INTERCROPPING IN COTTON G.Cot.Hy.10 UNDER IRRIGATED CONDITION

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ABSTRACT

A field experiment was conducted during the *kharif* season of 1998-99 at the Main Cotton Research Station, Gujarat Agricultural University, Surat on heavy black soil to study the effect of intercropping in cotton G.Cot.Hy.10 under irrigated condition.

Eight treatments consisting of cotton alone, cotton + groundnut, cotton + greengram, cotton + blackgram, cotton + soyabean, cotton + cowpea, cotton + maize and cotton + pigeonpea were tried in Randomized block design with four replications.

Inclusion of intercrops in cotton viz. groundnut, greengram, blackgram, cowpea did not affect plant height, number of monopodial and sympodial branches and number of bolls/plant and consequently yield of main cotton crop as compared to cotton alone. Inclusion of these intercrops increased total production

per unit area per year. The total production potential in terms of seed cotton equivalent was maximum in cotton + blackgram (3801 kg/ha) followed by cotton + greengram (3782 kg/ha), cotton + cowpea (3355 kg/ha) and cotton + groundnut (3151 kg/ha) in comparison with cotton alone (3094 kg/ha). Lowest cotton equivalent yield was obtained when maize was intercropped with cotton.

Boll weight, days to 50 per cent squaring; 50 per cent flowering; 50 per cent boll setting and 50 per cent boll bursting and quality characters of cotton viz. ginning percentage, lint index, seed index, 2.5 per cent span length, bundle strength, uniformity ratio, fibre fineness and maturity co-efficient were not affected by different intercropping systems as compared to cotton alone.

Maximum net returns of Rs.47670/ha was obtained in cotton + blackgram with cost benefit ratio of 2.89 followed by cotton + greengram Rs.47026/ha with cost benefit ratio of 2.85 and cotton + cowpea Rs.38599 with cost benefit ratio of 2.52.

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CERTIFICATE

This is to certify that the thesis entitled **INTERCROPPING IN COTTON G.Cot.Hy.10 UNDER IRRIGATED CONDITION** submitted by **Shri DIVYESHKUMAR DURLABHBHAI PATEL** in partial fulfilment of the requirements for the award of the Degree of **MASTER OF SCIENCE (AGRICULTURE)** in the subject of **AGRONOMY** of the Gujarat Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Navsari
Date : 15th April, 2000

(**P. G. Patel**)
Major Advisor

DECLARATION

This is to declare that the whole of the research work reported in this thesis for partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY** by the undersigned is the result of investigation done by him under the direct guidance and supervision of **Dr.P.G.Patel**, Professor and Head, Department of Agronomy, N.M.College of Agriculture, Gujarat Agricultural University, Navsari Campus, Navsari and that no part of the work has been submitted for any other degree so far.

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Place : Navsari

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(D. D. Patel)

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INTRODUCTION

I INTRODUCTION

Cotton "King of Fibre" is one of the most ancient and important commercial crop next only to foodgrains. The current status of cotton production and consumption pattern shows that India has made major strides since independence from net importer to self sufficiency and a marginal exporter of raw cotton. The share of cotton in textile is around 50 per cent globally whereas, in India it is around 65 per cent. In addition, it directly or indirectly provides huge employment in rural as well as urban sectors. Apart from its value as fibre, the potential of cotton in uses such as edible oil (seed oil) and other byproducts like particle board, paper, corrugated boxes is enormous. Only a part of this potential is now realised at present.

India ranks first in the world in respect of area in cotton and has a fourth place in total production. In India, cotton is grown on 91.12 lakh hectares area with a production of 161.5 lakh bales and an average productivity of 301 kg per hectare during 1998-99.

Cotton is one of the most important cash crop of Gujarat, grown on about 17.0 lakh hectare. Out of the total area under cotton, about 27 per cent is under irrigated and 73 per cent is under rainfed condition. The coverage of different species is 51.4 per cent in herbaceum, 8 per cent in hirsutum, 2.5 per cent in arboreum and 38.1 per cent in hybrids. Though Gujarat ranks second in area but ranks first in production among cotton growing states of India with a production of 45 lakh bales and an average productivity of 451 kg lint per hectare during 1998–99. Which is higher than national productivity of 305 kg lint/ha but much below the world average productivity of 600 kg lint/ha (Anon., 1999).

Cotton being a long duration, widely spaced crop, slow in germination and growth and takes two to three months for the interspace to be covered by the

canopy. In this period weeds come up in the unutilized space and compete with cotton crop for the available moisture, nutrients and sun light. So this period offers greatest potentiality to exploit the conditions for raising an intercrop in the vacant interspace between the rows of cotton and reduced the competition of weeds is greatly. Solaiappan and Chellaiah (1998) reported that intercropping of cotton + blackgram reduced the weed density and dry matter. Such depressive effect on weed growth due to legume intercropping was also reported earlier by Chatterjee and Mandal (1992) and Thakur (1994). Waterworth (1994) also suggested that a crop such as cotton which both tolerates a wide range of population density and has a late developing leaf canopy may be particularly well suited to intercropping.

Intercropping is not only serve as an insurance against total crop failure but also reduce soil erosion if the plants of the subsidiary crops have a trailing habit. The current concept of intercropping is to maintain optimum plant population of both component crops by adjusting crop geometry.

In Gujarat generally cotton is grown as mono crop. This mono cropping is risky and some times leads to complete failure of cotton crop particularly in rainfed area due to inadequate, erratic and unevenly distribution of rainfall. Monocropping system of cotton is also found to be conducive for development, build up and resurgence of different pests. It has been reported that monocropping of cotton is found to be conducive for pest development than cotton–rice, cotton–groundnut and cotton–cowpea or cotton–soyabean polyculture. The intercropping of cowpea, groundnut and *Setaria italica* in cotton reduced the damage caused to bolls by bollwarms and increase the seed cotton yield. Some of these systems also help to increase the abundance of predators and parasites in the cotton systems and thereby eliminate the process of laboratory multiplication of these natural enemies for the field releases (Anon., 1984).

The main principle involved in selecting intercrops are that they should not be competitive with the main crop for soil moisture, nutrients and sunlight. Considerable work has been done in selecting suitable crops like greengram, blackgram, soyabean, maize, pigeonpea, groundnut and cowpea were found suitable for intercropping in cotton. Shortage of oilseeds, legumes and pulses in the country have focussed the attention on intercropping systems which have capacity to improve the physical, biological and chemical properties of soil.

At present the monetary returns from cotton crop leads to decrease with increase in cost of inputs. In such situations, with a view to enhance the net income from unit area, intercropping appears to be the most feasible approach for increasing the total productivity and thereby higher monetary returns. Patel *et al.*(1995) revealed that cotton G.Cot.Hy.6 intercropped with soybean (G.1), uridbean (Zandewal) and mungbean (G-2) gave an additional profit than cotton alone.

Keeping in view the above points, the present investigation entitled "Intercropping in cotton G.Cot.Hy.10 under irrigated condition" was planned and conducted at the Main Cotton Research Station, Gujarat Agricultural University, Surat during *kharif* season of 1998-99 with the following objectives :

1. To evaluate the effect of different intercrops on growth, yield attributes and yield of cotton G.Cot.Hy.10.
2. To study the effect of different intercrops on quality characters of cotton G.Cot.Hy.10.
3. To findout suitable intercrop for cotton G.Cot.Hy.10.
4. To workout the economics of different treatments.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Intercropping, an important feature of crop production, is mostly considered as an insurance against vagaries of weather or natural calamities in India. Recently intercropping has been recognised as a potentially beneficial system of crop production and research evidence also suggests that intercopping can provides substantial yield advantages compared to sole cropping by simple expedient of growing crops together. Intercropping of cotton with legume or non legume crops is a common practice in India.

The present investigation "Intercropping in cotton G.Cot.Hy.10 under irrigated condition" was conducted. Attempts are, therefore, made here to present a brief summary of research work done in India and abroad on this aspect under following heads.

2.1 Effect of intercropping systems on yield of cotton

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2.2 Effect of intercrops on growth and yield attributes of cotton

2.3 Effect of intercrops on quality characters of cotton

2.4 Economics of intercropping

2.1 Effect of intercropping systems on yield of cotton

2.1.1 Cotton + Groundnut :

Giri and Upadhyay (1979) conducted an experiment under rainfed conditions on medium black soils (clayey) at Cotton Research Station, Marathawada Agricultural University, Parbhani during 1975-76 and 1976-77 and reported that cotton + groundnut intercropping was beneficial as the yields of seed cotton obtained from intercropping was at par with the yield obtained in cotton solid (normal) planting and paired row planting.

From experimental results, Birajdar *et al.*(1980) at Parbhani identified that intercropping of groundnut in between the two rows of irrigated cotton had no adverse effect on cotton yield and gave additional yields of 819 kg pods per hectare.

Bavale and Vyahalkar (1981) observed that intercropping of groundnut cv. S.B.XI in cotton cv. Godavari reduced the yield of seed cotton significantly as compared with cotton alone.

From the results of field experiment carried out at Amreli, Gujarat during 1985-86 and revealed that cotton planted at 60 x 30 cm spacing as sole crop gave significantly higher seed cotton yield (690 kg/ha) than cotton planted at 90 x 20 cm and intercropped with groundnut (454 kg) (Anon., 1986).

Deshpande *et al.*(1989) reported that yield of cotton intercropped with groundnut was decreased by 30.7 per cent compared with yield of seed cotton in pure stands but gross monetary returns increased because of groundnut gave an additional yield of 712 kg/ha.

A field experiment carried out by Prasad *et al.*(1989) from 1979-80 to 1981-82 on deep black soils belonging to Bellary in Karnataka and showed that seed cotton yield reduced by intercropping of groundnut.

Balkar *et al.*(1990) revealed that cotton + groundnut intercropping gave average seed cotton yield of 0.87 t/ha was lowered as compared with 1.04 t/ha for cotton in pure stands, but net return and LER were significantly increased.

Koraddi *et al.*(1990) found that cotton cv. Jayadhar + groundnut cv. Spanish intercropping system increased total yield and financial returns than in pure stands of cotton at Dharwad.

Koraddi *et al.*(1991) conducted an experiment in 1981-82 and 1982-83 at Dharwad and revealed that cotton cv. Sharada + groundnut cv. Spanish improved intercropping reduced seed cotton yield by 41-47 per cent compared with pure stands of cotton crop but had less effect on groundnut yields and increased total yield per hectare and approximately double net income obtained than cotton grown alone.

Palchamy *et al.*(1991) conducted an experiment in 1984-86 at Madurai, Tamil Nadu on groundnut and cotton (direct sown) were grown alone or groundnuts were intercropped with direct sown or transplanted cotton and reported that groundnut intercropped with direct seeded cotton gave significantly higher yield as well as higher net return.

An experiment conducted in the rainy seasons at 1986-88 at Akola, Maharashtra and reported that increase in seed cotton yield with sole cotton was 33.09 per cent compared with cotton + groundnut intercropping system (Shethi *et al.*, 1992).

An experiment was conducted during the rainy seasons of 1986-88 at Ghumusar Udayagiri, Orissa by Padhi *et al.*(1993) and they reported that the maximum reduction in cotton yield (20.64%) was found with groundnut, followed by finger millet (16.10%) and rice (13.61%) compared with sole cotton in normal planting.

Prasad *et al.*(1993) conducted an experiment in the rainy seasons of 1989-90 at New Delhi and reported that cotton + groundnut intercropping gave highest seed cotton equivalent yield followed by cotton + greengram intercropping and lowest with sole cotton.

Wankhade (1994) reported that cotton + groundnut intercropping decreased seed cotton yield by 25.5 per cent but monetary returns was greater than obtained with the sole cotton crop.

Waterworth (1994) concluded that there was no advantage from cotton + groundnut intercropping in the low rainfall area but found advantageous in the high rainfall area.

Patel *et al.*(1995) reported that seed cotton yield reduced numerically by intercropping of groundnut G.2 as compared to sole crop of cotton and reduction in seed cotton yield was not compensated by yield of groundnut.

2.1.2 Cotton + Greengram :

Giri and Upadhyay (1979) indicated that greengram was beneficial as the yield of seed cotton obtained in intercropping treatment was at par with the yield obtained in solid (normal) planting and paired row planting.

Nagre (1979) conducted an experiment on intercropping of cotton with mung, cowpea, tur, sesamum and sunflower at Punjabrao Krishi Vidhyapeeth, Akola, during *kharif* seasons of 1973 and 1974 and reported that in both the seasons cotton yield from pure crop of cotton and cotton + mung intercropping system were at par and both recorded significantly more yield than the other intercropping systems. Cotton + mung intercropping system recorded 48.49 per cent more total yield than pure crop of cotton.

Bavale and Vyahalkar (1981) conducted an experiment from 1977 to 1980 at Nanded and reported that seed cotton yield reduced significantly by intercropping of cotton with greengram as compared with sole cotton crop.

An experiment was conducted during winter season of 1977 on clay loam soil at Coimbatore, Tamil Nadu, on MCU-5 cotton and observed that raising cotton in paired row along with three rows of greengram has a complementary effect of legume in increasing the seed cotton yield. The maximum seed cotton yield of 1316 kg/ha was realised from cotton with 3 rows of greengram combination (Kunasekaran and Iruthayaraj, 1981).

Jain *et al.*(1982) conducted an experiment during 1979-80 and 1980-81 and reported that cotton + mung intercropping gave an average seed cotton yield of 1575 kg/ha which was lowered than seed cotton yield obtained from cotton grown alone (1624 kg/ha). Mung gave an additional yield of 285 kg/ha which was well compensated the reduction of seed cotton yield.

Field study was conducted on intercropping in cotton at the Indian Agricultural Research Institute, Regional Station, Sirsa and reported that cotton + mung intercropping reduced seed cotton yield as compared with cotton alone which was well compensated by additional yield of mungbeans (Rao, 1982).

Shaktawat and Singh (1985) conducted the field experiments on heavy clay loam soils of Udaipur in 1977-78 and 1978-79. They observed that greengram as an intercrop did not appreciably reduce the seed cotton yield and has no effect on the cotton stalk yield.

A field trial was planned during *kharif* season of 1983 at HAU, Hissar on sandy loam soil. From the results, Sheoran and Malik (1986) realised that inclusion of greengram in cotton slightly reduced the yield of seed cotton due to suppression of cotton growth in early stages. Moreover, additional yield of 4.5 q/ha of greengram was obtained in intercropping system.

Deshpande *et al.*(1989) reported from three years rainfed trials (1983-86) that cotton cv. AHH-468 + greengram intercropping decreased seed cotton yield by 11.7 per cent as compared with yield in pure stands of cotton, but gross

monetary return was not affected because of greengram gave an additional yield of 265 kg/ha.

Hasnam and Sulistyowati (1989), while working on performance of cotton varieties under intercropping with greengram at Malang, Indonesia in 1986 and 1987, screened out that seed cotton yields decreased from 2.91 to 1.79 t/ha when intercropped with greengram in 1986 and from 1.49 to 0.69 t/ha in 1987.

From the results of the field trials at Bellary, Karnataka in 1979-80 to 1981-82 on deep black soil, Prasad *et al.*(1989) reviewed that cotton intercropped with greengram yielded 3063 kg/ha compared with single crop of cotton (2945 kg/ha). Moreover, greengram gave an additional yield of 572 kg/ha.

Koraddi *et al.*(1990) conducted an experiment during 1978-79 and 1979-80 at Dharwad and reported that Cotton cv. Jayadhar + greengram cv. China mung intercropping gave mean seed cotton yield of 0.59-0.72 t/ha, while in pure stands of cotton gave 0.79 t/ha in *kharif* and 0.58 t/ha in *rabi* season.

Rao (1991) conducted an experiment in the *kharif* season of 1983-84 at Adilabad, Andhra Pradesh and reported that there were no significant differences in cotton yield when grown alone (585 kg/ha) or intercropped with greengram and blackgram (400599 kg/ha).

Sagare *et al.*(1992) indicated from a field investigation on montmorillonitic soil in India with 1.5 per cent slope that intercropping greengram with cotton increased seed cotton yield over cotton monoculture by 45 per cent and increased residual soil nitrogen by 57 kg/ha.

Sethi *et al.*(1992) reported that reduction in seed cotton yield with intercropping greengram was 20.7 per cent compared with sole cotton.

From the results of an experiment conducted during rainy seasons of 1986-88 on a well drained sandy-loam soil at Ghumusar Udayagiri, Padhi *et al.*(1993)

observed minimum reduction in cotton yield (10.1%) in association with greengram compared with sole cotton in normal planting.

Prasad *et al.*(1993) reported that cotton + greengram intercropping gave higher cotton equivalent yield than yield equivalent obtained from cotton alone.

Satao *et al.*(1993) reported that intercropping of mung in short duration SRT-1 variety of cotton could not be advocated as there was 45 per cent reduction in cotton yield as compared to sole crop of cotton.

Solaiappan *et al.*(1993) conducted an experiment at Srivillipur, Tamil Nadu in the 1985-86 summer seasons and revealed that the Kapas yield obtained from sole crop of cotton was significantly higher than the cotton intercropped with greengram in both the years.

Yadav *et al.*(1993) showed that cotton + greengram intercropping did not reduce seed cotton yield significantly.

Balasubramanian *et al.*(1994) conducted an experiment in summer 1980 at Cotton Research Station, Srivilliputhur, Tamil Nadu and reported that cotton + greengram intercropping did not reduce seed cotton yield significantly as compared to sole crop of cotton.

Jaganathan *et al.*(1994) conducted an experiment at Coimbatore, Tamil Nadu on intercropping in cotton TCH-665 and MCU-9 with 4 varieties of greengram and concluded that greengram variety T-44 and NPRG-3 are more suitable for intercropping in cotton variety TCH-665.

Khistaria *et al.*(1994) reported that greengram is profitable inter crop with the base crop of cotton grown on medium black soils of Saurasthra.

Mukerji and Verma (1994) reported that cotton yield was not significantly affected by cotton + greengram intercropping as compared with sole cotton crop.

Renganayaki and Subramanian (1994) conducted an experiment at Kovilangulam, Tamil Nadu and revealed that greengram Cv. Co BG-304

intercropped with cotton Cv.MCU-10 in a row ratio of 1:1 gave the highest cotton equivalent yield of 1353 kg/ha than cotton grown alone.

Intercropping 'ML 131' greengram with cotton in different row ratios did not record significant reduction in seed cotton yield, except in 1:1 row ratio of cotton + greengram compared with sole crop under square and paired-row planting in 1988. In 1989 the planting of greengram in paired row significantly decreased the seed cotton yield compared with sole crop in square planting. While, comparing seed cotton yield (1281 kg/ha) of sole cotton in paired rows, a decline was noticed due to intercropping of greengram in all the planting systems except 2:1 row proportion of cotton + greengram (Tomar *et al.*,1994).

Wankhade (1994) revealed that cotton (AKA 8401) + greengram (TAG 24) intercropping decreased seed cotton yield by 34.4 per cent as compared with sole cotton crop.

Patel *et al.*(1995) reported from three year experiment during 1987-90 at Surat, Gujarat that cotton cv. G.Cot.Hy.6 intercropped with greengram cv. G-2 and cv. K-851 gave numerically more seed cotton equivalent yield than cotton grown alone.

In a field trial in winter 1985 at Coimbatore, Lourduraj and Chinaswami (1996) revealed that the seed cotton yield of sole crop of cotton (1580 kg/ha) was on par with cotton intercropped with greengram (1527 kg/ha).

The study was initiated under irrigated condition on medium black soils at Arabhavi, Karnataka during 1990-93 by Rameshbabu *et al.* (1996) and they reported that cotton + greengram intercropping significantly reduced seed cotton yield as compared with sole short duration cotton crop.

Sharma *et al.*(1997) conducted an experiment during rainy seasons of 1992-93 to 1994-95 at Diphu, Assam to study the compatibility of intercropping of greengram and sesamum and observed non significant differences in seed

cotton yield among sole and intercropped treatments. However, reduction in yield varied from 4 to 18 per cent and 17 to 33 per cent in upland and deshi cotton. They further reported that total productivity in terms of cotton equivalent was increased in intercropping treatments. The increased in cotton equivalent was to the tune of 65 per cent and 191 per cent in upland and deshi cotton, respectively.

Intercropping greengram cv. ML-131 with cotton cv. Vikram did not produce significant reduction in cotton yield as compared with sole crop under square and paired row planting (Tomar *et al.*,1997).

2.1.3 Cotton + Blackgram :

Sanandachari *et al.*(1980) conducted an experiment during the years 1975-76 and 1976-77 and reported that in the first year of trial, normal method of planting with two rows of black gram recorded minimum reduction in seed cotton yield (39 kg/ha) compared to control besides giving an additional yield of 103 kg/ha of blackgram. In the second year, there was considerable increase (193 kg/ha) in seed cotton yield in the treatment as compared to that of control and the yield of blackgram was also maximum (593 kg/ha).

Bavale and Vyahalkar (1981) reported that cotton + blackgram intercropping gave slight reduction in cotton yield to the extent of 3 per cent and extra production of 280 kg/ha of blackgram.

Jain *et al.*(1982) observed that cotton in conjunction with blackgram proved the most beneficial among all the systems of intercropping.

