the above ground and below ground crop competition affect each other and a heavily shaded plant will develop weaker root system that will absorb less water and nutrients. Prajapathi *et al.* (1971) noticed maximum root distribution of *Prosopis juliflora* at 0 to 5 m from the hedge in the top 0 to 20 cm of soil. Increase in soil moisture content both with depth and distance from hedge was in confirmity with the decreasing order of root competition for moisture resulting in increasing order of yield.

Young (1989) reported that the trees with a vigorous root system and high water requirement may deprive adjacent crop of moisture, but in other circumstances, trees (acting as wind breaks) may have the effect of increasing the moisture available to plants close to them.

Direct competition for soil moisture was demonstrated in wind breaks in both temperate (Kort, 1988) and semi-arid regions (Vandenbeldt, 1990). Recent evidence for competitive extraction of water was suggested for agroforestry park lands and range lands (Belsky *et al.*, 1989).

Several studies of agroforestry system in the semi-arid regions of India showed that trees can compete strongly with crops for water. In some cases, losses in crop yield due to competition from trees were much higher than expected (Ong *et al.*, 1990).

Various agroforestry studies involving mixtures of trees and crops either as spatial mixed or spatial zoned indicated competition between the tree and crop components. The competition was more near the tree and decreased with increasing distance. All the tree species tested were seen competing with the crop, but the degree of competition varied with tree species (Itinal, 1987 and Bhat, 1988). Korwar (1992) reported that soil moisture content at all growth stages of field crops was highest in sole crop than under *Hardwickia* tree and lowest in Eucalyptus under dry land conditions.

In vertisols, available water capacity for 0-20 cm depth under the trees of *F.albida* was in general 1.5 to 2 times more than outside the tree and this was

attributed to the observed higher organic matter which might have enhanced the available water supply (Kamara and Haque, 1992).

Rao *et al.* (1991) found that crop yields were suppressed by *Leucaena* due to competition for moisture in alley cropping. It was noticed that the available water in 1.25 m depth of soil under alley cropping was lower than maize alone (Govindrajan *et al.*, 1996). Korwar and Radder (1997) concluded that although alley cropping increased organic carbon by 21 per cent and available 'N' by 19 per cent at the time of sowing, it did not result in increased crop yields because of competition for water between hedge rows and crops as indicated by reduction in soil moisture in alley cropping.

As reported by Isola *et al.* (1998) at Ibadan, soil moisture was higher under the alley cropping than in open field. Suresh and Rao (1998) reported favourable soil moisture status during all stages of the crop growth in sole crop followed by that under *F.albida*, *A.ferruginea* and *A. lebbeck*. It was noticed that the competition for soil moisture during the sorghum crop growing season was intensive except for pollarding treatment in Agrisilvicultural system (CRIDA, 98-99).

2.4 CHANGES IN SOIL FERTILITY

The leguminous trees exert great influence in building up soil N, soil organic matter. Some of them also help in improving other soil nutrients through leaf litter additions. By introducing these trees, the physical and chemical properties of the soils are improved to a great extent.

Soil fertility studies conducted by Singh and Lal (1969) under 14 year old tree communities of *Prosopis cineraria*, *P.juliflora* and bare site indicated that there was an overall improvement in soil fertility under the trees.

Studies with 12 year old tree plantations showed that organic matter, total nitrogen, P_2O_5 was high in *Prosopis cineraria* plantations at 0-15 cm depth compared to sole cropping (Agarwal *et al.*, 1975). Radwanski and Wickens (1981) found higher organic carbon, nutrient content, CEC and base saturation under tree canopies than in adjacent open land.

✓ Misra and Prasad (1980) indicated that the soil N and P increased, while K decreased after harvesting groundnut and sesamum under teak and sissoo agri-silvisystem.

Hazra (1987) after several years of study reported that the field capacity, organic carbon, CEC, available N, P and K content of soils were tremendously improved, while the pH, EC values were decreased under agroforestry systems.

Kamara and Haque (1992) observed that N, P and K levels were higher under tree canopy than out side. Soil fertility improvement was evident with intercropped maize in *Leucaena leucocephala* after two seasons of association, wherein it was found that the soil had a pH of 5.0, total organic carbon (1.95 %) and total nitrogen (0.38 %), compared to values of 6.00 0.87 and 0.05 per cent under monocropping for the three parameters respectively (Khonje, 1989).

Singh *et al.* (1989) noticed decrease in soil pH and electrical conductivity and increase in organic carbon and available 'N' content of the soil under lopped *Prosopis juliflora*, *Leptochloa fusa* agroforestry system. The intercropping experiments

with *F.albida* and *D.sissoo* revealed that besides enhancing the associated crop yields both the trees improved soil fertility (Bheemaiah *et al.*, 1992). The enhanced crop production beneath the tree canopy of *F.albida* was attributed to the amelioration of soil chemical, physical and biological properties by direct action of the tree (Geiger *et al.*, 1994).

Maize yields beneath the canopies of *F.albida* trees greatly exceeded than that found beyond tree canopies and this was mainly attributable to availability of nitrogen, which was 1.5 to 3 times higher beneath tree canopies than in open sites (Rhondes, 1995). There was decrease in soil pH and EC by 3-5 per cent and 10 per cent and increase in organic carbon (33.73 %) available plant nutrients (8-30 %) and exchangeable bases (7-8.3 %) under trees (Malik *et al.*, 1996).

Tripathi and Hazra (1997) reported decrease in soil pH (7.6) and bulk density (1.56 g cm^{-3}) and increased OC (0.56 %) EC (13.7), available N (225), P (9.2) and K (235 kg ha^{-1}) content under tree canopy when compared to treatments without tree component on rainfed alfisol. The amount of total N in *F.albida* trees alone and tree + maize were significantly higher than with maize alone on sandy loam soils (Chamshama *et al.*, 1998).

Mugendi *et al.* (1999) found maximum level of P, OC, exchangeable base forming cations and CEC under the tree than in the open fields in the surface soil. It was noticed that the nutrient level decreased with depth and increasing distance from the tree trunk (Hailu *et al.*, 2000).

2.5 INFLUENCE OF CROP ON TREE GROWTH AND BIOMASS

Perez and Mendez (1980) reported that the increase in fodder production in response to pruning height by producing more buds and new shoots in *Leucaena leucocephala*. It was noticed that the *G. tereticornis* and *L. leucocephala* gave significantly lower wood volume and biomass production when intercropped with maize and sorghum (Maghembe, 1986; Ahimani and Maghembe, 1988). Parotta (1987) confirmed the mean annual volume increments of 3.4 to 8.4 m³ for plantation of *A. lebbeck* managed in rotations of 10-15 years in India and Indonesia.

Jama and Getahun (1991) reported 140 and 24 per cent more height and DBH in intercropped *Faidherbia albida* than sole tree in fifth year after planting.

Karim *et al.* (1991) reported significantly higher average dry matter yield of trees when cut at 75 and 100 cm height than at 25 and 50 cm. The height and girth of *Faidherbia albida* tree were not affected by the growth of the associated castor and sunflower crops in different alley widths (Bheemaiah *et al.*, 1992). Studies conducted on nine year old trees of *A. lebbeck* in silvipastoral system revealed that the mean height, collar diameter and growth were of the order of 7.57 m, 18.01 cm and 16.01 cm respectively. The mean woody biomass was 154.8 kg tree⁻¹ giving an average production of 4.94 t ha⁻¹ year⁻¹ (Deb Roy, 1993).

Okario and Maghembe (1994) reported non significant effect of intercropping and tree spacings in total volume, height and biomass production of tree.

It was noticed that the coppice shoot production, green fodder and fuel wood yields increased with coppicing height in *Albizia lebbeck* (Saleem and Singh, 1995).

It was noticed that the cutting ensured vegetative growth during early dry season, with greater shoot development observed at a cutting height of 0.7 m than at 0.5 and 0.3 m cutting height (Tarawali *et al.*, 1996).

Bisht *et al.* (1998) recommended pollarding of tree at 2 m height. leaving main shoot intact to record significantly higher fuel and forage yield (2.9 kg tree^{-1} and $27.87 \text{ kg tree}^{-1}$, respectively) than completely pollarding at 2 m height.

Cham Shama *et al.* (1998) noticed that alley cropping of *F.albida* and *Leucocephala* with maize on sandy clay loam soils had no significant effect on mulch and wood production.

The height and DBH of *F.albida* was not affected by intercropping of groundnut (Kanchana, 1998).

It was reported that the biomass yield was increased significantly with cutting height of *S.sesban* hedge row from 0.5 m to 1.5 m (Viswanath *et al.*, 1997). Biomass produced from trees (*Eucalyptus* and *Leucaena*) adequately compensated for the crop yield reduction (Narain *et al.*, 1998).

Dhyani and Tripathi (1999) noticed positive effect of intercropping on height, diameter growth, crown width and timber volume of Alder, Albizia and cherry.

Singh *et al.* (1999) observed higher biomass of *H.binata* (311 kg ha^{-1}) and *G.officinalis* (350 kg ha^{-1}) under uncropped condition than under inter cropping with *Vigna radiata*, *Cyamopsis tetragonoloba* and *Pennisetum glaucum*.

Viswanatham *et al.* (1999) reported that lopping intensity did not affect the tree survival and canopy but collar diameter and DBH increased significantly at high intensity of lopping (75 %) than at 500 per cent lopping.

2.6 RETURNS IN AGROFORESTRY SYSTEMS

Gupta and Mohan (1982) reported that significantly higher net returns of Rs.360 to 3270 ha⁻¹ yr⁻¹ from tree species as compared to Rs. 40 to 300 ha⁻¹ yr⁻¹ from annual crops.

Shah (1987) found that in rural areas, agroforestry as a land use was a better option than sole crops. It not only helped the poor to fulfill their basic needs but also gave better output for their livelihood and also increased their income in the long run. It also showed that the agroforestry helped the rainfed farmer more than irrigated farmers.

Shankamarayana *et al.* (1987) reported highest revenue of Rs. 3895 ha⁻¹ from *Acacia tortilis* tree and *cenchrus* grass species as compared to Rs. 3000 and 1150 ha⁻¹ only from tree and grass respectively. Studies of Korwar (1986) revealed economic advantage of alley cropping over sole cropping of pearl millet and sorghum. Agroforestry gives more income to farmer per unit land area than sole agriculture or forestry. Several studies in different parts of the world suggest that agroforestry was more profitable to farmer than agriculture or forestry alone (Patel, 1988).

Cost-benefit analysis of integration of some trees with agricultural crops such as wheat, vegetables, pulses and soyabean indicated higher profitability (Chaturvedi, 1981 and Sharma, 1983). Patel (1988) reported that teak plantation raised with cotton and other agricultural crops showed much greater profitability

1.5 to 2.0 times than sole agriculture. Similarly, *casuarina* and bamboo plantation with agricultural crops gave higher net returns.

Verinumbe *et al.* (1984) using a linear progressive model indicated that *Leucaena* + maize alley cropping was economically attractive, under severe cash constraints and where hired labour was available at relatively low cost.

Economic analysis carried out for the alley cropping by Singh *et al.* (1989) for three years revealed that gross returns were higher in alley cropped systems. Alley cropped sorghum gave nearly twice the income of sole sorghum whereas the alley cropped pigeonpea gave almost 7 times the income over sole pigeonpea.

Mean maximum net returns were obtained from intercropping of *Leucaena* with cluster bean (Rs. 3540 ha⁻¹ yr⁻¹) which were significantly higher than the returns from sole crop of *Leucaena* at wider spacing but similar to the return from sole crops of cluster bean. *Leucaena* with maize (Rs. 3273 ha⁻¹ yr⁻¹) and black gram (Rs. 3125 ha⁻¹ yr⁻¹) gave significantly higher net returns over sole crops of *Leucaena* at wider spacing (Mittal and Singh, 1989).

Vani (1995) reported that the returns obtained from alley cropped castor were highly remunerative than sole cropped castor. Significantly higher gross and net returns and benefit cost ratio were obtained from wider tree spacings of *F.albida* with high dose of nitrogen. The analysis of economics of tree crop combination revealed that *F.albida* system gave the highest net returns with sorghum over cowpea and over sole sorghum. This was followed by *Albizia lebbbeck* and *Acacia ferruginea* based systems.

Subrahmanyam *et al.* (1996) observed that in *Dalbergia sissoo* based agroforestry system with sunflower and castor gave higher gross returns under intercropping when compared to sole cropping situation.

Endrias Hebana (1998) reported higher gross returns in alley cropping (Rs. 14129 ha⁻¹) over intercropping (Rs. 4734 ha⁻¹) in groundnut and *Albizia lebbbeck* agri-silvisystem.

Joseph *et al.* (1999) reported that mean gross returns obtained from sole sunflower was high Rs. 11060 ha⁻¹ followed by pollarding at 1.5 m height (Rs. 10887 ha⁻¹), which were superior over other treatments.

It was reported that the maximum gross returns were obtained with the sole cowpea (Rs. 6790) followed by coppicing at 60 cm height (Rs. 6372) and it was least with cowpea + *Albizia* without pruning (AICRP AF, 1998-99).

2.7 CORRELATION STUDIES

It was found that the plant height, pods plant⁻¹ and seeds pod⁻¹ were significantly and positively correlated with seed yield of cowpea (Ranvir *et al.*, 1982).

Kumar *et al.* (1983) reported that pods peduncle⁻¹, pod length and width, peduncle length were positively correlated with cowpea seed yield.

Fapohunda *et al.* (1984) noticed strong curvilinear relation between cowpea yield and evapotranspiration ($r = 0.87$). It was observed that the seeds pod⁻¹, pods plant⁻¹ and pod length showed positive correlation with seed yield of cowpea (Ombakho and Tyagi, 1987).

Patil *et al.* (1989) reported that grain yield was highly correlated with pods plant⁻¹ ($r=0.89$), 100-grain weight (0.74), cluster plant⁻¹ (0.65), pod length (0.62) and days to 50 per cent flowering (0.51).

Positive correlation existed between number of pods per plant and seed production (Oliveira *et al.*, 1990). Palled *et al.* (1990) reported that the grain yield was positively associated with stem girth, LAI, Leaf area duration, dry matter per plant, dry matter per panicle, Panicles length, grain number and weight per panicle in sorghum intercropped with *Leucaena leucocephala* Siddique and Gupta (1991) reported that seed yield plant⁻¹ was significantly correlated with number of clusters plant⁻¹ and number of pods plant⁻¹ in cowpea.

Khapre and Nerkar (1992) reported that the HI, specific and total biomass per plant showed positive correlation with grain yield of pigeonpea under (sorghum and pearl millet) intercropping systems. Oseni *et al.* (1992) noticed that there was positive correlation between seed yield and pods plant⁻¹ ($r=0.35$) while negative correlation was found between 100 seed weight and seed yield ($r=0.33$).

Altinbas and Sepetoglu (1993) reported that seed yield per plant was correlated significantly and positively with pods plant⁻¹, seeds pod⁻¹ and branches plant⁻¹.

Misra *et al.* (1994) noticed that leaf area, length, diameter and pod weight were positively correlated with green pod yield plant⁻¹. Similarly, seed yield per plant was positively correlated with plant height, number of branches, clusters and pods plant⁻¹, pod length, number of seeds pod⁻¹ and 100-seed weight (Tamil Selvam and Das, 1994).

