OPTIMISING THE YIELD RECOVERY OF SOME PULSE, OILSEED AND HIGH VALUE CROPS FOR INCREASING THE PROFITABILITY OF SORGHUM BASED CROPPING SYSTEM

THESIS

SUBMITTED TO THE

JAWAHARLAL NEHRU KRISHI VISHWA VIDYALAYA, JABALPUR

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By

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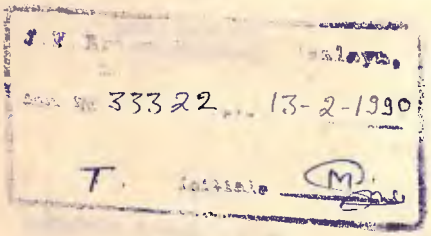

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CERTIFICATE - I

This is to certify that the thesis entitled "OPTIMISING THE YIELD RECOVERY OF SOME PULSE, OILSEED AND HIGH VALUE CROPS FOR INCREASING THE PROFITABILITY OF SORGHUM BASED CROPPING SYSTEM" submitted in partial fulfilment of the requirement for the degree of MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)" of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, is a record of the bonafide research work carried out by Shri ASHOK KUMAR MAHAJAN under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

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

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CERTIFICATE - II

This is to certify that the thesis entitled, "OPTIMISING THE YIELD RECOVERY OF SOME PULSE, OILSEED AND HIGH VALUE CROPS FOR INCREASING THE PROFITABILITY OF SORGHUM BASED CROPPING SYSTEM" submitted by Shri ASHOK KUMAR MAHAJAN to the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur in partial fulfilment of the requirement for the degree of "MASTER OF SCIENCE IN AGRICULTURE" in the Department of Agronomy has been approved by the External Examiner and by the Student's Advisory Committee after an oral examination on the same.

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INTRODUCTION

CHAPTER - I

INTRODUCTION

Out of 143 million hectares under cultivation in India as much as one third of the total area receives rainfall below 700 mm and consequently suffers from low yields. In other words 63 per cent of total food grain comes from dryland areas, having low and scanty rainfall. In such areas production risk is considerably more than that in irrigated areas as well as in high rainfall areas.

In such areas legume grains, oilseeds, millets are mostly grown, but production per unit area is too low. Owing to shortages of production of oilseeds and pulses in the world, their increase in production is utmost important without sacrifice the area of cereal/millet crops. Practically increase in production of pulses and oilseeds are not possible, unless the cropping intensity is increased. There are number of ways and concepts of increase in cropping intensity to gain more economic returns per unit area per unit time. Among them, intercropping is well recognised all over the world as the best device to achieve optimum utilization of soil water, nutrients and sunlight in time and space. "Growing of two or more crops in association, on the same piece of land so as to exploit it

effectively and efficiently, may scientifically be termed as intercropping".

Crop compatibility constitutes an essential ingradient for the success of an intercropping system. The growth rhythm, duration and the capacity to photosynthesize on low light intensities are some of the important criteria in the selection of a companian crop.

During last three decades, the population of our country has increased 320 million (+ 90 %). Whereas the net sown area could increase by 25 million (20 %), hence adapting such efficient cropping system is very important to meet the challenge of population explosion.

Sorghum, an important crop of M.P., is inherient very efficient and fits well in the intercropping systems with legumes and oilseeds such as pigeonpea, soybean, groundnut, green gram, black gram and cowpea giving 10-15 % extra monetary returns than sole cropping. The technique of wide, paired rows (30/90 cm) in sorghum does not effect its yield, because it is grown at full sole (optimum) plant population by manipulating the within row spacing but provides additional space which thus, gets more solar energy for photosynthesis.

Soybean and pigeonpea in pulses are also being grown in larger area and commands good position in our state as for as production is concerned too. Similarly

sunflower is newly introduced crop, now widely popularising day to day among farmers as mixed crop or as intercrops with different crops, but no scientific recommendation with sorghum has been made till yet.

The success of any intercropping system would depend upon the crop compatibility. Hence it is important to choose intercrops on the basis of their compatibility. The pattern of planting and maturity of intercrops could be adjusted onthe basis of active growth period and physiological characters.

With the availability of high yielding varieties of varying growth habits and duration, adequate plant population, proper plant protection measures balanced fertilizer application, the aim of intercropping is now mone towards augumenting total productivity of dryland areas.

In the present study, compatibility of sorghum with soybean, pigeonpea and sunflower are to be tested in intercropping system under different plant population.

Keeping this in view, a study on "Optimizing the yield recovery of some pulse, oilseed and high value crops for increasing the profitability of sorghum based cropping system" was conducted during kharif 1988-89 for following investigations.

1. To compare feasibility of intercropping with sole sorghum under rainfed conditions of Malwa tract.

2. To evaluate the compatibility of soybean, sunflower, and pigeonpea with sorghum, planted in variable ratios.

3. To assess the effect of intercropping system on the growth and biometric parameters in contrast to sole cropping.

4. To develop an economical relationship in sorghum based intercropping system.

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

The research work done by various scientists in India and abroad on different aspects of the sorghum based intercropping, particularly with pigeonpea, soybean and sunflower, has been briefly reviewed in this chapter (in chronological order).

2.1 Influence of sorghum genotypes on crop growth and yield

Eny (1977) reported that sorghum cultivar S IX consistently out yielded cv. serena with an average grain yield of 7.19 and 6.02 t/ha respectively.

Panwar and Jadhav (1977) and Raghunath (1977) reported CSH-1 and CSH-3 were high yielding sorghum hybrids irrespective of their sowing patterns.

Shrivastava and Singh (1980) reported that grain and dry fodder yields of sorghum were higher in cv. T 4 than in hybrid CSH-1 grown under rainied condition.

Bueno (1982) observed in Iowa (USA) that height of sorghum genotypes was affected with the row spacing and plant density, whereas, there was no effect on the maturity.

Trial conducted under All India Coordinated Sorghum Improvement Project at Indore, Umat (1984), Rathore (1985)

and Deshmukh (1986) showed that sorghum hybrid CSH-9 gave higher yield than CSH-6, SPV-346 and SPV-351.

2.2 Influence of row arrangement on crop growth and yield

Chandravanshi (1975) reported that sorghum grown in paired rows 30 cm apart with inter-row-spacing of 60 cm or in single rows 45 cm apart gave yields of 2.85 and 2.57 tonnes/ha, respectively.

Shelke and Krishnamoorthy (1978) at ICRISAT found that in two rows of sorghum 45 cm apart alternating with one row of pigeonpea had no adverse effect on sorghum grain and gave a small but consistant increase in pigeonpea yield, which was 60-70 % of the sole crop. In sorghum-pigeonpea intercropping (4:1, 2:4 and 1:4 rows) the plant height, number of grains, test weight and dry matter/plant increased, while the yield of both crops decreased with decrease in the number of rows (Hiremath, 1979).

Satyanarayan et al. (1979) also observed that intercropping of soybean and groundnut with sorghum in rows 60 cm apart had no adverse effect on sorghum yield and gave an additional yield.

Willey (1981) also revealed that the planting geometry of important intercropping combinations at ICRISAT were (a) Sorghum/pigeonpea (2:1 rows and 100 % component population) (b) pearl millet/groundnut (1:3 and 25 + 75 %) and sorghum/pearl millet (1:1 and 50 % + 50 %).

According to Singh (1981), the spatial pattern had only marginal effects on sorghum yield but greatly affected the yields of four intercrops viz., green gram, black gram, cowpea and groundnut. Waghmare et al., 1982 also reported paired sorghum (30/90 cm) with two rows of intercrop in between 90 cm space gave maximum yield of sorghum and intercrops viz., soybean, green gram and cowpea. In sorghum/pigeonpea (2:1) intercropping at ICRISAT the pigeonpea was sown in every third row but the population of each crop was maintained at its full sole crop level (100 % sorghum + 100 % pigeonpea i.e. optimum population of 1,80,000 plants/ha of sorghum and of 40,000 plants/ha of pigeonpea) by reducing within row spacing. The dry matter accumulation of intercropped sorghum was only slightly less than sole sorghum and grain yields were semilar (4240 and 4500 kg/ha respectively). Thus despite the high sown proportion of pigeonpea are almost full yield of sorghum was achieved by maintaining the full sorghum population (Whilley et al., 1982). From the trial conducted under All India Coordinated Research Project for Dryland Agriculture (AICRPDA) at Indore recommended the intercropping system as (a) sorghum/pigeonpea (2:2 or 2:1 rows) (b) maize/soybean (2:2) (c) pigeonpea/soybean (2:4 or 2:6) (d) maize/pigeonpea (2:2 or 2:1) and (e) sorghum/soybean (2:2 or 2:1 rows) (Anonymous, 1984).

Umarani et al. (1984) reported paired system of planting increased the sorghum production by about 24 % in

below normal situation of rainfall (78.79 cm). Whereas under good rainfall situation, planting pattern did not show any difference.

In the study under AICRPDA at Indore early sorghum CSH-6 intercropped with medium maturing pigeonpea like No.148 and Khargone-2 was found suitable for rainfed areas. It recommended sorghum/pigeonpea and sorghum/soybean under 2:2 or 2:1 row arrangement for both (Anonymous, 1984).

2.3 Influence of sorghum based intercropping system on crop growth and yield

2.3.1 Cereal/legume intercropping

Agboola and Fayemi (1972) found that the yield increased in cereals when intercropped with legumes might be due to availability of biologically fixed nitrogen by legumes to cereals.

Rao and Rana (1980) interpreted the data obtained from several All India trials and showed that the base crop sorghum and intercrop legumes gave 90 to 95 and 43 to 57 per cent yields of their sole crop, respectively.

Mafra et al. (1981) suggested for yield stability sorghum to be replaced corn in corn/legume intercropping without reducing legume yield, because sorghum is less affected by weather in North-East Brazil.

2.3.2 Sorghum/pigeonpea intercropping

In a sorghum/pigeonpea intercropping system erect type pigeonpea genotypes were found better than spreading type for intercropping (Venketeswarlu, 1969).

According to Willey and Rao (1979), the data of 94 experiments revealed that the sorghum/pigeonpea intercropping was more stable than sole cropping of both crops. Reddy and Reddy (1980) also observed that under rainfed conditions the pigeonpea yielded 1.09 to 1.13 t/ha as sole crop, but its yield was much reduced when intercropped with sorghum and cowpea. However, later crops gave the high pigeonpea seed equivalent yields of 2.52 to 2.57 t/ha. Pigeonpea cultivar No.148 was found better than Prabhat when intercropped with sorghum hybrid CSH-6 had no adverse effect on sorghum yield and gave an additional seed yield of 342 kg/ha (Bhalerao and Upadhyay, 1981).

Osiru and Kibiru (1981) reported that yields of mixture of sorghum/pigeonpea and finger mille/groundnut were large in comparison to respective seed crop stands. The best combinations of the sorghum based intercropping were with maize in central America, millets in West Africa and pigeonpea in India (Willey et al., 1982).

This study also showed that although the pigeonpea component suffered considerable competition (reduced branching) during the period of sorghum growth, it partially

compensated later (little effect on pod bearing branches) and was finally able to produce dry matter yield equivalent to 53 % of the sole crop. Since the sorghum competition largely suppressed the early vegetative growth of pigeonpea, the harvest index was increased from 22 per cent in sole cropping to 30 per cent in intercropping thus the intercropped pigeonpea seed yield was very considerable as 72 per cent of the sole crop (Willey et al., 1982).

In the study under AICRPDA at Indore, early sorghum CSH-6 (95-100 days) intercropped with medium maturing pigeonpea like No.148 (165-170 days) and Khargone-2 (150-155 days) was found suitable for rainfed areas of Malwa region in M.P. (Anonymous, 1984). Umat (1985) summarised the result of the experiments conducted on sorghum based intercropping under AICSIP at Indore showed that intercropping based on sorghum gave higher yield than sole cropping pigeonpea and soybean gave stable yield and 60 cm planting pattern was best. Best planting pattern in sorghum (CSH-6)/pigeonpea (K-2) intercropping was sorghum rows 60 cm apart with one row of pigeonpea, followed by sorghum paired rows (30/90 cm) with two rows of pigeonpea.

Umat (1984) revealed that sorghum hybrid CSH-9 and pigeonpea C-11 gave the highest yield assole crop as well as in intercropping. The crop yield being not affected by pigeonpea plant density of 40 and 80 thousand plants/ha. Similar results were also obtained by Rathore (1985).

whereas Deshmukh (1986) obtained highest total grain production from sorghum CSH-9 with pigeonpea No.148, although total productivity of grains did not vary significantly between CSH-9 + No.148/C-11 or CSH-6 + No.148.

Hunshal et al. (1987) reported that intercrops red gram (UPAS 120), green gram (S-9) and soybean (Bragg) had no adverse effect on yield and yield components of sorghum. He further concluded in relatively better years of rainfall, the population of sorghum in the intercropping system recorded higher grain yield over its 50 % plant population, whereas the yield of sorghum was less affected by intercropping than those of grain legumes. Between the two grain legumes, relative yield reduction in the intercrops from the respective sole crops was more in moong bean than in pigeonpea.

2.3.3 Sorghum/soybean intercropping

Chandravanshi (1975) concluded that intercropping of sorghum with soybean resulted in reduction in yield of grain sorghum. In his trial in 1972-73 sorghum in pure stands or intercropped with soybean, groundnut and moong gave average grain yield of 3.18, 2.44, 2.5 and 2.71 tonnes/ha respectively, whereas at the ICRISAT, the intercrops soybean, cowpea and pearl millet with base crop sorghum were found to be relatively non-competitive and utilized the environment most effectively (ICRISAT, 1978).

Willey and Rao (1979) observed that soybean was better than cowpea as intercrop with sorghum in alternate row pattern. Soybean yields with tall sorghum was 16 % less than those with short sorghum as a result of decreased pods/plant and seeds/pod. Tall sorghum cultivars were however, more productive than short cultivars (Elmore et al., 1981).

Waghmare et al. (1982) concluded the findings of experiments conducted at IARI, New Delhi that sorghum in paired rows (30/90 cm) with two rows of intercrops between 90 cm space gave the maximum yields of sorghum and intercrops. Crops used as intercrops were soybean, green gram and cowpea. Whereas in the study AICRPDA at Indore sorghum/soybean (2:2 or 2:1 rows) was found suitable for Malwa tract (Anonymous, 1984).

Hunshal et al. (1987) reported that intercrops viz., red gram, green gram and soybean had no adverse effect on yield and yield components of sorghum.

2.3.4 Sorghum/sunflower intercropping

Palaniappan et al. (1975) reported that sunflower when intercropped with sorghum depressed the yield of sorghum.

2.4 Influence of sorghum based intercropping on total grain production

Agboola and Fayemi (1972) found that yield of cereal

increased when intercropped with legumes. This was probably due to biologically fixed nitrogen by legumes available to cereal. At Indore Chandravanshi (1975) found that intercropping grain sorghum with soybean resulted in a reduction in yield of grain sorghum. While at Hyderabad in International Crops Research Institute for Semi-arid Tropics it was indicated from the annual report (1975-76) that when base crop of pigeonpea and sorghum were intercropped with pearl millet, soybean and cowpea, the intercropping systems were relatively non-competitive and utilized the environment most effectively.

Willey and Rao (1979) found that on red soil, soybean seemed a rather better intercrop than cowpea in alternate row pattern with sorghum and gave extra yield as comparedto sole crops.

Reddy and Reddy (1980) found that seed yield of pigeonpea in pure stand was 1.09 to 1.13 t/ha and its yield with sorghum and cowpea as a mixed stand was very less, but they gave the highest pigeonpea seed equivalent yields of 2.52-2.57 t/ha. While it was reported that yields of mixtures of sorghum/pigeonpea and finger millet/groundnut were large in comparison to respective sole crop stands. Osiru and Kibra (1981), Bhalerao and Upadhyay (1981) reported that intercropping of pigeonpea in between wide rows of sorghum had no adverse effect on sorghum yield and gave an additional average seed yield of 342 kg/ha. Singh

(1981) yield increased by 21.6, 20.3, 29.3, 36.5 and 14.2 per cent when grown in association with green gram, black gram grain and fodder cowpea and groundnut respectively. When compared with sorghum alone, Willey *et al.* (1981) suggested that as a sole crop, pigeonpea was relatively inefficient because of its low initial growth rate and low harvest index.

Umat (1984) and Rathore (1985) found that sorghum CSH-9 with pigeonpea C-11 gave the maximum grain production but it was at par with pigeonpea No.148, whereas Deshmukh (1986) found maximum total grain production from sorghum CSH-9 with pigeonpea No.148 nearly followed by total grain production from sorghum CSH-9 with pigeonpea C-11, but yields in both were at par.

In a trial conducted under AICRPDA at Indore during 1985-86, sorghum hybrid CSH-5 with pigeonpea variety AS 71-37 gave highest grain production (5974 kg/ha) followed by in order by the sorghum varieties, SPV-462 (5972 kg) and SPV-351 (5933 kg) per ha, (Anonymous, 1986). Whereas in the intercropping the sorghum hybrid CSH-6 with pigeonpea genotype AS 71-37 gave highest grain production (4138 kg/ha) followed in order by the sorghum variety SPV-495 (4130 kg/ha) and sorghum CSH-5 (3955 kg/ha) (Anonymous, 1988).

2.5 Influence of sorghum based intercropping on Land Equivalent Ratio (LER)

Tarhalkar and Rao (1975) reported that the highest LER of 1.54 was found in sorghum/pigeonpea followed by 1.43 in sorghum/soybean and 1.26 in sorghum/groundnut intercropping at Hyderabad. But at Indore under AICSIP trials, the sorghum based intercropping with pigeonpea, soybean and groundnut yielded LER of 1.38, 1.46 and 1.31 respectively (Anonymous, 1976). A trial was conducted by Wahua and Miller (1978) at USA and found 8 to 11 per cent yield advantages in sorghum/soybean intercropping, whereas Mohta and De (1980) concluded that growing soybean in between 90 cm row of soybean (1,80,000 plants/ha) gave the highest LER of 1.35 in India.

The pooled results of 40 experiments concluded by AICSIP, AICRPDA, ICRISAT etc. at different places of India during 1972-73 revealed that the LER of sorghum/pigeonpea (2:1) intercropping was 1.46 (Rao and Willey, 1981).

Faris et al. (1983) reported that the main relative yield advantage of maize/cowpea, maize/bean, sorghum/cowpea and sorghum/bean intercropping patterns was 32 per cent as indicated by LER in North-East Brazil.

At Indore under AICRPDA sorghum (CSH-6) with intercrops pigeonpea and soybean yielded LER of 1.53 and 1.13 respectively (Anonymous, 1984). Umat (1984) and Rathore

(1985) found maximum LER in sorghum (SPV-351) + pigeonpea (C-11) combination, whereas Deshmukh (1986) reported maximum LER in sorghum (CSH-6) + pigeonpea (C-11) combination.