An experiment conducted under rainfed conditions on black soil at Regional Agricultural Research Station, Lam Farm, Guntur, Andhra Pradesh during 1981-82 and revealed that higher yield of seed cotton (2094.6 kg/ha) was obtained when cotton cv. MCU-5 was planted in paired rows and intercropped with blackgram cv. T-9 which was significantly superior. Low yield was obtained in cotton planted in uniform rows as sole crop (1674.9 kg/ha). An additional yield

of 420 to 442 kg/ha of blackgram was obtained when grown as intercrop without affecting the yields of cotton (Janardhanan, 1982).

From the results of a field experiment at Udaipur, Shaktawat and Singh (1985) reported that the highest seed cotton production was obtained with solid (pure) planting of cotton followed by that intercropping with greengram or blackgram. Blackgram as an intercrop did not appreciably reduce seed cotton yield. Blackgram as an intercrop has no effect on the cotton stalk yield.

A field experiment was conducted at Devgadhbaria, Gujarat during *kharif* seasons of 1986-87. Result revealed that the seed cotton yield of budded cotton decreased by growing intercrop of blackgram. However, decreased in seed cotton yield was compensated by growing blackgram as an intercrop (Anon., 1987).

Birajdar *et al.*(1987) revealed that cotton intercropped with blackgram produced 20 per cent more cotton equivalent as compared to cotton sole crop.

Chellamuthu *et al.*(1987) conducted an experiment for three years (1980-81 to 1982-83) at Cotton and Millets Experiment Station, Kovilpatti and observed that intercrops, irrespective of their yield advantage, had reduced the Kapas yield of rainfed cotton and the reduction was upto 28 per cent. However, reduction in yield was compensated by the yield of blackgram.

Deshpande *et al.*(1989) reported that seed cotton yield was reduced significantly by growing intercrops in association with cotton. The reduction in seed cotton yield was to the tune of 17.9 per cent when blackgram var. T-9 intercropped with cotton.

Sankaranarayanan *et al.*(1989) conducted an experiment during *rabi* 1983-86 at Agricultural Research Station, Kavilpatti and reported that the seed cotton yield was reduced significantly in cotton + blackgram intercropping. The reduction was to the tune of 12.8 per cent as compared to sole cotton.

Muralikrishnasamy *et al.*(1990) revealed that yield of cotton in the paired row intercropped with blackgram cv. ADT-4 was equaled yield of cotton (1.1 t/ha) as a pure cotton crop and blackgram also gave an additional seed yield of 1 t/ha.

Rao (1991) reported that there were no significant differences in cotton yield when grown alone or intercropped with greengram and blackgram. However, additional yield of 486 kg/ha of blackgram was obtained when cotton intercropped with blackgram.

An experiment was conducted on sandy loam soil at Monera, Madhya Pradesh in 1983-84 by Tomar and Kushwaha (1991) and observed non significant effect of cotton + blackgram intercropping on seed cotton yield as compared with solid planting and paired row planting of cotton alone.

While working at Ghumusar Udayagiri, Orissa, Padhi *et al.*(1993) noted that minimum reduction in cotton yield in association with blackgram (5.9%) and increased the harvest index as compared with sole cotton in uniform and paired row planting.

Yadav *et al.*(1993) reported that intercropping of blackgram with cotton did not reduce the yield of cotton significantly as compared with cotton alone.

Balasubramanian *et al.*(1994) observed non significant effect of cotton + blackgram intercropping on seed cotton yield as compared with sole cotton.

Khistaria *et al.*(1994) conducted an experiment under rainfed conditions, on medium black soils, from 1977 to 1985 at the Dry Farming Research Sub station, Vallabhipur, Gujarat and revealed that cotton cv. GAU Cot-10 + blackgram cv. T-9 intercropping gave significantly higher cotton equivalent yield (1247 kg/ha) as compared to other intercropping systems.

Renganayaki and Subramanian (1994) showed that blackgram cv. NPRG-2 intercropped with cotton cv. MCU-10 in a row ratio of 1:1 gave the highest cotton equivalent yield of 1325 kg/ha than cotton grown alone.

An experiment was conducted during the rainy seasons of 1988 and 1989 on vertisols under AICCIP at Indore and reported that 'T-9' blackgram increased seed cotton yield significantly during 1988-89 in paired-row planting compared with sole American cotton (Tomar *et al.*,1994).

Field experiments were conducted at the Agricultural College and Research Institute, Tamil Nadu Agricultural University, Killikulam for two year (1990 and 1991) and showed that seed cotton yield was significantly reduced by intercropping blackgram in cotton in both the years. The reduction ranged from 12 to 18 per cent. Reduction in seed cotton yield was well compensated by additional yield from intercrop blackgram (Krishnasamy *et al.*, 1995).

Patel *et al.*(1995) showed that cotton cv. G.Cot.Hy-6 intercropped with blackgram cv. Zandewal gave 108 kg/ha more seed cotton equivalent yield than cotton alone. While cotton intercropped with blackgram cv. T-9 gave 60 kg/ha more seed cotton equivalent yield than sole cotton crop.

Tomar *et al.*(1997) revealed that cotton cv. Vikram + blackgram cv. T-9 intercropping increased Kapas yield by 9.5 and 11.2 per cent in paired row planting as compared with sole cotton crop.

Solaippan and Dason (1998) conducted an experiment at Agricultural Research Station, Kovilpatti during *rabi* seasons of 1993-94 and 1994-95 and reported that cotton + blackgram intercropping significantly reduced the seed cotton yield by 7.9 per cent and 10.3 per cent during 1993-94 and 1994-95, respectively. However, the yield reduction in cotton was well compensated by the yield of blackgram intercrop and gave more cotton equivalent yield of 760 kg/ha

and 647 kg/ha as compared with sole cotton crop which gave seed cotton yield of 671 kg/ha and 554 kg/ha during 1993-94 and 1994-95, respectively.

2.1.4 Cotton + Soyabean :

Giri and Upadhyay (1979) revealed that soyabean as an intercrop in cotton affected the cotton yield adversely.

From an experiment at Parbhani, Birajdar *et al.*(1980) reported that intercropping of soyabean decreased the cotton yield.

Jain *et al.*(1982) conducted an experiment at the main centre of AICCIP, Indore during 1979-80 and 1980-81 and revealed that cotton + soyabean intercropping depressed the seed cotton yield. However, relatively higher yields of soyabean crop very well compensated the deficit in seed cotton yield.

In rainfed trials in 1978-79 showed that cotton intercropped with soyabean gave lower seed cotton yields than in pure stands but soyabean gave an additional seed yield and markedly increased the net returns and land equivalent ratio (Shanthaveerabhadraiah and Patil, 1986).

Chellamuthu *et al.*(1987) reported that cotton + soyabean intercropping significantly reduced the Kapas yield of cotton as compared with cotton pure stand.

In a field experiment conducted at PKV, Akola during 1983-86 and revealed that soyabean not only reduced the cotton yield significantly but the total monetary returns also (Deshpande *et al.*, 1989).

From Kovilpatti, Sankaranarayanan *et al.*(1989) reported that the seed cotton yield was reduced significantly in cotton + soyabean intercropping to the tune of 10.3 per cent as compared to sole cotton.

Seshadri and Natarajan (1989) observed that soyabean as an intercrop gave 625 kg grain/ha but reduced the yield of cotton significantly as compared with sole cotton crop.

Muralikrishnasamy *et al.* (1990) reported that cotton + soyabean intercropping gave seed cotton yield of 0.8 t/ha as compared with 1.1 t/ha obtained in sole cotton crop. Soyabean gave an additional seed yield of 1.2 t/ha.

Abdel-Aal (1991) conducted an experiment at Shebin El-Kom, Egypt in 1989-90 and reported that cotton + soyabean intercropping decreased seed cotton yield as compared with cotton grown alone. Similarly Gomaa (1991) reported from an experiment at Alexandria University, Egypt in 1989-90 that cotton + soyabean intercropping decreased seed cotton yield.

Gode *et al.*(1992) conducted an experiment in the *kharif* season of 1982 at Nagpur, Maharashtra and revealed that seed cotton yield was 0.9 t/ha when grown alone and 0.51-0.75 t/ha when intercropped with soyabean. Soyabean seed yield was 1.66 t/ha when grown alone and 0.57 t/ha when intercropped with cotton.

Yadav *et al.*(1993) conducted an experiment during *kharif* season of 1981-82 at Indore, Madhya Pradesh and showed that the inclusion of soyabean as an intercrop reduced the cotton yield significantly.

Khistaria *et al.*(1994) reported that soyabean as an intercrop found to be beneficial as compared to the sole cotton.

The significant decrease in seed cotton yield owing to intercrop of 'JS 71-05' soyabean was observed in all the planting systems during both the years 1988 and 1989 (Tomar *et al.*, 1994).

Wankhade (1994) revealed that cotton cv. AKA-8401 + soyabean cv. Monetta intercropping decreased seed cotton yield by 47.9 per cent as compared with sole cotton crop.

Patel *et al.* (1995) revealed that cotton equivalent yield was not significantly affected by soyabean cv. G-1 or cv. G-2 when intercropped with cotton G.Cot.Hy.6.

Rameshbabu *et al.*(1996) revealed that soyabean intercropping with short duration variety of cotton significantly reduce seed cotton yield as compared with cotton alone.

Satao *et al.*(1996) conducted an experiment during *kharif* seasons of 1991-94 at Akola, Maharashtra and reported that cotton cv. AKA-8401 + soyabean cv. Monetta intercropping (1:1) at the 60 x 30 cm spacing produced a seed cotton yield of 0.83 t/ha and soyabean yield of 1.01 t/ha with higher land equivalent ratio of 1.55 and gross monetary returns as compared with sole cotton crop.

Tomar *et al.* (1997) reported that cotton cv. Vikram + soyabean cv. JS 71-05 intercropping significantly decreased seed cotton yield in all the planting systems during all the seasons of 1988-89 to 1990-91. The reduction in seed cotton yield was identical in soyabean cv. SS-2 but less than soyabean cv. JS 71-05 intercrop. Intercropping of cotton + soyabean (1:1) was more remunerative than the sole crop of cotton under rainfed conditions.

Rao *et al.*(1998) conducted an experiment on deep black soil at Regional Research Station, Raichur, Karnataka for three seasons from 1994-95 to 1996-97 and reported that in individual years except 1994-95 though reduction in seed cotton yield was not significant with soyabean but this intercrop exerted significantly lower seed cotton yield when pooled over three seasons.

2.1.5 Cotton + Cowpea :

Nagre (1979) reported that cotton cv. MCU-5 + cowpea cv. Pusa Dophasli intercropping reduced seed cotton yield but reduction was well compensated by cowpea yield. However, net monetary returns were 11 per cent less than sole crop of cotton.

From the results of an experiment during 1979-82, Prasad *et al.*(1989) revealed that cowpea as an intercrop affected cotton yield resulting in a yield of

2706 kg/ha over 2945 kg/ha from pure crop of cotton. Cowpea gave an additional yield of 739 kg/ha.

Sankaranarayanan *et al.*(1989) revealed that cotton cv. KC-1 + cowpea cv. Co-3 intercropping reduced seed cotton yield significantly to the tune of 23.8 per cent and not found profitable as compared with cotton alone.

A field experiment was conducted during 1984-87 at Coimbatore by Seshadri and Natarajan (1989) and showed that the growth and yield of upland cotton were significantly increased (15%) by intercropping 'Co Vu 623' cowpea.

Koraddi *et al.*(1990) showed that total yield and financial returns were higher in cotton + cowpea for fodder intercropping than cotton grown alone.

Results from an experiment during 1979-80 and 1980-81 at Hissar, Nehra *et al.*(1990) reported that intercropping with either of the crops (mungbean, cowpea for fodder and green manuring) reduced seed cotton yield in comparison to sole crop.

Tomar and Kushwaha (1991) intercropping of cowpea for grain with cotton reduced the yield of cotton significantly. However, yield was at par when cowpea for fodder was grown as intercrop with cotton.

Natarajan and Naik (1992) reported from Zimbabwe that cotton + cowpea intercropping reduced seed cotton yield significantly as compared with cotton sole crop, but the reduction was compensated by the yield of cowpea.

Azevedo *et al.*(1993) conducted an experiment in Brazil and reported that cotton intercropped with cowpea in 1:1, 2:1, 2:2 or 3:1 row arrangements gave more yield advantages over pure stands of the both crops. Double rows (2:2) produced 75 per cent of yield of sole cowpeas and had the highest total land equivalent ratio value (1.30).

Balasubramanian *et al.*(1994) reported that cotton cv. MCU-9 + cowpea cv. PLS-370 intercropping did not reduce seed cotton yield significantly over sole

cotton crop moreover cowpea as an intercrop gave an additional yield of 179.72 kg/ha.

Khistaria *et al.*(1994) revealed that cowpea cv. Pusa Phalguni as an intercrop was found to be beneficial as compared to the sole cotton cv. G.Cot.70.

Mukerji and Verma (1994) reported that seed cotton yield was not significantly affected by cotton + cowpea intercropping as compared with sole cotton crop.

Jagnnathan *et al.*(1996) conducted an experiment at Coimbatore, Tamil Nadu and observed that net returns with cotton cv. MCU-5 were higher when it was intercropped with cowpea cv. Co-3 sown before cotton.

Rameshbabu *et al.*(1996) reported that seed cotton yield was significantly reduced by cotton + cowpea intercropping as compared with cotton alone.

Endondo and Samatana (1999) conducted field trials in 1993-94 at Maroua, Cameroon and reported that cotton cv. IRMA-1243 + cowpea cv. IT 88 DM-368 intercropping with simultaneous sowing gave 50 per cent lower seed cotton yield than sole cotton crop. Cotton yield was reduced by 16 per cent and cowpea yield by 54 per cent when cowpeas were sown during earthing up.

2.1.6 Cotton + Maize :

From the results of a field experiment conducted at Parbhani during 1978-79, Birajdar *et al.*(1980) observed that cotton + maize intercropping decreased the seed cotton yield as compared to sole crop of cotton.

An experiment was conducted at Devgadhbaria, Gujarat during *kharif* seasons of 1986-87. Results revealed that the seed cotton yield of budded cotton decreased by growing intercrop of *kharif* maize. However, decreased in seed cotton yield was well compensated by growing maize as an intercrop (Anon., 1987).

Madiwalar *et al.*(1989) reported that cotton and maize grown in pure stands each with 100 per cent recommended NPK rate gave average seed cotton yield of 1.99 t/ha and maize grain yield of 2.68 t/ha, respectively. In intercropped stands, cotton and maize yields were 0.94-1.28 and 2.17-2.68 t/ha, respectively. This indicated that seed cotton yield reduced by 35.7 per cent.

Abdel-Malek *et al.*(1991) conducted an experiment at Mallawi Agricultural Research Station, Egypt and reported that cotton + maize intercropping reduced seed cotton yield by 44-52 per cent and maize grain yield by 43-70 per cent.

Mohamed and Salwau (1994) conducted an experiment at Moshtonor, Egypt in 1990-91 and reported that in intercropped cotton, the highest seed cotton yield was obtained with maize spaced at 60 cm between hills and supplying plants with 120 kg N/Feddan in both seasons, but this system reduced seed cotton yield by 8 per cent and 31 per cent as compared with sole crop of cotton during 1990 and 1991, respectively.

A field experiment was carried out by Rameshbabu *et al.*(1996) on medium black soils at Arabhavi during 1990-93 and reported that cotton + maize intercropping gave significantly higher seed cotton yield as compared with cotton cv. DCH 32 hybrid grown alone. Moreover, maize gave an additional yield of 2647 kg/ha. Hence, this system was found more remunerative than sole cotton.

Azevedo *et al.*(1997) conducted an experiment during 1994-96 at Paraiba, Brazil and observed that increasing density of cotton from 2500 to 10000 plants/ha significantly increased its yield without any significant or consistent effect on yield of maize. Increasing the density of maize 5000 to 20000 plants/ha significantly increased its yield but significantly reduced yield of cotton.

2.1.7 Cotton + pigeonpea :

An experiment conducted at Punjabrao Krishi Vidyapeeth, Akola, during *kharif* seasons of 1973-74 and reported that intercropping of cotton with

pigeonpea decreased the yield of cotton significantly by 62.5 per cent as compared with cotton alone. Pigeonpea gave an additional yield of 3.5 q/ha but it was not compensated the reduction in seed cotton yield (Nagre, 1979).

An investigation was carried out at Amreli, Gujarat during 1985-86. Results of the experiment revealed that cotton planted at 60 x 30 cm spacing as sole crop gave significantly higher seed cotton yield (690 kg/ha) than cotton planted at 90 x 20 cm and intercropped with pigeonpea (270 kg/ha) (Anon., 1986).

Birajdar *et al.*(1987) conducted an experiment in *kharif* seasons of 1976-78 and revealed that the intercropping of cotton with pigeonpea reduced the seed cotton yield significantly as compared with cotton alone.

Pothiraj and Srinivasan (1992) tested various intercrops like blackgram cv. Co-5, castor cv. TMV-5, pigeonpea cv. SA-1 and sorghum cv. Co-25 with cotton cv. MCU-10 and reported that the cotton equivalent yield was highest with cotton + pigeonpea intercropping (1.5 t/ha).

2.2 Effect of intercrops on growth and yield attributes of cotton

Nagre (1979) conducted an experiment at Punjabrao Krishi Vidyapeeth, Akola, during *kharif* seasons of 1973 and 1974 and reported that there was slight depressing effect of pigeonpea, cowpea and greengram, differences in height and number of branches/plant of pure cotton and intercropped cotton stand with these crops were not significant. The number of bolls produced in pure cotton stand were at par with the number of bolls produced in cotton + greengram intercropping and significantly more than the number of bolls/plant produced in all other intercropping systems. There was suppressing effect of sunflower, sesamum and pigeonpea on the number of bolls/plant. Boll weight was highest in pure cotton followed cotton + cowpea, cotton + greengram and cotton + pigeonpea intercropping system. Stalk yield from pure cotton and cotton +

greengram intercropping were at par and significantly more than stalk yield from cotton + sesamum, cotton + cowpea and cotton + sunflower during 1973. A similar trend was observed in 1974 also, except that the cotton + cowpea intercropping was at par with cotton + greengram and cotton + pigeonpea intercropping.

Kunasekaran and Iruthayaraj (1981) observed that cotton with two rows of greengram as an intercrop gave the maximum number of branches per plant. The number of bolls per plant and weight of boll were the highest in cotton with three rows of greengram.

Jain *et al.*(1982) revealed that number of balls/plant and plant height of cotton did not effect significantly by cotton + greengram, cotton + blackgram and cotton + soyabean intercropping system as compared with cotton crop alone in both the years 1979-80 and 1980-81 except cotton + soyabean intercropping significantly reduced number of bolls/plant in the year 1979-80.

While working at Parbhani during 1979-80 Musande *et al.*(1982) evaluated that cotton intercropped with greengram and blackgram were at par and both were significantly superior to cotton intercropped with groundnut for number of bolls/plant and boll size.

Rao (1982) reported that plant height and number of sympodial branches remained unaffected due to cropping systems, however, significantly more number of monopodial branches were recorded in pure cotton crop indicating that the intercrops suppressed the production of monopodial branches. Boll size was not significantly influenced by cropping systems. Significantly more number of bolls were produced under pure cotton and cotton + cowpea (green manure) intercropping while significant reduction was recorded when intercropped with greengram.

While working at JNKVV, Indore, Jain (1984) noted that differences in yield and number of bolls per plant of cotton were significant. Whereas, plant population, plant height and yield per plant of cotton were non significant due to intercropping with greengram, blackgram or soyabean.

At Udaipur, Shaktawat and Singh (1985) revealed that blackgram and greengram as intercrops have no effect on the cotton stalk yield.

Nehra and Kairon (1986) reported that plant height of cotton due to skip row planting with greengram as an intercrop was significantly higher than skip row planting without intercrops in 1979. Bolls per plant were not affected by intercropping of greengram in cotton.

Sheoran and Malik (1986) showed that inclusion of greengram as an intercrop in cotton slightly reduced the seed cotton yield due to suppression of cotton growth in early stages. Plant height, branches/plant, bolls/plant and boll weight were not influenced significantly due to intercropping in cotton with greengram.

From an experiment conducted at Akola during 1983-86, Deshpande *et al.* (1989) observed that due to competition of intercrops viz. greengram, blackgram, soyabean and groundnut, the main crop of cotton remained stunted with less biomass production, less squares, flowers and bolls which ultimately reduced the seed cotton yield.

From the results of an experiment, Seshadri and Natarajan (1989) revealed that the number of harvestable bolls was significantly more in intercropping with cowpea and were on a par with onion intercropping and significantly less with soyabean intercropping compared with pure cotton.

Shankaranarayanan *et al.*(1989) reported that the yield reduction in cotton was mainly due to less boll number due to the effect of intercrops like viz. blackgram, soyabean, cowpea and sunflower.

An experiment conducted at the Cotton Research Farm, Haryana Agricultural University, Hissar by Nehra *et al.*(1990) and reported that intercropping of cotton with moongbean, cowpea for fodder and cowpea for green manuring reduced all yield parameters and yield in comparison to sole cotton crop.