It was noticed that green fodder yield of cowpea was significantly and positively correlated with leaf area index, specific leaf weight, number of branches and dry matter yield (Aravindhan and Das, 1995). Biradar *et al.* (1996) reported that seed yield of cowpea was positively correlated with all the yield components viz., pod weight plant⁻¹, pod length, number of seeds pod⁻¹ and number of pods plant⁻¹. Similarly, seed yield exhibited a significant and positive correlation with clusters, flowers and pods plant⁻¹, plant height, pod set, pod length, seeds pod⁻¹ and 100-seed weight (Parihar *et al.*, 1997). Naveen *et al.* (1998) reported that grain yield of cowpea per plant was positively and significantly correlated with clusters plant⁻¹, pods plant⁻¹ and total biomass per plant.

It was observed that grains per pod ($r=0.77$) and length of pod ($r=0.70$) showed a high correlation with the green bean yield of cowpea (Murillo *et al.*, 1998). Further, Vardhan and Savithramma (1998) reported significant positive association of green pod yield plant⁻¹ with pod length, pod width, biomass and harvest index. Ashok *et al.* (1999) reported that the dry matter yield was positively correlated with transpiration and net assimilation rates.

MATERIAL AND METHODS

CHAPTER III

MATERIAL AND METHODS

An investigation was carried out to study the "Effect of pruning *Albizia lebbbeck* (L.) on yield and nutrient uptake of cowpea in Agri-silvisystem" at Agroforestry Research Division, ANGRAU, during *kharif* 1999 on rainfed Alfisols. The details of various materials used and methods followed are given as follows.

3.1 LOCATION

Geographically the site of the investigation was situated at 17°19' North latitude and 78°23' East longitude at an altitude of 534 m above mean sea level.

3.2 WEATHER CONDITIONS

Meteorological data recorded during the crop growth period is presented in Table 1.

The total rainfall received during the crop growth period was 316.1 mm in 25 rainy days which was 35 per cent less as compared to normal rainfall of 486.3 mm. The mean maximum temperature recorded was 30.11°C and the mean minimum temperature being 26.8°C. The bright sunshine hours per day varied from 2.5 to 8.6, while the relative humidity ranged from 80 to 94 per cent and 49 to 74 per cent for first and second hours, respectively.

3.3 SOIL

The soil samples were analysed for physical and chemical properties and presented in the Table 2. From the Table 2, it is clear that soil was sandy loam in

Table 1 : Weekly mean meteorological data during the crop growing period

Standard week	Date and Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)		No. of rainy days	Sunshine hours	Wind speed (km hr ⁻¹)	Evapo-ration (mm)	
		Maximum	Minimum	Mean	7.30 hrs	14.00 hrs	CGP					Normal
29	July 16-22 July	30.2	23.2	26.7	88	59	60.8	44.7	4.0	4.6	7.0	3.9
30	23-29 "	29.4	23.0	26.2	87	66	16.6	47.7	2.0	4.6	9.9	4.4
31	July 30-05 Aug	28.0	22.7	25.4	89	74	67.7	19.4	3.0	2.8	7.5	3.3
32	06-12 "	28.8	22.8	25.8	82	68	8.8	34.8	2.0	4.0	7.0	3.4
33	13-19 "	30.7	23.0	26.9	89	68	40.6	45.6	1.0	6.7	3.9	4.0
34	20-26 "	30.3	23.4	26.9	87	64	15.3	26.0	1.0	5.0	3.3	4.1
35	Aug 27-02 Sep	29.1	22.7	25.9	88	65	24.6	46.6	3.0	2.5	5.1	3.6
36	03-09 "	29.6	22.3	26.0	88	66	28.4	26.2	2.0	5.3	6.4	4.5
37	10-16 "	28.6	22.8	25.7	87	67	1.9	46.9	0.0	4.4	5.4	3.4
38	17-23 "	31.4	23.0	27.2	80	53	1.8	47.6	0.0	7.0	4.4	5.3
39	24-30 "	31.7	23.1	27.4	94	66	23.4	11.8	4.0	5.7	1.9	2.9
40	Sept 01-07 Oct	31.1	22.9	27.0	88	62	14.6	39.9	1.0	8.6	3.0	3.7
41	08-14 "	31.5	22.4	27.0	92	52	8.4	28.9	1.0	8.6	2.3	3.6
42	15-21 "	31.1	20.2	25.7	90	49	3.2	20.2	1.0	7.5	2.1	4.1

texture and neutral in reaction, medium in organic carbon and low in available N, P and K.

Table 2 : Physico-chemical properties of experimental soil

2a. Mechanical analysis

Coarse sand (%)	:	59.00	International pipetter
Fine sand (%)	:	13.80	method (Piper, 1966)
Silt (%)	:	14.40	
Clay (%)	:	12.80	
Soil type	:	Sandy loam	
Bulk density (g/cc)			
0-15 cm soil depth	:	1.62	Core sampler method
15-30 in soil depth	:	1.70	(Black, 1965)

3.4 CROPPING HISTORY

The cropping history of the experimental site for the previous two years is summarised in Table 3.

Table 2b : Physico-chemical properties of soil at varying depths in different treatments

Treatments	pH		EC (dS m ⁻¹)		OC (%)		N (kg ha ⁻¹)		P ₂ O ₅ (kg ha ⁻¹)		K ₂ O (kg ha ⁻¹)	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
	cm											
T ₁ - Sole crop	6.7	6.8	0.297	0.318	0.26	0.27	18.8	108.7	13.1	11.7	138.9	127.4
T ₂ - Sole tree without pruning	6.4	6.5	0.195	0.207	0.36	0.34	141.7	132.1	20.5	18.7	166.1	156.8
T ₃ - Crop with tree and without pruning	6.5	6.5	0.224	0.250	0.36	0.33	134.0	124.4	17.9	16.6	155.9	142.0
T ₄ - Coppicing at ground level	6.6	6.6	0.271	0.280	0.30	0.28	119.0	110.1	13.5	12.2	150.5	143.6
T ₅ - Coppicing at 30 cm	6.6	6.6	0.263	0.276	0.31	0.29	120.0	112.5	13.8	12.7	150.1	145.0
T ₆ - Coppicing at 60 cm	6.5	6.6	0.260	0.270	0.31	0.30	127.1	113.7	13.8	11.8	152.5	148.5
T ₇ - Pollarding at 1.5 m	6.5	6.6	0.258	0.271	0.31	0.30	124.2	115.1	14.2	12.2	152.7	145.5
T ₈ - Pollarding at 2.0 m	6.5	6.6	0.258	0.270	0.33	0.32	123.9	116.0	14.2	12.2	154.6	148.9
T ₉ - Pollarding at 2.5 m	6.5	6.6	0.256	0.267	0.33	0.32	128.0	118.2	14.5	12.6	155.0	147.6
T ₁₀ - Lopping	6.5	6.5	0.236	0.250	0.34	0.33	129.1	119.7	17.7	15.6	156.1	148.9
SE.D	0.1	0.1	0.006	0.007	0.01	0.01	6.3	5.3	2.8	2.5	8.5	7.9
CD (0.05)	NS	NS	0.013	0.015	0.03	0.02	13.3	11.1	NS	NS	NS	NS

Table 3 : Cropping history of experimental site

S.No.	Year	Season	Cropping pattern
1	1997-98	<i>kharif</i>	cowpea
		<i>rabi</i>	Fallow
		summer	Fallow
2	1998-99	<i>kharif</i>	cowpea
		<i>rabi</i>	Fallow
		summer	Fallow
3	1999-2000	<i>kharif</i>	cowpea

3.5 TECHNICAL PROGRAMME

3.5.1 Experimental design and layout

The experiment was conducted under six years old *Albizia lebbeck* (L.) plantation spaced at 4 x 4 m. The experimental area was divided into 30 individual plots with four trees in each plot (2 rows and 2 trees), except in 3 plots as shown in Fig. 1.

Trees	:	<i>Albizia lebbeck</i> (L.)
Spacing for trees	:	4 x 4 m
Crop	:	Cowpea (<i>Vigna unguiculata</i> (L.)
Plot size	:	8 x 8 m
Design	:	RBD
Replications	:	3

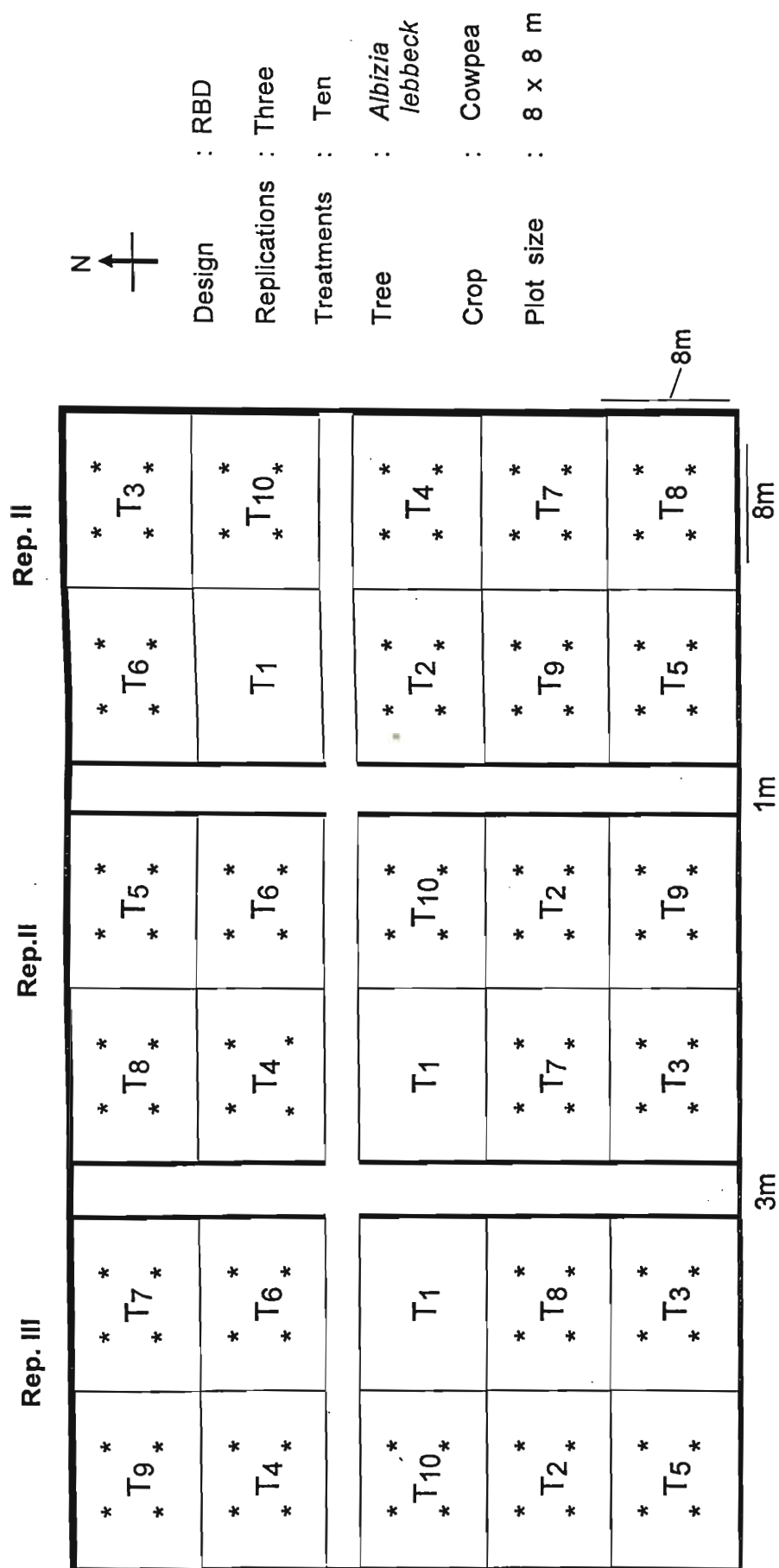


Fig. 1 : Layout of experimental field

3.4.2 Treatment details

- T₁ - Crop without tree (sole crop)
- T₂ - Trees without crop and without pruning
- T₃ - Trees with crop and without pruning
- T₄ - Coppicing at ground level
- T₅ - Coppicing at 30 cm height
- T₆ - Coppicing at 60 cm height
- T₇ - Pollarding at 1.5 m height
- T₈ - Pollarding at 2.0 m height
- T₉ - Pollarding at 2.5 m height
- T₁₀ - Lopping

3.5 PRUNING OF *ALBIZIA LEBBECK* (L.)

Pruning of trees (Four in number in each plot) was done at different heights as per the treatments before sowing of cowpea. The loppings were separated into leaf and branches and their fresh weight was recorded. Samples (500 g each) were oven dried at 70°C to constant weight and dry matter was determined.

3.6 BIOMETRIC OBSERVATIONS OF TREES

3.6.1 Tree height

The tree height was measured from the base of the tree to tip of the main stem and expressed in metres.

3.6.2 Diameter at breast height (DBH)

Diameter of the main stem was recorded at 1.35 m height from the base of the tree and expressed in metres.

3.6.3 Number of stumps per tree

Branches of four trees were counted and average of branches per tree were computed.

3.6.4 Length of stump (m)

Length of branch was measured from the base of branch to the growing point. The length of branches of four trees was taken under each treatment separately and was expressed in metres on per branch basis.

3.6.5 Girth of branch (cm)

The girth of branches of four trees was measured from base of the branch under each treatment separately and was expressed in centimetres per branch.

3.6.6 Absolute growth rate

The rate of increase in size of a growing plant (or part of it) in a given time under specific condition. It was calculated by using the following formula :

$$AGR = \frac{H_2 - H_1}{T_2 - T_1}$$

Where, H_1 and H_2 are the length of branch/girth of branch in centimeter. at time T_1 and T_2 , respectively in days.

3.7 CROP HUSBANDRY ADOPTED FOR COWPEA

3.7.1 Preparatory cultivation

The experimental field was prepared by working with tractor drawn disc plough followed by harrowing in order to obtain fine tilth. The land was finally levelled with a wooden plank and plots were laid out as per the layout plan.

3.7.2 Fertilizer application

Urea, single super phosphate and muriate of potash were used as sources of nitrogen, phosphorus and potassium respectively. The recommended dose of phosphorus (50 kg ha^{-1}), potassium (30 kg ha^{-1}) were applied basally, while nitrogen (30 kg ha^{-1}) was applied in two equal splits at sowing and 30 DAS.

3.7.3 Seeds and sowing

The cowpea crop was sown on 17.7.1999 after treating the seed with captan @ 3 g per kg of seed. The seed was hand dibbled in lines at a spacing of 30 x 10 cm.

3.7.4 Gap filling and thinning

Gap filling was done on third day after germination and thinning was done at 10 DAS retaining one seedling per hill.

3.7.5 Weeding

Hand weeding was done at 15 and 30 days after germination which allowed the crop to grow profusely.

3.7.6 Crop production

Monocrotophos (1.5 ml lit^{-1}) was sprayed at seedling stage and chlorpyrphos (2 ml lit^{-1}) was sprayed during pod formation to control the attack of aphids and pod borer.

3.7.7 Harvesting

Picking of pods was started from 70 DAS and completed with in 3 pickings. Pickings were done when the pods were at 85 per cent dried condition.

3.7.8 Drying

Harvested pods were sun dried for two days.

3.7.9 Threshing

Shelling was done manually by beating with sticks to remove the chaff in order to get the seeds separated. Winnowing was done to get the clean seeds.

3.8 PRE HARVEST BIOMETRIC OBSERVATIONS ON CROP

Five plants were selected in each treatmental plot for non- destructive sampling and were properly tagged for recording plant height. Similarly at each sampling interval, five plants for destructive sampling were selected at random to record observations like leaf area, dry matter production at 30, 60 and 90 DAS.

3.8.1 Plant height (cm)

Plant height was measured from the base of the plant to the growing point at 30 and 60 DAS and at harvest.

