BIOMASS PRODUCTION IN AN AGROFORESTRY SYSTEM INVOLVING FOOD AND FODDER CROPS

By
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THESIS
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DECLARATION

I hereby declare that this thesis entitled "BIOMASS PRODUCTION IN AN AGROFORESTRY SYSTEM INVOLVING FOOD AND FODDER CROPS" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "BIOMASS PRODUCTION IN AN AGROFORESTRY SYSTEM INVOLVING FOOD AND FODDER CROPS" is a record of research work done independently by Shri. R.K. Neupane under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

INTRODUCTION

India has the largest cattle population in the world ie, more than 236.2 million heads. But the level of their production is low as compared to that of other countries, mainly due to the lack of quality fodders. The area devoted for fodder production is only 4 per cent of the cultivated area which is substantially low when compared to the fodder needs of the cattle population of the country.

The shortage of fire wood has also increased due to increase in population. In some countries fire wood is the major living expense. In India, the National Planning Commission on Agriculture has estimated that there would be a shortage of 100 million cubic meters of fire wood by the year 1990. Besides, it has been estimated that 300 to 400 million tonnes of fresh cattle dung is annually burnt as dungcakes to compensate the fire wood shortage which would have added to the soil fertility status of the country. The percentage of cultivated area in the country is 45.6, which is the highest in the world (Kanwar, 1972) and there is very little scope of bringing additional marginal lands into arable farming. The integration of woody species with annual food crops is a better strategy for meeting the diverse needs of food, fodder and fuel wood and this strategy is termed as agroforestry.

Agroforestry is a collective name for land use systems and practices where woody perennials (trees, shrubs, palms, bamboos etc.) are deliberately used on the same land management unit with agricultural crops and/or animals, either in some form of spatial arrangement or in temporal sequence. In general, agroforestry normally involves two or more species of plants or plants and animals, at least one of which is a woody perennial. Secondly, an agroforestry system has two or more outputs and the cycle of an agroforestry system is more than one year.

Depending on the objectives, different types of agroforestry systems have been evolved. One of the most promising agroforestry technologies for food, fodder and fire wood production system is hedge row planting of appropriate species of woody perennials in crop production. In this system, the woody perennial is pruned periodically, during the cropping season to prevent shading and to provide green manures to the arable crops. Several fast growing nitrogen fixing woody perennials are being used in different countries.

Subabul (*Leucaena leucocephala* (Lam) de Wit) has shown considerable promise in agroforestry system. The major advantages of subabul in agroforestry practices are: Firstly, it conserves the fertility and nutrient levels by symbiotic nitrogen fixation. Secondly, it helps to optimise the combined production of fodder and agricultural crops. Thirdly, it minimizes soil erosion and lastly, it provides fodder, green manure and fire wood.

Subabul has got the ability to withstand frequent cuttings and regenerate vigorously after pruning (Djikman, 1950). The deep tap root system of subabul reduces the level of root competition with associated crops and allows recycling and pumping of nutrients from deeper layers of soil. The compatibility of subabul grown in hedge rows with maize, was established by Guevarra (1976). Kang et al. (1981 b) proposed leucaena based agroforestry as an alternative low nitrogen system in which maize yield can be sustained at relatively low levels of nitrogen. Hence there is ample scope for subabul in agroforestry practices.

Maize (Zea mays L.) is an important cereal used both for grain and fodder purpose. The performance of maize as an intercrop has been encouraging.

Sorghum (Sorghum vulgare Pers.) is one of the most important cereal crops suited for intensive cropping. It is particularly suited for intercropping with short duration annual legumes.

Bajra (Pennisetum typhoides L.) is a short duration drought resistant cereal, that can give good yields even under dry conditions.

Cowpea (Vigna unguiculata (L.) Walp) and blackgram (Phaseolus mungo L.) are both legumes which fit well in intercropping systems with cereals. These crops have the ability to give some yield, and at the same time benefit the associated grain crops.

Growing of legumes with cereals has been practiced because of their role in building soil fertility and their compatibility with cereals. Moreover cereal-legume mixtures help in the utilization of available nutrients.

Information regarding the production potential of annual cereals and legumes grown with subabul is meagre.

Similarly, information regarding the compatibility of annual crops with subabul is not available. Hence, in order to find out the feasibility of growing cereals and legumes with subabul as a green manure-cum-fodder crop, the present study was undertaken with the following objectives:-

1. To estimate the total biomass production in agroforestry systems (consisting of tree fodder and food crops).

2. To assess the compatibility of different legumes and cereals grown under varying plant densities of subabul.

3. To find out the economics of different agroforestry practices.

4. To find out the best combination of annual cereals and legumes that can be grown as an intercrop with subabul and to find out the plant density of subabul for fodder purpose.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Agroforestry is basically the integration of woody perennials with annual species and/or with animals either in some spatial or in temporal sequence. Leucaena (*Leucaena leucocephala* (Lam.) de Wit)is a versatile tree used in agroforestry systems, wherein prunings from it are used as green manures to interplanted annuals or as fodder for animals when the crops are not in the field. The major research works done in India and abroad on leucaena based agroforestry systems are reviewed here. Wherever the literature is scanty, works on related crops or species have also been included.

1. Effect of mixed plant communities on productivity

Evans (1960) reported that growing of two or more crops in association makes better use of productive resources and legumes increase the yield of non legume components in the mixture. Donald (1963) opined that morphologically and physiologically contrasting species will together be able to exploit the total environment more effectively and thereby will give increased yield. Whitney and Kanehiro (1967) observed that in grass-legume mixtures severe defoliation of legumes resulted in nitrogen release from legume roots to the associated grass. According to Panje (1973), increased production under mixed population results because of high and efficient use of solar radiation. Trenbath (1974) and Willey (1979) suggested that increased productivity results because of the complementary effects of component crops. Growth patterns of component crops differ in time, so that crops make their major demands for resources at different times, thus reducing the mutual competition. Still, the combined root system of components of a mixture may make better use of soil resources (Chatterjee and Maiti, 1984).

In crop mixtures involving legumes and cereals, the transfer of nitrogen from a legume to a cereal component has been suggested by Agboola and Fayemi (1971) and Finlay (1975). Aggarwal et al.(1976) observed that the inclusion of trees with annual crops would bring higher total returns due to changes in soil fertility, moisture conservation and the synergestic effects due to the root exudates. Henzell and Vallis (1977) opined that the type of cropping system that maximizes nitrogen transfer is one that uses the legumes for green-manure. According to Raintree (1985) the relationship between trees and their understory can be complementary, supplementary or some combinations depending on the components of the system and the factors limiting the growth of each component.

2. Effect of spacing on the growth characters of subabul.

(a) Plant growth and development.

Guevarra et al.(1978) reported that the stem diameter of leucaena was significantly higher at wider spacing, but the number of stems per hectare was significantly reduced at wider spacing. Savory (1979) observed a negative correlation between the plant density and the number of branches per plant as well as the forage yield per branch. Dutt (1981) reported that spacing had no effect on height or diameter at breast height of trees at 15 months after planting. According to Van Den Beldt and Brewbaker (1980) plant height and diameter at breast height rapidly decreased at plant densities beyond 20,000 plants/ha. Van Den Beldt (1982) observed that in the case of widely spaced plants, the competition for crop growth resources was minimum. Spacing had no effect on plant height at 18 months after planting, but plants tended to be taller at wider spacing after 3 years of planting (Visuttipitakul et al.(1983).

Relwani et al.(1983) found that heights of plants did not vary appreciably at the densities of 2500, 5000 or 10000 plants/ha, beyond which there was a fall in height with more dense plant population.

(b) Leaf-stem ratio.

Guevarra et al.(1978) observed that the per cent forage fraction from leucaena herbage tended to be slightly higher at the highest plant density. According to Pathak et al.(1980), plant density had a significant effect on the leaf-stem ratio where by it increased with decreasing density. It was found that a density of 4 plants/m^2 resulted in a ratio of 1.87 compared to the leaf stem-ratio of 2.17 for a density of 1.5 plants/m^2. Melendez and Rivena (1981) reported that forage dry matter production was inversely proportional to the leaf stem ratio, the lower ratio being associated with higher dry matter yields.

3. <u>Effect of spacing on drymatter production of subabul</u>.

Castillo et al.(1977) reported that there was increasing trend in drymatter yields at closer spacing. As plant spacing increased, yields of both forage and stem fraction decreased (Guevarra et al, 1978). There was decrease in fresh fodder yields with increase in inter row spacing (Anon, 1978). Castillo et al.(1979) observed highest production of leucaena herbage under high plant population and shorter cutting intervals. Ferraris (1979) found that closer spacing increased yields in the second year. Savory (1979) opined that at high plant density forage yield per plant is greatly reduced but the losses in forage yields from individual plants were upset by the increased number of plants and the total yield increased with increase in plant density. Field studies conducted at IGFRI, Jhansi (Pathak et al, (1980), indicated that at higher plant density, forage production was always higher and it decreased with decreasing density with every cutting date. It was revealed that plant density of 4 plants/m^2 produced significantly higher forage yields than 3 or 1.5 plants/m^2 densities.

Hu et al.(1980) mentioned that more wood could be produced with closer spacing. The actual volume and biomass with closer spacing above 10,000 plants/ha was decreasing while the green biomass was increasing

(Lu and Hu, 1981). Melendez and Rivena (1981) obtained decreased dry matter yields with increasing distance between rows from 50 to 150 cm. Lahiri (1983) observed higher biomass yield with closer spacing. Biomass yields 10 months after planting were 8.8 t/ha with 37 x 37 cm spacing compared to 5, 2.8, and 1.8 t/ha respectively, with 45 x 45, 60 x 60 and 100 x 100 cm spacings. Field studies conducted at Chiang Mai, Thailand (Visuttipitakul et al, 1983) revealed that total biomass yield at 1.5 years after planting was highest at 2 x 0.25 m spacing, while at 3 years it was highest at 2 x 0.5 m spacing.

Relwani et al.(1983) concluded that the volume and wood yield per hectare increased with increasing plant population. Ghatnekar et al.(1983) obtained higher forage biomass of 27.7 t/ha at 0.3 x 0.3 m spacing as compared to 8.69 t/ha at 2 x 2 m spacings. Torris (1983) concluded that as plant spacing increased, herbage dry matter yields decreased. Prasad et al.(1983) obtained maximum green fodder yields at 1 m row spacing though it was on par with 1.5 m row spacing.

4. Effect of spacing on the nutrient content of fodder from subabul.

Guevarra et al. (1978) observed that the actual nitrogen content of leucaena forage was not influenced by plant density or spacing, but the total crude protein yield was higher at closer spacing, because of increased dry matter production and the nitrogen yield per hectare per year decreased with increasing width of the intra row spacing. Ferraris (1979) mentioned an inverse relationship of dry matter yields with nitrogen content suggesting a 'dilution' effect at higher levels of dry matter production. Pathak et al. (1980) found that lower plant densities produced more crude protein per cent in leaves and stems than higher plant densities. It was further revealed that higher density produced more phosphorus content in leaf and lower density in stem. Hu et al. (1983) observed that spacing had no effect on nutrient accumulation in the above ground parts of leucaena.

5. Effect of subabul spacing/manuring on the growth and development of annual crops.

Siagian and Mabbayad (1980) mentioned that the application of leucaena prunings as green manures to interplanted corn produced significant increase in plant growth, leaf area index and 1000 grain weight of maize at 150 kg N/ha than at 75 kg N/ha. Favourable effects on the growth and development of maize by intercropping with subabul was also reported by Kang et al. (1981b) and Alvarez and Alferez (1982). Rosa et al. (1980) reported that intercropping of corn with leucaena had no substantial influence on plant height, ear height, number of ears per plant, tasseling, and shelling percentage. But the ear length and ear diameter were significantly increased.

6. Effect of subabul spacing on dry matter and grain yields of annual crops

Guevarra (1976) studied the effects of subabul herbage application on yields of interplanted maize under single and double hedge rows of leucaena. When trimmings from hedges planted 91 days before maize seeding and cut to a set level, were applied to maize at planting, 40, 60 and 90 days after planting, maize yields were obtained higher under double than under single hedge rows. Kluthcouski (1980) found that the application of 5 t/ha leucaena green leaves resulted in yield increases of beans from 1.4 to 2.2 t/ha. Rosa et al. (1980) reported that grain yields of maize were increased from 69.9 g/plant in pure stands to 73.4 g/plant when intercropped with subabul. Siagian and Mabbayad (1980) mentioned that application of leucaena leaves as green manures to interplanted corn produced significantly higher total dry matter and grain yields at 150 kg N/ha than at 75 kg N/ha.

Kang et al. (1981 a) concluded that grain yields of maize could be obtained at a high level by the application of 10 t/ha fresh leucaena prunings or a combination of 5 t/ha of fresh prunings and 50 kg N/ha. Application of prunings from full grown hedge rows spaced 4 m apart was able to sustain grain yields of interplanted corn at about 3.8 t/ha for two consecutive years with no N addition (Kang et al, 1981 b). Mendoza et al.(1981) observed that incorporation of leucaena prunings to intercropped maize resulted in higher grain yields at closer spacing than at wider spacing. Alvarez and Alferez (1982) obtained higher grain yields from interplanted maize when leucaena was spaced 2 m apart in single than in 5 m apart triple hedges. Pruning yields also followed the same trend. Chagas et al.(1983) observed that green manuring the bean fields with leucaena prunings had the same effect as NPK treatment and increased bean yields approximately six fold over the control. Increasing the rate of application of leucaena leaves from 0 to 20 t/ha increased taro leaf yield from 12.6 to 20.3 kg/plot and the total corm yield from 8.0 to 11.7 t/ha (Payot et al, 1983). Studies conducted at International Institute of Tropical Agriculture, Nigeria (Anon, 1984) over a period of 6 years indicated that grain yields of maize interplanted in 4 m wide alleys of leucaena hedges could be stabilized at 2 t/ha by regular application of prunings as green manures. Markhede et al.(1984) reported that grain and stover yields of sorghum were significantly increased by applying tops of leucaena to surface of plots given 0-25 kg N/ha but not to plots given 50 kg N/ha.

7. Effect of subabul spacing/manuring on the uptake of nutrients by annual crops.

Guevarra (1976) and Verimumbe (1981) opined that the uptake efficiency of leucaena N by maize was comparatively low but could be increased in subsequent seasons.

Siagian and Mabbayad (1980) studied the effects of application of leucaena prunings to intercropped maize on nutrient uptake and found that the uptake of nitrogen, Phosphorus and potassium by maize fertilized with leucaena leaves was significantly higher at 150 kg N/ha than at 75 kg N/ha. Kang et al. (1981 a) observed that addition of leucaena prunings alone or in combination with N significantly affected N uptake by maize. Markhede et al, (1984) reported that N and P uptake by sorghum were significantly increased by applying tops of leucaena to surface of plots given 0 - 25 kg N/ha, but not to plot given 50 kg N/ha as inorganic fertilizer.

8. Effect of annual species on growth and yield of perennial species

Mishra and Prasad (1980) observed that under agrisilvicultural studies, annual crops like groundnut (*Arachis hypogeae*) soybean (*Glycine max*)and sesame (*Sesamum indicum*) had no adverse effect on the growth of tree species like *Tectonia grandis* and *Dalbargia sisso*). Studies conducted by Maghembe and Redhead (1980) indicated that maize had more favourable effect on the growth of leucaena than beans (<u>Phaseolus spp</u>). Leucaena attained greater heights at the 17^{th} and the 23^{rd} weeks after planting when intercropped with maize as compared to beans.

Kang et al.(1981b) studied the effect of interplanting maize with leucaena on pruning yields and found that 5 - 6 prunings from 4 m wide hedges yielded 5 - 8 t/ha/yr of dry tops and the total annual dry matter yields of leucaena were affected by the N rate applied to the associated crop maize. Hartoyo (1982) reported that leucaena CV - K8 interplanted with groundnut and maize produced higher fresh fodder yields than when intercropped with <u>Pinus meskii</u>. Balasubramonian et al.(1984) observed that intercropping redgram (<u>Cajanus cajan</u>) with subabul was better in terms of total returns and biomass yield, which was attributed to the leguminous nature of both crops.

9. <u>Effect of cereals on the nodulation of legumes</u>.

Reddy and Chatterjee (1973) pointed out that nodulation of soybean in association with maize and sorghum was reduced on account of shading to the soybean crop. But Thompson (1977) and Willey (1979) suggested that cereals caused an increase in nitrogen fixation observed as a stimulation of nodule numbers and weight. Wahua (1984) found increase in nodule number, nodule weight and nitrogen fixation of soybean in association with sorghum. Wahua and Miller (1978) and Rabie and Kumazawa (1980) reported decreased nodulation due to shading. Kitamura et al.(1981) observed depression in nodule number due to the effect of associated crops. Pahwa and Patil (1983) reported that application of 5 t/ha of leucaena leaves lowered nodulation in cowpeas.

10. Mutual effect of cereals and legumes on the height of plants

Maize caused legume component to grow taller (Anon, 1973). According to Enyi (1973) intercropping sorghum with cowpeas or pigeon peas tended to increase its height, but maize with beans or cowpeas significantly reduced its height. Plant height of pigeon peas was increased when grown with maize and sorghum (Saraf et al. 1975). Ibrahim et al.(1977) found that maize plant height tended to decrease when grown with soybean, but

Singh and Guleria (1979) found no effect on maize plant height due to intercrop soybean. Bush and climbing bean had no effect on maize plant height (Francis et al, 1978). Krishnaswamy and Palaniappan (1979) found that the height of groundnut plants was significantly increased by ragi, onion or greengram as intercrops.

11. Mutual effect of cereals and legumes on flowering and maturity.

Ibrahim et al.(1977) mentioned that maturity of maize was delayed due to intercrop soybean, but Singh and Guleria (1979) observed no effect on maturity of maize due to soybean. Nadar (1980) observed that maize delayed the flowering and maturity of pigeon peas by three weeks. Remison (1982) and Wanki et al.(1982) reported that cowpea flowering was delayed due to the associated crop maize. Maturity period of cowpeas was affected by maize (Mitawa, 1985).

12. Mutual effect of cereals and legumes on yield components.

Jagannathan et al.(1974) found that the cob length of maize was increased due to the effect of intercrop legumes, presumably on account of the provision of a good part of nitrogen for the cereal at later stages. Soybean significantly increased the ear length of associated maize (Singh and Guleria, 1979). Nair et al. (1979) observed increase in thousand seed weight of maize due to intercrop soybean. Singh (1981) observed significant increase in length and weight of sorghum panicles and thousand seed weight, when grown in association with green gram, black gram or cowpea. Babooji and Kalra (1982) opined that legumes in association with maize invariably increased the yield and yield components. According to Enyi (1973), the companion cropping of sorghum and maize with pigeon peas, cowpeas and beans resulted in reduced length and weight of ears and cob in sorghum and maize, respectively.

Reddy and Chatterjee (1973) observed that mixed cropping soybean with sorghum significantly reduced the number of pods/plant and test weight of soybean. Number of pods/plant and seed size in mung bean were adversely affected due to associated maize (Anon, 1973). Maize and sorghum reduced the number of branches per plont and seeds/pod of interplanted pigeon peas due mainly to the harmful competition of maize and sorghum (Saraf et al, 1975). Krishnaswamy and Palaniappan (1979) observed significant reduction in pods/plant in groundnut due to the intercropping of ragi and green gram. The yield components of soybean like pods/plant and 200 seed weight were reduced significantly in millet-soybean combination, than in maize-soybean or sorghum-soybean combination due mainly to the shading caused by millets (Maneka and Dotto, 1980). Nyambo et al.(1980) also observed slight reduction in pods/plant of soybean or green gram in legume-millet combination than with other combinations. Elmore and Jacobs (1984) found decreased pods/plant, seeds/pod and seed weight of soybean due to the effect of tall sorghum crop. Chauhan and Dungarwal (1982) observed no adverse effect of legumes on yield attributes of maize, but cowpea reduced the number of cobs/m^2 and increased the number of kernels/plant (Wanki et al, 1982). Singh and Singh (1984) found no effect on thousand grain weight of maize due to the effect of mung bean and blackgram.

13. Mutual effect of cereals and legumes on dry matter and grain yields

De et al, (1978) reported that there was decrease in grain yields of sorghum by cowpea CV C 152, because of the severe competition offered to sorghum. Dry matter production in sorghum was increased by blackgram, cowpea or lablab bean (Ravichandran and Palaniappan 1979). Das and Mathur (1980) obtained heighest maize grain yields with udid as compared to with cowpea and groundnut. Waghmare and Singh (1984) found the highest grain and stover yields of sorghum when intercropped with cowpea and green gram.

Enyi (1973) found that intercropping maize or sorghum with pigeon peas, cowpeas or beans led to a reduction in grain and stover yield of cereal components.

Dusad and Morey (1979) reported that udid produced highest yields followed by mung bean and cowpeas when grown with sorghum. Krishnaswamy and Palaniappan (1979) mentioned that ragi and green gram in summer and ragi alone in Kharif reduced the dry matter yield of groundnut. Chaudhury (1981) observed that grain and dry matter yields of soybean, cowpea and chick pea were significantly reduced by maize and sorghum, but grain yields of cereals remained unaffected.

Singh and Chand (1969) reported that intercropping blackgram with maize did not affect the grain yield of maize. Agboola and Fayemi (1971) observed no appreciable effect on maize yields due to intercropping of cowpea and mung beans. Morachan et al.(1977) noted that sorghum yield was not affected by blackgram and cowpea as intercrops. Udid, soybean and rajmash (*Vicia faba*) had no adverse effect on maize grain yields (Chand, 1978). Singh and Joshi (1980) explained that moth bean (*Vigna aconitifolia*), guar (*Cyamopsis tetragonaloba*) and mung bean had no adverse effect on grain yields of pearl millet.

14. *Mutual effect of cereals and legumes on N, P, and K uptake*

Chand (1978) observed that N content and N uptake by maize was not affected by soybean, rajmash and udid as intercrops. N, P and K uptake by maize was not affected by soybean (Singh and Guleria), 1979). Ravichandran and Palaniappan (1979) found that N, P, and K uptake by sorghum was unaffected by legume intercrops. Singh and Chand (1979) observed that legumes had no effect on N uptake by maize at various stages of growth, but N level had a significant influence on it. Jagannathan et al

(1979) observed that maize grain protein content was increased in mixed stands with soybean. Chaudhury (1981) reported that maize N content was reduced by soybean, cowpeas and chickpeas. Eaglesham et al. (1981) observed that N content of maize was increased by cowpeas. Meera Bai and Raghavan Pillai (1983) found that the uptake of N, P and K by sorghum was higher when intercropped with velvet bean and blackgram, than when intercropped with cowpea. Waghmare and Singh (1984) observed that intercropping increased the N uptake by sorghum and the whole system. Muthuvel et al. (1984) found that grain N uptake by sorghum was maximum under blackgram + sorghum intercropping system than under cowpea + sorghum or greengram + sorghum systems.

15. Effect of subabul and intercropping in soil fertility.

(a) Effects due to subabul.

Djikman (1950) reported the usefulness of leucaena for soil fertility maintenance. Siagian and Mabbayad (1980) reported that total N and P status of the soil was not affected by rates of leucaena leaves applied.

But Kang et al.(1981) reported that addition of leucaena prunings increased the total N content of the soil. Torris (1983) suggested that soil fertility is gradually built up due to the application of leucaena prunings over seasons.

(b). Annual legumes.

Singh and Chand (1979) reported that growing of legumes with maize under rainfed conditions did not significantly affect the total N content of soil after harvest. Increase in total and available N content of the soil due to intercropping sorghum and pulses was reported by Morachan et al.(1977). Chandini and Raghavan Pillai (1980) found that intercropped legumes significantly increased the total N and available P content of the soil after harvest. Guilias and Vandiest (1981) opined that when legumes use fixed N for their growth, the uptake will be more of cations leading to the acidification of growth medium which ultimately leads to increased availability of P in the medium. Muthuvel et al.(1984) found that available N content of soil was maximum under blackgram + sorghum combination than other combinations of sorghum with legumes.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was under taken to find out the compatibility of raising different cereals and legumes as intercrops with subabul which can supply green manures to intercrops during its growth period and fodder for livestock during scarcity. The materials used and methods adopted are detailed below.

Materials

I. Location

The experiment was conducted in the Instructional Farm attached to the College of Agriculture, Vellayani.

II. Soil

The soil of the experimental area was red loom. The mechanical composition and chemical characteristics of the soil are presented Table I

Table I. Soil characteristics of the experimental area

a. Mechanical composition (per cent)

Coarse sand	-	13.8
Fine sand	-	33.5
Silt	-	28.2
Clay	-	24.5

b. Chemical characteristics

Total nitrogen (kg/ha)	-	1883.74
Available phosphorus (kg/ha)	-	37.68
Available potassium (kg/ha)	-	23.60
p^H (1:2.5 soil water ratio)	-	5.4

III. Cropping history of the field

The experimental site was under a bulk crop of fodder grasses during the last 20 years.

IV. Season

The experiment was started in April, 1984 by the planting of subabul. The first and the second crops of cereals and legumes were planted during the Rabi season of 1984 and Kharif of 1985. Annual crops of the first year were sown on 1-10-1984 and the harvest.completed on Jan, 1985. The second year crop was planted on 16-7-1985 and the harvest completed on the third week of Nov., 1985.

V. Weather conditions during the cropping period:

The weekly average maximum and minimum temperature, relative humidity, and weekly total rain fall during the cropping period of the cereals and legumes (Fig.1) and the

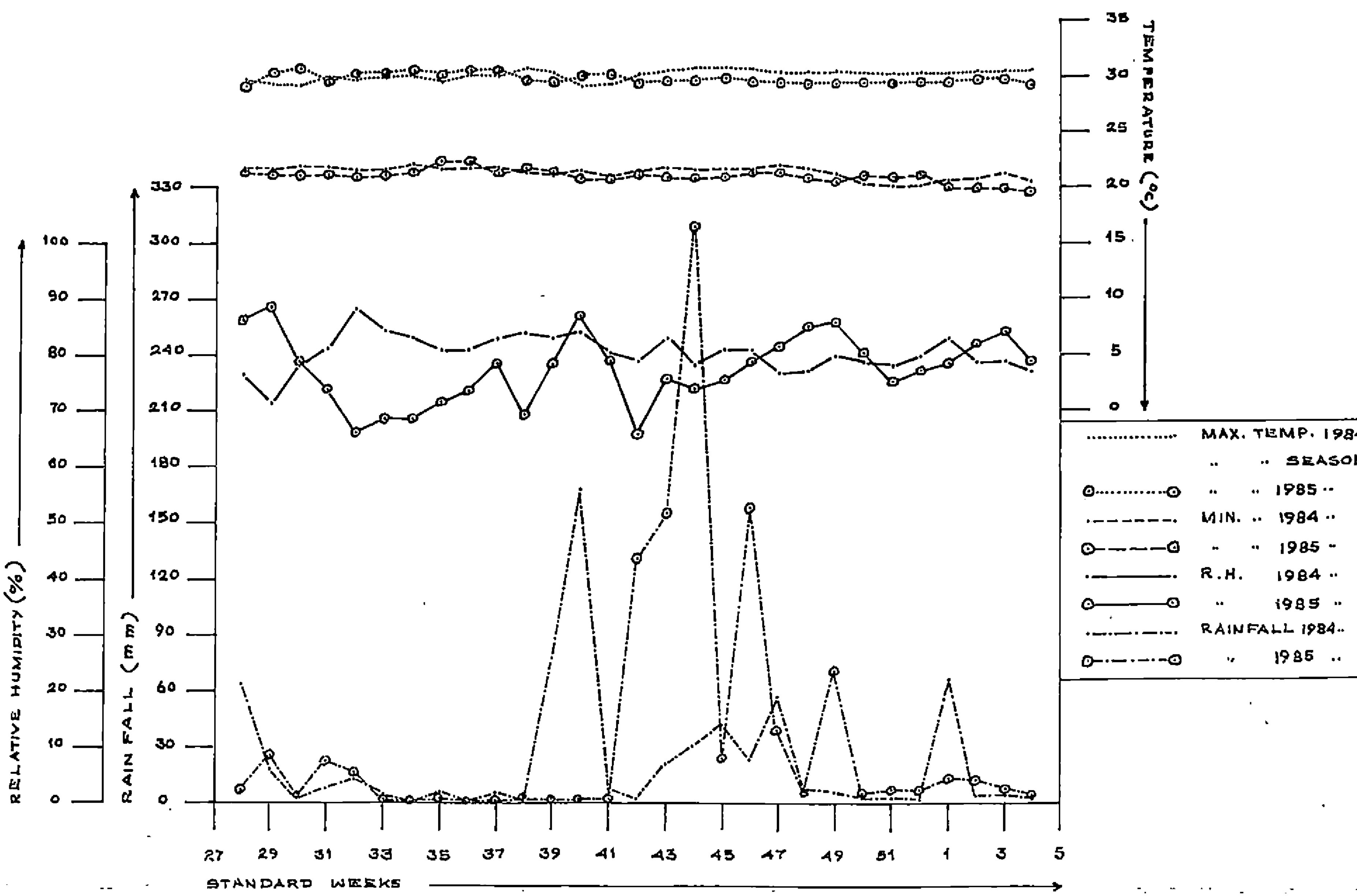

FIG. 1 WEATHER CONDITIONS DURING THE FIRST & THE SECOND YEAR CROP SEASONS

average values for the previous five years for the corresponding period are presented in Appendix-I.

The weekly average maximum temperature during the cropping period ranged between 28.42 and 31.17°C during the first and between 29.10 and 30.62°C during the second year, respectively. The weekly average minimum temperature ranged between 20.20 and 24.30°C in the first year, and between 21.2 and 23.99°C in the second year. The weekly average maximum temperature was the highest during Sept. 17 - 23, and Sept. 3 - 9 respectively in the first and the second year. The weekly average minimum temperature was the lowest during the period Dec. 17th to 23rd and Nov. 26th to Dec. 2nd during the first and the second year respectively.

The weekly total rainfall during the period varied between 3 and 172.3 mm during 1984, and 0.4 and 311 mm during 1985. The maximum quantities of 172.3 mm and 311 mm were received during 1st to 7th Oct., 1984 and 29th Oct. to 4th Nov. 1985 respectively.

The relative humidity during the cropping period ranged between 66.71 and 88.78 per cent in 1984, and 76.20 and 88.78 per cent in 1985.

VI. Varieties

Seeds of leucaena Hawaiian Giant Cv K 8, received from the Indian Grassland and Fodder Research Institute, Jhansi were used in this experiment. It is an outstanding, tall growing, apical dominant variety, with restricted basal branching. It produces twice the biomass of common type of leucaena (Anon, 1982), but is poor seeder compared to other types. This variety was reported to be compatible with maize as an intercrop in maize- leucaena alley cropping system (Kang et al, 1981 b).

Maize

Seeds of hybrid maize Ganga 5 received from the National Seeds Corporation were used. It is a high yielding variety maturing in 95 - 100 days and is quite adaptable to the locality.

Sorghum

Seeds of the variety CO-21 received from the School of Genetics, TNAU, Coimbatore were used. It is a tall growing variety with the duration of 115 - 118 days. It is quite suitable for intercropping with short duration annual legumes like cowpea and blackgram.

Bajra

Seeds of UCC-1, a high yielding variety maturing in 72 - 75 days, received from the School of Genetics, TNAU, Coimbatore, were used in this experiment. It is a variety well adapted to the locality.

Cowpea

The popular duel purpose variety C-152 from the collections of the All India Co-ordinated Project for Research in Forage Crops was used. This variety has the characteristic of retaining green leaves even at maturity.

Black gram

The variety used was Type-9. It was received from the National Seeds Corporation. It has good vegetative growth and is compatible as an intercrop with annual cereals.

VII. Viability of seed

The seeds were tested for viability before planting and were found to give about 95 per cent germination.

VIII. Fertilizers

Fertilizers with the following analysis were used.

a. Chemical fertilizers

Urea	: 46 per cent N
Super phosphate	: 16 per cent P_2O_5
Muriate of potash	: 60 per cent K_2O

b. Green manures

Foliage from subabul plants were pruned and applied as green manure to annual crops. The average composition of the prunings is tabulated below.

	N (per cent)	P (per cent)	K (per cent)
Stem portion	1.85-2.38	0.137-0.173	1.98-2.34
Leaf portion	3.30-5.11	0.149-0.177	0.83-1.12

Methods

Design

A 2 x 2 x 3 factorial experiment was laid out in 3 randomized blocks. The treatments consisted of growing 2 legumes and 3 cereals as an intercrop of subabul planted at 2 spacings. The lay out plan of the experiment and the planting pattern is given in Fig. 2.

