STUDIES ON OPTIMISING YIELD RECOVERY OF PIGEONPEA AND SUNFLOWER FOR INCREASING PROFITABILITY OF SORGHUM BASED INTERCROPPING SYSTEM

BY
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AFFECTIONATELY DEDICATED

TO MY PARENTS

D E C L A R A T I O N

I hereby declare that the dissertation or part thereof has not been previously submitted by me for a degree of any University.

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CERTIFICATE I

This is to certify that Shri Pandit Gampatrao Wahatule has satisfactorily prosecuted his course of research for a period of not less than one year and that the dissertation entitled " STUDIES ON OPTIMISING YIELD RECOVERY OF PIGEONPEA AND SUNFLOWER FOR INCREASING PROFITABILITY OF SORGHUM BASED INTERCROPPING SYSTEM ", submitted by him is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination for the award of the degree of Master of Science (Agriculture) in Agronomy. I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any University.

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PARBHANI
DATED: 29th June, 1985

CERTIFICATE II

This is to certify that the dissertation entitled " STUDIES ON OPTIMISING YIELD RECOVERY OF PIGEONPEA AND SUNFLOWER FOR INCREASING PROFITABILITY OF SORGHUM BASED INTERCROPPING SYSTEM " submitted by Shri Pandit Ganpatrao Wahatule to the Marathwada Agricultural University in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (Agriculture) in the subject of Agronomy has been approved by the student's advisory committee after oral examination in collaboration with the external examiner.

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(P.G. WAHATULE.)

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1. INTRODUCTION

1. INTRODUCTION

Intercropping is the important practice in agriculture. Since ancient time, farmers knew the importance of intercropping and they use to practice the concept of mixed cropping, which gave them stability against the vagaries of nature.

At present, under rainfed conditions we have to increase the production of our agricultural crops so that we can keep in pace with the fast increasing population and suffice the food needs of all the people. To increase the production, there are many ways such as multiple cropping, relay cropping, intercropping etc. At present, our 80 per cent area is rainfed where the moisture is generally sufficient for one season i.e. rainy season. In such scare condition of moisture it is difficult to adopt sequence, multiple or relay cropping.

Recently, a new concept of intercropping is developed in which a plant geometry of base crop is adjusted either in paired rows of skipping one row every after one or two rows of base crop and the created space is utilized for sowing one or two rows of intercrop, depending its plant type and canopy. Thus maintaining optimum plant population of base crop and additional plant population of intercrop in the unit area.

This new intercropping system have many advantages as under.

1. It serves as an insurance against the weather hazards.
2. It lessens the damages due to pest and diseases.
3. It enables the farmer to increase the cropping intensity.
4. Efficient utilization of resources of intercropping than that of sole crops.
5. Intercropping gives more stable yields than the sole crops primarily from compensation of one component when other fails to produce.

So, considering the rainfall from 500 to 700 mm, the land and other resources of crop production can be utilized to the fullest extent by adopting sorghum + pigeonpea intercropping, thus increasing the monetary returns/unit area.

Area under sorghum of our State is 66.46 million hectares and production is 50.53 million tonnes. This is some what surplus over our food needs, whereas the production of oilseeds and pulses is very low, not in our State only but also in whole India. The need of pulses and oil per head per day is 104 and 30 g respectively, but with our production of oilseed and

pulses, we can only supply 40 and 11 g pulses and oil per head per day. To compensate our needs, we have to import these things from other countries costing a lot of foreign exchanges. For import of oil only requires about 1000 million rupees which can be saved and incurred in other essential things, if we produce the sufficient oilseeds and pulses in our country and be self sufficient regarding oil and pulses. One way of increasing the production of these crops is to increase the area under these crops either as sole or a intercrop.

The results of the experiments on sorghum + pigeonpea intercropping conducted in AICSIP at various locations revealed that CSH-6 and CSH-1 are the beat genotype of sorghum for pigeonpea intercropping in paired row planting. Recently released CSH-9 is much popular among the cultivators due to its very high yield potentiality and quality grain. However, due to its more compititive effects on pigeonpea under intercropping resulting through its broad and lateral leaves, thick stem, more height etc. was not found compatible either in paired row or skipped row planting geometry under intercropping.

In present investigation, efforts were being made to minimise the competitive effects between base and

intercrop by strip planting with different row proportions of base and intercrops. Pigeonpea being legume crop, benifits the main crop by fixing up atmospheric nitrogen in the soil by symbiosis. In the past experiments it has been proved a most successful intercrop in the sorghum giving maximum yield/unit area and also maximum profit due to the differences in duration, habit, plant canopy, root system, growth pattern etc. between base and intercrop.

The sunflower was included because it is a oilseed crop fetches good prices in the market being a high value crop. Considering the surplus production of sorghum in State, in present investigation, plant population of sorghum was reduced by 34 and 50 per cent, permitting slight reduction in the yield of sorghum. However, this reduced plant population was compensated by high value crops like pigeonpea and sunflower so as to increase the recovery of these crops and making the whole system profitable as compared to the sole sorghum. Moreover, this modified intercropping system or strip cropping provides better convenience for sowing, interculturing, spraying, harvesting etc. as compared to paired row planting. Considering all these views in mind, the present investigation was carried out at

Sorghum Research Station, Parbhani during the year 1984-85 with following objectives.

1. To compare the suitability of modified intercropping of sorghum + pigeonpea/sunflower with sole cropping.

2. To study the recovery of intercrops in modified intercropping as compared to regular intercropping of 2:1 row proportion in paired row planting.

3. To findout the optimum row proportion of base and intercrop in modified cropping system.

4. To compare the convenience of modified intercropping with regular intercropping in field itself.

5. To findout the additional profit/loss of modified system as against regular intercropping and respective sole cropping.

6. To findout the feasibility and total out turn of modified intercropping as compared to sole and 2:1 row intercropping.

7. To findout most suitable/profitable and economic intercrop for sorghum based cropping system under Marathwada agro-climatic conditions.

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2. REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

This chapter includes the review of literature of the past work done by different workers on intercropping.

2.1 Effect of various plant densities of sorghum and pigeonpea on their yields

Munde and Pawar (1976) found that in intercropping of sorghum and pigeonpea, plant population of main crop sorghum if maintained at 1.5 lakh plants per hectare and that of intercrop pigeonpea at 0.5 lakh plants per hectare irrespective of spacing, The sorghum maturing at 110 days and pigeonpea maturing at 170 days can be advantageously intercropped.

Shelke (1977) reported that plant density of pigeonpea in intercropping system should be higher than that of recommended for sole crop.

Freyman and Venkateshwarlu (1977) conducted experiment on red soils near Hyderabad in rainfed season on various intercropping patterns of sorghum, pigeonpea, castor, pearl millet, cowpea, finger millet, soybean and black gram and studied mutual compititive effects and found that highest total yields were obtained when sorghum was grown at highest plant population tested (2,20,000 plant/ha) and intercropped with pigeonpea. Reducing the plant population of sorghum to accomodate

intercrop reduced yield and for which the intercrops did not compensate. Manipulating planting pattern to reduce mutual compitition had little effect on total yield. Grain yields of sorghum grown at high population (at least 2,20,000 plants/ha) generally surpassed yields from plots of sorghum intercropped with pigeonpea.

In intercropping studies with sorghum or maize in two rows 45 cm apart altering with 1 row of pigeonpea the three crops were grown at different plant populations of sorghum and maize had little effect on their grain yields but the denser population decreased seed yields of pigeonpea. The increase in the pigeonpea populations had no effect on cereal grain yields and gave small but consistant increase in pigeonpea yield (ICRISAT Annual Report, 1977-78).

Experiment conducted at Badnapur (M.S.) showed that 50,000 plants/ha was optimum planting density of pigeonpea for intercrop with sorghum and variety No.148 yielded highest. (Annual Res.Work on pulses, Agri.Res. Station, Badnapur, 1978-79).

Vanjaria et al. (1979) found that in intercropping system, sorghum crop with optimum recommended plant population and optimum or 1/2 plant population of pigeonpea gave maximum economic yield.

In an experiment carriedout at ICRISAT, it was found that the sorghum yields were reduced in intercropping system than sole crop. The yields of intercropped pigeonpea was relatively high. The maximum yield of sorghum (80 per cent of sole crop) in intercropping system was obtained at 1,80,000 plants/ha. The highest yield of pigeonpea was obtained at 81,000 plants per hectare which was double than the recommended plant population (40,000 plants/ha) (ICRISAT Annual report,1979-80).

Natrajan and Willey (1980) found that sorghum grain yields were not affected by pigeonpea if sorghum plant population was maintained as that recommended for sole crop. In case of pigeonpea, the plant population should be higher, than recommended for sole crop for getting higher yields.

At ICRISAT, an experiment was conducted on intercropping of sorghum with 3 pigeonpea varieties and found that there was no adverse effect on the yield of sorghum by the different pigeonpea plant densities if sorghum plant population maintained at optimum (ICRISAT Annual Report, 1981).

Intercropping pigeonpea with 80,000 plant population in sorghum per hectare gave maximum gross income. BDN-1 was found promising as intercrop in sorghum

as compared to Hy.3C and C-11 (Lomte and Dabhade, 1983).

In plant population studies, 0.75, 1.00 and 1.25 lakh/ha population were found at par and significantly superior to 0.5 lakh/ha. In intercropping studies of pigeonpea, the intercrop bajra gave significantly higher grain equivalent than other intercrops(Annual Report, 1980-81, M.A.U., Parbhani).

2.2 Planting pattern for intercropping system

Singh et al. (1973) observed that sorghum and pigeonpea gave grain yields of 1.91 and 0.56 t/ha, respectively when four rows of sorghum were alternated with rows of pigeonpea (rows 45 cm apart) and 1.67 and 0.42t/ha when sorghum and pigeonpea seed was mixed in 4:1 proportion and sown in the same row.

The results of intercrop experiment conducted at Parbhani (Annual Report, Sorghum Research Station, Parbhani, 1975-76) with sorghum showed no significant reduction in yield of sorghum in paired rows compared to uniform rows. Higher total yields and returns were obtained in paired rows of sorghum intercropped with green gram, soybean, groundnut and pigeonpea. Similar results were obtained by Chandrawanshi (1975).

At ICAR, two spreading and two compact pigeonpea cultivars were grown at 75 cm and 150 cm rows spacing with sorghum as an intercrop. Pigeonpea cv. St-1 (spreading) gave highest seed yield and there was no difference in yield between two spacing but for cultivar Hy.3A (compact) yield was reduced (Annual Report ICAR, 1975-76).

Munde (1976) growth behaviour of hybrid sorghum CSH-1 and pigeonpea (No. 148) were found compatible for intercropping in skipped rows. The association seems to be beneficial and not compititive in respect to growth periods, as sorghum was faster and intercrop was late.

The cultivation of sorghum in two rows 45 cm apart alternating its with one row of pigeonpea had no adverse effect on grain yield of sorghum compared with pure stands. The seed yield of pigeonpea was 70 per cent of that in pure stands in LER (ICRISAT, Annual Report, 1977-78).

Shelke (1979) observed the beneficial effects of intercrop in intercropping with sorghum CSH-6. The intercrops green gram, soybean and groundnut were compatible and did not affect the base crop of sorghum

even with its optimum plant density sown either in uniform rows of 60 cm or paired rows in 30 cm to 60 cm system.

Raikhelkar et al. (1979) in an experiment on multi storied, three crops intercropping system with sorghum obsérved that the grain yield of sorghum due to the sowing of sole crop of sorghum at 60 x 10 cm or 45 x 12 cm was at par with the sowing of paired row of sorghum at 30/90 cm with an additional row each of pigeonpea and green gram in between the two paired rows of sorghum, indicating no yield reduction of main crop due to sowing of additional one row each of green gram and pigeonpea.

Bhalerao (1979) found that monetary returns were increased considerably by following sorghum + pigeonpea intercropping with No.148 variety of pigeonpea. The practice of adopting 30 + 60 cm paired row planting with No.148 variety of pigeonpea as an intercrop in the skipped space was remunerative and practiciable.

Bhalerao and Upadhyay (1981) concluded that sorghum hybrid CSH-6 grown at 1,80,000 plants/ha in 45-90 cm wide rows or in 30-60 cm wide paired rows with 60-120 cm between the pairs of rows gave similar grain yields. Intercropping of pigeonpea cv. No.148 in

between the wider rows had no adverse effect on sorghum yield and gave an additional average seed yield of 342 kg/ha, cv. Prabhat as intercrop gave low yields.

Singh (1981) in field trials on spital arrangement in intercropping system under rainfed conditions in 1975-76, sorghum grain yields increased by 21.6, 20.3, 29.2, 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 CSH-6 alone. Spital arrangements had only marginal effects on sorghum yield but the yield of all intercrops were appreciably affected. Paired rows with 2 rows of intercrop in 90 cm spacing resulted in maximum yield of all the intercrops. The land equivalent ratio,(LER) was also influenced considerably by different intercrops x spital arrangements. Sowing of sorghum in paired rows with 2 rows of grain cowpea within 90 cm spacing gave maximum LER, however, net returns weremaximum with fodder cowpea in same spital arrangements.

Waghmare et al. (1982) in irrigated field trials on crop compitability and spital arrangement in sorghum CSH-6 were conducted in 1976 and 1978. Sorghum grain yield incrdased when green in association with

green gram, groundnut, grain and fodder cowpeas and soybean compared with pure stands of sorghum. Sowing sorghum in paired rows (30:90 cm) with two rows of intercrop in 90 cm space produced maximum yields of sorghum and intercrop.

2.3 Effect of sorghum-pigeonpea intercropping on growth

Jagnmathan et al. (1974) reported that an increase in the length and thickness of sorghum earheads in association with legumes.

Munde (1976) in his experiment found higher values of number of leaves and leaf area of sorghum with sorghum + pigeonpea intercropping.

Tiwari, Yadav and Laxman Singh (1977) found that in intercropping with sorghum and pigeonpea the spreading type pigeonpea varieties yielded more than semi compact type, they also had the highest primary and secondary branch number, spread, pod number/plant and seed yield/ plant.

In ICRISAT experiment (1977-78) found, in intercropping, growth of pigeonpea was supressed earlier but after the sorghum harvest, it compensated supressed growth.

observed that
Hiremath (1979) sorghum grain and straw yields were highest in pure strands and decreased with decrease in number of sorghum rows from 4 to 1. Total dry matter/ plant, LAI, plant height, width, number of grains/plant and 1000 grain weight increased as number of sorghum rows decreased. Similarly, pigeonpea had highest seed and straw in pure strands and as the number of rows decreased, dry matter/plant,LAI and pods/plant increased with decrease in row number.

Natrajan and Willey (1980) conducted two experiment at ICRISAT on deep vertisol during 1977-78 to study in detail the growth and resource use by sole crops and intercrops of sorghum and pigeonpea.

In the experiment attempts were made to improve light interception during the period by changing the row arrangement in 2 : 1 row pattern to 1:1 rows of sorghum and pigeonpea, increasing the pigeonpea population. Data so far available indicate that this have increased the light interception, in general this has produced a dry matter respomse.

Sundarrajan and Palanippan (1979) reported that under rainfed conditions the intercrops supressed the growth and branching of red gram as main crop and the reduction was more pronounced with bajra.

Ali and Malhotra (1970) found that sorghum-pigeonpea mixtures produced depressing effects on branches and number of pods/plant in legumes. The pigeonpea yield was adversely affected.

2.4 Intercropping as an insurance against insect pest disease and weather vegaries

Gupta (1953) found that mixed culture of pigeonpea and sorghum reduced the pigeonpea wilt considerably.

Batra (1962) indicated that the damage by earbug (Caloceries angustatus) to sorghum was reduced when it was grown mixed with pigeonpea. Sorghum grown mixed with cowpea was compatible except in areas where gram pod borer (H.armigera) occured. Sorghum mixed with pigeonpea appears to be useful in wardening off the attack of pod fly (Agromysa olitusa) to pigeonpea.

Sen et al. (1966) stated that mixed cropping proved to be insurance against natural hazards.

Hardas et al. (1979) observed that infestation levels of sorghum shootly (Atherigona soceata)were significantly lower when sorghum was cultivated in association with legumenous crops. Neither the associate crops nor the systems of association exerted any significant influence on the borer infestation level.

Population of sorghum earhead midge adults was significantly lowest, particularly where sorghum was alternately planted within the row with bajra and in lower where it was intercropped alternately within the row with soybean, pigeonpea and green gram in order.

2.5 Effect of intercropping of sorghum + pigeonpea on yield

Rao and Willey (1981) from 89 experiments they conducted, concluded that sorghum pigeonpea intercropping system is superior to sole cropping at all levels of yields and is widely adoptable. The failure of intercrop to obtain a special income level either constant prices or randomly various prices was less frequent than for sole cropping.