In the study under AICRPIA at Indore during 1985-86 the intercrop combination of sorghum hybrid CSH-5 and pigeonpea AS 71-37 appeared to be the most productive giving LER of 1.64 followed by sorghum hybrid CSH-6 + pigeonpea AS 71-37 i.e. 1.54 (Anonymous, 1986).

2.6 Influence of sorghum based intercropping on economic return

At Udaipur, Shrivastava and Singh (1975) found that the sorghum based intercropping with pigeonpea, black gram, groundnut, green gram and soybean gave the net profit of Rs.7260, 6605, 6410, 5210 and 5055 respectively, the net return from sole sorghum being Rs.4745/ha. While Tarhalkar and Rao (1975) reported that the gross monetary return from sorghum/pigeonpea, sorghum/soybean and sorghum/groundnut intercropping were Rs.8422, 7806 and 7521/ha respectively and for sole sorghum it was Rs.6772 at Hyderabad.

Ramdas *et al.* (1980) reported pigeonpea/groundnut as more profitable than sorghum/pigeonpea and soybean/pigeonpea in TamilNadu. Under rainfed conditions Jadhav *et al.* (1983) concluded that intercropping of green gram and groundnut in paired planting of sorghum increased the monetary returns by 9.91 and 13.77 per cent respectively.

The experimental findings of AICSIP and AICRPDA during the past decade in India were summerised by Willey et al. (1982) and found that the sorghum based intercropping with different legumes such as pigeonpea, soybean, groundnut, cowpea, green gram etc. were profitable giving the monetary returns of 10 to 50 per cent more than the sole crop depending upon the location and the type of intercrops. Moreover, the sorghum/pigeonpea intercropping was found to be profitable, stable and ideal for rainfed conditions in India.

Verma and Yadav (1983) calculated the monetary returns for sorghum/pigeonpea, sorghum/groundnut intercropping and for sole sorghum which was Rs.7641 to 8581, 7660 and 6806 to 6836/ha respectively. They further stated that taking sorghum (CSH-5) in 30 cm paired rows and planting one row of pigeonpea (UPAS 120) in 60 cm space between each pair of rows was the best pattern giving the highest gross income of Rs.8581/ha with a profit of Rs. 1715/ha over that of sole sorghum (Rs.6806/ha).

Umat (1984) reported that the highest monetary returns of Rs.5228/ha was obtained from the treatment of sorghum hybrid CSH-9 intercropped with pigeonpea genotype C-11 (40,000 plants/ha). Similar findings were observed by Rathore (1985) with maximum gross monetary returns of Rs.5658.66/ha. In the same place under AICRPDA trials the sorghum based intercropping with pigeonpea, soybean and

groundnut gave the respective gross monetary returns of Rs.5811, 6654 and 6058. For sole sorghum it was Rs.5364.62/ ha (Anonymous, 1984). Similarly for the above mentioned intercropping system and for sole sorghum the gross monetary returns were Rs.6370.92, 5617.93, 6200.89 and 5364.62/ha respectively (Umat, 1985).

Similarly in an experiment under AICRPDA at Indore, intercropping sorghum hybrid CSH-5 with pigeonpea variety AS 71-37 gave highest monetary return (Rs.12775/ha) followed in order by the sorghum varieties SPV-462 (Rs.12419/ha), SPV-351 (Rs.11980/ha), hybrid CSH-9 (Rs.11920/ha) and variety SPV-475 (Rs.11431/ha) which were at par. In the same year in an another experiment with 100 % and 75 % plant population of sorghum and pigeonpea gave maximum gross monetary return nearly followed by 100 % and 50 % plant population of sorghum and pigeonpea respectively (Anonymous, 1986). Sorghum hybrid CSH-6 with pigeonpea variety AS 71-37 also gave highest monetary returns (Rs.11728/ha) followed in order by the sorghum variety SPV-475 (Rs.10468/ha). Hybrid CSH-5 (Rs.9254/ha) and variety SPV-462 (Rs.9111/ha). In sole cropping, sorghum hybrid CSH-6 and CSH-5 gave high monetary returns i.e. Rs.6581/ha and Rs.5881/ha respectively (Anonymous, 1988).

MATERIALS AND METHODS

CHAPTER - III

MATERIALS AND METHODS

This chapter deals with a precise description of the materials used and the methods adopted during the course of the investigations.

3.1 Experimental site

The present experiment was conducted in field No.3, Agriculture Research Farm, College of Agriculture, Indore (M.P.) during Kharif season of the year 1988-89. This experiment was a part of All India Coordinated Sorghum Improvement Project agronomy experiments to be conducted at Indore.

3.2 Climate and season

Indore is situated in Malwa Plateau, West of Madhya Pradesh having a latitude of 22.43° North and longitude of 75.66° East with 555.5 metres above mean sea level. This region comes under sub-tropical climate. Most of the rainfall is received during mid-June to early October, temperature ranges 7°C to 9°C in winter and 23°C to 41°C in summer season as minimum and maximum.

The meteorological data i.e. average weekly temperature (°C) maximum and minimum, mean relative

humidity (%), weekly rainfall (mm) that prevailed during the period of crop growth presented in table 3.1 and Fig. 3.1 under standard meteorological weeks.

Table 3.1 Meteorological observations during the period of investigation from June 1988 to Jan. 1989*

Month	Standard week	Average weekly temperature °C		Mean relative humidity (%)	Weekly rainfall (mm)	Average weekly evapo-ration (mm)
		Maximum	Minimum			
June 88	23	41.86	27.56	60.46	1.52	12.03
	24	39.79	27.21	62.00	29.45	9.70
	25	34.47	24.57	82.57	6.85	5.51
	26	33.79	26.04	74.79	48.76	4.92
July 88	27	32.43	24.79	80.29	18.26	4.71
	28	31.43	24.79	87.00	95.49	4.02
	29	30.57	24.71	88.26	121.45	3.11
	30	28.93	23.57	93.14	59.16	3.13
	31	29.50	24.64	91.30	56.04	3.51
Aug. 88	32	28.93	23.86	91.57	88.88	3.51
	33	30.50	24.50	91.00	-	3.70
	34	28.21	24.14	92.57	175.86	2.55
	35	30.71	24.29	88.14	20.30	3.08
Sept.88	36	32.79	24.93	85.71	-	4.79
	37	32.86	24.21	84.70	42.92	3.92
	38	31.57	23.86	91.57	92.11	3.77
	39	30.76	24.21	90.86	62.40	3.07

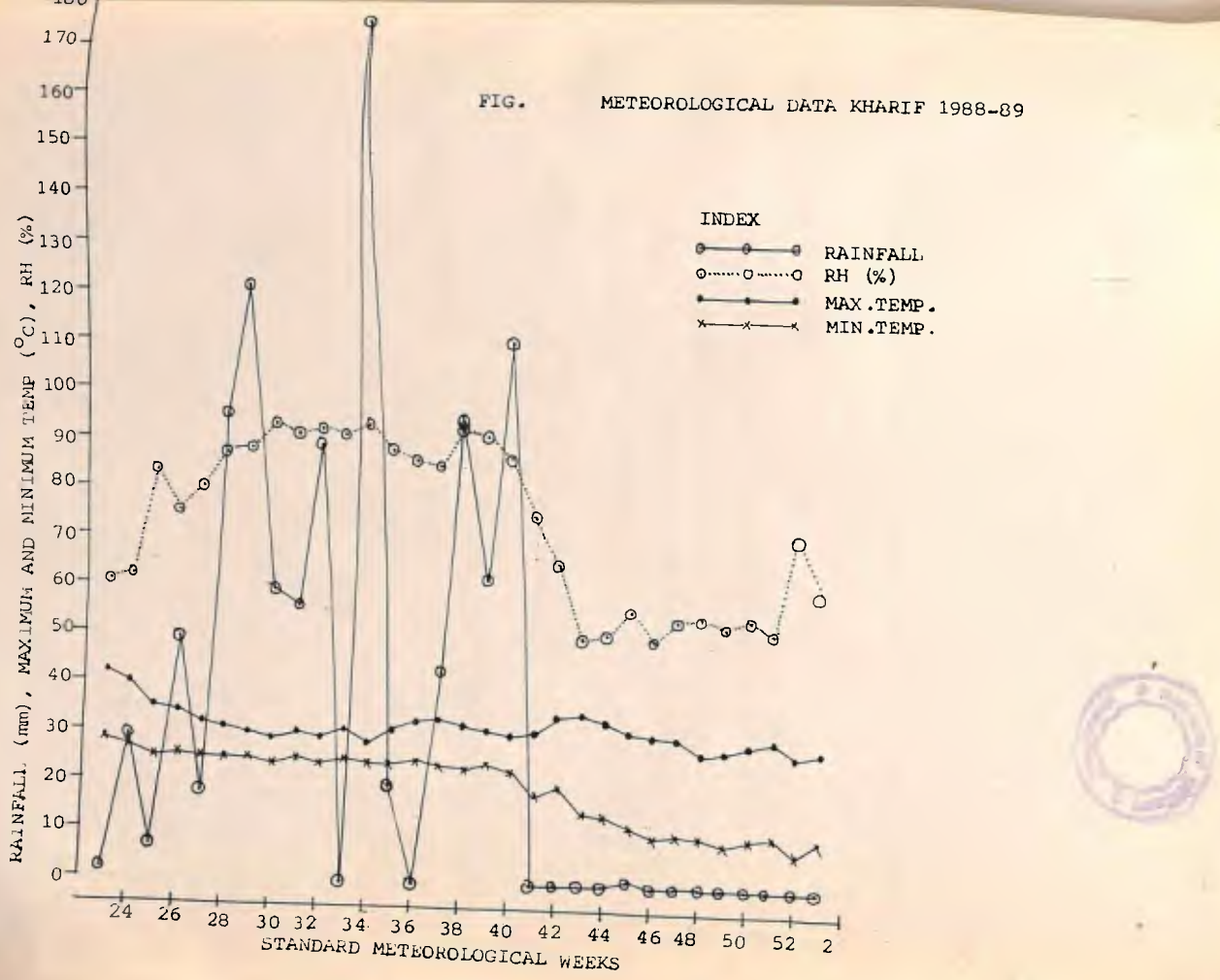
contd....

Table 3.1 (contd....)

Month	Standard week	Average weekly temperature °C		Mean relative humidity (%)	Weekly rainfall (mm)	Average weekly evapo-ration (mm)
		Maximum	Minimum			
Oct. 88	40	30.21	22.71	87.29	110.51	3.40
	41	30.86	18.21	74.71	-	3.89
	42	34.00	19.50	64.71	-	4.56
	43	34.07	15.36	50.57	-	4.59
	44	32.64	14.64	50.71	-	4.21
Nov. 88	45	31.29	12.21	55.71	1.27	4.16
	46	30.43	10.50	49.57	-	4.06
	47	30.07	11.29	53.57	-	3.67
	48	27.86	10.86	55.07	-	3.32
Dec. 88	49	28.43	9.21	53.32	-	3.12
	50	28.86	9.93	54.86	-	3.05
	51	29.29	10.79	51.71	-	3.08
	52	26.50	8.67	70.64	-	3.03
Jan. 89	1	28.14	10.21	59.57	-	3.32

*Data recorded from meteorological observatory under All India Coordinated Research Project on Dryland Agriculture, College of Agriculture, Indore

FIG. METEOROLOGICAL DATA KHARIF 1988-89



3.3 Soil

The soil of the experimental area was medium black clayey soil with uniform topography.

Before sowing, the surface soil samples (0-22.5 cm) were collected randomly with the help of soil auger from the experimental field. The samples were mixed to prepare composit sample which was air dried, sieved through 2 mm sieve and used for analysis.

The mechanical and chemical compositionof representative soil samples were carried out in soil testing laboratory of the College of Agriculture, Indore. The analytical results are presented in table 3.2.

Table 3.2 Mechanical and chemical composition of the soil of the experimental field

SN	Composition	Content	Method
A.	Mechanical		
	Sand	13.48 %	Hydrometer
	Silt	33.64 %	Hydrometer
	Clay	52.88 %	Hydrometer
B.	Chemical		
	pH	7.8	pH meter (glass electrode)
	Electrical conductivity	0.15 mmhos/cm	Conductivity meter at 25°C
	Organic carbon	0.65 % (low)	Walkley and Black's method
	Available nitrogen(N)	235 kg/ha(low)	Alkaline permangnate method
	Available phosphorus (P_2O_5)	19.0 kg/ha (medium)	Colorimeter
	Available potash(K_2O)	610kg/ha(high)	Flame photometer

Chemical analysis revealed that the soil of the experimental field was calcareous with alkaline reaction and high water holding capacity. It was also observed that the soil was low in available nitrogen and phosphorus but high in available potash. The results of mechanical analysis indicated that soil was clay in texture. Due to the dominance of montmorillonite and high clay content it had swelling and shrinkage property and high cation exchange capacity.

3.4 Previous cropping history of the field

The crops grown in the experimental field during last five years are given in table 3.3.

Table 3.3 Cropping history of experimental field

Year	Kharif	Rabi
1984-85	Sorghum	Wheat
1985-86	Soybean	Wheat
1986-87	Soybean	Wheat
1987-88	Maize+Pigeonpea	-
1988-89	Experiment	

3.5 Details of experiment

The experiment was laid out in simple randomised block design with three replications. Each replication had

13 treatment combinations. The actualplan of layout is given in Fig.3.2.

3.5.1 Experimental design and other details

(i)	Experimental design	- Randomised block design
(ii)	Number of replications	- Three
iii)	Number of treatments	- 13
(iv)	Total number of plots	- 13 x 3 = 39
(v)	Gross plot size	- 9 x 6.3 m = 56.7 sq m
(vi)	Net plot size	- 8 x 5.6 m = 43.2 sq m
vii)	Distance between replication	- 1 m
viii)	Distance between two plots in a replication	- 0.5 m

(ix) Row arrangement

(a) Sorghum, CSH-6/pigeonpea (2:1):

Two rows of sorghum speced 45 cm apart alternating with one row of pigeonpea at a distance of 45 cm from sorghum rows between 90 cm inter pair (10 rows of sorghum and 4 rows of pigeonpea per plot. Within rows plant to plant distance 12 cm and 20 cm was kept for sorghum and pigeonpea respectively, maintaining 66.6 % plant population of sorghum to its sole treatment).

(b) Sorghum, CSH-9/pigeonpea (2:1):

Two rows of sorghum speced 45 cm apart alternating at a distance of 45 cm from sorghum rows between 90 cm inter

pair (10 rows of sorghum and 4 rows of pigeonpea per plot at 12 cm and 20 cm planting distance respectively, maintaining 66.6 % plant population of sorghum to its sole treatment).

(c) Sorghum, CSH-9/pigeonpea (3:3):

Three rows of sorghum planted 45 cm apart alternating with three rows of pigeonpea with 45 cm row to row distance (8 rows of sorghum and 6 rows of pigeonpea per plot at 12 cm and 20 cm planting distance, respectively, maintaining 50 % plant population of sorghum to its sole treatment).

(d) Sorghum, CSH-9/sunflower (3:3):

Three rows of sorghum planted 45 cm apart alternating with three rows of sunflower with 45 cm row to row distance (8 rows of sorghum and 6 rows of sunflower per plot at 12 cm and 20 cm planting distance respectively, maintaining 50 % plant population of sorghum to its sole treatment).

(e) Sorghum, CSH-9/soybean (3:3):

Three rows of sorghum planted 45 cm apart alternating with three rows of soybean with 45 cm row to row distance (8 rows of sorghum and 6 rows of soybean per plot at 12 cm and 5 cm planting distance respectively, maintaining 50 % plant population of sorghum to its sole treatment).

(f) Sorghum, CSH-9/pigeonpea (4:2):

Four rows of sorghum spaced 45 cm apart alternating with two rows of pigeonpea, with 45 cm row to row distance (10 rows of sorghum and 4 rows of pigeonpea per plot at 12 cm and 20 cm planting distance respectively, maintaining 66.6 % plant population of sorghum to its sole treatment).

(g) Sorghum, CSH-9/sunflower (4:2):

Four rows of sorghum spaced 45 cm apart alternating with two rows of sunflower with 45 cm row to row distance (10 rows of sorghum and 4 rows of sunflower per plot at 12 cm and 20 cm planting distance respectively, maintaining 66.6 % plant population of sorghum to its sole in the occupied rows of sorghum).

(h) Sorghum, CSH-9/soybean (4:2):

Four rows of sorghum spaced 45 cm apart alternating with two rows of soybean with 45 cm row to row distance (10 rows of sorghum and 4 rows of soybean per plot at 12 cm and 5 cm planting distance respectively, maintaining 66.6 % plant population of sorghum to its sole treatment).

(i) Sole sorghum CSH-9:

14 rows of sorghum with 45 cm row to row distance and 12 cm plant to plant distance.

(j) Sole sorghum, CSH-6:

14 rows of sorghum with 45 cm row to row distance and 12 cm plant to plant distance.

(k) Sole pigeonpea:

14 rows of pigeonpea with 45 cm row to row distance and 20 cm plant to plant distance.

(l) Sole sunflower:

14 rows of sunflower with 45 cm row to row distance and 20 cm plant to plant distance.

(m) Sole soybean:

14 rows of soybean with 45 cm row to row distance and 5 cm plant to plant distance.

3.5.2 Treatments

There were 13 treatments.

A. Check treatments

1. Sorghum (CSH-6)/pigeonpea (C-11); 2:1 row proportion
2. Sorghum (CSH-9)/pigeonpea (C-11); 2:1 row proportion

B. Systems

3. Sorghum (CSH-9)/pigeonpea (C-11); 3:3 row proportion
4. Sorghum (CSH-9)/sunflower(Modern);3:3 row proportion

FIG. 3.3 EXPERIMENTAL LAYOUT PLAN (RANDOMISED BLOCK DESIGN)

5. Sorghum (CSH-9)/soybean (JS 72-44); 3:3 row proportion
6. Sorghum (CSH-9)/pigeonpea (C-11) ; 4:2 row proportion
7. Sorghum (CSH-9)/sunflower (Modern); 4:2 row proportion
8. Sorghum (CSH-9)/soybean (JS 72-44); 4:2 row proportion

C. Additional treatments

9. Sole sorghum (CSH-9)
10. Sole sorghum (CSH-6)
11. Sole pigeonpea (C-11)
12. Sole sunflower (Modern)
13. Sole soybean (JS 72-44)

3.6 Varietal characteristics

3.6.1 Sorghum cultivars

3.6.1.1 CSH-6

CSH-6 is a cross of 2219 A x CS 3541. The plants are about 160 to 180 cm tall and mature in about 95 to 100 days. The grains are pearly white and elliptical in shape. The upper leaves are narrow and pointed upwards (erectophyll) and hence this genotype is suitable for intercropping. The grain yield is about 30 to 36 q/ha.