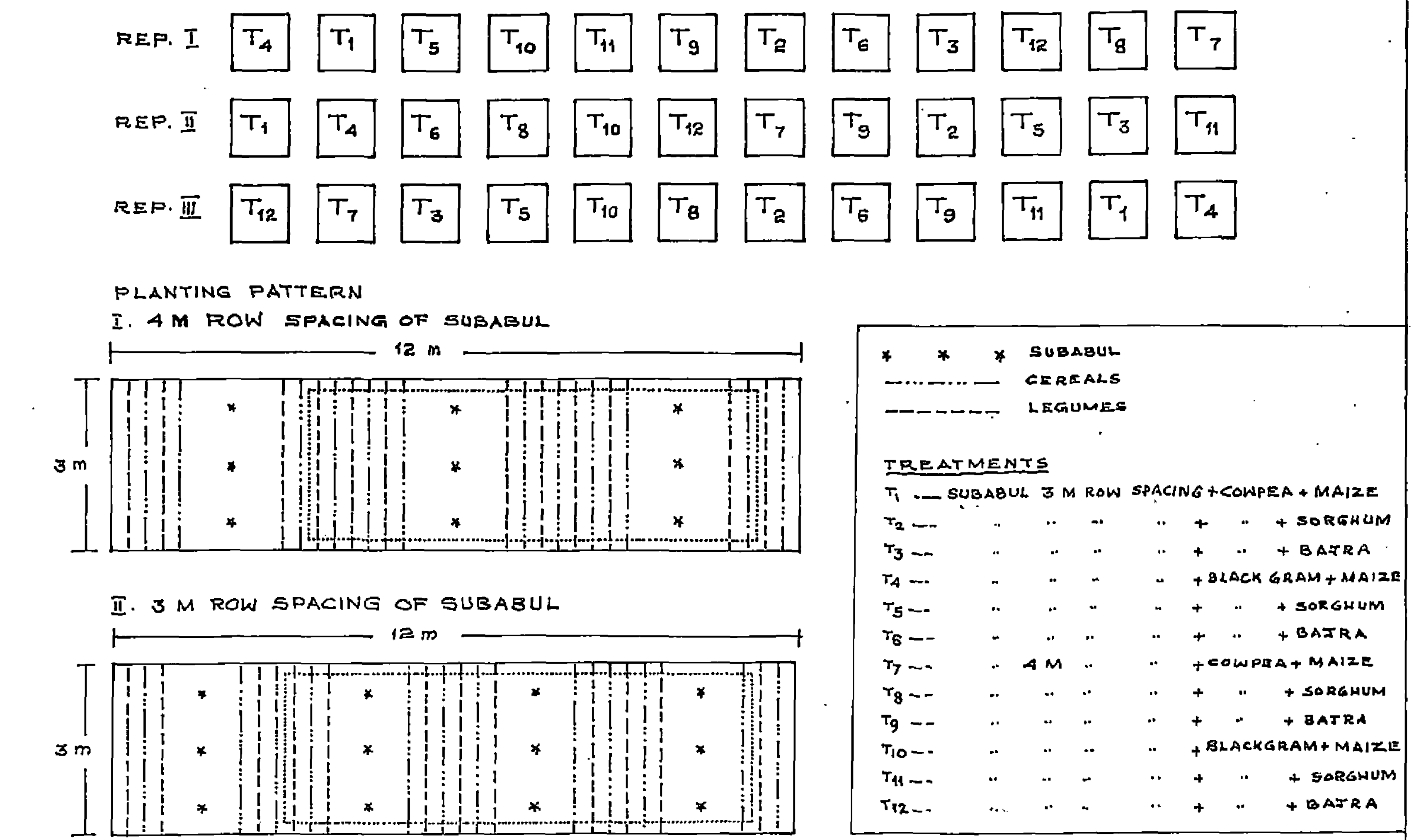

FIG. 2 LAYOUT PLAN OF 2 x 2 x 3 FACTORIAL EXPERIMENT IN RBD

Treatments

Subabul	(A_1) 3 m row spacing
	(A_2) 4 m row spacing
Legumes	(B_1) Cowpea : cv C-152
	(B_2) Blackgram : cv T-9
Cereals	(C_1) Maize : cv Ganga 5
	(C_2) Sorghum : cv CO-21
	(C_3) Bajra : cv UCC-1

Treatment Combinations

T_1	Subabul 3 m row spacing + Cowpea + Maize
T_2	" " " + Cowpea + Sorghum
T_3	" " " + Cowpea + Bajra
T_4	" " " + Blackgram + Maize
T_5	" " " + Blackgram + Sorghum
T_6	" " " + Blackgram + Bajra
T_7	Subabul 4 m row spacing + Cowpea + Maize
T_8	" " " + Cowpea + Sorghum
T_9	" " " + Cowpea + Bajra
T_{10}	" " " + Blackgram + Maize
T_{11}	" " " + Blackgram + Sorghum
T_{12}	" " " + Blackgram + Bajra

Number of replications - 3

Total number of plots -36

Plot size

Gross plot size	-	12 m x 3 m
Net plot size	-	8 m x 2.5 m

Spacing

(a) Annual crops	-	40 cm row spacing for legumes and cereals. Spacing between hills 25 cm for maize and 12.5 cm for other crops.
(b) Subabul	-	Subabul was planted at two spacings viz. 4 x 1 m and 3 x 1 m.
Total number of rows in the gross plot	-	24 (12 cereals + 12 legumes)
Total number of rows in the net plot	-	16 (8 cereals + 8 legumes)

Border rows:

Two rows of plants in the border were left all around the plot. Two additional rows each of cereals and legumes were left along the width-wise side of the plot to facilitate periodical removal of sample plants from the field. In the case of subabul, border rows were not left and observations were recorded from 3 plants selected randomly from the gross plot.

Field Culture

1. Preparation of the field

The experimental field was dug twice, clods broken and laid out into 3 blocks with 12 plots per block. The individual plots were thoroughly dug and perfectly levelled.

2. Fertilizer application

Nitrogen, phosphorus and potash were applied to different crops based on the package of practices recommendations of Kerala Agricultural University (Anon, 1982) as furnished below:

Crop	N	P_2O_5	K_2O (Kg/ha)
Maize	135	65	15
Sorghum	45	25	25
Bajra	40	10	10
Cowpea	20	30	10
Blackgram	20	30	10
Subabul	20	50	30

For annual crops a basal application of $\frac{1}{4}^{th}$ of nitrogen and full dose of phosphorus and potash were applied uniformly before planting. One fourth of nitrogen was top dressed to cereals 40 days after planting. Since prunings from subabul were applied to annual crops, the remaining dose of nitrogen was skipped. For subabul the fertilizer was applied based on the package of practice recommendation. A uniform dose of 375 kg/ha of lime (Anon, 1980) was applied before land preparation in each season.

3. Green manuring

Fifteen days prior to the planting of annual crops, 50 per cent of subabul foliage from the lower parts of plants were trimmed, weighed, chopped and incorporated into the field. This practice was repeated at 15th, 30th, 45th and the 60th day after planting of annual crops. In the second year also green manures were applied at the same intervals till the 60th day of planting. The total quantity of subabul prunings applied to the annual crops in the two crop seasons are detailed in Table 2.

Table 2. Quantity of prunings applied to annual crops

Treatment No.	Quantity (t/ha)	
	1984	1985
T_1	1.82	3.04
T_2	1.51	3.76
T_3	1.18	3.23
T_4	1.78	3.07
T_5	1.28	3.36
T_6	1.87	3.47
T_7	1.04	2.08
T_8	0.69	1.59
T_9	1.09	2.98

Table 2. contd.

Treatment No.	Quantity (t/ha)	
	1984	1985
T_{10}	1.36	2.79
T_{11}	1.33	2.71
T_{12}	1.60	2.73

4. Seeds and sowing

The seeds of legumes were inoculated with the appropriate Rhizobium species cultured in the microbiology laboratory attached to the Department of Plant Pathology, College of Agriculture, Vellayani. Subabul seeds were first scarified and then treated with Rhizobium.

The Rhizobium treated subabul seeds were planted in situ 6 months prior to the planting of annual crops in two spacings as per the treatments viz. 4 x 1 m and 3 x 1 m spacings. Legumes and cereals were planted in alternate rows on either side of subabul rows leaving 50 cm and 60 cm on either side of subabul in 3 and 4 m spaced subabul plantings, respectively as shown in Fig. 2.

Seeds were dibbled at 2 seeds per hole. Gap filling and thinning were done on the 7th day of sowing to secure uniform stand of the crop.

5. After cultivation

The soil was stirred lightly and weeds were removed at the time of the incorporation of green manures.

6. Irrigation

Life saving irrigation by pot watering was given during early days to save the plants from wilting due to dryness.

7. Plant protection

Ekalux (0.05 per cent) was sprayed twice during the flowering and pod development stages of legumes as a prophylactic measure to control the insect pests.

8. Harvesting

As per the programme, subabul foliage was pruned 15 days before the planting of annual crops in the first year and at 15 days intervals after the planting of it till the harvesting of second year crops, when subabul plants were cut at the ground level to estimate the above ground total biomass yield.

Matured pods of the legumes were harvested in 2 to 3 pickings. Cereals were harvested when 90 per cent of the plants got matured. The grains were separated from the pods of legumes and ears of cereals, dried and weighed.

Observations Recorded

The characters studied and observation recorded are detailed below:

A. Biometric observations

I. Subabul

1. Height of plants.

Three plants were selected randomly from each plot and tagged. Plant height was measured from ground level to the uppermost tip of the growing bud of selected plants, at the last stage of harvest. The mean height was computed and expressed in meters.

2. Diameter at breast height (DBH).

The girth of leucaena stem at breast height (1.3 m) as suggested by Kanazawa et al (1982) was measured for the 3 selected plants and the diameter computed at the last stage of harvest.

3. Leaf-stem ratio.

At each harvest of subabul fodder, a representative sample from the selected plants was taken and leaf-stem ratio computed on oven dry basis.

4. Green fodder yield.

Fifty percent of subabul foliage from the lower portion of plants were cut 15 days before the planting of annual crops in the first year and at every 15 days intervals after planting till the harvesting of the second year crops. The weight of fodder from each of the 25 cuts was recorded and the total weight expressed as total green fodder yield.

5. Dry fodder yield.

Samples of leucaena cut at each stage from the selected plants were air dried, then over dried at 80 ± 5°C till a constant weight was obtained and the dry fodder yield was computed based on the green fodder yield.

6. Firewood yield.

At the last stage of harvest, the selected 3 plants of leucaena were cut on the ground level and separated into leaves, branches and main stems. Firewood yield was calculated on oven dry basis, based on the yield of main stems of 3 selected plants from each plot.

7. Total above ground biomass.

The total above ground biomass was computed from the total of the dry fodder biomass over 25 cuts (including prunings used as green manures) and the firewood biomass and expressed on dry weight basis.

II. Annual crops

1. Height of plants.

Ten plants each of the cereals and legumes were selected at random from the net plot area and tagged. The height from the base of the plant to the tip of the growing point was measured in centimeters at the 30th and the 60th day after planting and at the harvest stage. The mean height of plants was worked out and recorded.

2. Number of nodules/plant.

At 50 per cent flowering of legumes, four plants were randomly selected, uprooted without any damage using a spade and cleaned. The nodule numbers were counted and the mean worked out and recorded.

3. Nodule weight/plant.

The separated nodules from the uprooted plants were oven dried at 80 ± 5°C till a constant weight was obtained and the weights were recorded and the average worked out.

4. Days to 50 per cent flowering.

For legumes the date on which 50 per cent of the plants in the net plot area had their first flower opened was recorded by visual observation and expressed in number of days. For sorghum and bajra the date on which 50 per cent of the plant flowered were recorded and for maize the date to 50 per cent silking was recorded and expressed in number of days.

5. Days to mature.

The date on which 90 per cent of the annual crops were ready for harvest was recorded and expressed in number of days to mature.

6. Number of pods/plant.

The total number of pods produced by the randomly selected plants of legumes were counted and the number of pods/plant computed.

7. Pod length/ear length.

Twenty pods of legumes from the selected plants were taken at random, its length measured and the average expressed in centimeters. For cereals the length of ears from the 10 observation plants were measured in centimeters and the average worked out.

8. Number of seeds/pod and number of grains/ear.

For legumes the number of seeds from the 20 randomly selected pods obtained from observation plants was counted and the average worked out. For cereals the number of grains from ears of 10 observation plants was counted and the average worked out.

9. Thousand grain weight.

Hundred seeds of legumes and cereals were randomly selected from the sample plants and their weights recorded and based on it 1000 grain weight was computed.

10. Dry matter production.

Dry matter production of legumes and cereals was computed at the 30th and 60th day and at harvest stage. Four plants each of cereals and legumes were uprooted air dried and then oven dried at 80 $\pm$ 5°C till a constant weight was obtained and the dry matter production was computed from it at the 30th and 60th day after planting. At the harvest stage, the plants selected for biometric observations were used for dry matter estimation.

11. Grain yield.

Grain yields of legumes and cereals were obtained from the harvest of plants from the net plot area. After harvest the grains were separated from the chaff, cleaned, dried and weighed. The weight was expressed at 12 per cent moisture.

12. Total biomass yield of the system.

Biomass yield of the system was computed by adding the yield of dry matter from legumes and cereals grown during 1984 and 1985 crops seasons, and the dry matter yield from subabul over the same period.

B. Chemical Analysis

I. Analysis of soil samples.

The composite soil samples collected prior to the experiment were analysed for total nitrogen, available phosphorus and available potassium. After the harvest of second year crops, chemical analysis of soil from individual plots was conducted and the results were statistically analysed.

Total nitrogen content of soil was determined by modified micro-kjeldahl method (Jackson, 1967), available phosphorus was determined by Bray's method (Jackson, 1967) and available potassium was determined by neutral normal ammonium acetate method (Jackson, 1967).

II. Analysis of plant samples.

For subabul representative samples of stem and leaf portion of fodder from the selected plants were taken at each harvest and analysed for N, P and K contents. The average was worked out and expressed in per cent dry weight basis.

For annual crops the N, P and K contents of grains and other plant parts were analysed at harvest from the plants used for dry matter estimation and the values were utilized for computing the nutrient uptake at harvest.

1. Nitrogen content.

Total nitrogen contents of samples were determined by modified micro-kjeldahl method (Jackson, 1967).

2. Phosphorus content.

Phosphorus contents of samples were determined by using triple acid extract method (Jackson, 1967). The Klett-summerson photoelectric colorimeter was used for reading colour intensity developed by Vanado-molybdo phosphoric yellow colour method.

3. Potassium content.

Potassium content of samples was determined after extraction with triple acid and reading in EEL flame photometer.

C. <u>Uptake studies</u>

The total uptake of nitrogen, phosphorus and potassium by cereals and legumes were computed based on the content of these nutrients in grains and other plant parts and their respective dry matter production at harvest.

D. Quality Aspects

1. Crude protein content.

The crude protein content was calculated by multiplying the percentage of nitrogen by a factor of 6.25 (Simpson et al, 1965). Crude protein yield from subabul was calculated based on the crude protein content of leaf and stem and their respective dry matter yields at each cutting. Crude protein yield from each stage was added to get the total crude protein yield. Crude protein yield from annual crops was computed based on the crude protein content of grains and other plant parts and their respective dry weight at harvest.

E. Statistical analysis

Data relating to the different parameters were analysed statistically by applying the technique of analysis of variance for factorial experiments in Randomized Block Design (Cochran and Cox, 1957) and the significance of main effects and interactions was tested by F test.

RESULTS

RESULTS

With the object of assessing the biomass production in an agroforestry system involving food and fodder crops like cereals and legumes when grown as intercrop with subabul, an experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani, during 1984 and 1985. Observations were made on growth, yield components, yield and quality characteristics of annual crops and subabul as well. The data recorded were analysed statistically and the results are given below. The mean values are given in Tables 3 to 66 and the analysis of Variance in Appendices II to XVI.

I Subabul

A. Growth Characters and Yield

(1). Height of trees.

The mean height of trees recorded at harvest (20 months after planting) is presented in Table 3 and the analysis of variance in Appendix II.

There was no significant difference in the height of subabul plants grown at two different spacings.

Table 3. Height of subabul trees (m) at harvest.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	1.82	1.85	1.85	1.89	1.77	1.84	Cowpea	1.85	1.82	1.85
4 x 1 m	1.86	1.91	1.87	1.84	1.94	1.86	Blackgram	1.87	1.91	1.86
Mean	1.84	1.88	1.86	1.86	1.85			1.86	1.86	1.85

Subabul spacing, legume = N.S.
Cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal and legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 4. Diameter at breast height (cm) of trees.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.04	1.97	2.00	2.01	2.01	2.00	Cowpea	2.01	2.04	2.06
4 x 1 m	2.02	2.10	2.06	2.05	2.08	2.06	Blackgram	2.05	2.02	2.03
Mean	2.03	2.03	2.03	2.03	2.04			2.03	2.03	2.04

Subabul spacing, legume = N.S.
Cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal and legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S = Not significant.

However, trees planted at 4 x 1 m spacing were found to be taller than those planted at 3 x 1 m spacing.

Intercropping of annual legumes and cereals with subabul did not show any significant difference in the height of trees. None of the interaction effects was also significant. The combination sorghum with blackgram recorded marginal increase in tree height, though the difference was not significant.

(2). Diameter at breast height (DBH).

The mean DBH of trees recorded 20 months after planting is presented in Table 4 and the analysis of variance in Appendix II.

Plant density of subabul had no significant effect on DBH of trees 20 months after planting. However, a slight increase in DBH was noticed on plants with 4 x 1 m spacing than with 3 x 1 m spacing, though not significant.

Intercropping annual legumes and cereals as well as their interaction effects were not significant in influencing DBH of subabul trees. The combination bajra with cowpea recorded the maximum DBH, though the difference among combinations was not significant.

(3). Leaf-stem ratio.

The mean leaf-stem ratio of subabul fodder obtained over a period of 20 months is presented in Table 5 and the analysis of variance in Appendix II.

The effect of spacing on leaf-stem ratio of fodder was significant. The leaf-stem ratio of fodder from trees planted at 4 x 1 m spacing was significantly higher than from those planted at 3 x 1 m spacing.

Intercropping of annual legumes and cereals had no significant influence on leaf stem-ratio. The interaction effects of subabul spacing x cereal and spacing x legume x cereal were significant on leaf-stem ratio. The combination bajra with cowpea recorded the highest value of leaf-stem ratio, though not significant.

(4). Green fodder yield.

The data on green fodder yield of subabul over a period of 20 months is presented in Table 6 and the analysis of variance in Appendix II.

Table 5. Leaf-stem ratio of subabul fodder.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.11	2.11	2.07	2.09	2.17	2.11	Cowpea	2.21	2.21	2.25
4 x 1 m	2.33	2.31	2.35	2.29	2.31	2.32	Blackgram	2.21	2.17	2.24
Mean	2.22	2.21	2.21	2.19	2.24			2.21	2.19	2.24

CD (0.05) subabul spacing = 0.04
Legume, cereal = N.S.
S. spacing x legume interaction = N.S.
CD (0.05) S. spacing x cereal = 0.069
Legume x cereal interaction = N.S.
CD (0.05) S. spacing x legume x cereal interaction = 0.098

Table 6. Green fodder yield (kg/plot) of subabul

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	12.54	13.12	12.53	13.94	12.01	12.83	Cowpea	10.67	10.36	10.38
	(6.27)	(6.56)	(6.26)	(6.97)	(6.00)	(6.41)		(5.33)	(5.18)	(5.19)
4 x 1 m	8.40	11.08	10.02	8.42	10.79	9.74	Blackgram	11.85	12.00	12.43
	(4.20)	(5.54)	(5.01)	(4.21)	(5.39)	(4.87)		(5.94)	(6.00)	(6.21)
Mean	10.47	12.10	11.26	11.18	11.40			11.26	11.18	11.40
	(5.23)	(6.05)	(5.63)	(5.59)	(5.70)			(5.63)	(5.59)	(5.70)

CD (0.05) S. spacing = 2.64
Legume, cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures in parenthesis indicate yield in t/ha. N.S. = Not significant.

Green fodder yield recorded significant difference due to plant spacing. Trees planted at 3 x 1 m spacing yielded significantly higher green matter (6.41 t/ha) than those planted at 4 x 1 m spacing (4.87 t/ha).

Intercropping annual cereals and legumes showed no significant influence on green fodder yield. None of the interaction effects was significant. However, the combination of bajra and blackgram recorded the highest yield among different combinations of annual cereals and legumes.

(5). Dry fodder yield.

The mean values of dry fodder yield of subabul obtained over a period of 20 months, is presented in Table 7 and the analysis of variance in Appendix III.

The effect of plant spacing on dry fodder yield was significant. The yield from trees planted at 3 x 1 m spacing was significantly higher (1.72 t/ha) than from those planted at 4 x 1 m spacing (1.33 t/ha).

Intercropping of annual cereals and legumes and their interactions did not affect the dry fodder yield

Table 7. Dry fodder yield (kg/plot) of subabul.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	3.19 (1.59)	3.72 (1.86)	3.42 (1.71)	3.59 (1.79)	3.35 (1.67)	3.45 (1.72)	Cowpea	2.89 (1.44)	2.64 (1.32)	2.71 (1.35)
4 x 1 m	2.31 (1.15)	3.03 (1.51)	2.71 (1.35)	2.31 (1.15)	2.99 (1.49)	2.67 (1.33)	Blackgram	3.23 (1.61)	3.26 (1.63)	3.63 (1.81)
Mean	2.75 (1.87)	3.37 (1.68)	3.06 (1.53)	2.95 (1.47)	3.17 (1.58)			3.06 (1.53)	2.95 (1.47)	3.17 (1.58)

CD (0.05) subabul spacing = 0.727
Legume, cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 8. Fire wood yield (kg/plot) of subabul.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	4.20 (2.10)	3.82 (1.91)	3.66 (2.00)	3.69 (1.83)	4.68 (2.34)	4.01 (2.00)	Cowpea	3.49 (1.74)	2.83 (1.41)	4.43 (2.21)
4 x 1 m	2.97 (1.48)	3.71 (1.85)	2.99 (1.49)	2.72 (1.36)	4.31 (2.15)	3.34 (1.67)	Blackgram	3.16 (1.58)	3.58 (1.79)	4.56 (2.28)
Mean	3.58 (1.79)	3.76 (1.88)	3.32 (1.66)	3.20 (1.60)	4.49 (2.24)			3.32 (1.66)	3.20 (1.60)	4.49 (2.24)

Subabul spacing, legume = N.S.
Cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha, N.S. = Not significant.

of subabul. However, the combination of bajra and blackgram recorded maximum dry fodder yield.

(6). Firewood yield.

The data on forewood yield of subabul recorded 20 months after planting is presented in Table 8 and the analysis of variance in Appendix III.

There was no significant difference in fire wood yield due to different plant spacings. However, a marginal increase in firewood yield was observed at 3 x 1 m spacing (2.00 t/ha) than at 4 x 1 m spacing (1.67 t/ha).

Intercropping of cereals and legumes and their interactions also showed no significant effect. Among different combinations of annual cereals and legumes, bajra with blackgram (Fig 4) recorded increased firewood yield, though not significant.

(7). Total above ground biomass yield.

The mean values of total above ground biomass yield of subabul over a period of 20 months is presented in Table 9 and the analysis of variance in Appendix III.

Different spacings of subabul recorded no significant influence on total above ground biomass yield.

Table 9. Total above ground biomass yield (kg/plot) of subabul.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	7.39 (3.69)	7.54 (3.77)	7.08 (3.54)	7.28 (3.64)	8.03 (4.01)	7.46 (3.73)	Cowpea	6.38 (3.19)	5.47 (2.73)	7.15 (3.57)
4 x 1 m	5.27 (2.63)	6.75 (3.37)	5.70 (2.85)	5.03 (2.51)	7.31 (3.65)	6.01 (3.00)	Blackgram	6.40 (3.20)	6.84 (3.42)	8.19 (4.09)
Mean	6.33 (3.16)	7.14 (3.57)	6.39 (3.19)	6.15 (3.07)	7.67 (3.83)			6.39 (3.19)	6.15 (3.07)	7.67 (3.83)

Subabul spacing, legume = N.S.
Cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 10. Nitrogen content (per cent) of subabul stems.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.09	2.13	2.16	2.13	2.05	2.11	Cowpea	2.23	2.14	2.06
4 x 1 m	2.19	2.19	2.22	2.17	2.18	2.19	Blackgram	2.15	2.16	2.17
Mean	2.14	2.16	2.19	2.15	2.11			2.19	2.15	2.11

CD (0.05) subabul spacing = 0.075
Legume, cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha, N.S. = Not significant.

However, trees planted at 3 x 1 m spacing recorded the highest total biomass yield (3.73 t/ha) as compared to the yield (3.00 t/ha) from trees planted at 4 x 1 m spacing.

Intercropping of annual cereals and legumes and their interaction effects were not significant in influencing the total biomass yield. The combination of bajra with blackgram (Fig. 4.) recorded the highest biomass yield (4.09 t/ha), though it was not significant.

B. Quality Aspects

(1). Nitrogen content of subabul stems.

The data on nitrogen content of stem portion of subabul fodder is presented in Table 10 and the analysis of variance in Appendix IV.

The effect of spacing on nitrogen content of stem was significant. Higher value of nitrogen content of stem was recorded from plants grown at 4 x 1 m spacing.

Intercropping of annual cereals and legumes did not show any significant effect on nitrogen content of stem. None of the interaction effects was significant. Among different combinations of cereals and legumes, the combination of maize and cowpea recorded the highest values of nitrogen content, though the difference was not significant.

(2). Nitrogen content of subabul leaves.

The data on mean nitrogen content in leaf portion of subabul fodder is presented in Table 11. and the analysis of variance in Appendix IV.

The nitrogen content of leaves was more among plants grown at 4 x 1 m spacing than at 3 x 1 m spacing. Intercropping of cereals and legumes did not record significant effect on the nitrogen content of leaves. None of the interaction effects was also significant on the nitrogen content of leaves. The combination of maize with cowpea recorded the highest nitrogen content among different combinations tried.

(3). Crude protein content of subabul stems.

The data on crude protein content of stem portion of subabul fodder is presented in Table 12, and the analysis of variance in Appendix IV.

Table 11. Nitrogen content (per cent) of subabul leaves.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	4.07	4.17	4.21	4.17	3.98	4.12	Cowpea	4.35	4.34	4.04
4 x 1 m	4.41	4.27	4.33	4.33	4.36	4.34	Blackgram	4.19	4.17	4.30
Mean	4.24	4.22	4.27	4.25	4.17			4.27	4.25	4.17

CD (0.05) subabul spacing = 0.19
Legume, cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 12. Crude protein content (per cent) of subabul stems.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	13.09	13.30	13.45	13.31	12.82	13.19	Cowpea	13.91	13.37	12.88
4 x 1 m	13.70	13.78	14.04	13.57	13.60	13.74	Blackgram	13.58	13.51	13.54
Mean	13.39	13.54	13.74	13.44	13.21			13.74	13.44	13.21

CD (0.05) subabul spacing = 0.449
Legume, cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

The effect of spacing on crude protein content of stems was significant. Crude protein content of stems at wider spacing was significantly higher than those at closer spacing.

Crude protein content of stem was not significantly affected by the intercropping of cereals and legumes or their interactions. The combination of maize with cowpea resulted in highest crude protein content, though it was not significant.

(4). Crude-protein content of subabul leaves.

The data on mean crude protein content in leaf portion of subabul fodder is presented in Table 13 and the analysis of variance in Appendix IV.

The effect of plant spacing on crude protein content was significant. The crude protein content of leaves was significantly higher (27.12 per cent) at wider spacing than at closer spacing (25.74 per cent). Intercroping of annual crops showed no significant effect on this character. Among different combinations of crops tried, the combination 'maize with cowpea' recorded the highest crude protein content, though it was not significant.

Table 13. Crude protein content (per cent) of subabul leaves.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	25.44	26.04	26.29	26.08	24.86	25.74	Cowpea	27.16	27.11	25.20
4 x 1 m	27.54	26.70	27.04	27.08	27.25	27.12	Blackgram	26.16	26.05	26.90
Mean	26.49	26.37	26.66	26.58	26.05			26.66	26.58	26.05

CD (0.05) subabul spacing = 1.22
Legume, cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 14. Phosphorus content (per cent) of subabul stems.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	0.145	0.141	0.141	0.143	0.144	0.143	Cowpea	0.147	0.148	0.150
4 x 1 m	0.152	0.162	0.160	0.159	0.152	0.157	Blackgram	0.154	0.154	0.145
Mean	0.148	0.151	0.150	0.151	0.148			0.150	0.151	0.148

CD (0.05) Subabul spacing, legume = 0.0023
Cereal = N.S.
CD (0.05) S. spacing x legume interaction = 0.0032
CD (0.05) S. spacing x cereal, legume x cereal interaction =0.0039
CD (0.05) S. spacing x legume x cereal interaction =0.0055

N.S. = Not significant.

(5). <u>Phosphorus content of subabul stems</u>.

The mean values on phosphorus content in stem portion of subabul fodder are presented in Table 14 and the analysis of variance in Appendix V.

Significant difference in phosphorus content of stem was recorded due to different spacings. Phosphorus content was significantly higher at 4 x 1 m spacing then at 3 x 1 m spacing. Intercropping of legumes recorded significant difference on phosphorus content of stems. Phosphorus content was significantly higher with blackgrem than with cowpea. Intercropping of cereals had no effect on the character. The interection effects of subabul spacing x legume, spacing x cereal, cereal x legume and spacing x legume x cereal were significant on phosphorus content of stems. Intercropping of maize and blackgram with subabul resulted in highest phosphorus content and it was on par with sorghum and blackgram but superior to all other combinations. The combination bajra and blackgram, recorded the lowest phosphorus content of stems.

(6). <u>Phosphorus content of leaves</u>.

The data on phosphorus content of leaf portion of subabul fodder is presented in Table 15 and the analysis

Table 15. Phosphorus content (per cent) of subabul leaves.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	0.161	0.175	0.169	0.169	0.167	0.168	Cowpea	0.157	0.159	0.158
4 x 1 m	0.155	0.151	0.152	0.153	0.153	0.153	Blackgram	0.164	0.163	0.162
Mean	0.158	0.163	0.160	0.161	0.160			0.160	0.161	0.160

CD (0.05) subabul spacing, legume = 0.002
Cereal = N.S.
CD (0.05) S. spacing x legume interaction = 0.0028

S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 16. Potassium content (per cent) of subabul stems.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	1.01	0.97	1.00	0.94	1.02	0.99	Cowpea	1.03	0.98	1.00
4 x 1 m	1.00	0.85	0.93	0.81	1.03	0.92	Blackgram	0.90	0.77	1.05
Mean	1.00	0.91	0.96	0.87	1.02			0.96	0.87	1.02

CD (0.05) S. spacing, legume = 0.012
CD (0.05) cereal = 0.015
CD (0.05) S. spacing x legume interaction = 0.017

CD (0.05) S. spacing x cereal, legume x cereal interaction = 0.021
CD (0.05) S. spacing x legume x cereal interaction = 0.029

N.S. = Not significant.

of variance in Appendix V.

Significant difference in phosphorus content of leaves was observed in subabul trees planted at two different spacings. Trees planted at closer spacing (3 x 1 m) recorded significantly higher phosphorus content of leaves than those planted at wider spacing (4 x 1 m).

Intercropping of legumes showed significant influence on phosphorus content. Intercropping of blackgram recorded higher phosphorus content in leaves than cowpea. Intercropping of cereals had no effect on it. The interaction effect of subabul spacing x legume was significant on phosphorus content of leaves. There was no difference in phosphorus content of leaves due to different combinations of legumes and cereals, though the combination maize + blackgram recorded the maximum value of phosphorus content.

(7). Potassium content of subabul stems.

The mean values on potassium content of stem portion of subabul fodder are presented in Table 16 and the analysis of variance in Appendix V.

Significant difference in potassium content of stems was recorded due to two different spacings. Trees planted at closer spacing (3 x 1 m) recorded significantly higher potassium content in stems than those planted at wider spacing (4 x 1 m).

Intercropping of cereals and legumes recorded significant difference in potassium content of stem. Higher potassium content of stems was obtained by intercropping cowpea as compared to blackgram. Intercropping of bajra resulted in the highest potassium content which was superior to intercropping of maize or sorghum, while the latter two were on par. The interaction effects of legume x plant density of subabul, cereal x plant density, legume x cereal and legume x cereal x plant density were all significant in influencing the potassium content. The combination bajra + blackgram recorded the highest potassium content of stem and was on par with maize + cowpea combination.