Venkateswarlu et al. (1981) experiments conducted at Hyderabad region found that full yields of sorghum and 60 per cent of the pigeonpea yield can be obtained by taking the intercropping of pigeonpea with CSH-5 and CSH-6.

Tarahalkar (1976) found higher yields of sorghum when intercropped with pigeonpea and this intercropping was found beneficial.

Ghatol (1977) in his experiment found that production per unit area per unit time with intercropping

of pigeonpea + black gram and pigeonpea + sorghum were more than their sole crops.

Reported higher gross returns of sorghum pigeonpea intercrops than sole crops of sorghum and pigeonpea in AICPS Annual Report (1975-76).

Giri and Bainade (1981) found that in intercropping of one row each of sesame and black gram, pigeonpea and groundnut or pigeonpea and black gram in between 90 cm wide interspace between paired rows of sorghum hybrid CSH-6 at 30 cm row spacing had no adverse effect on grain yield of sorghum but significantly increased grain equivalent yield.

Giri and Bainade (1981) intercropping in sorghum hybrid CSH-6 gave the sorghum grain equivalent yield 5.58 t/ha compared with 5.08 t/ha for sorghum in pure strands.

Pawar (1982) found that intercropping of two rows of groundnut in the interspace between pairs of sorghum rows increased the grain and fodder yield of sorghum compared with sorghum in pure strands and gave additional pod yield.

Pawar et al. (1982) intercropping of cowpea in irrigated sorghum had no adverse effect on the grain and

fodder yield of sorghum and gave an additional fodder yield by 7.69 - 10.35 t/ha in 1980-81.

Rao and Willey (1983) in their experiment of two rows of cereal and one row of pigeonpea tested four sorghum, two millet and four pigeonpea cvs. and concluded that the cereals usually produced a large proportions of their pure strand yields at later maturing pigeonpea. A tall millet gave best total LER early and short sorghum produced largest LER (1.51-1.59) and combination of early hybrids also gave good returns. Tall late sorghum gave poor yields of both components, smallest total LER (1.30) and little returns, pigeonpea intercrop yields became larger, as maturing differences between cereals with pigeonpea increased. A compitition of short, early but large yielding cereals with a pigeonpea that is as late as possible without incurring undue risk of moisture stress may be ideal.

Munde (1983) the different varieties of pigeonpea as intercrop in sorghum produced significant differences in grain yield var. BDN-3 was found superior (4.2 q/ha) over BDN-2 in production of yield (2.93 q/ha). This superiority could be attributed to the better growth characters both in vegetative and reproductive phase in BDN-3 than in BDN-2.

Deokar et al. (1983) studied different pigeonpea varieties with pearl millet and revealed that ICP-1 gave highest grain yield in intercropping system than BDN-1, T-21 and No.148 (Proceeding of the 5th Annual workshop pf AICRP Telhan Bhavan, Hyderabad 1979).

Ravichandra et al. (1975) obtained higher monetary returns when sorghum intercropped with black gram at Coimbatore, sorghum with pigeonpea and green gram at Rajendranagar as compared to their pure stands.

Shelke (1977) obtained higher gross returns when sorghum and pigeonpea were intercropped than the component crops taken as sole crops.

Kumarswamy and Hosmani (1978) observed that cotton + sorghum gave lower net profit than that cotton alone.

Rao and Willey (1979) reported that in sorghum intercropping systems, sorghum/pigeonpea, which has a large temporal differences averaged just above 40 per cent advantage, sorghum/soybean, where both are same maturity crop gave 24 per cent while the intermediate combination of sorghum + Green gram showed about 32 per cent.

Shelke (1979) reported that higher monetary returns were received from sorghum + groundnut when three intercrops (green gram, soybean and groundnut) were grown with sorghum at SRS, Parbhani.

Reddy and Reddy (1980) observed that multi intercrop system was most advantageous and found that treatments pigeonpea + green gram + sorghum and pigeonpea + green gram + groundnut were profitable one.

Umrani (1981) studied the various intercropping systems and found that in several intercropping systems sorghum + pigeonpea intercropping was promising. This intercrop system yields near normal production of about 5.35 q/ha.

Singh and Jain (1984) data from many experiments under rainfed conditions in different regions for India in which sorghum was grown alone or in association with Vagina radiata, V. sinensis, V.mungo, soybeans, groundnut and Cajanus cajan were analysed and yield advantages, stability of cropping system and regression of yield on environmental indices were determined. Sorghum yields ware suffered and decreased upto 10 per cent from intercropping with legumes (V. mungo and soybean) and increased slightly when cropped with V.radiata and V.sinensis, Yields decreased

as a result of compitition with sorghum, LER compared with single cropping ranged from 1.6 and 1.58 in sorghum+ V.unguiculata (V.sinensis) and sorghum/V.radiata, respectively and 1.33 when sorghum was intercropped with groundnut. All the systems gave more stable yields than old single cropping. Inclusion of legumes appreciably increased monetary returns.

2.6 Economic of sorghum legume intercropping

Motha (1971-72) at IARI, in trials on sorghum soybean intercropping system noticed that intercropping with sorghum greatly enhanced the retunns/ha over sorghum alone. Further in these studies 1:1 ratio at 45 cm had given the highest returns.

Lingegonda et al. (1972) stated that higher monetary returns were obtained through mixed cropping of groundnut and sorghum in ratio of 3:1 and 4:1.

Saxena and Yadao (1973) reported that intercropping of jowar with arhar gave an extra income of Rs. 161/- over that of arhar alone per hectare.

At Akola, sorghum taken either in uniform or paired rows and intercropped with green gram gave higher monetary returns. Sorghum+pigeonpea at Indore and Hyderabad gave good economic returns.

Pathak (1982) studied different varieties of pigeonpea with sorghum CSH-6 and revealed that the geonotype C-11 and BDN-1 were found profitable for intercrop system than that of Hy.3C.

Rao and Willey (1983) in two row cereal, one row pigeonpea intercropping system in 1978-79, 4 rows sorghum and two rows pigeonpea cv. on medium deep altisol found that cereals usually produced a large proportion of their pure strands yields. Millets matured relatively early which allowed large yields of later maturing pigeonpea. A tall millet gave best total LER of 1.78 and most monetary returns. Early and/or short sorghum produced large LER (1.51-1.59) and combination with an early hybrids also gave good returns. A tall late sorghum gave poor yields of both components, smallest total LER (1.30) and little return. Pigeonpea intercrop yields became larger as the maturity differences between cereals and pigeonpea increased. A combination of short early but large yielding cereals with a pigeonpea that is as late as possible without incurring under risk of moisture stress.

Verma and Pandey (1983) in Udaipur conditions variety Hy.2 proved best and gave a profit of Rs. 1449/- per hectare over a sole sorghum as compared to other varieties Pusa ageti, V. PAS-100, Prabhat and T-21 which

taken in sorghum. Prabhat was next best giving profit of Rs. 1328/- per hectare over sole crop of sorghum. Conducting experiment in 1980-81 among the long durational pigeonpea, variety Hy.3 proved to be best followed by C-11 with sorghum intercropping system.

Intercropping with pigeonpea with 80,000 plant population per hectare gave maximum gross income. BDN-1 was found promising as a intercrop in sorghum as compared to Hy-3C and C-11 (M.A.U., Annual Report, 1980-81).

Verma, Singh and Yadav (1983) reported increased net profit by intercropping pigeonpea or soybean with sorghum in alternate rows of 30 cm apart.

2-7 Effect of sorghum + sunflower intercropping on growth

Shaik and Upadhyay (1977) sunflower as companion crop of sorghum significantly depressed the weight of earhead, grain/panicle, dry matter accumulation and protein percentage of grain in sorghum. The loss of number of grains per panicle due to sunflower association was about 38 per cent.

2.8 Effect of sorghum + sunflower planting patter on yield

Mahamad and Upadhyay (1977) the grain yield components of sorghum were similar when grown in uniform

single rows, paired rows or partial rows with intercropping of groundnut in single row, but decreased when intercropped sunflower.

2.9 Effect of sorghum + sunflower intercropping on yield

At Sorghum Research Station, Parbhani (1974), total grain yield of sorghum and sunflower mixture was found to be severaly reduced than pure crop of sorghum.

Tarhalkar and Rao (1978) reported that intercropping system with sorghum, groundnut, pigeonpea, castor and sunflower resulted in increased yields, increase in the yield of these crops were 88, 78, 57.3 and 22.6 per cent, respectively.

Umrani and Parande (1979) studied the effect of intercropping on yields of rabi sorghum at Solapur with safflower, gram and rabi cotton. Grain yields of sorghum were reduced by 38, 67 and 18 per cent by gram, safflower and cotton respectively compared with sorghum alone. Safflower also reduced sorghum fodder yield by 43 per cent but cotton and gram had no significant effect on fodder production.

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3. MATERIALS AND METHODS

3. MATERIALS AND METHODS

The details of the materials used and the technique followed during the experiment are given in the chapter under following heads.

3.1 Experimental site

The experiment was conducted at Sorghum Research Station, Parbhani in kharif 1984-85. The site of experimental area was uniform in slope. In order to study the initial nitrogen status of soil, soil samples from 0-22.5 cm depth were collected from randomly selected spots before laying out the experiment. The composite sample for the site was prepared and the same was analysed for various physico chemical properties. Data obtained on composition of soil are given in Table 1.

Table 1 : Mechanical and chemical composition of soil from the experimental plot

Particulars	Results
A. Mechanical composition	
1. Coarse sand (per cent)	2.27
2. Fine sand (per cent)	18.15
3. Silt (per cent)	23.01
4. Clay (per cent)	51.96
5. Textural class	Clayey

1.	2.
B. Chemical composition	
1. Total nitrogen (per cent)	0.055
2. Total available phosphate	0.0020
3. Organic carbon	0.560
4. pH	8.20

3.2 Cropping history

The previous cropping history of the experimental plot from 1981-82 onwards is presented in Table 2.

Table 2 : Cropping history

Year	Crops	
	Kharif	Rabi
1981-82	Green gram	Irrigated wheat
1982-83	Sorghum	Sorghum ratoon
1983-84	Green gram	Safflower, linseed, gram
1984-85	Present experiment	-

3.3 Climatic and weather conditions

The meteorological data for the corresponding period and for last 30 years recorded at Meteorological Observatory, Marathwada Agricultural University, Parbhani,

along with the climatic norms are presented in Table 3.

Table 3 : Meteorological data of 1984-85 in comparison with average of last 30 years at MAU, Parbhani

Particulars	Period	June	July	Aug.	Sept.	Oct.	Nov.
Mean monthly temperature (maximum)	Normal	37.3	32.9	32.0	32.5	33.4	31.4
	1984-85	34.9	32.5	31.2	32.3	33.0	30.5
Mean monthly temperature (minimum)	Normal	24.5	23.4	22.9	22.0	19.0	14.3
	1984-85	24.6	23.4	22.3	21.3	20.4	12.3
Relative humidity at 7.25hrs	Normal	80.7	88.2	89.7	90.0	80.7	76.7
	1984-85	73.5	81.7	78.4	85.5	83.5	73.0
Rainfall (mm)	Normal	143.7	199.0	266.4	171.6	74.4	189.0
	1984-85	123.7	114.6	82.1	99.8	117.2	0.2
No.of rainy days	Normal	10.9	14.2	16.9	11.4	5.3	1.1
	1984-85	9.0	10.0	6.0	9.0	6.0	1.0

Total rainfall	Normal	785.68
	1984-85	585.20
No.of rainy days	Normal	54
	1984-85	46

Parbhani is situated at 409 M. altitude, 19° to 16' N latitude and 76° to 47' E longitude, and has subtropical climate. The average annual precipitation of last 30 years approximates to 875.08 mm which is

received mostly between June to September. The winter rains are uncertain. Most of the rainfall is received from South-West monsoon. Mean maximum temperature varies from 29.16°C in winter (December) to about 41.14°C, in Summer (May), whereas, mean minimum temperature varies from 11.95°C to 24.95°C during winter and summer respectively. Mean relative humidity ranges from 30 to 90 per cent.

Meteorological data presented in Table 3 indicate that the season kharif 1984 was favourable for sorghum crop growth. The total precipitation in the season of 1984 was 585 mm which was sufficient for the growth of sorghum.

The onset of South West monsoon was regular during the year 1984 at Parbhani but low rainfall was received in June. There was considerable rainfall during July and first week of August which helped better crop growth but there was a typical dry spell of 35 days from second week of August to first week of September. However, due to continuous cloudy atmosphere and favourable humidity, the growth of the crop was satisfactory.

3.4 Experimental details

3.4.1 Design and treatments

Design	Randomised block design
Replications	Three
Treatments	Total nine

A. Systems

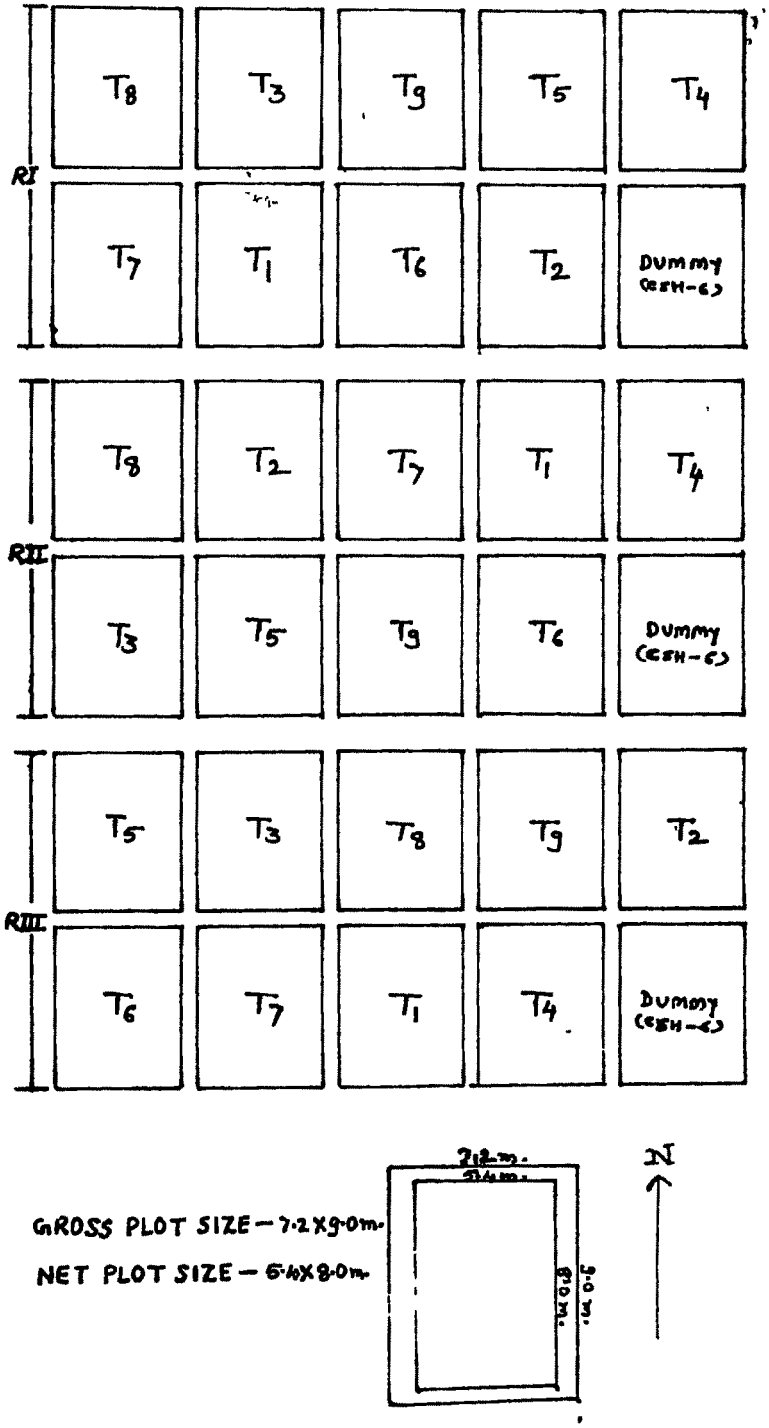
1. Sorghum + pigeonpea (3:3 row proportion) (CSH-9) + (BDN-2) in 45 cm rows) — T_1
2. Sorghum + Sunflower (3:3 row proportion) (CSH-9) + (EC 68414) 45 cm rows) — T_2
3. Sorghum + pigeonpea (4:2 row proportion) in (CSH-9) + (BDN-2) 45 cm rows) — T_3
4. Sorghum + sunflower (4:2 row proportion) in (CSH-9) + EC 68414) 45 cm rows) — T_4
5. Sorghum + pigeonpea (2:1 row proportion) in (CSH-6) * (BDN-2) 45 cm rows) (control) — T_5
6. Sorghum + pigeonpea (2:1 row proportion) in (CSH-9) + (BDN-2) 45 cm rows) — T_6

7. B. Additional treatments (3)

1. Sole sorghum CSH-9 — T_7
2. Sole pigeonpea BDN-2 — T_8
3. Sole sunflower EC 68414 — T_9

Note

Treatments T_1 and T_2 had 50 per cent plant population of sorghum while, T_3 and T_4 had 66 per cent population of recommended and the remaining treatments of sorghum had their optimum plant densities.