Gomaa (1991) revealed that cotton + soyabean intercropping decreased number of open bolls/plant, boll weight and lint yield but did not affect per cent lint as compared with sole cotton crop.

A field study, carried out by Tomar and Kushwaha (1991) noted that highest plant height was observed in cotton paired row + cotton intercropping system. Maximum number of bolls/plant was obtained in sole cotton paired row planting system.

Sethi *et al.*(1992) reported that growth parameters viz. plant height, number of sympodial branches and dry matter accumulation per plant and yield attributes viz. no. of bolls and seed cotton yield per plant were significantly affected by intercrops and were more in sole cotton crop than in cotton + groundnut and cotton + greengram intercropping systems. Yield of cotton stalk and lint/ha were maximum in sole cotton than in cotton + groundnut and cotton + greengram.

While, working at Ghumusar Udayagiri, Orissa, Padhi *et al.*(1993) revealed that cotton intercropped with rice, fingermillet, greengram, blackgram and groundnut reduced the plant height, sympodial branches, boll number and seed cotton yield/plant significantly leading to reduction in its yield, compared with the sole crop in regular rows.

From Srivilliputtur, Solaiappan *et al.*(1993) reported that there was a decline in plant height, sympodial number and boll number due to intercropping of greengram with cotton.

Balasubramanian *et al.*(1994) observed that plant height, number of sympodial branches and number of bolls per plant of cotton were non significantly affected by blackgram, greengram and cowpea intercrops as compared with cotton grown alone.

Mukerji and Verma (1994) found non significant effect on height and number of bolls per plant as well as boll size by intercropping treatments as compared with cotton alone.

Tomar *et al.*(1994) showed that in the year 1988, the number of bolls per plant were higher in cotton + blackgram cv. T-9 in 2:2 row ratio while lowest number of bolls per plant was recorded in 1:1 row ratio of cotton + soyabean cv. JS-71-05 intercropping. The boll size was unaffected due to intercropping of cotton + soyabean, cotton + blackgram and cotton + greengram cv. ML-13 intercropping, however in 1989, the boll size was significantly reduced due to intercropping of cotton + soyabean cv. SS-2, cotton + blackgram in 2:2 and cotton + blackgram in 1:1 row ratio.

Krishnasamy *et al.*(1995) reported that under intercropping situation, the plant height, dry matter production and yield attributes were similar for uniform row planting. Cotton sown as sole crop recorded higher number of sympodial branches (14.50 to 14.78) whereas under cotton + blackgram intercropping situation it ranged from 11.57 to 13.34 only. Similarly, number of bolls per plant recorded ranged from 16.85 to 18.32 for the sole cotton sown under uniform row and 12.96 to 15.50 for cotton + blackgram intercropping.

From the results of an experiment, Lourduraj and Chinaswami (1996) reported that growing greengram as an intercrop in cotton did not significantly influence the plant height, leaf area and dry matter production of cotton, although sole crop of cotton irrigated in every furrow recorded numerically higher DMP compared to cotton intercropped with greengram irrigated in every furrow.

Mukerji and Verma (1994) observed that fibre quality was not significantly affected by cotton + greengram and cotton + cowpea intercropping systems.

Tomar *et al.*(1997) reported that cotton cv. Vikram intercropped with soyabean cv. SS-2 and moong cv. ML-131 in 2:1 row ratio and soyabean cv. JS 71-05 in 1:1 row ratio recorded highest ginning percentage.

2.4 Economics of intercropping

Nagre (1979) concluded that cotton + greengram intercropping gave 27.87 per cent more net return than net return from pure crop of cotton. The monetary returns were decreased when cotton was intercropped with pigeonpea than cotton alone.

During 1975-76 differences in gross income was not significant, however maximum gross income was obtained in the treatment where two rows of blackgram were grown as intercrop in normal method of cotton planting. During 1976-77 gross income was significantly higher (Rs. 4168/ha) in similar treatment as compared with cotton alone in normal method of planting and rest of intercropping system (Sanandachari *et al.*, 1980).

Bavale and Vyahalkar (1981) reported that the differences in the monetary returns due to intercrops were significant. Intercropping of urd recorded significantly higher monetary returns (Rs.5301/ha) than intercropping of mung and groundnut and no intercrop.

Jain *et al.*(1982) revealed that the averaged over two years, monetary returns in cotton + blackgram intercropping system was highest (Rs.6089/ha) followed by cotton + soyabean (Rs.5130/ha), cotton + mung (Rs.4999/ha) and cotton alone (Rs.4708/ha). Whereas, cost benefit ratio was highest in cotton + blackgram (1:2.0) which was closely followed by cotton + soyabean (1:1.8), cotton sole (1:1.7) and cotton + mung (1:1.6).

Tomar *et al.*(1997) revealed that the number of bolls per plant were higher in cotton cv. Vikram + blackgram cv. T-9 intercropping in 2:2 row ratio being at par with sole cropping and significantly superior as compared to cotton cv. Vikram + soyabean cv. JS 71-05 intercropping in all the systems and soyabean variety SS-2 under 2:1 and 1:2 row ratio. Boll weight remained unaffected due to different treatments.

A field experiment was conducted during the winter seasons of 1993-95 at Agricultural Research Station, Kavilpatti by Solaippan and Dason (1998) and reported that plant height, dry matter production and sympodial branches in sole cotton crop were significantly higher than in intercropped cotton with the blackgram or clusterbean. Higher boll number and boll weight were also observed in sole cotton than in intercropped cotton.

2.3 Effect of intercrops on quality characters of cotton

Results of the experiments, carried out by Musande *et al.*(1981), revealed that quality characters of cotton viz., ginning percentage, mean fibre length, lint index and earliness index were not influenced significantly due to intercropping of greengram, blackgram or groundnut with cotton.

Azevedo *et al.*(1993) reported that cotton + cowpea intercropping gave no consistent effect on cotton fibre quality.

Balasubramanian and Subramanian (1993) conducted an experiment at Kovilpatti, Tamil Nadu during 1983-85 and reported that lint index, seed index, hallo length and ginning percentage were not significantly affected by cotton + greengram intercropping except in the year 1983-84 in which the ginning percentage was increased significantly under cotton + blackgram intercropping as compared with sole cotton when precipitation was above average.

Mohamed and Salwau (1994) reported that intercropping cotton with maize had no significant effect on the fibre properties of cotton.

Janardhanan (1982) reported that highest total monetary returns (Rs.11988.60/ha) were obtained in cotton planted in paired rows with three rows of blackgram as an intercrop than total monetary returns obtained in cotton planted in uniform rows without any intercrops (Rs.8709.48/ha).

Rao (1982) stated that an additional profit of Rs.1235/ha obtained from cotton + moongbean intercropping whereas net returns was slightly higher in cotton + cowpea (green manure) but less in cotton + cowpea (fodder) than pure cotton crop.

Nehra and Kairon (1986) summarised the results of experiments carried out at Haryana Agricultural University, Hissar during 1979 and 1980 on performance of different varieties of cotton in cotton + moong intercropping and indicated that intercropping was generally more remunerative and gave an additional income ranging from Rs.244 to 1466/ha due to intercropping.

Sheoran and Malik (1986) reported that net returns from cotton + greengram intercropping was higher by Rs.1068/ha as compared to Rs.2958/ha from sole cotton.

Results of an experiment conducted at Devgadhbaria, Gujarat showed that the additional net gain over sole crop of cotton in blackgram and *kharif* maize intercrop was Rs.5903 and 5691, respectively (Anon., 1987).

Birajdar *et al.*(1987) revealed that cotton intercropped with blackgram increased gross economic return significantly as compared to cotton sole crop and cotton intercropped with pigeonpea and sorghum. Sole cotton gave higher gross economic return than cotton + pigeonpea.

Deshpande *et al.*(1989) reported that cotton + groundnut intercropping gave significantly higher monetary returns (Rs.9726/ha) over sole crop of cotton (Rs.8723) and other intercropping treatments. The second best treatment in respect of monetary returns was cotton + moong which recorded Rs.8846/ha

which was also higher than sole crop of cotton where as monetary returns were lower in cotton + urid (Rs.8414/ha) and cotton + soyabean (Rs.6751/ha).

From Bellary in Karnataka, Prasad *et al.*(1989) reported that cotton + greengram combination gave maximum net profit of Rs.13416/ha over Rs. 11195/ha from pure cotton.

Muralikrishnasamy *et al.*(1990) observed that cotton + blackgram intercropping gave higher net return ($ 716/ha) followed by cotton + soyabean ($ 383/ha) as compared to cotton alone ($ 307/ha).

From the results of an experiment, Tomar and Kushwaha (1991) showed that cotton + blackgram intercropping in paired row gave an additional profit of Rs.1351/ha followed by cotton + cowpea for grain (Rs.1081) and cotton + cowpea for fodder (Rs.494) as compared to solid planting of cotton.

Prasad *et al.*(1992) observed that intercropping of cotton with groundnut gave higher net returns than sole cotton, but cotton + greengram gave less net returns. However, net returns per rupee invested was higher in cotton + groundnut and cotton + greengram intercropping than sole cotton.

Intercropping of cotton + greengram gave maximum net profit/ha followed by cotton + groundnut and sole cotton (Sethi *et al.*, 1992).

Padhi *et al.*(1993) showed that association of blackgram, greengram and groundnut with cotton increased monetary return, cost benefit ratio and monetary advantage compared with sole cotton in uniform and paired row planting. However, cotton + blackgram intercropping was better than other intercropping.

A field experiment was conducted at Indore (M.P.) indicated that net monetary returns as well as cost benefit ratio was highest in cotton + soyabean, cotton + blackgram and cotton + greengram intercropping as compared to sole cotton (Yadav *et al.*, 1993).

From Srivilliputhur, Tamil Nadu, Balasubramanian *et al.*(1994) reported that cotton + cowpea, cotton + blackgram and cotton + greengram gave higher net profit as well as cost benefit ratio than sole cotton.

Khistaria *et al.*(1994) revealed that cotton + blackgram, cotton + cowpea, cotton + soyabean, cotton + greengram, cotton + clusterbean and cotton + groundnut gave higher net additional return over sole cotton. Amongst intercrops blackgram and greengram were more suitable than other intercrops.

The net profit as well as cost benefit ratio from intercropping of cotton + blackgram, cotton + greengram and cotton + soyabean was higher than sole cotton crop under square and paired-row planting (Tomar *et al.*, 1994).

Krishnasamy *et al.*(1995) reported that higher net return of Rs. 17208/ha besides a higher cost benefit ratio of 3.38 was recorded under paired row planting of cotton with two rows of blackgram as intercrop applied with 60 kg N + Azospirillum.

Patel *et al.*(1995) conducted an experiment at Surat and reported that cotton intercropped with soyabeans cv. G-1, Uridbeans cv. Zandewal and mungbeans cv. G-2 gave an additional profit of Rs.1057, Rs.748 and Rs.708/ha, respectively compared with cotton grown alone.

From the results of an experiment at Coimbatore, Lourduraj and Chinaswami (1996) revealed that intercropping of cotton with greengram resulted in increased net returns (Rs.4209/ha) compared to sole crop of cotton (Rs.3406/ha).

Sharma *et al.*(1997) concluded that intercropping of greengram provided significantly higher net return than sole cotton.

Tomar *et al.*(1997) revealed that cotton + blackgram in paired row resulted in highest cost benefit ratio (3.08) followed by cotton + blackgram in 1:1 row ratio. The highest gross and net profit was obtained from intercropping of cotton

+ blackgram in paired row planting followed by cotton + soyabean (JS 71-05) in 1:1 row ratio. The net profit from intercropping of cotton with blackgram, greengram and soyabean was Rs.3739 to 6950/ha compared with that of Rs.2889/ha and Rs.2953/ha from sole cotton crop under square and paired row planting.

Rao *et al.*(1998) observed from three years experiment (1994 to 1997) that cotton + soyabean intercropping gave less net return (Rs.28710/ha) than obtained in sole cotton (Rs.29136/ha).

MATERIALS AND METHODS

III MATERIALS AND METHODS

The present investigation was initiated in *kharif* season of 1998-99 at the Farm of Main Cotton Research Station, Gujarat Agricultural University, Surat. Details of the materials used and methodology adopted during the course of this investigation are described in this chapter.

3.1 Experimental site

The field experiment was conducted on Plot No.13 of Main Cotton Research Station, Gujarat Agricultural University, Surat which is situated in South Gujarat, at a cross point of 20°-12' N latitude and 72°-52' E longitude at an elevation of 11.34 metres above mean sea level and is 18 kilometers away from seashore.

3.2 Climate and weather conditions

The climate of this area is typically tropical characterised by fairly hot summer, moderately cool winter and more humid and warm monsoon with heavy rains. In general, the monsoon commences in the first fortnight of June and ceases by the second fortnight of September. Pre monsoon rains in the first week of June and post monsoon rains in the month of October-November are not uncommon from the South-West monsoon, concentrating in the month of July and August. The average annual precipitation is 1350 mm (average of ten years).

The winter season sets in usually by the end of October and lasts upto February. The temperature starts declining in the middle of November and lowest minimum temperature of the season is recorded either in the month of December or January and hence these two are the coldest months of the season. In the month of February, the temperature starts rising and reaches the maximum in the month of May. April and May are the hotest months of the season.

Table 1 : Weekly meteorological data on weather parameters during crop season of 1998–99

Month and year	Std. week	Dates	Temperature (°C)		Relative humidity (%)		Bright sun–shine hrs.	Rainfall (mm)	Rainy days
			Max.	Min.	8.00 AM	2.30 PM			
June'98	23	04–10	35.5	27.8	75.7	66	–	20.0	2
	24	11–17	35.1	26.2	75.7	56	–	7.0	2
	25	18–24	35.2	26.5	76.0	52.2	–	2.0	1
	26	25–01	32.0	26.7	87.2	72.5	–	81.0	3
July'98	27	02–08	30.1	24.9	90.2	76.8	–	446.0	6
	28	09–15	32.7	24.8	85.4	69.4	–	24.0	5
	29	16–22	33.3	25.4	80.4	64.8	–	64.0	2
	30	23–29	32.9	26.3	83.3	58.4	–	–	–
	31	30–05	30.9	25.8	86.5	84.1	–	139.8	6
Aug.'98	32	06–12	29.2	26.2	85.0	84.1	2.25	17.6	1
	33	13–19	33.3	26.0	79.5	78.0	–	37.6	2
	34	20–26	32.0	27.0	84.4	76.4	2.4	74.1	3
	35	27–02	31.6	26.7	83.0	79.1	–	81.6	3
Sept.'98	36	03–09	31.4	24.8	89.2	75	5.93	49.8	3
	37	10–16	31.2	26.2	81.1	81	2.47	161.8	5
	38	17–23	31.0	26.0	73.4	74.4	2.54	55.0	4
	39	24–30	33.2	25.5	76.4	65.0	5.43	7.2	1
Oct.'98	40	01–07	35.0	27.1	70.1	59.7	8.1	26.8	1
	41	08–14	34.5	26.6	74.4	60.7	8.64	14.4	3
	42	15–21	30.7	21.9	70.2	71.5	5.11	59.8	4
	43	22–28	32.2	26.0	71.2	53.2	8.3	–	–
	44	29–04	33.5	23.8	75.5	52.8	7.96	13.2	1

Contd.

Month and year	Std. week	Dates	Temperature (°C)		Relative humidity (%)		Bright sun–shine hrs.	Rainfall (mm)	Rainy days
			Max.	Min.	8.00 AM	2.30 PM			
Nov.'98	45	05–11	32.4	23.5	68.4	41.8	8.25	22.0	2
	46	12–18	31.8	20.5	64	34.7	7.19	–	–
	47	19–25	37.0	21.1	63.8	36.1	6.46	–	–
	48	26–02	33.6	17.7	69.0	41.2	6.82	–	–
Dec.'98	49	03–09	33.0	16.0	67.7	39	7.12	–	–
	50	10–16	31.6	15.7	70.7	39.1	5.31	–	–
	51	17–23	32.0	15.8	67.8	39.7	7.92	–	–
	52	24–31	32.5	16.9	65.8	40.5	8.22	–	–
Jan.'99	1	01–07	30.8	15.6	76.5	36.2	6.64	–	–
	2	08–14	30.3	14.2	73.5	38.7	8.14	–	–
	3	15–21	32.6	14.6	67.2	53.5	7.65	–	–
	4	22–28	30.8	15.5	72.2	41.0	8.19	–	–
	5	29–04	30.0	13.0	69.0	37.1	8.16	–	–
Feb.'99	6	05–11	31.7	16.6	71.5	39.2	7.59	–	–
	7	12–18	33.9	19.1	70.1	34.0	7.39	–	–
	8	19–25	35.0	21.0	51.1	35.0	9.09	–	–
	9	26–04	36.6	21.0	66.2	41.8	8.62	–	–
March'99	10	05–11	34.7	22.3	69.5	57.7	7.74	–	–
	11	12–18	36.6	19.6	70.0	57.5	8.79	–	–
	12	19–25	36.8	20.5	67.0	50.2	8.6	–	–
	13	26–01	40.0	24.3	67.7	41.8	8.19	–	–

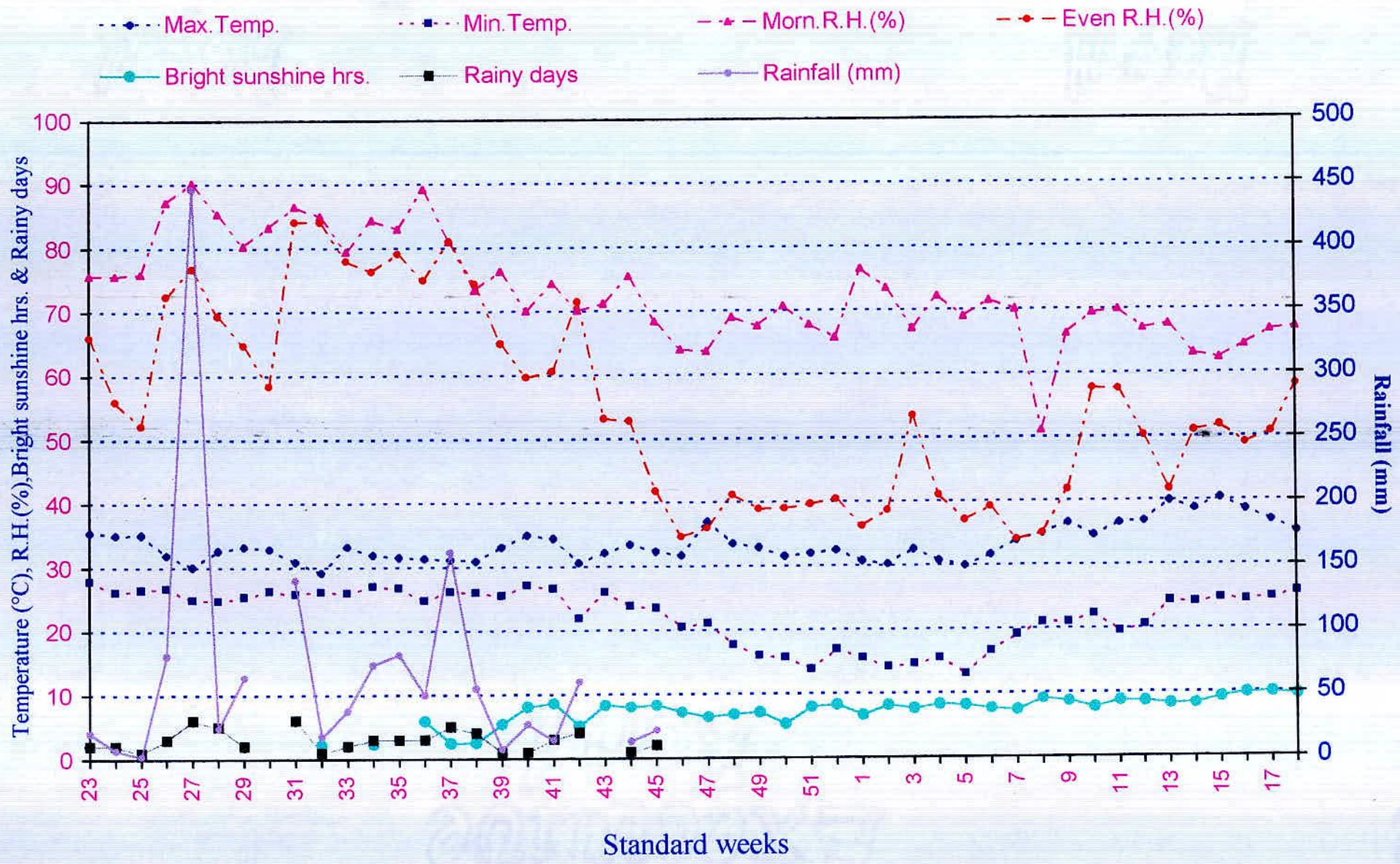

Fig.1 : Weekly meteorological data on weather parameters during crop season of 1998–99

In monsoon season, most of the days are cloudy, resulting in less sunshine hours. As the monsoon ends, the hours of sunshine increases though the days are shorter. More than seven hours of sunshine are available in the months of February, March, April and first fortnight of May.

The mean meteorological data on maximum and minimum temperature, relative humidity, rainfall and sunshine hours during the course of investigation recorded at the meteorological observatory of the research station are presented in Table 1 and depicted in Fig.1.