(8). Potassium content of subabul leaves.

The data on potassium content in leaf portion of subabul fodder is presented in Table 17 and the analysis of variance in Appendix V.

There was no significant difference in potassium content of leaves in trees planted at two different

Table 17. Potassium content (per cent) of subabul leaves.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	2.15	2.15	2.23	2.19	2.02	2.15
4 x 1 m	2.12	2.13	2.04	2.09	2.24	2.12
Mean	2.13	2.14	2.13	2.14	2.13	

	Maize	Sorghum	Bajra
Cowpea	2.14	2.16	2.10
Blackgram	2.13	2.12	2.16
	2.13	2.14	2.13

Subabul spacing, legume = N.S.
Cereal = N.S.
S. spacing x legume interaction = N.S.

CD (0.05) S. spacing x cereal = 0.063
Legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 18. Crude protein yield (gm/plot) of subabul fodder.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	693.93 (0.35)	799.09 (0.40)	742.07 (0.37)	774.51 (0.39)	722.96 (0.36)	746.51 (0.37)
4 x 1 m	574.24 (0.29)	668.01 (0.33)	672.31 (0.34)	515.89 (0.26)	675.17 (0.34)	612.12 (0.31)
Mean	634.08 (0.32)	733.55 (0.37)	707.19 (0.35)	645.20 (0.33)	699.06 (0.35)	

	Maize	Sorghum	Bajra
Cowpea	707.85 (0.35)	580.74 (0.29)	613.66 (0.31)
Blackgram	706.53 (0.35)	709.66 (0.36)	784.46 (0.39)
	707.19 (0.35)	645.20 (0.33)	699.06 (0.35)

S. spacing, legume, cereal = N.S.
S. spacing x legume interaction = N.S.

S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha. N.S. = Not significant.

spacings. However, potassium content in the leaves of trees planted at closer spacing was found higher.

Intercropping of cereals and legumes showed no significant difference on the potassium content of leaves. The interaction effect of cereal x subabul spacing was significant. A difference though statistically not significant was observed due to different combinations of annual legumes and cereals.

(9). Crude protein yield.

The data on crude protein yield from subabul fodder (leaves + stems) is presented in Table 18 and analysis of variance in Appendix III.

There was no significant difference in crude protein yield due to spacings. However under 3 x 1 m spacing the crude protein yield was higher than under 4 x 1 m spacing. Intercropping of annual legumes and cereals showed no significicnt influence on crude protein yield. None of the interaction effects was also significant. The combination of bajra + blackgram recorded highest crude protein yield, though not significant.

II Annual Crops

A. Growth Characters

(1). Height of plants

Tables 19 (a), 19 (b), 20 (a), 20 (b), 21 (a), 21 (b), 22 (a), 22 (b), 23 (a) and 23 (b) show the data on plant height of cereals and legumes at different growth stages and the respective analysis of variance is presented in Appendices VI and VII.

(a). Cereals.

Height of maize plants was significantly influenced by subabul spacing. Height of maize was more under 3 x 1 m spacing at all the stages of growth during the second year and at the 30th day only during the first year.

In the case of sorghum, the height of plants was significantly influenced by subabul spacing at the 30th and 60th day. At harvest, the effect of spacing was not significant. The effect of spacing on the height of bajra plants was significant at the 30th day in the first year and the effect was not significant at the later stages during both the years.

Intercropping of legumes or the interaction effect

Table 19(a). Height of maize (cm) at different stages of growth (first year).

	30th day			60th day			At harvest		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	42.7	42.8	42.7	84.6	89.3	86.9	92.2	92.2	92.2
4 x 1 m	38.2	38.2	38.2	82.3	85.0	83.6	86.1	96.6	91.3
Mean	41.4	42.5		83.9	87.3		89.1	94.4	

30th day		60th day		At harvest	
CD (0.05) S. spacing	=2.39	Subabul spacing	= N.S.	Subabul spacing	= N.S.
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

Table 19(b). Height of maize (cm) at different stages of growth (second year).

	30th day			60th day			At harvest		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	48.1	48.2	48.1	82.0	84.3	83.1	89.8	94.5	92.1
4 x 1 m	46.3	46.7	46.5	77.5	78.6	78.0	88.1	85.5	86.8
Mean	47.2	47.4		79.7	81.4		88.9	90.0	

30th day		60th day		At harvest	
CD (0.05) S. spacing	= 1.49	CD (0.05) S. spacing	= 4.52	CD(0.05) S. spacing	= 4.7
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

N.S. = Not significant.

Table 20(a). Height of sorghum (cm) at different stages of growth (first year).

	30th day			60th day			At harvest		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	33.6	33.6	33.6	75.7	70.7	73.2	176.3	170.0	173.1
4 x 1 m	28.7	28.9	28.8	67.3	68.2	67.8	167.7	174.5	171.1
Mean	31.1	31.2		71.5	69.4		172.0	172.2	

30th day		60th day		At harvest	
CD (0.05) subabul spacing	= 2.08	CD (0.05) S. spacing	= 3.44	S. spacing	= N.S.
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	CD (0.05) interaction	= 5.9

Table 20(b). Height of sorghum (cm) at different stages of growth (second year).

	30th day			60th day			At harvest		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	33.3	33.3	33.3	77.3	72.8	75.0	175.0	172.4	173.7
4 x 1 m	29.4	29.3	29.3	69.8	70.2	70.0	171.0	171.5	171.2
Mean	31.3	31.3		73.5	71.5		173.0	171.9	

30th day		60th day		At harvest	
CD (0.05) subabul spacing	= 2.98	CD (0.05) S. spacing	= 2.66	S. spacing	= N.S.
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

N.S. = Not significant.

Table 21(a). Height of bajra (cm) at different stages of growth (first year).

	30th day			60th day			At harvest		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	62.3	63.4	62.8	105.5	103.9	104.7	125.5	124.3	124.9
4 x 1 m	57.1	57.2	57.1	100.8	103.6	103.2	120.1	123.8	121.9
Mean	59.7	60.3		103.1	103.7		122.8	124.0	

30th day		60th day		At harvest	
CD (0.05) subabul spacing	= 1.26	Subabul spacing	= N.S.	Subabul spacing	= N.S.
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

Table 21(b). Height of bajra (cm) at different stages of growth (second year).

	30th day			60th day			At harvest		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	64.2	64.0	64.1	112.5	114.2	113.3	133.0	136.2	134.6
4 x 1 m	58.6	59.1	58.8	110.2	112.3	112.2	131.2	132.1	131.6
Mean	61.4	61.5		111.3	113.2		122.1	134.1	

30th day		60th day		At harvest	
Subabul spacing	= N.S.	Subabul spacing	= N.S.	Subabul spacing	= N.S.
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

N.S. = Not significant.

Table 22(a). Height of cowpea (cm) at different stages of growth (first year).

	30th day				60th day				At harvest			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	18.7	17.4	16.5	17.5	43.1	45.4	41.4	43.3	67.6	70.8	68.7	69.0
4 x 1 m	16.9	15.8	15.5	16.0	41.9	40.9	41.8	41.5	66.6	67.0	66.2	66.6
Mean	17.8	16.6	16.0		42.5	43.1	41.6		67.1	68.9	67.4	

CD (0.05) subabul spacing = 1.1
CD (0.05) cereal = 1.3
S. spacing x cereal interaction = N.S.

CD (0.05) S. spacing = 1.70
Cereal = N.S.
S. spacing x cereal interaction = N.S.

CD (0.05) S. spacing = 1.6
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Table 22(b). Height of cowpea (cm) at different stages of growth (second year).

	30th day				60th day				At harvest			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	22.5	23.1	21.8	22.4	45.9	49.0	45.1	46.7	71.9	76.7	70.5	72.4
4 x 1 m	22.5	20.9	21.6	21.3	25.9	24.8	25.8	45.5	70.2	70.5	71.6	70.8
Mean	22.5	22.0	21.7		45.9	46.9	45.4		71.1	72.6	71.0	

Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
Cereal = N.S.
CD (0.05) S. spacing x cereal interaction = 2.8

Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

N.S. = Not significant.

Table 23(a). Height of blackgram (cm) at different stages of growth (first year).

	30th day				60th day				At harvest			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	18.3	19.6	18.2	18.7	29.2	28.7	28.1	28.7	29.3	28.7	28.3	28.8
4 x 1 m	17.8	18.5	17.2	17.8	28.9	28.2	28.0	28.3	29.5	28.3	28.2	28.7
Mean	18.0	19.0	17.7		29.0	28.4	28.0		29.4	28.5	28.2	

CD (0.05) subabul spacing = 0.78
CD (0.05) cereal = 0.86
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
CD (0.05) cereal = 0.63
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
CD (0.05) cereal = 0.67
S. spacing x cereal interaction = N.S.

Table 23(b). Height of blackgram (cm) at different stages of growth (second year).

	30th day				60th day				At harvest			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	17.9	20.3	18.3	19.0	30.4	30.5	29.8	30.2	30.5	30.7	29.9	30.4
4 x 1 m	18.8	19.0	18.9	18.5	29.8	29.5	28.9	29.4	29.9	29.6	29.1	29.5
Mean	18.3	19.6	18.3		30.1	30.0	29.3		30.2	30.1	29.5	

Subabul spacing = N.S.
CD (0.05) cereal = 0.82
S. spacing x cereal interaction = 1.6

Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

N.S. = Not significant.

of subabul spacing x legume were not significant on plant height of maize, and bajra, in any of the years. The interaction of subabul spacing x legume was significant on the height of sorghum plants at harvest during the first year.

(b). Legumes.

The effect of subabul spacing on the height of cowpea was significant at all the stages in the first year and it was not significant in the second year. In the case of blackgram, the effect was significant at the first stage during the first year only.

The effect of growing cereals on the height of intercropped legumes was not consistent over seasons and stages. At the 30th day, the effect of sorghum was more pronounced than maize or bajra in increasing the height of blackgram plants during both the years. At the 60th day and thereafter maize and sorghum had positive effect on this character. Height of cowpea plants grown with maize was more at the 30th day, but the effect was less pronounced during the second year. The effect was not significant at the other stages of growth, but the height, tended to increase with sorghum and maize. The height of legume plants was always less when grown with bajra. The interaction effect of spacing of subabul x cereal was significant on plant height of blackgram at the 30th day and that of cowpea at the 60th day during the second year.

(2). Number of nodules/plant.

Tables 24 (a) and 24 (b) show the data on the number of nodules/plant at the flowering stages of cowpea and blackgram and the analysis of variance is presented in Appendix VII.

Significant reduction in the number of nodules/plant was noticed when legumes were intercropped in between 3 m wide rows as compared to 4 m wide rows of subabul, though the effect was not marked for blackgram during the first year.

Intercropping of cowpea or blackgram with sorghum and maize recorded more number of nodules. The effect of sorghum was superior to maize on the number of nodules/plant of cowpea during the first year and that of blackgram during the second year. The lowest number of nodules/plant was recorded, when legumes were grown in association with bajra.

Table 24(a). Number of nodules/plant of cowpea and blackgram (first year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	28.2	30.1	24.5	27.6	16.2	18.1	14.6	16.3
4 x 1 m	32.3	33.5	28.3	31.4	17.3	16.7	15.3	16.4
Mean	30.2	31.8	26.4		16.7	17.4	14.9	

CD (0.05) subabul spacing = 0.93
CD (0.05) cereal = 1.14
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
CD (0.05) cereal = 1.74
S. spacing x cereal interaction = N.S.

Table 24(b). Number of nodules/plant of cowpea and blackgram (second year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	26.2	28.1	23.1	25.8	15.3	17.3	15.0	15.9
4 x 1 m	31.0	31.3	25.8	29.4	18.1	20.2	18.0	18.8
Mean	28.6	29.7	24.4		16.7	18.7	16.5	

CD (0.05) subabul spacing = 1.40
CD (0.05) cereal = 1.72
S. spacing x cereal interaction = N.S.

CD (0.05) subabul spacing = 0.97
CD (0.05) cereal = 1.19
S. spacing x cereal interaction = N.S.

N.S. = Not significant.

(3). Weight of nodules/plant.

The data on the weight of nodules/plant of cowpea and blackgram are presented in Tables 25 (a) and 25 (b), and the analysis of variance in Appendix VII.

Significant increase in the weight of nodules in legumes was noticed when they were planted in between 4 m wide subabul rows, with an exception in the case of blackgram during the first year.

The effect of cereal intercropping on the nodule weight of both cowpea and blackgram was not significant in any of the years. The interaction effect of subabul spacing x cereal was significant on root nodulation of blackgram during the first year and that of cowpea during the second year.

(4). Number of days to flower.

The data on the number of days required from planting to the 50 per cent silking of maize, and flowering of sorghum, bajra, cowpea and blackgram are presented in Tables 26 (a), 26 (b), 27 (a) and 27 (b) and the analysis of variance in Appendices VI and VII.

Table 25(a). Weight of nodules/plant (mg) of cowpea and blackgram (first year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	43.5	44.0	44.5	44.0	30.1	29.0	28.0	29.0
4 x 1 m	48.3	47.0	45.5	46.9	28.1	31.2	30.5	29.9
Mean	45.9	45.5	45.0		29.1	30.1	29.2	

CD (0.05) subabul spacing = 1.80
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
Cereal = N.S.
CD (0.05) S. spacing x cereal interaction = 1.67

Table 25(b). Weight of nodules/plant (mg) of cowpea and blackgram (second year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	40.8	37.9	40.4	39.7	28.5	30.0	30.0	29.5
4 x 1 m	43.2	47.2	42.2	44.2	33.5	33.0	31.5	32.5
Mean	42.0	42.5	41.3		31.0	31.5	30.7	

CD (0.05) subabul spacing = 1.96
Cereal = N.S.
CD (0.05) S. spacing x cereal interaction = 3.40

CD (0.05) subabul spacing = 1.15
Cereal = N.S.
S. spacing x cereal interaction = N.S.

N.S. = Not significant.

Table 26(a). Days to 50 per cent silking in maize and flowering in sorghum and bajra (first year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	65.0	65.3	65.1	71.3	71.7	71.5	42.3	42.7	42.5
4 x 1 m	65.3	65.3	65.3	73.3	73.0	73.1	43.3	44.0	43.6
Mean	65.1	65.3		72.3	72.3		42.8	43.3	

Maize		Sorghum		Bajra	
Subabul spacing	= N.S.	CD (0.05) S. spacing	=1.33	CD(0.05) S. spacing	=0.78
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

Table 26(b). Days to 50 per cent silking in maize and flowering in sorghum and bajra(second year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	65.0	65.0	65.0	67.0	66.3	66.6	41.0	41.3	41.1
4 x 1 m	65.3	65.0	65.1	69.3	68.3	68.8	42.0	42.7	42.3
Mean	65.1	65.0		68.1	67.3		41.5	42.0	

Maize		Sorghum		Bajra	
Subabul spacing	= N.S.	CD (0.05) S. spacing	= 1.73	CD (0.05) S. spacing	=1.12
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

N.S. = Not significant.

Table 27(a). Number of days to flowering in cowpea and blackgram (first year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	56.7	55.3	56.0	56.0	39.3	40.3	39.7	39.7
4 x 1 m	57.3	56.3	57.0	56.9	40.3	41.0	40.3	40.5
Mean	57.0	55.8	56.6		39.8	40.6	40.0	

CD (0.05) subabul spacing = 0.65
CD (0.05) cereal = 0.80
S. spacing x cereal interaction = N.S.

CD (0.05) subabul spacing = 0.66
Cereal = N.S.
S. spacing x cereal interaction= N.S.

Table 27(b). Number of days to flowering in cowpea and blackgram (second year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	55.3	54.0	54.0	54.4	37.0	38.3	37.7	37.7
4 x 1 m	55.3	54.3	55.0	54.9	38.3	39.0	38.3	38.5
Mean	55.3	54.1	54.5		37.6	38.6	38.0	

CD (0.05) subabul spacing = 0.42
CD (0.05) cereal = 0.52
S. spacing x cereal interaction = N.S.

CD (0.05) subabul spacing = 0.73
Cereal = N.S.
S. spacing x cereal interaction = N.S.

N.S. = Not significant.

(a). Cereals.

There was no significant effect of subabul spacing on the number of days required for 50 per cent silking in maize. The effect of spacing was significant on the flowering in sorghum and bajra, during both the years. Flowering was significantly hastened when these crops were grown in between subabul rows with 3 m spacing.

Intercropping of cowpea or blackgram did not significantly influence the silking of maize and flowering of bajra and sorghum in both the years. Interaction effects were not significant on this character.

(b). Legumes.

The number of days required from planting to the 50 per cent first flowering in cowpea and blackgram were reduced significantly when intercropped with subabul having 3 m wide spacing.

The influence of cereals on the flowering of cowpea was significant, while the effect was not significant in the case of blackgram during both the years.

The number of days required for 50 per cent flowering in cowpea was significantly more when intercropped with maize than with sorghum or bajra.

(5). <u>Number of days to mature</u>.

The data on Tables 28 (a), 28 (b), 29 (a) and 29 (b) show the number of days required from planting to the maturity of annual cereals and legumes and their analysis of variance are presented in Appendices VI and VII.

(a). Cereals.

Raising maize between 3 m wide rows of subabul resulted in significant delay in the maturity of maize as compared to raising between 4 m wide rows. Subabul spacing had no effect on the maturity of sorghum and bajra.

Intercropping of cowpea or blackgram showed no significant influence on the number of days to maturity of maize and bajra in both the years and that of sorghum during the second year. During the first year, sorghum grown in association with cowpea matured earlier than that grown with blackgram.

(b). Legumes.

Significant delay in the maturity of blackgram was

Table 28(a). Number of days to maturity of maize, sorghum and bajra (first year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	98.0	97.7	97.8	119.7	120.7	120.2	76.0	76.0	76.0
4 x 1 m	95.3	95.3	95.3	119.3	120.0	119.6	75.0	74.6	74.8
Mean	96.6	96.5		119.5	120.3		75.5	75.3	

Maize		Sorghum		Bajra	
CD (0.05) subabul spacing	= 0.66	Subabul spacing	= N.S.	Subabul spacing	= N.S.
Legume	= N.S.	CD (0.05) legume	= 0.78	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

Table 28(b). Number of days to maturity of maize, sorghum and bajra (second year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	95.0	95.3	95.1	117.7	118.7	118.2	72.3	73.0	72.6
4 x 1 m	93.3	93.3	93.3	117.3	117.7	117.5	72.3	72.7	72.5
Mean	94.1	94.3		117.5	118.2		72.3	72.8	

Maize		Sorghum		Bajra	
CD (0.05) subabul spacing	= 0.71	Subabul spacing	= N.S.	Subabul spacing	= N.S.
Legume	= N.S.	Legume	= N.S.	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

N.S. = Not significant.

Table 29(a). Number of days to maturity of cowpea and blackgram (first year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	87.7	88.3	86.3	87.4	73.0	74.3	72.2	73.2
4 x 1 m	87.3	88.3	86.3	87.3	73.3	72.3	72.1	72.5
Mean	87.5	88.3	86.3		73.1	73.3	72.3	

Subabul spacing = N.S.
CD (0.05) cereal = 0.98
S. spacing x cereal interaction = N.S.

CD (0.05) subabul spacing = 0.59
CD (0.05) cereal = 0.72
CD (0.05) S. spacing x cereal interaction = 1.03

Table 29(b). Number of days to maturity of cowpea and blackgram (second year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	84.7	89.0	83.3	85.7	71.3	72.3	70.3	71.3
4 x 1 m	84.3	85.3	83.3	84.3	71.3	70.7	70.0	70.7
Mean	84.5	87.1	83.3		71.3	71.5	70.1	

Subabul spacing = N.S.
CD (0.05) cereal = 2.88
S. spacing x cereal interaction = N.S.

CD (0.05) subabul spacing = 0.46
CD (0.05) cereal = 0.57
CD (0.05) S. spacing x cereal interaction = 0.81

N.S. = Not significant.

noticed when planted in between 3 m wide rows as compared to 4 m wide rows of subabul, where as no significant difference on the number of days from planting to the maturity was observed on cowpea with different spacings of subabul in both the years.

Cereals showed significant influence on the maturity of intercropped legumes. Maturity of cowpea and blackgram was advanced when grown with bajra, while with sorghum, some delay in the maturity of these legumes was noted during both the years. The effect of sorghum was on par with maize for influencing the maturity of blackgram, but superior to maize in influencing the maturity of cowpea. The interaction of subabul spacing x cereal was significant on the maturity of blackgram during both the years.

B. Yield Components and Yield

(1). Number of pods/plant

The data on the number of pods/plant of cowpea and blackgram are furnished in Tables 30 (a) and 30 (b) and their analysis of variance in Appendix VII.

There was no-significant difference in the number

Table 30 (a). Number of pods/plant of cowpea and blackgram (first year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	7.3	7.9	7.2	7.5	10.0	11.0	9.5	10.2
4 x 1 m	7.4	7.8	6.9	7.3	10.0	10.5	9.0	9.8
Mean	7.3	7.8	7.0		10.0	10.7	9.2	

Cowpea:
Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Blackgram:
Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Table 30 (b). Number of pods/plant of cowpea and blackgram (second year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	5.7	6.7	5.5	6.0	8.5	8.9	7.9	8.4
4 x 1 m	5.5	6.0	5.0	5.5	7.9	8.3	7.3	7.8
Mean	5.6	6.3	5.2		8.2	8.6	7.6	

Cowpea:
Subabul spacing = N.S.
CD (0.05) cereal = 0.68
S. spacing x cereal interaction = N.S.

Blackgram:
Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

N.S. = Not significant.

of pods/plant of legumes due to subabul spacing. The effects of cereal intercropping and interaction effects were also not significant in the number of pods/plant except in the case of cowpea during the second year. Cowpea intercropped with sorghum had significantly more number of pods/plant in the second year.

(2). Ear length of cereals.

The data on the ear length of maize sorghum and bajra are presented in Tables 31 (a) and 31 (b) and the analysis of variance in Appendix VI.

The effect of subabul spacing in the ear length of sorghum was significant. In the case of sorghum intercropped in plots under 3 x 1 m spacing of subabul the ear length was more than in 4 x 1 m spacing. In the case of maize and bajra the effect of subabul spacing was not significant.

The effect of intercropping legume on the ear length of cereals was not consistent. The effect of blackgram was more than that of cowpea increasing the ear length of maize during the first year. Ear length of sorghum was significantly increased due to blackgram intercropping during both the years. There was no significant effect on ear length of bajra due to intercropping of legumes.

Table 31(a). Length of ear (cm) of maize, sorghum and bajra (first year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	9.1	10.4	9.7	10.0	11.7	10.8	12.3	12.9	12.6
4 x 1 m	9.1	10.3	9.7	9.4	10.9	10.1	10.7	13.0	11.8
Mean	9.1	10.3		9.7	11.3		11.5	12.9	

Maize		Sorghum		Bajra	
Subabul spacing	= N.S.	CD (0.05) S. spacing	= 0.33	Subabul spacing	= N.S.
CD (0.05) legume	= 0.34	CD (0.05) legume	= 0.33	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

Table 31(b). Length of ear (cm) of maize, sorghum and bajra (second year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	10.0	11.7	10.8	11.5	14.1	12.8	11.8	14.2	13.0
4 x 1 m	9.9	9.0	9.4	10.4	12.4	11.4	11.4	13.4	12.4
Mean	9.9	10.3		10.9	13.2		11.6	13.8	

Maize		Sorghum		Bajra	
Subabul spacing	= N.S.	CD (0.05) S. spacing	=0.37	S. spacing	= N.S.
Legume	= N.S.	CD (0.05) legume	=0.37	Legume	= N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

N.S. = Not significant.

(3). Pod length of legumes

The data on the pod length of cowpea and blackgram is presented in Tables 32 (a) and 32 (b) and the analysis of variance in Appendix VII.

There was no significant influence in the length of pods due to any of the treatment effects or due to their interaction effects.

(4). Number of grains/ear of cereals

The data on the number of grains/ear of maize, sorghum and bajra are presented in Tables 33 (a) and 33 (b) and the analysis of variance in Appendix VI.

Intercropping bajra under 3 m wide rows of subabul recorded more number of grains/ear than intercropping in 4 m wide rows during the second year only. An increase in the number of grains per ear of maize and sorghum was noticed when planted in 3 m wide rows of subabul, though the effect was not significant during both the years.

Intercropping of blackgram recorded significantly more grains per ear of maize and bajra during the second year. In the case of sorghum grains/ear was significantly more during both the years due to the effect of blackgram.

Table 32(a). Length of pod (cm) of cowpea and blackgram (first year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	12.6	13.4	12.7	12.9	3.1	3.1	3.0	3.1
4 x 1 m	13.2	12.7	12.7	12.9	3.1	3.0	3.0	3.0
Mean	12.9	13.0	12.7		3.1	3.0	3.0	

Cowpea		Blackgram	
Subabul spacing	= N.S.	Subabul spacing	= N.S.
Cereal	= N.S.	Cereal	= N.S.
S. spacing x cereal interaction	= N.S.	S. spacing x cereal interaction	= N.S.

Table 32(b). Length of pod (cm) of cowpea and blackgram (second year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	12.7	13.9	13.3	13.3	3.4	3.4	3.2	3.3
4 x 1 m	13.7	13.3	13.1	13.4	3.3	3.4	3.6	3.4
Mean	13.2	13.6	13.2		3.3	3.4	3.4	

Cowpea		Blackgram	
Subabul spacing	= N.S.	Subabul spacing	= N.S.
Cereal	= N.S.	Cereal	= N.S.
S. spacing x cereal interaction	= N.S.	S. spacing x cereal interaction	= N.S.

N.S. = Not significant.

Table 33(a). Number of grains/ear of maize, sorghum and bajra (first year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	123.8	131.6	127.7	154.9	203.0	178.9	906.6	929.2	917.9
4 x 1 m	123.9	130.7	127.3	154.0	199.7	176.8	829.5	895.1	862.3
Mean	123.8	131.1		154.4	201.3		868.0	912.1	

Maize		Sorghum		Bajra	
Subabul spacing	= N.S.	Subabul spacing	= N.S.	Subabul spacing	=N.S.
Legume	= N.S.	CD(0.05)legume	= 18.8	Legume	=N.S.
Interaction	= N.S.	Interaction	= N.S.	Interaction	=N.S.

Table 33(b). Number of grains/ear of maize, sorghum and bajra (second year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	149.3	168.2	158.7	175.2	253.4	214.3	967.6	1133.2	1050.4
4 x 1 m	129.1	164.9	147.0	157.3	240.0	198.6	852.0	1027.7	939.8
Mean	139.2	166.5	-	166.2	246.7		909.8	1080.4	

Maize		Sorghum		Bajra	
Subabul spacing	= N.S.	Subabul spacing	= N.S.	CD (0.05) S. spacing	=89.0
CD (0.05) legume	= 27.1	CD (0.05) legume	= 57.6	CD (0.05) legume	=89.0
Interaction	= N.S.	Interaction	= N.S.	Interaction	= N.S.

N.S. = Not significant.

(5). Number of seeds/pod of legumes

The data on the number of seeds/pod of cowpea and blackgram are presented in Tables 34 (a) and 34 (b) and the analysis of variance in Appendix VII.

The effect of spacing of subabul on the number of seeds/pod of cowpea was significant during the second year only. Cowpeas intercropped between 3 m wide rows of subabul recorded more seeds/pod than those intercropped between 4 m wide rows.

The effect of cereals in influencing the seeds per pod of cowpea and blackgram was significant during the first and the second year, respectively. The effect of sorghum was more prominent in increasing the seeds/pod of cowpea during the first year and that of blackgram during the second year. When intercropped along with bajra the number of seeds per pod of legumes was found lesser during both the years. Interaction effect of subabul spacing x cereal was significant on seeds/pod of blackgram during both the years and that of cowpea during the first year only.

(6). Weight of thousand grains

The data on the weight of thousand grains of maize,

Table 34(a). Number of seeds/pod of cowpea and blackgram (first year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	12.8	13.3	11.4	12.5	4.9	5.4	4.6	4.9
4 x 1 m	12.4	13.2	10.8	12.1	4.7	5.3	4.2	4.7
Mean	12.6	13.2	11.1		4.8	5.3	4.4	

Subabul spacing = N.S.
CD (0.05) cereal = 1.24
CD (0.05) S. spacing x cereal interaction = 1.76

Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Table 34(b). Number of seeds/pod of cowpea and blackgram (second year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	13.5	14.4	13.0	13.6	4.8	6.6	4.6	5.3
4 x 1 m	11.8	12.6	12.5	12.3	4.7	5.3	4.6	4.9
Mean	12.6	13.5	12.7		4.7	5.9	4.6	

CD (0.05) subabul spacing = 0.80
CD (0.05) cereal = N.S.
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
CD (0.05) cereal = 0.54
CD(0.05) S. spacing x cereal = 0.77

N.S. Not significant.

sorghum, bajra, cowpea and blackgram are furnished in Tables 35 (a), 35 (b), 36 (a) and 36 (b) and the analysis of variance in Appendices VI and VII.

(a). Cereals.

Plant density of subabul showed no significant effect on the thousand grain weight of cereals during both the years. Howevar a marginal increase in thousand grain weight was recorded by interplanting them in 3 m wide rows of subabul.

Intercropping of legumes had no significant effect on the thousand grain weight of maize or bajra during both the years. But thousand grain weight of sorghum was significantly increased by intercropping of blackgram during both the years. Interaction effects on thousand grain weight were also not significant.

(b). Legumes.

Spacing of subabul did not significantly influence the thousand seed weight of legumes in both the years. However a marginal increase in seed weight was noticed when legumes were intercropped between 3 m wide rows of subabul.

Table 35(a). Thousand grain weight (g) of maize, sorghum and bajra (first year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	193.1	195.3	194.2	27.1	28.3	27.7	4.9	5.0	4.9
4 x 1 m	191.5	195.1	193.3	26.4	28.4	27.4	4.8	4.8	4.8
Mean	192.3	195.2		26.7	28.3		4.8	4.9	

Subabul spacing = N.S.
Legume = N.S.
Interaction = N.S.

Subabul spacing = N.S.
CD (0.05) legume = 1.05
Interaction = N.S.

Subabul spacing = N.S.
Legume = N.S.
Interaction = N.S.

Table 35(b). Thousand grain weight (g) of maize, sorghum and bajra (second year).

	Maize			Sorghum			Bajra		
	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean	Cowpea	Blackgram	Mean
3 x 1 m	199.2	200.7	199.9	28.1	29.5	28.8	4.7	5.1	4.9
4 x 1 m	196.7	201.3	199.0	27.8	29.7	28.7	4.4	4.6	4.5
Mean	197.9	201.0		27.9	29.6		4.5	4.8	

Subabul spacing = N.S.
Legume = N.S.
Interaction = N.S.

Subabul spacing = N.S.
CD (0.05) legume = 1.09
Interaction = N.S.

Subabul spacing = N.S.
Legume = N.S.
Interaction = N.S.

N.S. = Not significant.

Table 36(a). Thousand seed weight (g) of cowpea and blackgram (first year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	88.7	89.3	87.2	88.4	35.6	35.9	34.3	35.3
4 x 1 m	87.8	88.7	86.0	87.5	35.3	35.3	34.5	35.3
Mean	88.2	89.0	86.6		35.4	35.6	34.4	

Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Table 36(b). Thousand seed weight (g) of cowpea and blackgram (second year).

	Cowpea				Blackgram			
	Maize	Sorghum	Bajra	Mean	Maize	Sorghum	Bajra	Mean
3 x 1 m	88.0	90.0	87.0	88.5	36.6	37.9	35.3	36.6
4 x 1 m	85.4	84.9	85.1	85.1	35.9	37.8	34.9	36.2
Mean	86.7	87.4	86.0		36.2	37.8	35.1	

Subabul spacing = N.S.
Cereal = N.S.
S. spacing x cereal interaction = N.S.

Subabul spacing = N.S.
CD (0.05) cereal = 1.1
S. spacing x cereal interaction = N.S.

N.S. = Not significant.

The effect of cereals on the thousand seed weight of cowpea was not significant in any of the year. Seed weight of blackgram was significantly influenced due to cereals during both the years. Thousand seed weights of legumes were more when intercropped with sorghum, though the effect was significant only in the blackgram during the second year. Bajra showed a depressing effect on the weight of seeds in all the cases. The interaction effects were not significant on this character.