GROSS PLOT SIZE – 7·2X9·0m.

NET PLOT SIZE – 6·4X8·0m.

PLAN OF LAYOUT

Plot size

Gross plot	7.2 x 9.0 m (16 rows)
Net plot	5.4 x 8.0 m (12 rows)

3.4.2. Layout

The experimental field was laid out as per plan after preparatory cultivation before sowing. The plan of layout is given in Fig.1. The layout consisted of 27 experimental units in three replications having nine units, eadh. The plan of layout of sorghum for all treatments is given in Figure 1.

The treatments were alloted randomly to various plots restricting randomization in each replication.

3.5 Cultivation

The schedule of cultural operations is given in Table 4.

3.5.1 Preparatory tillage

The land was ploughed 0-30 cm deep with tractor plough after harvest of previous crop. Loose friable andfine seed bed was prepared by subsequent harrowings with blade harrow. The stubbles and previous crop residues were collected and plot was cleaned. Lastly fine and compact seed bed was prepared by giving one harrowing by heavy inverted harrow.

Table 4 : Schedule of cultural, operations performed in the experimental plot during crop growth

Sr.No.	Field operations	Frequency	Date
A.	Pre-sowing		
1.	Ploughing	1	2.6.84
2.	Harrowing with blade harrow	2	19.6.84, 29.6.84
3.	Cleaning of the field	2	19.6.84, 29.6.84
4.	Experimental layout	1	30.6.84
B.	Sowing		
1.	Seed treatment of sorghum with carbofuron	1	16.7.84
2.	Dibbling of all the three crops	1	17.7.84
C.	Fertilizer application		
1.	Basal application as per treatment	1	17.7.84
2.	Top dressing as per treatment	1	15.8.84
D.	Post sowing operations		
1.	Gap filling in all the three crops	1	31.7.84
2.	Thinning	1	3.8.84
3.	Weeding and mulching	4	24.7.84, 13.8.84, 20.8.84, 30.8.84.
4.	Hand hoeing	3	30.7.84, 4.8.84, 18.8.84
5.	Spraying of endosulphon on sorghum	2	7.8.84, 14.11.84
6.	Dusting of BHC 10% of sorghum	3	21.8.84, 23.8.84, 16.9.84.
7.	Harvesting of sunflower	1	7.11.84
8.	Threshing and winnowing of sunflower	1	15.11.84
9.	Harvesting of sorghum	1	7.11.84
10.	Dreshing x winnowing of sorghum	1	15.11.84
11.	Harvesting of pigeonpea	1	10.1.85
12.	Threshing and winnowing of pigeonpea	1	22.1.85

3.5.2 Fertilizer application

In strip cropping treatments of 3:3 and 4:2 row proportion, recommended dose of 80 kg N and 40 kg P_2O_5/ha was given to the sorghum strip depending upon the area. Similarly, 20 kg N and 40 kg P_2O_5 to pigeonpea strip and 40 kg N and 60 kg P_2O_5/ha to sunflower strip was given depending upon the areas of respective crops. However, in 2:1 row proportion of sorghum + pigeonpea treatments, only recommended dose of sorghum i.e. 80 kg N and 40 kg P_2O_5/ha was given to sorghum rows.

For sorghum half dose of N through urea as per treatments and full dose of phosphorus was applied at sowing and remaining half dose of N was applied 30 days after sowing through urea. However, full dose of nitrogen and phosphorus were applied to pigeonpea and sunflower at the time of sowing only.

3.5.3 Seed sowing, gap filling and thinning

The seeds of hybrid sorghum CSH-9 and CSH-6 pigeonpea BDN-2 and sunflower EC 68414 were used for sowing by dibbling. Sorghum seed was treated with carbofuron in order to protect the crop from shoot-fly attack.

Three seeds each of sorghum, pigeonpea and sunflower were dibbled at each hill in their respective

rows in experimental field at moist zone (4-5 cm depth) on 17th July, 1984. The gapfilling was done on 27th July, 1984 to ensure the required plant population. The thinning was done on 3.8.84 and only one healthy and vigorous seedling was kept at each hill.

3.5.4 Crop protection measures

For protection of the crop against insect pests, spraying of endosulphan 35 EC at the concentration of 17 ml in 10 lit. of water was undertaken and timely dusting of BHC 10% were undertaken as given in Table 4.

3.5.5 Interculturing and weeding

The recommended practice of hoeing was undertaken. Weeding was done thrice.

3.5.6 Harvesting and threshing

The varieties of sunflower and sorghum matured at about 115 days and that of pigeonpea at about 170 days. The border strips were harvested earlier, harvesting and threshing was done plotwise separately. The produce was sundried and weighed.

3.6 Biometric observations

Details of biometric observations of sorghum pigeonpea and sunflower are presented in Table 5.

Table-5: Details of biometric observations

Sr. No.	Particulars	Frequency	Days from sowing	No.of plants observed
1	2	3	4	5
I. Pre-harvest studies				
A) Sorghum				
1.	Height per plant (cm)	6	30, 45, 60, 75, 95, 105	5
2.	Number of functional leaves/plant	6	30, 45, 60, 75, 95, 105	5
3.	Leaf area per plant (cm^2)	6	30, 45, 60, 75, 95, 105	1
4.	Dry matter per plant (g)	6	30, 45, 60, 75, 95, 105	1
5.	Dry matter of stem/plant (g)	5	45, 60, 75 95, 105	1
6.	Dry matter of leaves/plant (g)	5	45, 60, 75 95, 105	1
7.	Dry matter of earhead/plant (g)	4	60, 75, 95 105	1
8.	Length of panicle (cm)	1	105(at harvest)	1
9.	Breadth of panicle (gm)	1	105(at harvest)	1
10.	Length of middle internode	1	105(at harvest)	1
B) Pigeonpea				
1.	Height of main shoot (cm)	8	30, 45, 60, 76, 90, 105, 120, 150	5
2.	Number of primary branches/plant	8	30, 45, 60, 76, 90, 105, 120, 150	5
3.	Dry matter/plant (g)	8	30, 45, 60, 76, 90, 105, 120, 150	1

(contd...)

1	2	3	4	5
	C) Sunflower			
1.	Height of plant (cm)	6	30, 45, 60, 75, 90, 105	5
2.	Number of leaves	6	30, 45, 60, 75, 90, 105	5
3.	Stem girth (cm)	6	30, 45, 60, 75, 90, 105	5
4.	Dry weight of aerial parts	6	30, 45, 60, 75, 90, 105	1
5.	Head diameter (cm)	1	At harvest	5
II.	Post harvest studies			
	A) Sorghum			
1.	Weight of earhead (g)	1	At harvest	5
2.	Weight of grains per head	1	At harvest	5
3.	Total earhead weight (g)	1	At harvest	All
4.	Yield of grains/plot (Kg)	1	At harvest	All
5.	Yield of fodder/plot (Kg)	1	At harvest	All
6.	1000 grain weight (g)	1	At harvest	Plotwise sample
	B) Pigeonpea			
1.	Weight of pods per plant (g)	1	At harvest	5
2.	Weight of grains/plant (g)	1	At harvest	5
3.	Number of pods/plant	1	At harvest	5
4.	Total dry pod weight (Kg)	1	At harvest	All plants
5.	Yield of grains/net plot (kg)	1	At harvest	All
6.	Yield of stalk/plot (Kg)	1	At harvest	All
7.	1000 grain weight (g)	1	At harvest	Plotwise sample of grain

1	2	3	4	5
	C) Sunflower			
1.	Weight per head in g	1	At harvest	5
2.	Weight of grains/plant (g)	1	At harvest	5
3.	Yield of grains/plot (Kg)	1	At harvest	All plants
4.	Yield of Bhoosa/plot (Kg)	1	At harvest	All plants
	III. Chemical studies			
	A) Shrghum			
1.	Nitrogen content in grains	1	At harvest	Plotwise samples
	B) Pigeonpea			
1.	Nitrogen content in grains	1	At harvest	Plotwise samples
	C) Sunflower			
1.	Nitrogen content in grains	1	At harvest	Plotwise samples
2.	Oil content in grains	1	At harvest	Plotwise samples
	D) Soil			
1.	Nitrogen content	1	Before sowing	Sample was taken from complete plot

3.6.1 Sorghum

The details in respect of various biometric observations recorded are presented in Tables

3.6.1.1 Sampling technique

Various observations on growth studies were taken on five randomly selected plants of sorghum, sunflower and pigeonpea from each net plot. The selected plants were lebelled and all the biometric observations were recorded on them.

3.6.1.2 Pre-harvest studies

3.6.1.2.1 Emergence count

Emergence count was taken on 15th day of sowing from each net plot and emerged plants from each plot were counted.

3.6.1.2.2 Height per plant

The height was measured in cm from the base of the plant to the legule of fully opened leaf. After earhead emergence, the height was measured upto the base of earhead.

3.6.1.2.3 Number of functional leaves

Total number of fully opened green leaves per plant were recorded.

3.6.1.2.4 Leaf area per plant

Maximum length and breadth in cm of all the fully opened green leaves were measured and area per leaf was calculated by using following formula given by Stickler and Pauli (1961). The total leaf area per plant was calculated by summation of individual leaf area per plant.

Leaf area/leaf = Max. length x Max. breadth x 0.747

3.6.1.2.5 Dry matter accumulation studies

For the dry matter accumulation studies one plant from each net plots were selected at random at every stage of sampling. The plants so selected were uprooted and its roots were removed. The aerial portion of the plants was divided into various plant parts like stem, leaves and earhead according to stage of growth. These separated plant parts were collected in separate brown paper bags, properly labelled, air dried first and then dried in hot air oven at 60°C untill the constant weight was obtained and then weighed. The final constant weight was recorded as the dry matter weight in grams per plant.

3.6.2 Pigeonpea

3.6.2.1 Height per plant

The height of the plant was measured in cm from the ground level to the base of apical bud of the main shoot.

3.6.2.2 Number of branches per plant

The number of branches arising from the main shoots were recorded at fortnight intervals from 30 days onwards.

3.6.2.3 Dry matter accumulation per plant

One plant from each net plot was selected at random at every stage of observation. The selected plants were uprooted, and the aerial part was air dried first and then dried in hot air oven at 60°C untill the constant weight was obtained. The oven dried material then weighed separately on top pan balance and recorded in grams.

3.6.3 Sunflower

3.6.3.1 Height per plant

The height of the plant was measured in cm from the ground level to the base of apical bud.

3.6.3.2 No.of leaves

The fully developed green leaves were counted from each plant.

3.6.3.3 Stem girth

The girth of each stem of selected plant was measured in the middle portion of the plant.

3.6.3.4 Head diameter

The diameter of the head of selected plant was measured, each from 45 days onwards.

3.6.3.5 Dry matter accumulation per plant

One plant from each net plot was selected at every stage of observation. The selected plant was uprooted, the roots were removed and aerial parts first air dried and then dried in hot air oven, at 60°C untill the constant weight was obtained then weighed separately on top pan balance and recorded in grams.

3.7 Growth analysis

Data on growth characters viz. height, leaf area and dry matter per plant for sorghum were further analysed for working out the growth functions, A.G.R.,

R.G.R., and LAI. These physiological determinations of plant growth as affected by treatments reflect the plant yield. Hence these physiological constants were worked out in present study.

In case of sunflower the observations of height, no.of leaves and dry matter were recorded but as the treatments were only three the statistical analysis was not possible hence only means were given.

3.7.1 Absolute growth rate

Absolute growth rate is the total gain in height or weight by plant within a specific time interval. It is generally expressed as cm per day in case of plant height and grams per day in case of dry matter production per plant and is calculated by using following formula.

$$A.G.R. = \frac{(H_2 - H_1)}{(T_2 - T_1)} \quad \text{- Height}$$

$$A.G.R. = \frac{(W_2 - W_1)}{(T_2 - T_1)} \quad \text{- Total dry matter}$$

H_2 and H_1, W_2 and W_1, refer to plant height and dry matter weight of plant at T_2 and T_1 time respectively.

3.7.2 Relative growth rate (R.G.R.)

According to Blackman (1919) the increase in dry matter of plant is a continuous compound interest,

where in the increment in any interval adds to the capital for subsequent growth. The rate of increment is known as RGR, this growth constant was worked out by using the formula given by Fisher (1921).

$$RGR = \frac{(\log_e W_2 - \log_e W_1)}{(T_2 - T_1)}$$

where,

W_1 and W_2, are total dry matter weights at times T_1 and T_2 respectively. RGR is expressed as g/g/day Log_e = Napier logarithms (Logarithms to the base of e or 2.3026

3.7.3 Leaf area index

It is the ratio of leaf area per plant to the land area expressed in the same unit. The LAI was worked out using the formula given by Watson (1949).

$$LAI = \frac{\text{Leaf area in sq dm/plant}}{\text{Land area per plant in sq. dm.}}$$

3.8 Post harvest studies

3.8.1 Sorghum

3.8.1.1 Weight of earhead

Earheads from five randomly selected plants were harvested and after complete drying the weight was recorded in gram and mean weight per plant was calculated.

3.8.1.2 Weight of grain per plant

The weighed earheads of five selected plants were threshed, winnowed and grain weight was recorded in gram and mean weight per plant was calculated.

3.8.1.3 Test weight

Grains obtained from each net plot were used for test weight (1000 g wt.) studied by random sampling. Thousand grains were counted and weighed in gms to know the test weight.

3.8.1.4 Grain yield

At maturity the net plots were marked and all the plants from each net plot were harvested and kept for sun drying for eight days, except the five sample plants which were harvested separately for individual plant yields. The earheads were cut, weighed, threshed with wooden hand threshers and grain were cleaned with hand winnowing. The weight of the clean grains per net plot was recorded in Kg and was converted to Q/ha.

3.8.1.5 Yield of bhoosa

The bhoosa yield was calculated by deduction of grain yield from the weight of earheads and then converted into Q/ha.

3.8.1.6 Fodder yield

After harvest, sorghum plants were sun dried for about 20 days and their weights were recorded treatmentwise on the spring balance and the corresponding fodder yields were calculated on hectare basis.

3.8.1.7 Grain to fodder ratio:

This was computed from the yield of grains and fodder obtained from each net plot.

3.8.1.8 Grain to bhoosa ratio

This was calculated from the weight of grain and bhoosa obtained from each net plot of treatments.

3.8.1.9 Land equivalent ratio

For studying the best utilization of land, the land equivalent ratio for various treatments were calculated by using the following formula.

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

3.8.1.10 Sorghum equivallent

For comparing sole cropping with inter-cropping system the sorghum equivallent was calculated by using following formula.

Sorghum equivallent =

$$\text{Sorghum yield} + \text{Intercrop yield} \times \frac{\text{Price of intercrop Rs/ha}}{\text{Price sole crop Rs/ha}}$$

3.8.2 Pigeonpea

3.8.2.1 Number of pods per plant

The number of developed pods from five observations plants were counted and average per plant was worked out.

3.8.2.2 Weight of pods per plant

The dry weight of pods per plant recorded from the five sampled plants.

3.8.2.3 Weight of grains per plant

The weight of grains per plant was taken after threshing five sample plants and calculating the mean of same for per plant.

3.8.2.4 Test weight (g)

Weight of 1000 grains from produce of each net plot was recorded in gms.

3.8.2.5 Grain yield

The net plots were marked and plants from each net plot were harvested and kept for sun drying for eight days. The pods were plucked, weighed and threshed with wooden hand thresher. Grains were cleaned by hand winnowing. The weight of clean grains per net plot was recorded in Kg which was converted to Q/ha.

3.8.2.6 Stalk weight of dried plants

The plants from the net plot were dried for a month and then weighed and recorded accordingly.

3.8.2.7 Bhoosa yield

The bhoosa yield was calculated by deducting the grain yield from the dry pods.

3.8.2.8 Grain to bhoosa ratio

This was calculated from the weights of grain and bhoosa obtained from each net plot.

3.8.3 Sunflower

3.8.3.1 Weight of Head

Heads from five randomly selected plants were harvested separately and after complete drying, the weight of heads was recorded in gms and mean weight per plant was calculated.

3.8.3.2 Weight of seed per plant

The seed of five plants were procured by rubbing them on stones, winnowed and the seed weight was recorded in gms and mean weight per plant was calculated.

3.8.3.3 Test weight

Weight of 1000 seeds from the produce of net plot was recorded in gms.