3.8.2 Dry matter production (g plant⁻¹)

Dry matter production was recorded at 30, 60 DAS and at maturity by collecting five plants randomly from each treatmental plot. The samples were dried in shade and subsequent drying of samples was carried out in hot air oven at a temperature of 60°C to constant weight and the dry matter production computed.

3.8.3 Leaf area index (LAI)

The method proposed by Williams (1946) was followed for calculating LAI and which is expressed as follows :

$$LAI = \frac{\text{Leaf area of plant}}{\text{Ground area cover}}$$

The leaf area was measured using LI-3100 leaf area meter by passing all the detached leaves of five randomly selected plants and obtained total leaf area.

3.8.4 Crop growth rate (CGR)

Crop growth rate was calculated from the dry weight of whole plant using the formula suggested by Watson (1958) and expressed in $\text{gm}^{-2} \text{d}^{-1}$.

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

where W_1 and W_2 are the whole plant dry weights in grams (g) at time t_1 and t_2 , respectively in days and P is the unit ground area in m^{-2} .

3.9 PHYSIOLOGICAL PARAMETERS OF COWPEA

The physiological parameters like leaf temperature (LT), relative humidity (RH), photosynthetically active radiation (PAR), diffusive resistance (DR) and transpiration ratio (TR) were measured on the physiological active leaf by using LI-1600 steady state porometer at different heights of the plant i.e. at bottom, middle and top from 12 noon to 2 PM. These observations were recorded at 30 and 60 DAS.

3.10 POST HARVEST BIOMETRIC OBSERVATIONS

3.10.1 Number of pods per plant

Total number of pods from five labelled plants in each treatment were counted, averaged and expressed as number of pods per plant.

3.10.2 Length of dried pod (cm)

The length of the dried pods was recorded by selecting five pods at random in each labelled plant in each treatment and was expressed in centimetre.

3.10.3 Number of seeds per pod

The number of seeds in each dried pod was counted and recorded. Five pods were selected at random on each labelled plant and in each treatment.

3.10.4 Test weight (g)

After processing of the produce, the weight of 1000 seeds was taken at random in each treatment.

3.10.5 Shelling percentage

The percentage of seeds to pods by weight was recorded. A sample of 400 g of pods was taken from each treatment from all the replications. The pods were then shelled and the weight of seeds was recorded. Shelling percentage was calculated using the formula.

$$\text{Shelling percentage} = \frac{\text{Weight of seeds (g)}}{\text{Weight of pods (g)}} \times 100$$

3.10.6 Seed yield

The weight of dried seeds from each plot was recorded and expressed in quintals per hectare (q ha^{-1}).

3.10.7 Straw yield

Straw yield obtained from each treatment was thoroughly dried under sun and weighed. Straw yields were calculated and expressed in q ha^{-1} .

3.10.8 Harvest index (%)

Harvest index (HI) was calculated by using the following formula.

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

3.11 SOIL ANALYSIS

The initial soil samples were collected from 0-15, 15-30 cm soil depth from each treatmental plot before cowpea was sown. The soil samples were air dried, powdered and allowed to pass through 2 mm sieve and were analysed. Similarly post harvest soil samples were also collected and analysed for different physico-chemical properties.

3.11.1 Soil pH

Soil pH was determined by using a pH meter at 1:2.5 soil : water ratio (Jackson, 1967).

3.11.2 Electrical conductivity (dS m⁻¹)

Electrical conductivity from supernatant solution was determined using conductivity bridge (Jackson, 1967).

3.11.3 Organic carbon (%)

Organic carbon was determined in the soil samples by Walkely and Black wet oxidation method (Jackson, 1967).

3.11.4 Available N (kg ha⁻¹)

Available nitrogen was determined by potassium permanganate method as per the procedure outlined by Subbaiah and Asija (1956).

3.11.5 Available P_2O_5 ($kg\ ha^{-1}$)

Available P_2O_5 was determined by Olsen's method (Jackson, 1967) and expressed as $kg\ ha^{-1}$.

3.11.6 Available K_2O ($kg\ ha^{-1}$)

Available K_2O was determined by neutral normal ammonium acetate method (Jackson, 1967).

3.12 PLANT ANALYSIS

The plant samples collected at harvesting were partitioned into haulms, grain and straw. The oven dried samples were ground in a willey mill to pass through 40 mesh sieve and used for nutrient analysis.

3.12.1 N content

The nitrogen content was estimated by microkjeldahl (Piper, 1966) method after destroying the organic matter using H_2SO_4 and H_2O .

Phosphorus and potassium contents were determined in the extracts after digesting the plant material with the help of tri-acid mixture of 9 : 2 : 1 (HNO_3 : H_2SO_4 : $HClO_4$).

3.12.2 P content

The phosphorus content in the plant digest was determined by the method prescribed by AOAC (1970) and the intensity of colour developed was read on sepctronic-20 at 420 nm against blank.

3.12.3 K content

The potassium content was determined on Elico Flame Photometer (Piper, 1966).

3.12.4 NPK uptake (kg ha^{-1})

Uptake of N P K by grain and straw were worked out by multiplying the NPK content with the respective grain and straw yield.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\% \text{ nutrient concentration}}{100 (\text{kg ha}^{-1})} \times \text{grain/stalk yield}$$

3.13 SOIL MOISTURE STATUS

Soil moisture was determined by gravimetric method at sowing, 30, 60 DAS and harvesting of cowpea. The soil moisture was monitored from two depths, at 0-15 and 15-30 cm in each plot. It was reported on volumetric basis and expressed in cm/15 cm depth of soil.

3.14 ECONOMICS

3.14.1 Gross and net returns (Rs ha^{-1})

Gross returns were calculated by multiplying the economic yield in each treatment with the prevailing market price (Perin *et al.*, 1979) and returns from tree biomass wood were also added. Similarly, net returns were calculated by subtracting cost of cultivation from gross returns for each treatment.

3.14.2 Benefit-cost ratio

Benefit-cost ratio was obtained by dividing the present values of benefits (net returns) by the present values of cost (cost of cultivation).

3.15 STATISTICAL ANALYSIS

The data were analysed statistically applying the analysis of variance technique for simple random block design as suggested by Panse and Sukhatme (1967) and critical difference for examining treatment means for their significance was calculated at 5 per cent level of probability ($P = 0.05$). Correlation between seed yield and other parameters was worked out as per the procedure described by Snedecor (1959).



Plate 1 : Tree + crop at early growth stage



Plate 2 : Tree + crop at grand growth stage

Plate 3 : Sole crop (crop without tree)



Plate 4 : Crop with unpruned tree



Plate 5 : Crop with tree coppiced at ground level



Plate 6 : Crop with tree pollarded at 2 m height



Plate 7 : Crop with tree pollarded at 2.5 m height



Plate 8 : Crop with lopped tree

RESULTS

CHAPTER IV

RESULTS

The experimental results of present investigation entitled "Effect of pruning *Albizia lebbeck* (L.) on yield and nutrient uptake of cowpea in Agrisilvisystem" are described in this chapter.

4.1 INFLUENCE OF PRUNING ON GROWTH AND YIELD OF COWPEA

4.1.1 Growth characters

4.1.1.1 Plant height (cm)

Plant height of cowpea as influenced by different treatments at various growth stages is presented in Table 4. The results showed that plant height increased significantly with age of crop. However, it was highest between 30 and 60 DAS.

Plant height did not vary significantly due to treatments at 30 DAS. Perusal of data at 60 DAS revealed that the treatment T₇ (60.3 cm) recorded significantly more plant height than T₄ (52.5 cm), T₁₀ (52.1 cm) and T₃ (33.4 cm) but it was on par with T₆, T₈, T₉, T₅ and T₁. The treatment T₆, (coppicing at 60 cm), T₈, T₉, T₅, T₁, T₄ and T₁₀ did not differ significantly. It was further observed that the lowest plant height was associated with T₃ treatment where pruning was not carried out. At harvesting stage, maximum plant height was with T₇ (68.3 cm) treatment which was comparable with the plant height of T₈ (67.4 cm), T₆ (67.2 cm), T₉ (65.9 cm), T₁ (65.6 cm), T₅ (65.6 cm), T₄ (62.2 cm) and T₁₀ (58.2 cm). However, these were significantly superior to T₃ treatment where the plant height was lowest (34.6 cm).

Table 4 : Influence of pruning *Albizia lebbeck* on plant height (cm) and dry matter (g plant⁻¹) production of cowpea at different stages of crop growth

Treatments	Plant height (cm)			Dry matter ((g plant ⁻¹)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T ₁ - Sole crop	17.1	54.6	65.6	1.61	8.97	15.07
T ₂ - Sole tree without pruning	-	-	-	-	-	-
T ₃ - Crop with tree and without pruning	16.0	33.4	34.6	0.85	2.80	5.13
T ₄ - Coppicing at ground level	16.1	52.5	62.2	1.54	8.50	13.80
T ₅ - Coppicing at 30 cm	16.7	56.7	65.6	1.27	8.10	13.03
T ₆ - Coppicing at 60 cm	16.4	58.7	67.2	1.61	8.80	13.90
T ₇ - Pollarding at 1.5 m	16.6	60.3	68.3	1.64	7.77	11.90
T ₈ - Pollarding at 2.0 m	16.8	57.2	67.4	1.05	7.40	12.23
T ₉ - Pollarding at 2.5 m	20.1	56.8	65.9	1.21	6.67	9.57
T ₁₀ - Lopping	16.0	52.1	58.2	1.07	4.70	7.30
SE.D	1.6	3.4	3.69	0.29	0.50	1.88
CD(0.05)	NS	7.1	7.82	NS	1.05	3.99

Significant difference could not be observed among the treatments T₉ (65.9 cm), T₁ (65.6 cm), T₅ (65.6 cm) and T₄ (62.2 cm).

4.1.1.2 Dry matter production (g plant⁻¹)

Dry matter production of cowpea increased with the advancement of crop growth upto harvest (Table 4). The magnitude of increase was more between 30 and 60 DAS. The higher and lower dry matter production were obtained with T₇ (1.64 g plant⁻¹) and T₃ (0.85 g plant⁻¹) treatments respectively. There was no significant difference among different treatments with respect to dry matter accumulation at 30 DAS. At 60 DAS, T₃ treatment produced significantly lowest dry matter (2.80 g plant⁻¹) as compared to other treatments. The maximum biomass production was with T₁ treatment (8.97 g plant⁻¹) which was significantly higher than other treatments except T₆ (8.80 g plant⁻¹), T₄ (8.50 g plant⁻¹) and T₅ (8.10 g plant⁻¹). There were no significant differences either among T₆, T₄, T₅ and T₇ (7.77 g plant⁻¹) or T₅, T₇ and T₈ (7.40 g plant⁻¹). The T₁₀ treatment was superior to T₃ in dry matter production. It was observed that at harvesting stage cowpea plants accumulated significantly more dry matter in T₁ treatment (15.07 g plant⁻¹). It was at par with T₆ (13.90), T₄ (13.80), T₅ (13.03), T₈ (12.23) and T₇ (11.90 g plant⁻¹) but significantly superior to T₉ (9.57), T₁₀ (7.30) and T₃ (5.13 g plant⁻¹). Neither T₅, T₈, T₇ and T₉; T₉ and T₁₀ nor T₁₀ and T₃ differed significantly with respect to dry matter accumulation.

4.1.1.3 Crop growth rate (g g⁻¹ m⁻²)

Crop growth rate (CGR) of cowpea was significantly influenced by different treatments except at 30 DAS (Table 5). CGR increased with age of crop

Table 5 : Influence of pruning *Albizia lebbeck* on CGR ($\text{g g}^{-1} \text{m}^{-2}$) and LAI at different stages of cowpea

Treatments	CGR			LAI		
	0-30 DAS	30-60 DAS	60 DAS-Harvest	30 DAS	60 DAS	Harvest
T ₁ - Sole crop	1.78	8.18	6.68	0.42	1.34	1.20
T ₂ - Sole tree without pruning	-	-	-	-	-	-
T ₃ - Crop with tree and without pruning	0.94	2.17	2.59	0.24	0.62	0.48
T ₄ - Coppicing at ground level	1.71	7.74	5.89	0.37	1.22	1.16
T ₅ - Coppicing at 30 cm	1.41	7.59	5.93	0.37	1.20	1.14
T ₆ - Coppicing at 60 cm	1.78	7.43	6.26	0.36	1.21	1.16
T ₇ - Pollarding at 1.5 m	1.82	6.81	4.59	0.37	1.20	1.15
T ₈ - Pollarding at 2.0 m	1.16	7.06	5.37	0.36	1.18	1.12
T ₉ - Pollarding at 2.5 m	1.34	6.07	3.22	0.36	1.18	1.11
T ₁₀ - Lopping	1.19	4.03	2.72	0.32	0.98	0.85
SE.D	0.32	0.72	0.95	0.03	0.07	0.07
CD (0.05)	NS	1.53	2.02	0.06	0.14	0.14

upto 60 DAS and later decreased towards maturity. There were no significant differences among treatments with respect to crop growth rate at early stage of crop growth i.e., at 30 DAS. Cowpea in T₁ treatment had significantly higher crop growth rate (8.18) compared with other treatments except in T₄ (7.74), T₅ (7.59), T₆ (7.43), T₈ (7.06) and T₇ (6.81 g g⁻¹ m⁻²). Significantly lower crop growth rate was with T₃ treatment (2.17) followed by T₁₀ (4.03 g g⁻¹ m⁻²). Crop growth rate was not significantly varied due to T₅ (7.59), T₆ (7.43) T₈ (97.06), T₇ (6.81) and T₉ (6.07 g g⁻¹ m⁻²) treatments. Between 60 DAS and harvesting stage, the crop growth rate of cowpea was significantly more when grown as sole crop i.e. T₁ (6.68). However, it was at par with crop growth rate noticed in T₆ (6.26), T₅ (5.93) T₄ (5.89) and T₈ (5.37 g g⁻¹ m⁻²). Though T₃ gave lowest crop growth rate (2.59) but it was equal to T₇ (4.59) and T₁₀ (2.72). There was no conspicuous difference with respect to crop growth rate due to T₆, T₅, T₄, T₈ and T₇ treatments.

4.1.1.4 Leaf area index

Leaf area index (LAI) computed at different stages i.e., 30 DAS, 60 DAS and at harvest was influenced significantly by various treatments (Table 5). It increased progressively with crop age upto 60 DAS and decreased later. LAI of cowpea at 30 DAS varied from 0.24 to 0.42 in different treatments. It was found to be significantly high under sole cropped condition i.e., T₁ treatment (0.42). However, it did not differ significantly from T₅ (0.37), T₄ (0.37) and T₇ (0.37). The T₅ treatment (0.37) was significantly superior to T₃ (0.24) with respect to LAI. However, former one is at par with T₄, T₇, T₆, T₈, T₉ and T₁₀. Cowpea in T₃ treatment where no pruning of tree was carried out had significantly lower LAI (0.24). At 60 DAS, higher LAI was observed in T₁ treatment (1.34) followed by T₄ (1.22), T₆ (1.21),

T₅ and T₇ (1.20). These were significantly superior to T₈, T₉, T₁₀ and T₃ and were not influenced significantly by T₄, T₆, T₅, T₇, T₈ and T₉ treatments. At harvesting stage, higher and lower LAI values were obtained in T₁ (1.20) and T₃ (0.48) treatments, respectively. There was no conspicuous difference in LAI among T₁, T₄, T₆, T₇, T₅, T₈ and T₉ treatments. The treatment T₁₀ gave lower LAI next to T₃ (0.48).

4.1.1.5 Physiological parameters

Physiological parameters of cowpea that were recorded at different stages of the crop as influenced by various pruning practices are furnished in Table 6.