3.6.1.2 CSH-9

CSH-9 is a cross of 296 A x CS 3541. The plants are about 190 to 200 cm tall and mature in about 110-115 days. The leaves are broad and long. The panicles are semi-compact

and bear round, bold and pearly white grains. The average grain yield is around 35 to 40 q/ha.

3.6.2 Pigeonpea genotype

3.6.2.1 C-11

It matures in about 180 to 210 days. The average grain yield ranges from 15-20 q/ha. The grains are bold and red in colour. The test weight (1000 grain weight) is about 100 g. This variety is well suited in Malwa region for both types of cropping i.e. sole as well as intercropping.

3.6.3 Sunflower genotype

3.6.3.1 Modern

It matures in about 90-95 days. The average grain yield ranges from 10-12 q/ha. The grains are black in colour. The test weight (1000 grain weight) is about 65-70g. This variety was recommended for general cultivation in 1980 and is well suited in Malwa region for sole as well as mixed cropping.

3.6.4 Soybean genotype

3.6.4.1 JS 72-44 (Gaurava)

It is a cross of D 60-9647 x EC 7034. Plant height varies from 55 to 60 cm. Plants are determinate. It flowers in 40-42 days and matures in 104-106 days. Flowers are

purple, resistent to shattering. Seeds are medium in size, with 1000 seed weight of 90 g.

3.7 Details of field operations

3.7.1 Preparation on the field

The field was ploughed once with tractor followed by harrowing and planking.

3.7.2 Fertilizer application

Nitrogen, phosphorus and potash were applied through urea (46 % N), single superphosphate (16 % P_2O_5) and muriate of potash (60 % K_2O), respectively. Entire quantity of phosphorus and potash i.e. 40 kg/ha each, and 50 % dose of nitrogen i.e. 40 kg/ha were applied basally. Furrows were opened 45 cm apart for application of NPK. Remaining nitrogen i.e. 40 kg/ha, was given as side dressing (6-8 cm away from rows of sorghum) when sorghum was 30-35 days old.

Basal application of nitrogen (20 kg/ha) and phosphorus (40 kg/ha) was done by placing fertilizer in the furrows opened for pigeonpea and soybean each before seeding, whereas nitrogen to sunflower was given @ 40 kg/ha and phosphorus @ 40 kg/ha as basal dressing in the similar way.

3.7.3 Seed

Pure, healthy and good quality seeds were used for

sowing. The seeds of sorghum varieties CSH-6 and CSH-9, pigeonpea variety C-11 were received from Project Coordinator (Sorghum), Hyderabad, while seeds of JS 72-44, variety of soybean and modern, variety of sunflower were taken from Research Farm, College of Agriculture, Indore.

3.7.4 Seed treatment

Treated seeds of sorghum and pigeonpea received from Project Coordinator (Sorghum), Hyderabad were used, while the sunflower and soybean seeds were treated with Thiram @ 2 g/kg of seed to escape from fungal diseases. Afterwards, soybean seeds were also treated with Rhizobium culture @ 3 g/kg of seed just before sowing.

3.7.5 Time and method of sowing

The sowing was done on 28th June 1988 of all the crops simultaneously. In all the plots, sorghum, pigeonpea, sunflower and soybean were dibbled in rows at a depth of about 3-4 cm.

3.7.6 Thinning

Thinning was done by manually after 15 days of sowing to obtain the desired plant population.

3.7.7 Weeding

Two weedings were done by manual labourer on 12 and 27th July 1988.

3.7.8 Top dressing

Top dressing with nitrogen in the form of urea at 40 kg N/ha was done only in sorghum lines on 27th July 1988.

3.7.9 Plant protection

'Savin' 5 % granules were applied in leaf whorls of sorghum plant @ 10 kg/ha in the early stage of crop i.e. on 3rd August, 1988.

3.7.10 Harvesting

First of all guard rows were harvested for getting net plot. The five tagged plants for recording the post harvest observations were harvested separately before complete harvesting.

First of all sunflower variety modern was harvested on 13.10.1988. This was followed by soybean variety JS 72-44 on 14.10.1988, sorghum variety CSH-6 on 26.10.1988 sorghum variety CSH-9 on 14.11.1988 and finally pigeonpea variety C-11 was harvested on 4.1.1989.

3.7.11 Threshing and winnowing

After harvesting the produce of each plot was allowed to dry in the field for 3-4 days. The grain yield and straw yield obtained from each plot were weighed separately in kg.

3.8 Observation recorded

For recording observations five plants were selected randomly and tagged in each plot.

Since physiological growth stages are the important parameters to indicate the status of plant growth the growth observations were recorded from 30 days after sowing and at a 15 days interval upto maturity, covering all the physiological stages like initial seedling stage, grain/pod formation stage and maturity stage.

Details of the observation recorded during the course of investigation are given below.

3.8.1 Sorghum

3.8.1.1 Pre-harvest studies

3.8.1.1.1 Average final plant height

Average final plant height of five randomly selected tagged plants of sorghum per plot was measured in cm from base of cob to the base of the plant by the help of a metre scale just before harvest.

3.8.1.1.2 Average number of functional leaves at panicle emergence

The number of functional leaves per plant was counted on five randomly tagged plants at the time of panicle

emergence when there were maximum number of functional leaves. The leaves having more than 50 per cent green area to fully emerged leaf were considered as functional leaves.

3.8.1.1.3 Average leaf area per plant at panicle emergence (sq cm)

Five plants were selected randomly in each plot. The length and width of the fourth leaf from the top was measured in each plant. The leaf area was calculated as follows.

Maximum leaf length x maximum leaf width x 0.747 x average number of green leaves per plant (Sticker et al., 1961).

3.8.1.2 Post-harvest studies

3.8.1.2.1 Average length of panicle (cm)

Length of panicle of 5 randomly selected plants was recorded in cm from the base of lowest spikelet to the tip of the upper most spikelet.

3.8.1.2.2 Grain weight per panicle (g)

Grain weight of 10 randomly selected panicles per plot was recorded in grammes.

3.8.1.2.3 Grain yield per plot

The produce of each plot was threshed and winowed separately. Cleaned grains were weighed and yield per plot in kilogram was recorded.

3.8.1.2.4 Test weight

Test weight samples were drawn from harvested and cleaned grains of each plot. Broken grains were discarded while counting 1000 grains.

3.8.1.2.5 Stover yield per plot

Stover yield per plot was weighed separately in kilogram and recorded plot wise.

3.8.1.2.6 Harvest index

Total dry matter yield (whole plant excluding plant part below soil) and grain yield obtained from each plot were weighed separately in kg and expressed in percentage as follows:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (grain yield)}}{\text{Total dry matter}} \times 100$$

3.8.1.2.7 Grain stover ratio

The grain and stover yield obtained from each plot weighed separately in kg and expressed in percentage as follows:

$$\text{Grain-stover ratio} = \frac{\text{Grain yield}}{\text{Stover or fodder yield}} \times 100$$

3.8.2 Pigeonpea

3.8.2.1 Pre-harvest studies

3.8.2.1.1 Final plant height

The average final height of 5 randomly selected plants of pigeonpea was measured in cm by the help of metre scale just before harvest.

3.8.2.1.2 Number of green leaves per plant at flowering

The average number of green leaves of 5 randomly selected plants of pigeonpea was counted. Three leaf lets of a leaf was considered as one leaf.

3.8.2.2 Post-harvest studies

3.8.2.2.1 Grain yield per plot

The grain yield of each plot was recorded in kilograms separately after threshing and winnowing.

3.8.2.2.2 Test weight

Sample was drawn from finally cleaned grain of each plot and weight of 1000 grains was noted in g.

3.8.2.2.3 Stover yield per plot

Plot wise stover yield was recorded in g by weighing total stover yield per plot.

3.8.2.2.4 Grain stover ratio

The grain and stover yield obtained from each plot were weighed separately in kg and expressed in percentage as follows:

$$\text{Grain stover ratio} = \frac{\text{Grain yield}}{\text{Stover yield}} \times 100$$

3.8.3 Sunflower

3.8.3.1 Pre-harvest studies

3.8.3.1.1 Final plant height

The average plant height of 5 randomly selected plants of sunflower was measured in cm by the help of metre scale just before harvest.

3.8.3.1.2 Average number of functional leaves at flowering

The number of functional leaves per plant was counted on five randomly tagged plants at the time of flowering. The leaves having more than 50 % green area were considered as functional leaves.

3.8.3.2 Post-harvest studies

3.8.3.2.1 Grain yield per plot

The grain yield of each plot was recorded in kilogram separately after threshing and winnowing.

3.8.3.2.2 Test weight

Samples was drawn from finally cleaned grain of each plot and weight of 1000 grains was noted in g.

3.8.3.2.3 Stover yield per plot

Plot wise stover yield was recorded in g by weighing total straw per plot.

3.8.3.2.4 Grain stover ratio

The grain and stover yield obtained from each plot were weighed separately in kg and expressed in percentage as follows.

$$\text{Grain stover ratio} = \frac{\text{grain yield}}{\text{Stover yield}} \times 100$$

3.8.4 Soybean

3.8.4.1 Pre-harvest studies

3.8.4.1.1 Final plant height

The average plant height of 5 randomly selected plants of soybean was measured in cm by the help of metre scale just before harvest.

3.8.4.1.2 Average number of functional leaves at flowering

The number of functional leaves per plant was counted of five randomly tagged plants at the time of flowering emergence.

3.8.4.2 Post-harvest studies

3.8.4.2.1 Grain yield per plot

The grain yield of each plot was recorded in kilogram separately after threshing and winnowing.

3.8.4.2.2 Test weight

Samples was drawn from finally cleaned grain of each plot and weight of 1000 grains was noted in g.

3.8.4.2.3 Stover yield per plot

Plot wise stover yield was recorded in g by weighing total stover per plot.

3.8.4.2.4 Grain stover ratio

The grain and stover yield obtained from each plot were weighed separately in kg and expressed in percentage as follows:

$$\text{Grain stover ratio} = \frac{\text{Grain yield}}{\text{Stover yield}} \times 100$$

3.8.5 Sorghum and intercrops viz., pigeonpea, sunflower and soybean

3.8.5.1 Total grain yield per plot

Total grain yield in kilograms per plot was obtained by adding the grain yield of sorghum and intercrops in their respective treatments.

3.8.5.2 Total land productivity

To determine the total land productivity, land equivalent ratio (LER) for the different treatment combinations was calculated. LER was calculated by determining the ratio of the yield of an individual crop in a intercropping system to its yield in a pure crop and adding the fractions.

$$LER = \frac{\text{Yield of sorghum in intercropping system}}{\text{Yield of sorghum in sole crop}} + \frac{\text{Yield of intercrop in intercropping system}}{\text{Yield of intercrop in sole crop}}$$

3.8.5.3 Average monetary return from different treatments in terms of Rs/ha

The monetary return from different treatments was calculated on the basis of prevailing market values of sorghum grain @ Rs.192, pigeonpea @ Rs.450, soybean @ Rs.518, sunflower @ Rs.505, fodder of sorghum @ Rs.20 and pigeonpea stover @ Rs.20 per quintal.

3.9 Statistical analysis

The data obtained from various observations were analysed by methods of analysis of variance suggested by Yates (1937). The table of skeleton of analysis of variance for sorghum and for treatment under investigation are presented in table 3.4 and 3.5.

Table 3.4 Skeleton of analysis of variance for sorghum

Source of variation	DF	SS	MSS	Calculated 'F'	Table value of F at 5 %	Table value of F at 1 %
Replication	2				3.55	6.01
Sorghum	9				2.46	3.60
Error	18					
Total	29					

Table 3.5 Skeleton of analysis of variance for sorghum + intercrops viz., pigeonpea, sunflower and soybean treatments

Source of variation	DF	SS	MSS	Calculated 'F'	Table value of F at 5 %	Table value of F at 1 %
Replication	2				3.40	5.61
Treatments	12				2.18	2.89
Error	24					
Total	48					

The critical differences (C.D.) at 5 per cent level was calculated for judging the significant differences between different treatment means by using the following formula given by Panse and Sukhatme (1957):

$$S.Em. = \pm \sqrt{\frac{\text{Error mean sum of squares}}{n}}$$

S.Em. = Standard error of mean

n = Number of replications

CD at 5 % = $\pm$ S.Em. x $\sqrt{2}$ x t (error degree of freedom at 5 %)

Table value of 't' at 18 df for 5 % = 2.101

Table value of 't' at 24 df for 5 % = 2.064

EXPERIMENTAL FINDINGS

CHAPTER - IV

EXPERIMENTAL FINDINGS

The data recorded on various attributes of sorghum and different intercrops were subjected to analysis of variance. Results of these analysis are presented in following pages.

4.1 Analysis of variance of sorghum

Results of the ANOVA for 9 attributes of sorghum, viz., plant height, [redacted], leaf area, length of panicle, weight per panicle, grain yield, 1000 grain weight, stover yield, harvest index and grain stover ratio revealed that mean sum of squares for treatments were significant for all the characters, except the average number of leaves (Appendix I).

Mean sum of squares for replications were significant when tested against the error mean square for plant height, grain yield and 1000 grain weight (Appendix II).

4.1.1 Pre-harvest studies

4.1.1.1 Average final plant height of sorghum (cm)

Maximum plant height was observed for CSH-9 grown as sole crop (152.27 cm). However, it was statistically at par with 3 other treatments viz., T_4 (CSH-9 + sunflower,

3:3), T_7 (CSH-9 + sunflower, 4:2) and T_6 (CSH-9 + pigeonpea, 4:2). The latter was not significantly superior than T_1 (CSH-6 + pigeonpea, 2:1) but statistically superior to the rest of the treatments viz., T_2 , T_{10} , T_8 and T_3(Table 4.1).

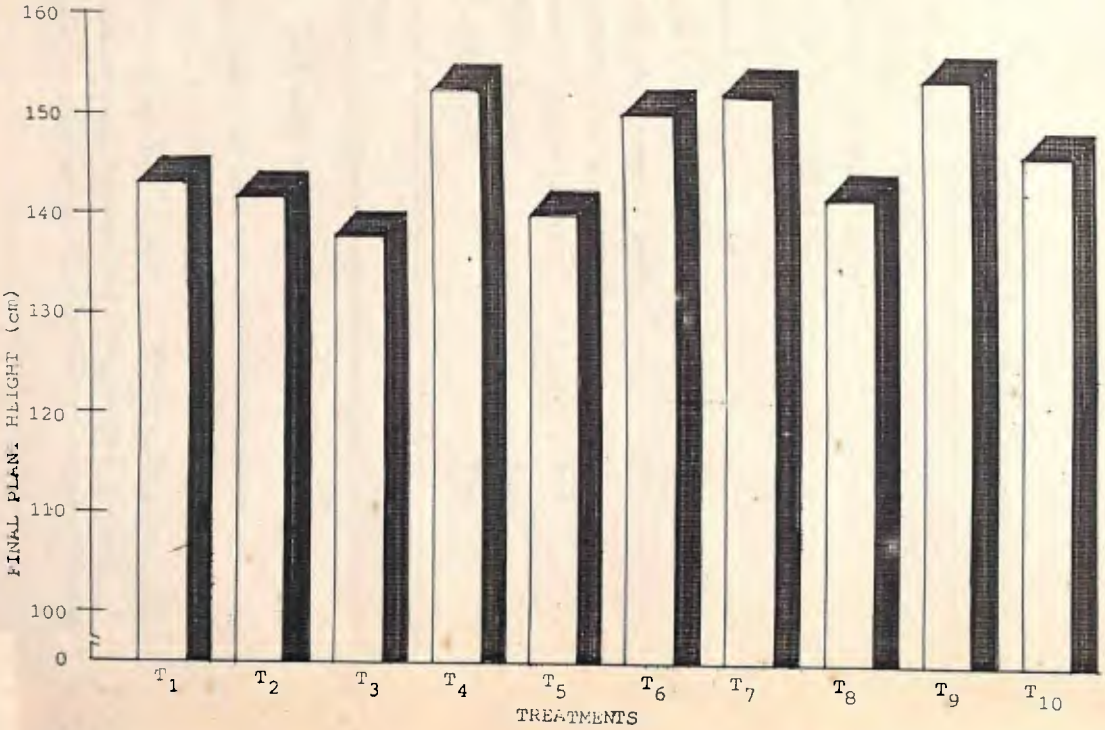
Table 4.1 Average final plant height of sorghum

T.No.	Treatments	Average plant height(cm)
T_1	CSH-6 + pigeonpea (2:1)	143.20
T_2	CSH-9 + pigeonpea (2:1)	141.67
T_3	CSH-9 + pigeonpea (3:3)	137.53
T_4	CSH-9 + sunflower (3:3)	152.00
T_5	CSH-9 + soybean (3:3)	139.70
T_6	CSH-9 + pigeonpea (4:2)	149.73
T_7	CSH-9 + sunflower (4:2)	151.33
T_8	CSH-9 + soybean (4:2)	140.97
T_9	CSH-9 (sole)	152.27
T_{10}	CSH-6 (sole)	141.07
	S.Em. ±	2.26
	CD 5 %	6.72

4.1.1.2 Number of green leaves per plant at panicle emergence

There was no significant difference among treatments with respect to functional leaves of sorghum at panicle emergence.

FIG. 4.1 FINAL PLANT HEIGHT OF SORGHUM IN DIFFERENT TREATMENTS



However, it was observed that T_5 (CSH-9 + soybean 3:3) had maximum number of functional leaves. This was closely followed by T_5 , T_4 and T_3 (Table 4.2).