3.8.3.4 Seed yield

The net plots were marked and heads from each net plot were harvested on maturity and were kept for sun drying for 15 days and then the seeds were separated by rubbing the head against stones. Seed were cleaned by hand winnowing. The weight of clean seed per plot was recorded in Kg which was converted to q/ha.

3.9 Chemical studies

3.9.1 Protein content in grains (Per cent)

Nitrogen content in grains of sorghum, pigeonpea and sunflower per treatment of all the replications was estimated by modified kjeldahl's method. The percentage of crude protein in sorghum, pigeonpea and sunflower was worked out by multiplying nitrogen percentage by the constant 6.25.

3.9.2 Oil content (per cent) of sunflower

The oil content of ~~seeds~~ of sunflower per treatment of all replications was estimated by Sockslet's method.

3.10 Statistical analysis and interpretation of data

Data obtained on various variables of the crops were analysed by analysis of variance method (Panse and Sukhatme, 1967). Total variance (S^2) and degrees of freedom (n-1) were partitioned in to different possible sources viz. replication, treatment and error. The significant treatments were computed by 'F' test and critical difference at 5 per cent level of significance was calculated wherever significant differences among the treatments were observed.

In case of sunflower as the treatments were only three and the statistical analysis was not possible only means were given.

3.10.1 Correlation studies

Correlation between grain yield per plant of sorghum and leaf area, dry matter, test wt., earhead length and earhead breadth were calculated. The correlation coefficient (r) was worked out by using formula,

$$r = \frac{sp\ (xy)}{ss\ (x)\ X\ ss\ (y)}$$

where,

r = correlation coefficient.

x = independent variable.

y = dependant variable.

3.10.2 Analysis of yield data

For comparison of yields of different intercrops yield data was analysed by two methods.

a) Analysis of grain yield in terms of total produce of grain per hectare.

b) Analysis in terms of gross income in rupees per hectare by taking into consideration, the prevailing market prices of grain yields of sorghum, pigeonpea and sunflower, sorghum fodder and pigeonpea stalk yields.

3.10.3 Net returns

The net returns were calculated by deducting the cost of cultivation from the gross income.

4. EXPERIMENTAL FINDINGS

4. EXPERIMENTAL FINDINGS

The experimental data, statistical parameters and results are presented in this Chapter.

4.1 Sorghum

4.1.1 Pre-harvest studies

4.1.1.1 Emergence count and final stand

In sorghum + pigeonpea intercropping treatments (T_5 and T_6) of 2:1 row proportions, where recommended plant population of sorghum was maintained, gave at par emergence count with sole crop of CSH-9 (T_7) and significantly higher emergence count than those treatments where 50 and 66 per cent plant population of sorghum was maintained. Similarly, emergence count in strip cropping treatments where 66 per cent plant population of sorghum was maintained was found significantly superior over those treatments in which 50 per cent of the recommended plant population of sorghum was maintained. However, in the same set of intercropping treatments where 50, 66 or 100 per cent plant population of sorghum was maintained the differences between the treatments of one set were not significant.

The trend of final stand was just similar to that of emergence count.

Table 6 : Emergence count and final stand of sorghum as influenced by various treatments

Sr. No.	Treatments	Emergence count	Final stand
1.	T_1	387	381
2.	T_2	389	380
3.	T_3	511	505
4.	T_4	509	502
5.	T_5	775	769
6	T_6	774	767
7.	T_7	778	769
	SE ±	0.76	1.00
	CDat 5%	2.37	3.08
Gen.Mean		589	582

4.1.1.2 Height of plant (cm)

Data on height of sorghum as affected by various treatments at different stages of crop growth are shown in Table 7.

Data on Table 7 clearly indicated that the mean height of sorghum plant increased continuously upto maturity. This increase was fast upto 60 days and thereafter it was slow. Maximum increase in height was recorded during 45 to 60 days.

There were significant differences in height due to various treatments.

Table 7 : Sorghum plant height as affected by various treatments (cm/plant)

Treatments	Days after sowing				
	30	45	60	75	90
T_1	16.33	73.86	118.20	157.60	158.46
T_2	16.00	64.40	112.60	152.80	154.56
T_3	17.33	72.73	116.06	156.60	157.86
T_4	17.26	60.53	110.06	152.53	154.53
T_5	14.50	57.63	103.60	144.20	145.80
T_6	18.53	71.13	114.80	153.40	154.90
T_7	16.66	71.93	115.86	155.20	156.56
SE ±	1.01	0.20	4.93	1.41	0.18
CD at 5%	NS	0.61	NS	4.36	0.55
Gen.Mean	16.65	67.45	113.02	153.19	154.66

At 30 days, differences in height due to various treatments were non significant.

In general, at all the remaining stages of crop growth (from 45 days upto harvest), treatments T_1 and T_3 were at par where 3:3 and 4:2 row proportions of sorghum + pigeonpea was maintained respectively and found significantly superior to rest of the treatments except at 75 days where treatments T_6 and T_7 were at par with treatments T_1 and T_3. In control treatment (T_5) where CSH-5 was included recorded lowest height as compared to other treatments in which CSH-9 was included.

4.1.1.3 Mean number of functional leaves per plant

Data on mean number of functional leaves per plant as influenced by various treatments are given in Table 8.

Table 8 : Mean number of functional leaves of sorghum as affected by various treatments

Treatments	Days from sowing				
	30	45	60	75	90
T_1	4.6	7.0	8.4	7.3	3.2
T_2	3.8	5.8	7.8	6.4	2.8
T_3	4.2	6.6	8.6	6.8	3.3
T_4	4.2	6.0	8.0	6.9	2.6
T_5	4.1	5.7	7.7	5.5	2.5
T_6	5.4	6.0	8.0	6.3	3.7
T_7	4.6	6.4	8.0	6.7	3.3
SE ±	0.17	0.19	0.14	0.13	0.21
CD at 5%	0.54	0.59	0.44	0.41	0.65
Gen.Mean	4.27	6.21	8.11	6.56	3.06

Mean number of functional leaves per plant increased upto 60 days and thereafter declined till maturity. The differences in number of functional leaves per plant due to various treatments were found significant at all the stages of crop growth.

At 30 days, number of functional leaves per plant were more or less same in all the treatments except slight reduction in T_2 treatment, where, sunflower was intercropped with sorghum in 3:3 rows proportion.

At 45 days and 60 days, significant differences between the treatments were noticed. During both the stages, treatments T_1, T_3 and T_7 where sole crop of sorghum CSH-9 (T_7) was taken and it was intercropped with pigeonpea in 3:3 and 4:2 row proportions, recorded significantly higher number of functional leaves than rest of the treatments which were at par.

Similarly, during later stages especially at 90 days sole crop of CSH-9 and its intercropping with pigeonpea treatments in all the proportions gave significantly more number of leaves than rest of the treatments.

In general, number of functional leaves/plant in CSH-6 was comparatively lower than CSH-9.

4.1.1.4 Mean leaf area per plant (sq cm)

Data regarding leaf area per plant (sq dm) as influenced by different treatments are presented in Table 9 and depicted in Fig. 1.

Table 9 : Mean leaf area of sorghum (dm^2) as affected by various treatments

Treatments	Days after sowing				
	30	45	60	75	90
T_1	9.04	31.66	46.82	40.44	17.72
T_2	7.34	23.68	36.24	28.71	12.56
T_3	13.95	27.68	45.07	36.95	17.92
T_4	11.32	22.92	38.53	26.33	15.78
T_5	5.11	19.28	36.76	21.79	9.39
T_6	9.81	29.50	42.83	33.31	18.39
T_7	7.53	26.65	41.27	36.35	16.61
SE ±	2.60	3.40	4.49	2.33	2.09
CD at 5%	NS	NS	NS	7.20	6.44
Gen.Mean	9.16	25.91	41.07	31.98	15.48

Data on leaf area revealed that leaf area per plant was comparatively more in sole CSH-9 and intercropped with pigeonpea than rest of the treatments. At 30, 45 and 60 days, the differences were not significant.

However, at 75 and 90 days, sole crop of CSH-9 and its all,intercropping treatments with pigeonpea produced significantly higher leaf area than rest of the treatments.

In general, sunflower had adverse effect on growth, number of leaves and leaf area of sorghum under intercropping system.

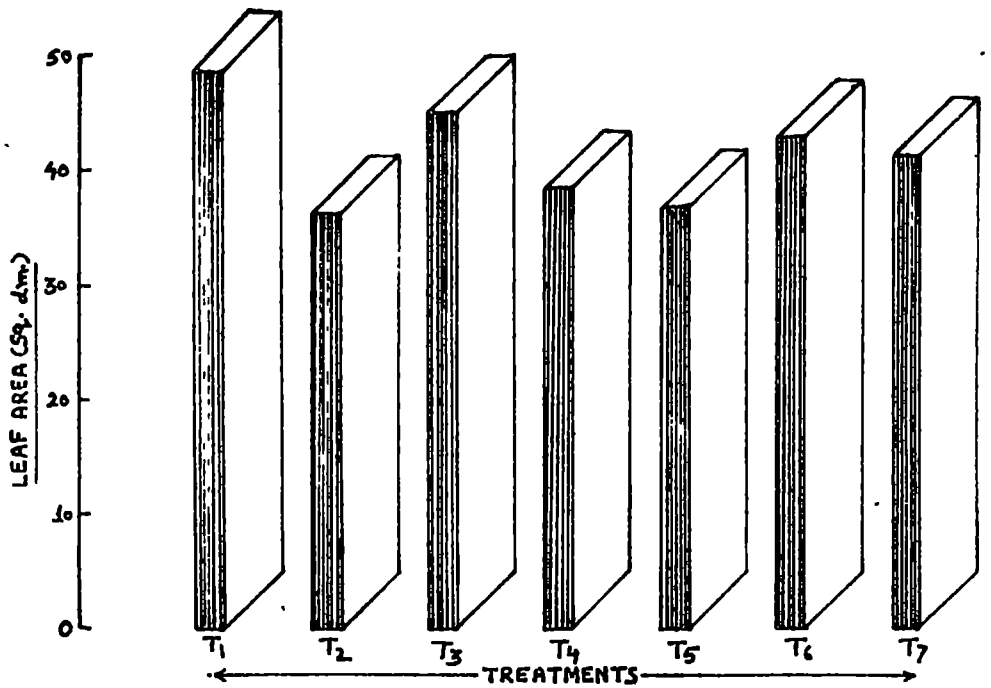


FIG. 2. LEAF AREA PER PLANT IN Sq. dm. OF SORGHUM AS AFFECTED BY VARIOUS TREATMENTS.

4.1.1.5 Dry matter accumulation per plant

Data on the total dry matter production per plant as affected by various treatments are given in Table 10 and depicted graphically in Fig. 2.

Table 10 : Total dry matter of sorghum as affected by various treatments (g/plant)

Treatments	Days after sowing					
	30	45	60	75	90	At harvest
T_1	3.96	16.50	73.60	129.60	147.83	159.16
T_2	4.50	9.75	46.75	68.08	103.08	120.12
T_3	6.83	14.83	69.70	118.60	139.66	149.91
T_4	7.50	11.41	52.58	79.60	111.41	119.29
T_5	3.08	14.66	41.75	58.08	79.58	95.12
T_6	4.50	13.16	58.83	100.80	111.66	125.00
T_7	6.16	14.66	62.00	106.30	141.25	150.11
SE ±	0.92	2.81	7.51	12.08	11.84	11.55
CD at5%	NS	NS	23.61	37.24	36.49	35.58
Gen.Mean	5.22	13.57	57.89	94.44	119.21	131.16

Table 10 showed that the dry matter accumulation was a continuous process upto harvest. The rate of dry matter accumulation was fast during 45 to 60 days. Maximum dry matter was recorded at harvest.

At 30 to 45 days after sowing, dry matter production per plant was not affected significantly by various treatments.

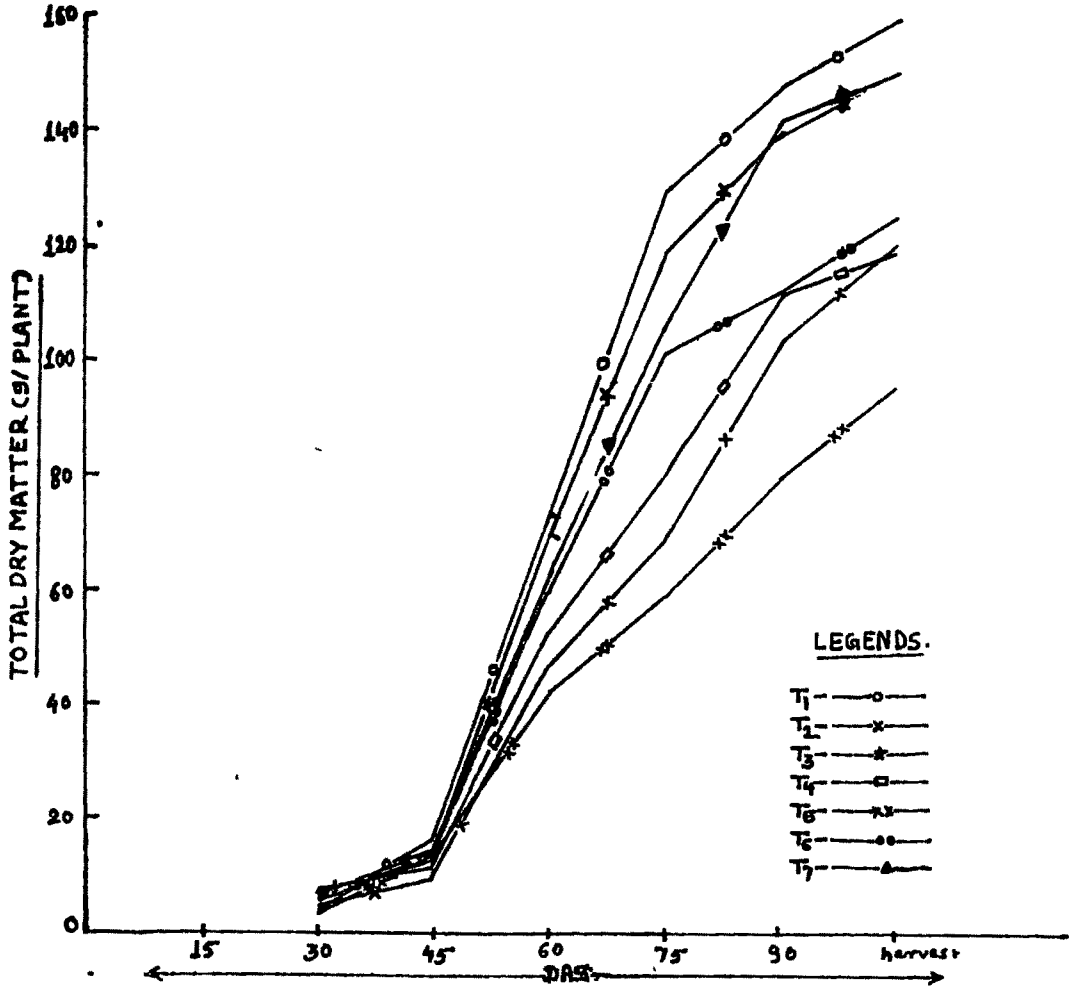


FIG.3. TOTAL DRY MATTER ACCUMULATION IN g/PLANT OF SORGHUM AS INFLUENCED BY VARIOUS TRETMENTS.

At 60 and 75 days after sowing, the dry matter production per plant was significantly more in the sole crop of CSH-9 and its all intercropping treatments with pigeonpea and sunflower specifically in 4:2 row proportions than T_2 and T_5 treatments.

Similarly, at 90 days after sowing and at harvest, the above treatments except T_4 (4:2 sorghum + sunflower) maintained its superiority in respect of dry matter accumulation over rest of the treatments.

At all the stages, maximum dry matter was produced in T_1 treatment where sorghum was intercropped with pigeonpea in 3:3 row proportions followed by T_3, T_7, T_6 except at 90 days and at harvest, where next best treatment was T_7 instead of T_3 in respect of dry matter production per plant.

At all the stages CSH-6 (T_5) recorded lowest dry matter production per plant as compared to all other treatments. Sunflower had adverse effect on the dry matter accumulation in both the proportions. Even under compititive situation of sunflower intercropping, CSH-9 produced comparatively more dry matter accumulation than CSH-6 at all the stages.

In all the pigeonpea treatments there was beneficial border effect of pigeonpea strip in 3:3 row proportion as compared to other treatments.

4.1.1.6 Growth functions

Data on AGR, RGR and LAI as affected by various treatments were not analysed statistically. The inferences are drawn on the basis of mean values.

4.1.1.6.1 Absolute growth rate for height (cm/plant/day)

Data on AGR are presented in Table 11.