4.1.1.5.1 Leaf temperature(⁰c) :

Leaf temperature recorded in cowpea at 30 and 60 DAS was not influenced significantly due to treatments (Table 6). Leaf temperature recorded at 30 DAS was slightly higher compared to 60 DAS.

4.1.1.5.2 Relative humidity (%)

It was observed from the data (Table 6) that the Relative humidity (RH) did not differ much among the treatments. RH values were higher at 60 DAS than at 30 DAS.

4.1.1.5.3 Photosynthetically active radiation (μ mole S⁻¹ cm⁻²)

Perusal of data presented in Table 6 revealed that there was significant difference among the treatments with respect to photosynthetically active radiation (PAR).

Table 6 : Influence of tree pruning on physiological parameters of cowpea

Treatments	30 DAS					60 DAS				
	LT (°C)	RH (%)	PAR (μ mole s^{-1} cm^{-2})	TR (μg s^{-1} cm^{-2})	DR (s cm^{-1})	LT (°C)	RH (%)	PAR μ mole s^{-1} cm^{-2}	TR (μg s^{-1} cm^{-2})	DR (s cm^{-1})
T ₁ - Sole crop	35.8	42.00	1733	36.27	0.36	32.8	47.06	1681	36.45	0.34
T ₂ - Sole tree without pruning	-	-	-	-	-	-	-	-	-	-
T ₃ - Crop with tree and without pruning	33.0	45.00	353	22.03	0.60	31.8	50.40	326	24.82	0.54
T ₄ - Coppicing at ground level	35.1	42.54	1530	34.57	0.40	32.4	47.90	1513	35.01	0.40
T ₅ - Coppicing at 30 cm	34.2	43.00	1457	33.79	0.45	32.4	48.13	1420	34.51	0.40
T ₆ - Coppicing at 60 cm	35.4	42.40	1620	35.76	0.45	32.7	47.55	1594	35.20	0.42
T ₇ - Pollarding at 1.5 m	34.3	44.13	1360	31.88	0.50	32.2	49.60	1346	32.50	0.49
T ₈ - Pollarding at 2.0 m	34.1	43.20	1447	32.09	0.47	32.4	48.93	1419	33.00	0.45
T ₉ - Pollarding at 2.5 m	34.0	44.33	1347	29.90	0.52	32.1	50.00	901	30.96	0.50
T ₁₀ - Lopping	33.8	44.53	482	24.59	0.57	31.9	50.20	414	29.11	0.52
SE.D	2.3	2.70	20	2.62	0.04	1.2	3.02	15	2.37	0.04
CD (0.05)	NS	NS	43	5.55	0.08	NS	NS	32	5.02	0.09

LT : Leaf temperature; RH : Relative humidity; PAR : Photosynthetically active radiation; TR : Transpiration rate; DR : Diffusive resistance

At 30 DAS sole cowpea had maximum PAR values of $1733 \mu \text{ mole S}^{-1} \text{ cm}^{-2}$ which was significantly higher than rest of the treatments followed by T₆, T₄, T₅, T₈, T₇ and T₉. In T₃ treatment, the values registered were lower ($353 \mu \text{ mol s}^{-1} \text{ cm}^{-2}$) followed by T₁₀. These were much inferior to rest of the treatments. In T₉, where pollarding was carried out at 2.5 m height the PAR of crop was found to be superior over T₁₀ and T₃. Significant differences were not seen between T₅ and T₈ as well as T₇ and T₉ with respect to PAR of cowpea.

Similar trend was observed at 60 DAS though the values were lower than those recorded at 30 DAS.

4.1.1.5.4 Transpiration rate ($\mu \text{g s}^{-1} \text{ cm}^{-2}$)

The data presented in the Table 6 revealed that various treatments showed significant difference among them. It was found that Transpiration rate (TR) of cowpea at 30 DAS was maximum in T₁ ($36.27 \mu \text{ g s}^{-1} \text{ cm}^{-2}$) which was significantly superior over T₉ and T₁₀. The minimum TR of $22.03 \mu \text{ g s}^{-1} \text{ cm}^{-2}$ was noticed in T₃ was independent of others and was significantly inferior. There were significant differences among T₃ and T₁₀; T₁₀ and T₉ with respect to TR of cowpea. Similar trend was observed at 60 DAS also. The values were more at 60 DAS than at 30 DAS.

4.1.1.5.5 Diffusive resistance (S cm^{-1})

It was observed that the Diffusive resistance (DR) values in T₃ (0.60 S cm^{-1}) at 30 DAS were found to be significantly higher than those of T₇, T₈, T₆ and T₅ but on par with T₁₀ and T₉. The lower DR was recorded in T₁ followed by coppicing treatments. Similar trend was observed at 60 DAS also.

4.1.2 Yield attributing characters

4.1.2.1 Pod length (cm)

Data presented in Table 7 indicated that the pod length of cowpea varied from 8.83 cm to 13.83 cm in different treatments. It was not significantly varied due to different treatments.

4.1.2.2 Pods per plant

Data on pods per plant as influenced by different treatments are presented in Table 7. Number of pods per plant were significantly higher in T₁ treatment (8.65) and was 25.18, 27.39, 86.02 and 126.40 per cent more over T₅, T₉, T₁₀ and T₃ treatments, respectively. The treatments T₆, T₄, T₇, T₈ and T₉ did not differ significantly.

4.1.2.3 Seeds per pod

Cowpea when grown as a sole crop produced significantly more number of seeds per pod in comparison with rest of the other treatments except T₆ (7.27) and T₄ (7.22) where coppicing was done at 60 cm and at ground level, respectively. The treatments T₁₀ and T₃ were significantly inferior to other treatments. Significant differences could not be observed among T₆ (7.27), T₄ (7.22), T₅ (6.77), T₈ (6.31), T₇ (6.30) and T₉ (5.83) treatments.

4.1.2.4 1000 seed weight (g)

Data on 1000 seed weight as influenced by different treatments showed that though sole cowpea registered maximum 1000 seed weight (81.8 g), it did not differ significantly from T₆ (80.4) T₄ (79.9), T₅ (79.6), T₈ (79.6) and T₇ (79.5 g). However, former one was found superior to T₉, T₁₀ and T₃. Significantly lower 1000 seed weight (74.8 g) was with T₃ treatment followed by T₁₀ (76.9) and

Table 7 : Effect of pruning *Albizia* on yield and yield attributes of cowpea

Treatments	Pod length (cm)	Pods per plant	Number of seeds per pod	1000 seed weight (g)	Seed yield (q ha ⁻¹)	Stalk yield (q ha ⁻¹)	HI (%)	Shelling percentage (%)
T ₁ - Sole crop	13.83	8.65	8.87	81.8	9.56	40.64	19.04	80.03
T ₂ - Sole tree without pruning	-	-	-	-	-	-	-	-
T ₃ - Crop with tree and without pruning	8.83	3.82	3.13	74.8	3.02	18.94	13.75	72.33
T ₄ - Coppicing at ground level	11.23	7.47	7.22	79.9	8.04	35.44	18.49	76.30
T ₅ - Coppicing at 30 cm	10.96	6.91	6.77	79.6	7.24	35.75	16.84	75.63
T ₆ - Coppicing at 60 cm	11.67	8.02	7.27	80.4	8.97	39.09	18.66	76.87
T ₇ - Pollarding at 1.5 m	10.93	7.15	6.30	79.5	6.77	35.70	15.94	75.60
T ₈ - Pollarding at 2.0 m	11.10	7.06	6.31	79.6	7.22	37.00	16.33	75.07
T ₉ - Pollarding at 2.5 m	10.90	6.79	5.83	77.8	5.09	28.90	14.97	75.00
T ₁₀ - Lopping	9.40	4.65	3.32	76.9	3.86	23.27	14.23	72.63
SE.D	1.64	0.79	0.80	1.7	0.58	2.63	0.29	2.08
CD (0.05)	NS	1.68	1.70	3.7	1.22	5.58	0.62	NS

T₉ (77.8 g). The treatments T₆, T₄, T₅, T₈, T₉ and T₁₀ were found to be on par with each other.

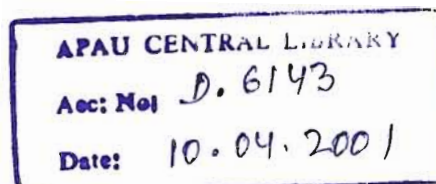
4.1.3 Seed yield (q ha⁻¹)

The results on seed yield were presented in Table 7. The data showed that the sole cowpea (T₁) produced maximum yield of 9.56 q ha⁻¹ which was significantly higher than rest of the treatments but at par with yield obtained in T₆ treatment (8.97 q ha⁻¹). Cowpea inter sown in unpruned tree (T₃) registered lower yield (3.02 q ha⁻¹) followed by T₁₀ (3.86 q ha⁻¹). These were inferior to other treatments. Seed yield obtained in T₉ (5.09 q ha⁻¹) treatment where pollarding of tree was done at 2.5 m height was found superior to T₁₀ (3.86) and T₃ (3.02 q ha⁻¹) treatments.

There were significant differences among T₆ (8.97) and T₄ (8.04); T₄ and T₅ (7.24); T₅ and T₈ (7.22) T₈ and T₇ (6.77 q ha⁻¹) with respect to cowpea seed yield.

4.1.4 Straw yield (q ha⁻¹)

It was seen that the data presented in Table 7 revealed that cowpea intercropped between unpruned trees (T₃) produced lowest straw yield of 18.94 q ha⁻¹ followed by T₁₀ treatment (23.27 q ha⁻¹). These two treatments were proved to be inferior to rest of pruning treatments. Sole cowpea (40.64 q ha⁻¹), however was superior to other treatments. Cowpea in the treatment T₉ produced 24.19 and 52.58 per cent more straw yield over T₁₀ (23.27) and T₃ (18.94 q ha⁻¹), respectively.



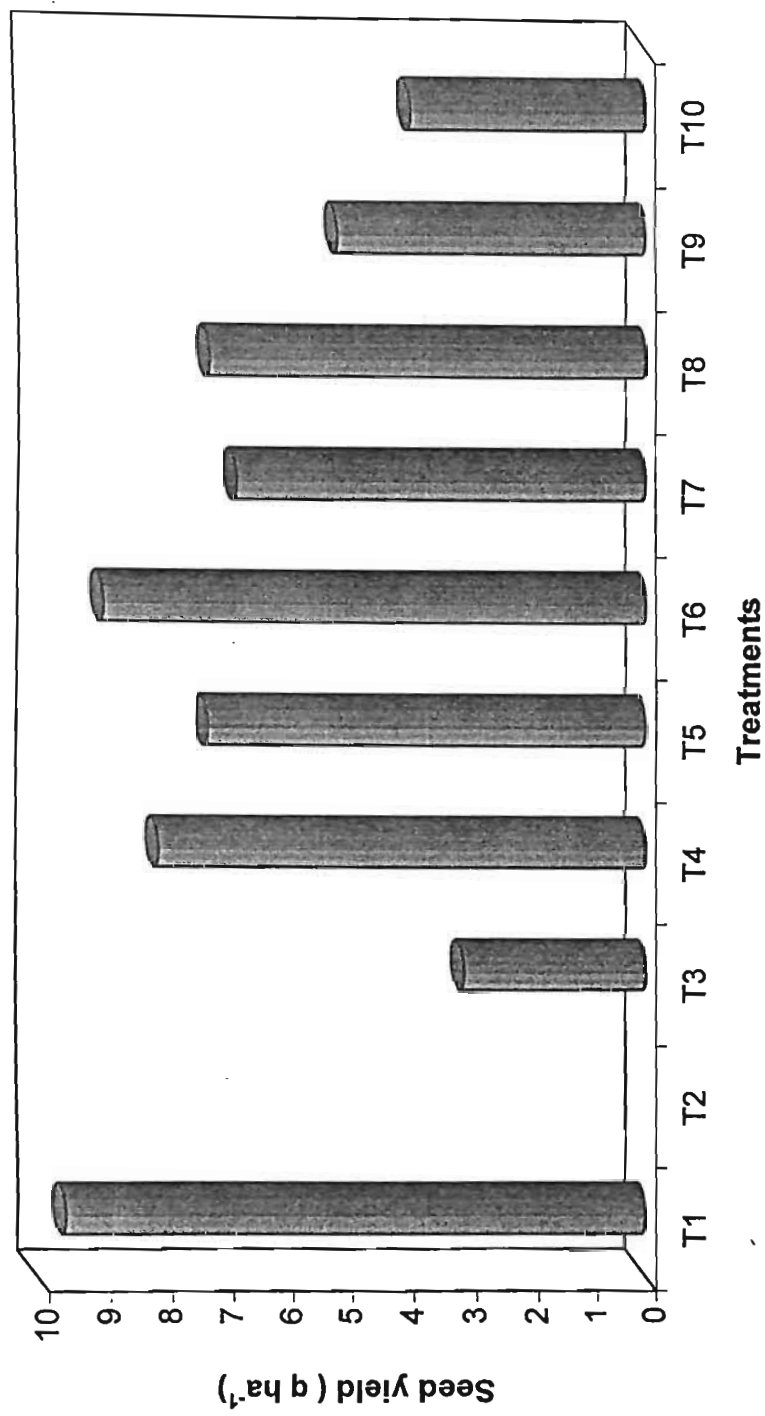


Fig. 2 : Effect of pruning Albizia on seed yield (q ha⁻¹) of cowpea

4.1.5 Harvest index (%)

The Harvest index (HI) values are presented in Table 7 showed that in T₁ (19.04), T₆ (18.66) and T₄ (18.49 %) were on par but were significantly higher than rest of treatments. It was also seen that T₅ (16.84) proved to be superior to T₉ (14.97) T₁₀ (14.23) and T₃ (13.75 %) but at par with T₈ (16.33). The treatments T₈ (16.33) and T₇ (15.94) or T₁₀ (14.23) and T₃ (13.75 %) did not differ significantly with respect to HI.

4.1.6 Shelling percentage (%)

Shelling percentage of cowpea ranged from 72.33 to 80.03 per cent among various treatments (Table 7). Shelling percentage did not differ significantly among various treatments.

4.1.7 N P K content

The data pertaining to N, P and K content in grain and straw of various treatments are presented in Table 8.

4.1.7.1 N P K content in grain

Various treatments studied did not show perceptible influence on N, P and K contents (%) in cowpea grains (Table 8). Maximum content of N (3.15 %), P (0.19 %) and K (1.13 %) were found in T₃. Minimum N was associated with T₄ (2.87 %) but P and K were with T₁ (0.17 % and 0.99 % respectively).

Table 8 : Effect of pruning *Albizia* on NPK content in grain and straw of cowpea

Treatments	Grain			Straw		
	N	P	K	N	P	K
	(%)			(%)		
T ₁ - Sole crop	2.94	0.17	0.99	1.88	0.15	0.76
T ₂ - Sole tree without pruning	-	-	-	-	-	-
T ₃ - Crop with tree and without pruning	3.15	0.19	1.13	1.99	0.17	0.87
T ₄ - Coppicing at ground level	2.87	0.17	1.06	1.91	0.15	0.79
T ₅ - Coppicing at 30 cm	2.94	0.17	1.04	1.93	0.15	0.81
T ₆ - Coppicing at 60 cm	3.02	0.17	1.03	1.97	0.15	0.81
T ₇ - Pollarding at 1.5 m	3.05	0.17	1.03	1.98	0.15	0.80
T ₈ - Pollarding at 2.0 m	3.06	0.17	1.05	1.95	0.16	0.80
T ₉ - Pollarding at 2.5 m	3.03	0.17	1.07	1.98	0.16	0.83
T ₁₀ - Lopping	3.10	0.17	1.10	1.98	0.16	0.83
SE.D	0.11	0.01	0.17	0.07	0.01	0.04
CD (0.05)	NS	NS	NS	NS	NS	NS

4.1.7.2 N P K content in straw

There was no significant difference among various treatments with respect to nitrogen, phosphorus and potassium content in cowpea straw. However, maximum N content in straw was obtained in T₃ (1.99 %) and minimum in T₁ (1.88 %).