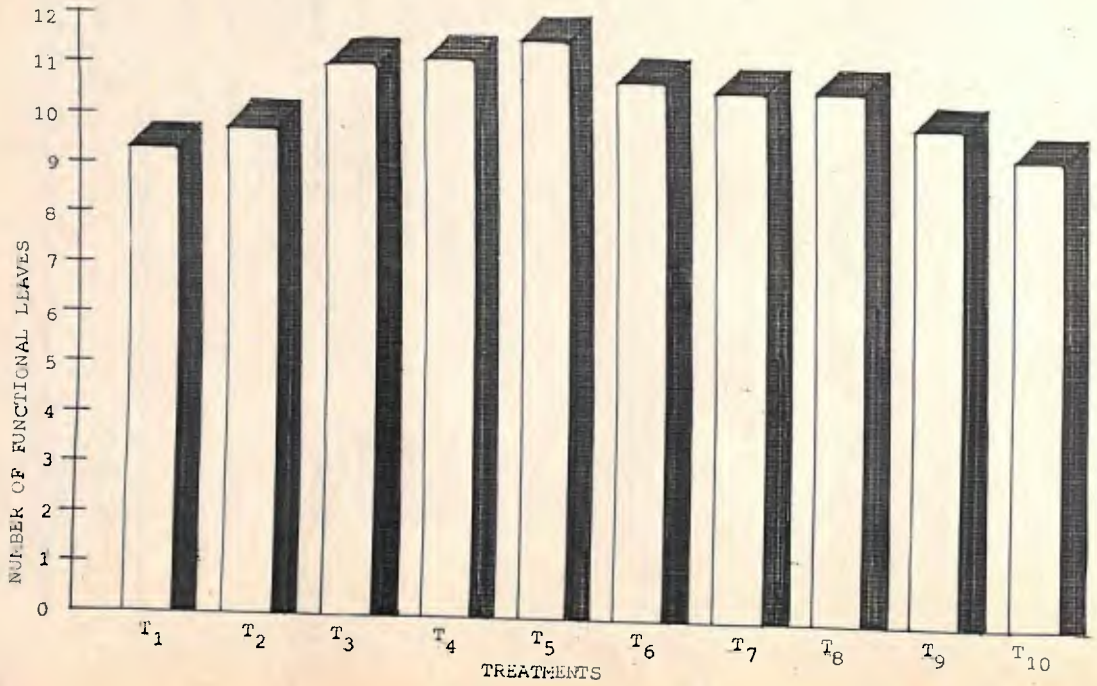
Table 4.2 Average number of functional leaves/plant at panicle emergence

T.No.	Treatments	Average number of functional leaves
T_1	CSH-6 + pigeonpea (2:1)	9.3
T_2	CSH-9 + pigeonpea (2:1)	9.7
T_3	CSH-9 + pigeonpea (3:3)	11.0
T_4	CSH-9 + pigeonpea (3:3)	11.1
T_5	CSH-9 + soybean (3:3)	11.5
T_6	CSH-9 + pigeonpea (4:2)	10.7
T_7	CSH-9 + sunflower (4:2)	10.5
T_8	CSH-9 + soybean (4:2)	10.5
T_9	CSH-9 (sole)	9.8
T_{10}	CSH-6 (sole)	9.2
	S.Em. ±	NS

4.1.1.3 Leaf area per plant at panicle emergence (sq cm)

Maximum leaf area was observed for CSH-9 grown with soybean in a 3:3 planting geometry (Table 4.3). However, it was statistically at par with T_4 (CSH-9 + sunflower, 3:3) and T_3 (CSH-9 + pigeonpea, 3:3). The latter was also significantly superior to rest of the treatments, except

FIG. 4.2 NUMBER OF FUNCTIONAL LEAVES PER PLANT OF SORGHUM IN DIFFERENT TREATMENTS



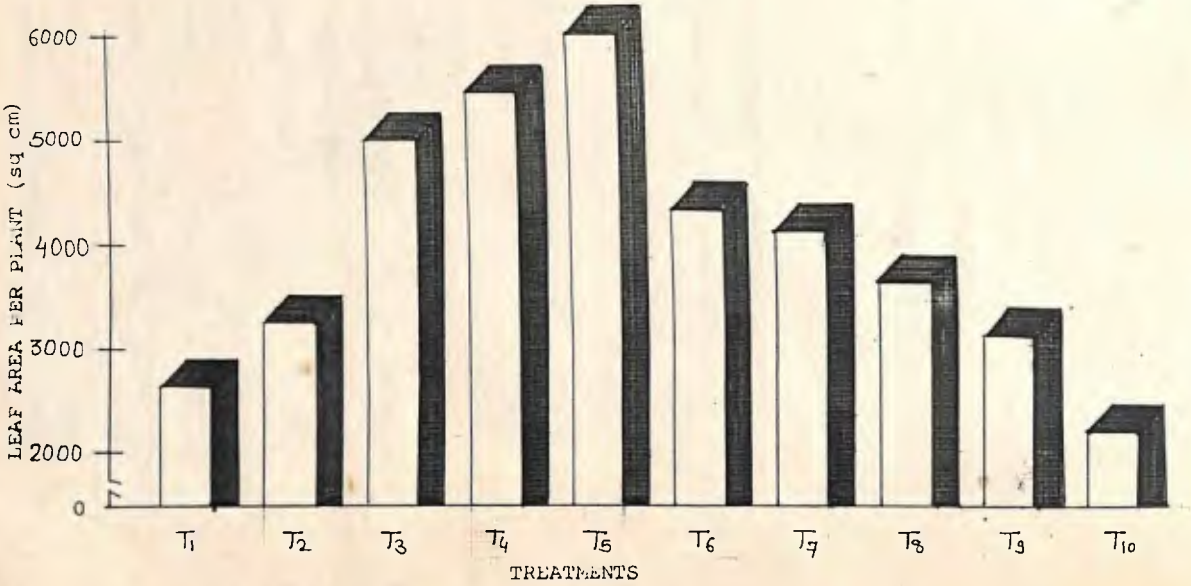
T_6 (CSH-9 + pigeonpea, 4:2) and T_7 (CSH-9 + sunflower, 4:2). The minimum area was observed for sole CSH-6 (T_{10}).

It was interesting to note that leaf area of CSH-9 grown as sole crop (T_9) and CSH-9 grown in association with pigeonpea in 2:1 planting geometry was at par. Similarly CSH-6 + pigeonpea, 2:1 in T_1 was at par with CSH-6 (sole) in T_{10}.

Table 4.3 Average leaf area per plant in sorghum at panicle emergence

T.No.	Treatments	Average leaf area/ plant (sq cm)
T_1	CSH-6 + pigeonpea (2:1)	2635.16
T_2	CSH-9 + pigeonpea (2:1)	3241.02
T_3	CSH-9 + pigeonpea (3:3)	5004.67
T_4	CSH-9 + sunflower (3:3)	5451.74
T_5	CSH-9 + soybean (3:3)	5973.91
T_6	CSH-9 + pigeonpea (4:2)	4314.19
T_7	CSH-9 + sunflower (4:2)	4078.31
T_8	CSH-9 + soybean (4:2)	3605.16
T_9	CSH-9 (sole)	3091.33
T_{10}	CSH-6 (sole)	2197.36
	S.Em. ±	433.28
	CD 5 %	1287.39

FIG. 4.3 LEAF AREA PER PLANT AT PANICLE EMERGENCE STAGE OF SORGHUM IN DIFFERENT TREATMENTS



4.1.2 Post harvest studies

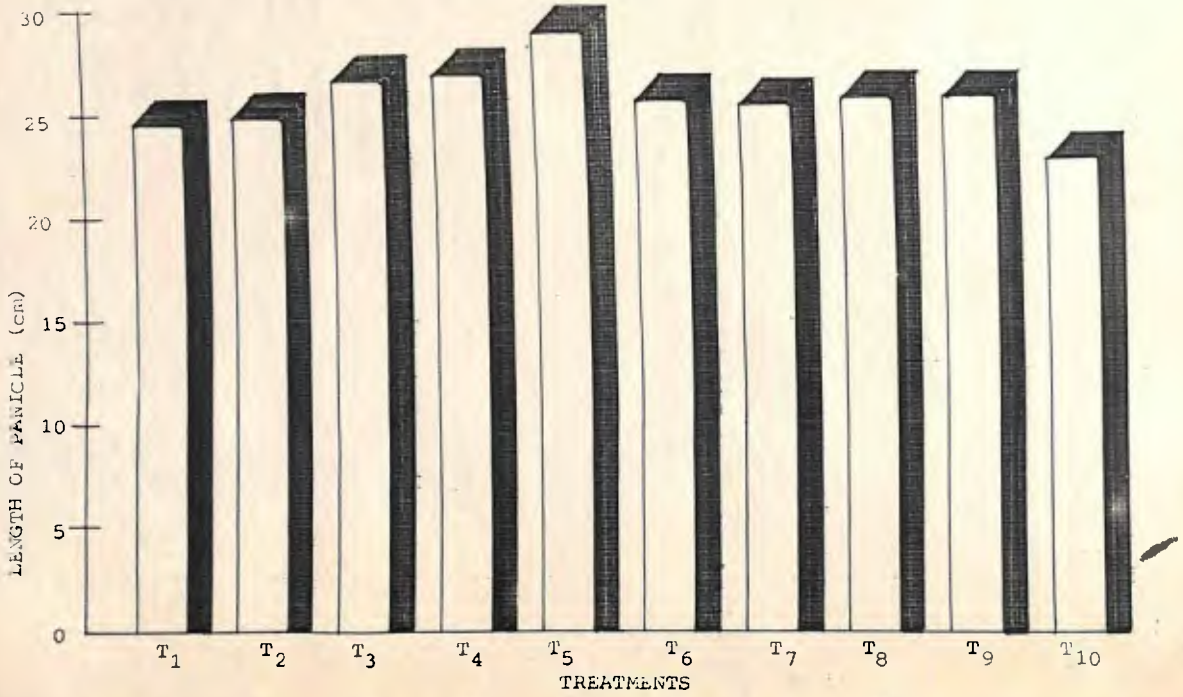
4.1.2.1 Average length of panicle (cm)

Maximum length of panicle was observed for T_5 (CSH-9 + soybean, 3:3). Treatment T_5 was neverthless statistically at par with T_4 and T_3 (Table 4.4). T_5 was significantly superior than rest of the treatments, excluding T_{10}. CSH-6 (sole) recorded minimum length of panicle. However, it was at par with 2 other treatments, viz., T_1 and T_2.

Table 4.4 Average length of panicle of sorghum

T.No.	Treatments	Average length of panicle (cm)
T_1	CSH-6 + pigeonpea (2:1)	24.67
T_2	CSH-9 + pigeonpea (2:1)	24.87
T_3	CSH-9 + pigeonpea (3:3)	26.40
T_4	CSH-9 + sunflower (3:3)	26.80
T_5	CSH-9 + soybean (3:3)	28.73
T_6	CSH-9 + pigeonpea (4:2)	25.67
T_7	CSH-9 + sunflower (4:2)	25.33
T_8	CSH-9 + soybean (4:2)	25.60
T_9	CSH-9 (sole)	25.47
T_{10}	CSH-6 (sole)	22.47
	S.Em. ±	0.88
	CD 5 %	2.64

FIG. 4.4 LENGTH OF PANICLE OF SORGHUM IN DIFFERENT TREATMENTS



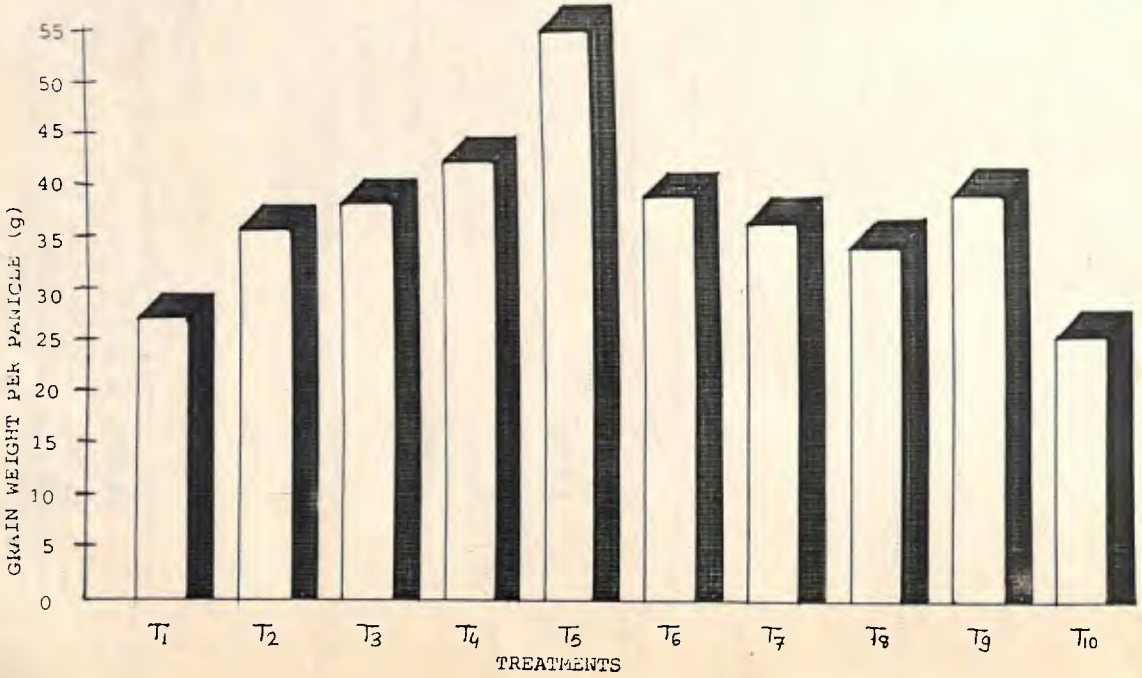
4.1.2.2 Grain weight per panicle (g)

The grain weight per panicle of CSH-9 was found maximum when grown in association with soybean in 3:3 planting geometry (Table 4.5). This treatment was significantly superior to rest of the treatments. CSH-9 recorded 42.0 g grain weight per panicle, when grown in association with sunflower in 3:3 system. However, this was statistically at par with 6 other treatments viz., T_9 , T_6 , T_3 , T_7 T_2 and T_8 and grain weight per panicle of CSH-6 was significantly lower than the CSH-9 (sole) but interestingly it was at par with T_1 , T_2 , T_8 and T_7 (Table 4.5).

Table 4.5 Grain weight per panicle in sorghum

T.No.	Treatments	Grain weight per panicle (g)
T_1	CSH-6 + pigeonpea (2:1)	27.20
T_2	CSH-9 + pigeonpea (2:1)	35.67
T_3	CSH-9 + pigeonpea (3:3)	38.12
T_4	CSH-9 + sunflower (3:3)	42.00
T_5	CSH-9 + soybean (3:3)	54.33
T_6	CSH-9 + pigeonpea (4:2)	38.50
T_7	CSH-9 + sunflower (4:2)	36.00
T_8	CSH-9 + soybean (4:2)	33.67
T_9	CSH-9 (sole)	33.50
T_{10}	CSH-6 (sole)	25.00
	S.Em. ±	3.92
	CD 5 %	11.65

FIG.4.5 GRAIN WEIGHT PER PANICLE OF SORGHUM IN DIFFERENT TREATMENTS



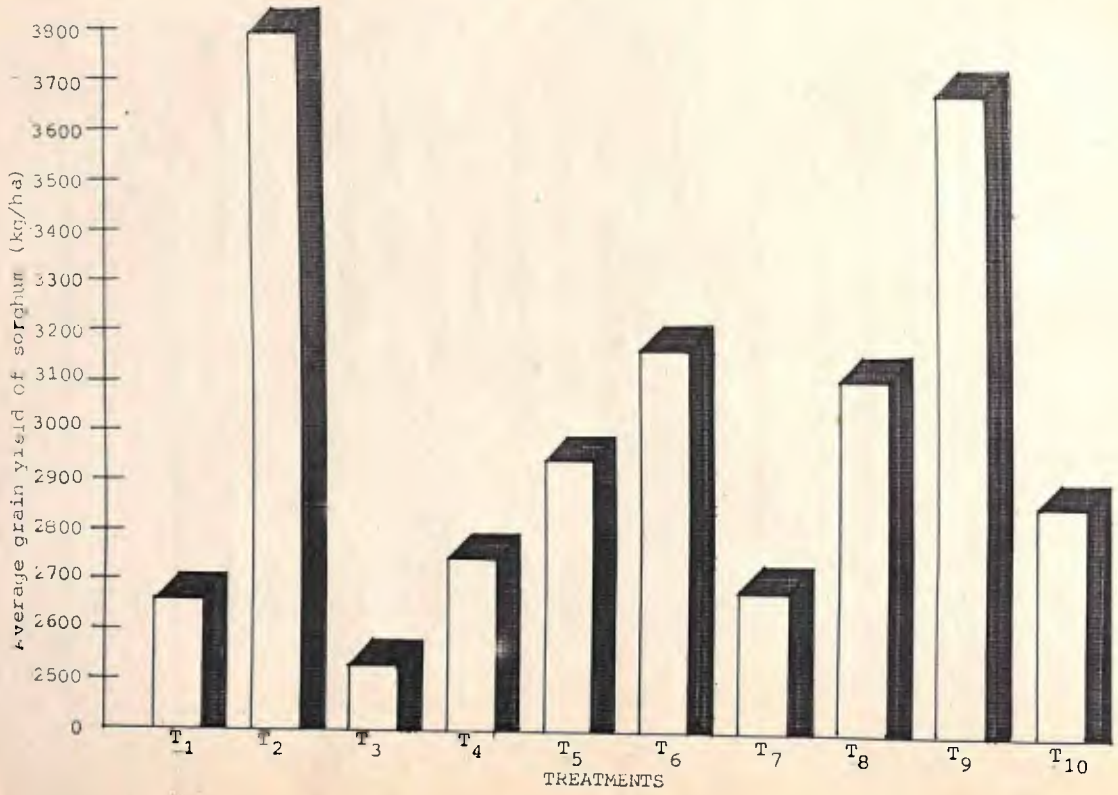
4.1.2.3 Grain yield (kg/ha)

It can be seen from the table 4.6 that maximum grain yield of sorghum was obtained from CSH-9 grown in association with pigeonpea in 2:1 planting pattern (T_2) which was at par with sole CSH-9 (T_9). These two treatments were significantly superior than rest of the treatments. The lowest grain yield of sorghum was recorded for CSH-9 in association with pigeonpea under 3:3 planting geometry (T_7) (Table 4.6).