Table 11 : Mean absolute growth rate of sorghum in cm per day as influenced by various treatments

Treatments	Days after sowing			
	30-45	45-60	60-75	75-90
T_1	3.83	2.95	2.62	0.08
T_2	3.22	3.21	2.68	0.11
T_3	3.69	2.88	2.70	0.08
T_4	2.88	3.30	2.83	0.13
T_5	2.87	3.06	2.70	0.10
T_6	3.50	2.91	2.57	0.10
T_7	3.68	2.92	2.62	0.09
Gen.Mean	3.38	3.03	2.67	0.10

Data in Table 11 indicated that lowest AGR was recorded in sorghum + sunflower intercropping treatment where 4:2 row proportion of sunflower was maintained.

Highest AGR was obtained in sorghum + pigeonpea 3:3 row proportion treatment (T_1). Absolute growth rate for dry matter between 45-60 days after sowing, was maximum in T_1 treatment followed by T_3, T_7 and T_6 treatments. Minimum AGR was obtained in T_5 treatment where CSH-6 was intercropped with pigeonpea in 2:1 row proportion. More or less similar trend was observed during 60 to 75 days. In the latter stages of crop growth, inconsistant trend was obtained.

4.1.1.6.2 Absolute growth rate for dry matter g/plant/day

Data regarding AGR for dry matter are shown in Table 12.

Table 12 : Mean AGR of sorghum in g/plant/day as affected by treatments

Treatments	Days after sowing				
	30-45	46-60	61-75	76-90	91-115
T_1	0.83	3.80	3.73	1.21	0.45
T_2	0.35	2.46	1.42	2.33	0.68
T_3	0.53	3.65	3.26	1.40	0.41
T_4	0.26	2.74	1.80	2.12	0.31
T_5	0.77	1.80	1.08	1.43	0.62
T_6	0.57	3.04	2.79	0.72	0.53
T_7	0.56	3.15	2.95	2.33	0.35
Gen.Mean	0.55	2.95	2.43	1.65	0.48

It is obvious from Table 12 that AGR increased upto 60 days and attained its peak from 45 to 60 days and again declined. The maximum RGR 3.80 g/plant per day was recorded during 45 to 60 days.

4.1.1.6.3 Relative growth rate for dry matter (g/g/day)

Data pertaining to RGR based on dry matter per plant in g/g/day are given in Table 13.

Table 13 : Mean RGR of sorghum in g/g/day as affected by different treatments

Treatments	Days after sowing				
	30-45	46-60	61-75	76-90	91-105
T_1	0.095	0.099	0.037	0.008	0.004
T_2	0.051	0.104	0.025	0.027	0.012
T_3	0.051	0.103	0.032	0.013	0.004
T_4	0.027	0.101	0.027	0.022	0.004
T_5	0.100	0.069	0.002	0.020	0.011
T_6	0.071	0.099	0.035	0.006	0.004
T_7	0.057	0.096	0.038	0.016	0.004
Gen.Mean	0.065	0.096	0.031	0.016	0.006

Data in Table 13 indicated that no definate trend was observed in RGR values due to various treatments at all the stages.

4.1.1.6.4 Leaf area index per plant (dm^2)

Data regarding leaf area index as influenced by various treatments are given in Table 14.

Table 14 : Leaf area index per plant as influenced by various treatments

Treatments	Days after sowing				
	30	45	60	75	90
T_1	0.16	0.56	0.83	0.71	0.31
T_2	0.13	0.42	0.64	0.51	0.22
T_3	0.24	0.49	0.80	0.65	0.31
T_4	0.20	0.40	0.64	0.46	0.28
T_5	0.11	0.42	0.81	0.48	0.20
T_6	0.21	0.65	0.95	0.74	0.40
T_7	0.13	0.47	0.73	0.64	0.29
Gen.Mean	0.16	0.48	0.77	0.59	0.28

In consistant trend was observed in LAI at all the stages due to various treatments.

4.1.2 Post harvest studies

4.1.2.1 Mean girth of middle internode, weight of grains per head and test weight

Data regarding mean girth of middle internode, weight of grains per head and test weight are given in Table 15.

Table 15 : Mean girth of middle internode, test weight (1000-grain weight) and grain weight/earhead of sorghum as influenced by varous treatments

Treatments	Mean girth of middle internode (cm)	Grain weight/ earhead (g)	Test weight (1000-grain) (g)
T_1	4.76	82.40	34.00
T_2	3.28	38.86	24.66
T_3	4.63	72.10	31.66
T_4	4.20	43.56	30.00
T_5	4.00	43.90	25.00
T_6	4.23	53.06	28.33
T_7	4.36	63.83	30.00
SE ±	0.29	4.45	0.27
CD at 5%	0.89	13.72	0.85
Gen.Mean	4.20	56.81	27.95

There were significant differences in all the characters due to various treatments.

Treatment T_1 had recorded maximum mean girth of middle internode which was at par with all the treatments except treatment T_2.

Data on test weight revealed that, treatment T_1 was significantly superior over all the treatments and T_2 had recorded lowest test weight, which was at par with treatments T_4 and T_5.

Data regarding grain weight per earhead showed that treatment T_1 had recorded highest values of grain weight per earhead and treatment T_2 was lowest regarding grain weight per earhead.

In general, all the yield contributing characters were maximum in T_1 treatment in which 3:3 row proportion of sorghum + pigeonpea was maintained. The other treatments gave more or less equal values for these yield contributing characters.

4.1.2.2 Studies on earhead characters

Data pertaining to earhead characters viz., length, breadth and weight per earhead are given in Table 16.

Table 16 : Mean length, width and weight of earhead of sorghum as influenced by various treatments

Treatments	Length of earhead (cm)	Width of earhead (cm)	Weight of earhead (g)
T_1	29.33	4.93	107.16
T_2	21.83	4.06	51.76
T_3	28.00	4.66	93.23
T_4	24.20	4.14	56.26
T_5	25.93	4.33	55.16
T_6	26.20	4.50	63.36
T_7	26.60	4.66	83.26
SE +	1.17	0.66	4.45
CD at 5%	NS	NS	13.72
Gen.Mean	26.01	4.46	72.88

The differences regarding length and breadth of earhead due to various treatments were not significant. The weight of earhead per plant showed significant differences due to various treatments. Treatment T_1 had recorded maximum weight per earhead. It was at par with treatment T_3 and superior over all other treatments. Treatment T_2 had recorded lowest weight per earhead.

4.1.2.3 Grain, fodder and bhoosa yield in q/ha

Data on grain, fodder and bhoosa yields are given in Table 17.

Table 17 : Mean grain, bhoosa and fodder yield in q/ha as influenced by various treatments

Treatments	Grain yield	Fodder yield	Bhoosa yield
T_1	37.80	70.21	10.94
T_2	12.30	29.71	3.93
T_3	46.83	80.24	13.20
T_4	23.37	48.99	6.82
T_5	40.39	51.31	11.34
T_6	46.40	97.90	13.81
T_7	52.46	99.54	15.90
SE ±	4.57	8.23	0.81
CD at 5%	14.08	25.36	2.49
Gen.Mean	37.15	63.99	10.85

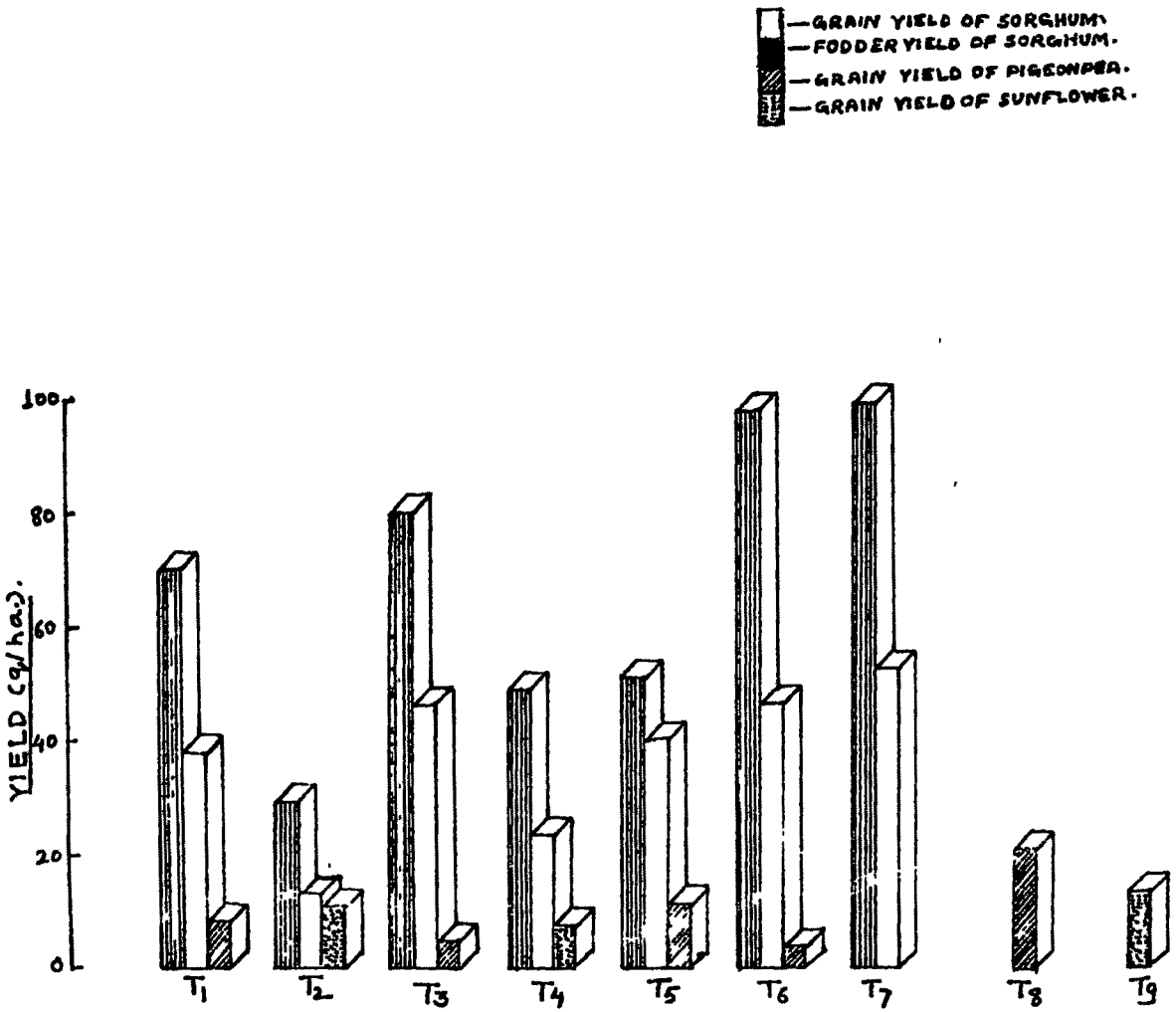


FIG. 5. GRAIN AND FODDER YIELDS OF SORGHUM; GRAIN YIELDS OF PIGEONPEA AND SUNFLOWER IN q/ha AS INFLUENCED BY VARIOUS TREATMENTS.

Data presented in Table 17 showed that grain yield of sole crop of CSH-9 was significantly more than the 50 per cent population of sorghum treatments maintained in 3:3 row proportion with pigeonpea and sunflower. In 66 per cent plant population of sorghum treatments maintained in 4:2 row proportions with pigeonpea, the sorghum grain yields were not differed significantly than sole crop of CSH-9. However, it was affected significantly in [illegible] sunflower.

The recovery of grain yields of sorghum CSH-9 in 50 per cent plant population treatments, maintained in 3:3 row proportions with pigeonpea and sunflower was 72 and 24 per cent respectively, whereas, 89 and 45 per cent, respectively in 66 per cent plant populations, treatment, maintained in 4:2 row proportion. In 2:1 row proportion, the recovery of CSH-9 grain yield was 88 per cent. The results indicate that sunflower had significant adverse effect on grain yield of sorghum in both the ratios under study.

The trend of fodder and bhoosa yield was more less similar as in case of grain yield.

4.1.2.4 LER and sorghum grain equivalent

Data on land equivalent ratio and sorghum grain equivalent are presented in Table 18.

Table 18 : LER and sorghum grain quivalent (q/ha) as influenced by various treatments

Treatments	Land equivalent ratio	Sorghum grain equivalent (q/ha)
T_1	1.12	73.72
T_2	1.03	55.74
T_3	1.11	74.99
T_4	1.02	58.63
T_5	1.32	83.01
T_6	1.06	72.24
T_7	1.00	66.71
T_8	-	63.38
T_9	-	47.98
Gen.Mean	1.09	66.27

The data indicated that maximum LER was obtained in treatment T_5 with CSH-6 and BDN-2 in 2:1 row proportions, followed by T_1, T_3 and T_6 where intercropping treatments with sorghum CSH-9 in 3:3, 4:2 and 2:1 row proportions were maintained,respectively. Treatments T_2 and T_4 with sorghum + sunflower intercropping in 3:3 and 4:2 row proportion had shown lowest LER.

Similar trend was obtained in case of sorghum grain equivalent as that of LER.

4.1.2.5 Grain to bhoosa and grain to fodder ratio

Data regarding grain to bhoosa and grain to fodder ratio are given in Table 19.

Table 19 : Grain to bhoosa ratio and grain to fodder ratio as influenced by various treatments

Treatments	Grain to bhoosa ratio	Grain to fodder ratio
T_1	3.33	0.54
T_2	3.13	0.41
T_3	3.51	0.58
T_4	3.42	0.48
T_5	3.70	0.79
T_6	3.36	0.47
T_7	3.30	0.53
Gen.Mean	3.39	0.57

Data regarding grain to bhoosa and grain to fodder ratio as affected by various treatments are not analysed statistically, inferences are drawn on the basis of mean values.

Data presented in Table 19 showed that grain to bhoosa ratio was highest in T_5. Lowest grain to bhoosa ratio was obtained in T_2 treatment.

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Persual to the Table showed that, grain to bhoosa ratio was highest in T_5 treatment, the next best treatment was T_3. Lowest grain to bhoosa ratio was obtained in T_2 treatment.

Grain to fodder ratio was also maximum in CSH-6 i.e. T_5 treatment. In sole crop CSH-9 treatment, and in treatment where CSH-9 was intercropped with pigeonpea except T_6, the grain to fodder ratio was more or less similar and was comparatively more than T_2 and T_4 treatments, in which CSH-9 was intercropped with sunflower. The later two treatments showed more or less equal values.

4.1.3 Chemical studies

4.1.3.1 Nitrogen and protein content in grain

Data pertaining to nitrogen and protein content of sorghum as affected by various treatments are given in Table 20.

Table 20 : Nitrogen content in grain of sorghum as influenced by various treatments

Treatments	'N' content	Protein per cent
T_1	1.86	11.62
T_2	1.54	9.62
T_3	1.76	11.00
T_4	1.57	9.81
T_5	1.80	11.25
T_6	1.69	10.56
T_7	1.64	10.25
Gen.Mean	1.69	10.59

Data on nitrogen content revealed that maximum nitrogen content was observed in sorghum + pigeonpea with 3:3 row proportions treatment, followed by T_5 in which CSH-6 and pigeonpea was grown in 2:1 row proportions. The nitrogen content was reduced in sorghum + sunflower intercropped treatments in both the proportions as compared to sorghum + pigeonpea intercropped system.

Trend of protein percentage in grain was just similar to that of nitrogen content.

4.2 Pigeonpea

4.2.1 Pre-harvest studies

4.2.1.1 Mean height of pigeonpea per plant (cm)

The mean height of pigeonpea as influenced by various treatments at various stages of crop are given in Table 21.

Table 21 : Plant height (cm) of pigeonpea as affected by various treatments

Treatments	Days after sowing							
	30	45	60	75	90	105	120	At harvest
T_1	21.5	55.33	86.13	115.60	126.76	147.16	164.20	165.66
T_3	21.96	53.13	76.00	112.26	131.70	153.16	167.40	169.60
T_5	20.60	49.66	78.90	108.03	129.66	156.30	170.36	171.40
T_6	22.08	54.10	78.33	85.93	97.46	116.88	146.80	148.86
T_8	21.25	49.46	74.13	110.06	127.40	159.86	172.98	175.26
SE ±	1.24	2.27	8.21	5.76	8.39	7.89	4.28	3.51
CDat5%	NS	NS	NS	18.81	27.35	25.73	14.00	11.44
Mean	21.47	52.34	78.70	106.37	122.60	146.67	164.36	166.16

Data revealed that there was continuous increase in height upto harvest. The increase was maximum during 60-105 days.

The treatment differences were not found significant upto 60 days. From 75 days onwards, the differences were significant at all the stages. At 75 days, treatments T_1, T_3, T_5 and T_8 were at par with each other and significantly superior to treatment T_6. Treatment T_1 had recorded maximum height. Similar trend was observed in all the subsequent observations.