4.1.7.3 N P K uptake in grain (kg ha⁻¹)

The N P K uptake values with respect of cowpea grain were presented in Table 9. It was observed that cowpea grain in T₁ (28.10) followed by T₆ (27.09 kg ha⁻¹) registered significantly higher N uptake when compared to other treatments. The treatment T₃ (9.51 kg ha⁻¹) was inferior to others except T₁₀. No significant differences were noticed among T₄ (23.08), T₈ (22.09) T₅ (20.99) and T₇ (20.65 kg ha⁻¹) as well as between T₉ (15.42) and T₁₀ (11.96 kg ha⁻¹).

The treatments T₁ and T₆; T₆ and T₄; T₈ and T₄; T₈ and T₅; T₅ and T₇ were on par with respect to P uptake by cowpea grain. There was no significant variation either between T₄ and T₁₀ or T₁₀ and T₃ in phosphorus uptake. Though T₁ treatment gave significantly more potassium uptake of 9.46 kg ha⁻¹ compared with other treatments, it was on par with T₆ (9.24) and T₄ (8.52 kg ha⁻¹). There were no significant differences among T₄, T₈ and T₅ as well as T₈, T₅ and T₇. The treatment T₃ gave lower potassium uptake (3.41 kg ha⁻¹) but it was on par with T₁₀ (4.25 kg ha⁻¹). The treatments T₁₀ and T₉ did not differ significantly with regard to K uptake.

4.1.7.4 N P K uptake in straw (kg ha⁻¹)

The results indicated that the treatment T₆ registered higher N uptake (77.01 kg ha⁻¹) which was significantly superior to T₉ (57.22), T₁₀ (46.31) and

Table 9 : Effect of pruning *Albizia* on N, P and K uptake (kg ha⁻¹) in grain and straw of cowpea

Treatments	Grain			Straw		
	N	P	K	N	P	K
	(kg ha ⁻¹)			(kg ha ⁻¹)		
T ₁ - Sole crop	28.10	1.58	9.46	76.40	6.01	30.76
T ₂ - Sole tree without pruning	-	-	-	-	-	-
T ₃ - Crop with tree and without pruning	9.51	0.56	3.41	36.74	3.13	16.42
T ₄ - Coppicing at ground level	23.08	1.36	8.52	67.69	5.46	28.10
T ₅ - Coppicing at 30 cm	20.99	1.19	7.43	67.07	5.21	28.08
T ₆ - Coppicing at 60 cm	27.09	1.50	9.24	77.01	5.71	31.66
T ₇ - Pollarding at 1.5 m	20.65	1.15	6.97	71.04	5.50	28.56
T ₈ - Pollarding at 2.0 m	22.09	1.23	7.58	72.15	5.77	29.71
T ₉ - Pollarding at 2.5 m	15.42	0.85	5.45	57.22	4.54	24.07
T ₁₀ - Lopping	11.96	0.65	4.25	46.31	3.66	19.39
SE.D	1.70	0.095	0.59	5.16	0.41	2.13
CD (0.05)	3.61	0.20	1.24	10.94	0.86	4.52

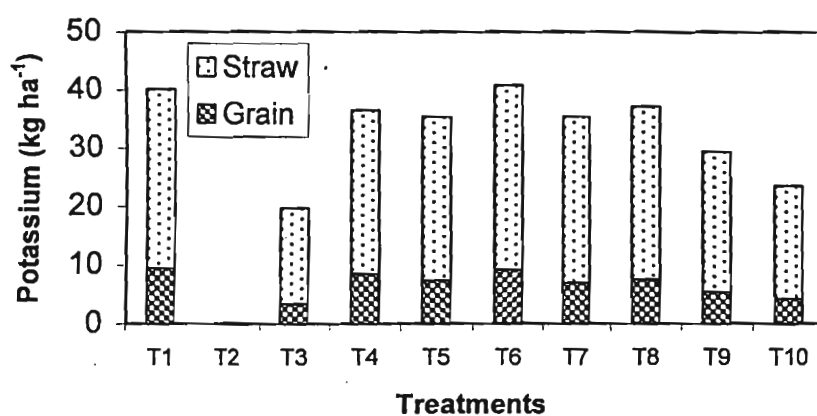
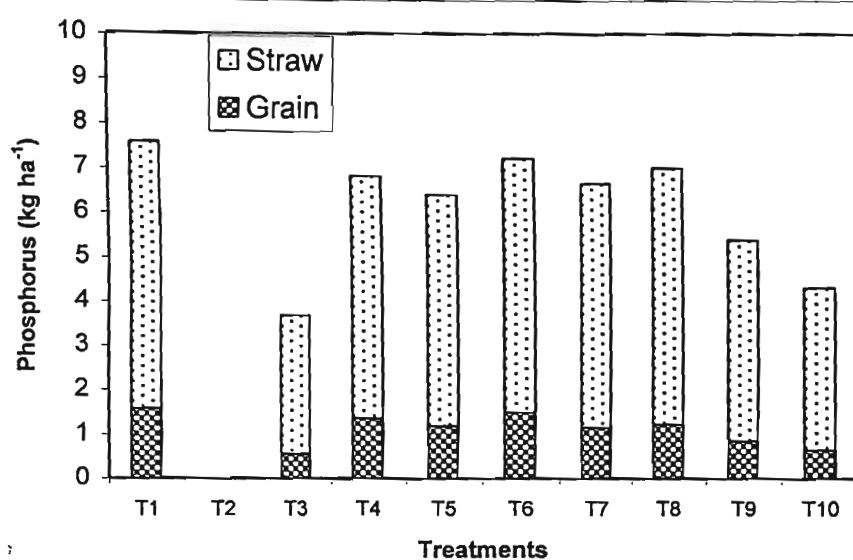
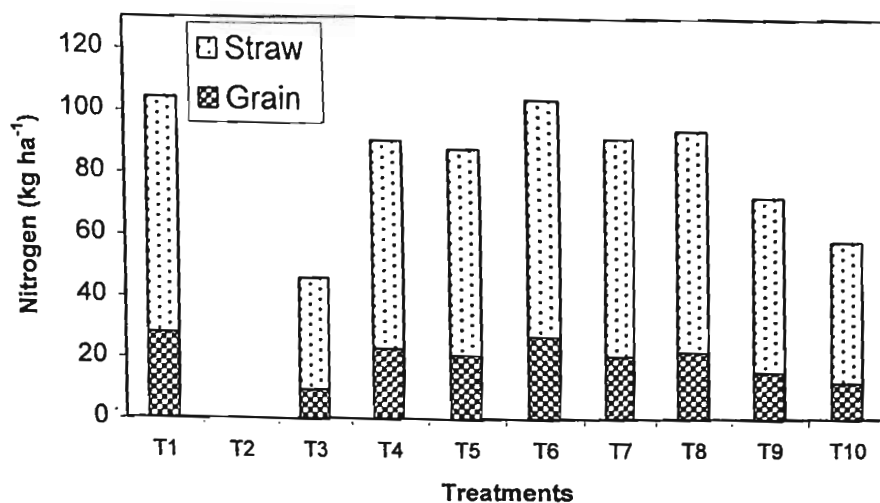


Fig. 3. Effect of pruning *Albizia* on N, P and K uptake (kg ha⁻¹) in grain and straw of cowpea

T₃ (36.74 kg ha⁻¹) but on par with other treatments (Table 9). The treatments T₃ and T₁₀ were significantly inferior to rest of the treatments. Significant differences were not observed among T₄ (67.69), T₅ (67.07) and T₉ (57.22 kg ha⁻¹). However, these treatments were significantly superior to T₁₀ (46.31) and T₃ (36.74 kg ha⁻¹) with respect to N uptake.

The cowpea straw in T₃ (3.13 kg ha⁻¹) followed by T₁₀ (3.66 kg ha⁻¹) accumulated lowest phosphorus compared with rest of the treatments. The treatment T₁ was significantly superior to T₉, T₁₀ and T₃. However, these values were equal to other treatments. The treatments T₅ (5.21) and T₉ (4.54 kg ha⁻¹) did not differ significantly in phosphorus uptake in straw.

The treatments T₆ (31.66) and T₃ (16.42 kg ha⁻¹) gave higher and lower K uptake. The former was found to be equal to T₁, T₈, T₇, T₄ and T₅, while the latter was equal to T₁₀. There was no conspicuous variation with respect to K uptake among T₇ (28.56), T₄ (28.10), T₅ (28.08) and T₉ (24.07 kg ha⁻¹) treatments.

4.2 EFFECT OF TREES ON SOIL MOISTURE STATUS

The data on soil moisture measured from two depths (0-15 and 15-30 cm) were expressed on volume basis for different growth stages of cowpea and presented in Table 10.

In general, soil moisture content increased with depth of soil from 0-15 cm to 15-30 cm. The moisture content of the soil showed a decreasing trend from sowing to harvesting stage of crop.

Table 10 : Effect of tree pruning on soil moisture status (cm) in cowpea crop at varying depths and different stages

Treatments	Sowing			30 DAS			60 DAS			Harvest		
	0-15 cm		15-30 cm	0-15 cm		15-30 cm	0-15 cm		15-30 cm	0-15 cm		15-30 cm
T ₁ - Sole crop	4.50		4.67	4.47		4.59	3.37		3.57	2.00		2.30
T ₂ - Sole tree without pruning	4.41		4.53	4.40		4.53	3.53		3.63	2.37		2.57
T ₃ - Crop with tree and without pruning	4.40		4.50	3.93		4.10	2.73		2.90	1.37		1.63
T ₄ - Coppicing at ground level	4.46		4.63	4.23		4.47	3.28		3.43	1.93		2.15
T ₅ - Coppicing at 30 cm	4.46		4.60	4.20		4.48	3.27		3.39	1.90		2.13
T ₆ - Coppicing at 60 cm	4.45		4.53	4.23		4.50	3.27		3.47	1.93		2.10
T ₇ - Pollarding at 1.5 m	4.43		4.67	4.20		4.46	3.20		3.43	1.86		2.10
T ₈ - Pollarding at 2.0 m	4.40		4.57	4.17		4.40	3.17		3.40	1.83		2.07
T ₉ - Pollarding at 2.5 m	4.43		4.47	4.20		4.35	3.13		3.37	1.85		2.04
T ₁₀ - Lopping	4.42		4.58	4.03		4.22	2.95		3.13	1.60		1.96
SE.D	0.21		0.11	0.18		0.15	0.20		0.20	0.20		0.18
CD (0.05)	NS		NS	NS		NS	NS		NS	0.41		0.38

At the time of sowing, the total soil moisture upto 30 cm depth was highest in sole cowpea i.e. T₁ (9.17 cm) followed by T₄, T₅, T₇, T₅ and T₆. The soil moisture recorded was lowest in T₃ (Trees with crop and without pruning) which was less by 0.05 and 0.17 cm over sole cowpea (T₁) at both 0-15 and 15-30 cm depths respectively, but there was no significant difference among various treatments (Table 10).

Significant differences were not observed among various treatments with respect to soil moisture status at 30 DAS. However, the moisture was highest in sole crop i.e. T₁ (9.06 cm) followed by T₂, T₆, T₄ and T₅. Soil moisture depletion was more in T₃ which had 0.92 cm less value than that of sole cowpea.

The soil moisture status at 60 DAS showed non- significant difference among the treatments. However, the soil moisture was highest in T₂ at both the depths of 0-15 (3.53 cm) and 15-30 cm (3.63 cm) respectively. Lowest soil moisture of 2.73 and 2.90 cm was observed in T₃ at 0-15 and 15-30 cm, respectively. At the time of harvesting, sole tree (T₂) had recorded maximum soil moisture content of 2.37 and 2.57 cm at 0-15 and 15-30 cm respectively, which was significantly higher than rest of the treatments except T₁ (2.00 and 2.30 cm at 0-15 and 15-30 cm respectively. Trees with crop and without pruning (T₃) had significantly lower soil moisture status of 1.37 and 1.63 cm at 0-15 and 15-30 cm depths respectively but on par with T₁₀. Soil moisture status of all pruning treatments (T₄, T₅, T₆, T₇, T₈, T₉ and T₁₀) were on par with sole cowpea (T₁) at both soil depths (Fig. 4).

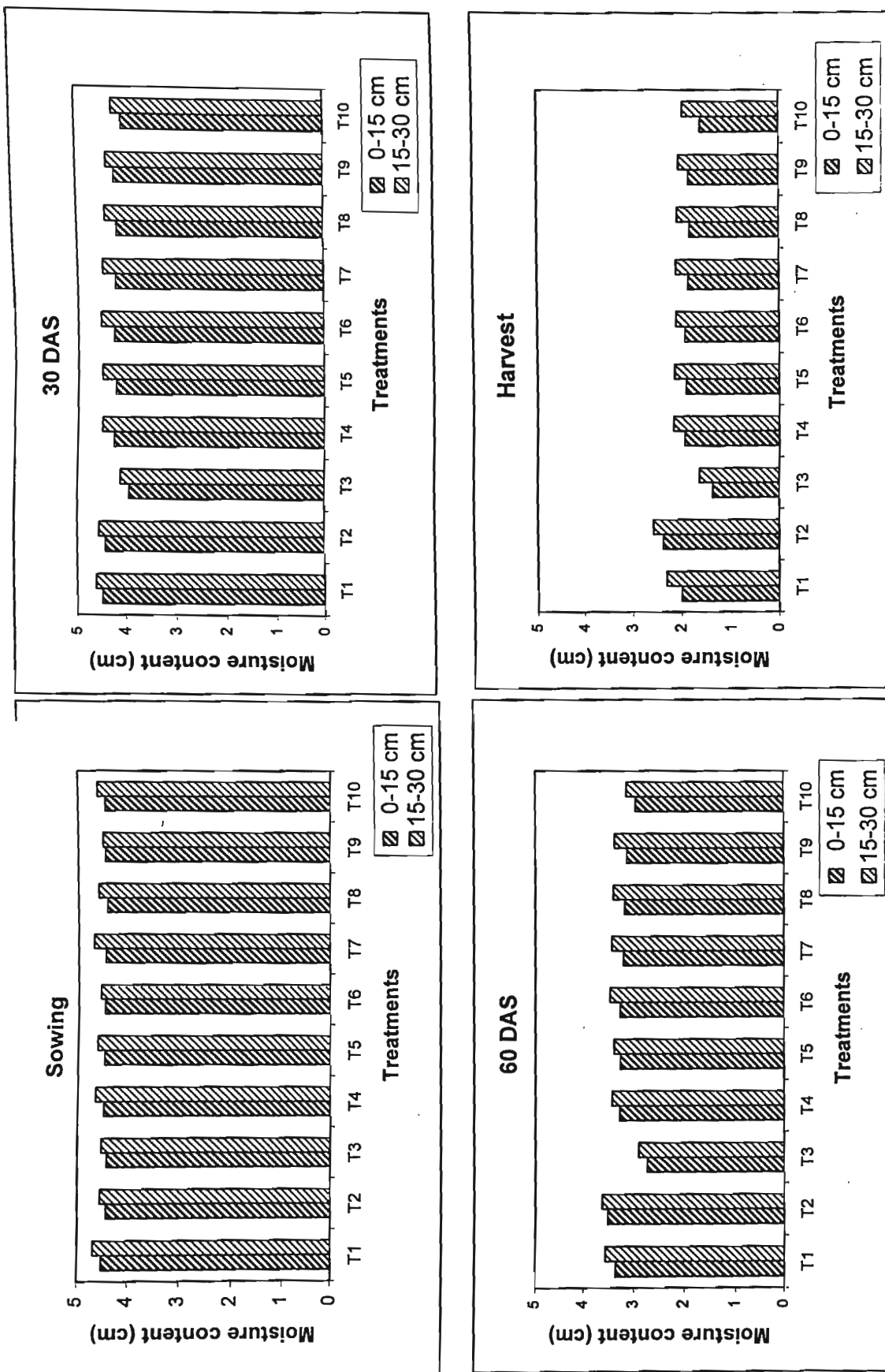


Fig. 4 : Effect of tree pruning on soil moisture status (cm) in cowpea crop at varying depths and different stages

4.3 PHYSICO-CHEMICAL PROPERTIES OF SOIL

The various chemical properties of soil viz., pH, EC, organic carbon and available N, P_2O_5 and K_2O were differed significantly at both the depths in pre and post harvest soils (Table 11 and 12). The data indicated that except pH and EC, the other parameters registered a declining trend with increasing depth of the soil from 0-15 to 15-30 cm.