Table 4.6 Average grain yield of sorghum

T.No.	Treatments	Average grain yield (kg/ha)
T_1	CSH-6 + pigeonpea (2:1)	2662.00
T_2	CSH-9 + pigeonpea (2:1)	3787.87
T_3	CSH-9 + pigeonpea (3:3)	2534.70
T_4	CSH-9 + sunflower (3:3)	2736.10
T_5	CSH-9 + soybean (3:3)	2944.40
T_6	CSH-9 + pigeonpea (4:2)	3164.30
T_7	CSH-9 + sunflower (4:2)	2682.80
T_8	CSH-9 + soybean (4:2)	3099.50
T_9	CSH-9 (sole)	3564.80
T_{10}	CSH-6 (sole)	2849.50
	S.Em. ±	108.40
	CD 5 %	311.60

FIG. 4.6 AVERAGE GRAIN YIELD OF SORGHUM IN DIFFERENT TREATMENTS (kg/ha)



4.1.2.4 1000-grain weight (g)

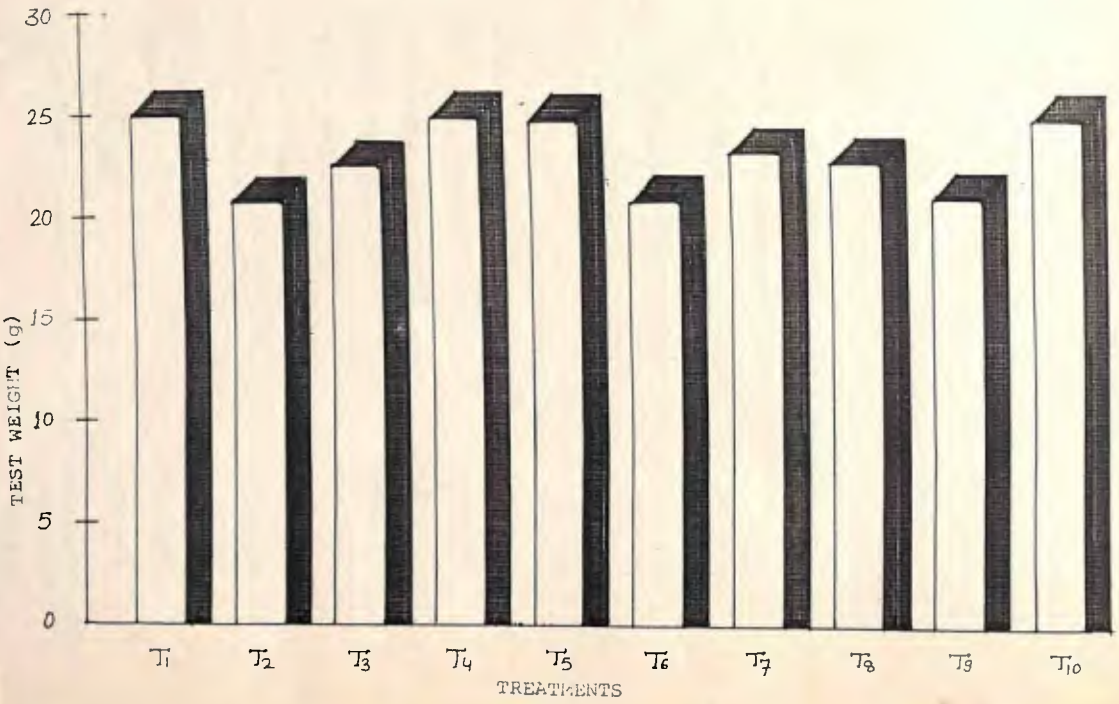
It was observed that CSH-6 in association with pigeonpea in 2:1 planting geometry (T_1) had highest 1000 grain weight (Table 4.7). 1000-grain weight observed for T_4, T_5, T_{10} and T_7 was at par with T_1.

Minimum 1000-grain weight was observed for T_9 (CSH-9 sole) which was statistically at par with T_2, T_8 and T_3.

Table 4.7 1000-grain weight of sorghum

T.No.	Treatments	Average 1000 grain weight (g)
T_1	CSH-6 + pigeonpea (2:1)	24.93
T_2	CSH-9 + pigeonpea (2:1)	21.73
T_3	CSH-9 + pigeonpea (3:3)	22.67
T_4	CSH-9 + sunflower (3:3)	24.33
T_5	CSH-9 + soybean (3:3)	24.27
T_6	CSH-9 + pigeonpea (4:2)	21.53
T_7	CSH-9 + sunflower (4:2)	23.67
T_8	CSH-9 + soybean (4:2)	22.47
T_9	CSH-9 (sole)	21.47
T_{10}	CSH-6 (sole)	24.20
	S.Em. ±	0.60
	CD 5 %	1.80

FIG. 4.7 TEST WEIGHT OF SORGHUM AS AFFECTED BY DIFFERENT TREATMENTS



4.1.2.5 Stover yield of sorghum (kg/ha)

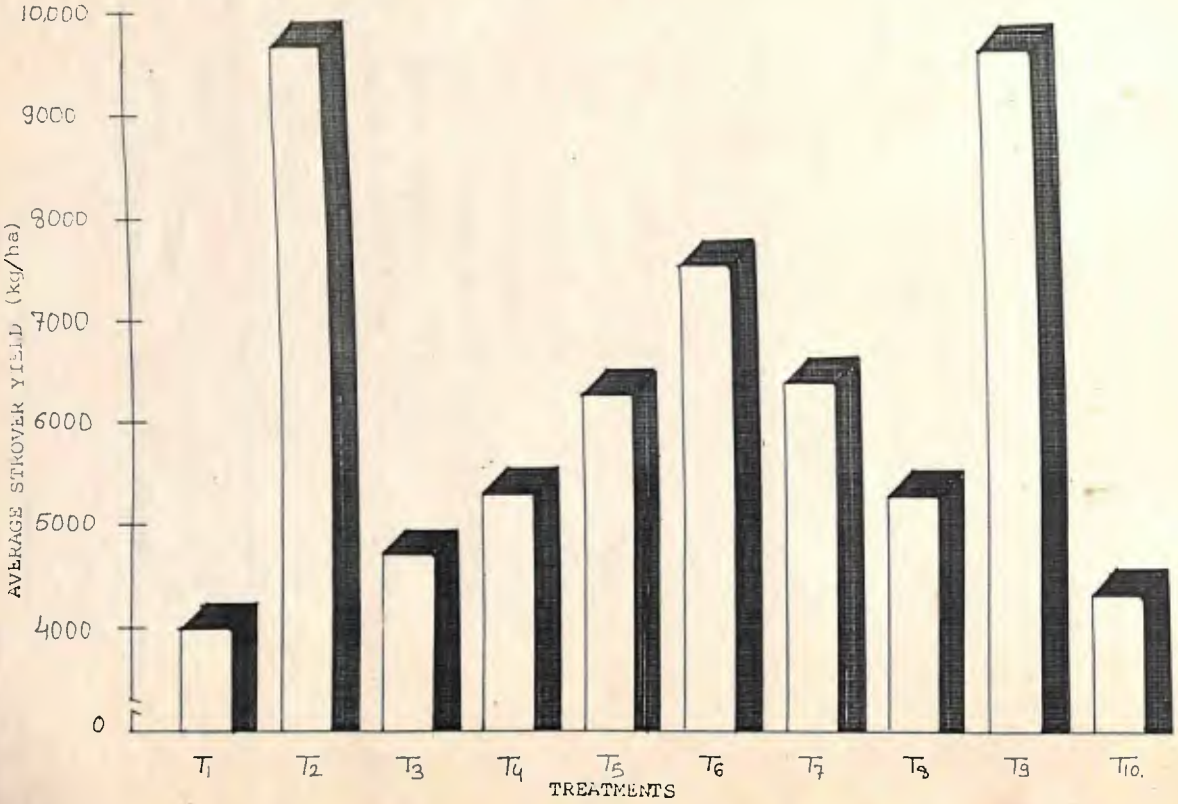
Maximum straw yield was recorded for CSH-9 grown in association with pigeonpea in 2:1 planting geometry (Table 4.8). However, it was statistically at par with T_9 i.e. CSH-9 sole. These two treatments were significantly superior to the rest of treatments.

The minimum stover yield was recorded for CSH-6 in association with pigeonpea under 2:1 planting geometry (T_1). It was neverthless, not inferior than T_{10}, T_8 and T_4.

Table 4.8 Stover yield of sorghum

T.No.	Treatments	Stover yield of sorghum (kg/ha)
T_1	CSH-6 + pigeonpea (2:1)	4012.27
T_2	CSH-9 + pigeonpea (2:1)	9644.91
T_3	CSH-9 + pigeonpea (3:3)	4706.71
T_4	CSH-9 + sunflower (3:3)	5324.07
T_5	CSH-9 + soybean (3:3)	6254.00
T_6	CSH-9 + pigeonpea (4:2)	7484.49
T_7	CSH-9 + sunflower (4:2)	6327.08
T_8	CSH-9 + soybean (4:2)	5246.76
T_9	CSH-9 (sole)	9490.74
T_{10}	CSH-6 (sole)	4320.83
	S.Em. ±	545.06
	CD 5 %	1619.44

FIG. 4.8 AVERAGE SORGHUM STROVER YIELD AS AFFECTED BY DIFFERENT TREATMENTS (kg/ha)



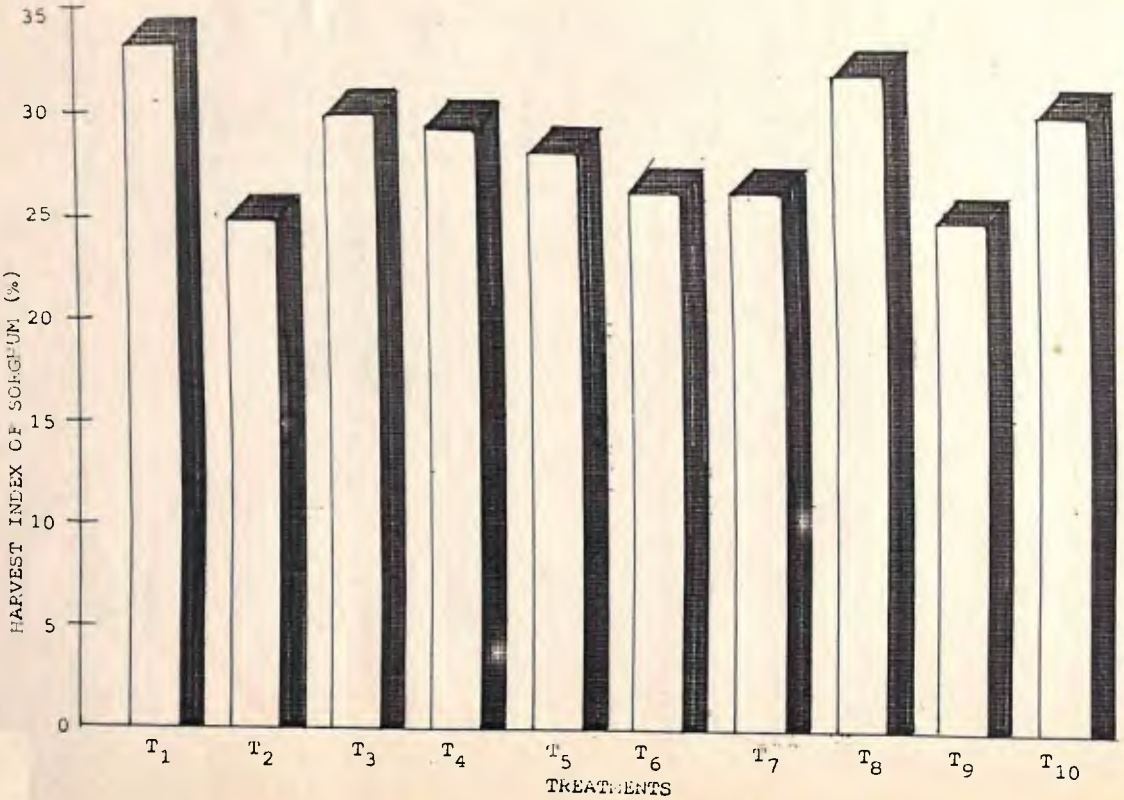
4.1.2.6 Harvest index of sorghum

Maximum harvest index of 33.37 was recorded for CSH-6 in association with pigeonpea in 2:1 planting geometry in T_1. However, it was statistically superior to all other treatments except T_8 (CSH-9 + soybean, 4:2) and T_3 (CSH-9 + pigeonpea, 3:3). Minimum harvest index of 24.46 was observed in CSH-9 as sole crop (T_9) (Table 4.9).

Table 4.9 Harvest index of sorghum

T.No.	Treatments	Harvest index (%)
T_1	CSH-6 + pigeonpea (2:1)	33.37
T_2	CSH-9 + pigeonpea (2:1)	24.82
T_3	CSH-9 + pigeonpea (3:3)	29.85
T_4	CSH-9 + sunflower (3:3)	29.29
T_5	CSH-9 + soybean (3:3)	27.95
T_6	CSH-9 + pigeonpea (4:2)	25.96
T_7	CSH-9 + sunflower (4:2)	25.90
T_8	CSH-9 + soybean (4:2)	31.46
T_9	CSH-9 (sole)	24.46
T_{10}	CSH-6 (sole)	29.50
	S.Em. ±	1.21
	CD 5 %	3.60

FIG. 4.9 HARVEST INDEX OF SORGHUM



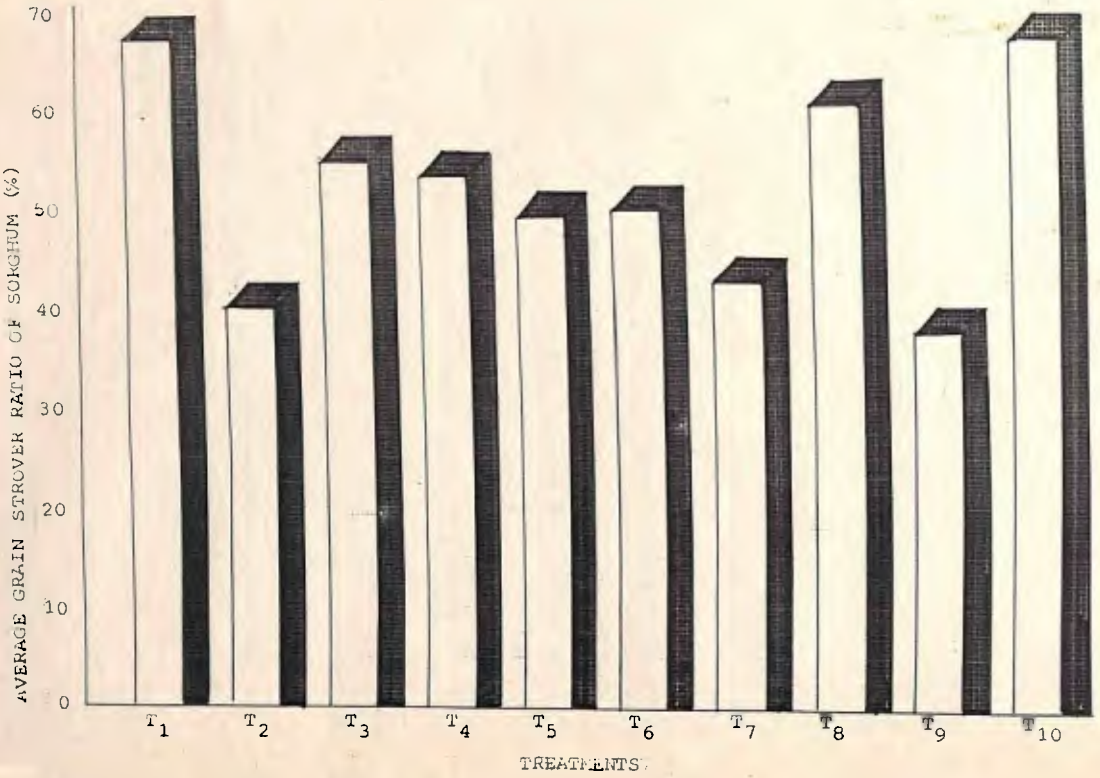
4.1.2.7 Grain stover ratio

Maximum grain stover ratio was observed for CSH-6 in association with pigeonpea under 2:1 planting pattern. This was statistically at par with its sole in T_{10}. Both these treatments are significantly superior to the rest of the treatments. The minimum grain stover ratio was observed in sole CSH-9 under T_9 and this was significantly superior to rest of the treatments except T_5 (Table 4.10).

Table 4.10 Average grain stover ratio of sorghum

T.No.	Treatments	Average grain stover ratio (%)
T_1	CSH-6 + pigeonpea (2:1)	66.65
T_2	CSH-9 + pigeonpea (2:1)	39.90
T_3	CSH-9 + pigeonpea (3:3)	54.38
T_4	CSH-9 + sunflower (3:3)	52.79
T_5	CSH-9 + soybean (3:3)	48.83
T_6	CSH-9 + pigeonpea (4:2)	49.25
T_7	CSH-9 + sunflower (4:2)	42.48
T_8	CSH-9 + soybean (4:2)	59.98
T_9	CSH-9 (sole)	37.26
T_{10}	CSH-6 (sole)	66.34
	S.Em. ±	2.04
	CD 5 %	6.06

FIG.4.10 GRAIN STROVER RATIO OF SORGHUM AS AFFECTED BY DIFFERENT TREATMENTS



4.2 Pigeonpea

4.2.1 Pre-harvest studies

4.2.1.1 Average final plant height of pigeonpea (cm)

It was clear from the table 4.11 that maximum plant height was associated with sole pigeonpea. It decreased when intercropped with CSH-9 in 4:2 and 3:3 planting system.

Table 4.11 Average final plant height of intercrops as affected by different planting system (cm)

Planting pattern / Inter-crops	Sorghum CSH-9				Sorghum CSH-6
	Sole	3:3	4:2	2:1	2:1
Pigeonpea	196.6	192.7	192.6	192.3	189.9
Sunflower	117.2	114.27	115.67	-	-
Soybean	54.1	66.7	61.3	-	-

4.2.1.2 Average number of functional leaves per plant

Maximum number of functional leaves was recorded from pigeonpea in association with CSH-6 in 2:1 planting geometry. It decreased with the decrease in number of rows of pigeonpea from 14 when intercropped with CSH-9 (Table 4.12).

FIG.4.11 FINAL PLANT HEIGHT OF INTERCROPS AS AFFECTED BY DIFFERENT TREATMENTS

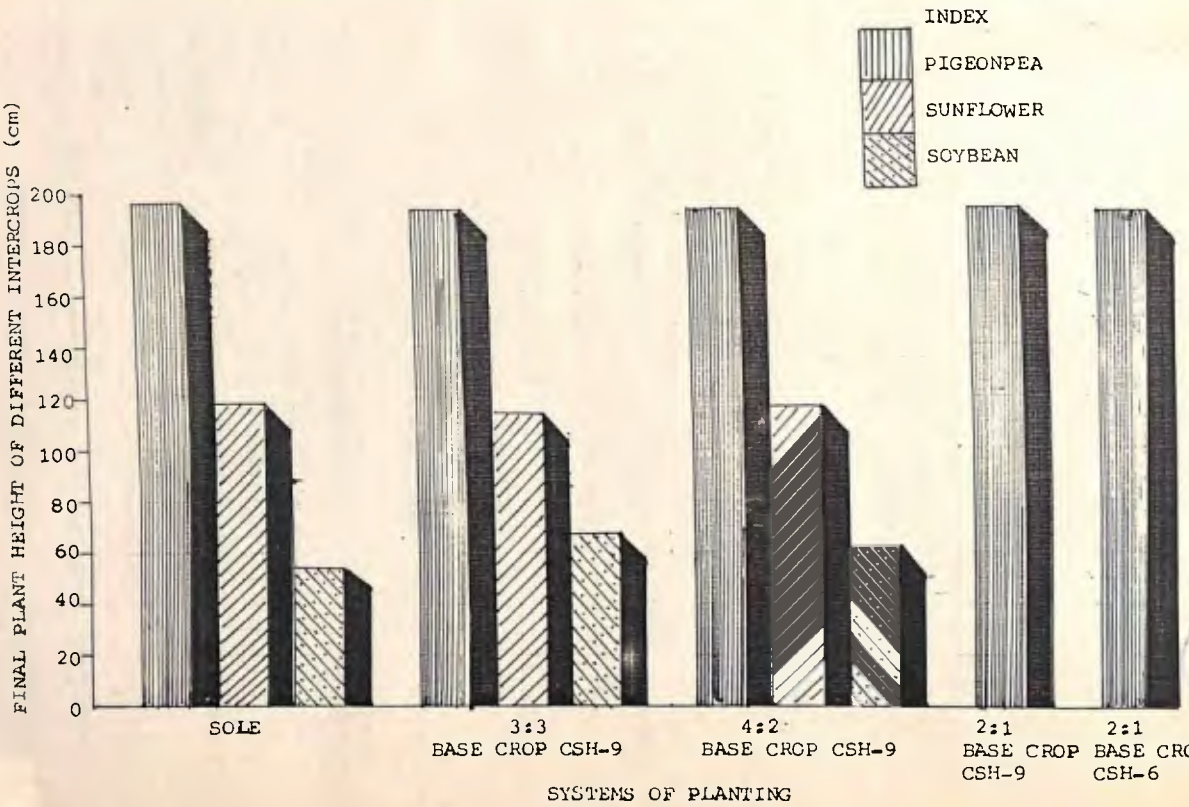


Table 4.12 Average number of functional leaves per plant of intercrops at flowering as affected by different planting system

Planting pattern / Intercrops	Sorghum CSH-9				Sorghum CSH-6
	Sole	3:3	4:2	2:1	2:1
Pigeonpea	136.2	122.7	110.5	123.7	151.6
Sunflower	15.2	15.0	16.9	-	-
Soybean	22.7	15.5	16.8	-	-

4.2.2 Post-harvest studies

4.2.2.1 Test weight (g)

Maximum test weight was recorded from CSH-9 + pigeonpea, 2:1 whereas the minimum test weight was recorded in its sole cropping (Table 4.13).