It could be observed from the Table 1 that the maximum temperature ranged between 29.2 to 40°C, while the minimum temperature ranged between 13 to 27.8°C. The mean morning humidity ranged from 51.1 to 90.2 per cent while the evening humidity ranged from 34 to 84.1 per cent.

The total rainfall recorded during the rainy season was 1404.7 mm with 60 rainy days during the crop growth period. The bright sunshine hours ranged from 2.25 to 9.09.

It could be seen from meteorological data that rainy and winter seasons were found normal for satisfactory growth of the cotton crop and all the intercrops.

3.3 Soil characteristics

The soil of the experimental field was deep, moderately drained clayey soils which represents the typical black cotton soils of South Gujarat having high water holding capacity. These soils crack vertically upon drying upto a depth of 90-120 cm. The clay content ranges from 56.48 to 64.97 per cent.

With a view to determine the physico-chemical properties of the experimental field, respective soil samples from the entire experimental area were collected from 0-22.5 and 22.5-45 cms depth from randomly selected spots before laying out the experiment. These samples were thoroughly mixed and a composite

Table 2 : Physico–chemical properties of the soil of experimental site

Particular	Value of different soil depth (cm)		Methods employed
	0–22.5	22.5–45	
A). Physical characteristics :			
Sand (%)	22.38	16.60	International Pipette method (Piper, 1950)
Silt (%)	21.14	18..43	
Clay (%)	56.48	64.97	
Texture	Clayey		
B). Chemical characteristics :			
Organic carbon (%)	0.48	0.46	Walkley and Black's rapid titration method (Jackson, 1967)
Total nitrogen (%)	0.04	0.03	Modified Kjeldahl's method (Jackson, 1967)
Available N (kg/ha)	207	201	Alkaline Permanganate method (Black, 1965)
Available P_2O_5 (kg/ha)	36.59	24.01	Olsen's method (Olsen's *et al.*, 1954)
Available K_2O (kg/ha)	576	547	Flame photometer method (Jackson, 1967)
Soil pH (1:2.5 soil : water ratio)	7.8	8.23	Backman's pH meter (Jackson, 1967)
Electrical conductivity (dS/m) at 25°C	0.48	0.35	Schofield method (Gaur, 1967)

samples was prepared. The samples were then grouped in a wooden mortar and after passing through a 2 mm sieve were analysed for various physico-chemical properties and the average values obtained are given in Table 2.

It appears from the Table 2 that soil of the experimental plot was clayey in texture having pH value of 7.8 to 8.23. There is no problem of salinity. From fertility point of view, the soil of the experimental plot can be placed in fertility scale of low for nitrogen, medium for phosphorus and high for potash.

3.4 Cropping history of the experimental field

Details of crops grown at the experimental site in different seasons for the last three years are mentioned in Table 3. The cotton crop was fertilized with 320-0-0 kg N-P-K/ha.

Table 3 : Cropping history of the experimental plot for previous three years

Year	Season	Crop
1995–96	*Kharif*	Cotton (G.Cot.Hy.8)
	Rabi	–
	Summer	Fallow
1996–97	*Kharif*	Cotton (G.Cot.Hy.10)
	Rabi	–
	Summer	Fallow
1997–98	*Kharif*	Cotton (G.Cot.Hy.10)
	Rabi	–
	Summer	Fallow
1998–99	*Kharif*	Present experiment

3.5 Experimental techniques

The details of the experimental techniques employed for the investigation was as under :

3.5.1 Details of layout :

Details of layout have been depicted in Fig.2.

3.5.2 Design :

Randomized Block Design was employed in this investigation.

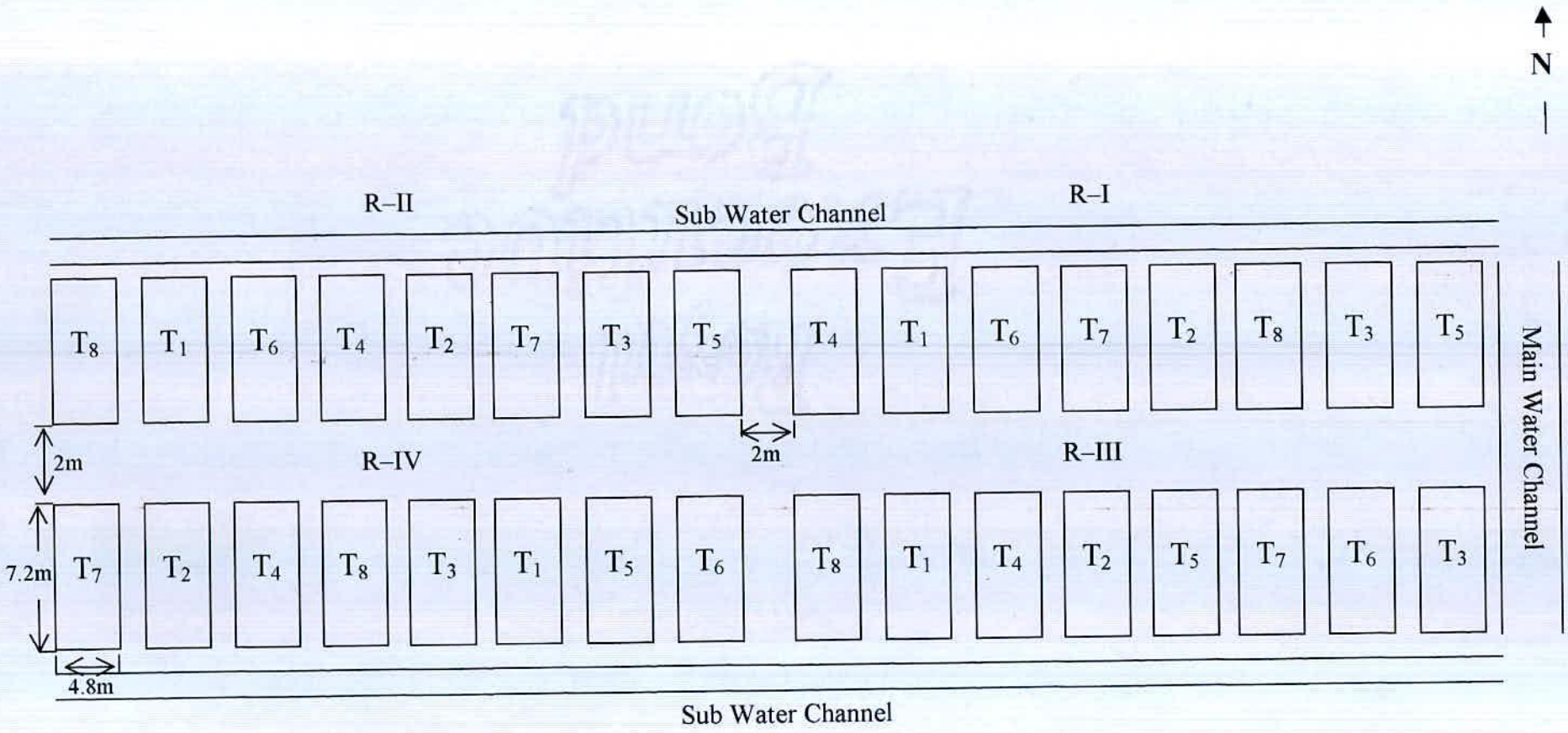

Fig.2 : Layout of experiment

3.5.3 Replications : Four.

3.5.4 Treatment details :

T_1 = Cotton alone (G.Cot.Hy 10) –

T_2 = Cotton + Groundnut (GG 2) (1:2)

T_3 = Cotton + Greengram (GM 2) (1:2)

T_4 = Cotton + Blackgram (T 9) (1:2)

T_5 = Cotton + Soybean (GS 2) (1:2)

T_6 = Cotton + Cowpea (Pusa Phalguni) (1:2)

T_7 = Cotton + Maize (GM 2) (1:2)

T_8 = Cotton + Pigeonpea (BDN 2) (1:1)

3.5.5 Plot size :

Gross : 4.8 m x 7.2 m

Net : 2.4 m x 6.3 m

3.5.6 Description of the varieties of different crops used in the experiment :

Cotton - G.Cot.Hy.10 :

Gujarat state seed sub committee released this variety in 1994. The variety matures in 7-8 months. Yield potential of this variety is about 35 to 38 q/ha. It is capable of spinning a good 40_s-50_s counts with nepfree yarn.

Groundnut - GG 2 :

It is released by state seed sub-committee of Gujarat approved for *kharif* cultivation in 1985. It is an erect type and maturity period is 100-105 days. Yield potentiality of this variety is about 13 to 15 q/ha.

Green gram - GM 2 :

Gujarat state seed sub-committee endorsed this variety in 1993. Seeds of this variety are medium in size and having yield 11 to 12 q/ha. It matures in 60-70 days.

Black gram - T 9 :

Gujarat state seed sub-committee endorsed this variety for cultivation in 1979. The variety is released by AICRP (Pulses), Kanpur and is adopted for cultivation in Gujarat. Yield of this variety is 10 q/ha. It matures in 70-75 days.

Soyabean - GS 2 :

Gujarat state seed sub-committee endorsed this variety in 1983. Yield of this variety is about 20-25 q/ha. It matures in 105-110 days.

Cowpea - Pusa Phalguni :

This variety was selected from Canadian variety by IARI, New Delhi. It matures in 65-75 days. Average yield of this variety is 12 to 15 q/ha.

Maize - GM 2 :

It is released by Gujarat state seed sub-committee in 1993. Yield of this variety is about 25 to 30 q/ha. It matures in 85-90 days.

Pigeon pea - BDN 2 :

Gujarat state seed sub-committee endorsed this variety for cultivation in 1985. It is short in height. Seeds are white in colour. It is mid-late variety (185 days). Average yield of this variety is 20 to 23 q/ha.

3.6 Details of field operations

3.6.1 Preparation of land :

The experimental field was prepared by ploughing followed by harrowing (discing) twice by tractor drawn implements. Then tractor drawn plank was driven in the directions to develop a good tilth. Ridges were prepared with bullock drawn harrow at 120 cm apart in dry condition in the third week of June.

3.6.2 Cultural operation :

The calendar of cultural operations carried out during the period of investigation is presented in Table 4.

3.6.2.1 Sowing :

On previously opened ridges at 120 cm apart, each ridges was marked at 45 cm apart as per layout. Sowing was done on 26-6-98. Two seeds of cotton G.Cot.Hy.10 were dibbled per each hill at 3-4 cm depth on the marking place manually. As per layout, all intercrops were sown in two line at 45 cm spacing between two rows of cotton except pigeonpea, which was sown in one line between two rows of cotton.

3.6.2.2 Gap filling :

In order to maintain a uniform plant stand gap filling was done in all plots 12 days after sowing.

3.6.2.3 Fertilizer application :

The cotton crop was fertilized with 240 kg nitrogen/ha in the form of urea in four equal splits at 25-30 days interval starting from 20 days after sowing. Whereas, groundnut, greengram, blackgram, soyabean, cowpea and pigeonpea were fertilized with 25-50-0 kg NPK/ha, while maize was fertilized with 80-40-0 kg NPK/ha in the form of di-ammonium phosphate and urea. The entire quantity of nitrogen and phosphorus were applied as basal at the time of thinning to intercrops.

3.6.2.4 Weeding and interculturing :

Four hand weedings were carried out at 20, 40, 60 and 80 days after sowing. Three interculturings were carried out at an interval of 20 days after third weeding with desi harrow (only in treatment T_1).

3.6.2.5 Plant protection measures :

For control of insect-pests necessary plant protection measures were taken from time to time. The details of the plant protection measures are given in Table 4.

3.6.2.6 Irrigation :

During the entire crop growth period, three irrigations were given after the last effective rain (Table 4).

3.6.2.7 Harvesting of intercrops :

Groundnut :

All the plants were uprooted and pods were separated from the plants plotwise from different replications on 16.11.98 and put it for drying a week and weighed it.

Greengram :

Two pickings of pods were done plotwise from different replications on 15.9.98 and 3.10.98 and then seeds were separated from pods by threshing and winnowing after drying a week and weighed it.

Blackgram :

All plants were harvested plotwise from different replications from nearer to the ground level on 6.10.98 and put it for drying a week and seeds were separated by threshing and winnowing and weighed it.

Soyabean :

All plants were harvested plotwise from different replications from the nearer to the ground level on 26.11.98 and put it for drying a week and seed were separated by threshing and winnowing and weighed it.

Cowpea :

Two pickings of pods were done plotwise from different replications on 15.9.98 and 3.10.98 and then seeds were separated from pods by threshing and winnowing after drying a week and weighed it.

Maize :

All the maize cobs were collected from the plants plotwise from different replications on 10.11.98 and put it for drying a week and seeds were separated from the cobs manually and weighed it.

Pigeonpea :

All plants were harvested plotwise from different replications on 11.1.99 and put it for drying a week. Then seeds were separated by threshing and winnowing and weighed it.

3.6.2.8 Picking of cotton :

First the border rows were picked. Along the length one row from each side and along the breadth one plant from each side was picked first and thus all the net plots were separated. The net plots were picked separately. First picking was done on 31.12.98 and the subsequent pickings were done at an interval of 30 days after first picking. In all, three pickings were done. The weight of the total produce after each picking was recorded for each plot.

3.7 Pre-harvest studies

3.7.1 Plant population :

The number of plants were counted from net plot area and were recorded twice i.e. first, at 12 days after sowing and the second, just before harvesting. They were then converted to percentage.

3.7.2 Plant height of cotton (cm) :

The periodical plant height of tagged plants were measured in cm from the base of the plant (ground level) to the tip of main shoot and the average values were recorded at squaring at flowering, at first ball bursting and at harvest.

3.7.3 Days to 50 per cent squaring, 50 per cent flowering, 50 per cent boll setting and 50 per cent boll bursting :

The number of days from the date of sowing to the date of squaring, flowering, boll setting and boll bursting appeared in 50 per cent plants were counted and recorded.

3.8 Post-harvest studies

3.8.1 Seed cotton yield :

The seed cotton yield after each picking from each net plot was recorded. They were summed up and total seed cotton yield was obtained and converted to kilograms per hectare.

3.8.2 Number of bolls/plant :

The number of burst bolls of previously tagged five plant from each plot were counted and the average number of bolls per plant was recorded separately for each plot.

3.8.3 Boll weight :

The number of bolls and their weight were recorded separately in each plot. Finally the average boll weight was worked out by dividing the total weight of seed cotton with number of picked bolls. The weight of seed cotton per boll was recorded for each plot.

3.8.4 Monopodial and sympodial branches per plant :

When the plant reached to its full maturity stage, the total number of monopodial and sympodial branches on the main stem were counted from previously tagged five plants and the number of monopodial and sympodial branches per plant were recorded for each plot.

3.8.5 Stalk yield of cotton :

Cotton stalks from net plot after the last picking were pulled out and dried under the sun till constant weight was attained and they were weighed, recorded and converted to kilograms per hectare.

3.9.6 Yield of inter crop :

Yield of each intercrop from each net plot was recorded. They were then converted to kilograms per hectare.

3.9.7 Straw/fodder yield of inter crops :

After harvesting the economic yield from all intercrops from each net plot, straw/fodder of all the intercrops were dried under the sun till constant weight attained and weighed it.

3.9.8 Ginning percentage :

Laboratory model gin designed by the Cotton Technological Research Laboratory, Mumbai was used for ginning the seed cotton samples for estimation of ginning percentage. Produce of seed cotton of each plot was ginned. Seeds and lint were weighed separately and ginning percentage was calculated by using the following formula :

$$\text{Ginning percentage} = \frac{\text{Weight of lint (g)}}{\text{Weight of lint + seed}} \times 100$$

3.9.9 Seed index :

From the samples taken for determining ginning percentage, 100 seeds from each individual sample were taken randomly and weighed in gm on pan balance and recorded for each plot.

3.9.10 Lint index :

The lint index represents the absolute weight of lint produced by 100 seeds in grams. It was computed using the formula of Hutchinson and Ramiah (1938).

$$\text{Lint index} = \frac{\text{Seed index x Ginning percentage}}{\text{100 - Ginning percentage}}$$

3.9.11 Harvest index of cotton (%) :

The harvest index was computed by using following formula :

$$H.I. = \frac{\text{Economical yield}}{\text{Biological yield}} \times 100$$

$$H.I. = \frac{\text{Yield of seed cotton}}{\text{Yield of seed cotton + Yield of stalks}} \times 100$$

3.10 Fibre quality characters :

3.10.1 Bundle strength (g/tex) :

The tensile strength is measured using a flat bundle of fibres using a finite gauge, usually 3 millimeters (1/8 inch), where the two clamps are separated by a spacer. Stelometer instrument is used for determining bundle strength at 3 mm gauge length.

$$\text{Tenacity (g/t)} = \frac{\text{Breaking strength in kg x 15}}{\text{Weight of bundle in mg}}$$

3.10.2 2.5% Span length (mm) :

It is a new concept of fibre length parameter and 2.5% span length corresponds well with the American Classer's staple length and it is measured in millimeter with the help of Digital Fibrograph.

3.10.3 Uniformity ratio (%) :

It is defined as the ratio of 2.5% span length to 50% span length expressed as percentage. Uniformity ratio measures the co-efficient of variation of fibre length.

3.10.4 Fibre fineness (Micronaire value) (10^{-6} g/in.) :

It was measured by the equipment "Micronaire" by the Air Flow method. It measures the fibre weight per unit length directly.

3.10.5 Fibre maturity co-efficient :

It is an index of the extent of development of the secondary cell wall of fibre and unitary expression to indicate the relative maturity of fibre.

The maturity was measured by Micronaire instrument with 3/8 inch spacer and without spacer. The difference between these two values is an indication of the maturity. It was computed by following formula :

M.C. = 0.1579 B + 0.4670

where,

M.C. = Maturity co-efficient

B = Difference between the readings with and without spacer

3.11 Economics

In intercropping system, the effectiveness of different treatments can be judged by following ways :

3.11.1 Cotton equivalent yield

3.11.2 Net return

3.11.1 Cotton equivalent yield :

Cotton equivalent yield was worked out with the help of following formula :

$$CEY = \frac{\text{Price of grain/seed/pod of intercrop (Rs./kg)}}{\text{Price of base crop cotton (Rs./kg)}} \times \text{Grain/seed/pod yield of intercrop (kg/ha)} + \text{Seed cotton yield (kg/ha)}$$

3.11.2 Net return :

The gross realization in terms of rupees per hectare was worked out by taking into consideration the yields of cotton and intercrops as well as fodder yield of each treatment and their respective prices prevailing during the year 1998-99.

Likewise, the cost of cultivation per hectare was worked out by considering the expenses incurred on cultivation operations from preparatory tillage to harvesting, cost of inputs viz., seeds, fertilizers and pesticides applied to each treatment as well as cost of cleaning etc. The cost of cultivation was then deducted from the gross realization to work out net income under each treatment. The Cost Benefit Ratio (CBR) was also calculated on the basis of following formula for each treatment :

$$CBR = \frac{\text{Total realization (Rs./ha)}}{\text{Total expenditure (Rs./ha)}}$$

Table 4 : Calendar of important field operations

Sr.No.	Field operations	Date
(A). Pre–sowing operations :		
1.	Ploughing with tractor	23.05.98
2.	Discing	30.05.98
3.	Planking	05.06.98
4.	Field layout and preparation of plots, bunds and channels	17.06.98
5.	Preparing ridges for sowing of cotton and intercrops seeds and marking at proper required spacing	17.06.98
(B). Sowing and post–sowing operations :		
6.	Sowing (i) Cotton (ii) Intercrops	26.06.98 26.06.98
7.	Gapfilling and germination count	09.07.98
8.	Weeding 1st 2nd 3rd 4th	16.07.98 10.08.98 24.09.98 30.10.98
9.	Interculturing (only in treatment T_1) 1st 2nd 3rd	22.07.98 20.08.98 30.09.98
10.	Irrigation 1st 2nd 3rd	19.11.98 23.12.98 20.01.99
11.	Plant protection measures :	
	(i) Phosphamidon (dimecron 85 EC) 0.03%	28.07.98
	(ii) Endosulphan (Thiodan 35 EC) 0.075%	19.08.98
	(iii) Monocrotophos (Nuvacron 40 EC) 0.04%	09.09.98
	(iv) Permethrin (Parmasect 25 EC) 0.015%	08.10.98
	(v) Quinalphos (Ekalux 25 EC)	10.11.98
	(vi) Decamethrin (Decis 2.8 EC) 0.00125%	28.11.98
	(vii) Monocrotophos (Nuvacron 40 EC) 0.04%	15.12.98

Contd.