(7). Dry matter yield

The data on dry matter yield of cereals, legumes and their total yield at the 30th, 60th day and at the harvest stages are presented in Tables 37 (a), 37 (b), 38 (a), 38 (b), 39 (a), 39 (b), 40 (a), 40 (b), 41 (a), 41 (b), 42 (a), 42 (b), 43 (a), 43 (b), 44 (a), 44 (b) 45 (a), 45 (b) and 48 (c) and the respective analysis of variance in Appendics VIII, IX, X and XI.

(a). Cereal.

The effect of spacing of subabul on the dry matter yield of cereals was significant at all the stages of growth. Pooled analysis of data at harvest stage also

Table 37(a). Dry matter yield (kg/plot) of cereal at 30th day (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.37	2.62	2.25	1.88	3.35	2.49	Cowpea	2.20	1.35	2.93
4 x 1 m	1.96	2.38	2.15	1.31	3.04	2.17	Blackgram	2.21	1.84	3.46
Mean	2.16	2.50	2.20	1.59	3.19			2.20	1.59	3.19

CD (0.05) subabul spacing, legume = 0.14
CD (0.05) cereal = 0.17
S. spacing x legume interaction = N.S.

CD (0.05) S. spacing x cereal, = 0.24
SD (0.05) legume x cereal interaction
CD (0.05) S. spacing x legume x cereal interaction = 0.35

Table 37(b). Dry matter yield (kg/plot) of cereal at 30th day (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.56	2.56	2.34	1.97	3.34	2.55	Cowpea	2.30	1.88	2.99
4 x 1 m	2.23	2.46	2.23	1.69	3.11	2.34	Blackgram	2.27	1.78	3.46
Mean	2.39	2.50	2.28	1.83	3.22			2.28	1.83	3.22

CD (0.05) subabul spacing = 0.12
Legume = N.S.
CD (0.05) cereal = 0.15
S. spacing x legume interaction = N.S.

CD (0.05) S. spacing x cereal, = N.S.
CD (0.05) legume x cereal interaction = 0.22
S. spacing x legume x cereal interaction = 0.32

N.S. = Not significant.

Table 38(a). Dry matter yield (kg/plot) of cereal at 60th day (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	3.98	4.54	3.25	3.94	5.58	4.26	Cowpea	2.94	3.86	4.97
4 x 1 m	3.87	3.74	2.86	3.59	4.96	3.80	Blackgram	3.17	3.67	5.58
Mean	3.92	4.14	3.05	3.76	5.27			3.05	3.76	5.27

CD (0.05) subabul spacing = 0.35
Legume = N.S.
CD (0.05) cereal = 0.42
S. spacing x legume interaction = N.S.

S. spacing x cereal, legume x cereal interaction = N.S.
CD (0.05) S. spacing x legume x cereal interaction = 0.85

Table 38(b). Dry matter yield (kg/plot) of cereal at 60th day (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	4.52	4.53	3.68	4.72	5.17	4.52	Cowpea	3.20	5.00	4.24
4 x 1 m	3.78	3.71	3.22	4.38	3.63	3.74		3.70	4.10	4.57
Mean	4.15	4.12	3.45	4.55	4.40			3.45	4.55	4.40

CD (0.05) subabul spacing = 0.26
Legume = N.S.
CD (0.05) cereal = 0.32
S. spacing x legume interaction = N.S.

CD (0.05) S. spacing x cereal, legume x cereal interaction = 0.45
CD (0.05) S. spacing x legume x cereal interaction = 0.64

N.S. = Not significant.

Table 39(a). Dry matter yield (kg/plot) of cereal at harvest (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	5.40 (2.70)	6.28 (3.14)	6.23 (3.11)	5.78 (2.89)	5.50 (2.75)	5.84 (2.92)
4 x 1 m	4.38 (2.19)	4.90 (2.45)	4.93 (2.46)	4.56 (2.28)	4.43 (2.21)	4.64 (2.32)
Mean	4.89 (2.44)	5.59 (2.79)	5.58 (2.79)	5.17 (2.58)	4.96 (2.48)	

	Maize	Sorghum	Bajra
Cowpea	5.07 (2.53)	4.92 (2.46)	4.68 (2.34)
Blackgram	6.09 (3.04)	5.42 (2.71)	5.25 (2.62)
Mean	5.58 (2.79)	5.17 (2.58)	4.96 (2.48)

CD (0.05) subabul spacing, legume = 0.43
Cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 39(b). Dry matter yield (kg/plot) of cereal at harvest (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	5.81 (2.90)	7.07 (3.53)	7.26 (3.63)	7.16 (3.58)	4.90 (2.45)	6.44 (3.22)
4 x 1 m	4.35 (2.17)	5.41 (2.70)	5.54 (2.77)	5.03 (2.51)	4.06 (2.03)	4.88 (2.44)
Mean	5.08 (2.54)	6.24 (3.12)	6.40 (3.20)	6.09 (3.04)	4.48 (2.24)	

	Maize	Sorghum	Bajra
Cowpea	5.40 (2.70)	5.78 (2.89)	4.05 (2.02)
Blackgram	7.40 (3.70)	6.41 (3.20)	4.91 (2.45)
Mean	6.40 (3.20)	6.09 (3.04)	4.48 (2.24)

CD (0.05) S. spacing, legume = 0.60
CD (0.05) cereal = 0.74
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha. N.S. = Not significant.

Table 40(a). Dry matter yield (kg/plot) of legume at 30th day (first year).

	Cowpea	Blackgram	Maize	Sorghumb	Bajra	Mean
3 x 1 m	0.81	0.62	0.67	0.83	0.65	0.71
4 x 1 m	0.76	0.62	0.66	0.76	0.65	0.69
Mean	0.78	0.62	0.66	0.79	0.65	

	Maize	Sorghum	Bajra
Cowpea	0.73	0.91	0.71
Blackgram	0.59	0.67	0.59
	0.66	0.79	0.65

Subabul spacing = N.S.
CD (0.05) legume = 0.04
CD (0.05) cereal = 0.05
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 40(b). Dry matter yield (kg/plot) of legume at 30th day (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	0.88	0.66	0.73	0.89	0.68	0.77
4 x 1 m	0.81	0.63	0.69	0.78	0.68	0.72
Mean	0.84	0.64	0.71	0.83	0.68	

	Maize	Sorghum	Bajra
Cowpea	0.80	0.97	0.76
Blackgram	0.63	0.70	0.60
	0.71	0.83	0.68

CD (0.05) S. spacing, legume = 0.04
CD (0.05) cereal = 0.05
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
C.D. (0.05) S. spacing x legume x cereal interaction = 0.16

N.S. = Not significant.

Table 41(a). Dry matter yield (kg/plot) of legume at 60th day (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	1.67	1.46	1.55	2.13	1.01	1.56	Cowpea	1.61	2.05	1.26
4 x 1 m	1.61	1.52	1.61	1.75	1.33	1.56	Blackgram	1.56	1.83	1.08
Mean	1.64	1.49	1.58	1.94	1.17			1.58	1.94	1.17

Subabul spacing, legume = N.S.
CD (0.05) cereal = 0.20
S. spacing x legume interaction = N.S.
CD (0.05) S. spacing x cereal = 0.29
Legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 41(b). Dry matter yield (kg/plot) of legume at 60th day (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.33	1.89	2.13	2.63	1.58	2.11	Cowpea	2.16	2.55	1.87
4 x 1 m	2.06	1.78	1.80	2.52	1.44	1.92	Blackgram	1.76	2.59	1.15
Mean	2.19	1.83	1.96	2.57	1.51			1.96	2.57	1.51

CD (0.05) S. spacing, legume = 0.12
CD (0.05) cereal = 0.15
S. spacing x legume interaction = N.S.
S. spacing x cereal interaction = N.S.
CD (0.05) legume x cereal interaction = 0.21
CD (0.05) S. spacing x legume x cereal, interaction = 0.30

N.S. = Not significant.

Table 42(a). Dry matter yield (kg/plot) of legume at harvest (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	1.75 (0.87)	1.43 (0.71)	1.58 (0.79)	2.08 (1.04)	1.10 (0.55)	1.59 (0.79)	Cowpea	1.58 (0.79)	2.04 (1.02)	1.35 (0.69)
4 x 1 m	1.57 (0.78)	1.56 (0.79)	1.56 (0.78)	1.94 (0.97	1.22 (0.61)	1.57 (0.78)	Blackgram	1.56 (0.78)	1.98 (0.99)	0.97 (0.48)
Mean	1.66 (0.83)	1.50 (0.75)	1.57 (0.78)	2.01 (1.00)	1.16 (0.58)			1.57 (0.78)	2.01 (1.00)	1.16 (0.78)

Subabul spacing, legume = N.S.
CD (0.05) cereal = 0.25
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 42(b). Dry matter yield (kg/plot) of legume at harvest (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.31 (1.15)	1.85 (0.92)	2.10 (1.05)	2.59 (1.29)	1.55 (0.77)	2.08 (1.04)	Cowpea	2.12 (1.06)	2.53 (1.26)	1.83 (0.91)
4 x 1 m	2.01 (1.00)	1.72 (0.86)	1.74 (0.87)	2.48 (1.24)	1.37 (0.68)	1.86 (0.93)	Blackgram	1.72 (0.86)	2.54 (1.27)	1.09 (0.54)
Mean	2.16 (1.08)	1.78 (0.89)	1.92 (0.96)	2.53 (1.26)	1.46 (0.73)			1.92 (0.96)	2.53 (1.26)	1.46 (0.73)

S. spacing, legume = N.S.
CD (0.05) cereal = 0.51
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha. N.S. = Not significant.

Table 43(a). Total yield (cereal + legume) of dry matter (kg/plot) at 30th day (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	3.18	3.24	2.91	2.71	4.02	3.21	Cowpea	2.92	2.27	3.66
4 x 1 m	2.72	2.98	2.82	2.08	3.68	2.85	Blackgram	2.80	2.51	4.04
Mean	2.95	3.12	2.86	2.39	3.85			2.86	2.39	3.85

CD (0.05) subabul spacing, legume = 0.15
CD (0.05) cereal = 0.19
S. spacing x legume interaction = N.S.

CD (0.05) S. spacing x cereal, legume x cereal =0.27
CD (0.05) S. spacing x cereal x legume interaction =0.44

Table 43(b). Total yield (cereal + legume) of dry matter (kg/plot) at 30th day (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	3.44	3.20	3.08	2.86	4.02	3.32	Cowpea	3.10	2.85	3.75
4 x 1 m	3.03	3.09	2.92	2.47	3.79	3.06	Blackgram	2.90	2.47	4.06
Mean	3.23	3.14	3.00	2.66	3.90			3.00	2.66	3.90

CD (0.05) subabul spacing, legume = 0.13
CD (0.05) cereal = 0.16
CD (0.05) S. spacing x legume interaction = 0.19

Subabul spacing x cereal = N.S.
CD (0.05) legume x cereal interaction = 0.23
CD (0.05) S. spacing x legume x cereal interaction = 0.33

N.S. = Not significant.

Table 44(a). Total yield (cereal + legume) of dry matter (kg/plot) at the 60th day (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	5.65	5.99	4.80	6.07	6.58	5.82	Cowpea	4.54	5.92	6.23
4 x 1 m	5.48	5.27	4.47	5.35	6.31	5.37	Blackgram	4.72	5.51	6.65
Mean	5.56	4.63	3.63	5.71	6.44			4.63	5.71	6.44

CD (0.05) subabul spacing = 0.40
Legume = N.S.
CD (0.05) cereal = 0.49
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 44(b). Total yield (cereal + legume) of dry matter (kg/plot) at the 60th day (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	8.91	8.36	7.55	9.57	8.73	8.64	Cowpea	6.97	9.84	7.95
4 x 1 m	7.59	7.15	6.52	8.98	6.60	7.37	Blackgram	7.10	8.71	7.44
Mean	8.25	7.75	7.03	9.27	7.69			7.03	9.27	7.69

CD (0.05) S. spacing, legume = 0.36
CD (0.05) cereal = 0.44
S. spacing x legume interaction = N.S.
CD (0.05) S. spacing x cereal, legume x cereal interaction = 0.63
CD (0.05) S. spacing x legume x cereal interaction = 0.89

N.S. = Not significant.

Table 45(a). Total yield (cereal + legume) of dry matter (kg/plot) at harvest (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	7.14 (3.57)	7.71 (3.85)	7.81 (3.90)	7.86 (3.93)	6.59 (3.29)	7.42 (3.71)	Cowpea	6.66 (3.33)	6.96 (3.48)	6.02 (3.01)
4 x 1 m	5.94 (2.97)	6.48 (3.24)	6.48 (3.24)	6.50 (3.25)	5.65 (2.82)	6.21 (3.10)	Blackgram	7.64 (3.82)	7.41 (3.70)	6.22 (3.11)
Mean	6.54 (3.27)	7.09 (3.54)	7.15 (3.57)	7.18 (3.59)	6.12 (3.06)			7.15 (3.57)	7.18 (3.59)	6.12 (3.06)

CD (0.05) subabul spacing, legume = 0.54
CD (0.05) cereal = 0.66
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 45(b). Total yield (cereal + legume) of dry matter (kg/plot) at harvest (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	8.11 (4.05)	8.91 (4.45)	9.35 (4.67)	9.74 (4.87)	6.43 (3.21)	8.51 (4.25)	Cowpea	7.50 (3.75)	8.31 (4.15)	5.85 (2.92)
4 x 1 m	6.34 (3.17	7.13 (3.56)	7.27 (3.63)	7.51 (3.75)	5.42 (2.71)	6.73 (3.36)	Blackgram	9.12 (4.56)	8.94 (4.47)	6.00 (3.00)
Mean	7.22 (3.61)	8.02 (4.01)	8.31 (4.16)	8.62 (4.31)	5.92 (2.96)			8.31 (4.16)	8.62 (4.31)	5.92 (2.96)

CD (0.05) subabul spacing, legume = 0.68
CD (0.05) cereal = 0.77
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha, N.S. = Not significant.

showed significant effect on this character. Intercropping of cereals in 3 x 1 m spacing of subabul recorded significantly higher yield than intercropping in 4 x 1 m spacing.

The effect of intercropping legumes on the dry matter yield of cereals was significant at the 30th day during the first year only. At the 30th day cereals intercropped with blackgram recorded more yield than those intercropped with cowpea. At the 60th day, intercropping of legumes showed no significant effect on the dry matter yield of cereals. At the harvest stage, intercropping with blackgram had significant effect on it. Dry matter yield of cereals intercropped with blackgram was higher than with cowpea, during both the years.

There was significant difference on the dry matter yield of cereals at the 30th and 60th day after sowing during both the years. At the 30th day, bajra recorded the highest yield followed by maize and sorghum. Bajra maintained this trend on to the 60th day as well during the first year. But during the second year, sorghum recorded more dry matter production, which was on par with bajra and both were superior to maize. At the harvest stage, the difference between cereals on dry matter yield was significant only in the second year. Dry matter yields of maize and sorghum were on par but superior to bajra. The interaction effect of spacing of subabul and cereal was significant at the 30th day during the first year and at the 60th day, during the second year, respectively. The interaction effect of legume x cereal was significant at the 30th day on both the years, while at the 60th day the effect was significant during the second year only. The interaction of spacing x legume x cereals was significant at the 30th day during the first year and at 60th day during both the years. The dry matter yield at the harvest stage was significantly higher during the second year and the interaction effect cereal x year was significant on this character.

(b). Legume.

Spacing of subabul showed significant effect on the dry matter yield of legumes at the 30th and 60th day after sowing during the second year only. Legumes interplanted in 3 x 1 m spacing of subabul recorded significantly higher dry matter yield than those intercropped in 4 x 1 m spacing at these stages. Though not significant, tho same trend was noticed at other stages also.

Significant difference was noticed in the dry matter yield of legumes at the 30th day during both the years. Cowpea recorded higher dry matter yield than blackgram. Except in the first year at the 60th day, the same trend was noticed till harvest.

The effect of cereals on dry matter yield of legumes was significant at all stages of growth during both the years. Sorghum was significantly higher than bajra and maize in increasing the dry matter yield of legumes at the 30th and 60th day after planting. At the harvest stage, analysis of the pooled data also indicated the same trend. Legumes grown along with bajra always recorded the lowest dry matter yield. The dry matter yield of legumes was significantly higher during the second year, at the harvest stage. Interaction effects were not significant and sorghum + cowpea combination recorded the highest dry matter yield at harvest.

(c). Total yield of dry matter (cereal + legume).

The effect of spacing of subabul on total yield of dry matter was significant at all the stages of growth. Pooled analysis of data at the harvest stage also showed the same trend. Intercropping of annual crops in 3 x 1 m spacing of subabul was significantly superior to intercropping in 4 x 1 m spacing in increasing the total yield of dry matter in all the cases. An increase of 23 per cent in dry matter yield was realized by intercropping in 3 x 1 m spacing of subabul over 4 x 1 m spacing.

The effect of legumes on the total yield of dry matter was not consistent. At the 30th day blackgram recorded significantly more yield than cowpea during the first year while cowpea out yielded blackgram in the second year, though it was not significant. At the 60th day in the second year, the effect of cowpea was significantly higher than that of blackgram. But at the harvest stage, the influence of blackgram was significantly higher than cowpea in both the years.

There was significant difference on the total yield of dry matter due to the effect of cereals. At the 30th and 60th day in the first year, bajra recorded the highest yield followed by maize and sorghum. The same trend was noticed in the second year also at the 30th day.

But at the 60^{th} day in the second year, the yield of sorghum was higher than that of maize and bajra.

The combination maize + blackgram recorded higher total dry matter at harvest, though it was not significant. Dry matter yield recorded during the second year was significantly higher at the harvest stage than that during the first year.

(8). Grain yield

The data on mean grain yields of cereals, legumes and their total yield are presented in Table 46 (a), 46 (b), 47 (a), 47 (b), 48 (a), 48 (b) and 48 (c), and the respective analysis of variance in appendices VIII, IX, X. and XI.

(a). Cereals.

Subabul spacing recorded significant difference on the yield of intercropped cereals during both the years. Intercropping of cereals under 3 x 1 m spacing of subabul recorded significantly higher yield than intercropping under 4 x 1 m spacing.

Intercropped legumes showed significant effect on the grain yield of cereals. The effect of intercropping

Table 46(a). Grain yield (kg/plot) of cereal (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	1.74 (0.87)	1.90 (0.95)	2.13 (1.06)	1.35 (0.67)	1.99 (0.99)	1.82 (0.91)
4 x 1 m	1.32 (0.66)	1.73 (0.86)	1.90 (0.95)	1.34 (0.67)	1.32 (0.66)	1.52 (0.76)
Mean	1.53 (0.76)	1.81 (0.90)	2.01 (1.00)	1.34 (0.67)	1.65 (0.82)	

	Maize	Sorghum	Bajra
Cowpea	1.77 (0.88)	1.29 (0.64)	1.52 (0.76)
Blackgram	2.26 (1.13)	1.39 (0.69)	1.79 (0.89)
Mean	2.01 (1.00)	1.34 (0.67)	1.65 (0.82)

CD (0.05) subabul spacing, legume = 0.26
CD (0.05) cereal = 0.32
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 46(b). Grain yield (kg/plot) of cereal (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	2.20 (1.10)	2.49 (1.24)	3.10 (1.55)	1.95 (0.97)	1.98 (0.99)	2.34 (1.17)
4 x 1 m	1.47 (0.73)	2.24 (1.12)	2.21 (1.10)	1.87 (0.93)	1.49 (0.74)	1.85 (0.92)
Mean	1.83 (0.91)	2.36 (1.18)	2.65 (1.32)	1.91 (0.95)	1.73 (0.86)	

	Maize	Sorghum	Bajra
Cowpea	2.22 (1.11)	1.73 (0.86)	1.55 (0.77)
Blackgram	3.08 (1.54)	2.09 (1.04)	1.91 (0.95)
Mean	2.65 (1.32)	1.91 (0.95)	1.73 (0.86)

CD (0.05) subabul spacing, legume = 0.36
CD (0.05) cereal = 0.44
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within the parenthesis indicate yield in t/ha. N.S. = Not significant.

Table 47(a). Grain yield (kg/plot) of legume (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	0.61 (0.30)	0.59 (0.29)	0.56 (0.27)	0.80 (0.40)	0.45 (0.22)	0.60 (0.30)	Cowpea	0.56 (0.28)	0.71 (0.35)	0.47 (0.23)
4 x 1 m	0.55 (0.27)	0.56 (0.28)	0.56 (0.28)	0.65 (0.32)	0.45 (0.22)	0.55 (0.27)	Blackgram	0.56 (0.28)	0.73 (0.36)	0.43 (0.21)
Mean	0.58 (0.29)	0.57 (0.28)	0.56 (0.28)	0.72 (0.36)	0.45 (0.22)			0.56 (0.28)	0.72 (0.36)	0.45 (0.22)

Subabul spacing, legume = N.S.
CD (0.05) cereal = 0.07
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 47(b). Grain yield (kgplot) of legume (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	0.56 (0.28)	0.52 (0.26)	0.44 (0.22)	0.84 (0.42)	0.33 (0.16)	0.54 (0.27)	Cowpea	0.44 (0.22)	0.69 (0.34)	0.32 (0.16)
4 x 1 m	0.41 (0.20	0.43 (0.21)	0.43 (0.21)	0.54 (0.27)	0.29 (0.14)	0.42 (0.21)	Blackgram	0.43 (0.22)	0.68 (0.34)	0.30 (0.15)
Mean	0.48 (0.24)	0.47 (0.23)	0.43 (0.21)	0.69 (0.34)	0.31 (0.15)			0.43 (0.21)	0.69 (0.34)	0.31 (0.15)

CD (0.05) subabul spacing = 0.10
Legume = N.S.
CD (0.05) cereal = 0.12
S. spacing x legume interaction = N.S.
CD (0.05) S. spacing x cereal = 0.18
Legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha, N.S. = Not significant.

Table 48(a). Total yield (cereal + legume) of grain (kg/plot), (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.35 (1.17)	2.49 (1.24)	2.68 (1.34)	2.15 (1.07)	2.44 (1.22)	2.42 (1.21)	Cowpea	2.24 (1.12)	2.00 (1.00)	1.99 (0.99)
4 x 1 m	1.81 (0.90)	2.29 (1.14)	2.37 (1.18)	1.99 (0.99)	1.78 (0.89)	2.05 (1.02)	Blackgram	2.81 (1.40)	2.13 (1.06)	2.23 (1.11)
Mean	2.08 (1.04)	2.39 (1.19)	2.52 (1.26)	2.06 (1.03)	2.11 (1.05)			2.52 (1.26)	2.06 (1.03)	2.11 (1.05)

CD (0.05) subabul spacing, legume = 0.26
CD (0.05) cereal = 0.31
S. spacing x legume interaction = N.S.
Subabul spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 48(b). Total yield (cereal + legume) of grain (kg/plot), (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	3.75 (1.87)	3.01 (1.50)	3.52 (1.76)	2.79 (1.39)	2.31 (1.15)	2.88 (1.44)	Cowpea	2.66 (1.33)	2.41 (1.75)	1.87 0.93
4 x 1 m	1.88 (0.94)	2.66 (1.33)	2.64 (1.32)	2.40 (1.20)	1.78 (0.89)	2.27 (1.13)	Blackgram	3.51 (1.75)	2.77 (1.38)	2.21 (1.10)
Mean	2.31 (1.15)	2.83 (1.41)	3.08 (1.54)	2.59 (1.29)	2.04 (1.02)			3.08 (1.54)	2.59 (1.29)	2.04 (1.02)

CD (0.05) subabul spacing, legume = 0.33
CD (0.05) cereal = 0.41
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha, N.S. = Not significant.

Table 48(c). Mean table for pooled data of dry matter and grain yield of cereal, legume and their total (kg/plot) at harvest.

	Dry matter yield			Grain yield		
	Cereal	Legume	Total	Cereal	Legume	Total
Spacing						
3 x 1 m	6.14	1.83	7.97	2.08	0.57	2.65
4 x 1 m	4.76	1.72	6.48	1.69	0.48	2.17
CD (0.05)	0.36	N.S.	0.40	0.21	0.04	0.20
Legume						
Cowpea	4.98	1.91	6.89	1.68	0.53	2.21
Blackgram	5.91	1.65	7.56	2.09	0.52	2.61
CD (0.05)	0.36	0.22	0.40	0.21	N.S.	0.20
Cereal						
Maize	5.99	1.75	7.34	2.33	0.50	2.83
Sorghum	5.63	2.28	7.91	1.63	0.71	2.34
Bajra	4.72	1.31	6.03	1.70	0.38	2.08
CD (0.05)	0.44	0.27	0.49	0.26	0.05	0.25
Season/year						
I year	5.24	1.58	6.82	1.67	0.58	2.25
II year	5.66	1.97	7.63	2.10	0.49	2.59
CD (0.05)	0.36	0.22	0.40	0.21	0.04	0.20

N.S. = Not significant.

blackgram in increasing the yield of cereals was significantly more than that of cowpea during both the years. The combination of maize + blackgram recorded the highest yield of cereals than the other combinations, though it was not significant.

There was significant difference in the grain yield among cereals during both the years. Maize recorded significantly higher grain yield than sorghum and bajra, and the latter two were on par. Sorghum recorded the lowest yield during the first year but out yielded bajra during the second year. Grain yield of cereals was significantly higher in the second year as compared to the first year. None of the interaction effects was significant.

(b). Legumes.

Interplanting of legumes under 3 x 1 spacing of subabul recorded higher yield of legumes than under 4 x 1 m spacing. This effect was more prominent during the second year.

There was no significant difference in the grain yield of different legumes. However, grain yield of cowpea was slightly more than that of blackgram. Significant difference in the yield of legumes was noted due to the effect of cereals during both the years. Among the cereals, the effect of sorghum was significantly better than maize and bajra in increasing the yield of intercropped legumes. Grain yield of legumes was consistently depressed by intercropping with bajra. The combination sorghum + blackgram or cowpea recorded higher yield though the difference was not significant. Significantly higher grain yield was recorded during the second year. The interaction effects of spacing of subabul x cereals and spacing of subabul x cereal x legume were significant on the grain yield of legumes during both the years.

(c). Total yield of grain (cereals + legumes).

Spacing of subabul showed significant effect on the total yield of grain during both the years. Pooled analysis of data also indicated significant effect of spacing on the total yield of grain. Intercropping cereals and legumes under 3 x 1 m spacing of subabul recorded higher total yield than intercropping under 4 x 1 m spacing.

Legume intercrops showed significant effect on the total yield during both the years. During both the years, the effect of blackgram was significantly higher than that of cowpea.

The effect of cereals on the total grain yield was significant. Maize recorded the highest total yield and it was superior to sorghum and bajra during both the years. Sorghum registered the lowest yield during the first year but out yielded bajra during the second year. The combination maize + blackgram recorded the highest yield than the other combinations though it was not significant. Total yield of grain recorded during the second year was significantly higher than that of the first year. None of the interaction effect was significant.

(9). Total biomass yield of the system.

The data on the total biomass yield of the system (dry matter yield of annual crops during the first and second year at harvest + the total biomass yield of subabul during the same period) are presented in Table 49 and the analysis of variance in Appendix XVI.

Subabul spacing showed significant effect on the total biomass yield of the system. Spacing of 3 x 1 m recorded significantly higher biomass (11.63 t/ha) than

Table 49. Total biomass yield (kg/plot) of the system (first and second year annual crops + subabul).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	22.39 (11.19)	24.16 (12.08)	24.23 (12.11)	24.50 (12.25)	21.08 (10.54)	23.27 (11.63)	Cowpea	20.55 (10.27)	20.34 (10.17)	19.04 (9.52)
4 x 1 m	17.57 (8.78)	20.36 (10.18)	19.47 (9.73)	19.05 (9.52)	18.39 (9.19)	18.97 (9.48)	Blackgram	23.16 (11.58)	23.20 (11.60)	20.43 (10.21)
Mean	19.98 (9.99)	22.26 (11.13)	21.85 (10.92)	21.77 (10.88)	19.73 (9.86)			21.85 (10.92)	21.77 (10.88)	19.73 (9.86)

CD (0.05) subabul spacing, legume = 1.72

Cereal = N.S.

S. spacing x legume interaction = N.S.

S. spacing x cereal and legume x cereal interaction = N.S.

S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha. N.S. = Not significant.

the spacing of 4 x 1 m (9.48 t/ha) ie., an increase of 23 per cent in biomass production was recorded under 3 x 1 m spacing over 4 x 1 m spacing.

Intercropping of legumes showed significant effect on the biomass yield. Among the two legumes, the effect of blackgram was superior to cowpea in increasing the biomass yield. Intercropping of cereals had no influence on biomass yield. The combination of sorghum/maize + blackgram recorded higher yield than other combinations, though the difference was not significant.

C. Uptake Studies

(1). Uptake of nitrogen

The data on the uptake of nitrogen by cereals and legumes and their total uptake at the harvest stage are presented in Tables 50 (a), 50 (b), 51 (a), 51 (b), 52 (a), and 52 (b), and their respective analysis of variance in Appendices XII, XIII and XIV.

(a). Cereals.

The effect of spacing of subabul on nitrogen uptake by cereals was significant during both the years. Nitrogen uptake by cereals planted under 3 x 1 m spacing of subabul was significantly higher than under 4 x 1 m

Table 50(a). Uptake of nitrogen (kg/ha) by cereal at harvest (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	32.24	36.88	34.09	35.61	33.97	34.56	Cowpea	27.58	33.52	27.04
4 x 1 m	26.53	29.18	27.70	29.93	25.93	27.35	Blackgram	34.20	32.02	32.86
Mean	29.38	33.03	30.89	32.77	29.95			30.89	32.77	29.95

CD (0.05) subabul spacing, legume = 3.27
Cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 50(b). Uptake of nitrogen (kg/ha) by cereal at harvest (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	37.96	44.17	44.95	47.22	31.02	41.06	Cowpea	32.25	42.29	23.84
4 x 1 m	27.63	36.16	33.50	38.23	23.95	31.89	Blackgram	46.19	43.16	31.13
Mean	32.79	40.16	39.22	42.72	27.48			39.22	42.72	27.48

CD (0.05) subabul spacing, legume = 4.26
CD (0.05) cereal = 5.52
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

Table 51(a). Uptake of nitrogen (kg/ha) at harvest by legume (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	23.12	24.45	21.79	34.02	15.54	23.78	Cowpea	21.01	26.38	18.40
4 x 1 m	20.74	24.07	21.33	26.41	19.49	22.41	Blackgram	22.11	34.05	16.63
Mean	21.93	24.26	21.56	30.21	17.51			21.56	30.21	17.51

Subabul spacing, legume = N.S.
CD (0.05) cereal = 5.04
S. spacing x legume interaction = N.S.
S. spacing x cereal. legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 51(b). Uptake of nitrogen (kg/ha) at harvest by legume (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	30.29	25.96	25.67	37.07	21.63	28.12	Cowpea	25.34	31.84	25.83
4 x 1 m	25.05	23.86	22.89	32.00	18.47	24.45	Blackgram	23.22	37.23	14.28
Mean	27.67	24.91	24.28	34.53	20.05			24.28	34.53	20.05

Subabul spacing, legume = N.S.
CD (0.05) cereal = 6.46
S. spacing x legume interaction = N.S.
S. spacing x cereal interaction = N.S.
Legume x cereal interaction = 9.13
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

Table 52(a). Total uptake (legume + cereal) of nitrogen (kg/ha) at harvest (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	55.35	61.34	55.88	69.64	49.51	58.35
4 x 1 m	47.27	53.25	49.03	56.33	45.42	50.26
Mean	51.31	57.29	52.45	62.98	47.46	

	Maize	Sorghum	Bajra
Cowpea	48.59	59.90	45.44
Blackgram	56.32	66.07	49.48
	52.45	62.98	47.46

CD (0.05) subabul spacing, legume = 5.39
CD (0.05) cereal = 6.60
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 52(b). Total uptake (legume + cereal) of nitrogen (kg/ha) at harvest (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	68.26	70.12	70.61	84.30	52.65	69.19
4 x 1 m	52.68	60.02	56.39	70.24	42.43	56.35
Mean	60.47	65.07	63.50	77.27	47.54	

	Maize	Sorghum	Bajra
Cowpea	57.60	74.14	49.67
Blackgram	69.41	80.40	45.41
	63.50	77.27	47.54

CD (0.05) subabul spacing, legume = 5.35
CD (0.05) cereal = 6.55
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

spacing.

The effect of legumes on the uptake of nitrogen by cereals was significant. Cereals grown with blackgram recorded higher uptake than those grown with cowpea during both the years. Interaction effects were not significant. Maize + blackgram combination registered the highest uptake during both the years, though it was not significant. During the second year a higher rate of uptake was noticed.