4.2.1.2 Mean number of primary branches as affected by various treatments

Data regarding mean number of primary branches per plant are given in Table 22.

Table 22 : Mean number of primary branches of pigeonpea as affected by various treatments

Treatments	Days after sowing							
	30	45	60	75	90	105	120	At harvest
T_1	1.86	3.93	6.26	6.53	7.73	8.73	10.9	11.00
T_3	1.80	3.66	5.43	6.86	7.73	8.20	8.76	8.86
T_5	1.83	3.26	6.73	7.03	8.76	10.16	11.46	11.76
T_6	0.46	0.86	1.60	1.66	2.03	2.46	3.39	3.33
T_8	1.86	3.46	6.96	7.70	9.10	10.60	11.76	12.00
SE ±	0.61	0.47	0.64	0.51	0.52	0.74	0.71	0.65
CDat5%	NS	1.55	2.11	1.66	1.70	2.41	2.32	2.12
Gen.Mean	1.56	3.03	6.00	5.96	7.07	8.03	9.24	9.39

It is evident from the data that number of branches per plant increased upto harvest. There were no significant differences between treatments at 30 days. From 45 days onwards upto harvest, the treatments T_1, T_3, T_5 and T_8 were at par and were significantly superior over treatment T_6. Treatment T_8 had recorded highest number of branches, where sole crop of pigeonpea was grown.

4.2.1.3 Dry matter accumulation per plant of pigeonpea as affected by various treatments

Data on dry matter accumulation per plant as affected by various treatment, during crop growth are presented in Table 23.

Table 23 : Mean dry matter accumulation per plant of pigeonpea as influenced by various treatments g/plant

Treatments	Days after sowing							
	30	45	60	75	90	105	120	At harvest
T_1	0.71	7.07	14.36	19.10	30.64	51.22	67.43	87.49
T_3	0.68	6.72	13.66	18.17	29.14	48.72	64.14	83.23
T_5	0.80	7.96	16.18	21.52	34.50	57.69	75.94	98.53
T_6	0.45	4.49	9.12	12.13	19.46	32.53	42.83	55.57
T_8	0.82	8.14	16.54	22.00	35.28	58.98	77.63	100.75
SE ±	0.02	0.16	0.11	0.08	0.23	0.21	0.31	0.82
CDat5%	0.09	0.52	0.36	0.28	0.76	0.68	1.02	2.67
Gen.Mean	0.69	6.87	13.97	18.58	29.40	49.82	65.59	55.11

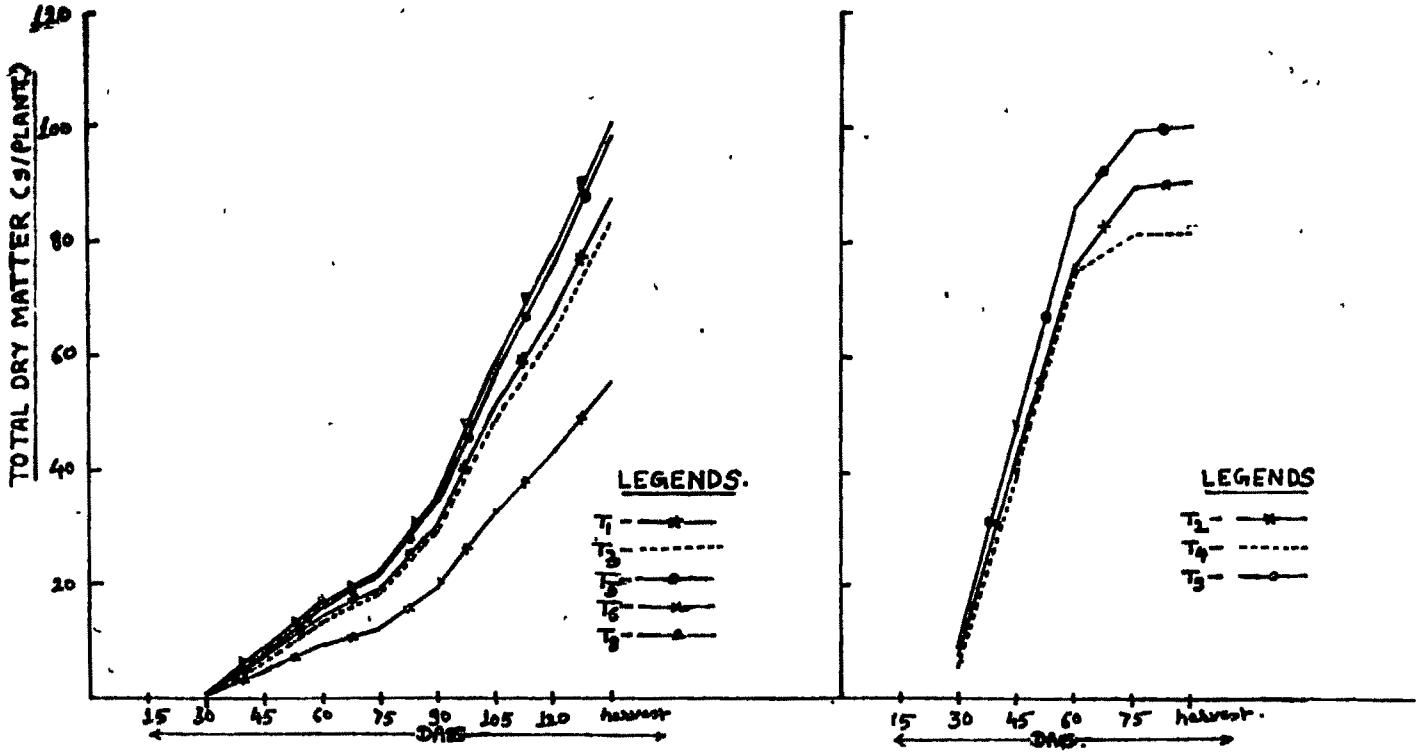

FIG-4 TOTAL DRY MATTER ACCUMULATION IN g/PLANT OF PIGEONPEA AND SUNFLOWER AS INFLUENCED BY VARIOUS TREATMENTS.

Table showed that treatments T_8 and T_5 were at par and gave significantly higher dry matter accumulation per plant than rest of the treatments at 30,45 and 60 days after sowing. During subsequent stages of crop growth upto harvest, maximum dry matter was recorded in sole crop which was significantly more than intercropped treatments. Among the intercropped treatments, maximum dry matter production per plant of pigeonpea was obtained in treatment T_5 in which CSH-6 was intercropped with pigeonpea in 2:1 row proportion, which was significantly superior than rest of the treatments. The next best treatments were T_1 and T_3. Lowest dry matter accumulation was obtained in T_6 treatment where CSH-9 was intercropped with pigeonpea in 2:1 row proportion.

In general, sole crop of pigeonpea was significantly superior to intercrop of pigeonpea, particularly in reproductive phase. Amongst intercropping treatments, pigeonpea intercropped with CSH-6 showed superiority over other treatments and pigeonpea intercropped with sorghum CSH-9 showed very poor performance at all the stages of pigeonpea.

4.2.2 Post harvest studies

4.2.2.1 Mean weight of pods per plant, mean weight of grains per plant and test weight (g) of pigeonpea

It is evident from Table 24 that there were significant differences between weight of pods per plant

Table 24 : Mean weight of pods per plant, weight of grains per plant and test weight of grains of pigeonpea(g)

Treatments	Weight of pods/ plant (g)	Weight of grains/plant (g)	Test weight (g)
T_1	28.00	18.00	106.66
T_3	26.11	14.98	106.66
T_5	29.00	18.66	106.60
T_6	14.50	9.10	105.56
T_8	30.00	21.66	106.68
SE +	2.75	2.65	0.41
CD at 5%	8.97	8.66	NS
Gen.Mean	23.52	15.08	106.42

and weight of grains per plant in both the aspects. Sole crop treatment T_8 had recorded highest test weight and was at par with T_1, T_3 and T_5 and was superior to treatment T_6 with 2:1 row proportion of CSH-9 + BDN-2. As regard test weight, treatment differences due to various treatments were not significant.

4.2.2.2 Yield of grain, stalk and bhoosa (q/ha) of pigeonpea

Data on grain, stalk and bhoosa yield in q/ha of pigeonpea are presented in Table 25.

The data on the grain yield of pigeonpea indicated that maximum grain yield of pigeonpea was obtained in sole crop treatment T_8 followed by control treatment (CSH-6 +

Table 25 : Grain stalk and bhoosa yield of pigeonpea in q/ha as affected by various treatments

Treatments	Grain yield	Stalk yield	Bhoosa yield
T_1	8.40	22.12	3.28
T_3	4.87	17.12	2.96
T_5	11.53	30.36	4.36
T_6	3.75	9.81	1.15
T_8	20.87	54.95	7.75
SE ±	0.25	0.64	0.17
CD at 5%	0.82	2.11	0.56
Gen.Mean	9.88	26.87	3.90

BDN-2 in 2:1 in row proportion) as compared to 3:3, 4:2 and 2:1 row proportions with CSH-9. The recovery of grain yields of pigeonpea on 3:3, 4:2 and 2:1 row proportion with CSH-9 was 40, 23 and 18 per cent, respectively in comparison to sole crop of pigeonpea; whereas, it was 55 per cent in control treatment (T_5).

Similar results were obtained regarding stalk and bhoosa yield of pigeonpea as that of grain yields.

4.2.2.3 Grain to bhoosa ratio

Data regarding grain to bhoosa ratio are shown in Table 26.

Table 26 : Grain to bhoosa ratio of pigeonpea

Treatments	Grain to bhoosa ratio
T_1	2.56
T_3	2.52
T_5	2.64
T_6	3.26
T_8	2.69
Gen.Mean	2.74

Data presented in Table 26 showed that the sole crop treatment T_8 had recorded highest grain to bhoosa ratio, followed by T_1, T_3, T_5 and T_6 treatments.

4.2.3.1 Nitrogen and protein content in pigeonpea grain

Table 27 : Nitrogen and protein content in pigeonpea grains

Treatments	Nitrogen (per cent)	Protein (per cent)
T_1	3.12	19.50
T_3	3.11	14.93
T_5	3.12	19.50
T_6	3.10	19.37
T_8	3.10	19.37
Gen.Mean	3.11	18.53

The data regarding nitrogen and protein content in Table 27 showed that there were not much differences

between the treatments in respect of nitrogen and protein content in grain.

4.3. Sunflower

4.3.1 Pre-harvest

Data regarding pre-harvest observations of sunflower as affected by different treatments during the period of crop growth are presented in Table 28.

Table 28 : Data regarding pre harvest biometric observations of sunflower showing mean height, number of leaves, stem girth and dry matter accumulation per plant

Treatments	Days after sowing				
	30	45	60	75	At harvest
1.	2.	3.	4.	5.	6.
Height (cm)					
T_2	39.40	113.40	165.20	193.86	193.86
T_4	37.40	112.73	163.83	173.82	173.99
T_9	39.83	123.33	169.26	195.06	195.08
Gen.Mean	38.87	116.48	166.09	187.58	188.64
Number of functional leaves					
T_2	10.86	14.66	18.80	16.60	13.50
T_4	10.26	14.46	18.73	15.30	12.37
T_9	11.40	15.60	19.13	17.25	13.96
Gen.Mean	10.84	14.90	18.88	16.38	13.27

Table 28 contd. ...

1.	2.	3.	4.	5.	6.
Stem girth (cm)					
T_2	3.10	5.60	6.86	7.21	7.21
T_4	3.10	5.33	6.66	7.12	7.12
T_9	3.24	5.66	7.00	7.37	7.37
Gen.Mean	3.14	5.53	6.84	7.23	7.23
Dry matter per plant (g)					
T_2	7.00	42.12	76.22	89.12	90.25
T_4	5.50	39.32	75.94	80.93	81.05
T_9	9.00	52.83	86.23	99.27	100.00
Gen.Mean	7.16	44.75	79.46	89.77	90.43

Data on all these characters are not analysed statistically because of only three treatments of sunflower. Therefore inferences are drawn on mean values.

Height of sunflower increased upto 75 days and thereafter it was constant upto harvest. At all the stages, the height of sole sunflower was comparatively more than the intercropped treatments in both 3:3 and 4:2 row proportions.

The other characters viz., number of functional leaves, stem girth and dry matter accumulation per plant was

more in sole crop of sunflower, than the sunflower intercropped with sorghum in 3:3 and 4:2 row proportions, at all the stages. Among the intercropped treatments in 3:3 and 4:2 row proportions, the values for all these characters were more or less equal.

4.3.2 Post harvest observations

Weight of head per plant, grain weight per plant Test weight, diameter of the head and yield in q/ha of sunflower

Table 29 : Data regarding post harvest observations of sunflower as affected by various treatments

Treatments	Mean diameter/ head (cm)	Weight/ head (g)	Weight of grains/ head (g)	Test weight (g)	Yield of grains (q)
T_2	11.46	33.66	17.33	51.33	10.79
T_4	10.33	30.00	16.66	51.00	7.85
T_9	12.10	37.00	17.66	51.66	13.45
Gen.Mean	11.29	33.55	17.21	51.33	10.69

The data showed that sole crop (T_9) had recorded maximum values for all the given yield contributing characters followed by treatment T_2 and T_4 in which sunflower was grown in 3:3 and 4:2 row proportions with sorghum.

Data on grain yield was also not analysed statistically. Grain yield of sunflower in 3:3 and 4:2 row proportion were 10.79 and 7.85 q/ha as against 13.45 q/ha under its sole crop.

4.3.3 Chemical analysis

4.3.3.1 Nitrogen, protein and oil content of grains of sunflower

Data regarding nitrogen, protein and oil content of the grains of sunflower are given in Table 30.

Table 30 : Data showing nitrogen content in grain, protein content and oil content in grain of sunflower

Treatments	Nitrogen (per cent)	Protein (per cent)	Oil (per cent)
T_2	1.53	9.56	34.00
T_4	1.52	9.50	30.00
T_9	1.55	9.68	36.00
Gen.Mean	1.53	9.58	33.33

Treatment T_9 of sole crop had recorded maximum values of all the three parameters followed by T_2 and T_4 in which sorghum and sunflower were grown in 3:3 and 4:2 row proportions.

4.4 Correlation studies

4.4.1 Sorghum

Correlation coefficients between leaf area, dry matter, length of earhead, breadth of earhead/plant and test weight (1000-grain weight) with grain yield/plant were worked out and showed in Table 31.

Table 31 : Correlation coefficients between grain yield/plant and yield contributing characters of sorghum

Sr.No.	Plant characters	Correlation coefficient 'r'
1.	Leaf area and yield per plant	-0.1014
2.	Dry matter and yield per plant	0.5133*
3.	Earhead length and yield per plant	0.4722*
4.	Breadth of earhead and yield per plant	-0.3326
5.	Test weight and yield per plant	0.5469*

* significant at 5 per cent

It is seen from Table 31 that the correlation coefficients were positive and significant in dry matter, earhead length per plant and test weight with grain yield per plant. However, negative correlation was found between leaf area and breadth of earhead per plant and grain yield per plant.

4.5 Net returns

Data on net returns (Rs./ha) presented in Table 32.

Table 32 : Net returns (Rs./ha) as affected by various treatments

Treatments	Gross returns	Net returns	Cost of cultivation
T_1	9970	7970	2000
T_2	7363	5263	2100
T_3	10027	7861	2166
T_4	7915	5683	2232
T_5	11222	8322	2900
T_6	9755	6755	3000
T_7	9073	6573	2500
T_8	8553	7053	1500
T_9	6475	4775	1700
SE ±	-	3.18	-
CD at 5%	-	9.55	-
Gen.Mean	8928	6695	2233

Prices of various components of crop in Rs./q

1.	Sorghum grain	135	5.	Pigeonpea bhoosa	20
2.	Sorghum fodder	20	6.	Sunflower grain	450
3.	Pigeonpea grain	350	7.	Sunflower stalk	10
4.	Pigeonpea stalk	20			

Data presented in Table 32 revealed that maximum net returns of Rs. 8322 per hectare was obtained in treatment T_5

(CSH-6) + BDN-2 in 2:1 row proportion) which was at par with treatment T_1 and T_3 (in 3:3 and 4:2 of CSH-9 and BDN-2, respectively). Treatments T_1, T_3 and T_5 were significantly superior to rest of the treatments. Net returns obtained from the sole crop of CSH-9 (T_7) was at par with the net returns obtained from CSH-9 + BDN-2 in 2:1 row proportion (T_6).

Sorghum + sunflower in all the combinations gave the inferior net returns even to that of sole crop of CSH-9, lowest net returns was recorded in the sole crop sunflower followed by sorghum + sunflower in 3:3 and 4:2 row proportion.