Sr.No.	Field operations	Date
12.	Fertilizer application :	
	(i) For cotton 1st Split	09.07.98
	2nd Split	02.08.98
	3rd Split	28.08.98
	4th Split	23.09.98
	(ii) For intercrops Entire dose as basal	09.07.98
13.	Picking of seed cotton 1st	31.12.98
	2nd	06.02.99
	3rd	05.03.99
14.	Harvesting of intercrops	
	(i) Groundnut	16.11.98
	(ii) Greengram	03.10.98
	(iii) Blackgram	06.10.98
	(iv) Soyabean	26.11.98
	(v) Cowpea	03.10.98
	(vi) Maize	10.11.98
	(vii) Pigeonpea	11.01.99
15.	Uprooting cotton plants	06.03.99
16.	Dry weight of cotton stocks	14.03.99

RESULTS

IV RESULTS

The present investigation was carried out with a view to study "Intercropping in cotton G.Cot.Hy.10 under irrigated condition" during *kharif* season of 1998-1999 at the Main Cotton Research Station, Gujarat Agricultural University, Surat. Results collected for various characters during the course of investigation have been presented in this chapter. The results have also been presented graphically wherever found appropriate.

4.1 Growth characters of cotton

4.1.1 Plant population (%) :

4.1.1.1 Initial plant population (12 DAS) :

A perusal of data presented in Table 5 indicated that different intercropping systems tried in the experiment did not exert their significant effects on the plant population of cotton at 12 days after sowing.

4.1.1.2 Plant population at harvest :

An examination of data (Table 5) showed that the differences in plant population at harvest due to different treatments were found to be non-significant.

4.1.2 Plant height :

4.1.2.1 Plant height at squaring :

The data on plant height recorded at squaring are presented in Table 6 and graphically depicted in Fig.3. The plant height at squaring stage was significantly influenced by different treatments. Maximum plant height (86.5 cm) was observed in treatment T_1 i.e. cotton alone which was significantly higher than treatments T_5 i.e. cotton + soyabean (60.4 cm), T_7 i.e. cotton + maize (44.5 cm) and T_8 i.e. cotton + pigeonpea (40.3 cm). But it was found at par with treatments T_2 (75.3 cm), T_3 (82.9 cm), T_4 (77.3 cm) and T_6 (78.4 cm). The

Table 5 : Plant population (%) of cotton at 12 days after sowing and at harvest as influenced by various treatments

Treatment details	Plant population (%)	
	Initial (12 DAS)	At harvest
T_1 – Cotton alone	93.7	98.2
T_2 – Cotton + Groundnut (1:2)	91.9	94.6
T_3 – Cotton + Greengram (1:2)	92.8	95.5
T_4 – Cotton + Blackgram (1:2)	91.0	96.4
T_5 – Cotton + Soyabean (1:2)	91.0	94.6
T_6 – Cotton + Cowpea (1:2)	91.9	97.3
T_7 – Cotton + Maize (1:2)	94.6	96.4
T_8 – Cotton + Pigeonpea (1:1)	93.7	94.6
S.Em.±	1.77	2.33
C.D.at 5%	NS	NS
C.V.%	3.82	4.85

second best treatment in respect of this character was T_3 i.e. cotton + greengram (82. 9 cm) which was significantly higher than T_5, T_7 and T_8 but remained at par with T_2, T_4 and T_6 which in turn were significantly higher than T_5, T_7 and T_8.

Treatment T_5 recorded significantly higher plant height (60.4 cm) than treatments T_7 and T_8. Significantly lowest plant height (40.3 cm) was recorded under treatment T_8 i.e. cotton + pigeonpea which was at par with treatment T_7 (44.5 cm).

4.1.2.2 Plant height at flowering :

Significant variation in plant height measured at flowering was observed due to different treatments (Table 6 and Fig.3). Treatment T_1 i.e. cotton alone recorded significantly higher plant height (123.8 cm) than treatments T_5, T_7 and T_8. But it was at par with treatments T_2, T_3, T_4 and T_6. Significantly lowest plant height (55.9 cm) was recorded in treatment T_8 i.e. cotton + pigeonpea which was found at par with treatment T_7 (64.1 cm).

4.1.2.3 Plant height at first boll bursting :

Plant height at first boll bursting was significantly affected by various treatments (Table 6 and Fig.3). Significantly highest plant height (159.1 cm) was recorded in treatment T_1 i.e. cotton alone over treatments T_5, T_7 and T_8. But remained at par with treatments T_2, T_3, T_4 and T_6. Treatment T_8 i.e. cotton + pigeonpea recorded significantly lower plant height (72.1 cm) at first boll bursting which was found statistically at par with treatment T_7 (82.0 cm).

4.1.2.4 Plant height at harvest :

Differences in plant height at harvest due to different treatments were found to be significant (Table 6 and Fig.3). Maximum plant height of 172.0 cm was recorded in treatment T_1 (cotton alone) which was significantly superior over treatments T_5, T_7 and T_8 but did not differ significantly with treatments T_2 (149.9 cm), T_3 (164.8 cm), T_4 (153.6 cm) and T_6 (156.2 cm). Treatment T_8 i.e.

Table 6 : Plant height of cotton at squaring, flowering, first boll bursting and at harvest as influenced by various treatments

Treatment details	Plant height at squaring (cm)	Plant height at flowering (cm)	Plant height at first boll bursting (cm)	Plant height at harvest (cm)
T_1 – Cotton alone	86.5	123.8	159.1	172.0
T_2 – Cotton + Groundnut (1:2)	75.3	107.9	138.6	149.9
T_3 – Cotton + Greengram (1:2)	82.9	118.1	152.3	164.8
T_4 – Cotton + Blackgram (1:2)	77.3	110.0	141.9	153.6
T_5 – Cotton + Soyabean (1:2)	60.4	86.2	111.1	120.1
T_6 – Cotton + Cowpea (1:2)	78.4	111.9	144.4	156.2
T_7 – Cotton + Maize (1:2)	44.5	64.1	82.0	88.8
T_8 – Cotton + Pigeonpea (1:1)	40.3	55.9	72.1	77.9
S.Em.±	4.34	6.91	10.05	12.72
C.D.at 5%	12.8	20.3	29.6	37.4
C.V.%	12.72	14.21	16.05	18.79

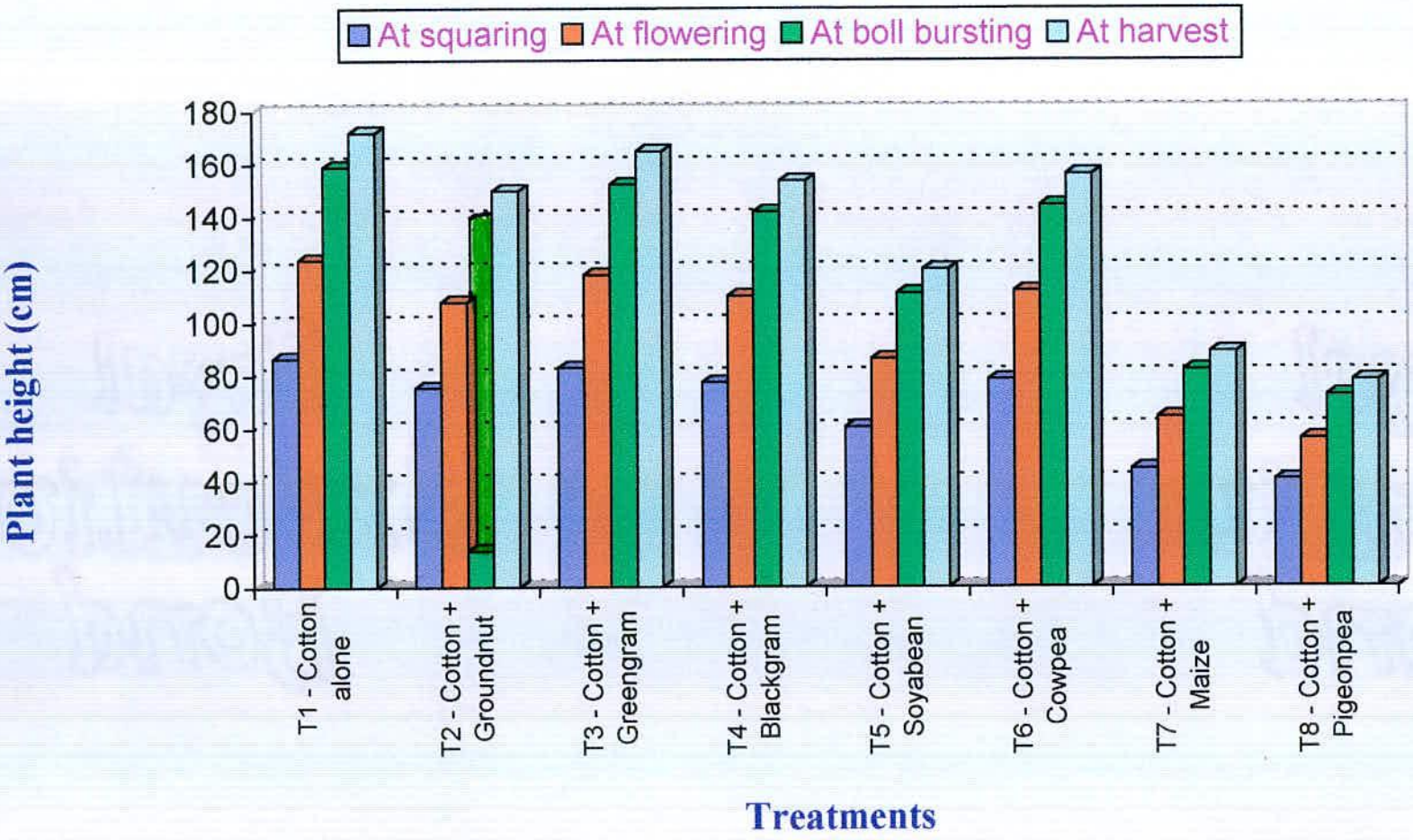

Fig. 3 : Plant height of cotton at squaring, flowering, first boll bursting and at harvest as influenced by various treatments

cotton + pigeonpea recorded significantly lowest plant height (77.9 cm) which remained at par with treatment T_7 (88.8 cm). The second best treatment in this character was T_3 i.e. cotton + greengram (164.7 cm) which was significantly higher than treatment T_5, T_7 and T_8 but remained at par with rest of the treatments. Lowest plant height at harvest was recorded in treatment T_8 i.e. cotton + pigeonpea (77.9 cm) which was significantly lower than all the treatments except treatment T_7 i.e. cotton + maize (88.8 cm).

4.1.3 Days to different stages of cotton :

4.1.3.1 Days to 50 per cent squaring :

The data on days to 50% squaring of cotton as affected by different treatments are presented in Table 7. Various intercropping treatments did not affect significantly on the days to 50% squaring of cotton as compared to cotton alone.

4.1.3.2 Days to 50 per cent flowering :

A perusal of data presented in Table 7 indicated that different intercropping systems tried in the experiment did not exert their significant effects on days to 50% flowering of cotton over cotton alone 50% flowering was delayed when cotton was inter cropped with blackgram (T_4) and pigeonpea (T_8).

4.1.3.3 Days to 50 per cent boll setting :

The data pertaining to 50% boll setting of cotton as influenced by different treatments are given in Table 7. Days to 50% boll setting were not affected significantly by different treatments.

4.1.3.4 Days to 50 per cent boll bursting :

It is clear from the data (Table 7) that days to 50 per cent boll bursting of cotton was not affected by various treatments. Boll bursting was slightly delayed when cotton was intercropped with blackgram (T_4) and pigeonpea (T_8).

Table 7 : Days to 50 per cent squaring, 50 per cent flowering, 50 per cent boll setting and 50 per cent boll bursting of cotton as influenced by various treatments

Treatment details	Days to 50 per cent squaring	Days to 50 per cent flowering	Days to 50 per cent boll setting	Days to 50 per cent boll bursting
T_1 – Cotton alone	48.5	68.6	90.0	126.0
T_2 – Cotton + Groundnut (1:2)	43.3	66.2	84.0	122.4
T_3 – Cotton + Greengram (1:2)	50.3	68.1	87.5	126.5
T_4 – Cotton + Blackgram (1:2)	47.0	70.5	91.7	131.1
T_5 – Cotton + Soyabean (1:2)	45.8	65.3	79.7	117.9
T_6 – Cotton + Cowpea (1:2)	46.0	65.5	85.0	120.4
T_7 – Cotton + Maize (1:2)	43.8	67.1	87.7	124.3
T8 – Cotton + Pigeonpea (1:1)	44.0	70.6	92.0	130.1
S.Em.±	2.52	3.73	4.98	7.64
C.D.at 5%	NS	NS	NS	NS
C.V.%	10.93	11.01	11.43	12.25

4.1.4 Morphological characters of cotton :

The morphological characters like the number of monopodial and sympodial branches per plant of cotton as affected by various intercropping treatments recorded at harvest are presented in Table 8 and graphically depicted in Fig.4.

4.1.4.1 Monopodial branches :

An appraisal of results showed that the different treatments exerted their significant effect on number of monopodial branches per plant at harvest. Maximum monopodial branches per plant (3.7) was produced in treatment T_1 (cotton alone) which was significantly higher than treatments T_5, T_7 and T_8 but it was at par with treatments T_2, T_3, T_4 and T_6. Significantly lowest number of monopodial branches per plant (2.3) was recorded in treatment T_8 i.e. cotton + pigeonpea which was at par with treatments T_5 and T_7 (Table 8 and Fig.4).

4.1.4.2 Sympodial branches :

It is evident from the data given in Table 8 and graphically depicted in Fig.4 that the effect of different treatments was found significant in number of Sympodial branches per plant at harvest. Treatment T_1 i.e. cotton alone recorded the highest number of Sympodial branches per plant (20.6) which was significantly higher than treatments T_5, T_7 and T_8, but remained at par with treatments T_2, T_3, T_4 and T_6. Lowest sympodial branches per plant (13.1) was obtained when cotton was intercropped with pigeonpea followed by cotton + maize and cotton + soyabean. These treatments remained at par with each other.

4.2 Yield attributes

4.2.1 Number of bolls per plant :

The data on number of bolls per plant are presented in Table 9 and graphically depicted in Fig.5.

Table 8 : Number of monopodial and sympodial branches of cotton as influenced by various treatments

Treatment details	Branches / plant at harvest	
	Monopodial	Sympodial
T1 – Cotton alone	3.7	20.6
T2 – Cotton + Groundnut (1:2)	3.0	17.1
T3 – Cotton + Greengram (1:2)	3.5	19.9
T4 – Cotton + Blackgram (1:2)	3.0	17.2
T5 – Cotton + Soyabean (1:2)	2.7	15.6
T6 – Cotton + Cowpea (1:2)	3.2	18.6
T7 – Cotton + Maize (1:2)	2.6	14.5
T8 – Cotton + Pigeonpea (1:1)	2.3	13.1
S.Em.±	0.26	1.43
C.D.at 5%	0.8	4.2
C.V.%	17.84	16.83

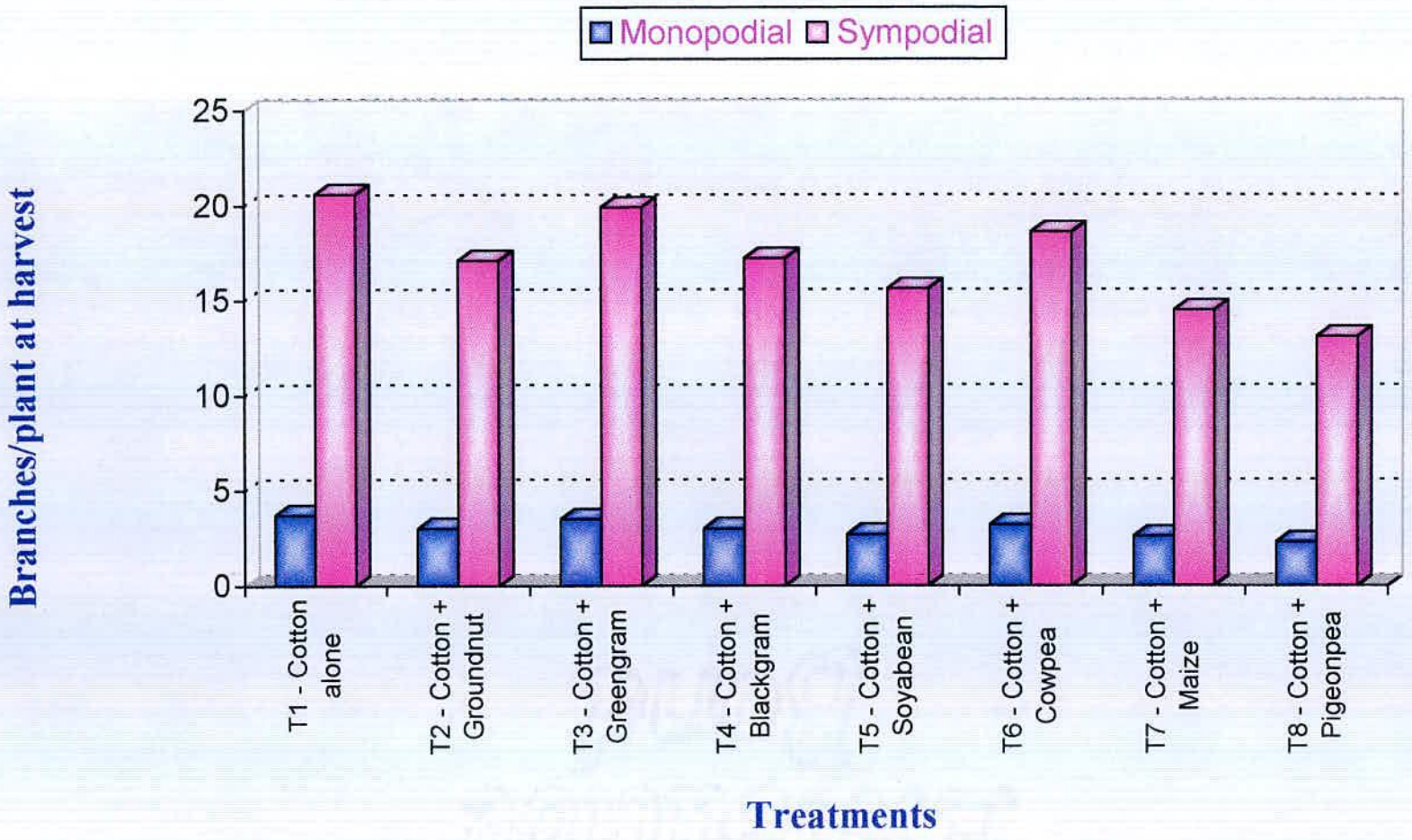

Fig. 4 : Number of monopodial and sympodial branches of cotton as influenced by various treatments

Table 9 : Number of bolls per plant and boll weight of cotton as influenced by various treatments

Treatment details	No. of bolls Per plant	Boll Weight (gm)
T1 – Cotton alone	57.5	3.0
T2 – Cotton + Groundnut (1:2)	47.1	3.2
T3 – Cotton + Greengram (1:2)	52.6	3.2
T4 – Cotton + Blackgram (1:2)	49.0	3.1
T5 – Cotton + Soyabean (1:2)	37.7	3.3
T6 – Cotton + Cowpea (1:2)	48.4	3.2
T7 – Cotton + Maize (1:2)	27.4	3.2
T8 – Cotton + Pigeonpea (1:1)	25.8	3.1
S.Em.±	3.84	0.09
C.D.at 5%	11.3	NS
C.V.%	17.81	5.95

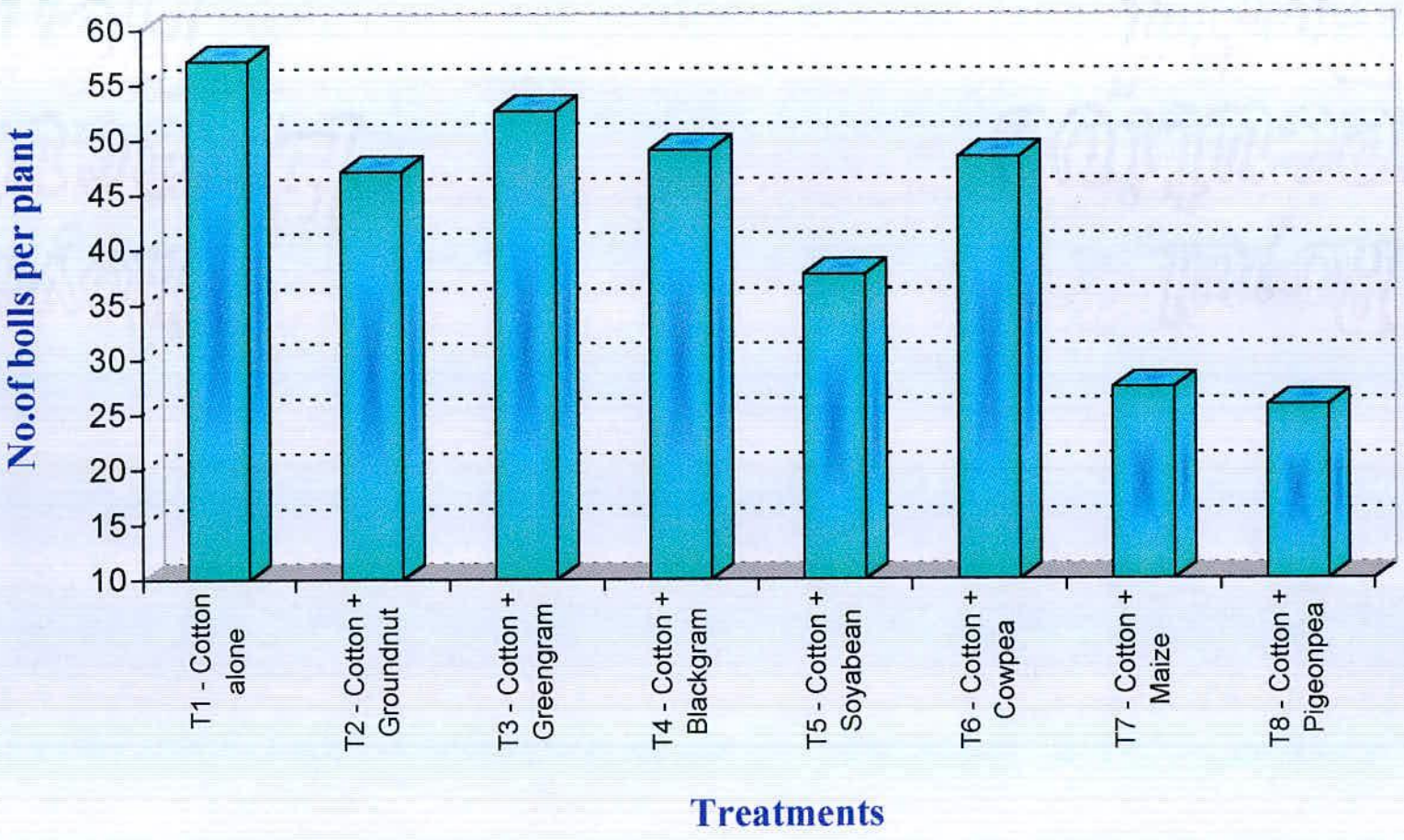

Fig. 5 : Number of bolls per plant of cotton as influenced by various treatments

The number of bolls per plant at harvest was significantly influenced by different treatments. The number of bolls per plant were significantly higher in treatment T_1 i.e. cotton alone (57.5) than treatments T_5, T_7 and T_8, but it was observed at par with treatments T_2, T_3, T_4 and T_6. Significantly less number of bolls were recorded under treatment T_8 i.e. cotton + pigeonpea, which was found at par with treatment T_7 i.e. cotton + maize. The reduction in number of bolls per plant was to the tune of 55.1 per cent when cotton was intercropped with pigeonpea over cotton grown alone.