(b). Legumes.

Intercropping legumes under 3 x 1 m spacing of subabul did not show any significant increase in the uptake of nitrogen by legumes during both the years. Significant difference was not observed in the uptake of nitrogen among legumes, though blackgram and cowpea recorded higher uptake in the first and second years respectively.

Cereals showed significant effect on the uptake of nitrogen by legumes during both the years. The uptake of nitrogen by legumes was more due to the effect of sorghum than due to maize and bajra during both the years. Legumes intercropped with bajra recorded the lowest uptake, though it was on par with those intercropped with maize. The interaction effects of cereals x legumes was significant on nitrogen uptake, during the second year only. The combination sorghum + blackgram recorded the highest uptake and it was on par with sorghum + cowpea combination during the second year. Though not significant, similar trend was observed during the first year also. Bajra + blackgram combination recorded the lowest uptake of nitrogen by legumes during both the years.

(c). Total uptake of nitrogen (cereals + legumes).

There was significant difference in the total uptake of nitrogen by cereals and legumes due to spacing of subabul. Crops planted under 3 x 1 m spacing of subabul registered significantly higher uptake than those planted under 4 x 1 m spacing during both the years. Legumes showed significant influence on the uptake during the first year only. The effect of blackgram in influencing the uptake was higher than that of cowpea during the first year and this trend was maintained during the second year also.

Cereals showed significant influence on the total nitrogen uptake during both the years. Sorghum recorded the highest uptake and it was superior to maize and bajra.

Bajra showed the lowest uptake during both the years and was on par with maize during the first year only. The combination sorghum + blackgram showed consistent higher uptake than other combinations, though it was not significant.

(2). Uptake of phosphorus

The data on the uptake of phosphorus by cereals, legumes and their total at the harvest stage are presented in Tables 53 (a), 53 (b), 54 (a), 54 (b), 55 (a) and 55 (b), and their respective analysis of variance in Appendices XII, XIII and XIV.

(a). Cereals.

The effect of spacing of subabul on the uptake of phosphorus by cereals was significant. Cereals intercropped under 3 x 1 m spacing of subabul recorded significantly higher uptake than those intercropped under 4 x 1 m spacing during both the years.

The intercropped legumes showed significant influence on the uptake of phosphorus. Intercropping blackgram was more effective than intercropping cowpea with cereals in enhancing the uptake during both the years.

Significant difference was noticed in the uptake

Table 53(a). Uptake of phosphorus (kg/ha) at harvest by cereal (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	7.15	8.47	6.11	5.97	11.34	7.82	Cowpea	4.95	5.28	8.97
4 x 1 m	5.65	6.86	4.88	5.12	8.74	6.25	Blackgram	6.04	5.81	11.12
Mean	6.40	7.66	5.49	5.54	10.04			5.49	5.54	10.04

CD (0.05) subabul spacing, legume = 0.93
CD (0.05) cereal = 1.14
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 53(b). Uptake of phosphorus (kg/ha) at harvest by cereal (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	8.55	9.83	7.64	8.31	11.62	9.19	Cowpea	5.54	6.82	9.25
4 x 1 m	5.84	7.88	5.56	6.01	9.02	6.86	Blackgram	7.66	7.51	11.39
Mean	7.19	8.85	6.60	7.16	10.31			6.60	7.16	10.32

CD (0.05) subabul spacing, legume = 0.75
CD (0.05) cereal = 0.92
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

Table 54(a). Uptake of phosphorus (kg/ha) at harvest by legume (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.67	2.05	2.44	2.96	1.68	2.36	Cowpea	2.38	3.03	1.94
4 x 1 m	2.23	1.83	2.07	2.42	1.59	2.03	Blackgram	2.12	2.36	1.33
Mean	2.45	1.94	2.25	2.69	1.63			2.25	2.69	1.63

CD (0.05) subabul spacing, legume =0.32
CD (0.05) cereal =0.39
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 54 (b). Uptake of phosphorus (kg/ha) at harvest by legume (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	3.02	2.16	2.36	3.47	1.95	2.59	Cowpea	2.54	3.41	2.31
4 x 1 m	2.48	1.76	2.00	2.63	1.73	2.12	Blackgram	1.82	2.69	1.37
Mean	2.75	1.96	2.18	3.05	1.84			2.18	3.05	1.84

Subabul spacing = N.S.
CD (0.05) legume = 0.54
CD (0.05) cereal = 0.67
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

Table 55(a). Total uptake (legume + cereal) of phosphorus (kg/ha) at harvest (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	9.79	10.51	8.48	8.94	13.02	10.15	Cowpea	7.26	8.31	10.91
4 x 1 m	7.88	8.68	6.95	7.54	10.34	8.28	Blackgram	8.16	8.18	12.45
Mean	8.83	9.59	7.71	8.24	11.68			7.71	8.24	11.68

CD (0.05) subabul spacing = 1.04
Legume = N.S.
CD (0.05) cereal means = 1.28
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 55(b). Total uptake (legume + cereal) of phosphorus (kg/ha) at harvest (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	12.19	11.88	9.99	12.69	13.40	12.03	Cowpea	8.07	11.14	11.57
4 x 1 m	8.34	9.64	7.56	8.65	10.76	8.99	Blackgram	9.48	10.20	12.59
Mean	10.26	10.76	8.77	10.67	12.08			8.77	10.67	12.08

CD (0.05) subabul spacing = 1.03
Legume = N.S.
CD (0.05) cereal = 1.26
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

of phosphorus among cereals during both the years. Bajra recorded significantly higher uptake than maize and sorghum and the latter two were on par. Maize registered the lowest uptake in all the cases. 'Bajra + blackgram' combination showed the highest uptake of phosphorus by cereals, though it was not significant. Uptake tended to be higher during the second year.

(b). Legumes.

Significant difference in the uptake of phosphorus by legumes was noticed due to spacing of subabul during the first year only. Legumes interplanted between 3 m wide rows of subabul showed higher uptake than those interplanted between 4 m wide rows of subabul and the effect was not significant during the second year.

There was marked difference among legumes on the uptake of phosphorus. The uptake was significantly higher by cowpea than by blackgram during both the years. Cereals exerted significant influence on phosphorus uptake by legumes during both the years. Sorghum favoured increased uptake and was superior to maize and bajra during the second year and to bajra only during the first year. Interaction effects were not significant on phosphorus uptake.

(c). Total uptake of phosphorus (cereals + legumes).

The effect of subabul spacing on the total uptake of phosphorus was significant during both the years. Intercropping cereals and legumes in between 3 m wide rows of subabul resulted in significantly higher uptake than intercropping between 4 m wide rows.

There was no significant effect on the total uptake of phosphorus due to legumes. Cereals had significant influence on the uptake during both the years. Bajra registered the highest uptake and was superior to maize and sorghum. The lowest uptake was recorded with maize, which was superior to sorghum during the second year only.

None of the interaction effects was significant. However, 'bajra + blackgram' combination recorded consistently more uptake during both the years.

(3). <u>Uptake of potassium</u>

Tables 56 (a), 56 (b), 57 (a), 57 (b), 58 (a) and 58 (b) show the data on the uptake of potassium by cereals, legumes and their total uptake, and the respective analysis of variance are presented in Appendices XII, XIII and XIV.

Table 56(a). Uptake of potassium (kg/ha) at harvest by cereal (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	26.66	31.65	21.91	21.97	43.57	29.15	Cowpea	17.84	17.69	37.31
4 x 1 m	21.90	22.95	16.91	15.99	34.37	22.42	Blackgram	20.98	20.28	40.64
Mean	24.28	27.30	19.41	18.98	38.97			19.41	18.98	38.97

CD (0.05) subabul spacing, legume = 2.17
CD (0.05) cereal = 2.65
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 56 (b). Uptake of potassium (kg/ha) at harvest by cereal (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	28.79	33.57	24.71	27.08	41.76	31.18	Cowpea	18.26	20.21	34.92
4 x 1 m	20.13	22.79	18.87	16.57	28.94	21.46	Blackgram	25.33	23.44	35.78
Mean	24.46	28.18	21.79	21.82	35.35			21.79	21.82	35.35

CD (0.05) subabul spacing = 4.42
Legume = N.S.
CD (0.05) cereal = 5.41
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

Table 57(a). Uptake of potassium (kg/ha) at harvest by legume (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	10.74	5.19	7.70	10.63	5.56	7.96	Cowpea	9.55	12.94	8.43
4 x 1 m	9.87	5.26	7.31	9.23	6.15	7.56	Blackgram	5.46	6.92	3.28
Mean	10.30	5.22	7.50	9.93	5.85			7.50	9.93	5.85

Subabul spacing = N.S.
CD (0.05) legume = 1.30
CD (0.05) cereal = 1.59
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 57(b). Uptake of potassium (kg/ha) at harvest by legume (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	13.93	6.61	10.32	12.70	7.80	10.27	Cowpea	12.54	15.10	10.50
4 x 1 m	11.49	5.03	7.98	10.58	6.22	8.26	Blackgram	5.76	8.18	3.52
Mean	12.71	5.82	9.15	11.64	7.01			9.15	11.64	7.01

Subabul spacing = N.S.
CD (0.05) legume = 2.08
CD (0.05) cereal = 2.55
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

Table 58(a). Total uptake (legume + cereal) of potassium (kg/ha) at harvest (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	37.39	36.85	29.62	32.60	49.13	37.12	Cowpea	27.29	30.62	45.75
4 x 1 m	31.71	28.22	24.12	25.22	40.55	29.96	Blackgram	26.45	27.20	43.93
Mean	34.55	32.53	26.87	28.91	44.84			25.87	28.91	44.84

CD (0.05) subabul spacing = 2.94
Legume = N.S.
CD (0.05) cereal = 3.61
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 58(b). Total uptake (legume + cereal) of potassium (kg/ha) at harvest (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	42.72	40.21	35.02	39.81	49.56	41.46	Cowpea	30.78	35.31	45.43
4 x 1 m	31.63	27.92	26.84	27.31	35.17	29.77	Blackgram	31.08	31.82	39.29
Mean	37.17	34.06	30.93	33.56	42.36			30.93	33.56	42.36

CD (0.05) subabul spacing = 4.45
Legume = N.S.
CD (0.05) cereal = 5.45
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

(a). Cereals.

Spacing of subabul showed significant influence on the uptake of potassium by cereals during both the years. Cereals planted in between 3 m wide rows of subabul recorded significantly higher uptake than those planted between 4 m wide rows.

Intercropped legumes showed significant influence on the uptake of potassium during the first year only. Intercropping of blackgram increased the uptake of potassium by cereals than cowpea, though the effect was not significant during the second year.

Marked difference was observed in potassium uptake among cereals during both the years. Bajra recorded the highest uptake and was superior to maize and sorghum and the latter two were on par during both years. The combination 'bajra + blackgram' resulted in the highest uptake though it was not significant.

(b). Legumes.

The effect of spacing of subabul was not significant on the uptake of potassium by legumes in both the years. Uptake tended to be higher when legumes were intercropped under closely spaced subabul than under widely spaced ones.

Significant difference was recorded in potassium uptake among legumes. Cowpea recorded the highest uptake which was superior to blackgram during both the years.

The effect of cereals on the uptake of potassium by intercropped legumes was significant. The effect of sorghum in increasing the uptake of potassium by legumes was superior to maize and bajra during the first year and to bajra only during the second year. None of the interaction effects was significant on it.

(c). Total uptake of potassium.

The effect of spacing of subabul was significant on total uptake of potassium by annual crops during both the years. Intercropping cereals and legumes in between 3 m wide rows of subabul recorded higher total uptake than intercropping between 4 m wide rows. The effect of legumes was not significant on the total uptake during both the years. There was significant difference in the total uptake of potassium due to cereals. Among cereals bajra recorded highest uptake during both the years. None of the interaction effects was significant

D. Quality Aspects

(1). Crude protein yield.

The data on crude protein yield of cereals, legumes and their total at harvest and the total of the system (crude protein of the first and the second year annual crops + crude protein from subabul fodder during the same period) are presented in Tables 59 (a), 59 (b), 60 (a), 60 (b), 61 (a), 61 (b), and 62, and the respective analysis of variance in Appendices XV and XVI.

(a). Cereals.

Intercropping cereals in between 3 m wide rows of subabul recorded significantly higher yield of crude protein than intercropping in between 4 m wide rows during both the years.

Legume intercrops recorded significant difference on crude protein yield. Growing blackgram in association with cereals resulted in higher yield than growing cowpea, during both the years. There was no significant difference in crude protein yield among cereals during the first year. During the second year, sorghum recorded the highest yield and was superior to maize and bajra while the latter two were on par.

The interaction effect of legumes x cereals was significant on crude protein yield during the first year only. The combination 'maize + blackgram' recorded the highest yield and was on par with sorghum + cowpea,

Table 59 (a). Crude protein yield (g/plot) of cereal (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	391.99 (0.19)	461.05 (0.23)	409.73 (0.20)	445.22 (0.22)	424.62 (0.21)	426.52 (0.21)	Cowpea	327.43 (0.16)	419.04 (0.21)	338.04 (0.17)
4 x 1 m	331.02 (0.16)	364.71 (0.18)	345.44 (0.17)	374.08 (0.19)	324.08 (0.16)	347.86 (0.17)	Blackgram	427.74 (0.21)	400.25 (0.20)	410.66 (0.20)
Mean	361.50 (0.18)	412.88 (0.21)	377.58 (0.18)	409.65 (0.20)	374.35 (0.18)			377.58 (0.18)	409.65 (0.20)	374.35 (0.18)

CD (0.05) subabul spacing, legume = 38.69
Cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal interaction = N.S.
Legume x cereal interaction =67.00
S. spacing x legume x cereal interaction = N.S.

Table 59 (b). Crude protein yield (g/plot) of cereal (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	474.52 (0.24)	552.59 (0.28)	562.66 (0.28)	590.29 (0.29)	387.73 (0.19)	513.56 (0.26)	Cowpea	403.16 (0.20)	528.72 (0.26)	298.05 (0.15)
4 x 1 m	345.43 (0.17)	452.00 (0.23)	418.75 (0.21)	477.91 (0.24)	299.48 (0.15)	398.71 (0.20)	Blackgram	578.25 (0.29)	539.49 (0.27)	389.16 (0.19)
Mean	409.47 (0.20)	502.29 (0.25)	490.70 (0.24)	534.10 (0.26)	343.05 (0.17)			490.70 (0.24)	534.10 (0.26)	343.05 (0.17)

CD (0.05) subabul spacing, legume = 53.82
CD (0.05) cereal = 65.92
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha. N.S. = Not significant.

Table 60 (a). Crude protein yield (g/plot) of legume (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	289.00 (0.14)	305.67 (0.15)	272.41 (0.14)	425.33 (0.21)	194.25 (0.09)	297.33 (0.14)	Cowpea	262.58 (0.13)	329.82 (0.16)	229.99 (0.11)
4 x 1 m	259.26 (0.13)	300.91 (0.15)	266.56 (0.13)	330.07 (0.16)	243.63 (0.12)	280.08 (0.14)	Blackgram	276.40 (0.14)	425.59 (0.21)	207.89 (0.10)
Mean	274.13 (0.13)	303.29 (0.15)	269.49 (0.13)	377.70 (0.18	218.94 (0.11)			269.49 (0.13)	377.70 (0.18)	218.94 (0.11)

Subabul spacing, legume = N.S.
CD (0.05) cereal = 63.05
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 60 (b). Crude protein yield (g/plot) of legume (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	378.61 (0.19)	324.55 (0.16)	320.84 (0.16)	463.44 (0.23)	270.43 (0.13)	351.57 (0.17)	Cowpea	253.16 (0.13)	397.97 (0.20)	322.84 (0.16)
4 x 1 m	270.71 (0.13)	284.40 (0.14)	222.55 (0.11)	400.02 (0.20)	210.09 (0.10)	277.55 (0.14)	Blackgram	290.23 (0.14)	465.50 (0.23)	157.69 (0.08)
Mean	324.66 (0.16)	304.47 (0.15)	271.69 (0.13)	431.73 (0.21)	240.26 (0.12)			271.69 (0.13)	431.73 (0.21)	240.26 (0.12)

CD (0.05) subabul spacing = 64.22
Legume = N.S.
CD (0.05) cereal = 78.65
S. spacing x legume interaction = N.S.
S. spacing x cereal = N.S.
CD (0.05) legume x cereal = 111.23
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha, N.S. = Not significant.

Table 61(a). Total yield (g/plot) of crude protein (legume + cereal) (first year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	692.28 (0.35)	766.74 (0.38)	698.60 (0.35)	871.07 (0.43)	618.87 (0.31)	729.51 (0.36)
4 x 1 m	604.78 (0.30)	665.63 (0.33)	633.72 (0.30)	704.18 (0.35)	567.71 (0.28)	635.20 (0.32)
Mean	648.53 (0.32)	716.18 (0.36)	666.16 (0.33)	787.63 (0.39)	593.29 (0.29)	

	Maize	Sorghum	Bajra
Cowpea	628.19 (0.31)	749.38 (0.37)	568.03 (0.28)
Blackgram	704.13 (0.35)	825.88 (0.41)	618.55 (0.31)
Mean	666.16 (0.33)	787.63 (0.39)	593.29 (0.29)

CD (0.05) subabul spacing = 69.95
Legume = N.S.
CD (0.05) cereal = 85.67
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 61(b). Total yield (g/plot) of crude protein (legume + cereal) (second year).

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean
3 x 1 m	853.16 (0.43)	919.00 (0.46)	882.70 (0.44)	1050.70 (0.52)	724.80 (0.36)	886.03 (0.44)
4 x 1 m	658.50 (0.33)	747.30 (0.37)	704.90 (0.35)	873.40 (0.44)	530.40 (0.26)	702.90 (0.35)
Mean	755.83 (0.38)	833.15 (0.41)	793.80 (0.39)	962.05 (0.48)	627.60 (0.31)	

	Maize	Sorghum	Bajra
Cowpea	720.00 (0.36)	926.70 (0.46)	620.80 (0.31)
Blackgram	867.60 (0.43)	997.40 (0.50)	634.40 (0.32)
Mean	793.80 (0.39)	962.05 (0.48)	627.60 (0.31)

CD (0.05) subabul spacing = 85.08
Legume = N.S.
CD (0.05) cereal =104.20
S. spacing x legume interaction = N.S.
S. spacing x cereal, legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha. N.S. = Not significant.

Table 62. Total yield of crude protein (kg/plot) of the system.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	2.24 (1.12)	2.48 (1.24)	2.32 (1.16)	2.70 (1.35)	2.06 (1.03)	2.36 (1.18)	Cowpea	2.05 (1.02)	2.25 (1.13)	1.80 (0.90)
4 x 1 m	1.84 (0.92)	2.08 (1.04)	2.01 (1.00)	2.09 (1.04)	1.77 (0.88)	1.96 (0.98)	Blackgram	2.28 (1.14)	2.53 (1.26)	2.04 (1.02)
Mean	2.04 (1.02)	2.28 (1.14)	2.16 (1.08)	2.39 (1.19)	1.92 (0.96)			2.16 (1.08)	2.39 (1.19)	1.92 (0.96)

CD (0.05) subabul spacing, legume = 0.171
CD (0.05) cereal = 0.210
S. spacing x legume interaction = N.S.
S. spacing x cereal and legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Figures within parenthesis indicate yield in t/ha.

N.S. = Not significant.

bajra + blackgram and sorghum + blackgram, but superior to the other two combinations. Similar trends were observed during the second year also.

(b). Legumes.

Crude protein yield of legumes intercropped between 3 m wide rows of subabul was significantly higher than that of legumes intercropped between 4 m wide rows during the second year only.

Cereals grown with legumes recorded highly significant influence on crude protein yield of legumes. The effect of sorghum was superior in enhancing the yield than maize and bajra which were on par during both the years. The interaction effect of cereals x legumes was significant on crude protein yield during the second year. only. The combination 'sorghum + blackgram' recorded the maximum yield which was on par with 'sorghum + cowpea' combination.

(c). Total yield of crude protein (cereals + legumes).

Planting cereals and legumes in between 3 m wide rows of subabul was superior to planting in between 4 m wide rows in increasing the total yield of crude protein, during both the years. There was no significant effect of legumes on the total protein yield. Cereals showed significant influence on it during both the years. Sorghum recorded the maximum crude protein yield which was superior to bajra, but on par with maize. Interaction effects were not significant. The combination, 'sorghum + blackgram' recorded the maximum yield of crude protein though it was not significant.

(d). Total yield of crude protein from the system.

Total yield of crude protein from the system was higher when annual crops were planted in between 3 m wide rows of subabul as compared to planting in 4 m wide rows.

Annual legumes and cereals grown along with subabul significantly influenced total yield of crude protein of the system. Higher yield was obtained with black gram than with cowpea. Among the cereals sorghum registered highest yield and was superior to maize and bajra, and bajra recorded the lowest yield. Interaction effects were not significant and the combination 'sorghum + blackgram' recorded the maximum yield of crude protein of the system.

E. Soil Fertility Studies

(1). <u>Total nitrogen content of soil.</u>

The data on total nitrogen content of soil after the experiment is furnished in Tab 63 and the analysis of variance in Appendix XVI.

There was significant difference in the total nitrogen content of the soil due to spacing of subabul. The nitrogen content of soil was significantly higher when subabul was planted at 3 x 1 m spacing. The effect of intercropping legumes and cereals was also significant on nitrogen content of soil. Intercropping of blackgram as well as bajra resulted in the higher nitrogen content of the soil. The influence of maize and sorghum was on par. The combination 'bajra + blackgram' registered the maximum nitrogen content though not significant.

(2). Available phosphorus content of soil.

Table 64 shows the data on available phosphorus content of soil after the experiment and the analysis of variance is presented in Appendix XVI.

Subabul spacing showed significant difference in the available phosphorus content of the soil. Planting subabul at 3 x 1 m spacing resulted in higher available phosphorus content in soil than planting at 4 x 1 m spacing. The effect of legumes was significant on

Table 63. Total nitrogen content of soil (kg/ha) after the experiment.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	1644.44	1777.78	1733.33	1566.62	1833.33	1711.11	Cowpea	1566.67	1433.33	1733.33
4 x 1 m	1511.11	1688.89	1500.00	1533.33	1766.67	1600.00	Black gram	1666.66	1666.67	1866.67
Mean	1577.77	1733.33	1616.66	1550.00	1800.00			1616.66	1550.00	1800.00

CD (0.05) subabul spacing, legume = 84.81
CD (0.05) cereal =103.87
S. spacing x legume interaction = N.S.
S. spacing x cereal and legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

Table 64. Available phosphorus content of soil (kg/ha) after the experiment.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	42.10	42.58	42.49	42.34	42.20	42.34	Cowpea	41.62	41.68	40.95
4 x 1 m	40.73	41.72	41.02	41.36	41.31	41.33	Blackgram	41.88	42.02	42.55
Mean	41.41	42.15	41.75	41.85	41.75			41.75	41.85	41.75

CD (0.05) subabul spacing, legume = 0.698
Cereal = N.S.
S. spacing x legume interaction = N.S.
S. spacing x cereal and legume x cereal interaction = N.S.
S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

phosphorus content of the soil. Blackgram significantly increased the available phosphorus content of the soil than cowpea. There was no significant difference in the soil phosphorus content due to the effect of cereals. Interaction effects were also not significant.

(3). <u>Available potassium content of soil</u>

The data on available potassium content of soil after the experiment is furnished in Table 65 and the analysis of variance in Appendix XVI.

There was no marked difference in the available potassium content of the soil due to spacing of subabul. Intercropping of legumes showed significant difference on available K content of the soil. Potassium content was more due to intercropping with blackgram than with cowpea. Cereals also showed significant influence on K content in the soil. Maize recorded the highest K content of the soil and was superior to sorghum and bajra. Interaction effects were not significant. The combination maize + blackgram recorded the highest available K content of soil, though it was not significant.

Table 65. Available potassium content of soil (kg/ha) after the experiment.

	Cowpea	Blackgram	Maize	Sorghum	Bajra	Mean		Maize	Sorghum	Bajra
3 x 1 m	36.07	36.76	38.80	36.20	34.25	36.41	Cowpea	37.80	35.86	33.75
4 x 1 m	35.53	36.75	38.30	36.20	33.92	36.14	Blackgram	39.30	36.55	34.41
Mean	35.80	36.75	38.55	36.20	34.08			38.55	36.00	34.08

Subabul spacing = N.S.

CD (0.05) legume = 0.821

CD (0.05) cereal = 1.005

Subabul spacing x legume interaction = N.S.

S. spacing x cereal, legume x cereal interaction = N.S.

S. spacing x legume x cereal interaction = N.S.

N.S. = Not significant.

F. Economics

The economics of production of grain, fodder and fire wood by different combinations of cereals and legumes under varying plant spacing of subabul are given in Table 66.

It is seen from the table that all the combinations of cereals and legumes grown in between 3 x 1 m spacing of subabul recorded higher profit than the corresponding ones grown in 4 x 1 m spacing. The highest net profit was recorded by maize + blackgram combination under 3 x 1 m spacing of subabul, where the net profit was Rs.5447.28/ha over a period of 20 months. This was followed by the same combination under 4 x 1 m spacing of subabul (Rs.4895.68/ha over the same period).

Table 66. Economics of agroforestry system involving food and fodder crops.

Treatments	Cost of production (over two seasons) (Rs.)	Total grain yield (t/ha)	Value of grain (Rs.)	Green fodder of subabul (t/ha)	Value of green fodder (Rs.)	Fire wood (t/ha)	Value of fire wood (Rs.)	Total income (Rs.)	Net profit (Rs.)
1	2	3	4	5	6	7	8	9	10
Maize + cowpea under 3 x 1 m spacing of subabul	5496.22	2.41 (0.45)	6025.00 (1350.00)	6.28	1256.00	2.15	892.20	9523.20	4026.98
Surghum + cowpea under 3 x 1 m spacing of subabul	5013.37	1.57 (0.86)	2826.00 (2580.00)	7.16	1432.00	1.77	734.50	7572.50	2559.13
Bajra + cowpea under 3 x 1 m spacing of subabul	5070.60	1.94 (0.43)	4326.20 (1290.00)	5.37	1074.00	2.38	987.70	7677.90	2607.30
Maize + blackgram under 3 x 1 m spacing of subabul	5502.22	2.81 (0.54)	7025.00 (2052.00)	6.25	1250.00	1.50	622.50	10949.50	5447.28

Figures within parenthesis indicate grain yield and value of legumes.

Table 66. Contd.

1	2	3	4	5	6	7	8	9	10
Sorghum + blackgram under e x 1 m spacing of subabul	5019.37	1.72 (0.77)	3096.00 (2926.00)	6.76	1352.00	1.92	796.80	8170.80	3151.43
Bajra + blackgram under 3 x 1 m spacing of subabul	5084.41	2.04 (0.35)	4549.20 (1330.00)	6.64	1328.00	2.30	954.50	8161.70	3076.29
Maize + cowpea under 4 x 1 m spacing of subabul	5496.22	1.59 (0.54)	3975.00 (1620.00)	4.39	878.00	1.33	551.95	7024.95	1529.73
Sorghum + cowpea under 4 x 1 m spacing of subabul	5013.37	1.45 (0.53)	2610.00 (1590.00)	3.20	640.00	1.06	439.90	5279.90	266.53

Figures within parenthesis indicate grain yield and value of legumes.

Table 66. Contd.

1	2	3	4	5	6	7	8	9	10
Bajra + cowpea under 4 x 1 m spacing of subabul	5070.60	1.15 (0.37)	2564.50 (1110.00)	5.01	1002.00	2.06	854.90	5531.40	460.80
Maize + blackgram under 4 x 1 m spacing of subabul	5502.22	2.75 (0.45)	6875.00 (1710.00)	5.62	1124.00	1.66	688.90	10397.90	4895.68
Sorghum + blackgram under 4 x 1 m spacing of subabul	5019.37	1.76 (0.65)	3168.00 (2470.00)	5.22	1044.00	1.66	688.90	7370.90	2351.53
Bajra + blackgram under 4 x 1 m spacing of subabul	5084.41	1.65 (0.38)	3679.50 (1444.00)	5.78	1156.00	2.25	933.75	7213.25	2128.84

Figures within parenthesis indicate grain yield and value of legumes.

DISCUSSION

DISCUSSION

The present investigation was undertaken to find out the biomass production of an agroforestry system and also to select the most suitable combination of food crops like cereals and legumes that can be grown under different plant densities of subabul (*Leucaena leucocephala* (Lam.) de Wit) which is used as a green manure cum fodder plant. The data collected on various growth characters, yield components, yield and quality aspects of all the crops in the system were analysed statistically and the results of the experiment are discussed below.

I. Subabul

A. Growth Characters and Yield

(1). Height of trees.

The results in Table 3 revealed that plant density had no significant effect on the height of trees. However, trees planted at 4 x 1 m spacing were found to be taller than those planted at 3 x 1 m spacing. In the case of widely spaced plants, competition for crop growth resources is minimum (Van Den Beldt, 1982). This low level of competition at 4 x 1 m spacing in the present study might have resulted in marginal increase in the height of trees. Similar findings were also reported by Dutt (1981), Relwani et al.(1983), and Visuttipitakul et al.(1983).

Intercropping of cereals and legumes with subabul did not influence the height of trees. This may be attributed partly to the difference in morphology and growth habits of annual crops grown in the present study and woody species like subabul as reported by Mishra and Prasad (1980) in the case of groundnut, soybean and sesamum on the growth of *Tectonia grandis* and *Dalbergia sisso*.

(2) Diameter at breast height.

The results presented in Table 4, revealed that plant density of subabul had no appreciable influence on the DBH of trees. However, there was marginal increase in DBH at wider spacing over closer spacing. This might be due to the lesser competition between plants for growth resources at wider spacing. Van Den Beldt and Brewbaker (1980) and Dutt (1981) also reported non significant increase in DBH of subabul trees of similar ages grown at wider spacing.

(3). Leaf-stem ratio.

The results shown in Table 5 revealed that plant density had profound influence on the leaf-stem ratio of fodder. Trees planted at wider spacing of 4 x 1 m recorded significantly higher ratio than those planted at closer spacing of 3 x 1 m. This may be attributed to the less number of branches or stems produced at wider spacing as compared to those at closer spacing. This result is in agreement with the findings of Guevarra et al.(1978) and Pathak et al.(1980), wherein they found that the leaf-stem ratio decreased with increasing plant densities.

The significant interaction between spacing of subabul x cereal and between spacing of subabul x cereal x legumes may be due to the differential growth of cereals under different plant densities of subabul on account of different quantities of prunings incorporated in to these treatments.

(4). Green fodder yield.

The results presented in Table 6 revealed that green fodder yield was significantly influenced by spacing of subabul. Trees planted at 3 x 1 m spacing produced significantly higher green fodder yield than those planted at 4 x 1 m spacing. Savory (1979) observed a negative correlation between the plant density and the number of branches per plant as well as the forage yield per branch, but at high plant densities the losses in forage yield from individual plants were upset by the increased number of plants and the total yield increased with increase in plant density. Thus, the higher yield at 3 x 1 m spacing realized in the present investigation, may be attributed to the more number of branches and high plant population as compared to those at 4 x 1 m spacing. Similar findings of increased green fodder yield at high plant densities have been reported by Anon.(1978), Castillo et al.(1979), Ferraris (1979) and Prasad et al.(1983).

(5). Dry fodder yield.