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5. DISCUSSION

5. DISCUSSION

It is evident from the data on soil analysis that soil was clayey in texture, medium in nitrogen and slightly alkaline in reaction.

Data on weather conditions revealed that the total precipitation of 585.2 mm was received during the year under report, was quite low compared to normal. A typical dry spell of 35 days was observed from first week of August to first week of September, which is generally a high rainfall period at Parbhani. At Parbhani, fairly good yields of sorghum were recorded during this year inspite of long dry spell and this may be because of continuous cloudy weather throughout that period and high retentive capacity of soil. Also, rainfall received during September coincided with ear emergence and grain filling stage, which might have improved the yields. There was not much variation between minimum and maximum temperatures, but low humidity during August helped in minimising pest complex.

Sowing of experiment was done on 17th July.

In order to study growth of sorghum, pigeonpea and sunflower, it was considered to study the nature of plant growth measured in terms of height, leaf area, dry matter, number of branches, stem girth, number of functional leaves etc. which are discussed as under.

SORGHUM

Table-33 would reveal that the growth of the crop in terms of mean height, number of functional leaves increased progressively from sowing upto 60 days of crop growth. Though the mean height increased till harvest the maximum increase in height (45.57 cm) was recorded during 45 to 60 days which was 73 per cent of total height. Accordingly, maximum AGR for height cm/plant/day, was recorded between 45 to 60 days. The mean number of functional leaves (4.27) and corresponding leaf area (9.16 dm^2) observed at 30 days, also reached to the maximum at 60 days (8.11) and (41.07 dm^2) respectively, declined thereafter due to drying of leaves. LAI (0.16) recorded at 30 days reached to the maximum (0.77) at 60 days of sowing. The faster rate of growth in respect of all these characters during 30 to 60 days after sowing was due to grand growth period of sorghum crop.

The total dry matter accumulation increased steadily upto maturity, a rapid increase in dry matter accumulation i.e. 44.32 was observed during 45 to 60 days as compared to other stages of crop.

The correlation coefficients between sorghum plant characters viz., dry matter, test weight and length of earhead with grain yield per plant were found positive.

Table-33: An extract of relevant information giving effects of various treatments on growth, yield and quality of sorghum.

Sr. No.	Particulars	T_1	T_2	T_3	T_4	T_5	T_6	T_7
1.	Mean height in cm at harvest	158.46	154.56	157.86	154.53	145.86	154.90	156.56
2.	Mean number of functional leaves at 60 days	8.4	7.8	8.6	8.0	7.7	8.0	8.3
3.	Mean leaf area per plant (sqdm) at 60 days	46.82	36.24	45.07	38.53	36.76	42.83	41.27
4.	Total dry matter weight (g/plant) at harvest	159.16	120.12	149.91	119.29	95.12	125.00	150.11
5.	Mean girth of middle internode(cm) at harvest	4.70	3.28	4.63	4.20	4.00	4.23	4.36
6.	Mean length of earhead (cm) at harvest	29.33	21.83	28.00	24.20	25.93	26.20	26.60
7.	Mean width of earhead (cm) at harvest	4.93	4.06	4.66	4.14	4.33	4.5	4.66
8.	Mean weight of earhead	107.13	51.76	93.23	56.26	55.16	63.36	83.26
9.	Mean weight of grains/earhead (g)	82.40	38.86	72.10	43.56	43.90	53.06	63.83
10.	1000 grain weight (g)	34.00	24.66	31.66	30.00	25.00	28.33	30.00
11.	Grain yield (Q/ha)	37.80	12.30	46.33	23.31	40.39	46.40	52.46
12.	Fodder yield (Q/ha)	70.21	29.71	80.24	48.99	51.31	67.90	99.54
13.	Grain/bhoosa ratio	3.33	3.13	3.51	3.42	3.70	3.36	3.30
14.	Grain/fodder ratio	0.54	0.41	0.58	0.48	0.79	0.68	0.53
15.	Bhoosa yield (Q/ha)	10.94	3.93	13.20	6.82	11.34	13.81	15.90
16.	Nitrogen content of grains	1.86	1.54	1.76	1.57	1.80	1.69	1.64
17.	Protein content of grains	11.62	9.62	11.00	9.81	11.25	10.56	10.25

PIGEONPEA

Data on growth characters presented in table-34 revealed that, increase in plant growth in respect of height and dry matter was continuous upto maturity. The height of main shoot increased continuously showing maximum height of 166.16 cm per plant at harvest but increase was most rapid during 60 to 105 days after sowing.

The number of primary branches increased continuously upto harvest. Dry matter accumulation per plant increased from 0.69 g/plant at 30 days upto 85.11 g/plant at harvest.

The grand growth period of vegetative phase appears to be from 60 to 105 days as height increased from 78.70 to 146.67 cm and number of branches increased from 6 to 8.03. However, increase in dry matter was rapid after 90 days due to increased dry matter contribution from reproductive parts.

The growth behaviour of hybrid sorghum CSH-6 and pigeonpea BDN-2 was found compatible for intercropping as vegetative and reproductive phases occurred at different times during crop season and hence association seems to be complimentary without compitative effects on growth of both the crops. Sorghum was faster in growth and maturing

Table-34: An extract of relevant information giving effects of various treatments on growth, yield and quality of pigeonpea.

Sr. No.	Particulars	T_1	T_3	T_5	T_6	T_8
1.	Mean height in cm at harvest	165.66	169.60	171.40	148.86	175.26
2.	Mean number of primary branches/ plant at harvest	11.00	8.86	11.76	3.33	12.00
3.	Total dry matter weight per plant (g) at harvest	87.49	83.23	98.53	55.57	100.75
4.	Mean weight of pods/plant at harvest (g)	28.00	26.11	29.00	4.50	30.00
5.	Mean weight of grains/plant at harvest	18.00	14.98	18.66	2.10	21.66
6.	1000 grain weight (g)	106.66	106.66	106.60	105.56	106.68
7.	Grain yield (q/ha)	8.40	4.87	11.53	3.75	20.87
8.	Stalk yield (q/ha)	22.12	17.12	30.36	9.81	54.95
9.	Bhoosa yield (q/ha)	3.28	2.96	4.36	1.15	7.75
10.	Grain to bhoosa ratio	2.56	2.52	2.64	2.49	2.69
11.	Nitrogen content in grains	3.12	3.11	3.12	3.10	3.10
12.	Protein content in grains	19.50	14.93	19.50	19.37	19.37

early (115 days) whereas, pigeonpea was slower in growth and maturing late (170 days) thus temporal differences between two crops made the combination advantageous.

Whereas, in case of CSH-9 which is a high yielder hybrid had adverse effect on growth of pigeonpea, mainly because of had spreading crop geometry, more height, thick stem and compites with pigeonpea for light and other resources of crop production, resulting in drastic reduction in the yield of intercrop pigeonpea, especially in 2:1 row proportion.

SUNFLOWER

Data regarding various growth characters of sunflower are given in table-35.

Data clearly indicate that the height and girth of stem of sunflower increased upto 75 days, thereafter it remained constant. The maximum increase in height was found between 45 to 60 days after sowing which was 49.52 cm.

Number of functional leaves increased from sowing to 60 days and then as maturity advanced the number decreased upto harvest. The maximum number of leaves (18.8) were noticed at 60 days.

Table-35: An extract of relevant information giving effects of various treatments on growth, yield and quality of sunflower.

Sr. No.	Particulars	T_2	T_4	T_9
1.	Mean height in cm at harvest	193.86	173.99	195.08
2.	Mean number of the functional leaves at 60 days	18.80	18.73	19.13
3.	Mean girth of stem (cm) at harvest	7.21	7.12	7.37
4.	Mean dry matter weight (g) per plant at harvest	90.25	81.05	100.00
5.	Mean diameter per head (cm)	11.46	10.33	12.10
6.	Mean weight per head (g)	33.66	30.00	37.00
7.	Mean weight of grains per head (g)	17.33	16.66	17.66
8.	1000 grain weight (g)	51.33	51.00	51.66
9.	Grain yield q/ha	10.79	7.85	13.45

The dry matter accumulation had shown increase upto harvest, but the rate of dry matter accumulation was more during 45 to 60 days which was 34.75 g/plant.

The faster growth rate between 30 to 60 days was because of grand growth period of sunflower.

EFFECT OF DIFFERENT TREATMENTS ON SORGHUM CROP

Data on effect of different treatments are given in the table-33.

Data indicated that there were significant differences due to various treatments on the sorghum.

In regards of height, dry matter accumulation, number of leaves and leaf area per plant were found more in treatment T_1 having 3:3 row proportion of sorghum + pigeonpea followed by T_7 of sole crop of CSH-9 and T_3 with 4:2 row proportion of sorghum + pigeonpea. This was probably because in 3:3 row proportions there was less competative effect between CSH-9 and pigeonpea, specifically during early stages of crop, when CSH-9 was fast in growth and pigeonpea was comparatively slow in growth, thus getting complimentary effects. This had overall beneficial effects on growth of sorghum. In the treatment T_3, with 4:2 proportion, because of less pigeonpea population the effects on sorghum growth of pigeonpea was less marked. In treatment T_6 with regular intercropping pattern in 2:1 row proportion with pigeonpea +

CSH-9, there was less beneficial effect due to the association of pigeonpea on sorghum as compared to T_1. The growth was more or less similar to the sole crop.

Treatment T_5 with CSH-6 and BDN-2 in regular 2:1 row proportion, sorghum had significantly less height, number of leaves, dry matter as compared to other treatments. This was because of the genetic behaviour of CSH-6 and not due to the pigeonpea association.

Munde (1976) also reported beneficial effects on growth characters of sorghum in sorghum + pigeonpea intercropping.

The sorghum in the treatments T_2 and T_4 with sunflower had shown significantly less values of growth characters as against pigeonpea association. The height, number of leaves, dry matter was minimum in treatment T_2 with 3:3 row proportion of sorghum + sunflower which was somewhat more in 4:2 row proportions in treatment T_4. This was because, the sorghum and sunflower are of similar maturity period and they grow simultaneiously in all the respect, their grand growth period is similar i.e. 30 to 60 days which had compitative effect on sorghum and therefore inspite of any complementary effects there was drastic reduction in all the yield contributing characters of sorghum which ultimately reduced the yield.

Shaikh and Upadhyay (1977) had found that, sunflower as a companian crop had significantly depressed the dry matter accumulation, weight of earhead and grain/panicle, the protein content was also found to be lessened in the grains of sorghum. Loss of grain per panicle was about 38 per cent due to sunflower association.

EFFECT OF DIFFERENT TREATMENTS ON THE ASSOCIATED CROP PIGEONPEA:

Data on the effect of different treatments on pigeonpea are given in table-34.

It reveals that sole crop had recorded highest values of height, number of branches, dry matter etc. The values of all the above characters were found to be reduced due to the compitative effects of sorghum. The effects was more pronounced in CSH-9 regular intercropping (T_6) than CSH-6 (T_5). There was maximum reduction in regular planting pattern with CSH-9 because of its spreading crop canopy, long duration high yield potentiality as compared to erect habit short duration and low yielding potentiality of CSH-6.

Similar trend was observed in all yield contributing characters.

Similar results were obtained by Dhake (1959), Cheura (1958), Ali and Malhotra (1970), Shelke (1977) and Sundarrajan and Palanippan (1979).

There was no significant reduction in the nitrogen content of pigeonpea due to various treatments. This was because of availability of sufficient nitrogen in soil to nourish the crop of pigeonpea specifically under intercropping treatments.

EFFECT OF DIFFERENT TREATMENTS ON ASSOCIATED CROP, SUNFLOWER:

The sunflower had recorded highest plant height, number of leaves, dry matter and stem girth in sole crop.

The values of all these characters reduced drastically when the sunflower was grown in association with the sorghum. The values of height, number of leaves, dry matter and stem girth was reduced in 3:3 row proportions and still less values were found in 4:2 row proportions.

There was less earhead diameter, head weight, weight of grains per head in association of sorghum, this was due to sorghum and sunflower are compitative crops and hence their association was not found beneficial. On the contrary reduced the values of yield contributing characters.

In 3:3 row proportion there was less compitition than 4:2 row proportions and hence the crop was affected less in 3:3 row porportion.

Similar results were obtained by Shaikh and Upadhyay (1977). The nitrogen, protein and oil content in sunflower grains were also found reduced due to the sorghum association, the values were high in sole crop followed by crop in 3:3 row proportion and least were found in 4:2 row proportions with sorghum. This might have attributed through poor growth and yield contributing characters in sorghum-sunflower associationship.

ANALYSIS OF YIELD

YIELD OF SORGHUM:

The yield of sorghum was highest in sole cropping and was less in the intercropping. Though the leguminous crop had beneficial effects on yield/plant, but because there was reduced plant populations of sorghum in intercropping system, the yields were affected accordingly. The plant population when reduced by 50 and 33 per cent, the yields were also affected.

However, critical inspection of the data on the grain yield of sorghum revealed that, the recovery of sorghum grain in 3:3 row proportion of sorghum + pigeonpea with 50 per cent plant population of sorghum (T_1) was 72 per cent which comes 144 per cent as compared to sole crop of sorghum (T_7). This clearly indicates that there was a beneficial

border effect of pigeonpea strip in this treatments, which helped in increasing all the growth characters well as yield attributing characters of sorghum ultimately resulted in increased efficiency of sorghum grain production to the extent of 44 per cent in comparison to sole crop of CSH-9.

Similarly in 4:2 row proportions of sorghum + pigeonpea with 66 per cent plant population of sorghum (T_3) the recovery was 89 per cent which comes about 120 per cent in comparison with sole crop of sorghum (CSH-9)(T_7). In this treatment also beneficial border effect of pigeonpea strip was there but it was comparatively less than 3:3 row proportion.

In regular intercropping of CSH-9 in 2:1 row proportion of sorghum + pigeonpea (T_6) even after maintaining 100 per cent plant population of the sorghum the recovery was only 88 per cent that is equal to T_3 (66 per cent plant population of sorghum) indicating no beneficial border effect of pigeonpea line on the grain yield of sorghum.

In comparison to treatment T_5 and T_6 the grain yields of sorghum CSH-9 with 50 and 66 per cent plant population of sorghum in association of pigeonpea were at par, indicating good associationship of CSH-9 and pigeonpea specifically in given treatments of strip cropping (T_1 and T_3).

The reduction in the yields of sorghum was more pronounced in case of sunflower as compared to pigeonpea with the same plant population.

Sorghum and sunflower being more or less similar in habit, height, duration and growth pattern, there was compitition for light, space, moisture and all other resources of crop production between these two crops which suppressed all the growth and yield contributing characters of sorghum thus getting a very poor yield in both the proportions. This finding concluded that sorghum sunflower are not compatible crops for intercropping.

Similar results were obtained at sorghum research station, Parbhani (1974) and Shaikh and Upadhyay (1977).

YIELDS OF PIGEONPEA:

The yield levels of pigeonpea were 2075 Kg/ha in sole crop followed by 1153 Kg/ha in regular intercropping with CSH-6 (T_5) 840 Kg/ha in 3:3 row proportion (T_1) and 487 Kg/ha in 4:2 row proportions with CSH-9 (T_3) and minimum yield 375 Kg/ha was recorded in 2:1 row proportion with CSH-9 (T_6).

Critical review of this finding revealed that the recovery of grain yield of pigeonpea in 3:3, 4:2 and 2:1 row proportion with CSH-9 was 40, 23 and 18 per cent

respectively in comparison to sole crop of pigeonpea, as against 55 per cent in control treatment T_5 (2:1, CSH-6 + BDN-2).

The cropping efficiency of pigeonpea in all these intercropping treatments in comparison to utilization of land, comes about 80, 69 and 36 per cent in 3:3, 4:2 and 2:1 row proportions with CSH-9 respectively as against 110 per cent in control treatment (T_5) in comparison to sole crop of pigeonpea and hence CSH-6 seems to be most suitable genotype for pigeonpea under 2:1 row proportion whereas CSH-9 seems to be most unsuitable genotype specially in 2:1 row proportion. However, looking to the cropping efficiency of pigeonpea with CSH-9 in 3:3 and 4:2 row proportion in comparison to control treatment, this genotype seems to be compatible in strip cropping either in 3:3 or 4:2 row proportion, rather than regular intercropping in 2:1 row proportion.

From this finding it can be inferred that if at all pigeonpea is to be intercropped with CSH-9 it should be taken either in 4:2 or in 3:3 row proportions.

Shelke (1977), Khan (1979) and Khan (1980) reported that there was reduction in the yield of pigeonpea due to intercropping in comparison to sole cropping of pigeonpea.

YIELDS OF SUNFLOWER:

The yield levels of sunflower were 1345 Kg/ha in sole cropping, 1079 and 785 Kg/ha in 3:3 and 4:2 row proportions with sorghum respectively.