Table 4.13 Test weight of intercrops as affected by different planting system (g)

Planting pattern / Intercrop	Sorghum CSH-9				Sorghum CSH-6
	Sole	3:3	4:2	2:1	2:1
Pigeonpea	84.0	91.3	92.4	90.9	87.6
Sunflower	30.9	30.6	29.5	-	-
Soybean	89.2	88.7	90.4	-	-

FIG. 4.12 AVERAGE NUMBER OF FUNCTIONAL LEAVES PER PLANT OF INTERCROPS AS AFFECTED BY DIFFERENT TREATMENTS

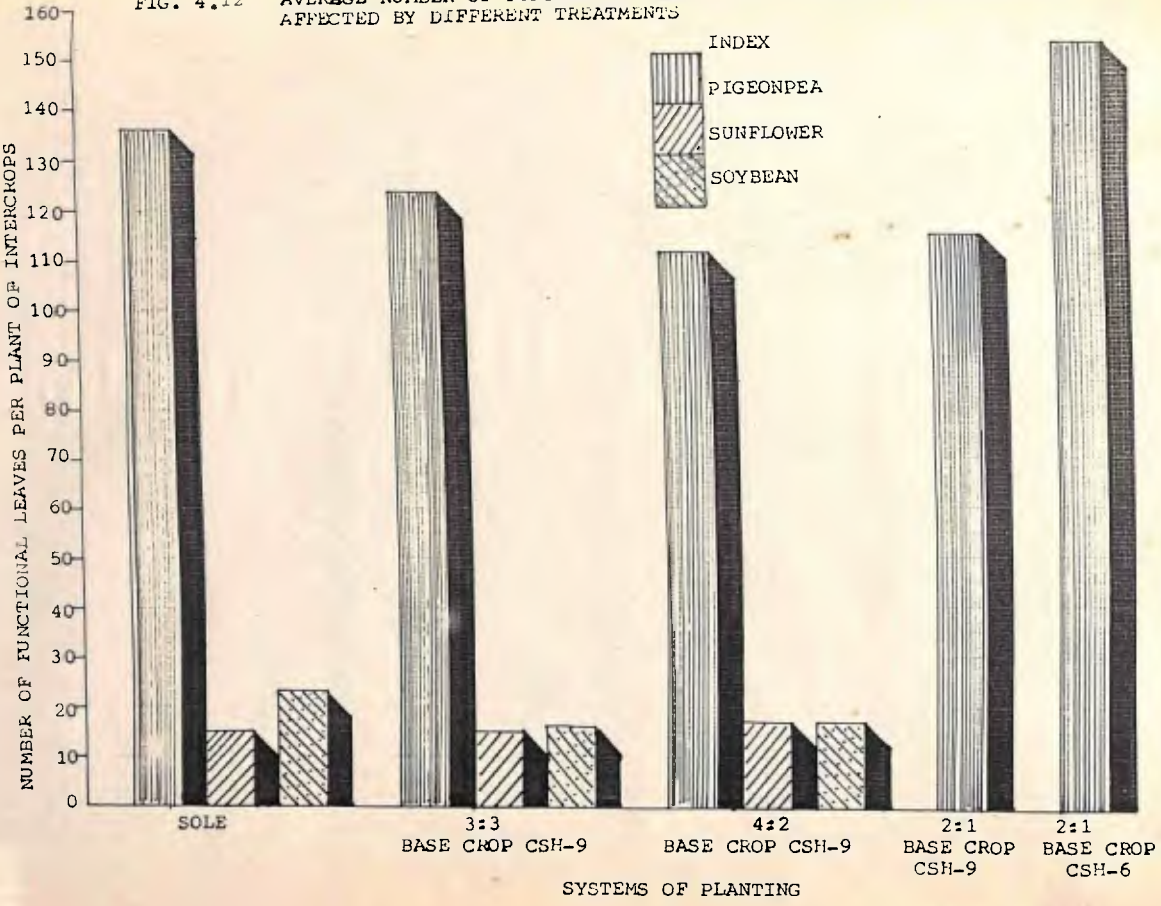
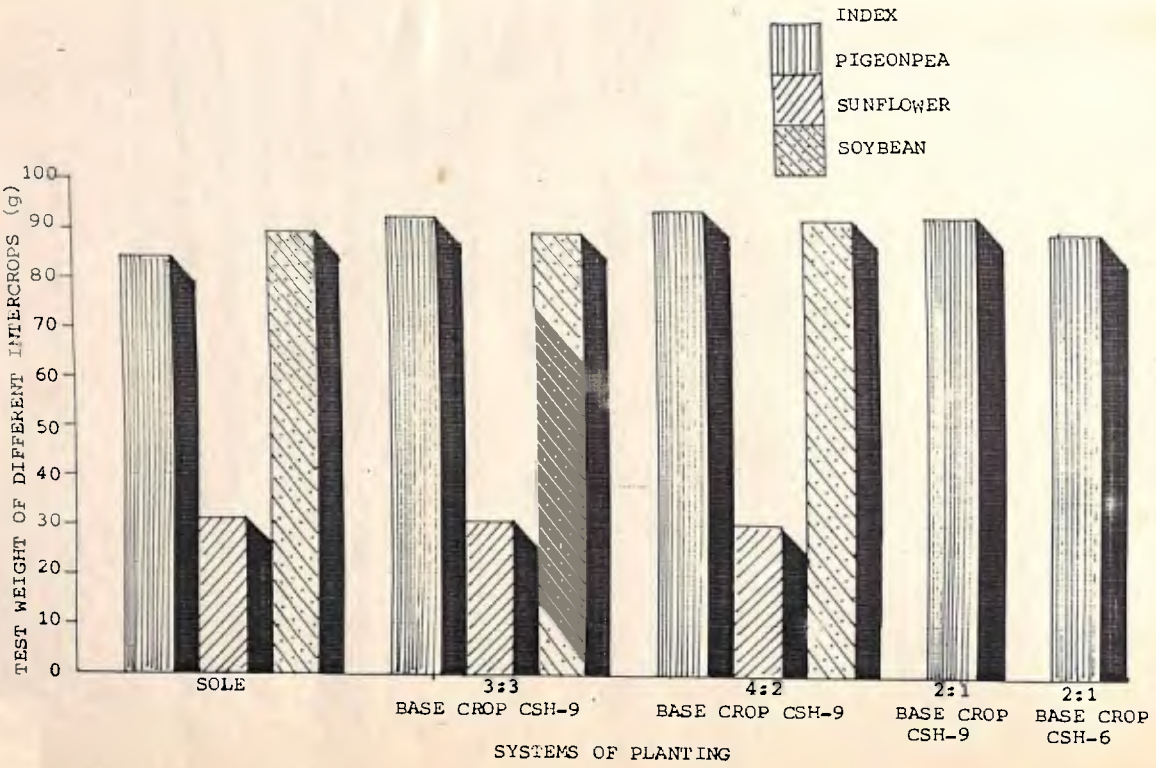


FIG. 4.13 TEST WEIGHT OF INTERCROPS AS AFFECTED BY DIFFERENT TREATMENTS (g)



4.2.2.2 Grain yield (kg/ha)

Sole pigeonpea showed maximum grain yield. It reduced as the number of rows of pigeonpea decreased from 14. Under 2:1 planting geometry, pigeonpea showed higher grain yield with CSH-6 in comparison with CSH-9 (Table 4.14).

Table 4.14 Grain yield of intercrops as affected by different planting system (kg/ha)

Planting pattern / Intercrops	Sorghum CSH-9				Sorghum CSH-6
	Sole	3:3	4:2	2:1	2:1
Pigeonpea	1242.36	559.49	470.60	356.48	501.62
Sunflower	567.13	240.74	141.20	-	-
Soybean	1527.78	594.57	312.50	-	-

4.2.2.3 Stover yield (kg/ha)

Maximum stover yield was recorded from sole pigeonpea. It reduced when intercropped with sorghum. As the number of rows of pigeonpea reduced from 14 the stover yield also reduced. Pigeonpea recorded more stover yield when intercropped with CSH-6 than with CSH-9 under 2:1 planting geometry (Table 4.15).

FIG. 4.[illegible] AVERAGE GRAIN YIELD OF INTERCROPS AS AFFECTED BY DIFFERENT TREATMENTS

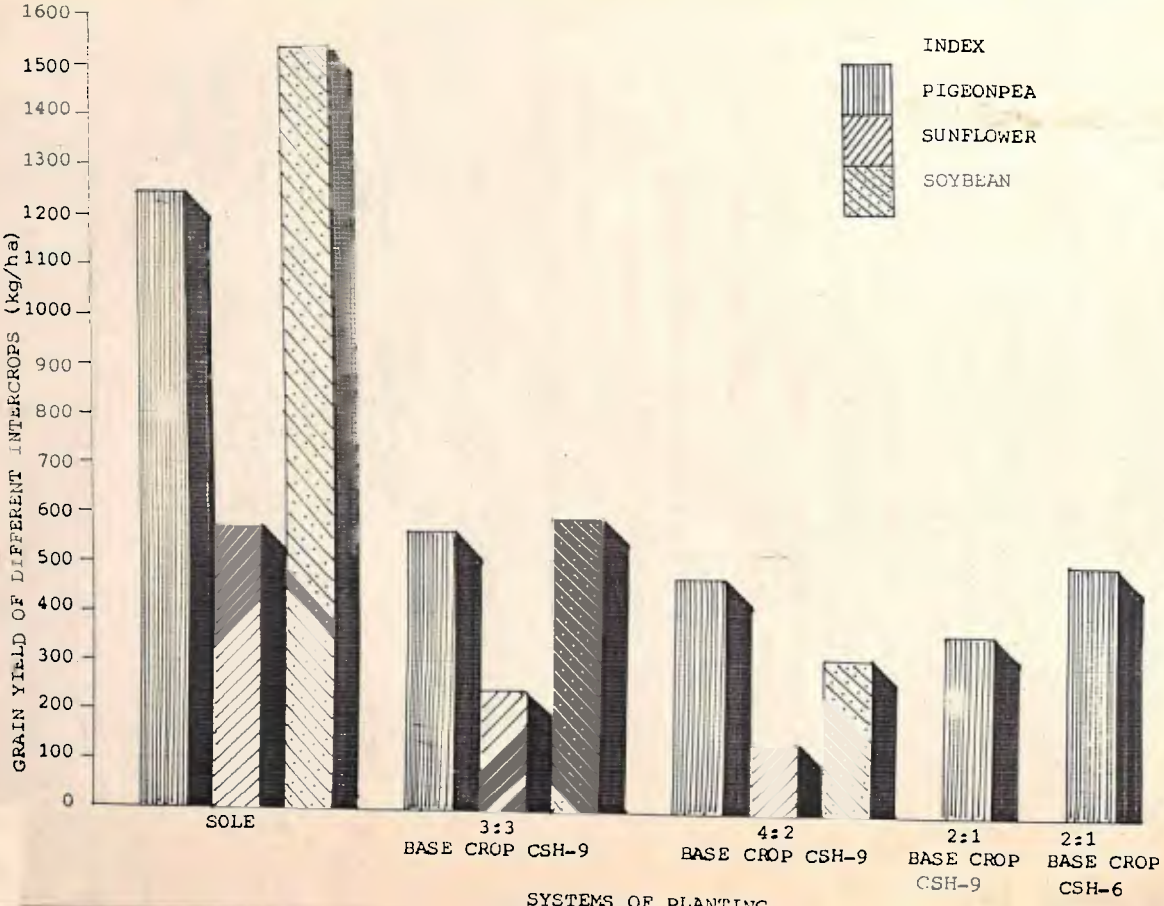


Table 4.15 Stover yield of intercrops as affected by different planting system (kg/ha)

Planting pattern / Intercrops	Sorghum CSH-9				Sorghum CSH-6
	Sole	3:3	4:2	2:1	2:1
Pigeonpea	3780.79	1581.71	1003.01	733.10	1041.67
Sunflower	1254.63	886.57	481.48	-	-
Soybean	1481.48	625.00	337.96	-	-

4.2.2.4 Grain stover ratio (%)

Highest grain stover ratio was observed in CSH-6 + pigeonpea, 2:1 followed by CSH-9 + pigeonpea, 4:2 and CSH-9 + pigeonpea, 2:1. Minimum grain stover ratio was recorded from pigeonpea sole (Table 4.16).

Table 4.16 Grain stover ratio of intercrops as affected by different planting system (%)

Planting pattern / Intercrops	Sorghum CSH-9				Sorghum CSH-6
	Sole	3:3	4:2	2:1	2:1
Pigeonpea	32.86	35.37	46.92	45.78	48.16
Sunflower	45.20	27.15	29.33	-	-
Soybean	103.12	95.18	92.46	-	-

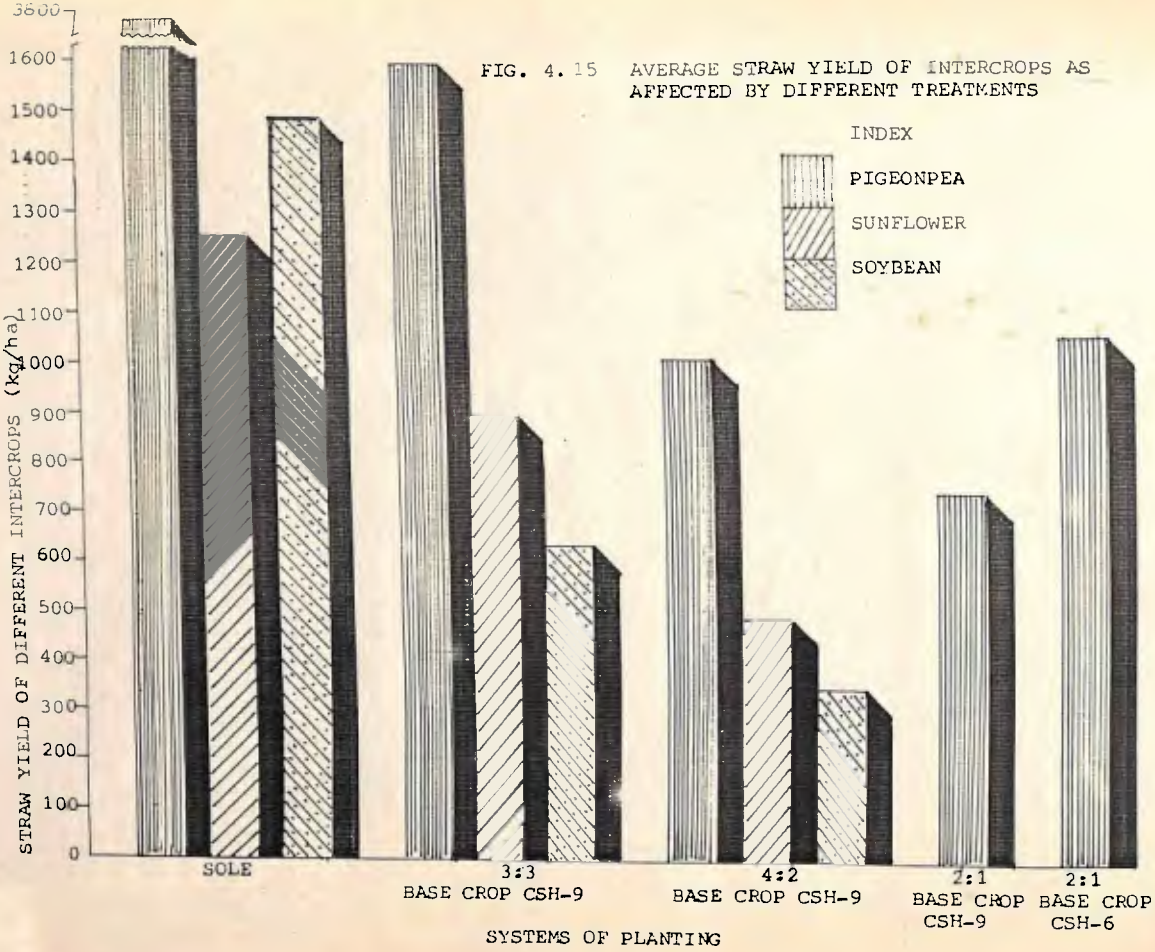
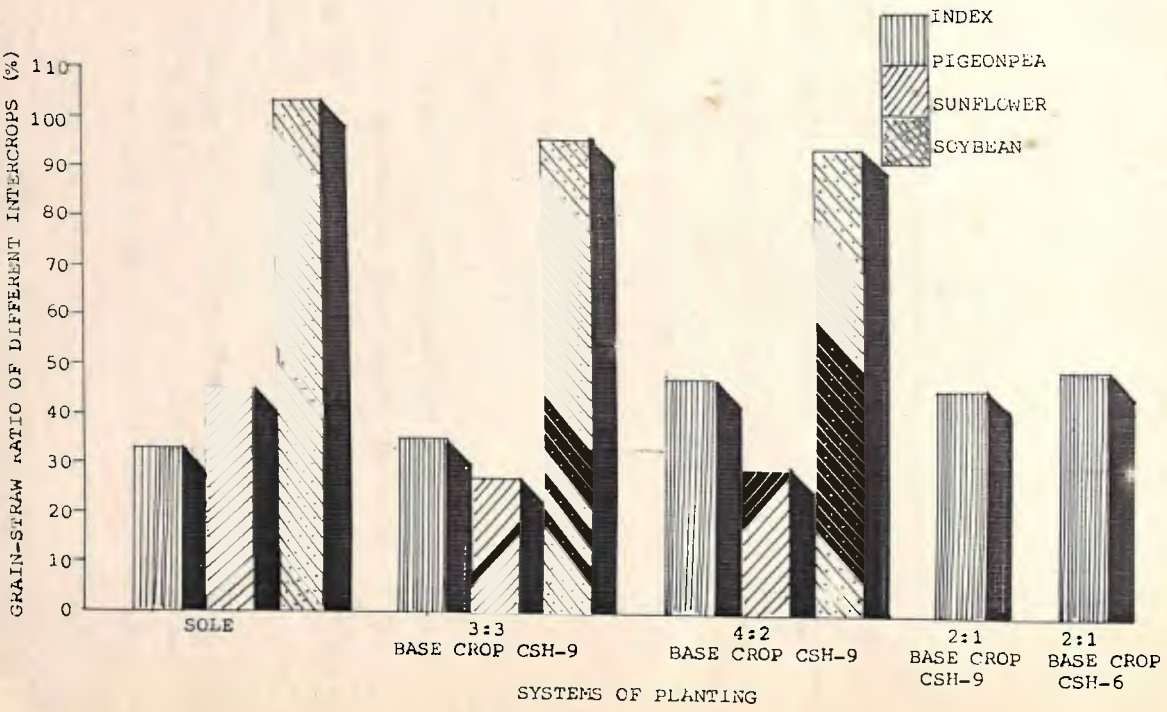


FIG. 4.15 AVERAGE STRAW YIELD OF INTERCROPS AS AFFECTED BY DIFFERENT TREATMENTS

FIG. 4.16 GRAIN-STRAW RATIO OF INTERCROPS AS AFFECTED BY DIFFERENT TREATMENTS



4.3 Sunflower

4.3.1 Pre-harvest studies

4.3.1.1 Average final plant height of sunflower (cm)

Maximum plant height was observed for sole sunflower followed by CSH-9 + sunflower, 4:2 and CSH-9 + sunflower, 3:3. Table (4.11)

4.3.1.2 Average number of functional leaves per plant

Maximum number of functional leaves per plant was recorded in CSH-9 + sunflower, 3:3 which was closely followed by sunflower sole and CSH-9 + sunflower, 3:3 (Table 4.12).