The results given in Table 7 indicated that the effect of subabul spacing on dry fodder yield was significant. The yield from trees planted at 3 x 1 m spacing was significantly higher than from those planted at 4 x 1 m spacing. Melendez and Rivena (1981) observed that forage dry matter production in subabul was inversely proportional to the leaf-stem ratio, the lower

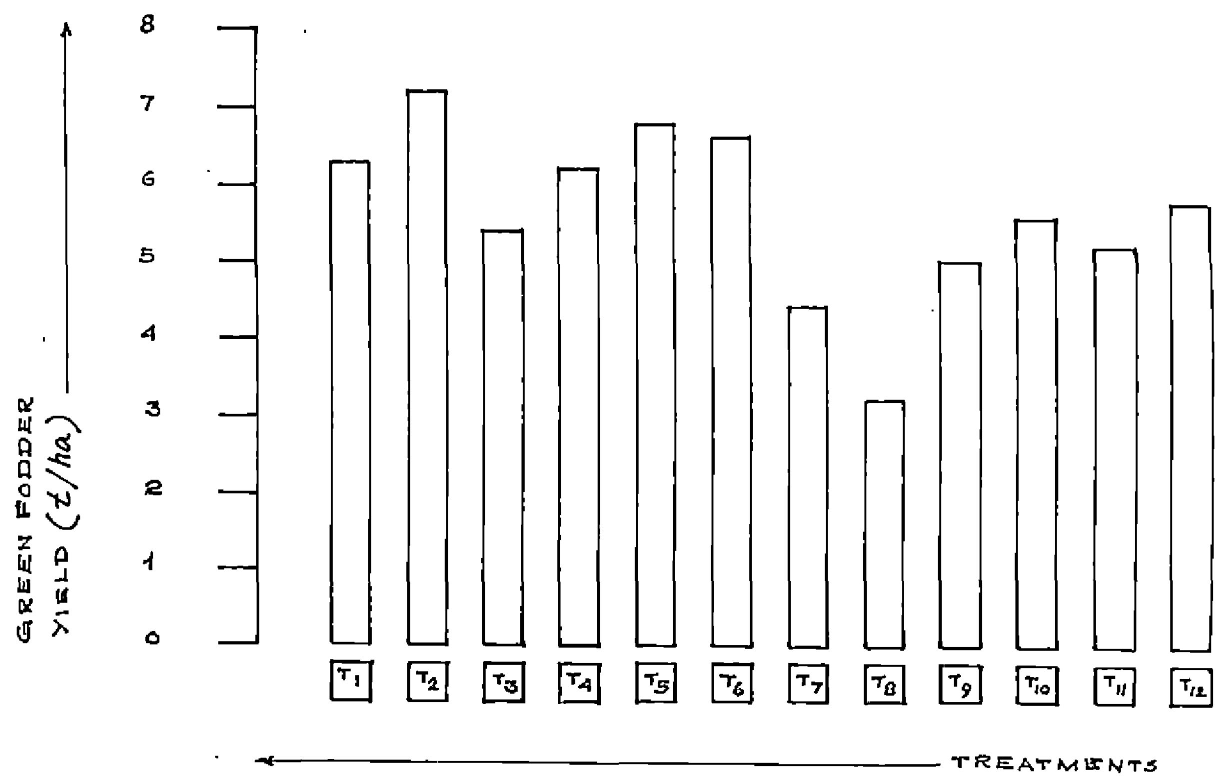

FIG. 3 TOTAL GREEN FODDER YIELD OF SUBABUL

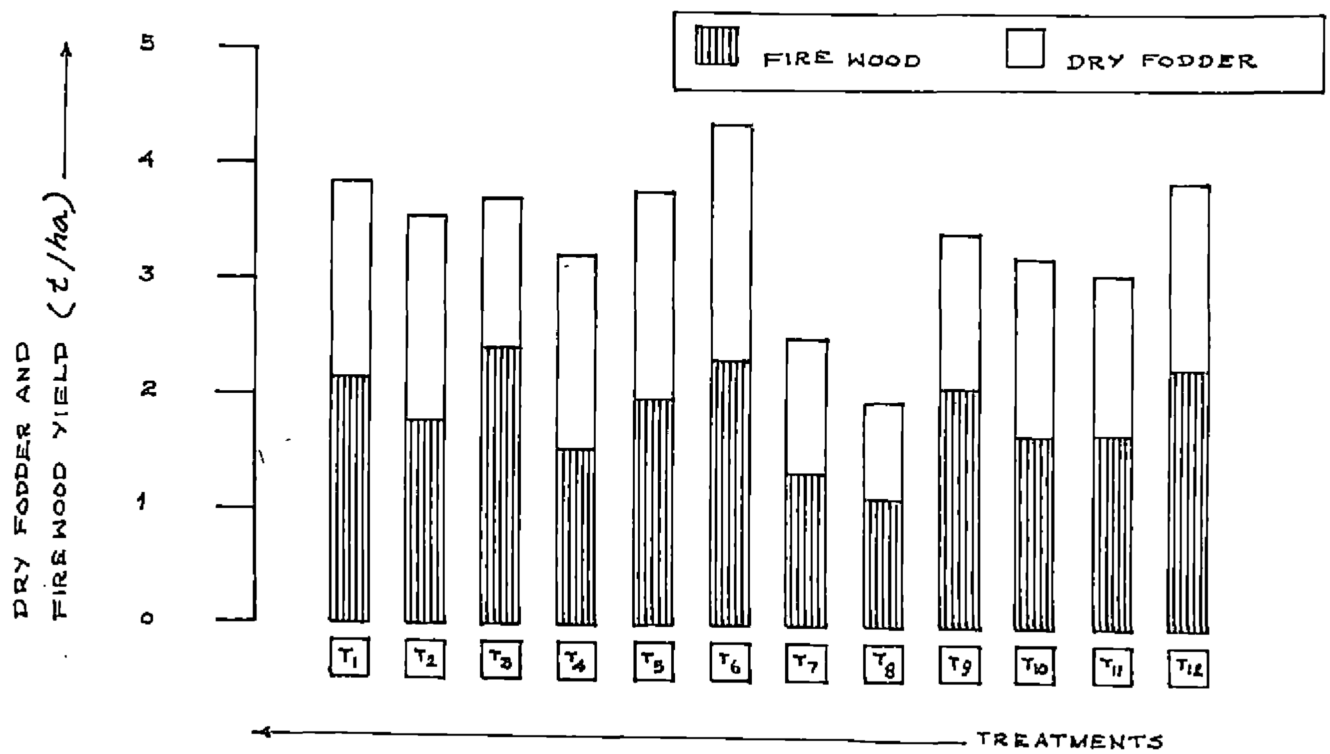

FIG. 4 TOTAL DRY FODDER AND FIREWOOD YIELD OF SUBABUL

ratio being associated with higher dry matter yield. The leaf-stem ratio at 3 x 1 m spacing in the present investigation, was significantly lower than that at 4 x 1 m spacing, which might have resulted in higher dry fodder yield at closer spacing than at wider spacing. Moreover, the green fodder yield was higher (Table, 6) at closer spacing and hence the dry fodder yield also showed the same trend. Increased dry fodder yield at closer spacing have been reported by Guevarra et al. (1978), Pathak et al. (1980), Melendez and Rivena (1981), Ghatnekar et al. (1983) and Torris (1983).

Interplanting of bajra and black gram showed non significant increase in dry fodder yield over other combinations, which may be attributed to the mutual beneficial effect of these species with subabul.

(6). Firewood yield.

The results shown in Table 8, revealed that fire wood yield from subabul was not markedly influenced by spacing or by intercropping of cereals and legumes or by their interaction effects. The marginal increase in diameter at breast height and height of trees at wider spacing (4 x 1 m) might have negated the effect of high plant population at closer spacing (3 x 1 m) in significantly influencing the firewood yield. This might have resulted in the non significant increase in firewood yield at closer spacing than at wider spacing. This observation is in agreement with the findings of Hu et al.(1980) and Relwani et al (1983).

The marginal increase in firewood yield due to the effect of bajra + blackgram combination over other combinations may be attributed to the mutual beneficial effect between these species and subabul.

(7). Total above ground biomass production.

The results furnished in Table 9 pointed out that there was no significant increase in total biomass production at closer (3 x 1 m) spacing over wider (4 x 1 m) spacing. Although dry fodder yield was significantly higher at closer spacing, the same trend was not obtained in the case of total biomass yield which may be attributed to the non significant effect of plant densities on firewood yield (Table,8). The result of the present investigation showing an increasing trend of biomass production at closer spacing is supported by the findings of Lahiri (1983) and Visuttipitakul et al.(1983) in subabul.

B. Quality Aspects

(1). Nitrogen content of subabul stems.

The results in Table 10 revealed that there was significant difference in nitrogen content of stems of subabul trees planted at different spacings. High nitrogen content of stems was recorded from trees grown at 4 x 1 m spacing as compared to those grown at 3 x 1 m spacing. Dry fodder yield recorded at closer spacing was significantly higher than that recorded at wider spacing. The reason for the low nitrogen content of stems at closer spacing may be mainly due to the 'dilution' effect. Ferraris (1979) mentioned an inverse relationship of dry matter yield with nitrogen content suggesting a dilution effect at higher levels of dry matter production in subabul.

(2). Nitrogen content of subabul leaves.

The results presented in Table 11 revealed that plant density had significant influence on nitrogen content of leaves. Nitrogen content of leaves was high in trees grown at 4 x 1 m spacing than those grown at 3 x 1 m spacing. This might be on account of higher yields of dry matter obtained at closer spacing in the present study, which resulted in the dilution of nitrogen as suggested by Ferraris (1979).

(3). Crude protein content of leaves and stems.

The results presented in Tables 12 and 13 showed that significant difference in protein content of leaves and stems was observed among trees planted at different spacings. Trees planted at wider spacing recorded more crude protein content in leaves and stems than those planted at closer spacing. Ferraris (1979) mentioned that there was a negative correlation between the yield and quality characteristics like protein content in subabul fodder. Due to increased production of dry fodder, protein content might have been reduced considerably at closer spacing than at wider spacing. Similar results of high crude protein content of leaves and stems at low plant density have been reported from IGFRI by Pathak et al. (1980) in subabul.

(4). Phosphorus content of subabul stems.

The results shown in Table 14 revealed that there was significant difference in phosphorus content of stems of trees planted at different spacings. Phosphorus content of stem was significantly higher in trees planted at wider spacing than in trees planted at closer spacing.

The dry fodder yield under wider spacing was lower than under closer spacing. This might have resulted in high stem phosphorus content at wider spacings. At closer spacing, stem phosphorus might have been mobilized and utilized for the production of more leaves and stems, resulting in lower phosphorus content in stems. Similar finding of increased phosphorus content of stems at wider spacing was reported by Pathak et al. (1980).

Phosphorus content of subabul stem was high when blackgram was intercropped with subabul. This may be due to the complementary effect of blackgram and subabul on phosphorus uptake. It can be noted from Tables 54 (a) and 54 (b) that the uptake of phosphorus by blackgram was lower than that of cowpea, which might have resulted in a higher quantity of left over phosphorus in the soil for the subabul to consume. The significant interaction between plant density of subabul x legumes, plant density x cereals and cereals x legumes may be attributed to the differential growth patterns of these crops at different spacings of subabul brought about by different quantities of prunings incorporated into these treatments, especially during the early period of growth.

Interplanting of 'maize + blackgram' with subabul resulted in the highest phosphorus content in stem, which may be due to the complementary effect of these food and fodder crops used.

(5). Phosphorus content of subabul leaves.

The results given in Table 15 showed that there was significant difference in phosphorus content of leaves in trees grown at different spacings. Trees grown at closer spacing recorded significantly higher phosphorus content than those grown at wider spacing. Similar findings of increased phosphorus content in leaves at closer spacing have been reported by Pathak et al. (1980). Intercropping of blackgram resulted in higher content of leaf phosphorus than intercropping of cowpea, which may be due to the complementary effect of these species. The increase in phosphorus content in leaves of subabul trees due to the inter cropping of 'maize + black gram' combination though not statistically significant, may be due to the mutual beneficial effect of these species in utilizing the available phosphorus in the soil.

(6). Potassium content of subabul stems.

The results presented on Table 16 revealed significant difference in potassium content of stems in trees planted at different spacings. Potassium content of stem was higher in trees planted at closer spacing. At closer spacing, the competition between plants is more as reported by Van Den Beldt (1982). Due to this competition the plant roots might have extended deeper, exploiting greater depths of soil which in turn might have resulted in increased uptake and content of potassium in stems of closely spaced trees. Besides, the increased photosynthetic activity at closer spacing for producing more dry matter might have stimulated increased uptake of potassium, because the stimulation of stomatal opening is generally accompanied by stimulation of potassium uptake (Humble and Hsiao, 1980). The above finding holds good in the present study also.

Intercropping of bajra and blackgram together with subabul resulted in the highest potassium content in stems of subabul and it was on par with maize + cowpea combination. This may be on account of the complementary effects of these species.

(7). Potassium content of subabul leaves.

The results shown in Table 17 revealed that there was no significant increase in potassium content in leaves of trees planted at closer spacing, as compared to those planted at wider spacing. The significant interaction between cereals and spacing of subabul manifested that maize and sorghum favoured increase in potassium content of leaves, while bajra showed a negative effect on it at closer spacing.

(8). Crude protein yield from subabul fodder.

The results in Table 18 showed that total yield of crude protein from subabul fodder did not vary significantly due to spacings. However, crude protein yield tended to be higher among trees planted at closer spacing. Although the total dry fodder yield was higher at closer spacing (Table 7), significant difference in crude protein yield was not obtained due to the negative correlation between dry matter yield and crude protein content as suggested by Ferraris (1979). This might have resulted in slight increase in crude protein yield at closer spacing as compared to wider spacing. Similar results have been reported by Guevarra et al. (1978) in subabul.

II Annual Crops

A. Growth Characters

(1). <u>Height of plants.</u>

(a). Cereals.

It could be seen from Tables 19 (a), 19 (b), 20 (a), 20 (b), 21 (a) and 21 (b) that spacing of subabul showed significant influence on the height of interplanted cereals at the 30th day. Cereals grown in between 3 m wide rows of subabul recorded more height than those grown between 4 m wide rows at the 30th day during both the years. Significant increase in the height of plants was maintained upto the 60th day in the case of sorghum during both the years. In the case of maize, the same trend was noticed till harvest during the second crop season only. In general, there was increase in plant height in the case of all cereals planted in between 3 m wide rows of subabul. It could be seen that at high plant densities (close spacing) of subabul, the quantities of prunings incorporated into the soil were more and the plant height being a character dependent on nutrition might have been influenced by increased application of prunings. The increased application of prunings might have encouraged the root growth in cereals resulting in higher rate of nutrient absorption which is manifested in increased height of plants. Increase in plant growth due to the application of subabul prunings was reported by Siagian and Mabbayad (1980).

(b). Legumes.

Raising legumes in between 3 m wide rows of subabul recorded significant increase (Tables 22 (a), 22 (b), 23 (a), and 23 (b)) in plant height of legumes at the 30th day during the first year only. Cowpea plants maintained this increase in height on to the harvest stage. During the second year also, similar trend was noticed though not significant. At the early stage, legumes might have utilized the nitrogen from the prunings thus showing the response at the 30th day. At the later stages, nitrogen fixed by legumes might have been sufficient for their growth and hence the effects were minimal at the later stages of growth.

The effect of cereals on the height of intercropped legumes was not consistent. At the 30th day blackgram grown with sorghum recorded more height, which may be attributed to the slow growth of sorghum at the early stage. At the 60th day and after that also maize and sorghum had positive effect on this character due mainly to the less competitive effect of these species. It would be seen that nodulation was better due to the effect of sorghum and maize (Tables 24 (a), 24 (b)) which might have resulted in increased height at the later stage of growth. Plant height of cowpea also showed similar trend except that at the second year it had more height with maize at the 30th day and with sorghum at the 60th day. Similar findings were reported by Anon. (1973) and Saraf et al. (1975). Bajra depressed the height of legumes in all the cases due mainly to its shading on the legumes, which resulted in reduced nodulation and growth and hence reduced height of plants.

(2). Number of nodules/plant.

It is evident from the results presented in the Tables 24 (a) and 24 (b) that significant reduction in the number of nodules/plant of legumes was noticed due to intercropping of legumes between 3 m wide rows of subabul. The increased availability of nitrogen in the root zone due to the application of more prunings might have reduced the nodule formation in this treatment. Small and Leonard (1969) opined that the inhibitory effect of combined nitrogen was on account of the diversion of photosynthates to the roots and the deprivation of the nodules of carbohydrates. Inhibition of nodulation due to the application of higher quantities of subabul prunings was reported by Pahwa and Patil (1983).

Intercropping cowpea or blackgram with sorghum and maize resulted in increased number of nodules. The effect of sorghum was superior to maize on number of nodules/plant of cowpea during the first year and that of blackgram during the second year. A depressing effect was noticed due to bajra on this character. In association with sorghum or maize, the nitrogen released by legumes in the root zone might have been depleted by these cereals rapidly, creating low nitrogen concentration near the nodules and thus stimulating the formation of additional nodules as suggested by Thompson (1977), Wahua (1984) and Willy (1979). In the case of bajra due to its fast growing and early maturing habit among the cereals, excessive shading to the intercropped legumes at early stages might have caused adverse effect on photosynthesis and the supply of photosynthates for the formation of nodules. Reduced nodulation due to the effect of shading was reported by Reddy and Chatterjee (1973), Wahua and Miller (1978) and Rabic and Kumazawa (1980).

(3). Weight of nodules/plant.

The results in Tables 25 (a) and 25 (b) revealed that significant increase in the weight of nodules/plant of legumes were noticed when they were planted in between 4 m wide rows than between 3 m wide rows with an exception in the case of blackgram during the first year. Subabul prunings applied in lesser quantities at the wider spacing, might have increased the nodule weight of legumes.

(4). Number of days to flower.

(a). Cereals.

The results presented in Tables 26 (a) and 26 (b) revealed that the number of days required from planting to the 50 per cent flowering of bajra and sorghum was reduced due to the effect of growing them between 3 m wide rows of subabul during both the years. The increased availability of nutrients due to the incorporation of more prunings might have resulted in faster vegetative growth which ultimately resulted in hastening the flowering in these crops. Pal et al. (1985) observed that increased application of nitrogen hastened flowering in sorghum.

In the present investigation, the increased availability of nitrogen due to more prunings might have hastened the flowering of these cereal crops.

(b). Legumes.

Results presented in Tables 27 (a) and 27 (b) has shown that the number of days required for 50 per cent flowering of legumes was significantly reduced, when grown between 3 m wide rows of subabul, during both the years. This may be due to the faster vegetative growth of legumes which might have enabled them to grow taller and initiate early flowering.

Significant delay in the flowering of cowpea due to intercropping with maize noticed in this study may be on account of the inhibitory effect of maize on cowpea. Delayed flowering in cowpea due to the effect of maize was reported by Remison (1982) and Wanki et al. (1982).

(5). Number of days to mature.

(a). Cereals.

The results in Tables 28 (a) and 28 (b) show that maturity of maize was delayed due to intercropping it between 3 m wide rows of subabul. The greater availability of nitrogen in this treatment due to more prunings, might have resulted in prolonging the post flowering period and the maturity of maize. Singh and Guleria (1979) also reported delayed maturity of maize due to higher level of applied nitrogen.

The maturity of sorghum was delayed significantly due to intercropping with blackgram during the first year. This may be on account of the fact that root nodules of early harvested blackgram might have disintegrated, and decomposed in the soil and enriched the rhizosphere of associated sorghum with higher available nitrogen, which in turn would have delayed its maturity. Similar finding was reported by Ibrahim et al. (1977).

(b). Legumes.

Maturity of blackgram was delayed (Tables 29 (a) and 29 (b))when planted in between 3 m wide rows of subabul. Wahua and Miller (1978) reported that decrease in the number of nodules is accompanied by an increase in the activity of nodules for nitrogen fixation for a longer period which delays the senescence of leaves. In the present investigation nodule number was reduced at closer spacing, which might have resulted in prolonging the duration of nitrogen fixation and delaying the senescence of leaves and maturity.

There was significant influence in the maturity of cowpea and blackgram due to the effect of associated cereals. Maturity of cowpea and blackgram was hastened by bajra, where as the sorghum delayed the maturity. This may be due to the adverse effect of bajra when legumes were grown in association with it.

B. Yield Components and Yield

(1). Number of pods/plant.

Intercropping legumes with sorghum resulted in more number of pods than intercropping with maize or bajra, though it was significant only in the case of cowpea during the second year. Bajra recorded the lowest number of pods in all the cases. Since bajra and the legumes matured almost at the same period, it became more competitive early in the season and this might have reduced the height and nodulation which ultimately reduced the number of pods/plant. The favourable effect of sorghum and maize on number of pods/plant may be due to the difference in the maturity of these cereals and legumes. The present result of increasing trends in number of pods/plant due to sorghum and maize, and decreasing trends due to bajra is in agreement with the findings of Maneka and Doto (1980), Nyambo et al. (1980) and Elmore and Jacobs (1984).

(2). Ear length of cereals.

It is clear from Tables 31 (a) and 31 (b) that growing cereals in between 3 m wide rows of subabul showed significant increase in the earlength of sorghum, while the increase was not significant in the case of maize and bajra during both the years. This may be on account of the favourable effect of the application of higher quantities of subabul prunings into this treatment. The increase in earlength of cereals with increased availability of nitrogen is in agreement with the findings of Gautam et al. (1985).

Among legumes, blackgram was found superior to cowpea in increasing the ear length of associated crop maize during the first year and that of sorghum during both the years. The nitrogen fixed by early maturing blackgram was probably made available to the associated maize and sorghum by excretion and decay of nodules as suggested by Agboola and Fayemi (1972), which might have resulted in increased ear length of these cereals. Because of its late maturity cowpea appeared to have offered little benefit to the associated cereals. The present finding is in agreement with those of Jagannathan et al. (1974), Singh and Guleria (1979) and Singh (1981).

(3). <u>Pod length of legumes.</u>

The data in Tables 32 (a) and 32 (b) demonstrated that there was no significant difference on pod length of blackgram or cowpea due to the effect of plant densities of subabul, associated cereals and their interaction effects. Pod length is a character dependent on genetic control and had little influence due to treatment effects.

(4). <u>Number of grains/ear of cereals.</u>

A perusal of the results in Tables 33 (a) and 33 (b) revealed that growing cereals in between 3 m wide rows of subabul resulted in significantly more number of grains/ear of bajra during the second year and in non significant increase in other cereals. The increased availability of nutrients due to higher quantities of prunings applied might be responsible for the increase in the number of grains/ear of bajra. Maize and sorghum might not have utilized all the nitrogen released by decomposition of subabul prunings, because of relatively faster rate of decomposition and the comparatively long duration of these crops, which resulted in non significant increase in grains/ear.

Raising blackgram in association with cereals produced more grains/ear of maize and bajra during the second year and that of sorghum during both the years. It could be seen from tables 24 (a) and 24 (b) that the effect of sorghum was more favourable in increasing the nodule numbers/plant of legumes in the early stages. In the later stages, in return sorghum was benefitted by the same legume probably due to the excretion and decay of its nodules which is manifested in terms of more number of grains/ear during both the years. The superior performance of blackgram over cowpea may be attributed to the differences in quality and quantity of excreted nitrogen by these legumes as suggested by Virtanen et al. (1937) and Rewari et al. (1957). Similar finding was reported by Wanki et al. (1982).

(5). Number of seeds/pod of legumes.

It is clear from the results in Tables 34 (a) and 34 (b) that the legumes planted in between 3 m wide rows of subabul produced significantly more number of seeds/pod in the case of the second year cowpea. This may be due to the beneficial effect of increased availability of nutrients in the treatment as is evident from the uptake data (Tables 54 (a), 54 (b), 57 (a) and 57 (b)).

There was significant difference in seeds/pod of legumes due to the effect of associated cereals. Sorghum was more efficient in increasing the seeds/pod of cowpea during the first year and that of blackgram during the second year. This may be attributed to the less competitive effect of sorghum on these legumes during the pod development stage, as is evident from the increased nodule numbers/plant. Bajra showed a depressing effect on number of seeds/pod during both the years. This may be on account of the severe competition of bajra on legumes, due to its fast growing and early maturing characters. These results are in agreement with the findings of Elmore and Jacobs (1984). Variation noticed in different seasons, may be due to the variation in the quantities of prunings applied and consequent rate of growth of these crops.

(6). Weight of thousand grains.

(a). Cereals.

The data presented in Tables 35 (a) and 35 (b) indicated that there was marginal increase in thousand grain weight of cereals due to the effect of spacing of subabul. The quantity of subabul prunings incorporated into the soil was probably not enough to bring about a significant change in thousand grain weight in the present study. This is in contrary to the findings of Siagian and Mabbayad (1980), wherein positive and significant effect on thousand grain weight of maize has been recorded due to the effect of subabul prunings.

Intercropping of legumes showed significant difference in thousand grain weight of sorghum. Sorghum grown with blackgram recorded significantly more weight of thousand grains than that grown with cowpea. This may be probably due to the soil enrichment brought about by substantial increase in nodulation (Tables 24 (a), 24 (b)) of blackgram. In the case of cowpea, the nitrogen fixed might have been utilized for its own growth leaving little for the benefit of associated cereals. Similar findings have been reported by Singh (1981) and Nair et al. (1979) in sorghum and maize respectively.

(b). Legumes.

The results outlined in Tables 36 (a) and 36 (b) indicated that blackgram grown in association with sorghum recorded higher weight of thousand grains than that grown with maize or bajra. This effect was significant during the second year only. Similar trend though not significant was recorded in the thousand seed weight of cowpea. The increase in weight of legume seeds grown in association with sorghum may be attributed to the complementary effect of sorghum as suggested by Willey (1979). Similar results were reported by Singh (1981) in cowpea. The consistent trend of decrease in weight of seeds of legume grown in association with bajra may be attributed to the more competitive nature of bajra during the grain filling stage of legumes. These results are in agreement with those of Maneka and Doto (1980) and Elmore and Jacobs (1984).

(7). Dry matter yield.

(a). Cereals.

Results presented in Tables 37 (a), 37 (b), 38 (a) 38 (b), 39 (a), 39 (b) and 48 (c) revealed that cereals grown in between 3 m wide rows of subabul produced higher yield than those grown in between 4 m wide rows at all the stages of growth. Pooled analysis of data at harvest stage also showed the same trend. The increased availability of nutrients due to the application of higher quantities of prunings might have facilitated a favourable effect on the growth and development of cereals which manifested in increased yield in this treatment. The uptake of nitrogen, phosphorus and potassium by cereals (Tables 50 (a), 50 (b), 53 (a), 53 (b), 56 (a), and 56 (b)) also clearly indicated that the uptake was higher at 3 m wide rows of subabul. This increased uptake of major nutrients might have resulted in better growth and hence higher dry matter yield. Siagian and Mabbayad (1980) and Mendoza et al. (1981) have also reported increased dry matter production in maize due to the application of higher quantities of prunings. Narkhede et al. (1984) observed similar results in sorghum.

Dry matter yield of cereals grown with blackgram was higher at the 30th day. This may be due to less competition by blackgram which enabled cereals to grow faster and accumulate more dry weight at the early stage.

At the harvest stage also cereals grown with blackgram registered significantly higher yield than those grown with cowpea. Nitrogen fixed by blackgram was probably made available to the cereals at the later stages by excretion and decay of nodules as suggested by Agboola and Fayemi (1972) which might have resulted in higher yield. The quality and the quantity of excreted nitrogen vary among legumes (Virtanen et al., 1937 and Riwari et al., 1957). This may explain the differences observed in the legume associations.

(b). Legumes.

Results in Tables 40 (a), 40 (b), 41 (a), 41 (b), 42 (a), 42 (b) and 48 (c) showed that the legumes grown in between 3 m wide rows of subabul produced more dry matter at the first two stages during the second year only and the increase was not significant at the harvest stage. The higher dry matter yield obtained at earlier stages may be on account of the increased growth and development of legumes due to the availability of more nutrients at the early stages in this treatment. Uniform results were not recorded in different seasons on account of fluctuation in the growth pattern of these crops due to differences in the amount of prunings incorporated.

Dry matter yield of legumes was higher when grown in association with sorghum at all the stages of growth in both the years. This may be because of the favourable effect of sorghum on plant height and nodulation of legumes which resulted in increased growth and accumulation of dry matter. Long duration cereal crops like sorghum by avoiding competition, induce a favourable effect on the associated short duration legumes (Willey, 1979).

Dry matter yield of legumes was found to be higher during the second year especially at the harvest stage. This may be due to the favourable effect of more quantities of subabul prunings applied during the second year.

(c). Total dry matter yield (cereals + legumes).

From Tables 43 (a), 43 (b), 44 (a), 44 (b), 45 (a), 45 (b), and 48 (c) it could be seen that the dry matter yield of annual crops were higher when grown in between 3 m wide rows of subabul at all the stages of growth.

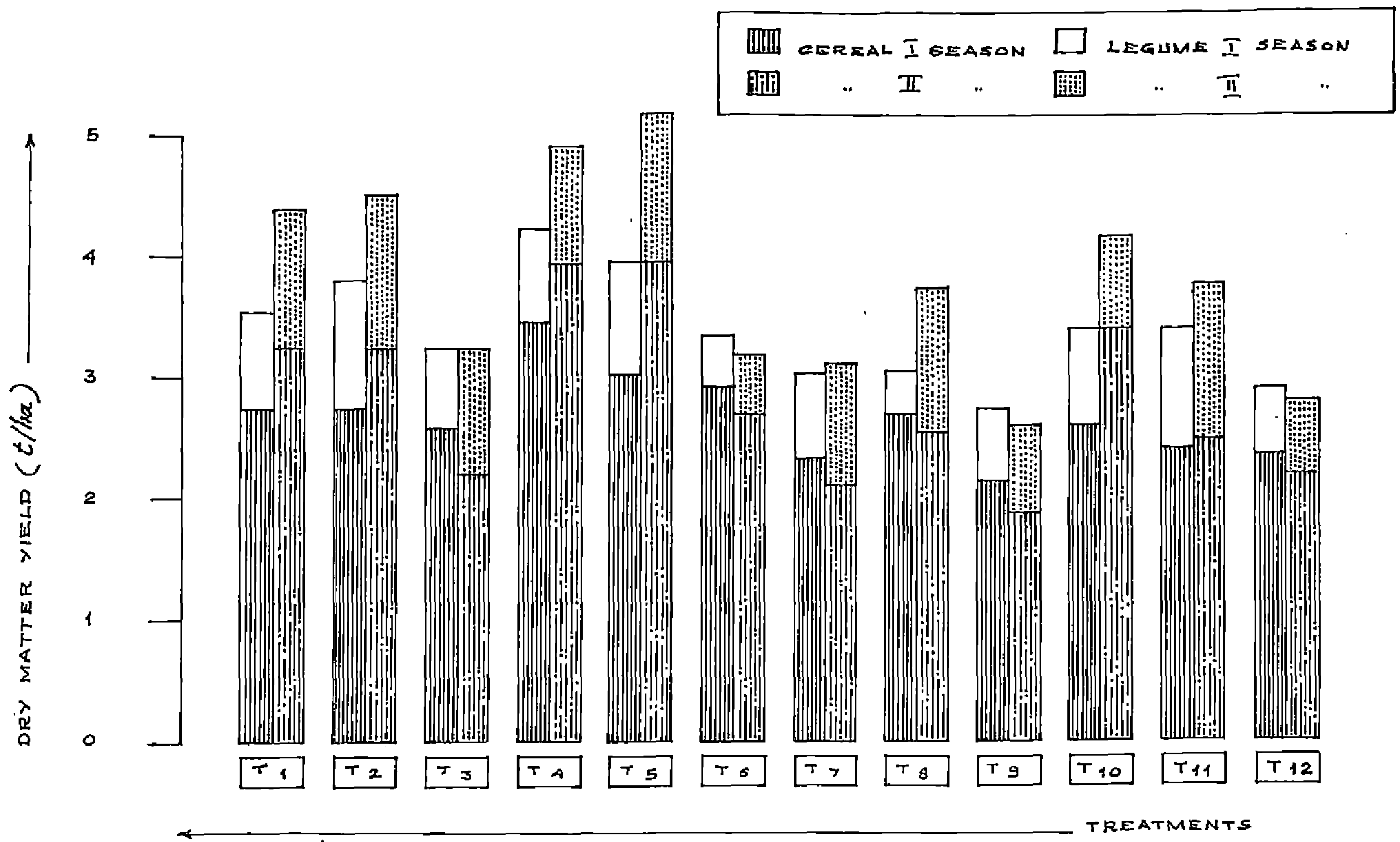

FIG. 5 DRY MATTER YIELD OF CEREALS AND LEGUMES AT HARVEST

Pooled analysis of data at the harvest stage also showed the same trend. Significant increase in the dry matter yield of cereals and marginal increase in legumes in this treatment might have resulted in the increased total dry matter yield.

Significant effect of blackgram was noted in increasing the total yield at the 30th day and at harvest which may be probably on account of increased growth and development of cereals at these stages. At the early stage competition from blackgram to the associated cereals might have been less and hence they would have used soil nitrogen efficiently. At the later stages, the fixed nitrogen became available by the death and decay of nodules, thus benefitting the cereals in realizing higher yield.

The contribution of bajra to total dry matter yield was more at the early stages, while at the later stages, sorghum and maize contributed more to the total dry matter yield on account of differential growth patterns and longer duration of these crops.

(8). Grain yield.

(a). Cereals.