4.3.1 Soil pH

The pH values of T_2 and T_{10} treatments have decreased in post harvest soils in both the depths. In addition to these treatments, the decrease was also seen in T_3 at 0-15 cm layer, whereas in T_7 at 15-30 cm depth, there was slight reduction. However, the remaining treatments showed marginal increase with soil depth. In all the treatments while there was no significant difference in pH values in initial soil, the post harvest soils showed significant difference at both the depths. At 0-15 cm depth, the pH values ranged from 6.7 (T_1) to 6.4 (T_2). It was noticed that the values obtained in T_4 , T_5 , T_6 and T_9 were on par with T_1 while T_8 , T_7 , T_{10} and T_3 recorded similar values as recorded in T_2 (Table 11).

4.3.2 Electrical conductivity ($dS\ m^{-1}$)

The Electrical conductivity (EC) of soil was found to increase marginally after cropping in all treatments, maximum value being in T_1 ($0.310\ dS\ m^{-1}$) at 0-15 cm soil depth. It was significantly superior followed by coppicing and pollarding treatments. It was observed that minimum EC content of $0.206\ dS\ m^{-1}$ in T_2 was significantly inferior and independent to others, followed by T_3 and T_{10} . Rest of the treatments were intermediary in their values while similar trend was observed at

Table 11 : Influence of tree pruning on soil pH, EC and OC at varying depths before and after cropping

Treatments	pH						EC (dS m ⁻¹)						OC (%)					
	0-15 cm			15-30 cm			0-15 cm			15-30 cm			0-15 cm			15-30 cm		
	BC	AC		BC	AC		BC	AC		BC	AC		BC	AC		BC	AC	
		BC	AC		BC	AC		BC	AC		BC	AC		BC	AC		BC	AC
T ₁ - Sole crop	6.7	6.8	6.8	6.8	6.8	6.8	0.297	0.310	0.318	0.321	0.26	0.24	0.26	0.24	0.27	0.26	0.26	0.26
T ₂ - Sole tree without pruning	6.4	6.4	6.5	6.5	6.5	6.5	0.195	0.206	0.207	0.213	0.36	0.38	0.36	0.38	0.34	0.35	0.35	0.35
T ₃ - Crop with tree and without pruning	6.5	6.5	6.5	6.5	6.5	6.5	0.224	0.243	0.250	0.250	0.36	0.37	0.36	0.37	0.33	0.34	0.34	0.34
T ₄ - Coppicing at ground level	6.6	6.6	6.6	6.6	6.6	6.6	0.271	0.277	0.280	0.282	0.30	0.29	0.30	0.29	0.28	0.28	0.28	0.28
T ₅ - Coppicing at 30 cm	6.6	6.6	6.6	6.6	6.6	6.6	0.263	0.269	0.276	0.277	0.31	0.31	0.31	0.31	0.29	0.30	0.30	0.30
T ₆ - Coppicing at 60 cm	6.5	6.5	6.6	6.6	6.6	6.6	0.260	0.265	0.270	0.272	0.31	0.32	0.31	0.32	0.30	0.31	0.31	0.31
T ₇ - Pollarding at 1.5 m	6.5	6.5	6.6	6.6	6.6	6.5	0.258	0.260	0.271	0.271	0.31	0.33	0.31	0.33	0.30	0.32	0.32	0.32
T ₈ - Pollarding at 2.0 m	6.5	6.5	6.6	6.6	6.6	6.6	0.256	0.262	0.270	0.269	0.33	0.34	0.33	0.34	0.32	0.33	0.33	0.33
T ₉ - Pollarding at 2.5 m	6.5	6.5	6.6	6.6	6.6	6.6	0.256	0.258	0.267	0.267	0.33	0.34	0.33	0.34	0.32	0.33	0.33	0.33
T ₁₀ - Lopping	6.5	6.5	6.5	6.5	6.5	6.5	0.236	0.245	0.250	0.251	0.34	0.35	0.34	0.35	0.33	0.33	0.33	0.33
SE.D	0.1	0.1	0.1	0.1	0.1	0.1	0.006	0.008	0.007	0.005	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (0.05)	NS	0.2	NS	NS	0.2	0.2	0.013	0.016	0.015	0.010	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.03

BC Before cropping

AC After cropping

15-30 cm soil depth. In pre-harvest soil samples, there was no significant difference in values among the treatments. Maximum EC was obtained in T₁ (0.297 dS m⁻¹) and minimum in T₃ (0.195 dS m⁻¹) particularly at 0-15 cm depths (Table 11).

4.3.3 Organic carbon (%)

Organic carbon (OC) content of the soil increased significantly after cropping in all treatments except in T₁ and T₄ (Table 11). Maximum OC content at 0-15 cm was obtained in T₂ (0.38 %) while the rest of treatments being inferior. The OC content obtained in sole cowpea was significantly inferior and independent to others. It showed that lopping and pollarding were on par with T₃ while rest of the treatments being intermediary and not comparable to each other. Similar trend was observed at 15-30 cm soil depth also. While before cropping there was significant difference among the treatments and higher and lower values being observed in T₂ (0.36 %) and T₁ (0.26 %) respectively at 0- 15 cm. Similar trend was observed at 15-30 cm soil depth also.

4.3.4 Available N (kg ha⁻¹)

The data presented in Table 12 indicated that the available nitrogen in soil was markedly higher in surface layers (0-15 cm). It was noticed that the available N was increased after cropping in all treatments except in T₁. The highest available N was noticed in T₂ (144.8 kg ha⁻¹). It was found to be significantly superior to other treatments but on par with T₃. The lower available N was noticed in T₁ (115.8 kg ha⁻¹) which was on par with T₄ and T₅. The rest of the treatments were intermediary and were comparable to each other. Similar trend was observed at 15-30 cm soil depth also. The trend obtained in initial soil samples was similar

Table 11 : Effect of tree pruning on available N, P₂O₅ and K₂O (kg ha⁻¹) of soil at varying depths before and after cropping

Treatments	N						P ₂ O ₅						K ₂ O					
	0-15 cm			15-30 cm			0-15 cm			15-30 cm			0-15 cm			15-30 cm		
	BC	AC		BC	AC		BC	AC		BC	AC		BC	AC		BC	AC	
T ₁ - Sole crop	118.8	115.8		108.7	107.9		13.1	12.8		11.7	11.6		138.9	132.8		127.4	122.9	
T ₂ - Sole tree without pruning	141.7	144.8		132.1	133.4		20.5	22.5		18.7	19.7		166.1	169.7		156.8	156.5	
T ₃ - Crop with tree and without pruning	134.0	135.6		124.4	127.4		17.9	19.4		16.6	17.5		155.9	155.8		142.0	146.9	
T ₄ - Coppicing at ground level	119.0	122.1		110.1	110.6		13.5	14.0		12.2	12.6		150.5	145.4		143.6	137.3	
T ₅ - Coppicing at 30 cm	120.0	123.3		112.5	116.3		13.8	14.0		12.7	12.0		150.1	148.1		145.0	140.4	
T ₆ - Coppicing at 60 cm	127.1	129.2		113.7	117.3		13.8	14.3		11.8	12.8		152.5	148.5		148.5	140.8	
T ₇ - Pollarding at 1.5 m	124.2	127.5		115.1	117.7		14.2	15.2		12.2	13.7		152.7	148.7		145.5	139.6	
T ₈ - Pollarding at 2.0 m	123.9	128.9		116.0	116.8		14.2	14.9		12.2	13.5		154.6	148.7		148.9	141.8	
T ₉ - Pollarding at 2.5 m	128.0	129.3		118.2	118.9		14.5	15.7		12.6	13.4		155.0	149.4		147.6	140.9	
T ₁₀ - Lopping	129.1	131.9		119.7	120.9		17.7	18.0		15.6	16.8		156.1	154.8		148.9	144.8	
SE.D	6.3	5.2		5.3	6.2		2.8	1.6		2.5	1.4		8.5	7.4		7.9	6.0	
CD (0.05)	13.3	10.8		11.1	13.1		NS	3.3		NS	2.9		NS	15.6		NS	12.7	

BC Before cropping

AC After cropping

that of post harvest soils. Maximum available N being with T₂ (141.7 kg ha⁻¹) and the minimum was seen in T₁ (118.8 kg ha⁻¹).

4.3.5 Available P₂O₅ (kg ha⁻¹)

In general, higher amount of available P₂O₅ was recorded in surface soil and it was decreased with increase in depth of soil in all treatments (Table 12). It was increased after cropping in all treatments except in T₁, maximum value being obtained in T₂ (22.5 kg ha⁻¹) at 0-15 cm soil depth. It was significantly superior over T₉, T₇, T₈ and T₆. The lower P₂O₅ of 12.8 kg ha⁻¹ was obtained in T₁ but was on par with T₄, T₅, T₆, T₈, T₇ and T₉. Similar trend was observed at lower depth of soil (15-30 cm) also.

4.3.6 Available K₂O (kg ha⁻¹)

The available K₂O content at the surface soil layer (0- 15 cm) was appreciably higher in case of all treatments. Maximum available K₂O was noticed in T₂ (169.7 kg ha⁻¹), while minimum was in T₁ and was significantly superior to pollarding and coppicing treatments but on par with T₃ and T₁₀. The lower content of 132.8 kg ha⁻¹ was recorded in T₁ which was significantly inferior but on par with T₄ and T₅. The other treatments are intermediary and on par with each other (Table 12). Similar trend was also observed at 15-30 cm soil depth. Before cropping, there was no significant difference among the treatments. However, the maximum available K₂O was noticed in T₂ (166.1 kg ha⁻¹) and the lowest in T₁ (138.9 kg ha⁻¹) at 0-15 cm soil depth.

4.4 EFFECT OF PRUNING ON TREE GROWTH AND BIOMASS PRODUCTION

4.4.1 Number of stumps per tree

The data pertaining to number of stumps (branches) per tree as influenced by various pruning treatments are given in Table 13.

Albizia when pollarded at 2.0 m height produced maximum number of stumps per tree (7.6) followed by 6.2 in T₇ and 6.0 in T₉ and were significantly higher than other treatments. There was no significant difference among T₇, T₉ and T₁₀ treatments. The treatment T₇ was superior (6.2) over T₁₀, T₅, T₆ and T₄ except T₉. Number of stumps per tree were on par with each other in T₁₀, T₅, T₆ and T₄ treatments.

4.4.2 Effect of pruning on tree growth in association with cowpea

The data (Table 13) on growth of *Albizia* tree, after cropping indicated that the height of tree was increased with all treatments. However, pruning treatments had showed higher increment on tree height compared to unpruned treatments. The increase of 1.76 m in height was observed in T₅ followed by T₆ (1.64 m) and least was seen in T₃ (0.85 m).

The girth at breast height (GBH) was appreciably increased under unpruned condition. It was showed that of 6.7 and 6.2 cm GBH increments were observed in T₃ and T₂ respectively. However, the increment was lowest (3.2 cm) where pollarded at 1.5 m height i.e. T₇.

Table 12 : Effect of pruning on tree growth and biomass production

Treatments	Number of branches	Tree height (m)		Girth at breast height (cm)		Woody biomass (q ha ⁻¹)	Leaf biomass (q ha ⁻¹)
		BC	AC	BC	AC		
T ₁ - Sole crop	-	-	-	-	-	-	-
T ₂ - Sole tree without pruning	-	7.0	7.92	57.7	63.9	-	-
T ₃ - Crop with tree and without pruning	-	6.86	7.71	58.3	64.6	-	-
T ₄ - Coppicing at ground level	3.2	0.00	1.32	-	-	17.77	1.79
T ₅ - Coppicing at 30 cm	4.0	0.30	2.06	-	-	19.83	2.33
T ₆ - Coppicing at 60 cm	3.9	0.60	2.24	-	-	23.33	2.65
T ₇ - Pollarding at 1.5 m	6.2	1.50	3.04	31.6	34.8	40.37	3.34
T ₈ - Pollarding at 2.0 m	7.6	2.00	3.35	33.2	38.0	38.03	3.23
T ₉ - Pollarding at 2.5 m	6.0	2.50	3.50	37.0	41.5	38.40	3.32
T ₁₀ - Lopping	5.0	6.74	7.60	54.6	54.6	28.23	2.67
SE.D	0.9	-	-	-	-	2.08	0.35
CD (0.05)	2.0	-	-	-	-	4.52	0.77
BC Before cropping							
AC After cropping							

4.4.3 Woody biomass (q ha^{-1})

Albizia produced highest woody biomass yield of 40.37 q ha^{-1} when pollarding was done at 1.5 m height (T_7) and was nearly equal to wood biomass obtained due to pollarding at 2.5 m height (T_9 : 38.40 q ha^{-1}) and 2.0 m height (T_8 : 38.03 q ha^{-1}). These were superior to other treatments. The treatment T_{10} where *Albizia* was subjected to lopping, significantly higher wood biomass of 28.23 q ha^{-1} obtained as compared to T_6 (23.33), T_5 (19.83) and T_4 (17.77 q ha^{-1}). *Albizia* in T_4 registered significantly lower woody biomass (17.77 q ha^{-1}) followed by 19.83 equal in T_5 treatment. The treatments T_6 and T_5 were at par.

4.4.4 Leaf biomass (q ha^{-1})

Albizia when pollarded at 1.5 m height (T_7) produced higher leaf biomass of 3.34 q ha^{-1} and was nearly equal to biomass obtained from T_9 and T_8 . These were superior to T_5 and T_4 but on par with T_{10} and T_6 . *Albizia* when coppiced at ground level (T_4) registered significantly lower yield (1.79 q ha^{-1}) followed by T_5 .