4.2.2 Boll weight :

A perusal of data (Table 9) revealed that variation in boll weight due to different treatments were found to be non significant. However, boll weight was slightly lower when cotton was grown alone than intercropped with different crops.

4.3 Yield of crops

4.3.1 Lint yield of cotton :

Data furnished in Table 10 and graphically depicted in Fig.6 showed that lint yield of cotton was significantly affected by various treatments. Maximum lint yield (1081 kg/ha) of cotton was obtained in treatment cotton alone (T_1) which was significantly higher than T_5 i.e. cotton + soyabean (772 kg/ha), T_7 i.e. cotton + maize (558 kg/ha) and T_8 i.e. cotton + pigeonpea (495 kg/ha). But remained at par with rest of the treatments. The increase in lint yield in T_1 i.e. cotton alone was to the tune of 28.58%, 48.38% and 54.21% over T_5, T_7 and T_8, respectively. The second best treatment in respect of lint yield of cotton was T_3 (1060 kg/ha) which was also significantly higher than treatments T_5, T_7 and T_8 but remained at par with T_2, T_4 and T_6. Lowest lint yield of cotton (495 kg/ha) was recorded in treatment T_8 which was significantly lowest than all other

Table 10 : Lint yield and seed yield of cotton as influenced by various treatments

Treatment details	Lint yield of cotton (kg/ha)	Seed yield of cotton (kg/ha)
T_1 – Cotton alone	1081	2013
T_2 – Cotton + Groundnut (1:2)	950	1744
T_3 – Cotton + Greengram (1:2)	1060	1904
T_4 – Cotton + Blackgram (1:2)	986	1774
T_5 – Cotton + Soyabean (1:2)	772	1386
T_6 – Cotton + Cowpea (1:2)	991	1814
T_7 – Cotton + Maize (1:2)	558	1033
T_8 – Cotton + Pigeonpea (1:1)	495	895
S.Em.±	83.32	155.56
C.D.at 5%	245	457
C.V.%	19.3	19.8

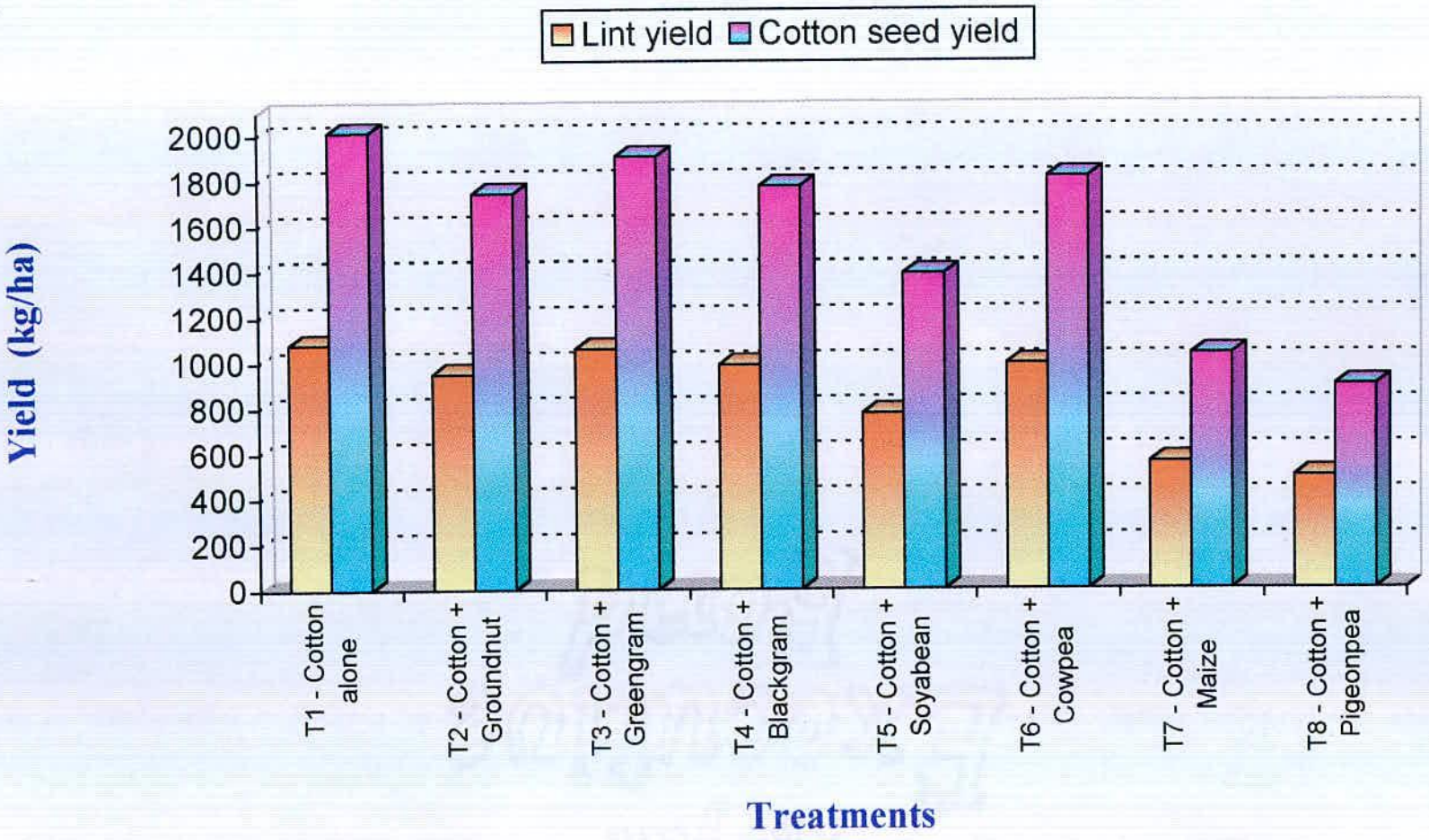

Fig.6 : Lint yield and seed yield of cotton as influenced by various treatments

treatments except treatment T_7. Treatment T_5 recorded 772 kg/ha lint yield of cotton which was significantly higher than treatment T_8 but was at par with treatment T_7.

4.3.2 Cotton seed yield :

The data presented in Table 10 and graphically depicted in Fig.6 indicated that different treatments exerted their significant effect on the cotton seed yield. Treatment T_1 (cotton alone) recorded significantly higher cotton seed yield (2013 kg/ha) than treatments T_5 i.e. cotton + soyabean (1386 kg/ha), T_7 i.e. cotton + maize (1033 kg/ha) and T_8 i.e. cotton + pigeonpea (895 kg/ha), but it remained at par with treatments T_2, T_3, T_4 and T_6. The increase in cotton seed yield in treatment T_1 i.e. cotton alone was to the tune of 31.15%, 48.68% and 55.54% over T_5, T_7 and T_8, respectively. The second best treatment in respect of cotton seed yield was T_3 i.e. cotton + greengram which was also significantly higher than treatments T_5, T_7 and T_8 but remained at par with rest of the treatments. Significantly lowest cotton seed yield (895 kg/ha) was observed in treatment T_8 which remained at par with treatment T_7.

4.3.3 Seed cotton yield :

It is evident from the data (Table 11 and Fig.7) that the effect of different treatments on seed cotton yield was found to be significant. The treatment T_1 (cotton alone) gave significantly higher seed cotton yield (3094 kg/ha) than treatments T_5 i.e. cotton + soyabean (2158 kg/ha), T_7 i.e. cotton + maize (1591 kg/ha) and T_8 i.e. cotton + pigeonpea (1390 kg/ha). But remained at par with rest of the treatments. The increase in seed cotton yield in treatment T_1 (cotton alone) was to the tune of 936 kg/ha, 1503 kg/ha and 1704 kg/ha over treatments T_5, T_7 and T_8, respectively. The second best treatment in respect of seed cotton yield was T_3 i.e. cotton + greengram (2964 kg/ha) which was significantly higher than T_5 i.e. cotton + soyabean, T_7 i.e. cotton + maize and T_8 i.e. cotton +

Table 11 : Seed cotton yield of cotton and grain/seed/pod yield of intercrops as influenced by various treatments

Treatment details	Seed cotton yield		Grain/seed/pod yield of intercrops (kg/ha)
	(kg/ha)	(%)	
T_1 – Cotton alone	3094	100	-
T_2 – Cotton + Groundnut (1:2)	2694	87.07	549
T_3 – Cotton + Greengram (1:2)	2964	95.80	737
T_4 – Cotton + Blackgram (1:2)	2760	89.21	750
T_5 – Cotton + Soyabean (1:2)	2158	69.75	1374
T_6 – Cotton + Cowpea (1:2)	2805	90.66	495
T_7 – Cotton + Maize (1:2)	1591	51.42	1496
T_8 – Cotton + Pigeonpea (1:1)	1390	44.93	1098
S.Em.±	237		
C.D.at 5%	699		
C.V.%	19.5		

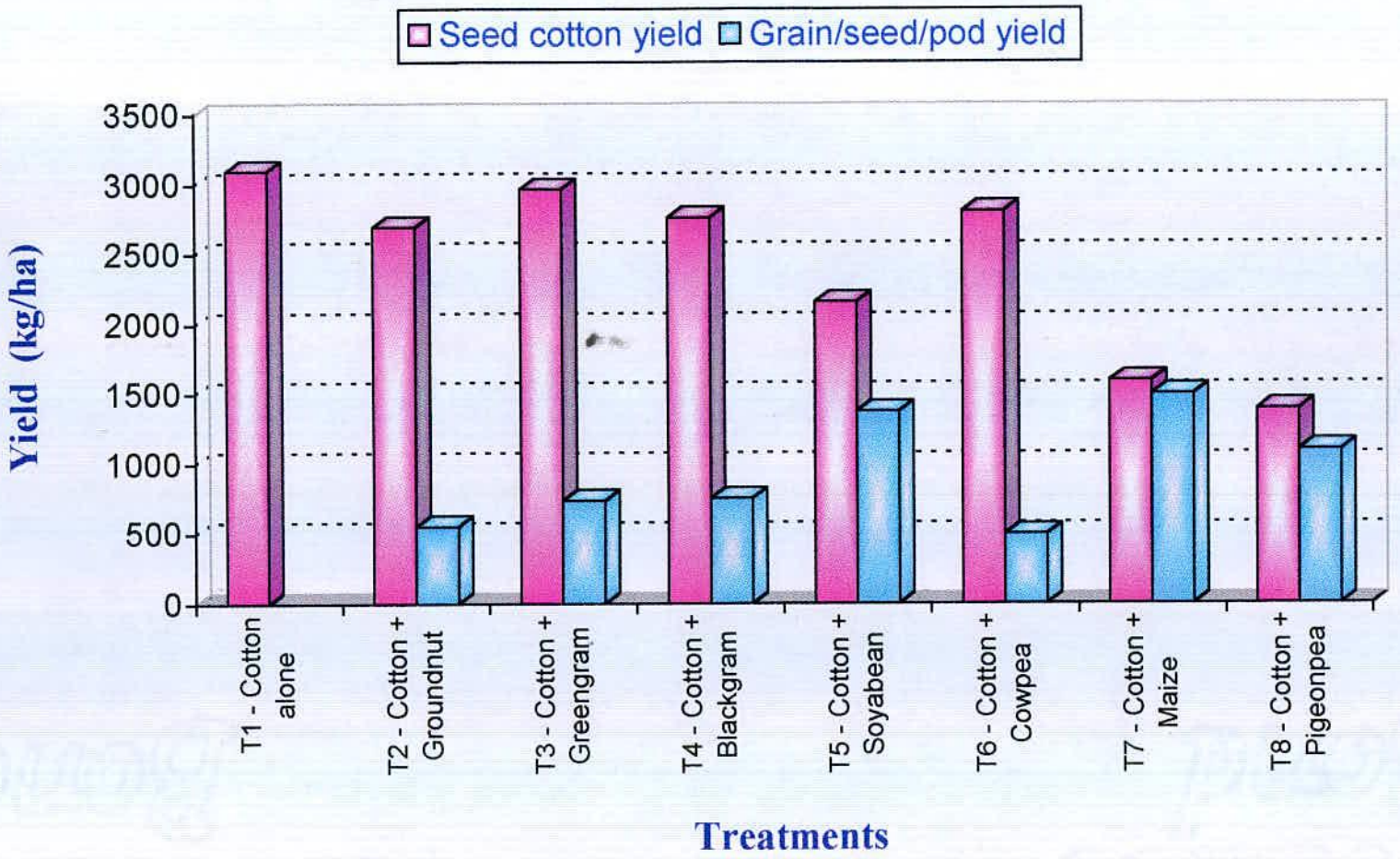

Fig.7 : Seed cotton yield and Grain/seed/pod yield of intercrops as influenced by various treatments

pigeonpea but remained at par with rest of the treatments. Treatment T_6 i.e. cotton + cowpea recorded 2805 kg/ha which was significantly higher than T_7 i.e. cotton + maize and T_8 i.e. cotton + pigeonpea but remained at par with rest of the treatments. Treatment T_4 i.e. cotton + blackgram gave significantly higher seed cotton yield than T_7 i.e. cotton + maize and T_8 i.e. cotton + pigeonpea but remained at par with T_6 i.e. cotton + soyabean (2158 kg/ha) which in turn was significantly higher than treatment T_8 but remained at par with T_7. The data further revealed that maximum reduction of 55.05% in seed cotton yield was observed in treatment T_8 i.e. cotton + pigeonpea followed by T_7 i.e. cotton + maize (48.57%) and T_5 i.e. cotton + soyabean (30.25%) than cotton alone. The reduction was least (4.20%) when cotton intercropped with greengram (T_3) followed by T_6 i.e. cotton + cowpea (9.34%) than cotton alone. Seed cotton yield obtained from treatment T_5 (2158 kg/ha) was significantly higher than treatment T_8 but it was at par with treatments T_2, T_4, T_6 and T_7.

4.3.4 Grain/seed/pod yield of intercrops :

Grain/seed/pod yield of intercrops are given in Table 11 and graphically depicted in Fig.7. Grain yield of maize was 1496 kg/ha which was much higher than produced by any of grain legumes. Among grain legumes soyabean produced highest grain yield of 1374 kg/ha followed by pigeonpea which produced 109[illegible]kg/ha. Performance of blackgram and greengram was better than groundnut and cowpea. Yield of cowpea was lowest (495 kg/ha).

4.3.5 Stalk yield of cotton (kg/ha) :

The data given in Table 12 and graphically depicted in Fig.8 indicated that stalk yield of cotton was significantly influenced by different treatments. Significantly higher stalk yield of cotton was recorded in treatment T_1 (7084 kg/ha) over treatments T_2 (5799 kg/ha), T_3 (5928 kg/ha), T_5 (5244 kg/ha), T_7 (3735 kg/ha) and T_8 (3156 kg/ha) but it was at par with treatments T_4 (6246

Table 12 : Stalk yield of cotton and fodder/straw yield of intercrops as influenced by various treatments

Treatment details	Stalk yield (kg/ha)	Fodder/straw yield of intercrops (kg/ha)
T_1 – Cotton alone	7084	-
T_2 – Cotton + Groundnut (1:2)	5799	839
T_3 – Cotton + Greengram (1:2)	5928	1149
T_4 – Cotton + Blackgram (1:2)	6246	1080
T_5 – Cotton + Soyabean (1:2)	5244	1750
T_6 – Cotton + Cowpea (1:2)	6300	758
T_7 – Cotton + Maize (1:2)	3735	4388
T_8 – Cotton + Pigeonpea (1:1)	3156	1110
S.Em.±	355	
C.D.at 5%	1044	
C.V.%	13.06	

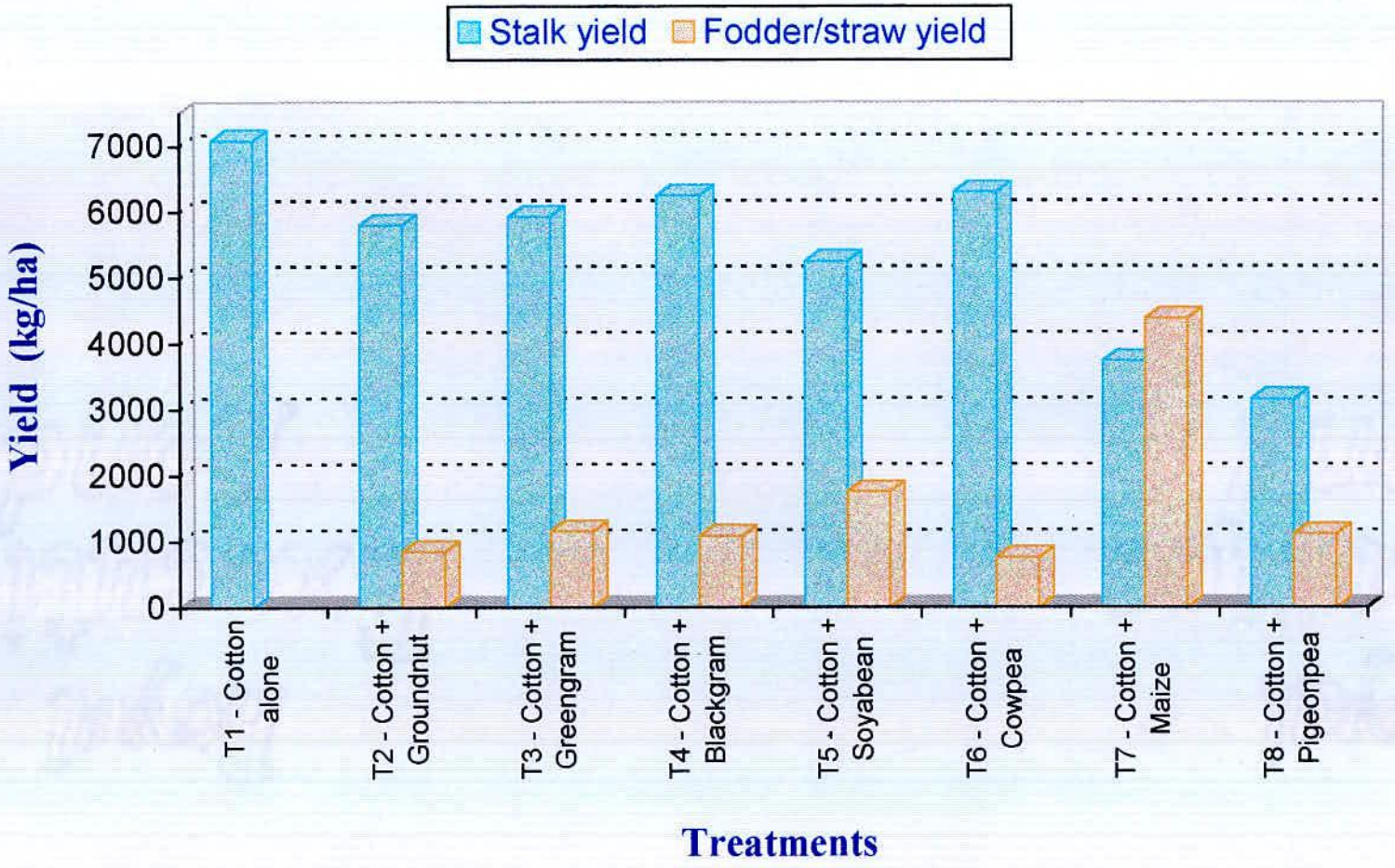

Fig.8 : Stalk yield of cotton and fodder/straw yield of intercrops as influenced by various treatments

kg/ha) and T_6 (6300 kg/ha), which did not differ with each other but was significantly superior over T_7 and T_8. Significantly lowest stalk yield of cotton was obtained in treatment T_8 (3156 kg/ha) which remained at par with T_7.