4.3.2 Post harvest studies

4.3.2.1 Test weight (g)

Sole sunflower showed maximum test weight. This was closely followed by CSH-9 + sunflower, 3:3 and CSH-9 + sunflower, 4:2 (Table 4.13).

4.3.2.2 Grain yield (kg/ha)

Maximum grain yield of sunflower was associated with its sole treatment. It decreased with the decrease in the number of rows of sunflower from 14 (Table 4.14).

4.3.2.3 Stover yield (kg/ha)

Sole sunflower recorded maximum stover yield. It was followed by CSH-9 + sunflower, 3:3 and CSH-9 + sunflower, 4:2 in order (Table 4.15).

4.3.2.4 Grain stover ratio

Maximum grain stover ratio was observed in sole sunflower. Whereas minimum grain stover ratio was associated with CSH-9 + sunflower 3:3 (Table 4.16).

4.4 Soybean

4.4.1 Pre harvest studies

4.4.1.1 Average final plant height (cm)

Maximum plant height of soybean was recorded in CSH-9 + soybean 3:3 followed by CSH-9 + soybean, 4:2 and sole soybean in order (Table 4.11).

4.4.1.2 Average number of functional leave per plant

Data boxed in table 4.12 showed that sole soybean recorded maximum functional leaves/plant. It was followed by CSH-9 + soybean, 4:2 and CSH-9 + soybean, 3:3 in order.

Table (4.12)

4.4.2 Post harvest studies

4.4.2.1 Test weight (g)

Maximum test weight of soybean was with CSH-9 +

soybean, 4:2. It was followed by CSH-9 + soybean, 3:3 and sole soybean, in order (Table 4.13).

4.4.2.2 Grain yield (kg/ha)

Data contained in table 4.14 revealed that sole soybean gave maximum grain yield. It was followed by CSH-9 + soybean, 3:3 and CSH-9 + soybean, 4:2, in order. (Table 4.14)

4.4.2.3 Stover yield (kg/ha)

Maximum stover yield was associated with sole soybean. It was followed by CSH-9 + soybean, 3:3 and CSH-9 + soybean, 4:2, in order. (Table 4.15)

4.4.2.4 Grain stover ratio

Maximum grain stover ratio was observed in sole soybean, which was followed by CSH-9 + soybean, 3:3 and CSH-9 + soybean, 4:2 in order. (Table 4.16)

4.5 Analysis of variance for treatments

Results of the ANOVA for total grain production, gross monetary return, sorghum equivalent ratio revealed that mean sum of squares of treatments were significant for all the characters (Appendix II).

Mean sum of squares for replications were not significant when tested against the error mean squares for above sited characters (Appendix II).

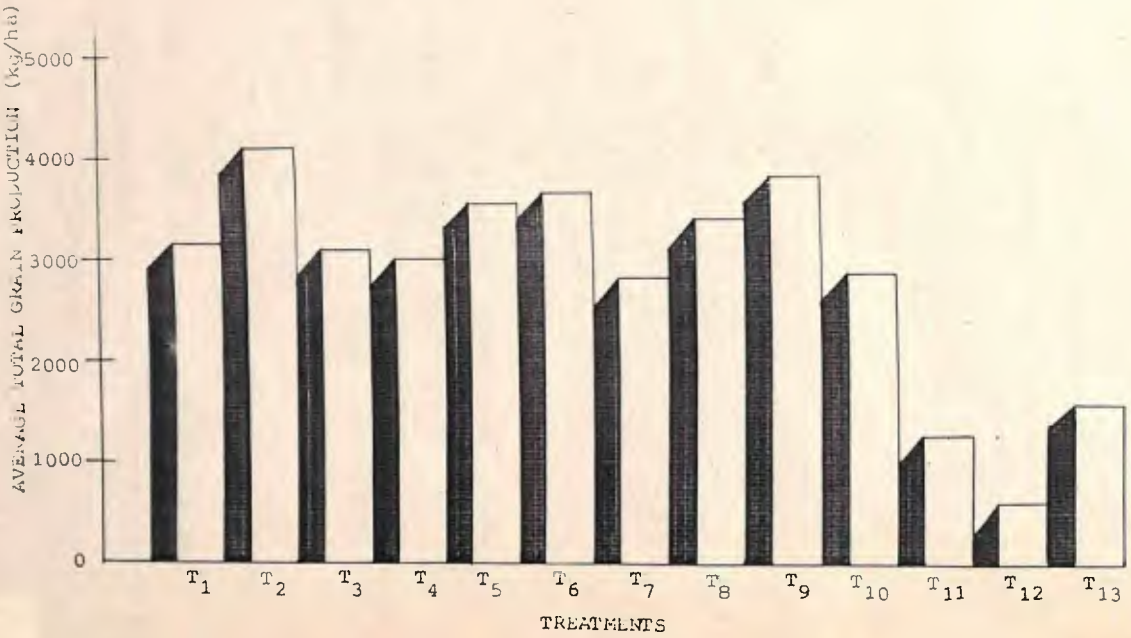
4.5.1 Total grain production (kg/ha)

Maximum total grain yield of 4122.69 kg/ha was recorded in T_2. This was significantly higher than the rest of the treatments. This was followed by T_6 , T_9 , T_5 and T_8. T_6 was statistically not superior than T_9 , T_5 and T_8 but significantly superior than the rest of the treatments. Minimum grain yield was recorded in T_{12} , which was significantly inferior to the rest of the treatments (Table 4.17).

Table 4.17 Total grain production (kg/ha)

T.No.	Treatments	Average total grain production
T_1	CSH-6 + pigeonpea (2:1)	3163.65
T_2	CSH-9 + pigeonpea (2:1)	4122.69
T_3	CSH-9 + pigeonpea (3:3)	3094.21
T_4	CSH-9 + sunflower (3:3)	2976.85
T_5	CSH-9 + soybean (3:3)	3539.81
T_6	CSH-9 + pigeonpea (4:2)	3634.26
T_7	CSH-9 + sunflower (4:2)	2822.45
T_8	CSH-9 + soybean (4:2)	3412.04
T_9	CSH-9 (sole)	3564.80
T_{10}	CSH-6 (sole)	2849.50
T_{11}	Pigeonpea (sole)	1242.36
T_{12}	Sunflower (sole)	576.13
T_{13}	Soybean (sole)	1527.78
	S.Em. ±	142.36
	CD 5 %	415.51

FIG.4.17 AVERAGE TOTAL GRAIN PRODUCTION OF DIFFERENT TREATMENTS (kg/ha)



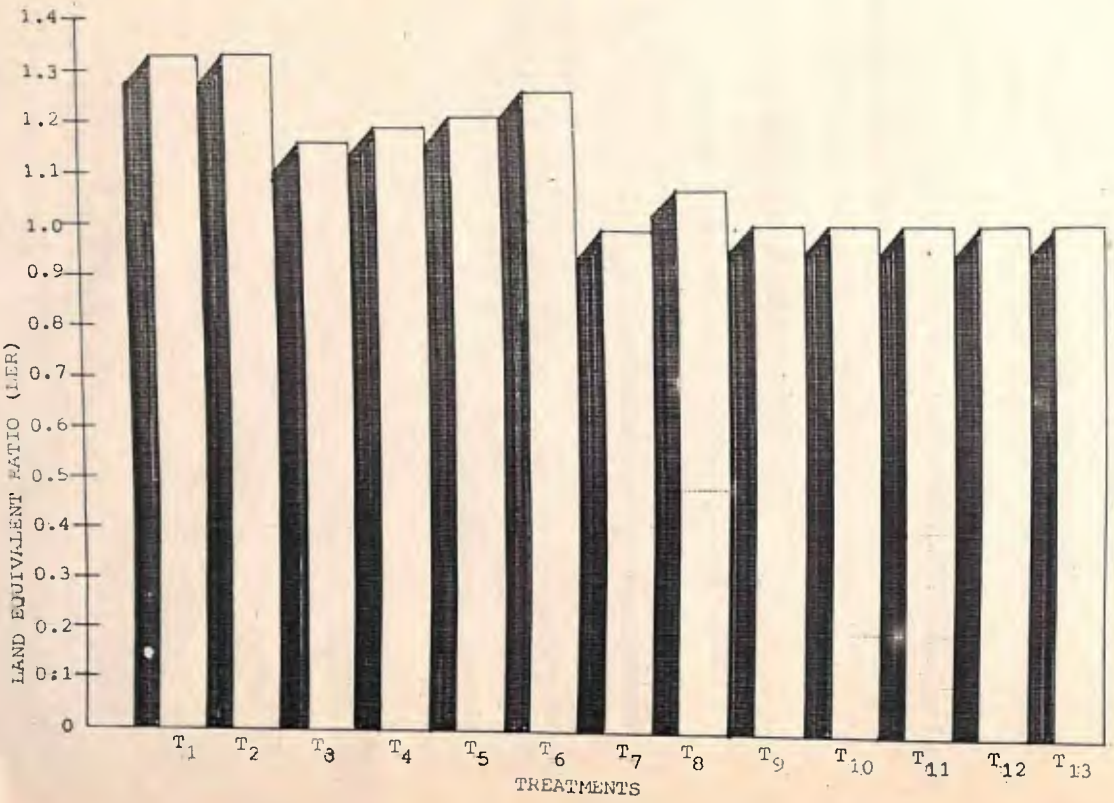
4.5.2 Land equivalent ratio (LER)

The efficiency of the sorghum based intercropping systems was evaluated in terms of total land productivity as expressed by the land equivalent ratio (LER).

Table 4.18 Total land productivity in terms of LER as influenced by different treatment

T.No.	Average grain yield (kg/plot)				LER		
	Sorghum		Intercrops				
	Sole	Inter-crop	Sole	Inter-crop	Sor-ghum	Inter-crop	Total
T_1	12.31	11.50	5.37	2.17	0.93	0.40	1.33
T_2	15.40	16.36	5.37	1.45	1.06	0.27	1.33
T_3	15.40	10.95	5.37	2.42	0.71	0.45	1.16
T_4	15.40	11.82	2.45	1.04	0.77	0.42	1.19
T_5	15.40	12.72	6.60	2.57	0.82	0.39	1.21
T_6	15.40	13.67	5.36	2.03	0.88	0.38	1.26
T_7	15.40	11.59	2.45	0.60	0.75	0.24	0.99
T_8	15.40	13.39	6.60	1.35	0.87	0.20	1.07
T_9	15.40	15.40	-	-	1.00	-	1.00
T_{10}	12.31	12.31	-	-	1.00	-	1.00
T_{11}	-	-	5.37	5.37	-	1.00	1.00
T_{12}	-	-	2.45	2.45	-	1.00	1.00
T_{13}	-	-	6.60	6.60	-	1.00	1.00

FIG. 4.18 LAND EQUIVALENT RATIO (LER) IN DIFFERENT TREATMENTS



It can be seen from the table 4.18 that the treatment T_1 and T_2 were equal and yielded the maximum LER of 1.33. This maximum LER was associated with the sorghum (irrespective of variety, whether CSH-6 or CSH-9) along with pigeonpea under 2:1 planting geometry. This was followed by T_6 , T_5 , T_4 and T_3 giving the LER of 1.26, 1.21, 1.19, 1.16, respectively. Least LER of 0.99 was recorded from T_7 , showing lesser LER to the component sole crops.

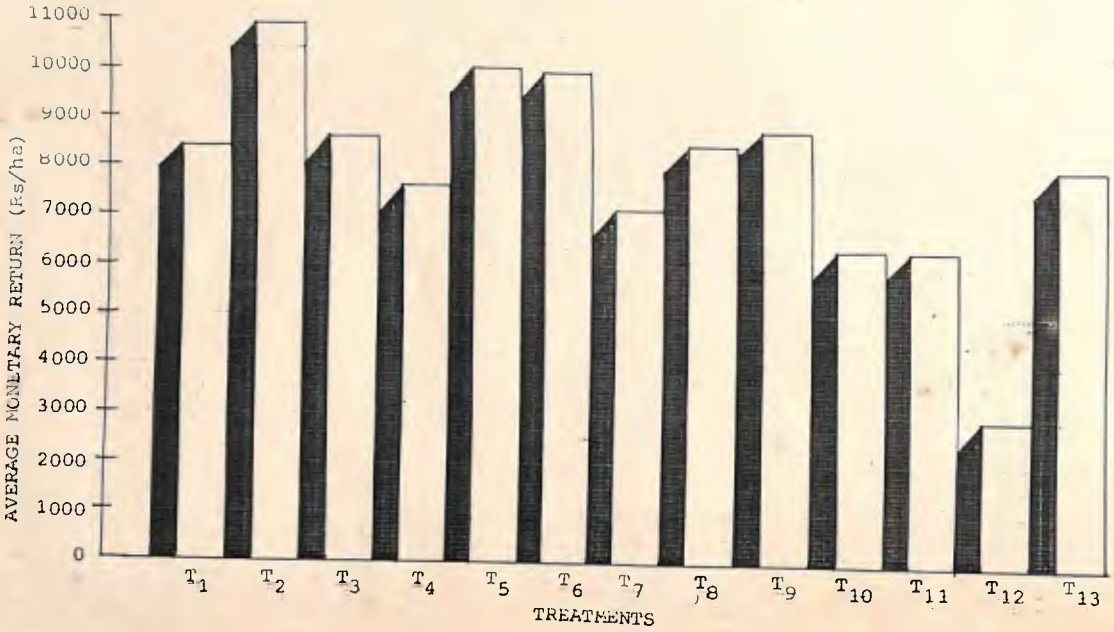
4.5.3 Gross monetary return (Rs/ha)

Maximum gross monetary return of Rs.10893.52/ha was obtained from T_2 (CSH-9 + pigeonpea, 2:1). This was at par with T_5 and T_6. Latter treatment was significantly superior than T_{13} , T_4 , T_7 , T_{11} , T_{10} and T_2 but at par with T_9 , T_3 , T_1 , and T_8. The lowest gross monetary returns was obtained from T_{12} , which was significantly inferior to the rest of the treatments (Table 4.19).

Table 4.19 Gross monetary return

T.No.	Treatments	Gross monetary return (Rs/ha)
T_1	CSH-6 + pigeonpea (2:1)	8379.63
T_2	CSH-9 + pigeonpea (2:1)	10893.52
T_3	CSH-9 + pigeonpea (3:3)	8611.11
T_4	CSH-9 + sunflower (3:3)	7613.42
T_5	CSH-9 + soybean (3:3)	9986.11
T_6	CSH-9 + pigeonpea (4:2)	9888.89
T_7	CSH-9 + sunflower (4:2)	7125.00
T_8	CSH-9 + soybean (4:2)	8377.31
T_9	CSH-9 (sole)	8740.74
T_{10}	CSH-6 (sole)	6335.65
T_{11}	Pigeonpea (sole)	6347.22
T_{12}	Sunflower (sole)	2863.42
T_{13}	Soybean (sole)	7914.35
	S.Em. ±	546.30
	CD at 5 %	1594.91

FIG.4.19 AVERAGE MONETARY RETURN AS AFFECTED BY DIFFERENT TREATMENTS (Rs/ha)



DISCUSSION

CHAPTER - V

DISCUSSION

A simplest cropping system would be to grow a single crop. However, most of the farmers grow more than one crop. In India, as many as 84 different crops are used in mixed cropping but very rarely we find that more than 4 are grown at a time (Swindale, 1979). The objective of intercropping is to:

(i) insure against total crop failures under aberrant weather conditions or pest epidemics

ii) increase the total productivity per unit land area, and

iii) equitably and judiciously utilize land resources and farming inputs, including labour.

Cereals and legumes are often mixed, probably more for dietary reasons than for any beneficial effect that the nitrogen fixing powers of legume convey to the associated cereal crop or to a subsequent one.

In the traditional way of mixed cropping, seeds of 2 or more crops are either mixed in same rates and sown or certain proportions are adopted. Thus populations of all the component crops is less than the recommended population,

which results in reduced yields of individual crops. It makes the mixture equivalent to individual crops grown separately in same field except for possible intercrop interaction and for reduced incidence of pests.

The new concept of intercropping has been developed primarily to maximize the production and profits over space and time by maintaining full population (100 % recommended) of both component crops (Singh, 1983). It is now known that as compared to sole cropping intercropping makes better use of natural resources of sunlight, land and water. It may have some beneficial effects on pest and disease problems, although overall results are some what in conclusive. Advantage of growing legumes with a non legume may be the saving of nitrogenous fertilizers. These advantages show up a ultimate benefits in yield and increases as much as 70 % over sole crop on same piece of land have been recorded (Swindale, 1979). However, evidence over this aspect are less definite (Willey, 1979).