4.5 EFFECT OF PRUNING HEIGHT ON GROWTH OF STUMPS

4.5.1 Length of stump

The data on length of stump (branch) recorded at various growth stages as influenced by different pruning treatments are presented in Table 14. The results showed that there was no significant difference among the treatments at 60 days after pruning (DAP). However, it was observed that there was increase in stump length with increase in pruning height. Maximum being in T_9 (120.3 cm) while minimum was in T_4 (95.7 cm). Similarly, at 120 DAP, T_9 (170.0 cm) recorded

Table 14 : Effect of pruning on growth of stumps (Branches)

Treatments	Length of branch (cm)		AGR	Girth of branch (cm)		AGR
	60	120	60-120	60	120	60-120
	DAS					
T ₄ - Coppicing at ground level	95.7	130.0	0.56	5.43	6.30	0.02
T ₅ - Coppicing at 30 cm	102.7	139.0	0.60	6.01	7.00	0.02
T ₆ - Coppicing at 60 cm	105.3	144.0	0.65	6.22	7.30	0.02
T ₇ - Pollarding at 1.5 m	111.0	162.0	0.85	6.85	8.20	0.02
T ₈ - Pollarding at 2.0 m	113.7	166.0	0.87	7.04	8.35	0.02
T ₉ - Pollarding at 2.5 m	120.3	170.0	0.83	7.10	8.47	0.02
SE.D	5.0	8.0	0.07	0.13	0.18	0.00
CD (0.05)	NS	26.0	0.21	0.42	0.56	NS

significantly more length over T₅ and T₄ but it was on par with T₈, T₇ and T₆, lowest obtained in T₄ (130.0 cm) which was on par with T₅ and T₆.

4.5.2 Absolute growth rate to length of stump (cm day⁻¹)

Absolute growth rate (AGR) of stump from 60 to 120 DAP was significantly influenced by different treatments. It was maximum in T₈ (0.87 cm day⁻¹) but it was on par with T₇ and T₉. Though T₄ recorded lowest AGR (0.56 cm day⁻¹) but it was on par with T₅ and T₆. The treatments T₇, T₉ and T₆ were comparable with each other.

4.5.3 Girth of stump (cm)

The data on girth of stump at different stages were presented in the Table 14. The maximum value was recorded in T₉ (7.10 cm) which was significantly superior over T₆ and T₅ but on par with T₈ and T₇. Minimum girth was obtained in T₄ (5.43 cm) which was independent and significantly inferior. There was no significant difference between T₅ and T₆. Similar trend was observed at 120 DAP also with maximum girth being observed in T₉ (8.47 cm) and the lowest in T₄ (6.30 cm).

4.5.4 Absolute growth rate to girth of stump (cm day⁻¹)

Absolute growth rate with respect to girth of stump from 60-120 DAP was not significantly influenced by different treatments. Maximum being observed in T₉ and T₇ (0.02 cm day⁻¹) while the minimum was in T₄ (0.02 cm day⁻¹).

4.6 ECONOMICS

4.6.1 Gross returns (Rs. ha⁻¹)

It was observed from the data (Table 15) that maximum gross returns of Rs. 11048 ha⁻¹ was realised with adoption of coppicing at 60 cm height, followed by pollarding at 2.0 m (Rs. 10558 ha⁻¹), Pollarding at 1.5 m (Rs 10267 ha⁻¹), Coppicing at ground level (Rs. 9605 ha⁻¹) and sole crop (Rs. 9560 ha⁻¹). Lower gross returns were obtained from crop with tree without pruning (Rs. 3020 ha⁻¹). The rest of the treatments were intermediary.

4.6.2 Net returns (Rs ha⁻¹)

Net returns (Table 15) from cowpea in association with *A. lebbeck* under coppicing at 60 cm height (T₆) resulted in appreciably higher value of Rs. 6278 ha⁻¹ followed by T₈ (Rs. 5788), T₇ (Rs. 5497), T₁ (Rs. 5290) and T₄ (Rs.4835). Negative returns (- Rs.1250 ha⁻¹) were obtained in T₃.

4.6.3 Benefit-cost ratio

The Benefit-cost ratio (BCR) followed the same trend as that of net returns (Table 15). Treatment T₆ had higher BCR of 1.32 followed by sole cowpea (1.24), T₈ and T₇. But T₃ had BCR of -0.29. Rest of the treatments were intermediary.

4.7 CORRELATION STUDIES

Simple correlation coefficients (*r'* values) were worked out between seed yield and other parameters and are presented in Table 16. All the parameters were significantly correlated with seed yield except plant height at 30 DAS.

Table 15 : Gross and net returns, cost of cultivation (Rs ha⁻¹) and BC-ratio of cowpea as influenced by pruning practices

Treatments	Gross returns	Cost of cultivation	Net returns	B:C ratio
T ₁ - Sole crop	9560	4270	5290	1.24
T ₂ - Sole tree without pruning	-	-	-	-
T ₃ - Crop with tree and without pruning	3020	4270	-1250	-0.29
T ₄ - Coppicing at ground level	9605	4770	4835	1.01
T ₅ - Coppicing at 30 cm	9013	4770	4243	0.89
T ₆ - Coppicing at 60 cm	11048	4770	6278	1.32
T ₇ - Pollarding at 1.5 m	10267	4770	5497	1.15
T ₈ - Pollarding at 2.0 m	10558	4770	5788	1.21
T ₉ - Pollarding at 2.5 m	8428	4770	3658	0.77
T ₁₀ - Lopping	6332	4770	1562	0.33

Significant positive correlation was observed between seed yield and plant height at 60 ($r = 0.6301$) and 90 DAS ($r = 0.3531$) respectively. Similarly, physiological parameters i.e, leaf temperature ($r=0.9369$ and 0.9827), photosynthetically active radiation ($r=0.9254$ and 0.9745) and transpiration rate ($r=0.9735$, $0.9596-1$) also showed significantly positive correlation at 30 and 60 DAS respectively, whereas significant negative correlation was observed for relative humidity ($r= -0.9285$ and -0.9478) and diffusive resistance ($r=-0.9478$ and -0.9164) at 30 and 60 DAS, respectively with seed yield.

Significant positive correlation was observed between seed yield and dry matter production. ($r = 0.8109$, 0.9503 and 0.9825). Leaf area index ($r = 0.8520$, 0.8474 and 0.8339), crop growth rate ($r = 0.8074$, 0.9303 , 0.9735) at 30, 60 and 90 DAS respectively. It was further observed the pod length ($r = 0.9010$), pods plant⁻¹ ($r = 0.9522$), No. of seeds per pod ($r = 0.9629$), 1000 seed weight ($r = 0.9758$), shelling per cent ($r = 0.9216$), straw yield ($r = 0.9696$), harvest index ($r = 0.9775$) and N P K uptake at harvesting stage also correlated positively with seed yield.

DISCUSSION

CHAPTER V

DISCUSSION

Low and unstable yields are a common phenomenon causing hardship to farmers in semi-arid regions. The difficulties faced by farmers for applying costly inputs like fertilizers are manifold and infact uneconomical in those areas because of frequent failure of monsoon. Copius amount of knowledge and technology available for such situation was just not enough to mitigate such problems. An alternative, therefore, is to be suggested to partially meet the demands of such farmers. One such alternative can be an agroforestry system, that promises sustainable income, though not to full extent.

Albizia lebbeck being an important NFTs could be integrated with a pulse crop like cowpea to achieve much needed benefits with the tree management in order to allow the sunlight to pass through the tree foliage and reach the ground, thereby sustaining the yield of underneath crop. The results obtained in a study with respect to "Effect of pruning *Albizia lebbeck* (L.) on yield and nutrient uptake of cowpea in agri-silvisystem" is discussed in this chapter.

5.1 INFLUENCE OF PRUNING ON GROWTH AND YIELD OF COWPEA

5.1.1 Growth characters

The plant height of cowpea at 60 and 90 DAS was significantly influenced by pruning practices. However, it was found to be lowest at 90 DAS in T₃ (34.6 cm) followed by T₁₀ (58.2 cm). The rest of the treatments were on par with sole crop (65.6 cm) with respect to the plant height. Tree without pruning contributing to lower PAR values on crop could be the reason for such a trend in T₃ and T₁₀.

Plant height is a character associated with internode elongation along with proportionate growth increment wherever favourable conditions like maximum sunlight conveying on crop surface exist. This phenomenon was not prevailing in treatments with pruning and hence the higher values obtained in these treatments. Similar results were reported by Cham Shama *et al.* (1998) and Mishra *et al.* (1998).

Dry matter production alongside CGR of cowpea at harvest under sole crop ($15.07 \text{ g plant}^{-1}$) was superior over T_9 and T_{10} but was on par with T_4 , T_5 , T_6 , T_7 and T_8 , while inferior values being obtained in T_3 . Higher values in sole crop might be due to minimum competition for natural resources like soil moisture and solar radiation as encountered in treatments with tree. These results were in conformity with the findings of Osman *et al.* (1998).

Like dry matter production, leaf area index values at 60 and 90 DAS were higher in sole crop in relation to other treatments. However, in pruning treatments, LAI was on par with sole crop indicating the advantage of pruning trees. Such pruning practices with some advantage certainly encourages the farmers to adopt farming systems as advocated in this study. Similar results were observed by Leihmar *et al.* (1996), Madhusudan (1997) and Osman *et al.* (1998).

5.1.2 Physiological parameters

Leaf temperature (LT) at 30 and 60 DAS was not significantly influenced by any of the treatments. However, maximum LT values were observed in sole cowpea and minimum in T_3 . This could be due to minimum amount of PAR reaching the crop canopy in T_3 . This being so, the values of RH followed the reverse trend with high values in T_3 (50.4 %) over other treatments. The obvious reason for such

trend can be high humidity under unpruned treatments with trees possessing dense crown. Bheemaiah *et al.* (1998), and Kanchana (1998) also reported similar results in Agri-silvi systems. The PAR, which is a prerequisite for maximum dry matter production followed the trend expected while recording maximum values in T₁ followed by coppicing and pollarding treatments particularly at 30 and 60 DAS. These observations permit to conclude that due to pruning of *Albizia* trees in this particular study, there was a definite possibility to increase the availability of incoming solar radiation to the understorey crop canopy. Such results were reported by Hazra and Tripathi (1986), Misra and Bhat (1994) and Bheemaiah *et al.* (1998). Similar to the PAR values, TR also varied significantly due to imposition of pruning treatment and followed the trend similar to PAR indicating the importance of these physiological parameters for achieving maximum yields in agroforestry systems of this nature.

5.1.3 Yield and yield components

Yield components like pods plant⁻¹, number of seeds pod⁻¹ and 1000-seed weight were found significantly superior under sole cowpea over T₉, T₁₀ and T₃ but was on par with T₆, T₄, T₅, T₈ and T₇. These values being superior, contributed ultimately in obtaining higher seed yields, when compared with lower seed yields and yield contributing factors in T₃. This could be obvious reason for poor growth of cowpea under the constraints of poor nutrient availability coupled with certain other factors like shade etc.,

In addition to these well known factors responsible for low yields, a reason understandably might be the allelopathic influence. Root exudates of trees presumably contain certain toxic substances like parabenzoic acid, coumaric acid etc. These toxins also play a vital role in influencing the growth of crops. Such observations

were recorded earlier by Paroda and Muthan (1979), Lal (1989) and Sreemannarayana *et al.* (1994).

Higher photosynthetic activity in cowpea largely contributed to higher dry matter production in sole crop and in treatments with pruning relative to dry matter produced in unpruned treatments. Similar results were reported by Madhusudan (1997), Kanchana (1998), Mishra *et al.* (1998) and Osman *et al.* (1998). In Consonance with both dry matter and seed yield pattern, high harvest index was recorded in T₁, T₆ and T₄ treatments presumably due to higher seed yield.

5.1.4 Nutrient uptake

The total N P K uptake were maximum in sole crop (N : 104.50, P : 7.59; K : 40.22 kg ha⁻¹) and were equal to those obtained under T₆ (N: 104.10; P : 7.21 and K: 40.90 kg ha⁻¹) where coppicing was carried out at 60 cm height. Lower values were obtained in T₃ (N : 46.25; P : 3.69 and K : 19.83 kg ha⁻¹). Nutrient uptake being resultant parameter of concentration and dry matter production obviously recorded less values in treatments with low dry matter production though the nutrient concentration was high in such treatments; these results clearly indicated such trend with values of high NPK content in plant both in grain and straw. The reason being when there was low dry matter production, the scope for dilution is presumably less, thereby leading to higher nutrient concentration in plants, in treatment where ever pruning was not imported. Similar results were reported by Hazra and Tripathi (1986), Suresh (1996), Endrias (1998) and AICRP AF (1997-99).

5.2 EFFECT OF TREES ON SOIL MOISTURE STATUS

Several studies on agroforestry in semi-arid regions of India, in general, showed that trees can compete strongly with crop for water and nutrients. In some cases, losses in crop yield due to competition from trees were much higher than expected (Ong *et al.*, 1990). Results of the present study indicated that in general, soil moisture depletion was maximum from surface soil than that of from sub surface soil, as it was found that at 0-15 cm depth, moisture depletion was maximum in all the treatments except in T₁ and T₂ indicating competition for moisture by both tree and crop. The data presented were showed similar trend with respect to the soil moisture content at harvesting stage of crop. The moisture status was maximum in T₂ (2.37 and 2.57 cm) and T₁ (2.00 and 2.30 cm) at 0-15 and 15-30 cm, respectively, while in treatments like T₃ had lower soil moisture status of 1.37 and 1.63 cm at 0-15 and 15-30 cm respectively, but was on par with T₁₀. The results obtained were in line with the findings of Rao *et al.* (1991), Karwar (1992), Govinda Rajan *et al.* (1996) and Suresh and Rao (1998). In the present study, it was also found that the soil moisture content of all pruning treatments were on par with sole crop (T₁) indicating the beneficial effect of pruning. The result obtained at CRIDA (1998-99) under agri-silvisystem confirmed these results.

5.3 CHANGES IN PHYSICO-CHEMICAL PROPERTIES OF SOIL

The presence of perennial woody species either in integration with crop or in pure system was expected to bring about desirable changes in site characters. In the present investigation the data indicated that except pH and EC, the other parameter registered a declining trend with increasing depth of the soil from 0-15 to 15-30 cm. Similar results were observed by Hailu *et al.* (2000), pH of the soil

decreased after cropping in T₂, T₁₀ and T₃. However, the remaining treatments showed marginal increase in pH which might be because of sizable accumulation of leaf litter in the vicinity of tree over a period of six years. The change in pH was resulted such accumulation of litter and biological decomposition that followed later under infavourable condition. Similar results were reported by Hazra (1987), Singh *et al.* (1989) and Tripathi and Hazra (1997). Such accumulation of leaf litter and resulting decomposition also contributed to high organic carbon that increased significantly after cropping in all the treatments except in T₁ and T₄, maximum being obtained in T₂ and T₃, while T₁ was inferior and independent to others. Another reason could be deep and extensive root system of the tree, that might have extracted nutrients from deeper layer and enriched the soil surface through the leaf fall. This recycling of nutrients play an important role in improving the fertility status of surface soil. Similar improvement in OC under trees was reported by Khonje (1989), Singh *et al.* (1989), Tripathi and Hazra (1997) and Mungendi *et al.* (1999). In consonance with high organic carbon content, the available N (144.8 and 133.4 kg ha⁻¹), P₂O₅ (22.5 and 19.7 kg ha⁻¹), and K₂O (169.7 and 156.5 kg ha⁻¹) at 0-15 and 15-30 cm depths, respectively in T₂ showed higher values in these treatments where ever tree was integrated. However, the lower values were recorded in T₁ (N : 115.8 and 107.9; P₂O₅ : 12.8 and 11.6; K₂O : 132.8 and 122.9 kg ha⁻¹) at 0-15 and 15-30 cm depths, respectively. With particular reference to increase in available P₂O₅ content, the probable reason that can be advocated was, by presence of organic acids that release into soil over period of time, mobilize the bound phosphorus and converting that into available form. Similar results were reported by

Agarwal *et al.* (1975), Hazra (1987), Kumara and Haque (1987), Tripathi and Hazra (1997) and Chamshama *et al.* (1998).