4.3.6 Fodder/straw yield of intercrops :

The data of fodder/straw yield of intercrops are given in Table 12 and graphically depicted in Fig.8. The straw yield of maize was much higher (4388 kg/ha) as compared to legumes and groundnut. Among grain legumes soyabean produced highest straw yield of 1750 kg/ha and followed by greengram (1149 kg/ha), pigeonpea (1110 kg/ha), blackgram (1080 kg/ha), groundnut (839 kg/ha) and cowpea (758 kg/ha).

4.4 Harvest index of cotton

The mean data on harvest index of cotton are tabulated in Table 13. The harvest index (efficiency index) of cotton was not influenced significantly by various treatments. However, maximum harvest index (33.2%) was obtained in treatment cotton + greengram (T_3) followed by treatment T_2 i.e. cotton + groundnut (31.7%). Numerically lowest harvest index of cotton was obtained in treatment T_5 (28.9%).

4.5 Ginning percentage

The data presented in Table 14 indicated that the different treatments tried in the experiment did not manifest their significant effect on the ginning percentage of cotton. Ginning percentage of cotton ranged between 35.0 and 35.8.

4.6 Seed index

The data on seed index tabulated in Table 14 showed that different treatments did not exert any significant effect on the seed index of cotton. Seed index of cotton ranged between 9 and 10. Seed index was lowest (9.00) in

Table 13 : Harvest index of cotton as influenced by various treatments

Treatment details	Harvest index of cotton (%)
T_1 – Cotton alone	30.4
T_2 – Cotton + Groundnut (1:2)	31.7
T_3 – Cotton + Greengram (1:2)	33.2
T_4 – Cotton + Blackgram (1:2)	30.6
T_5 – Cotton + Soyabean (1:2)	28.9
T_6 – Cotton + Cowpea (1:2)	30.6
T_7 – Cotton + Maize (1:2)	29.7
T_8 – Cotton + Pigeonpea (1:1)	30.8
S.Em.±	1.67
C.D.at 5%	NS
C.V.%	10.89

Table 14 : Ginning percentage, seed index and lint index of cotton as influenced by various treatments

Treatment details	Ginning %	Seed index	Lint index
T_1 – Cotton alone	35.0	9.6	5.20
T_2 – Cotton + Groundnut (1:2)	35.3	9.5	5.19
T_3 – Cotton + Greengram (1:2)	35.8	9.9	5.50
T_4 – Cotton + Blackgram (1:2)	35.8	10.0	5.56
T_5 – Cotton + Soyabean (1:2)	35.8	9.4	5.23
T_6 – Cotton + Cowpea (1:2)	35.4	9.6	5.28
T_7 – Cotton + Maize (1:2)	35.1	9.3	5.01
T_8 – Cotton + Pigeonpea (1:1)	35.6	9.0	4.98
S.Em.±	0.4	0.26	0.16
C.D.at 5%	NS	NS	NS
C.V.%	2.3	5.5	6.2

treatment T_8 i.e. cotton + pigeonpea and was highest (10.0) in treatment T_4 i.e. cotton + blackgram.

4.7 Lint index

It is clear from the data (Table 13) that lint index of cotton was not significantly affected by various treatments. Lint index of cotton ranged between 4.98 and 5.56. Lint index was lowest (4.98) in treatment T_8 i.e. cotton + pigeonpea whereas it was highest (5.56) in treatment T_4 i.e. cotton + blackgram.

4.8 Fibre quality characters

4.8.1 2.5% span length :

The data presented in Table 15 clearly showed that different treatments had no significant influence on 2.5% span length of lint. However, cotton intercropped with groundnut had slightly lower 2.5% span length (27.15 mm) while cotton intercropped with soyabean had slightly higher (28.10 mm) 2.5% span length than other treatments.

4.8.2 Bundle strength :

The data pertaining to bundle strength of lint of cotton are presented in Table 15 indicated that bundle strength of lint of cotton did not influence significantly by different treatments. Bundle strength of lint of cotton ranged between 21.7 and 23.6. Maximum bundle strength (23.65) was observed in treatment T_6 i.e. cotton + cowpea whereas minimum bundle strength (21.7) was observed in treatment T_4 i.e. cotton + blackgram.

4.8.3 Uniformity ratio :

The data on uniformity ratio (Table 16) revealed that different treatments did not give any significant effect on uniformity ratio of lint of cotton. Treatment T_8 i.e. cotton + pigeonpea had slightly higher uniformity ratio (50.3%). While treatment T_6 i.e. cotton + cowpea had slightly lower uniformity ratio (47.8%) than all other treatments.

Table 15 : 2.5% Span length (mm) and bundle strength (g/tex) of lint of cotton as influenced by various treatments

Treatment details	2.5% Span length (mm)	Bundle strength (g/tex)
T_1 – Cotton alone	27.25	23.5
T_2 – Cotton + Groundnut (1:2)	27.15	21.8
T_3 – Cotton + Greengram (1:2)	27.95	22.4
T_4 – Cotton + Blackgram (1:2)	27.23	21.7
T_5 – Cotton + Soyabean (1:2)	28.10	23.2
T_6 – Cotton + Cowpea (1:2)	27.93	23.6
T_7 – Cotton + Maize (1:2)	27.35	22.0
T_8 – Cotton + Pigeonpea (1:1)	27.68	23.0
S.Em.±	0.38	0.66
C.D.at 5%	NS	NS
C.V.%	2.7	5.8

Table 16 : Uniformity ratio, fibre fineness as well as maturity co-efficient of cotton as influenced by various treatments

Treatment details	U.R.(%)	Fibre fineness (M.V.) 10^{-6} / in	Maturity co-efficient
T_1 – Cotton alone	49.0	3.1	0.72
T_2 – Cotton + Groundnut (1:2)	49.5	3.5	0.77
T_3 – Cotton + Greengram (1:2)	50.0	3.3	0.75
T_4 – Cotton + Blackgram (1:2)	50.0	3.3	0.76
T_5 – Cotton + Soyabean (1:2)	48.8	3.6	0.79
T_6 – Cotton + Cowpea (1:2)	47.8	3.5	0.78
T_7 – Cotton + Maize (1:2)	48.0	3.5	0.77
T_8 – Cotton + Pigeonpea (1:1)	50.3	3.4	0.77
S.Em.±	0.78	0.13	0.02
C.D.at 5%	NS	NS	NS
C.V.%	3.2	7.5	5.0

4.8.4 Fibre fineness (Micronaire value) :

The mean data on fibre fineness are presented in Table 16. Micronaire value of lint expressed as fibre fineness did not differ significantly due to different treatments. The fibre fineness ranged between 3.1 and 3.6.

4.8.5 Maturity co-efficient :

The data presented in Table 16 indicated that maturity co-efficient was not affected by various treatments. Maturity co-efficient of lint of cotton ranged between 0.72 and 0.79.

4.9 Economics of the treatments

4.9.1 Cotton equivalent yield :

The data pertaining to the effect of different intercropping systems on cotton equivalent yield are presented in Table 17 and illustrated graphically in Fig.9.

Cotton equivalent yield of cotton was significantly influenced by different intercropping systems. Significantly the highest cotton equivalent yield (3801 kg/ha) was recorded in treatment T_4 (cotton + blackgram) over treatment T_5 (2921 kg/ha), T_7 (2131 kg/ha) and T_8 (2509 kg/ha) but remained at par with rest of the treatments. The increase in cotton equivalent yield in treatment T_4 was to the tune of 23.2, 43.9 and 34.0 per cent than treatments T_5, T_7 and T_8, respectively. Lowest cotton equivalent yield (2131 kg/ha) was obtained in treatment T_7 i.e. cotton + maize which was significantly lower than cotton alone (3094 kg/ha) but was at par with treatment T_8 (2509 kg/ha). The data further revealed that cotton equivalent yield was 5.5%, 31.12% and 18.91% lower in treatment cotton + soyabean (T_5), cotton + maize (T_7) and cotton + pigeonpea (T_8) than cotton alone (T_1), respectively. This indicated that reduction in seed cotton yield was not compensated by yield of soyabean, maize and pigeonpea.

Table 17 : Effect of different treatments on Cotton equivalent yield

Treatment details	Cotton equivalent yield (kg/ha)
T_1 – Cotton alone	3094
T2 – Cotton + Groundnut (1:2)	3151
T3 – Cotton + Greengram (1:2)	3782
T4 – Cotton + Blackgram (1:2)	3801
T5 – Cotton + Soyabean (1:2)	2921
T6 – Cotton + Cowpea (1:2)	3355
T7 – Cotton + Maize (1:2)	2131
T8 – Cotton + Pigeonpea (1:1)	2509
S.Em.±	258
C.D.at 5%	760
C.V.%	16.7

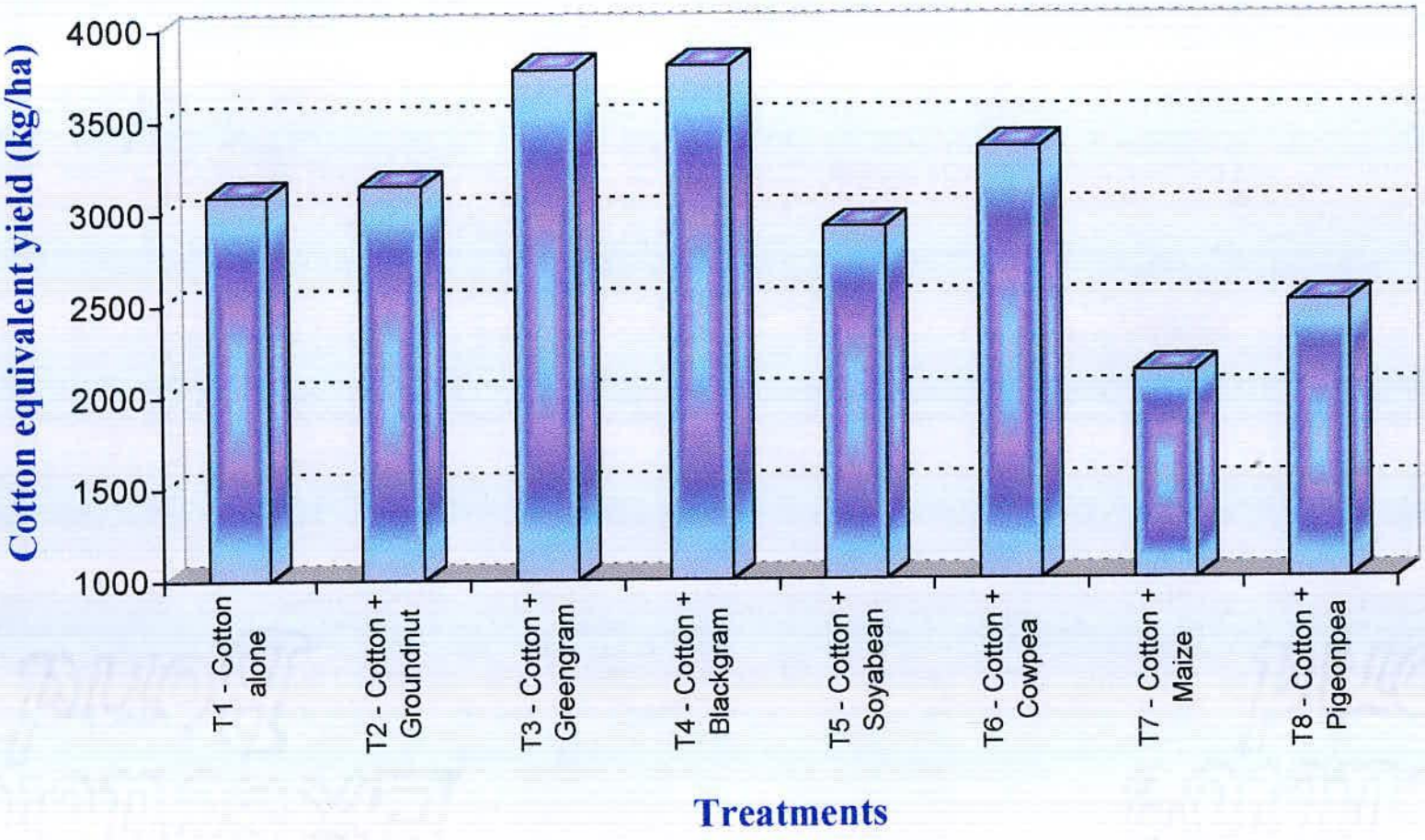

Fig. 9 : Effect of different treatments on cotton equivalent yield

4.2.2 Net return :

The data on net return in rupees per hectare as influenced by different treatments are presented in Table 18 and also depicted graphically in Fig.10.

The data revealed that maximum net return (Rs.47670/ha) was obtained in treatment T_4 i.e. cotton + blackgram followed by treatment T_3 i.e. cotton + greengram (Rs.47026/ha) both remained at par with T_1, T_2 and T_6 but showed significant superiority over T_5 i.e. cotton + soyabean (Rs.31950/ha), T_7 i.e. cotton + maize (Rs.23632/ha) and T_8 i.e. cotton + pigeonpea (Rs.25154/ha). Treatment T_6 i.e. cotton + cowpea secured third position (Rs.38599/ha) in respect of net return which remained at par with T_1, T_2 and T_5 but significantly superior over T_7 i.e. cotton + maize and T_8 i.e. cotton + pigeonpea, which in turn remained at par with T_1 i.e. cotton alone, T_2 i.e. cotton + groundnut and T_5 i.e. cotton + soyabean. The increased in net return in treatment T_4 i.e. cotton + blackgram and treatment T_3 i.e. cotton + greengram was to the tune of Rs.12685, Rs.12987, Rs.15720, Rs.9071, Rs.24038, Rs.22516 and Rs.12041, Rs.12343 Rs.15076, Rs.8427, Rs.23394 and Rs.21872 than T_1, T_2, T_5, T_6, T_7 and T_8, respectively. The data further revealed that intercropping of cotton + blackgram, cotton + greengram and cotton + cowpea were only found advantageous than growing cotton alone, as these system gave Rs.12685, Rs.12041 and Rs.3614/ha more net returns, respectively, than cotton alone. The net return was reduced to the tune of Rs.302/ha, Rs.3035/ha, Rs.11353/ha and Rs.9831/ha where cotton intercropped with groundnut, soyabean, maize and pigeonpea, respectively as compared to cotton alone.

4.2.3 Cost benefit ratio :

The data regarding the cost benefit ratio of different treatments are presented in Table 18 and graphically depicted in Fig.10 indicated that the maximum cost benefit ratio of 2.89 was recorded in treatment T_4 i.e. cotton +

Table 18 : Effect of different treatments on net return and cost benefit ratio

Treatment details	Net return (Rs./ha)	Cost-benefit ratio
T_1 – Cotton alone	34985	2.44
T_2 – Cotton + Groundnut (1:2)	34683	2.32
T_3 – Cotton + Greengram (1:2)	47026	2.85
T_4 – Cotton + Blackgram (1:2)	47670	2.89
T_5 – Cotton + Soyabean (1:2)	31950	2.32
T_6 – Cotton + Cowpea (1:2)	38599	2.52
T_7 – Cotton + Maize (1:2)	23632	2.02
T_8 – Cotton + Pigeonpea (1:1)	25154	2.09
S.Em.±	4549	0.17
C.D.at 5%	13380	0.49
C.V.%	25.7	13.79

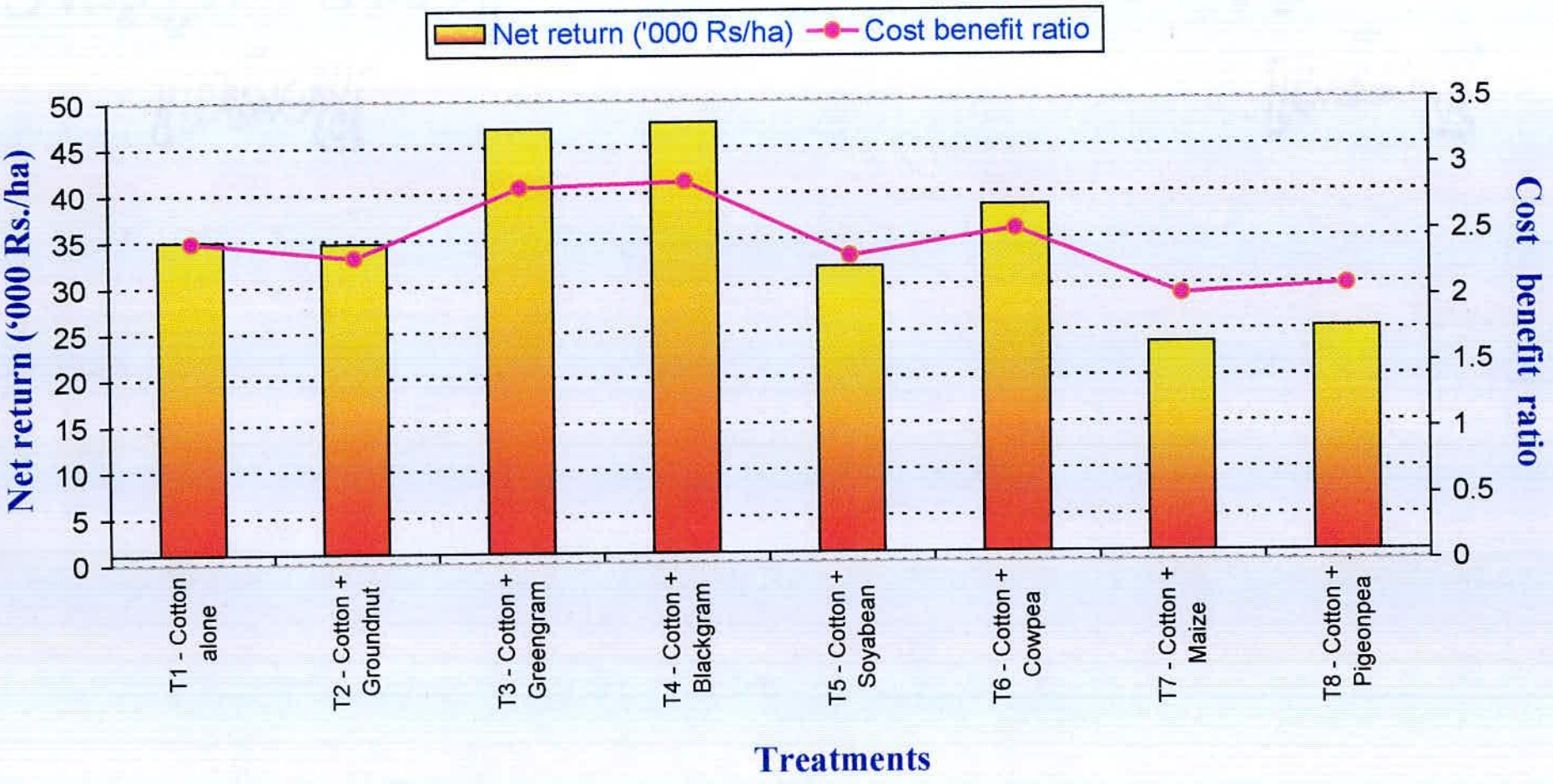

Fig.10 : Effect of different treatments on net returns and cost benefit ratio

blackgram followed by treatment T_3 i.e. cotton + greengram (2.85) both remained at par with treatment T_6 i.e. cotton + cowpea (2.52) and treatment T_1 i.e. cotton alone but significantly higher than treatments T_2 i.e. cotton + groundnut, T_5 i.e. cotton + soyabean, T_7 i.e. cotton + maize and T_8 i.e. cotton + pigeonpea.

DISCUSSION

V DISCUSSION

The results of the present investigation are presented in previous chapter and in this chapter, it is contemplated to discuss critically the variations observed in growth parameters, yield attributes, yield, quality characters of cotton, and cotton equivalent yield and economics under the influence of different treatments. It has been attempted to establish "Effect and cause relationship" in light of available evidence and literature.

The entire discussion has been divided into the following heads :

5.1 Effect of weather on cotton crop and inter crops

5.2 Effect of intercrops on growth parameters of cotton

5.3 Effect of intercrops on yield attributes of cotton

5.4 Effect of intercrops on yield of cotton

5.5 Effect of intercrops on quality characters of cotton

5.6 Effect of different treatments on cotton equivalent yield

5.7 Economics of different treatments

5.1 Effect of weather on cotton crop and inter crops

The meteorological data given in Table 1 and Fig.1 indicate clearly that relative humidity, sunshine hours, maximum and minimum temperature were normal and favourable for healthy growth of cotton and intercrops throughout the season during 1998-99. An examination of total rainfall in general and distribution of rainfall in particular revealed that there was no moisture stress during the different growth stages of cotton as well as intercrops; resulted in profuse growth of all the crops.