It could be seen from Tables 46 (a), 46 (b) and

48 (c) that grain yield of the cereals grown in between 3 m wide rows of subabul was significantly higher during both the years. Perusal of the Tables 31 (a), 31 (b), 33 (a), 33 (b), 35 (a) and 35 (b) could reveal that the growth and yield attributing characters like grains/ear, ear length and 1000 grain weight were favourably influenced by closer spacing. This favourable effect on yield contributing characters, due mainly to the application of increased quantities of subabul prunings might have resulted in increased yield. Guevarra (1976), Kang et al. (1981 a, 1981 b), Siagian and Mabbayad (1980), Mendoza et al. (1981), Alvarez and Alferez (1982) and Torris (1983) have also reported increased grain yield of maize grown between closely spaced subabul plants and due to the incorporation of increased quantities of subabul prunings. Narkhede et al. (1984) obtained similar results in sorghum.

Cereals grown with blackgram recorded significantly higher yield than those grown with cowpea during both the years. Pooled analysis of data also showed the same trend. It could be seen that blackgram exerted a favourable effect on the ear length and grains/ear of cereals substantially and on 1000 grain weight marginally, which might have resulted in increased grain yield of cereals. Dusad and Morey (1979) reported yield increase in sorghum due to the effect of blackgram on account of more excretion of nitrogen from the nodules and better efficiency of nitrogen fixation. Similar findings were reported by Das and Mathur (1980), Chauhan and Dungerwal (1982) and Waghmare and Singh (1984).

The comparatively lower yield of cereals grown in association with cowpea may be attributed to the more competitive effect of cowpea on cereals as reported by De et al. (1978). This may also be due to its longer duration and it might not have contributed substantial quantity of nitrogen to cereals at the later stages. Decrease in the yield of maize and sorghum due to the effect of cowpea was reported by Enyi (1973) and Singh (1981).

Maize recorded significantly higher yield and was superior to sorghum and bajra which may be attributed to the species differences. The effect of years was significant on grain yield of cereals. Yield was higher during the second year on account of the higher quantities of prunings applied, and the favourable effect of timely rainfall.

(b). Legumes.

Growing legumes in between 3 m wide rows of subabul gave higher grain yield (Tables 47 (a), 47 (b) and 48 (c)) than growing in between 4 m wide rows, which may be attributed to the beneficial effect of larger quantities of prunings applied on the growth and development of legumes. Increased yield of beans due to the application of higher quantities of subabul prunings was reported by Kluthcouski (1980) and Chagas et al. (1983).

Sorghum was superior to maize and bajra in increasing the yield of intercropped legumes. Favourable effect of sorghum on the nodulation, number of seeds/pod, number of pods/plant and 1000 grain weight of legumes might have resulted in increased grain yield. Due to its longer duration, sorghum might have avoided competition with associated legumes, which enabled the latter to express their production potential. Enyi (1973) also reported favourable effect of sorghum on the grain yield of legumes. Grain yield of legumes grown in association with bajra was lower due to the competition for light between legumes during their growth stages. Agboola and Fayemi (1971 observed that grain yield of cowpea was significantly reduced due to the shading from tall associated crops.

Grain yield of legumes was significantly higher during the second year on account of the increased availability of nutrients brought about by the application of more quantities of prunings. The significant interaction between the spacing of subabul and cereals suggested the negative effects of higher plant densities on legume yield, due to the favourable effects on cereals.

(c). Total grain yield (cereals + legumes).

It is evident from the Tables 48 (a), 48 (b) and 48 (c) that the total grain yield of the system (cereals + legumes) was significantly higher due to intercropping in between 3 m wide rows of subabul. Pooled analysis of data also showed the same trends. The significant and positive effect on the grain yield of cereal and legume components due to the closer spacing of subabul was probably responsible for increase in total yield of the system.

Blackgram recorded higher total yield than cowpea, due mainly to the positive effect of blackgram on the yield and yield components of cereals. This might have been possible due to the mutual beneficial effect of these species. Maize and sorghum offered less competition to blackgram, which resulted in better nodulation and fixation of nitrogen. But since it was harvested earlier

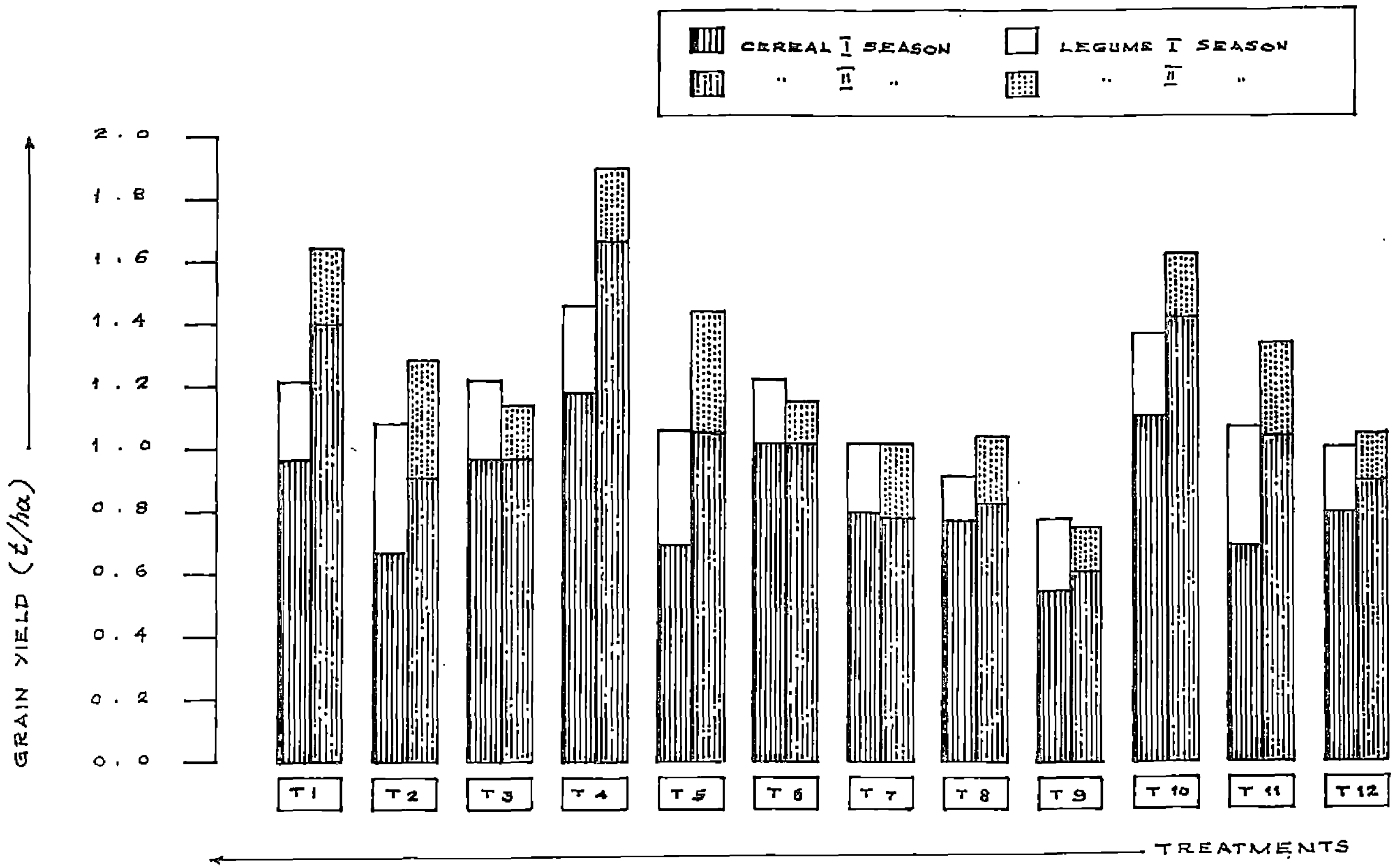

FIG. 6 GRAIN YIELD OF CEREALS AND LEGUMES

the fixed nitrogen might have been made available to the cereals at the later stages as suggested by Agboola and Fayemi (1972). This increased availability of nitrogen together with the absence of competition at the later stages might have resulted in the increase in the grain yield of cereals and hence the total yield.

The differences in the total yield among the cereals, may be attributed to the species difference and their yielding abilities. Higher total yield was obtained from maize + blackgram combination (Fig. 6) which may be attributed to the compatibility of these species with subabul.

(9). <u>Total biomass yield of the system.</u>

The results in Table 49 revealed that the total biomass yield of the system (total dry matter yield at harvest of the first and the second year annual crops + the total biomass of subabul) was significantly influenced by the spacing of subabul. An increase of 23 per cent in the biomass production in favour of 3 x 1 m spacing of subabul over 4 x 1 m was recorded. This increase in biomass yield may be attributed to the higher biomass production of subabul and the other components during both the years, at higher plant densities. Higher biomass yield of subabul recorded in this study at closer spacing may be due to the increased number of plants/ha and the higher biomass yield of annual crops was the result of increased application of prunings in this treatments and the interaction effects between the species.

Intercropping of annual legumes showed significant influence on the biomass yield and influence of blackgram was significantly superior to cowpea. The combination sorghum and blackgram produced more biomass (Fig. 7) than the other combinations which may be due to the complementary effects of these species on subabul. Balasubramonian et al. (1984) also reported favourable effect of sorghum and bajra on the biomass yield of subabul.

C. Uptake Studies

(1). Uptake of nitrogen.

(a). Cereals.

It was observed (Tables 50 (a) and 50 (b)) that cereals grown in between 3 m wide rows of subabul showed significantly higher uptake of nitrogen than those grown in between 4 m wide rows. The increased availability of nitrogen on account of higher amount of prunings applied, might have encouraged better growth and development as is evident from the dry matter yield, which ultimately resulted in the higher uptake of nitrogen. Increased uptake of nitrogen due to the application of higher quantities of subabul prunings was also reported by Siagian and Mabbayad (1980) and Kang et al. (1981 a, 1981 b).

Cereals grown with blackgram recorded significantly higher nitrogen uptake than those grown with cowpea. The early nodulation and excretion and decay of nodules as suggested by Agboola and Fayemi (1971) might have stimulated the growth of cereals in these treatments and this might have resulted in significant difference in dry matter yield and the uptake of nitrogen at harvest. Morachan et al. (1977) reported increased nitrogen uptake by maize and Waghmare and Singh (1984) by sorghum due to intercropping.

The higher uptake of nitrogen by sorghum and maize in the second year may be on account of the increased dry matter production of these crops at harvest.

(b). Legumes.

Results presented in Tables 51 (a) and 51 (b) showed that during both the years there was significant difference in the uptake of nitrogen by legumes due to the effect of cereals. Legumes intercropped with sorghum recorded higher nitrogen uptake than those intercropped with maize or bajra. The effect of maize was on par with bajra. Increased nitrogen uptake of legumes grown in association with sorghum may be due to its favourable effects on nodulation and dry matter production of legumes.

The significant interaction between cereals and legumes noticed during the second year is an indication of maximum uptake by the combination 'sorghum + blackgram' which was on par with 'sorghum + cowpea'. This may be due to the difference in the dry matter production of these varying combinations.

(c). Total uptake of nitrogen (legumes + cereals).

It could be seen from Tables 52 (a) and 52 (b) that the total uptake of nitrogen was significantly higher when annual crops were planted in between 3 m wide rows of subabul. Since the total biomass production in this treatment was higher and the uptake of nitrogen by the cereal component was also higher, this might have resulted in higher total uptake at closely spaced subabul rows.

There was significant difference in the total uptake of nitrogen due to the effect of legumes, during the first year only. Blackgram recorded more uptake than cowpea. The total dry matter and grain yields were higher with blackgram, which may explain the higher uptake in this treatment. The variation noticed between years may be due to the differences in subabul prunings applied and also in the quantity of rainfall received during the crop growth periods.

Among the cereals, sorghum recorded the highest uptake and was superior to maize and bajra. This may be due to the higher dry matter produced in this treatment. The present finding is in agreement with the results obtained by Aggarwal et al. (1978) wherein total nitrogen uptake was significantly related to the above ground biomass.

(2). Uptake of phosphorus.

(a). Cereals.

Tables 53 (a) and 53 (b) showed that phosphorus uptake was significantly higher when cereals were planted in between 3 m wide rows of subabul than when planted in between 4 m wide rows. The favourable effect of higher quantities of subabul prunings in this treatment might have stimulated the early growth and greater ramification of roots of cereals. This together with increased availability of phosphorus due to the effect of green manuring, might have helped in more uptake of phosphorus. Increased uptake of phosphorus due to the application of subabul prunings at higher rates was reported by Siagian and Mabbayad (1980) in maize and Nerkhede et al. (1984) in sorghum.

There was significant difference in the phosphorus uptake of cereals due to the effect of legumes. Cereals grown with blackgram recorded significantly higher uptake than those grown with cowpea. Blackgram grown in association with cereals might have helped in greater ramification of root systems in cereals as suggested by Gangwar and Kalra (1978) and this might have helped in more uptake of phosphorus.

The significant difference in phosphorus uptake observed among cereals may be on account of the differential phosphorus requirement of these crops.

(b). Legumes.

It was observed from Tables 54 (a) and 54 (b) that the uptake of phosphorus was higher when legumes were planted in between 3 m wide rows of subabul than 4 m wide rows and the effect was significant during the first year only. The increased dry matter and grain yield production in this treatment might have necessitated a higher uptake of phosphorus. Maloth and Prasad (1976) reported that application of phosphorus almost doubled its uptake by cowpea. In the present case, green manuring might have made more phosphorus available in the soil and this might have resulted in higher uptake.

There was significant difference in the phosphorus uptake of legumes due to the effect of cereals, though it was not uniform between years. Legumes intercropped with sorghum recorded more uptake than those intercropped with maize and bajra during the second year and with bajra during the first year only. This may be due to the difference in dry matter production of legumes in these treatments.

(c). Total uptake of phosphorus.

As seen from the Tables 55 (a) and 55 (b) the total uptake of phosphorus was significantly higher when annual crops were grown in between 3 m wide rows of subabul. The uptake of phosphorus by individual components of the system (cereals and legumes) was higher. This may be the reason for increased total phosphorus uptake in this treatment.

Bajra registered the maximum phosphorus uptake and was superior to maize and sorghum, which may be related to the differential requirement of this nutrient element for their growth and development.

(3). Uptake of potassium.

(a). Cereals.

Results presented in Tables 56 (a) and 56 (b) showed that cereals planted between 3 m wide rows of subabul recorded higher uptake of potassium than those planted in between 4 m wide rows. The increased dry matter and grain yields together with the increased uptake of nitrogen and phosphorus in this treatment might have resulted in increased uptake of potassium also. Siagian and Mabbayad (1980) also reported more uptake of potassium when the rate of applied subabul prunings was increased.

Legume intercrops produced significant difference in potassium uptake by cereals. Cereals in association with blackgram recorded more uptake, than those with cowpea. This increased uptake of potassium by cereals may be attributed to the non-utilization by blackgram (Tables 51 (a), 51 (b)). According to Drake (1964), legume roots have higher cation exchange capacity than cereal roots. Roots having low cation exchange capacity have greater affinity for monovalent cations like K^+. Hence in the present case, cereals might have competed effectively with blackgram for potassium resulting in increased uptake by cereals.

The significant difference observed in the uptake of potassium among cereals may be on account of the difference in dry matter and grain yields and their requirements for the same.

(b). Legumes.

Significant difference (Tables 57 (a) and 57 (b)) was observed in potassium uptake by legumes. Cowpea recorded higher uptake of potassium than blackgram due probably to the difference in dry matter and grain yields.

Cereals grown with legumes had significant influence on the uptake of potassium by legumes. Legumes intercropped with sorghum registered higher uptake than those intercropped with maize and bajra during the first year and with bajra only during the second year. This may be due to the complementary effect of sorghum and legumes as suggested by Willey (1979), because the uptake of potassium by sorghum was lower, that enabled legumes to express higher uptake.

(c). Total uptake of potassium.

The results in Tables 58 (a) and 58 (b) indicated that cereals planted in between 3 m wide rows of subabul recorded significantly higher uptake than those planted at 4 m wide spacing. It could be seen from Tables 56 (a)

56 (b), 57 (a) and 57 (b), that the uptake of potassium by cereal and legume components was higher in this treatment and hence total uptake was also higher.

D. Quality Aspects

(1). Crude protein yield.

(a). Cereals.

It could be seen from Tables 59 (a) and 59 (b) that cereals grown in between 3 m wide rows of subabul recorded significantly more yield than those grown in between 4 m wide rows. The increased yield of crude protein may be attributed to the increased dry matter production and increased uptake of nitrogen. Higher amount of prunings might have made more nitrogen available to the crops, resulting in more dry matter and crude protein yields.

Growing blackgram in association with cereals resulted in higher yield of crude protein, which may be attributed to the transfer of fixed nitrogen to the cereals, resulting in higher yields. Agboola and Fayemi (1972) noticed that the current transfer of fixed nitrogen was more due to blackgram intercropping. Sorghum recorded the maximum yield during the second year which may be due to more efficient utilization of the applied prunings. The combination maize + blackgram recorded the highest yield during the first year and similar trend was maintained during the second year also.

(b) Legumes.

Crude protein yield (Tables 60 (a) and 60 (b)) was significantly higher when legumes were grown in between 3 m wide rows of subabul during the second year only. During the second year the fixed nitrogen might have been utilized for producing dry matter and grain yield. This increased dry matter yield at harvest during the second year might have resulted in more yield of crude protein in this treatment.

Cereals produced marked difference on the crude protein yield of legumes. Legumes grown with sorghum produced more yield than those grown with maize and bajra, which may be due to the complementary effect of sorghum and also due to the increased nodulation of legumes with sorghum (Tables 24 (a), 24 (b), 25 (a) and 25 (b)).

(c). Total yield of crude protein (legumes + cereals).

The data presented in Tables 61 (a) and 61 (b) revealed that the total yield of crude protein was higher when annual crops were planted in between 3 m wide rows, which may be due to the higher yields of crude protein of cereal and legume components of the system during both the years.

Cereals exibited marked influence on the yield of crude protein. Sorghum recorded maximum total crude protein yield and was superior to bajra, but was on par with maize, which may be due to the increased dry matter production and uptake of nitrogen. The combination sorghum + blackgram recorded the maximum total yield, though not significant.

(d). Total yield of crude protein from the system.

Total crude protein yield of the system (Table 62) over a period of 20 months was higher when annual crops were planted in between 3 m wide rows of subabul. The increased crude protein yield of annual crops and that of subabul (Table, 18) in this treatment may be the reason for increased yield. Blackgram among legumes, and sorghum among cereals recorded higher crude protein yields. The combination of sorghum + blackgram (Fig. 8) tended to produce higher crude protein yield of the system though

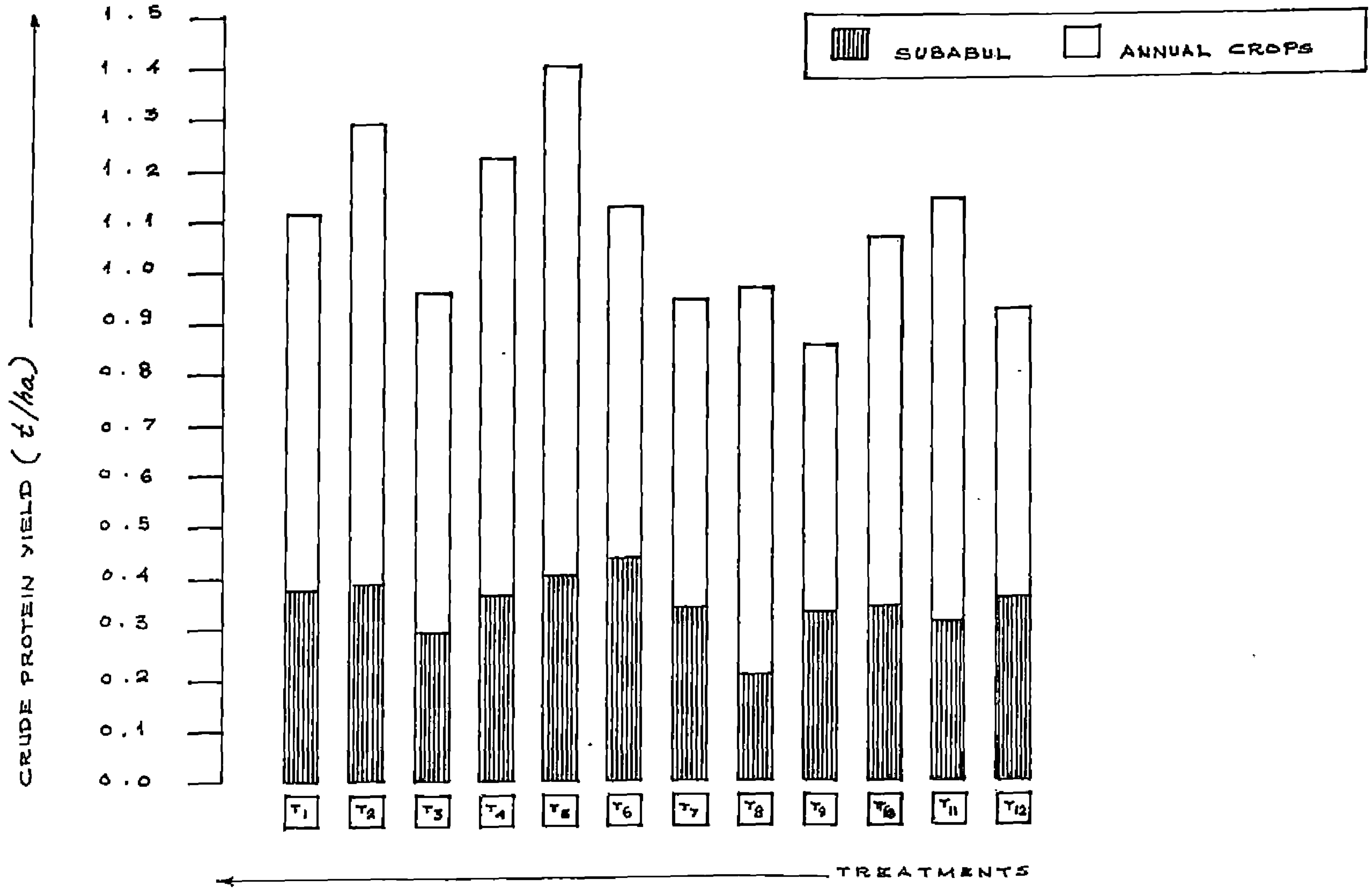

FIG. 8 TOTAL CRUDE PROTEIN YIELD OF SUBABUL AND ANNUAL CROPS OVER TWO SEASONS

not significant. This may be due to the favourable effect of these species when grown with subabul.

E. Soil Fertility Studies

(1). Total nitrogen content of soil.

The results in Table 63 revealed that the total nitrogen content of soil after the experiment was maximum when subabul trees were planted at 3 x 1 m spacing. At closer spacing, greater quantities of prunings were incorporated in the soil, which might have resulted in the build up of nitrogen in the soil. Similar findings have also been reported by Kang et al. (1981).

Analysis of the soil after experiment showed that Blackgram was superior to cowpea in enhancing the total nitrogen content. This might be due to the fact that nitrogen fixed by cowpea might have been utilized by the crop itself, because of its longer maturity period as suggested by Singh and Chand (1979).

(2). Available phosphorus content of soil.

The results in Table 64 revealed that available phosphorus content of soil was highest when subabul trees were planted at the spacing of 3 x 1 m. The increase in the quantity of prunings in this treatment might have resulted in more available phosphorus in the soil. Blackgram was more efficient then cowpea in increasing the available phosphorus content of soil. Increase in the available phosphorus content due to the effect of legumes was also reported by Chandini and Raghavan Pillai (1980) and Guilias and Van diest (1981).

(3). Available potassium content of soil.

Available potassium content of soil (Table 65) was recorded maximum when blackgram was intercropped with cereals. The uptake of potassium by blackgram was less as compared to that by cowpea, which might have resulted in more available potassium when blackgram was intercropped. Potassium content in the soil was highest due to the effect of maize, and lowest due to the effect of bajra. This may be due to the higher uptake and removal of potassium by bajra.

F. Economics

The results in Table 66 and Fig. 9 revealed that all the combinations of annual cereals and legumes grown

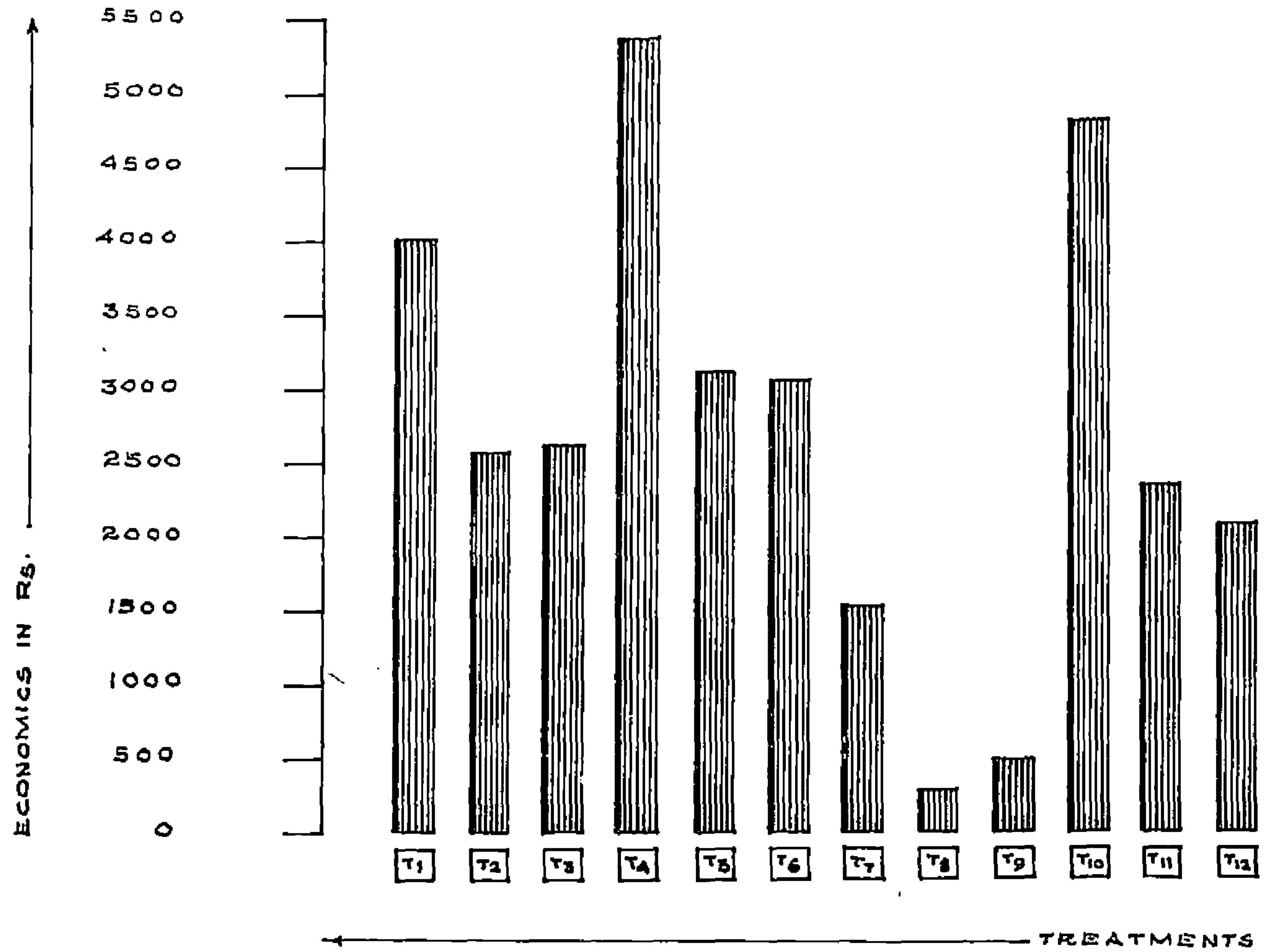

FIG. 9 ECONOMICS OF AGROFORESTRY SYSTEM INVOLVING FOOD AND FODDER CROPS

in between 3 m wide rows of subabul recorded higher net profit than the corresponding ones grown in between 4 m wide rows. The maximum net profit from the agroforestry system was secured by 'maize + blackgram' combination grown under 3 m wide rows of subabul where the net profit was Rs.5447.28/ha. This was closely followed by the same combination under 4 m wide rows of subabul (Rs.4895.68/ha).

SUMMARY

An investigation was carried out in the Instructional Farm, College of Agriculture, Vellayani, during 1984 and 1985 with the objectives of finding out the biomass production in an agroforestry system involving food and fodder crops and also to select the most suitable cereal-legume combination to be grown as intercrop under different plant densities of subabul. Subabul was planted at 3 x 1 m and 4 x 1 m spacings, 6 months prior to the planting of annual crops. Annual legumes (cowpea and blackgram) and cereals (maize, sorghum and bajra) were planted in alternate rows between the rows of subabul. Subabul foliage was pruned and applied as green manures 15 days prior to the planting of annual crops, and at every 15 days interval after planting upto the 60^{th} day, to supplement the nitrogen requirement of annual crops. The trial was laid out as a factorial experiment in Randomized Block Design with three replications. The results of the study are summarized below:

1. Plant height of annual cereals and legumes was the highest when grown between 3 m wide rows of subabul.

2. The number of days required for flowering in sorghum, bajra, cowpea and blackgram was reduced, when these crops were grown in between 3 m wide rows of subabul than 4 m wide rows.

3. Maturity in maize and blackgram was delayed, when grown in between 3 m wide rows of subabul.

4. Ear length of sorghum, the number of grains/ear of bajra and seeds/pod of cowpea were higher when intercropped under higher plant density of subabul.

5. The number of nodules/plant and weight of nodules/plant of legumes were reduced, due to higher plant density of subabul.

6. Leaf-stem ratio of subabul fodder was highest under lower plant density.

7. Nitrogen and crude protein contents of stem and leaf portion of subabul fodder were highest under lower plant density.

8. Phosphorus content of stem was higher at low plant density, whereas phosphorus content of leaves was higher at higher plant density.

9. Potassium content of stem was highest due to higher plant density. Highest potassium content in the stem of subabul was noticed when bajra and blackgram together were grown as its intercrops.

10. Green fodder and dry fodder yield of subabul were maximum under higher plant density.

11. Dry matter and grain yield of annual cereals and legumes, the total biomass yield of the system and the total crude protein yield of the system were more under higher plant density of subabul.

12. The total uptake of nitrogen, phosphorus and potassium by annual cereals and legumes together were the highest under higher plant density of subabul.

13. Total nitrogen content and available phosphorus content of soil were the highest under 3 x 1 m spacing of subabul.

14. Maize + blackgram combination gave the highest grain yield.

15. Highest biomass production was recorded by the agroforestry system involving subabul + sorghum and blackgram which was closely followed by subabul, maize and blackgram.

16. Intercropping annual cereals and legumes between 3 m wide rows of subabul was found to be more profitable than intercropping between 4 m wide rows. The combination maize + blackgram under 3 m wide rows of subabul was the best combination in terms of grain yield and profitability.

FUTURE LINE OF WORK

From the study it was clear that the combination 'maize + blackgram' grown between 3 m wide rows of subabul was the best combination. Higher grain yields as compared to other combinations in this study were obtained at 50 per cent of the recommended dose of nitrogen and supplemented by subabul prunings. In this study, since only 2 levels of subabul densities were used, it would be proper to test different levels of plant densities to see, if inorganic nitrogen could be skipped off by incorporation of subabul prunings.

The performance of other foodcrops of the region eg. colocasia, tapioca, banana, yam, etc., intercropped with subabul and using subabul as green manure can be investigated.

In the present study, the output from the livestock component was not taken into consideration. In future studies, the output from animal component may also be included, so as to get the full benefits from agroforestry practices.

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APPENDICES

APPENDIX - I. Weather data during the crop period and its variation from the average for past five years

Standard weeks	Period	Rainfall (mm) 1984	Rainfall (mm) Variation	Temperature °C Maximum 1984	Temperature °C Maximum Variation	Temperature °C Minimum 1984	Temperature °C Minimum Variation	Relative humidity (%) 1984	Relative humidity (%) Variation
1	2	3	4	5	6	7	8	9	10
28	July 9-15	64	+3.8	29.29	-0.58	23.36	+0.76	85.78	-2.27
29	16-22	18	+4.9	28.62	-1.3	23.53	+0.85	88.78	+2.18
30	23-29	00	-19.1	28.85	-0.34	23.60	+1.64	73.54	-11.42
31	30 Aug-5	9	-41.62	29.75	+0.9	23.60	+1.62	74.14	-23.67
32	6-12	12	-18.64	29.39	-0.11	23.10	+0.93	66.71	-23.67
33	13-19	3	-58.92	30.10	+0.84	23.17	+1.29	68.57	-21.44
34	20-26	00	-27.86	30.17	+0.52	24.39	+2.6	68.00	-20.31
35	27 Sept-2	5	+0.2	29.43	-0.91	23.96	+1.29	72.12	-14.53
36	3-9	00	-15.4	30.21	-0.25	24.39	+1.86	74.14	-13.64
37	10-16	00	-38.62	30.13	-0.05	23.85	+1.31	79.78	-7.29
38	17-23	3	-85.06	31.17	+1.1	23.82	+1.72	69.64	-18.8

Positive sign (+) shows increase over the average data and negative sign (-) the decrease

APPENDIX - I. Contd.