5.4 TREE GROWTH AND BIOMASS PRODUCTION

Tree growth in an agri-silvisystem form a key factor for measuring overall benefits derived in such system. Biomass production from tree can be either from branches, leaves or from roots. In this case, the branches that grew after imposing various pruning practices contributed sufficiently to sustain the overall productivity of a system involving cowpea as an intercrop. *Albizia* when pollarded at 2.0 m height produced maximum number of stumps per tree (7.6) followed by T7 and T9 and were significantly higher over other treatments, while lower number of branches were observed in T4 (3.2). The increase in shoot production might be due to stimulation imparted by higher magnitude of stem carbohydrates to the site of shoot production. The observation made by Perez and Mendatez (1980) also confirms these findings. It was observed that pruning treatments showed higher increment in height compared to unpruned trees as it was seen that there was an increase of 1.76 m in height in T5 followed by T6 and least was with T3 (0.85 m). The probable reason being presence of more number of branches in unpruned areas to share the food material as compared to those available on pruned trees. *Albizia* produced highest woody biomass yield of 40.37 q ha⁻¹ when pollarding was done at 1.5 m height (T7) and was nearly equal to T9 and T8. *Albizia* in T4 registered significantly lower woody biomass (17.77 q ha⁻¹) followed by T5. Similar trend was observed with respect to leaf biomass due to more number of stumps per tree. Length and girth of stump were more in pollarding treatments than in

coppicing treatments. Similar results were observed by Saleem and Singh (1995), Karim *et al.* (1991) and Viswanath *et al.* (1997).

5.5 EFFECT OF PRUNING ON GROWTH OF STUMPS

It was observed that there was an increase in branch length with increase in pruning height at 60 and 120 DAP, maximum being in T₄ while lower was in T₃. Absolute growth rate (AGR) of stump in respect of length from 60 to 120 DAP was maximum in T₈ but was on par with T₇ and T₉. Similarly, the higher values of girth of stumps were obtained in pollarding treatments which were significantly superior over coppicing treatments. The initial shoot regrowth with increase in cutting height could be attributed to greater surface area from which regrowth occurred. Similar results were reported by Tarawali *et al.* (1996).

5.6 ECONOMICS

Economic evaluation of different treatments showed that maximum gross returns of Rs. 11048 ha⁻¹ was realised with adoption of coppicing at 60 cm height followed by T₈ and T₇, while lowest was obtained from T₃ (Rs. 3020 ha⁻¹). Similarly, net returns from cowpea in association with *Albizia* under T₆ (Rs. 6278 ha⁻¹) were high followed by T₈, T₇ and T₄ which were due to less adverse effect on intercrops and higher biomass production of stumps. The low i.e. negative returns resulted in T₃ (- Rs.1250 ha⁻¹) was due to this poor yield of cowpea. These results were in conformity with the findings of Korwar (1986), Vani (1995) Endrias (1998) and Joseph *et al.* (1999). The benefit-cost ratio was maximum in T₆ (1.32) followed by T₁, T₈ and T₇, but T₃ had negative value (-0.29). Rest of the treatments were intermediary.

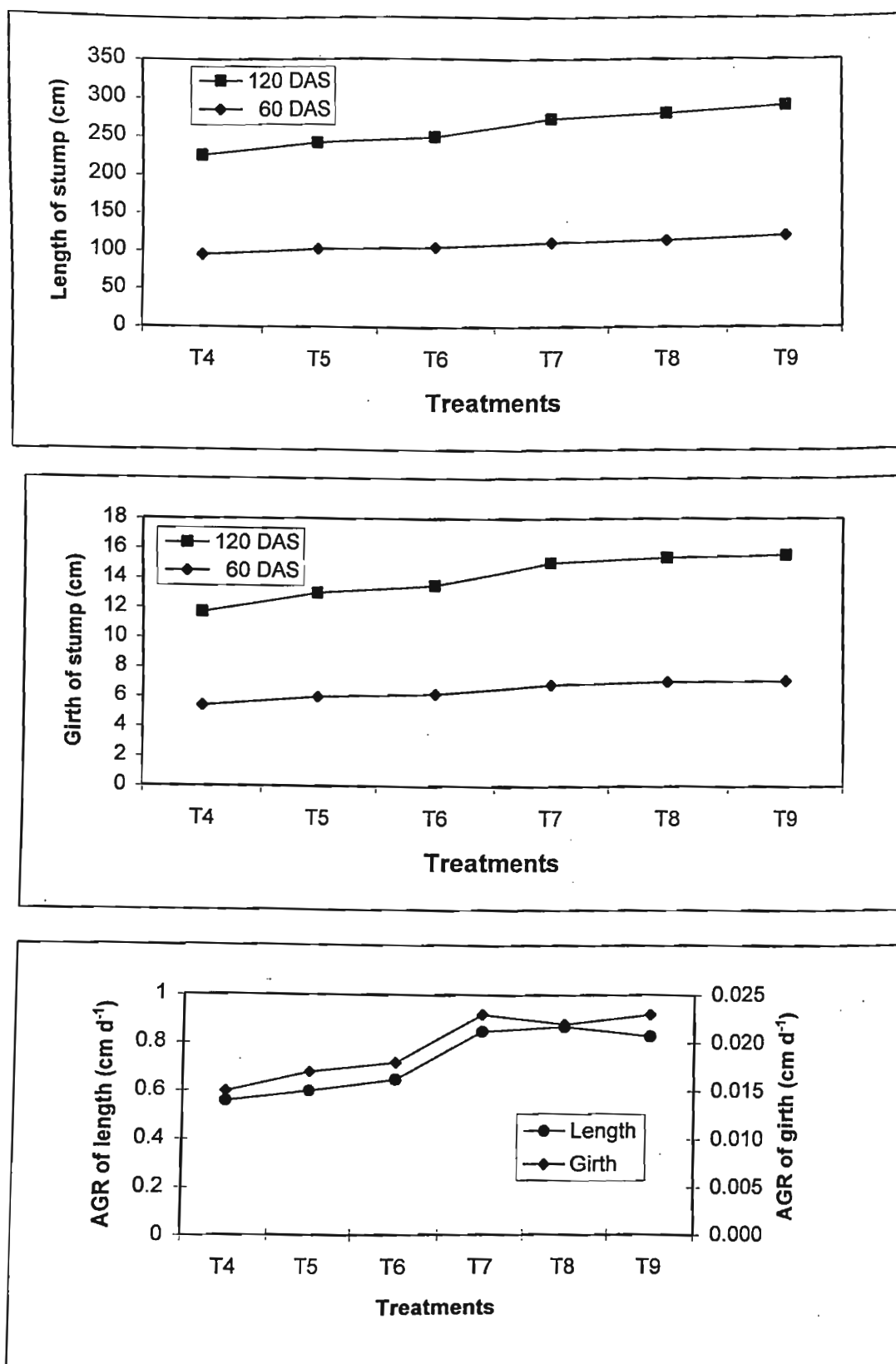


Fig. 5 : Effect of pruning on growth of stump

The results obtained in the present study are further supported by Chaturvedi (1981) and Joseph *et al.* (1998).

5.7 CORRELATION

A close perusal of the data revealed that the characters viz., plant height, dry matter production, LAI, CGR, leaf temperature, PAR and TR, and Pod length, pod per plant, Number of seeds per pod, 1000 seed weight, shelling per cent and straw yields were positively correlated with seed yield and also among themselves. But RH and DR were negatively correlated with seed yield. These results were in confirmity with those of Fapohunda *et al.* (1984), Palled *et al.* (1990), Biradar *et al.* (1996) and Ashok *et al.* (1999).

SUMMARY AND CONCLUSIONS

CHAPTER VI

SUMMARY AND CONCLUSIONS

The present investigation entitled "Effect of pruning *Albizia lebbeck* (L.) on yield and nutrient uptake of cowpea in agri- silvisystem" was conducted during *kharif* 1999 at Agroforestry Research Division, ANGRAU, Rajendranagar, Hyderabad. The site was sandy loam in texture and low in available N, P and K. The experiment was laid out in a randomised block design consisting of 10 treatments and replicated thrice. These include sole crop, tree without crop, tree with crop and without pruning, lopping, coppicing at 0, 30 and 60 cm height as well as pollarding at 1.5, 2.0 and 2.5 m height.

The objectives of the study were a) to evaluate performance of cowpea under different pruning practices, b) to assess nutrient uptake of crop in relation to pruning practices. c) to study comparative soil moisture status in different treatments and d) to study the growth pattern of stumps in different treatments. The results from the investigation are summarised here under.

1. Cowpea in T₉ treatment attained significantly higher plant height at 30 DAS, while it was true with the treatment T₇ (pollarding at 1.5 m height) at 60 DAS and at harvest relative to other treatments.
2. Significantly higher dry matter was observed at 60 DAS and at harvest showing conspicuous differences among the treatments while there was no such difference at 30 DAS.
3. Though different treatments did not vary significantly with respect to CGR at 30 DAS, T₁ and T₃ treatments obtained significantly higher and

lower CGR values at 60 DAS as well as at harvest. Cowpea showed significantly higher leaf area index in sole crop (T₁) followed by T₅, T₄, T₇ at 30 DAS and T₄, T₅, T₆ and T₇ at 60 DAS.

4. Sole cowpea and cowpea intercropped in trees and without pruning as well as lopping treatment recorded higher and lower number of pods per plant, number of seeds per pod and 1000 seed weight.
5. Highest leaf temperature was associated with sole cowpea whereas T₃ recorded lower temperature at 30 and 60 DAS. However, leaf temperature obtained at 30 DAS were higher than at 60 DAS. This was true with maximum and minimum PAR and transpiration values associated with T₁ and T₃ treatments respectively; in comparison the RH and DR values were greater at 60 DAS than at 30 DAS. The lowest diffusive resistance was observed in the treatment T₁ followed by coppicing treatments while T₃ was superior over other treatments.
6. The seed yield obtained from cowpea grown alone (T₁) registered significantly higher yield of 9.56 q ha⁻¹ followed by T₆ (8.97 q ha⁻¹) whereas cowpea intersown in unpruned tree (T₃) produced lowest yield of 3.02 q ha⁻¹. Straw yield followed the same trend as that of seed yield.
7. Harvest index values were higher in T₁, T₆ and T₄ as that of seed yield and lower in T₃ and T₁₀.
8. Nitrogen, phosphorus and potassium uptake by cowpea was highest in T₁ and T₆ while lowest in T₃ and T₁₀.

9. Soil moisture status showed an increasing trend as the depth increased from 0 to 30 cm from sowing to harvesting stage. At harvesting stage, there was significant differences in soil moisture between the treatments. While treatments T₂ (Sole tree) registered significantly higher soil moisture status, minimum was associated with T₃ at all the stages of crop growth.
10. Soil pH values obtained in various treatments either at 0-15 cm or 15-30 cm depth, did not differ significantly before the crop season though there was slight increase with depth. The highest and lowest soil pH values were obtained with T₁ and T₃ treatments at 0-15 cm depth. Similar values were recorded in T₁ and T₁₀ treatments.
11. The soil EC values increased with increase in depth in post harvest soils both at 0-15 cm and 15-30 cm depths. The treatments T₁ and T₂ were superior and inferior respectively with respect to soil EC values.
12. The organic carbon content of soil showed an inverse relationship with depth. The values were slightly higher in post harvest soils at 0-15 cm depth of soil in all treatments except T₁. Treatment T₂ followed by T₃ recorded higher values while lower OC was with T₁.
13. The available soil N, P₂O₅ and K₂O decreased with increase in soil depth. The values were increased after cropping in all treatments except in T₁. The higher values were observed in T₂ treatment while the lower values were obtained in T₁ (Sole cowpea).
14. *Albizia* in the treatments T₈ (Pollarding at 2.0 m) and T₄ (Coppicing at ground level) produced maximum (7.6) and minimum (3.2) number of

branches per tree. There was an increase in tree height by 1.76 m in T₅ which was maximum and minimum in T₃ (0.85 m) but the girth values recorded at breast height of tree increased apparently under unpruned condition showing maximum increment in T₃ and least in T₇. Higher and lower wood biomass (40.37 and 17.77 q ha⁻¹) and leaf biomass (3.34 and 1.79 q ha⁻¹) were associated with T₇ and T₄ treatments respectively.

15. Various treatments did not differ significantly pertaining to length of stump and AGR related to girth of branches. Length of stump at 60 and 120 DAS and girth of the branch at 60 and 120 DAS were greater in T₉ (Pollarding at 2.5 m) and lower in T₄ (Coppicing at ground level).
16. The treatments T₆ (coppicing at 60 cm height) realised highest gross returns of Rs. 11048 ha⁻¹ which was 15.56 per cent more over sole cowpea (T₁) whereas tree with crop and without pruning registered lower returns of Rs. 3020 ha⁻¹. The T₆ treatment was proved to be advantageous as it gave maximum net returns (Rs. 6278 ha⁻¹) and BCR of 1.32. Cowpea in T₃ treatment registered negative net returns. Sole crop proved to be superior over T₄, T₅, T₉ and T₁₀.
17. Significant positive correlation was observed between seed yield and plant height at 60 and 90 DAS, leaf temperature, PAR, TR at 30 and 60 DAS, dry matter production, LAI, CGR, Yield attributes, NPK uptake in grain and straw. Negative correlation was observed between seed yield and relative humidity and diffusive resistance at 30 and 60 DAS.

Conclusions

From the results of the present study, it can be concluded that yield of cowpea can be sustained by adopting pruning practices. Most effective being coppicing at 60 cm height which allowed sufficient radiation to crop resulting in high photosynthetic efficiency.

Albizia being an NFT showed a great advantage in terms of soil fertility build up. The presence of trees helped in improving the status of organic carbon, available nitrogen, phosphorus and potassium in soil comparable to sole crops. The nutrient build up due to trees over the years helped in supplementing nitrogen needs of associated arable crops like cowpea, thus reducing the cost of production of such crops under dryland condition.

Pollarding of *Albizia* resulted in higher values of number of stumps, length and girth of stump and biomass production of tree over coppicing treatments. Pruning of *Albizia* not only sustained the yield of cowpea but also made good yields from extra biomass generated through branch pruning. In the present study, the tree crop association with coppicing at 60 cm height helped in realising higher net returns and B:C ratio as a consequence of higher tree biomass production.

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* Original not seen

APPENDICES

Appendix A
Calendar of Field Operations

Operation	Date
I. Pruning of trees	2-7-1999
II. Land preparation	
(a) First ploughing	6-7-1999
(b) Second ploughing	9-7-1999
(c) Levelling and layout	12-7-1999
III. Fertilizer application (basal) and sowing	17-7-1999
IV. Inter cultivation operations	
(a) Gap filling	21-7-1999
(b) Thinning	26-7-1999
(c) First weeding	27-7-1999
(d) Second weeding	7-8-1999
(e) Top dressing with urea	18-8-1999
V. Plant Protection	
(a) Spraying with monocrotophos	5-8-1999
(b) Spraying with chloropyriphos	20-9-1999
VI. Pickings/harvesting	
(1) First picking	29-9-1999
(2) Second picking	7-9-1999
(3) Third picking	15-9-1999

Appendix B

Price of inputs and outputs used in calculating net returns.

A. Inputs

Item	Unit	Price (Rs.)
Seed cowpea	kg	15.00
Fertilizers N (Urea)	kg	8.30
P ₂ O ₅ (SSP)	kg	19.00
K ₂ O (MOP)	kg	7.50
Monocrotophos	1 lit	225.00
Chloropyriphos	1 lit	210.50
Labour	day	40.00
Tractor	hour	150.00

B. Outputs

Item	Unit	Price (Rs/kg)
Cowpea grain	kg	10.00
<i>Albizia lebbeck</i>		
woody biomass	kg	0.80
Leaf biomass	kg	0.80