No severe incidence of diseases, insects/pests were observed during the crop growth period. Thus, whatever variations observed in the various characters studied within the investigation are attributed to different treatments exercised in this experiment.

5.2 Effect of intercrops on growth parameters of cotton

Plant population of cotton :

It was observed from the data (Table 5) that different intercropping systems have no significant influence on plant population of cotton at 12 DAS and at harvest. This might be due to the fact that cotton plant had well established before or after competition starts from intercrops in early growth stages and so optimum plant population was maintained in sole crop of cotton as well as cotton intercropped with various intercrops. This finding is in agreement with the findings of Jain (1984) who observed that plant population of cotton was not affected by intercropping of green gram, black gram and soyabean.

Plant height of cotton :

It was realized from the data given in Table 6 and Fig.3 that the plant height of cotton plants at squaring, flowering, first boll bursting and at harvest was significantly more in treatment T_1 (cotton alone) than cotton intercropped with soyabean, maize and pigeonpea. This was obviously due to relatively longer growth phase of pigeonpea, soyabean and maize which coincided with the peak period of cotton crop and hence these crops have suppressing effect on height of cotton crop. While, plant height of cotton was not significantly affected by cotton + groundnut, cotton + greengram, cotton + blackgram and cotton + cowpea intercropping as compared with cotton alone (T_1). This may be due to short statured nature and compact growth habit of groundnut, greengram, blackgram and cowpea combined with its adaptability to the soil and climatic condition. In agreement with these results, non-significant differences in plant height of cotton were also reported by Nagre (1979) in cotton + greengram and cotton + cowpea intercropping. Similar trend of results was also reported by Jain *et al.*(1982) in cotton + greengram and cotton + blackgram, Jain (1984) in cotton + greengram, cotton + blackgram intercropping, Sheoran and Malik (1986) in cotton + greengram, Balasubramanian *et al.*(1994) in cotton + greengram, cotton

+ blackgram and cotton + cowpea, Mukerji and Verma (1994) in cotton + greengram and cotton + cowpea and Lourduraj and Chinaswami (1996) in cotton + greengram intercropping.

Days to different stages of cotton :

It was observed from the data (Table 7) that different treatments have no significant influence on days to 50 per cent squaring, 50 per cent flowering, 50 per cent boll setting and 50 per cent boll bursting. This is because these characters are generally governed by genetically and hence not affected by intercropping with various crops.

Monopodial and sympodial branches :

Monopodial as well as sympodial branches per plant were higher in treatment cotton alone (T_1). Cotton alone had a definite advantage over other treatments in the sense that this will completely free from competition with intercrops. Cotton alone (T_1) produced significantly more monopodial as well as sympodial branches per plant than treatment T_5 i.e. cotton + soyabean, T_7 i.e. cotton + maize and T_8 i.e. cotton + pigeonpea. This may be due to the prolong competition with intercrops (soyabean, maize and pigeonpea) for nutrients, moisture and environmental resources with consequential reduction in stem elongation and branches per plant. Prolonged suppressive effect of soyabean, maize and pigeonpea, as an intercrop component with cotton, might have decreased the monopodial as well as sympodial branches. In respect of monopodial and sympodial branches per plant, cotton alone (T_1) is at par with the treatment T_2 i.e. cotton + groundnut, T_3 i.e. cotton + greengram, T_4 i.e. cotton + blackgram and T_6 i.e. cotton + cowpea. This might be due to complementary effect of groundnut, greengram, blackgram and cowpea and cotton crop. These results are in corroboration with those reported by Nagre (1979) in cotton + greengram and cotton + cowpea, Sheoran and Malik (1986) in cotton + greengram, Balasubramanian *et al.*(1994) in cotton + greengram, cotton +

blackgram and cotton + cowpea intercropping as compared with cotton grown alone.

5.3 Effect of intercrops on yield attributes of cotton :

Number of bolls per plant :

The number of bolls per plant of cotton was maximum (57.5) in treatment T_1 i.e. cotton alone which was significantly higher than treatment T_5 (cotton + soyabean), T_7 (cotton + maize) and T_8 (cotton + pigeonpea). A significant reduction in number of bolls/plant in cotton + soyabean (T_5), cotton + maize (T_7) and cotton + pigeonpea (T_8) intercropping as compared with cotton alone might be attributed to depressing effect of these intercrops because of higher growth, more canopy and longer duration resulted in competition for nutrient, light and temperature, consequently poor development of cotton crop. These results are in line with the findings of Nagre (1979) who reported that number of bolls/plant reduced when cotton intercropped with pigeonpea. Seshadri and Natarajan (1989) and Gomaa (1991) reported that number of bolls/plant was significantly less with cotton + soyabean intercropping compared with pure cotton. However, significant reduction in number of bolls/plant was not observed in treatment T_2 i.e. cotton + groundnut, T_3 i.e. cotton + greengram, T_4 i.e. cotton + blackgram and T_6 i.e. cotton + cowpea as compared with cotton alone (T_1). The probable reason for no reduction in number of bolls/plant that there was very less competition for nutrient, moisture and light due to short duration and compact statures of these intercrops. These findings are in close confirmity with those of Nehra and Kairon (1986) and Sheoran and Malik (1986) reported that number of bolls/plant in cotton + greengram intercropping were same as that produced in cotton grown alone. These results are also in agreement with Nagre (1979) in cotton + greengram, Jain *et al.*(1982) in cotton + greengram and cotton +

blackgram, Balasubramanian *et al.*(1994) in cotton + greengram, cotton + blackgram and cotton + cowpea, Mukerji and Verma (1994) in cotton + greengram and cotton + cowpea intercropping as compared with cotton alone.

Boll weight :

Variation in boll weight due to different treatments were found to be non significant (Table 9). These findings are in accordance with the findings of Rao (1982), Mukerji and Verma (1994) and Tomar *et al.*(1997); they reported that boll weight remained unaffected due to intercropping as compared to cotton alone.

5.4 Effect of intercrops on yield of cotton

The reduction in lint, seed and seed cotton yield with intercropping of soyabean, maize and pigeonpea may be attributed to longer duration of these intercrops competed with main crop of cotton for nutrient, moisture and sunlight resulted in poor growth of cotton crop consequently low yield. The reduction in lint yield, was to the tune of 309, 523 and 586 kg/ha, cotton seed was to the tune of 627, 980 and 1118 kg/ha and seed cotton yield was to the tune of 936, 1503 and 1704 kg/ha by intercropping of soyabean, maize and pigeonpea, respectively, than cotton alone. Maximum reduction of 55.05 per cent in seed cotton was observed in cotton + pigeonpea intercropping (T_8) which is due to pigeonpea having profuse growth and deep rooted crop and being longer duration more or less similar to cotton; followed by T_7 i.e. cotton + maize (48.57%) and T_5 i.e. cotton + soyabean (30.25%). Several scientists have also reported reduction in yield by intercropping of soyabean, Giri and Upadhyay (1979), Birajdar *et al.*(1980), Deshpande *et al.*(1989), Sankaranarayanan *et al.* (1989), Seshadri and Natarajan (1989), Yadav *et al.* (1993) and Tomar *et al.* (1994); by intercropping of pigeonpea, Nagare (1979), Birajadar *et al.*(1987); and by intercropping of maize, Birajdar *et al.*(1980) and Abdel-Malek (1991); than cotton alone. However, the yield of seed cotton was not adversely affected

by intercropping of groundnut, greengram, blackgram and cowpea because of short statures and short duration of these crops resulted in less competition for nutrients, moisture and sunlight with main crop of cotton. These results are in close confirmity with those reported by Giri and Upadhyay (1979), Birajdar *et al.*(1980), Bavale and Vyahalkar (1981), Jain *et al.*(1982), Shaktawat and Singh (1985), Sheoran and Malik (1986), Rao (1991), Padhi *et al.* (1993), Yadav *et al.*(1993), Balasubramanian *et al.*(1994), Mukerji and Verma (1994), Patel *et al.*(1995), Lourduraj and Chinaswami (1996) and Tomar *et al.* (1997).

Stalk yield of cotton :

The data pertaining to the effect of different treatments on Stalk yield of cotton are given in Table 12. It was observed that significantly higher Stalk yield was recorded under treatment T_1 i.e. cotton alone over treatments T_2 i.e. cotton + groundnut, T_3 i.e. cotton + greengram, T_5 i.e. cotton + soyabean, T_7 i.e. cotton + maize and T_8 i.e. cotton + pigeonpea. This might be due to no competition for nutrient, moisture and light resulted in profuse growth of plants in sole cotton than cotton intercropped with groundnut, greengram, soyabean, maize and pigeonpea. Shethi *et al.*(1992) reported reduction in stalk yield when cotton was intercropped with groundnut and greengram as compared to sole cotton. While, treatment T_1 i.e. cotton alone was at par with treatments T_4 i.e. cotton + blackgram and T_6 i.e. cotton + cowpea in respect to stalk yield of cotton. Shaktawat and Singh (1985) showed that stalk yield of cotton was not significantly affected by cotton + blackgram intercropping as compared with cotton alone.

Harvest index of cotton :

Harvest index is the ratio of economic yield and biological yield express in percentage which depend upon proporsnate increase or decrease in seed cotton and stalk yield. Though the differences in harvest index (efficiency index)

was not significant. Cotton + groundnut and cotton + greengram recorded slightly higher harvest index than sole cotton.

5.5 Effect of intercrops on quality characters of cotton

Ginning percentage, seed index, lint index, 2.5% span length, bundle strength, uniformity ratio, fibre fineness and maturity co-efficient were not influenced by various treatments. This finding is in line with that of Musande *et al.* (1981) who reported that quality characters of cotton viz., ginning percentage, mean fibre length, lint index and earliness index were not influenced significantly due to intercropping of greengram, blackgram or groundnut with cotton. Similarly, in respect of quality characters of cotton, non significant differences were observed by Azevedo *et al.*(1993) in cotton + cowpea, Mohamed and Salwau (1994) in cotton + maize and Mukerji and Verma (1994) in cotton + greengram and cotton + cowpea intercropping as compared with cotton grown alone.

5.6 Effect of different treatments on cotton equivalent yield

Apart from the competitive effects, prevailing prices of economic produce become an additional factor in choosing the components of intercropping system and so yields of intercrops were converted to cotton equivalent yield and added to cotton yield (Table 17). Cotton equivalent yield was significantly higher in treatment cotton + blackgram (T_4) over treatments T_5 i.e. cotton + soyabean, T_7 i.e. cotton + maize and T_8 i.e. cotton + pigeonpea. The increase in cotton equivalent yield in cotton + blackgram (T_4) was to the tune of 23.2, 43.9 and 34.0 per cent than cotton + soyabean (T_5), cotton + maize (T_7) and cotton + pigeonpea (T_8), respectively. The finding is in accordance with findings of Khistaria *et al.*(1994) who reported significantly higher cotton equivalent yield in cotton + blackgram intercropping as compared to other intercropping systems and sole crop of cotton. The seed cotton equivalent yield was at par but numerically higher in treatment T_4 i.e. cotton + blackgram, T_3 i.e. cotton +

greengram, T_6 i.e. cotton + cowpea and T_2 i.e. cotton + groundnut as compared with cotton alone (T_1), this indicate that reduction in seed cotton yield was well compensated by yield of blackgram, greengram, cowpea and groundnut. These results are in close confirmity with those reported by Prasad *et al.*(1993) who reported that cotton + groundnut and cotton + greengram intercropping gave higher cotton equivalent yield than obtained from cotton alone. Numerically increased in cotton equivalent yield was also reported by Renganayaki and Subramanian (1994) and Patel *et al.*(1995) in cotton + greengram and cotton + blackgram intercropping systems than cotton alone.

The data further revealed that cotton equivalent yield in sole cotton was significantly higher (3094 kg/ha) than cotton + maize (2131 kg/ha) and also numerically higher than cotton + soyabean (T_5) and cotton + pigeonpea (T_8), indicated that reduction in seed cotton yield was not compensated by yield of soyabean, maize and pigeonpea. Nagare (1979) reported that the reduction in seed cotton yield was not compensated by yield of pigeonpea.

5.7 Economics of different treatments

Net return :

Net return obtained from cotton + blackgram (Rs.47670) and cotton + greengram (Rs.47026) were significantly higher than treatment T_5 - cotton + soyabean, T_7 - cotton + maize and T_8 - cotton + pigeonpea. Net returns obtained from cotton + cowpea was significantly higher (Rs.38599/ha) than cotton + maize (T_7) and cotton + pigeonpea (T_8) intercropping. An additional net returns of Rs.12685, Rs.12041 and Rs.3614/ha were obtained by growing blackgram, greengram and cowpea as intercrops in cotton than growing cotton as sole crop, respectively. This could be attributed to higher yield advantage under intercropping of cotton with blackgram, greengram and cowpea. In agreement with these results, higher net monetary return was also reported by Nagare (1979), Sheoran and Malik (1986) and Prasad *et al.*(1989) in cotton + greengram

intercropping, Padhi *et al.*(1993) and Yadav *et al.*(1993) in cotton + blackgram and cotton + greengram intercropping, Balasubramanian *et al.*(1994) in cotton + greengram, cotton + blackgram and cotton + cowpea intercropping. The net return was reduced in cotton + groundnut, cotton + soyabean, cotton + maize and cotton + pigeonpea intercropping as compared with cotton alone. This results corroborates the findings of Nagare (1979) and Birajdar *et al.*(1987) who reported that the monetary returns were decreased when cotton was intercropped with pigeonpea than cotton alone. Similarly, Rao *et al.*(1998) also reported that cotton + soyabean intercropping gave less net return than obtained in sole cotton. Hence, blackgram, greengram and cowpea were found to be most suitable and companion crops for intercropping in cotton. These results are in confirmity with the finding of Padhi *et al.*(1993) who observed that blackgram was most suitable crop for intercropping in cotton. Similarly, Khistaria *et al.*(1994) also reported that amongst intercrops blackgram and greengram were more suitable than other intercrops.

Cost Benefit ratio :

The maximum cost benefit ratio was recorded in treatment T_4 i.e. cotton + blackgram (Rs.2.89) followed by treatment T_3 i.e. cotton + greengram (Rs.2.85) and T_6 i.e. cotton + cowpea (Rs.2.52) as compared to cotton alone (Rs.2.44). These results are in line with the findings of Balasubramanian *et al.*(1994) who reported that cotton + cowpea, cotton + greengram and cotton + blackgram intercropping gave higher cost benefit ratio than sole cotton. The lowest cost benefit ratio was observed in treatment T_8 i.e. cotton + pigeonpea followed by treatment T_7 i.e. cotton + maize, T_5 i.e. cotton + soyabean and T_2 i.e. cotton + groundnut. This may be due to more reduction in seed cotton yield which was not compensated by yield of respective intercrops and higher cost of cultivation lead to less monetary net return and cost benefit ratio.

SUMMARY AND CONCLUSIONS

VI SUMMARY AND CONCLUSION

A field experiment was carried out during the *kharif* season of 1998-99 on the heavy black soil of the farm of Main Cotton Research Station, Gujarat Agricultural University, Surat to study the intercropping in cotton G.Cot.Hy.10 under irrigated condition. Eight treatments comprising of cotton alone, cotton + groundnut, cotton + greengram, cotton + blackgram, cotton + soyabean, cotton + cowpea, cotton + maize and cotton + pigeonpea were tried in Randomized Block Design with four replications.

The results presented and discussed in the preceding chapters are summarized in this chapter.

1. Intercropping of soyabean, maize and pigeonpea in cotton adversely affected the plant height, number of sympodial and monopodial branches/plant, number of bolls/plant and eventually the yield of base crop of cotton; but did not affect significantly by cotton + groundnut, cotton + greengram, cotton + blackgram and cotton + cowpea intercropping systems as compared with cotton alone.
2. Plant population, days to 50 per cent squaring, 50 per cent flowering, 50 per cent boll setting and 50 per cent boll bursting and harvest index of cotton did not affect significantly by various intercropping systems as compared with cotton alone.
3. None of the intercropping systems showed adverse or favourable effects on any of quality characters of cotton viz. ginning percentage, seed index, lint index, 2.5 per cent span length, uniformity ratio, fibre fineness, maturity co-efficient and bundle strength as compared with cotton alone.

4. Maximum seed cotton yield of 3094 kg/ha was obtained when cotton grown alone followed by cotton + greengram (2964 kg/ha), cotton + cowpea (2805 kg/ha), cotton + blackgram (2760 kg/ha) and cotton + groundnut (2694 kg/ha) intercropping systems. Significantly lowest seed cotton yield of 1390 kg/ha was obtained in cotton + pigeonpea intercropping followed by cotton + maize (1590 kg/ha) and cotton + pigeonpea (2158 kg/ha) intercropping systems as compared with cotton alone.

5. cotton equivalent yield was higher when cotton intercropped with blackgram (3801 kg/ha), greengram (3782 kg/ha), cowpea (3355 kg/ha) and groundnut (3151 kg/ha) as compared with cotton grown alone (3094 kg/ha). While lowest cotton equivalent yield of 2131 kg/ha was obtained in cotton + maize intercropping system followed by cotton + pigeonpea (2509 kg/ha) and cotton + soyabean (2921 kg/ha) intercropping systems which were lower than cotton grown alone.

6. Cotton + blackgram intercropping gave highest net return Rs.47670/ha and cost-benefit ratio of 2.89. The other combinations of intercropping were in the descending order. Cotton + greengram and cotton + cowpea intercropping which gave net returns of Rs.47026/ha and Rs.38599/ha, respectively, as compared to cotton alone (Rs.34985/ha). While, cotton intercropped with groundnut, soyabean, pigeonpea and maize gave less net returns and cost-benefit ratio as compared to cotton grown alone.

7. Among all intercropping systems, cotton + blackgram, cotton + greengram and cotton + cowpea intercropping were more productive and remunerative than cotton grown alone.

Conclusion :

Based on the results of one year experimentation, it seems quite logical to indicate that intercropping of cotton + blackgram, cotton + greengram and cotton + cowpea were distinctly superior over cotton alone and found the most profitable by realising the higher net returns of Rs.47670, Rs.47026 and Rs.38599/ha, respectively, as compared with cotton alone under irrigated condition on heavy black soil of South Gujarat condition.

Future line of work :

1. The experiment should be repeated for one more year for evaluating consistency and applicability of the treatments.
2. Effect of intercrops on soil properties should be studied.
3. Residual effect of intercrops on the succeeding crops should be studied.
4. Effect of intercropping on weed density and predators and parasites should be studied.

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* Original not seen.

APPENDICES

Appendix I : Economics of various treatments

Treatment details	Gross income (Rs./ha) from				Total gross income (Rs./ha)	Total cost of cultivation (Rs./ha)	Net income (Rs./ha)	Cost-Benefit Ratio
	Seed cotton yield	Stalk yield	Seed/grain yield of intercrop	Fodder yield of intercrop				
T_1 – Cotton alone	55705	3542	-	-	59247	24262	34985	2.44
T_2 – Cotton + Groundnut (1:2)	48501	2900	8231	1258	60890	26207	34683	2.32
T_3 – Cotton + Greengram (1:2)	53356	2964	14740	1378	72438	25412	47026	2.85
T_4 – Cotton + Blackgram (1:2)	49689	3123	18744	1295	72851	25181	47670	2.89
T_5 – Cotton + Soyabean (1:2)	38857	2622	13740	875	56094	24144	31950	2.32
T_6 – Cotton + Cowpea (1:2)	50499	3150	9905	379	63933	25334	38599	2.52
T_7 – Cotton + Maize (1:2)	28651	1867	9726	6582	46826	23194	23632	2.02
T_8 – Cotton + Pigeonpea (1:1)	25020	1578	20152	1331	48081	22927	25154	2.09

Appendix II : Cost of seeds and market price of farm produce

A. Cost of seeds

Cotton	-	Rs. 556 / kg
Groundnut	-	Rs. 30 / kg
Greengram	-	Rs. 40 / kg
Blackgram	-	Rs. 45 / kg
Soyabean	-	Rs. 12 / kg
Cowpea	-	Rs. 40 / kg
Maize	-	Rs. 9 / kg
Pigeonpea	-	Rs. 30 / kg

B. Market price of farm produce

Seed cotton	-	Rs. 18 / kg
Cotton stalk	-	Rs. 0.50/kg

Intercrops		Grain/Seed/Pod		Fodder/Straw
Groundnut	-	Rs. 15 / kg	-	Rs. 1.50 / kg
Greengram	-	Rs. 20 / kg	-	Rs. 1.20 / kg
Blackgram	-	Rs. 25 / kg	-	Rs. 1.20 / kg
Soyabean	-	Rs. 10 / kg	-	Rs. 0.50 / kg
Cowpea	-	Rs. 20 / kg	-	Rs. 0.50 / kg
Maize	-	Rs. 6.50 / kg	-	Rs. 1.50 / kg
Pigeonpea	-	Rs. 18.35 / kg	-	Rs. 1.20 / kg

CERTIFICATE

This is to certify that I have no objection for supplying any copy or any part of this thesis to any scientist at a time through reprographic process, if necessary for rendering reference service in a library or documentation centre.

Place : Navsari

Date : 15th April, 2000

(D. D. Patel)