1	2	3	4	5	6	7	8	9	10
39	24-30	75.2	+54.06	30.03	+0.44	23.10	+0.62	78.85	-9.47
40	Oct 1-7	172.3	+149.9	28.46	-1.78	22.03	-0.38	87.64	+1.58
41	8-14	9.6	-42.1	29.46	+1.06	23.10	+0.88	78.92	-6.45
42	15-21	0.0	-6.6	30.10	-0.85	21.71	-0.56	65.35	-20.75
43	22-28	19.9	-31.0	30.25	-0.17	22.46	+0.07	76.57	-12.87
44	29-Nov-4	0.0	-42.32	30.32	+0.13	23.71	+1.12	74.21	-14.96
45	5-11	42.5	-3.06	30.75	+0.89	23.92	+1.84	75.92	-9.29
46	12-18	25.2	-55.4	30.64	+0.28	24.03	+1.78	79.78	-6.25
47	19-25	58.3	+43.24	30.21	-0.32	23.5	+0.95	81.71	+4.55
48	26-Dec-2	4.6	-25.7	30.35	-0.15	23.85	+1.61	85.00	+1.95
49	3-9	5.4	-24.9	30.53	-0.28	23.5	+1.26	85.07	+4.02
50	10-16	0.0	-10.4	30.78	0.0	21.57	-0.42	80.14	-0.93
51	17-23	0.0	-10.15	30.17	-0.61	20.21	-2.00	75.00	-13.73
52	24-31	0.0	-12.8	30.87	+0.29	20.78	-0.77	77.56	-7.41
1	Jan 1-7	61.2	+54.2	30.53	-0.36	21.6	+0.42	78.00	+2.61
2	8-14	0.0	0.0	30.85	-0.34	22.39	+1.55	82.14	+8.02
3	15-21	0.0	-6.2	30.77	+0.21	22.85	+1.69	84.07	+5.07
4	21-28	0.0	0.0	30.82	0.26	21.14	+0.25	79.50	+5.72

Positive sign (+) shown increase over the average data and negative sign (-) the decrease.

APPENDIX - I Contd.

Stand and weeks	Period	Rainfall (mm) 1985	Rainfall (mm) Variation	Temperature °C Maximum 1985	Maximum Variation	Minimum 1985	Minimum Variation	Relative humidity (%) 1985	Relative humidity (%) Variation
1	2	3	4	5	6	7	8	9	10
28	July 9-15	10.0	-50.2	29.87	0.0	22.2	-0.4	76.21	-11.85
29	16-22	27.2	+14.1	30.3	+4.5	22.46	-0.22	71.57	-15.03
30	23-29	2.6	-16.5	30.53	+1.34	22.47	+0.51	79.78	-10.21
31	30-Aug-5	25.0	-25.62	29.99	+0.33	22.77	+0.79	82.21	- 8.1
32	6-12	21.3	- 9.5	30.46	+0.96	22.98	+0.81	88.28	-2.10
33	13-19	0.0	-61.92	30.38	+1.12	23.67	+1.69	84.78	-5.23
34	20-26	0.0	-27.8	30.55	+0.90	23.62	+1.29	83.57	4.74
35	27-Sept 2	0.4	4.4	30.62	+0.28	24.24	+1.57	81.35	-5.30
36	3-9	0.0	-15.4	30.62	+0.16	24.30	-1.77	81.35	-6.43
37	10-16	0.0	-38.6	30.41	+0.23	23.22	+0.68	83.28	-3.79
38	17-23	0.0	-88.1	30.38	+0.31	23.46	+1.36	83.76	4.68
39	24-30	0.0	-21.1	29.92	+0.33	23.40	+0.91	83.14	-5.18
40	Oct 1- 7	0.0	-22.4	30.25	+0.01	22.39	-0.02	84.14	-2.18

Positive sign (+) shows increase over the average data and negative sign (-) the decrease

APPENDIX - I Contd.

1	2	3	4	5	6	7	8	9	10
41	8-14	0.0	-51.7	30.38	-0.14	22.85	+0.63	80.25	-5.09
42	15-21	128.0	+121.4	29.54	-1.41	22.44	+0.17	79.00	-7.10
43	22-28	155.0	+104.1	29.57	-0.58	23.07	+0.68	82.50	-7.00
44	29-Nov 4	311.0	+268.6	29.19	-1.00	22.58	-0.01	78.00	-11.17
45	5-11	28.8	-16.7	30.07	-0.21	23.99	+1.91	80.28	-4.93
46	12-18	152.2	+71.5	29.63	-0.73	23.30	+1.05	80.71	-5.32
47	19-25	45.8	-30.7	29.70	-0.83	22.78	+0.23	77.00	-9.26
48	26-Dec 2	8.0	-22.3	29.98	-0.52	21.21	-1.03	77.00	-6.05
49	3-9	70.1	-57.2	29.90	-0.91	22.4	+0.19	77.00	-4.05
50	10-16	4.1	-6.44	29.80	-0.98	22.50	+0.51	76.00	-5.07
51	17-23	0.0	- 10.1	30.10	-0.68	21.90	-0.31	79.00	-9.73
52	24-31	0.0	- 15.3	32.30	+1.41	20.60	-0.95	75.00	-9.97
1	Jan 1- 7	0.0	-1.9	32.30	+1.41	20.7	-0.48	74.00	+1.39
2	8-14	13.2	+13.2	31.90	+0.71	22.8	+1.96	79.00	+4.88
3	15-21	0.0	-6.2	32.8	+0.82	20.8	-0.36	75.00	-4.00
4	21-28	0.0	0.0	32.5	+1.42	23.1	+2.21	78.00	+4.22

Positive sign (+) shows increase over the average data and negative sign (-) the decrease

APPENDIX - II. Abstract of analysis of variance for height of trees (m), diameter at breast height (cm), leaf-stem ratio and green fodder yield (kg/plot) of subabul

Source	Df	Mean squares			
		Height of trees	Diameter at breast height	Leaf-stem ratio	Green fodder yield
Block	2	0.073*	0.038	0.157**	13.757
A	1	0.019	0.024	0.388**	85.597*
B	1	0.013	0.000	0.001	23.922
C	2	0.00002	0.001	0.008	0.156
A x B	1	0.001	0.044	0.0001	9.916
B x C	2	0.005	0.005	0.0006	0.531
A x C	2	0.040	0.0017	0.0177**	14.676
A x B x C	2	0.014	0.017	0.023**	6.400
Error	22	0.011	0.012	0.003	14.540

* Significant at 0.05 level.

** Significant at 0.01 level.

A = Subabul spacing

B = Legumes

C = Cereals

APPENDIX - III. Abstract of analysis of variance for dry fodder yield (kg/plot), firewood yield (kg/plot), total biomass yield (kg/plot) and crude protein yield (g/plot) of subabul.

Source	Df	Mean squares			
		Dry fodder yield	Fire wood yield	Total biomass yield	crude protein yield
Block	2	1.138	0.390	2.379	86998.0
A	1	5.473*	4.054	18.993	141488.0
B	1	3.543	0.297	5.918	89038.0
C	2	0.148	6.111	8.000	13619.0
A x B	1	0.090	2.889	3.982	294.0
B x C	2	0.246	0.867	1.741	24171.0
A x C	2	0.638	0.278	1.501	40299.0
A x B x C	2	0.647	0.405	1.704	33169.0
Error	22	1.108	3.517	7.606	52814.7

* Significant at 0.05 level.

A = Subabul spacing
B = Legumes
C = Cereals

APPENDIX - IV. Abstract of analysis of variance for nitrogen content (per cent) and crude protein content (per cent) of stem and leaf portions of subabul fodder.

Source	Df	Mean squares			
		Nitrogen content		Crude protein content	
		Stem	Leaf	Stem	Leaf
Block	2	0.097**	0.140	3.609**	6.960
A	1	0.054*	0.437*	2.646*	17.162*
B	1	0.002	0.003	0.212	0.131
C	2	0.015	0.033	0.870	1.807
A x B	1	0.003	0.121	0.033	4.747
B x C	2	0.025	0.190	0.735	7.459
A x C	2	0.005	0.015	0.211	2.327
A x B x C	2	0.014	0.132	0.390	2.350
Error	22	0.011	0.080	0.423	3.163

* Significant at 0.05 level.

** Significant at 0.01 level.

A = Subabul spacing

B = Legumes

C = Cereals

APPENDIX - V. Abstract of analysis of variance for phosphorus and potassium content (per cent) of stem and leaf portions of subabul fodder

Source	Df	Mean squares			
		Phosphorus content		Potassium content	
		Stem	Leaf	Stem	Leaf
Block	2	0.000004	0.000001	0.00372*	0.0027
A	1	0.00179**	0.0021[illegible]**	0.03423**	0.0044
B	1	0.000087**	0.00021**	0.07934**	0.00003
C	2	0.000036	0.000001	0.06760**	0.00038
A x B	1	0.00056**	0.0007[illegible]*	0.02832**	0.00007
B x C	2	0.000092**	0.000009	0.05129**	0.00603
A x C	2	0.00010**	0.000008	0.01382**	0.13900**
A x B x C	2	0.00004*	0.0000004	0.01964**	0.00617
Error	22	0.00001	0.000008	0.000313	0.00270

* Significant at 0.05 level.

** Significant at 0.01 level.

A = Subabul spacing

B = Legumes

C = Cereals

APPENDIX - VI. Abstract of analysis of variance for growth characters and yield components of cereal

Sl. No.	Plant character		Mean squares Block (2)	A (1)	B (1)	A x B (1)	Error (6)
1	2		3	4	5	6	7
1	Height of the plant (cm)						
	Maize						
	a. 30th day	I	11.554	171.763**	0.0136	0.0292	2.664
		II	14.568**	8.007*	0.164	0.0527	1.127
	b. 60th day	I	102.043	4.812	96.335	75.000	71.208
		II	50.324	179.414**	15.875	4.312	10.274
	c. At harvest	I	99.367	2.250	83.226	82.156	32.330
		II	25.890	152.789**	49.593	1.101	9.108
	Sorghum						
	a. 30th day	I	20.542*	69.118**	0.0517	0.0322	2.177
		II	4.651	46.805*	0.0058	0.0029	4.450

Figures in parenthesis indicate degrees of freedom.

* Significant at 0.05 level
** Significant at 0.01 level

I = First year.
II = Second year.

APPENDIX - VI. Contd.

1	2	3	4	5	6	7
b. 60th day	I	69.341*	88.023**	13.023	24.933	5.957
	II	28.066*	76.507**	12.203	17.519	3.548
c. At harvest	I	65.200*	12.406	0.156	130.680**	9.005
	II	20.500	24.406	6.625	3.468	4.197
Bajra						
a. 30th day	I	15.023**	99.187**	1.148	0.906	0.801
	II	15.781	82.472	0.105	0.515	15.673
b. 60th day	I	168.175	19.460	1.273	14.328	46.513
	II	137.765	13.625	10.812	0.078	70.677
c. At harvest	I	167.726	26.125	4.203	18.000	57.263
	II	129.453	25.812	12.421	3.625	74.195
2. Days to 50 per cent flowering						
a. Maize	I	0.000	0.082	0.032	0.085	0.333
	II	0.083	0.085	0.085	0.078	0.750

Figures in parenthesis indicate degrees of freedom.

* Significant at 0.05 level

** Significant at 0.01 level

I = First year

II = Second year

APPENDIX - VI. Contd.

1	2	3	4	5	6	7
b. Sorghum	I	1.333	8.335*	0.000	0.332	0.888
	II	1.750	14.083**	2.083	0.086	0.750
c. Bajra	I	2.083*	4.082**	0.750	0.083	0.305
	II	1.750	4.083*	0.750	0.820	0.638
3. Days to maturity						
a. Maize	I	0.332	18.750**	0.078	0.085	0.222
	II	0.025	10.085**	0.085	0.078	0.250
b. Sorghum	I	0.085	0.750	2.093*	0.078	0.304
	II	0.083	0.085	0.750	0.082	0.305
4. Length of ear (cm)						
a. Maize	I	0.422*	0.001	5.161**	0.001	0.057
	II	0.821	11.271	2.622	1.710	2.197
b. Sorghum	I	0.975**	1.540**	3.167**	0.020	0.054
	II	1.440**	5.740**	16.100**	0.240	0.070

Figures in parenthesis indicate degrees of freedom,

* Significant at 0.05 level I = First year

** Significant at 0.01 level II = Second year

APPENDIX - VI. Contd.

1	2		3	4	5	6	7
	c. Bajra	I	2.470	1.763	6.453	1.919	2.622
		II	0.138	0.929	14.383	0.116	2.750
5.	No. of seeds/ear						
	a. Maize	I	399.148**	0.500	158.859	0.734	34.604
		II	364.062	413.031	2257.781*	215.031	368.375
	b. Sorghum	I	123.718	13.406	6594.15**	4.468	177.947
		II	1855.594	734.843	19416.600**	14.656	1666.860
	c. Bajra	I	2544.000	9284.000	5834.000	1392.000	2300.000
		II	8278.000	36673.000*	87313.000**	78.000	3971.000
6.	Weight of thousand grains (g)						
	a. Maize	I	118.093	2.656	24.656	1.593	26.119
		II	51.406	2.656	28.531	7.531	38.223
	b. Sorghum	I	1.181	0.292	7.793**	0.498	0.553
		II	0.218	0.004	9.083**	0.424	0.605
	c. Bajra	I	0.207	0.070	0.006	0.033	0.045
		II	0.674	0.492	0.243	0.043	0.188

Figuresiin parenthesis indicate degrees of freedom.

* Significant at 0.05 level
** Significant at 0.01 level

I = First year
II = Second year

APPENDIX - VII. Abstract of Analysis of Variance for growth characters and yield components of legume

Sl. No.	Plant character		Mean squares Block (2)	A (1)	C (2)	A x C (2)	Error (10)
1	2		3	4	5	6	7
1.	Height of the plant (cm)						
	Cowpea						
	a. 30th day	I	4.874*	9.679*	5.104*	0.302	1.161
		II	2.041	9.678	5.483	1.911	2.005
	b. 60th day	I	57.352**	14.222*	3.540	9.750	2.631
		II	42.298**	6.355	3.385	10.384*	2.464
	c. At harvest	I	7.484	27.632**	5.252	2.804	2.484
		II	2.687	11.054	4.355	10.414	3.665
	Blackgram						
	a. 30th day	I	0.400	3.379*	3.002*	0.180	0.454
		II	0.903	0.785	3.183*	2.028*	0.412
	b. 60th day	I	0.775	0.347	1.526*	0.034	0.243
		II	12.702*	3.468	0.987	0.068	1.444

Figures in parenthesis indicate degrees of freedom.

* Significant at 0.05 level — I = First year

** Significant at 0.01 level — II = Second year

APPENDIX - VII . Contd.

1	2		3	4	5	6	7
	c. At harvest	I	0.671	0.043	2.220*	0.123	0.276
		II	12.732*	3.125	0.939	0.082	1.456
2.	Number of nodules/plant						
	a. Cowpea	I	1.400	63.843**	46.384**	0.185	0.791
		II	0.521	58.320**	45.893**	1.831	1.791
	b. Blackgram	I	1.886	0.055	9.664*	2.827	1.836
		II	0.406	37.844**	9.101**	0.222	0.868
3.	Weight of nodules/plant (mg)						
	a. Cowpea	I	14.884*	39.046**	1.273	5.330	2.964
		II	4.352	91.126**	2.355	26.054*	3.499
	b. Blackgram	I	4.267*	3.647	1.747	9.493**	0.844
		II	1.235	45.125**	0.875	4.625	2.334
4.	Days to 50 per cent flowring						
	a. Cowpea	I	0.389	3.554*	2.056*	0.054	0.389
		II	0.166	0.890*	2.166**	0.388	0.166

Figures in parenthesis indicate degrees of freedom.

* Significant at 0.05 level
** Significant at 0.01 level

I = First Year
II = Second year

APPENDIX - VII. Contd.

1	2		3	4	5	6	7
	b. Blackgram	I	0.666	2.722*	1.166	0.054	0.400
		II	0.888	3.594*	1.555	0.222	0.638
5.	Days to maturity						
	a. Cowpea	I	0.054	0.062	6.054**	0.054	0.589
		II	0.695	8.000	23.167*	6.164	5.033
	b. Blackgram	I	0.722	2.000*	2.390*	2.167*	0.321
		II	0.667	2.000*	3.167**	1.164*	0.200
6.	Number of pods/plant						
	a. Cowpea	I	0.020	0.077	1.027	0.053	0.950
		II	0.490	1.075	1.827*	0.066	0.282
	b. Blackgram	I	0.375	0.500	3.375	0.125	1.675
		II	1.920	1.680	1.535	0.008	0.555

Figures in parenthesis indicate degrees of freedom.

* Significant at 0.05 level

** Significant at 0.01 level

I = First year

II = Second year

APPENDIX - VII. Contd.

1	2		3	4	5	6	7
7.	Length of pod (cm)						
	a. Cowpea	I	0.245	0.0004	0.202	0.684	0.756
		II	0.327	0.0576	0.345	1.052	0.398
	b. Blackgram	I	0.014	0.002	0.0150	0.003	0.010
		II	0.013	0.013	0.0008	0.091	0.658
8.	Number of seeds/pod						
	a. Cowpea	I	0.661	0.579	7.126**	8.117*	0.940
		II	1.919	8.053*	1.343	0.876	0.585
	b. Blackgram	I	0.900	0.079	1.139	1.531*	0.363
		II	0.354	0.845	3.472**	0.795*	0.101
9.	Weight of thousand grain (g)						
	a. Cowpea	I	84.757**	3.578	9.187	0.101	4.920
		II	80.375	56.531	51.851	9.585	25.270
	b. Blackgram	I	4.381*	0.203	2.683	0.249	1.010
		II	7.724*	1.503	31.457**	0.413	0.857

Figures in parenthesis indicate degrees of freedom.

* Significant at 0.05 level — I = First year

** Significant at 0.01 level — II = Second year

APPENDIX - VIII. Abstract of analysis of variance for the dry matter yield (kg/plot) at different growth stages and grain yield (kg/plot) of cereal.

Source	Df		Mean squares			
			Dry matter yield			Grain yield
			30th day	60th day	at harvest	
Block	2	I	0.984*	0.329	1.008	0.105
		II	0.107	0.012	1.549	1.398*
A	1	I	0.958**	1.809*	12.924**	0.785*
		II	0.394**	5.476**	22.039	2.138*
B	1	I	1.019**	0.004	4.354**	0.735*
		II	0.103	5.798	12.156**	2.684**
C	2	I	7.842**	15.456**	1.169	1.361**
		II	6.129**	4.312**	12.725**	2.837**
A x B	1	I	0.064	1.073	0.287	0.135
		II	0.146	0.152	0.834	0.512
B x C	2	I	0.244*	0.488	0.228	0.112
		II	0.285**	1.744**	1.592	0.248
A x C	2	I	0.172*	0.531	0.368	0.337
		II	0.021	1.341**	1.314	0.492
A x B x C	2	I	0.723**	0.957*	0.127	0.009
		II	0.633**	1.857**	1.349	0.109
Error	22	I	0.040	0.257	0.403	0.143
		II	0.035	0.144	0.777	0.273

* Significant at 0.05 level, I = First year.

** Significant at 0.01 level, II = Second year.

APPENDIX - IX. Abstract of analysis of variance for the dry matter yield (kg/plot) at different growth stages and grain yield (kg/plot) of legume.

Source	Df		Mean squares: Dry matter yield: 30th day	60th day	at harvest	Grain yield
Block	2	I	0.002	0.213	0.139	0.1170*
		II	0.0001	0.112	0.133	6.1724**
A	1	I	0.005	0.008	0.001	0.0199
		II	0.020	0.344	0.409	0.1230*
B	1	I	0.253**	0.210	0.199	0.0004
		II	0.338**	1.180**	1.261*	0.0001
C	2	I	0.757**	1.802**	2.192**	0.2298**
		II	0.081**	3.450**	3.488**	0.4426**
A x B	1	I	0.005	0.382	0.253	0.0026
		II	0.004	0.659	0.065	0.0031
B x C	2	I	0.115	0.262	0.115	0.0034
		II	0.010	0.422	0.422	0.0782*
A x C	2	I	0.004	0.330	0.053	0.0258
		II	0.009	0.389	0.049	0.0011
A x B x C	2	I	0.095	0.098	0.022	0.0263
		II	0.015	0.126	0.133	0.0319
Error	22	I	0.003	0.608	0.092	0.0087
		II	0.004	0.323	0.357	0.0090

* Significant at 0.05 level, I = First year.

** Significant at 0.01 level, II = Second year.

APPENDIX - X. Abstract of analysis of variance for total yield (cereal + legume) of dry matter at different growth stages and the total yield of grain (kg/plot)

Source	Df		Mean squares			
			Dry matter yield			Grain yield
			30th day	60th day	at harvest	
Block	2	I	0.122	0.759	0.712	0.111
		II	0.100	0.938	1.853	2.350*
A	1	I	0.108**	1.783*	13.135**	1.249*
		II	0.494**	14.493**	28.396**	3.269*
B	1	I	0.262*	0.313	2.717*	0.845*
		II	0.068	2.284**	5.700*	2.460*
C	2	I	6.639**	9.853**	4.367**	0.771*
		II	4.989**	15.887**	26.147**	3.292*
A x B	1	I	0.101	0.706	0.015	0.259
		II	0.198*	0.030	0.021	0.587
B x C	2	I	0.210*	0.566	0.483	0.156
		II	0.374**	1.181	1.629	0.256
A x C	2	I	0.222*	0.182	0.156	0.199
		II	0.043	2.070**	1.338	0.211
A x B x C	2	I	0.654**	0.135	0.239	0.011
		II	0.562**	2.599**	1.138	0.243
Error	22	I	0.507	0.386	0.622	0.142
		II	0.038	0.281	0.835	0.241

* Significant at 0.05 level, I = First year.

** Significant at 0.01 level, II = Second year.

APPENDIX - XI. Abstract of pooled analysis of variance for the dry matter and grain yield of legume, cereal and their total (kg/plot) at harvest

Source	Df	Mean squares					
		Dry matter yield			Grain yield		
		Legume	Cereal	Total	Legume	Cereal	Total
Block	2	0.11	1.09	0.67	3.00	0.57	0.74
A	1	0.23*	34.27*	40.05**	0.12	2.75**	5.11*
B	1	1.24	15.47*	8.01**	0.0003*	2.96**	2.04*
C	2	5.60*	10.24*	25.87**	0.67*	3.65**	2.61*
D	1	2.75*	3.11*	11.81**	0.18*	3.31**	1.16*
A x B	1	0.29	0.33	0.004	0.004	0.58	0.26
B x C	2	0.44	1.52	1.97	0.004	0.33	0.06
A x C	2	0.04	0.86	1.16	0.10	0.54	0.40
A x D	1	0.18	0.59	1.44	0.01	0.16	0.65

* Significant at 0.05 level,
** Significant at 0.01 level,

A = Subabul spacing
B = Legumes
C = Cereals
D = Seasons (years)

APPENDIX - XI. Contd.

Source	Df	Mean squares					
		Dry matter yield			Grain yield		
		Legume	Cereal	Total	Legume	Cereal	Total
B x D	1	0.23	0.96	0.25	0.00	0.25	0.06
C x D	2	0.08	3.71*	4.58 *	0.01	0.34	0.49
A x B x C	2	0.62	0.33	0.24	0.05 *	0.06	0.12
A x B x D	1	0.03	0.03	0.001	0.0001	0.06	0.006
A x C x D	2	0.059	0.50	0.27	0.005	0.28	0.60
B x C x D	2	0.089	0.31	0.17	0.001	0.02	0.03
A x B x C x D	2	0.090	1.18	1.17	0.003	0.05	0.007
Pooled Error	44	0.230	0.590	0.728	0.008	0.208	0.191

* Significant at 0.05 level,
** Significant at 0.01 level,

A = Subabul spacing
B = Legumes
C = Cereals
D = Seasons (years)

APPENDIX - XII. Abstract of analysis of variance for the uptake (kg/ha) of nitrogen, phosphorus and potassium at harvest by cereal

Source	Df		Mean squares		
			Nitrogen	Phosphorus	Potassium
Block	2	I	0.490	2.518	6.251
		II	121.780	7.646 *	35.769
A	1	I	405.000*	21.754**	406.906**
		II	756.014*	48.594**	850.850**
B	1	I	119.670*	14.264*	82.197**
		II	487.941**	24.529*	124.71
C	2	I	24.77	81.891*	1566.114**
		II	764.477**	48.331**	734.26 **
A x B	1	I	9.031	0.019	34.927
		II	12.158	0.283	10.126
B x C	2	I	60.218	2.017	0.445
		II	128.296	2.085	29.706
A x C	2	I	4.376	2.559	14.296
		II	14.501	0.210	37.874
A x B x C	2	I	0.927	0.242	2.320
		II	34.530	0.495	35.050
Error	22	I	22.407	1.821	9.862
		II	39.094	1.205	40.954

* Significant at 0.05 level, I = First year.

** Significant at 0.01 level, II = Second year.

APPENDIX - XIII. Abstract of analysis of variance for the uptake (kg/ha) of nitrogen, phosphorus and potassium at harvest by legume

Source	Df		Mean squares		
			Nitrogen	Phosphorus	Potassium
Block	2	I	44.03	0.05	14.69
		II	33.65	0.47	5.26
A	1	I	17.136	1.005*	1.41
		II	121.160	2.010	36.52
B	1	I	48.98	2.35**	232.61**
		II	68.33	5.64**	427.86**
C	2	I	505.29**	3.42**	50.37**
		II	665.77**	4.69**	64.93**
A x B	1	I	8.98	0.10	1.99
		II	22.13	0.04	1.57
B x C	2	I	70.07	0.15	2.80
		II	216.28**	0.04	0.29
A x C	2	I	102.26	0.16	2.95
		II	4.55	0.32	0.46
A x B x C	2	I	27.30	0.50	2.10
		II	28.00	0.42	2.27
Error	22	I	35.48	0.21	3.54
		II	58.21	0.63	9.09

* Significant at 0.05 level, I = First year.
** Significant at 0.01 level, II = Second year.

APPENDIX - XIV. Abstract of analysis of variance for the total (cereal + legume) uptake (kg/ha) of nitrogen, phosphorus and potassium at harvest

Source	Df		Mean squares Nitrogen	Phosphorus	Potassium
Block	2	I	37.90	2.40	5.68
		II	242.96	13.96	124.36
A	1	I	588.56**	31.43**	460.34**
		II	1482.48**	83.13**	1229.94**
B	1	I	321.85**	5.30	37.09
		II	191.04	2.19	66.98
C	2	I	753.79**	55.61**	1161.24**
		II	2655.33**	32.98**	430.07**
A x B	1	I	0.02	8.15	19.38
		II	67.10	5.78	3.18
B x C	2	I	10.35	2.13	5.10
		II	199.82	4.76	31.35
A x C	2	I	67.15	1.50	7.24
		II	15.38	2.29	30.38
A x B x C	2	I	24.53	0.80	8.66
		II	7.62	0.85	40.87
Error	22	I	60.81	2.30	18.19
		II	60.00	2.22	41.46

* Significant at 0.05 level, I = First year.

** Significant at 0.01 level, II = Second year.

APPENDIX - XV. Abstract of analysis of variance for the crude protein yield of cereal, legume and their total yield (g/plot) at harvest

Source	Df		Mean squares		
			Cereal	Legume	Total (cereal + legume)
Block	2	I	301.08	6679.05	6190.85
		II	1379.85	20237.05*	11752.69
A	1	I	5683.3	2676.29	80038.46*
		II	118696.3**	49315.12*	301899.30 **
B	1	I	23752.93*	7046.75	41194.51
		II	76705.03**	3664.73	55796.50
C	2	I	4568.97	78947.95**	115676.15**
		II	119622.90**	126518.15**	335601.80**
A x B	1	I	2816.81	2009.82	415.89
		II	1828.08	10328.63	1179.90
B x C	2	I	11657.89*	15980.91	661.60
		II	20253.29	1332.75*	13599.90
A x C	2	I	1113.20	11254.23	11991.34
		II	2337.73	47974.54*	285.68
A x B x C	2	I	670.55	3962.94	5522.40
		II	5274.39	392.20	3020.99
Error	22	I	3131.69	5544.63	10237.92
		II	6060.95	5629.62	15145.40

* Significant at 0.05 level, I = First year.

** Significant at 0.01 level, II = Second year.

APPENDIX - XVI. Abstract of analysis of variance for total biomass yield and total crude protein yield (kg/plot) and total nitrogen, available phosphorus and available pottassium (kg/ha) content of soil after the experiment

Source	Df	Mean squares				
		Total yield of system		Soil content of		
		Biomass	Crude protein	Total N	Available P	Available K
Block	2	5.379	0.172	3444.0	1.517	0.402
A	1	167.042**	1.460**	1111112.0*	11.167**	0.695
B	1	46.993**	0.537**	217776.0**	4.767*	8.230*
C	2	17.373	0.676**	2011112.0**	0.033	59.900**
A x B	1	2.401	0.000001	4448.0	0.593	0.605
B x C	2	1.869	0.0023	14444.0	1.730	0.666
A x C	2	6.196	0.093	3444.0	0.291	0.193
A x B x C	2	1.926	0.023	7076.0	0.611	0.152
Error	22	6.335	0.0615	15050.5	1.020	1.411

* Significant at 0.05 level,
** Significant at 0.01 level,

A = Subabul spacing
B= Legumes
C = Cereals

BIOMASS PRODUCTION IN AN AGROFORESTRY SYSTEM INVOLVING FOOD AND FODDER CROPS

By

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ABSTRACT OF THE THESIS
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ABSTRACT

An experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani, during the period from Apr. 1984 to Nov. 1985, with the object of finding out the biomass production in an agroforestry system involving food and fodder crops and also to select the most suitable cereal-legume combination to be grown as intercrop under different plant densities of subabul. Subabul was planted at 3 x 1 m and 4 x 1 m spacings six months prior to the planting of annual crops in 1984. Annual legumes (cowpea and blackgram) and cereals (maize, sorghum and bajra) were planted in alternate rows in the space between the rows of subabul. Subabul foliage was pruned and applied as green manures to the annual crops 15 days before planting and at every 15 days interval after planting upto the 60th day in the first year. Subsequent prunings at every 15 days interval till the planting of annual crops in July, 1985 were recorded as green fodder. Subabul foliage was pruned and applied as green manures to the annual crops at every 15 days interval after planting upto the 60th day in the second year also. Subsequent prunings at every 15 days interval till the harvesting of annual

crops were recorded as green fodder. The experiment was laid out as a factorial experiment in randomised block design with three replications.

Results from the investigation revealed that the leaf-stem ratio of subabul fodder was highest when subabul was planted 4 x 1 m spacing. Nitrogen and crude protein content of leaf and stem, and phosphorus content of stem portions of fodder were the highest at 4 x 1 m spacing of subabul

Green fodder and dry fodder yield were maximum under 3 x 1 m spacing of subabul. Phosphorus content of leaf and potassium content of stem portions of fodder were the highest under high plant densities of subabul.

In the case of annual crops, ear length of sorghum, number of grains/ear of bajra and number of seeds/pod of cowpea were the highest under subabul planted at 3 x 1 m spacing. Dry matter and grain yields of annual legumes and cereals were the highest when grown under subabul planted at 3 x 1 m spacing.

Maximum total biomass production was recorded from the Agroforestry system consisting of subabul, sorghum and blackgram. In terms of grain yield, 'maize and blackgram' was found to be the best combination of annual cereal and legume that can be grown as intercrop with subabul.

Intercropping annual cereals and legumes under 3 x 1 m spacing of subabul was found to be more profitable than intercropping under 4 x 1 m spacing and maize + blackgram under 3 x 1 m spacing of subabul was the best combination in terms of grain yield and profitability.