Experiments of the All India Coordinated Sorghum Improvement Project (AICSIP) indicated that CoH-6 pigeonpea in 2:1 planting geometry of CoH-9 in place of CoH-6 was most remunerative intercropping system. However, as pointed out earlier the intercrop yield was adversely influenced. Endeavour were therefore, desired to identify a planting geometry and a

compatible oilseed/pulse intercrop such that the recovery of intercrop could be more than presently observed and hence more profitable. Present experiment was an effort in this direction.

5.1 Sorghum attributes

5.1.1 Growth characters

All the 10 treatments exhibited significant differences amongst themselves in respect of final plant height and leaf area per plant, whereas number of green leaves per plant did not differ significantly.

Maximum plant height was recorded for CSH-9 (sole). However, it was at par with CSH-9 + sunflower, 3:3; CSH-9 + sunflower, 4:2 and CSH-9 + pigeonpea, 4:2. These results suggested that growth of sorghum was not adversely influenced by sunflower and pigeonpea when grown in 4:2 planting geometry. On the other hand, height was significantly reduced when grown with pigeonpea in 3:3 planting geometry. It was at par with T_5 , T_8 and T_2. It was interesting to note that height of sorghum was reduced when grown with a low canopy crop like soybean.

Maximum number of leaves per plant was observed in T_5 (CSH-9 + soybean, 3:3). However the number of green leaves on an average was always higher than its sole except T_2 , when intercropped with pigeonpea, sunflower and soybean. Maximum leaf area per plant was observed for CSH-9

in T_5. It was at par with T_4 and T_3. Further, it was observed that leaf area per plant significantly increased when intercropped with either of pigeonpea, sunflower and soybean under 4:2 and 3:3 planting geometry.

Yield contributing characters

There were significant differences among the treatments for length of panicle grain weight per panicle and test weight.

Maximum length of panicle was recorded for CSH-9 grown in association with soybean in 3:3 planting geometry. It was not however, significantly superior than panicle length for CSH-9 grown in 3:3 planting ratio with sunflower and pigeonpea. Panicle length was significantly reduced in length when grown with pigeonpea in 2:1 ratio as compared with T_5. It appeared that panicle length was relatively shorter when CSH-9 was grown in 4:2 system with any of the intercrops. However, it was at par with CSH-9 sole.

Maximum grain weight per panicle was also recorded for CSH-9 grown in association with soybean in 3:3 planting geometry. It was significantly superior than the rest treatments. This may be due to more efficient utilization of nutrients, moisture and solar energy because of wider spacing between rows and less competition by intercrop of which morphological and physiological characters differ from sorghum crops. However, highest test weight was

observed for CSH-6 in T_1. It was interesting that as the number of rows of CSH-9 decreased, test weight of CSH-9 increased when intercropped with soybean, sunflower and pigeonpea. Similar results were obtained in sorghum/pigeonpea intercropping by Hiremath (1979) whereas Kulkarni (1985) reported that sorghum/pigeonpea intercropping did not affect the length of panicle significantly.

5.1.3 Grain yield

CSH-9 recorded maximum grain yield when grown with pigeonpea in 2:1 system. It was at par with CSH-9 sole. This provided evidence to show that sorghum grown with pigeonpea in 2:1 planting geometry did not show adverse influence of pigeonpea on sorghum yield. On the other hand, yield of pigeonpea was a bonus. Likewise CSH-6 grown with pigeonpea in 2:1 planting geometry had yield statistically at par with CSH-6 grown as sole crop. Similar findings were reported by Shelke and Krishnamoorthy (1978), Bhalerao and Upadhyay (1981), Willey et al. (1982) and Hunshal et al. (1987). On the other hand growing of pigeonpea or soybean or sunflower in 4:2 and 3:3 with sorghum had significant adverse influence on grain yield. Hiremath (1979) reported similar findings in sorghum/pigeonpea intercropping.

The results of the Appendix III shows that yield recovery was maximum when grown with pigeonpea in 4:2 system as compared with either sole crop of sorghum (88 %)

or CSH-9 + pigeonpea, 2:1 (83 %). Least recovery was observed when sorghum was grown with pigeonpea in 3:3 system (71 % and 67 %). This is obvious because the population of sorghum was only 50 %.

Sunflower emerged as a dominanting crop adversely influencing sorghum yield when grown with sorghum in 4:2 planting geometry. When grown in 3:3 system soybean had relatively less adverse influence on yield of sorghum than pigeonpea.

In 3:3 planting geometry i.e. when population of sorghum was only 50 %, yield was much more adversely influenced by sunflower, a highly competitive crop. Palaniappan et al. (1975) and Tarhalkar and Rao (1979) reported decline in yield of sorghum when grown with sunflower.

5.1.4 Stover yield

It appeared from the findings that there was significant differences among the treatments for stover yield of sorghum.

Maximum stover yield was recorded in T_2 (CSH-9 + pigeonpea 2:1). It was statistically at par with CSH-9 sole. However, lowest stover yield was recorded in T_1 (CSH-6 + pigeonpea, 2:1). It was not significantly superior to its sole cropping in T_{10}. As the number of

rows of sorghum decreased in intercropping system of sorghum CSH-9 with pigeonpea, soybean and sunflower, the stover yield of sorghum also decreased. This may be due to reduced population of sorghum as in case of grain yield of sorghum discussed earlier. Similar results were obtained by Hiremath (1979).

5.1.5 Harvest index

It is a term coined by Ronald (1968) to identify plants which can efficiently partition the dry matter produced by it. Efficient plants are known to partition more of the dry matter in to economic product. For example Anantharaman et al. (1978) reported that for sorghum hybrid CSH-1 the harvest index was 50 % whereas for indigenous tall and late maturing varieties BP 53 and Aispuri it was 29 %. Maximum harvest index was recorded for CSH-9 + pigeonpea in 2:1 planting geometry. It was significantly superior not only than CSH-6, sole but all other treatments, except 2 other treatments, viz., T_8 and T_3. This suggested that harvest index values of CSH-6 and CSH-9 significantly improved as compared with their own sole crop harvest index values when grown with intercrops. However, this was not true for CSH-9 in all planting system and with all the intercrops.

5.1.6 Grain stover ratio

There were significant differences among the treatments for grain stover ratio of sorghum. Maximum grain stover ratio was observed for CSH-6 in association with pigeonpea in 2:1 planting geometry. It was statistically at par with its sole cropping in T_{10} , but significantly superior to rest of the treatments. Least grain stover ratio was observed for CSH-9 sole in T_9 which was at par with T_2 (CSH-9 + pigeonpea, 2:1), but significantly superior to the rest of the cropping system based on sorghum CSH-9.

It was interesting that sorghum when intercropped with either of intercrops viz., pigeonpea, soybean and sunflower in different planting geometry i.e. 2:1, 3:3, and 4:2, showed higher grain stover ratio to its sole grain stover ratio. This may be due to higher grain production/ plant with intercrops.

5.2 Pigeonpea attributes

Table 4.12 revealed that intercropped pigeonpea remained little dwarf as compare to the plants in pure stand. More competative nature of sorghum may be held responsible for this as reported by Rao and Willey (1980).

Highest number of leaves per plant was recorded in sole pigeonpea but reduced when intercropped with CSH-9. It was interesting that pigeonpea showed greater number of

green leaves per plant in CSH-6 + pigeonpea, 2:1 as compare to CSH-9 + pigeonpea, 2:1. It is probably due to earlier maturity of CSH-6 than CSH-9, which was harvested earlier and provided sufficient space to pigeonpea in its grand phase.

Effect of different treatments on test weight of pigeonpea was presented in table 4.14. They showed that intercropping of pigeonpea reduced the test weight, which was considered to be the major factor of low yields of pigeonpea with the intercropping system.

Data boxed in table 4.15 revealed that intercropping of sorghum and pigeonpea reduced the grain yield of pigeonpea as compared to its sole cropping. As the number of rows of pigeonpea decreased from 14, grain yield also decreased. This maybe due to its reduced population and reduced test weight in different intercropping system. It was interesting that under 2:1 planting geometry, pigeonpea recorded higher grain yield with CSH-6 than with CSH-9. This may be due to acute and vertically erect leaves of CSH-6 which made pigeonpea capable to get more sunlight and its early maturing quality. Similar trend was observed for straw yield of pigeonpea, showing highest straw yield of pigeonpea from the treatment pigeonpea sole. But just opposite trend was observed for grain stover ratio of pigeonpea in different planting systems. As it was very clear from table 4.17 that grain stover ratio increased

with the decrease in the number of rows of pigeonpea from 14 in different planting system.

5.3 Sunflower attribute

Sole sunflower showed maximum plant height but it reduced when intercropped with sorghum, whereas maximum number of leaves per plant was associated with sorghum under 4:2 planting geometry.

It was clear from the table 4.14 that highest test weight was recorded in the sunflower as sole cropping and it decreased with the decrease in the rows from 14. Similar trend was observed from grain yield and straw yield of sunflower, which may be due to reduced population of sunflower and reduced test weight (reduced test weight may be due to not proper grain filling) of its grain in different planting geometry with sorghum.

Maximum grain straw ratio was observed in sole sunflower. This may be due to the same reason pointed out earlier that grain yield and test weight was higher in sole sunflower as compare to sorghum/sunflower in different planting geometry.

5.4 Soybean attributes

Highest plant height was observed soybean intercropped with sorghum under 3:3 planting geometry. Further more soybean showed greater plant height under different

planting systems when compared with its sole cropping. However, maximum number of green leaves per plant was associated with the sole soybean and it decreased when intercropped with sorghum.

Maximum test weight was observed for soybean under 4:2 planting geometry, whereas maximum grain yield was recorded for sole soybean. It was obvious that as the number of rows of soybean decreased from 14, grain yield of soybean also decreased due to its reduced population. Similar trend was observed for straw yield and grain stover ratio of soybean.

5.5 Sorghum + intercrops viz., pigeonpea, sunflower and soybean

5.5.1 Total grain yield

In order to evaluate the total grain production/plot, grain yield of sorghum/plot and intercrop/plot were added together. Results of analysis revealed that there were significant differences among the 13 treatment combinations. Analysis for grain yield of sorghum had already suggested that the grain yield of sorghum CSH-9 obtained from plot intercropped with pigeonpea under 2:1 planting geometry were not significantly different from yields of sole plot of CSH-9. The total production of T_2 (CSH-9 + pigeonpea, 2:1) was found to be maximum (4122.69 kg/ha) and it was statistically superior to all other 12

treatments. Umat (1984) and Rathore (1985) also observed similar findings.

5.5.2 Land equivalent ratio (LER)

The results revealed that T_1 and T_2 had maximum LER of 1.33. However, it was interesting to note that there was decline in the yield of sorghum in case of T_1 and rise in the production of pigeonpea. On the other hand, CSH-9 did not exhibit decline in yield when grown with pigeonpea in 2:1 planting geometry as compared to its sole crop yield. However, contribution of pigeonpea to the LER was practically half compared with the LER of pigeonpea in T_1. It is a known fact that the average grain yield of CSH-9 is more than CSH-6 not only when grown as sole crop, but also when grown in association with intercrops (Anonymous, 1986). The plant type of CSH-6 is different than CSH-9. Plants of CSH-6 are dwarfer, have narrower leaves and upper leaves are some what pointing upwards (erectophyll nature). Consequently this genotype competes least with intercrop. However, the plants of CSH-9 are sturdier, have broad, long leaves which droop horizantally and hence cause shading of intercrop.

The LER of CSH-9 in 4:2 and 3:3 planting geometry was adversely affected because the population of this hybrid was only 66 % and 50 % respectively as compared to its sole crop population.

The LER of intercrops was relatively more in 3:3 planting geometry than their corresponding LERs in 4:2 system. The reason is obvious. In 3:3 planting pattern, population of intercrops was 50 % of their sole crop density however in 4:2 planting pattern, populations of intercrop was only 33-34 %.

LER of sorghum was least when grown with sunflower suggesting that this crop adversely influenced the base crop. Soybean on the other hand could exhibit its normal yield potential when grown with sorghum.

5.5.3 Gross monetary return

Enhanced production of grains from a unit of land would be reflected in increased monetary returns. It was observed that CSH-9 + pigeonpea in 2:1 planting geometry yielded maximum returns. However, it was statistically at par with CSH-9 + soybean 3:3 and CSH-9 + pigeonpea, 4:2. The results revealed an interesting fact that monetary returns from CSH-9 + pigeonpea (2:1) were significantly more than CSH-9 sole. Similar results were obtained by Shrivastava and Singh (1975) and Tarhalkar and Rao (1975) However, monetary returns from T_5 and T_6 at par with CSH-9 sole. Monetary returns from pigeonpea, sole, sunflower sole and soybean sole were also significantly lower than T_2.

Grain yield of sorghum in T_2 was at par with sole CSH-9. Additional yield of pigeonpea in 2:1 system has

contributed to the significantly more monetary returns obtained from this systems. Shelke and Krishnamoorthy (1978), Bhalerao and Upadhyay (1981), Willey et al. (1982) and Umat (1984) were in agreement with this finding.

The grain yield of CSH-9 in T_5 and T_6 was significantly inferior than CSH-9 sole indicating significant decline in yield of sorghum when grown in association with either pigeonpea in 4:2 or soybean in 3:3 planting systems. Monetary returns of T_5 and T_6 , which were observed to be at par with T_2 could be attributed to more returns from pigeonpea and soybean compensating for loss in yield of sorghum grown in 4:2 and 3:3 system with pigeonpea and soybean respectively. On the whole it appears that CSH-9 grown in association with pigeonpea in 2:1 planting geometry the most remunerative intercropping system. However, CSH-9 + pigeonpea, 4:2 and CSH-9 + soybean 3:3 could also be adopted by the farmers.

SUMMARY AND CONCLUSION

CHAPTER - VI

SUMMARY AND CONCLUSION

A field experiment entitled "Optimizing the yield recovery of some pulse, oilseed and high [illegible] value crops for increasing the profitability of sorghum based cropping system" was conducted during kharif season of 1988-89 at JNKVV Campus College of Agriculture, Indore.

The experiment consisted of 14 treatment combinations (2 treatment combinations of two sorghum cultivars viz., CSH-6 and CSH-9 with pigeonpea in 2:1 planting geometry + 6 treatment combinations of sorghum CSH-9 with pigeonpea, sunflower and soybean in 3:3 and 4:2 planting geometry + 5 sole crop treatments of sorghum and intercrops.

1. Sorghum

Maximum plant height was noted in CSH-9 as sole crop whereas highest number of functional leaves per plant, leaf area per plant, average length of panicles and grain weight per panicle were obtained from CSH-9 + soybean (3:3). Furthermore maximum test weight and harvest index was obtained from CSH-6 + pigeonpea (2:1). However, maximum grain yield, stover yield and grain stover ratio was obtained from CSH-9 + pigeonpea (2:1) treatment.

2. Sorghum based intercropping system

It is inferred from the findings of the present investigation that best combination was CSH-9 + pigeonpea (2:1) giving maximum monetary return of Rs.10,893.52 ha^{-1} followed by CSH-9 + soybean 3:3 and CSH-9 + pigeonpea, 4:2 giving 8.33 and 9.22 per cent less monetary returns respectively to that of treatment CSH-9 + pigeonpea (2:1). Treatment i.e. CSH-9 + pigeonpea (2:1) also gave maximum total production (4122.69 kg/ha) showing its statistical superiority among all the treatments. Both the treatments CSH-6 + pigeonpea (2:1) and CSH-9 + pigeonpea (2:1) showed highest LER of 1.33.

Conclusion

1. It is concluded from the above that the best combination was found to be the sorghum cultivar CSH-9 grown in association with pigeonpea in 2:1 planting geometry, giving maximum total grain production, monetary return and LER.

2. Next to pigeonpea, soybean proved to be suitable intercrop with sorghum cultivar CSH-9 under 3:3 planting geometry.

3. Among pigeonpea, sunflower and soybean, pigeonpea and soybean proved to be the suitable intercrops with CSH-9 under 2:1 and 3:3 planting geometry respectively, specially for the Malwa conditions.

Experiment should be repeated for IInd time to confirm the above results.

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*Original not seen.

APPENDIX

APPENDIX - I Analysis of variance for different character of sorghum mean of squares

Source of variation	D.F.	Mean sum of squares									
		Pre harvest characters			Post harvest characters						
		Final plant height (cm)	Functional leaves per plant (No.)	Leaf area per plant (sq cm)	Length of panicle (cm)	Grain weight of 10 panicles (g)	Grain yield/ plot (kg)	1000 grain weight per plot (g)	Straw yield/ plot (kg)	Harvest index (%)	Grain straw ratio (%)
Replication	2	77.93*	0.33 NS	596615.80 NS	0.82 NS	4973.04 NS	2.22*	6.12*	8.63 NS	8.26 NS	43.75 NS
Treatment	9	98.07**	1.87 NS	4590461.40**	9.19**	19504.70**	12.15**	5.12**	227.20**	27.56**	317.02**
Error	18	15.37	5.92	563193.94	2.34	4609.14	0.62	1.05	16.63	4.40	75.08

NS = Non significant

* Significant at 5 %

** Significant at 1 %

APPENDIX-II Analysis of variance for average grain production (kg/plot) and monetary return (Rs/plot)

Source of variation	D.F.	Mean sum of squares	
		Average grain production(kg/ha)	Monetary return (Rs/ha)
Replication	2	2.48NS	15.47NS
Treatment	12	61.74**	232.55**
Error	24	1.14	16.75
Total	38		

NS = Non significant

**Significant at 1 %

APPENDIX-III Recovery of sorghum in various system (%)

System	As compared with	
	CSH-9 (sole)	CSH-9 + pigeonpea 2:1
CSH-9 + pigeonpea 3:3	71.09	66.91
CSH-9 + sunflower 3:3	76.77	72.23
CSH-9 + soybean 3:3	82.59	77.73
CSH-9 + pigeonpea 4:2	88.78	83.53
CSH-9 + sunflower 4:2	75.25	70.82
CSH-9 + soybean 4:2	86.94	81.82

VITA

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The author of this thesis ASHOK KUMAR MAHAJAN s/o Shri Shrikrishna Mahajan was born on 2nd February 1965 in Khargone (M.P.). He completed his primary and middle school education at Khargone. He passed the Higher Secondary School Certificate Examination of Madhya Pradesh Board of Secondary Education, Bhopal in the year 1982 from Devi Ahilya Higher Secondary School No.1 Khargone with First division. He also got distinction in Higher Mathematics, Physics and Hindi.

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He, then joined M.Sc.(Ag.) course in the same institution in Agronomy in 1987. In the previous year he was awarded Merit cum means scholarship. He completed all his course requirement for Master degree with an OCGA of out of 4.00 scale (%) in 1989. For the partial fulfilment of the degree he was allotted a problem for thesis work, which has been duly completed by him and presented in the form of manuscript.