The reduction in the yield was due to reduced plant population in both the treatments and reduction was more due to compitative effects between sorghum and sunflower.

Though the recovery of the sunflower in both 3:3 and 4:2 row proportions was quite satisfactory in comparison to sole crop of sunflower, but due to its pronounced effect on the sorghum, the recovery of sorghum grain yield was only 24 and 45 per cent in 3:3 and 4:2 row proportions with sorghum respectively, indicating most incompatibility of sorghum and sunflower associationship under intercropping system. From this finding it can be concluded that sorghum sunflower intercropping is not at all suitable, feasible and economical.

NET RETURNS:

The net returns given in the table-32 were calculated on the basis of prevailing prices in the market of various components of the crops and the prices of the input. Though the prices of the output and input are always subjected to the fluctuations, but the fluctuation is not

generally exceeding to the extent of (±) 10-15 per cent. Therefore the results obtained from the various treatments were considered for giving the adhoc recommendations.

Treatments T_1, T_3 and T_5 were at par and significantly superior to rest of the treatments. This finding clearly indicates that the modified system of intercropping in 3:3 and 4:2 row proportion specifically for CSH-9 and BDN-2 was comparable to our present recommended intercropping system of CSH-6 + BDN-2 in 2:1 row proportion in which 100 per cent plant population of sorghum CSH-6 was maintained. Data on net return further revealed that the regular intercropping of 2:1 row proportion (T_6) was not found at all economical for CSH-9 as the net return obtained in this system was only Rs.6755/- per hectare which was significantly lower than the treatments T_1 and T_3. In these treatments (T_1 and T_3) regular intercropping was modified to strip cropping of 3:3 and 4:2 row proportion of sorghum + pigeonpea respectively with a main objective of avoiding compitative effects between sorghum and pigeonpea and making the whole system profitable than the sole crop of CSH-9. These higher net returns in T_1 and T_3 treatments were obtained through the higher yields of sorghum and pigeonpea in comparison to treatment T_6. The additional profit obtained in corresponding treatments was Rs.1275/- and Rs.1106/- per hectare than treatment T_6.

Inspite of any pforit in sorghum + sunflower intercropping treatments, there was a loss of Rs.1310/- and 890/- per hectare in 3:3 and 4:2 row proportion of sorghum + sunflower intercropping treatments respectively in comparison to sole crop of CSH-9 (T_7), indicating most uneconomical combination.

In addition to higher net return obtained in modified strip cropping of sorghum + pigeonpea, it was found more feasible, practicable and convenient in respect of sowing, interculturing, harvesting etc. in comparison to 2:1 row proportion of sorghum and pigeonpea.

Sunflower was found uneconomical and compatible crop for sorghum based intercropping system.

6. SUMMARY AND CONCLUSIONS

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An agronomic investigation to find out suitable cropping system, for optimising yield recovery of pulse and oilseed crops under sorghum based inter-cropping system was carried out during kharif, 1984 at Sorghum Research Station, Parbhani. The soil of experiment was clayey in texture and uniform in slope, medium in nitrogen and alkaline in reaction.

The experiment was laid out in randomised block design with nine treatments replicated three times. Treatments consisted, four treatments of 3:3 and 4:2 row proportions of sorghum + pigeonpea/sunflower, two treatments in 2:1 row proportion of CSH-6 and CSH-9 with pigeonpea and three treatments of respective sole crops (sorghum, pigeonpea and sunflower).

Besides yield data, periodical observations were recorded on growth and yield contributing characters of all the three crops i.e. sorghum, pigeonpea and sunflower to evaluate treatment effects. Some important findings emerging out from this investigation are summarised below.

SORGHUM:

The growth attributes viz., height, number of leaves, leaf area per plant in general had shown differences due to various treatments.

In sorghum + pigeonpea treatments with 3:3, 4:2 and 2:1 rows had shown beneficial effects on growth characters of sorghum and had recorded more values of all the characters than sole crop where as; sunflower associated sorghum in both 3:3 and 4:2 row proportion had shown reduced values of growth characters as compared to sole and intercropped sorghum with pigeonpea.

Similarly, regarding yield contributing characters, through these were no differences between the treatments in respect of length and breadth of earhead but test weight, weight of grains per head had shown the same trend that was found in yield contributing characters of sorghum.

PIGEONPEA:

The height, number of branches, dry matter per plant was affected significantly by various treatments. The values of height, number of branches, dry matter per plant were found to be maximum in sole crop and had shown reduction in all the treatments of sorghum associated pigeonpea. The reduction was maximum in case of treatment T_6 (CSH-9 and BDN-2 in 2:1 row proportion) as compared to sole crop (T_8) and was minimum in case of pigeonpea grown in association

with CSH-6 in 2:1 row proportion (T_5) which was followed by (T_1 (3:3 row proportion of sorghum and pigeonpea) and T_3 (4:2 row proportion).

The yield contributing characters like number of pods, weight of grains/plant had shown significant differences. Treatment T_8 of sole crop had recorded maximum values of these yield contributing characters followed by T_5 (control treatment), T_1 and T_3 with 3:3 and 4:2 row proportions of sorghum and pigeonpea respectively. The lowest values of yield contributing characters were obtained in treatment T_6 with 2:1 row proportion of CSH-9 and BDN-2. Regarding test weight the treatment differences were not upto the level of significance.

Similarly, nitrogen and protein content of pigeonpea grain was not affected by the various treatments.

SUNFLOWER:

Height, number of leaves, stem girth and dry matter were affected significantly by the various treatments. Treatment T_9 of sole crop had recorded highest values of height, number of leaves, stem girth and dry matter accumulation per plant followed by T_2 with 3:3 row proportions of sorghum + sunflower. Lowest values of above given growth characters were recorded in treatment T_4 with 4:2 row proportion of sorghum and sunflower.

Similarly, regarding yield contributing characters viz., head diameter, weight of the grains per head, test weight were maximum in treatment T_8 followed by treatment T_2 and T_4.

The trend of nitrogen, protein and oil content was just similar to that of growth and yield contributing characters. Maximum grain yield of sorghum was obtained in treatment T_7 which was at par with treatments T_1 and T_3 and significantly superior to rest of the treatments.

Among intercropped treatments, treatments T_1 and T_3 were at par and significantly superior to other treatments.

Pigeonpea was found compatible and sunflower was found compitative for sorghum based intercropping system.

In pigeonpea and sunflower the yields of sole crops were significantly more than their respective intercropped treatments. Under intercropping of 3:3 row proportion gave higher yields than 4:2 row proportion in case of bobh the crops.

Net returns obtained in 4:2 and 3:3 row proportions of sorghum + pigeonpea was comparable to that of CSH-6 + BDN-2 intercropping treatment in 2:1 row proportion and significantly superior than sole crop of CSH-9 (T_7) or its intercropping with pigeonpea in 2:1 row proportion (T_6).

Sunflower was not found at all economical for sorghum based intercropping system.

CONCLUSION:

Sorghum CSH-9 being very high yielding and most popular hybrid among the cultivators as compared to CSH-6, can be very well intercropped with pigeonpea either in 3:3 or 4:2 row proportion of sorghum CSH-9 and BDN-2 for making the whole system profitable than sole crop of CSH-9 or intercropping of CSH-9 in 2:1 row proportion with pigeonpea, under Marathwada agroclimatic conditions specifically in medium to heavy soils with rainfall ranging from 500-800 mm.

LITERATURE CITED

LITERATURE CITED

Ali, S.A. and Malhotra, D.M. 1970. Mixed cropping and scientific analysis. Science and Culture. 36:196.

Batra, H.N. 1962. Mixed cropping and pest attack. Indian Fmg. 11 (11) : 17-19 and 25.

Bhalerao, S.S. 1979. Studies on crop geometry of kharif sorghum CSH-6 in association with different cultivars of pigeonpea. Ph.D. Thesis (unpublished), Parbhani, MAU.

Bhalerao, S.S. and Upadhyay, U.C. 1981. Crop geometry studies in sorghum in association with pigeonpea varieties. Indian Journal of Agri.Science. 51 (11) : 778-781.

Deokar, A.B.; Bharud, R.W. and Umrani, N.K. 1983. Studies on different pigeonpea varieties with pearlmillet. International Pigeonpea News letter, pp.22.

Freyman, S. and Venkateshwrlu, J. 1977. Intercropping on rainfed red soils of Deccan plateau, India. Candian Journal of Plant Science, 57 (3) : 697-705.

Ghatol, S.A. 1977. Intercropping of pigeonpea with legumes and cereal under semiarid conditions. Indian farming. 27 : 7.

Giri, A.N. and Bainade, S.S. 1981. Studies on intercropping system with hybrid sorghum CSH-6. Indian Journal of Agronomy, 26 (3) : 351-352.

Gupta, S.L. 1953. The effect of mixed cropping of arhar (Cajanus cajan) with jowar on the incidence of arhar wilt. Agric. and Ani.Husb., 3 : 31.

Hardas, M.G.; Bhagwat, V.R. and Sharangat, B.K. 1979. Influence of associate cropping system on the incidence of sorghum-pest complex. Paper presented at 'Sorghum Symposium' held at PBN on the occasion of Golden Jublee of Sorghum Research Station, Parbhani.

Hiromath, S.M. 1979. Effect of row proportions and N. application on growth and yield of sorghum and pigeonpea in intercropping system. Thesis (unpublished) Banglore, Univ. of Agril.Sci.

Jaganathan, N.T.; Morchan, Y.B. and Ramaih, S. 1974. Studies on effect of maize and soybean association in different proportions and spacing on yield. Madras Agri. J., 61 (8) : 386-391.

Kumar-Swamy, A.S. and Hosmani, 1978. 'Intercropping in Varlaxmi cotton' Mysore J. Agril.Sci., 12 :212-216.

Lingegouda, B.K.; Shanthavirbadraih, S.M. and Inamdar, S.S. 1972. Studies on mixed cropping of groundnut and hybrid sorghum. Indian J.Agron., 17 : 27-29.

Lomte, M.H. and Dabhade, R.S. 1982. Response of redgram genotypes to population in intercropping. Sorghum Newsletter (25) pp.50-51.

Mohta, 1971 and 1972. Progress report, Division of Agron., I.A.R.I., New Delhi.

Munde, S.M. 1976. Skipped row and intercropping experiment on kharif sorghum as base crop and pigeonpea as intercrop. M.Sc.Thesis (unpublished), Parbhani, MAU.

Munde, S.M. and Pawar, K.R. 1976. Current approach for intercropping in hybrid sorghum. Sorghum News letter., 19 : 62-63.

Munde, S.M. 1983. Studies on pigeonpea varieties and nitrogen management in sorghum intercropping system. Thesis submitted for M.Sc.(Agri.) (unpublished), Parbhani, MAU.

Natarajan, M. and Willey, R.W. 1980. Growth studies in sorghum pigeonpea intercropping with particular emphasis on canopy development and light interception. Annual report of ICRISAT, pp. 180-187.

Natrajan, M. and Willey, R.W. 1980. Sorghum pigeonpea intercropping and effect of plant population density, (1) growth and yield. Journal of Agri.Science U.K. 95 (1) : 51-58.

Pathak. 1982. Response of redgram genotype to population in intercropping system. M.Sc.Thesis (unpublished) Parbhani, MAU.

Pawar, H.H. 1982. Studies on intensity of intercropping of groundnut in sorghum. Journal of Maharashtra Agril. Universities, 7 (2) : 12-15.

Pawar, H.K.; Gaunkar, V.Y. and Umrani, N.K. 1982. Intercropping of cowpea in sorghum under irrigated conditions. Journal of Maharashtra Agril.Universities, 7 (2) : 151-153.

Raikhelkar, S.V.; Bainade, S.S. and Lande, B.R. 1979. Multistoried three crops intercropping system with sorghum. Paper presented in 'Sorghum Symposium' held at S.R.S., Parbhani, on 24-25 Feb., 1979.

Rao, M.R. and Willey, R.W. 1979. Sorghum in rainfed intercropping system. Paper presented i at the Goldent Jublee Symposium, S.R.S.,Parbhani.

Rao, M.R. and Willey, R.W. 1981. Stability of performance of a pigeonpea/sorghum intercrop system. ICRISAT, international workshop on intercropping :306-317.

Rao, M.R. and Willey, R.W. 1983. Effect of genotype of cereal/pigeonpea intercropping as Alfisols of the semiarid topics of India. Experimental Agri., 19 (1) : 67-68.

Ravichandran, D.K.; Padmanabhan, S.P. and Balasubramanyam,A. 1975. Planting pattern for sorghum intercrop system Newsletter, 19 : 27.

Reddy, A.R. and Reddy, M.R. 1980. Relative efficiency of a multiintercrop system in pigeonpea under rainfed conditions. Indian J.of Agron., 25 (3):508-510.

Saxena, M.C. and Yadao, D.S. 1973. Multiple cropping with short duration pulses. Indian J. Agron.,11 :357-361.

Sen, S.; Sengupta, K.; Sur, S.C. and Mukherjee, K. 1966. A study on mixed cropping of arhar. Indian J. Agron., 11 (4) : 357.

Shaikh Mahammad, Upadhyay, U.C. 1977. Effect of companion cropping on yield attributes of rainfed sorghum. Indian J.Agron., 1977, 23 (3) : 176-181.

Shelke, V.B. 1977. Studies on crop geometry in dryland intercropping system. Thesis submitted to M.A.U., Parbhani for Ph.D. degree.

Shelke, V.D. 1979. Intercropping in sorghum. Paper presented at 'Sorghum symposium' held at S.R.S., Parbhani.

Singh, S.P. 1981. Studies on spital arrangements of sorghum legume intercropping systems. Journal of Agril., Sci., U.K. 97 (3) : 655-661.

Singh, S.P. and Jain, O.P. 1984. Stability studies in sorghum based intercropping systems under rainfed conditions in India. Zeitscherift for Acker und pflanzenball, 153 (1) : 40-51.

Singh Laxman., Sharma, D. and Maheswari, S.K. 1973. Pigeonpea doses better in mixture with dwarf sorghums JNKVV Res.J., 7 (2) : 100-101.

Sundarajan and Pallaniappan, S.P. 1979. Effect of intercropping on growth and yield components of redgram. Indian J. Agric. Res., 13 (3) : 127-132.

Tarahalkar, P.D. 1976. Studies on sorghum pigeonpea intercropping. Paper presented at All India Sorghum Workshop held at Parbhani, 1976.

Tarahalkar, P.D.;1976, Rao, N.G.P. 1975. Changing concept practices of cropping system. Indian farming 25 (31) : 37.

Tiwari, A.S.; Yadaw, L.N. and Laxman Singh. 1977. Spreading plant types dose better in pigeonpea. Tropical grain legume bulletin. (7) : 7-9.

Umrani, N.K. 1981. Intercropping for higher production of pulses. Indian Fmg., 31 (9) : 13-14.

Umrani, N.K. and Parande, K.S. 1979. Studies on intercropping in rabi sorghum. Journal of MHA. Agril.Univ., 4 (3) :311.

Vanjaria, N.K.; Desai, D.T.; Tikka, S.B.S. and Desai, K.B. 1979. Studies on intercropping in grain sorghum, Sorghum News letter, 22 pp. 42-43.

Verma, J.K. and Pandey, B.B. 1983. Intercropping pigeonpea with sorghum in Rajasthan. International pigeonpea News letter, pp. 23.

Verma, J.K.; Singh, B.P. and Yadav, G.L. 1983. Returns from intercropping pulses with sorghum in Rajasthan, International pigeonpea News letter, 2 pp. 29.

Venkateswarlu, J.; Sanghi, N.K.; Rao, U.M.B. and Rao, C.H. 1981. Maximum production in a sorghum/pigeonpea intercropping system in semi arid tropics. ICRISAT Report pp. 30-34.

Waghmare, A.B.; Krishnan, T.K. and Singh, S.P. 1982. Crop compatibility and spital arrangement in sorghum based cropping system. Journal of Agril., Sci., 99 (3) : 19-21.

AICRAPDA. 1974. Proceeding of the 5th annual workshop of AICRAPDA held at Telhan Bhavan, Hyderabad.

Sorghum Research Station. 1974. Annual report, Parbhani MAU.

ICAR, 1975-76. Annual Report. pp. 53-54.

Sorghum Research Station 1975-76. Annual Report Parbhani,MAU.

ICRISAT 1977.78. Annual report, Hyderabad ICRISAT.

Agricultural Research Station 1978-79. Annual work on pulses. Annual report, Badnapur. M.A.U.

ICRISAT. 1979-80. Farming studies; plant population studies on pigeonpea. Annual report Hyderabad, ICRISAT.

Marathwada Agricultural University 1980-81. Annual report. Parbhani, M.A.U.

ICRISAT. 1981. Plant population in intercrop Annual report Hyderabad, ICRISAT.

* Original not seen.