STUDIES ON THE EFFECT OF INTERCROPPING OF SORGHUM WITH GRAIN LEGUMES UNDER SEMI ARID CONDITIONS

K. Chandra Sekhara Reddi

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1977

CERTIFICATE

It is hereby certified that this thesis entitled, 'STUDIES ON THE EFFECT OF INTERCROPPING OF SORGHUM WITH GRAIN LEGUMES UNDER SEMI-ARID CONDITIONS', is a bonafide record of work done by Mr. K. Chandra Sekhara Reddi, under our guidance and supervision and that no part of it has previously formed, in whole or part, the basis for the award of any degree, diploma or other distinction. Such help or source of information as has been availed in this connection is duly acknowledged.

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CONTENTS

INTRODUCTION

The intercropping practice becomes more relevant to semi-arid tropics where water is the primary constraint to agricultural production. This aims at making the best use of the land and water resources, thereby obtaining crop growth during the period from pre-monsoonic to the post-monsoonic rains as long as water is available for the growing crops. Another objective of the intercropping technique is to ensure the survival and production of at least one crop of the several crops in the combination, resulting into economic yield under unfavourable weather conditions. And when the season happens to be normal, particularly in respect of precipitation, the total production under the system should prove to be higher than that obtained by growing either of the crops.

Recent studies on intercropping conducted under optimum technology have indicated substantial increase in yields of crops compared to the same crops grown singly. Intercropping techniques could further be developed for yield increase by the choice of suitable cultivars, planting time, optimum population, suitable spacing, etc. so that total leaf area duration is extended to an optimum with conditions conducive to a prolonged period of light interception by the crop canopy. Certain studies on intercropping have also revealed that the uptake of the available nutrients and their utilization is also higher under the system (Whittington and O'Brien, 1968 and Lakhani, 1976).

Intercropping, in contrast to single cropping, involves many crop combinations that must be investigated as individual crops within the combinations in order to evolve the most suitable system. It, therefore, becomes desirable to make a choice of crops, especially the main crop, out of several possible combinations.

Based on these fundamentals and understanding of crop combination the present study was programmed involving sorghum as the principal crop raised in combination with pigeonpea (Cajanus cajan L.) and mung bean (Phaseolus aureus L.). Sorghum is the main crop grown in dry regions and the grain is also used for food by large number of people. Similarly pigeonpea, a long duration crop, and mungbean, a short duration crop, are popular pulse crops in the area. Available experimental data on inter-cropping of sorghum with these two pulse legumes is not adequate and the system needs further studies. With this aspect in view and with an object of collecting data on the crop combinations and their effect on yield of component crops, present investigations were designed with three levels of nitrogen and three different spacings keeping the population of sorghum constant under each combination.

REVIEW OF LITERATURE

Intercropping in cereals with legumes

The practice of intercropping with many objectives has been in vogue by the farmers since time immemorial. La pliza has been accredited for his findings that a legume crop has beneficial effect on a non-legume when these two are grown together (Mirchandani and Misra, 1957). Several workers have confirmed that a leguminous crop benefitted the companion non-legume crop when the two were grown together (Lyon and Bizzel, 1911; Kellerman and Wright, 1914; Westgate and Oakley, 1914; Warburton, 1915; Howard, 1916; Lyon, 1930; Nowtnowna, 1937; Wagner and Wilkins, 1947 and Aiyer, 1949). Early research conducted by Wallace (1888) and Voelcker (1893) revealed that growing a cereal crop with a legume maintained soil fertility status at a normal level.

Recent intercropping studies, under optimum technology, made by Andrews (1972), Harwood (1973), Rao (1974) and Krantz et al (1976) indicated substantial (50% or more) yield increase from various combinations of alternate row intercropping over those of two separate sole crop cultures (Papadakis, 1941; Paul and Joachim, 1941 and Evans, 1960-61).

A. NUTRIENT UPTAKE AND WATER USE:

Available literature has revealed that intercropping has marked effect on uptake of nutrients. In some studies increased uptake of nutrients has been attributed to increased rooting depths which was the result of intercropping (Whittington and O'Brien, 1968 and Lakhani, 1976).

Some findings revealed that greater nutrient uptake has been found without differences in rooting pattern (Dalal, 1974; Hall, 1974, and Liboon and Harwood, 1975). Some members reported that companion crops can make their nutrient demands at different growth stages, thus temporal differences in nutrient demands occurred independent of differences in the actual maturity period of crops (Whittington and O'Brien, 1968; Kassam and Stokinger, 1973; Finlay, 1974 and Lakhani, 1976). Component crops differing enormously in their abilities to compete for nutrients has been reported by some researchers (Chang and Lai, 1963; Ibrahim and Kabesh, 1971; Davies and Harwood, 1975); and this may be particularly so when nutrients are limiting (Liboon and Harwood, 1975). This has considerable bearing on the compatibility of crops and the suitable proportions in which they are established with a reasonable balance in competition.

There is evidence that intercropping can give more efficient temporal use of water (Andrews, 1972; Sastry, 1973 and Lakhani, 1976).

B. SORGHUM INTERCROPPED WITH MUNG BEAN

Osiru and Willey (1972) reported that mixture of dwarf sorghum and beans gave considerably higher yields than it could have been achieved by growing the two crops singly, and this phenomenon was attributed to the better utilisation of soil resources by the crops. The annual report of All India Coordinated Sorghum Improvement Project (AICSIP) (Anonymous 1975-76) has indicated the effects of growing sorghum along with mung bean on yield of grain. The results from different centers were contradicting each other.

Grain and straw yields in sorghum remaining unaffected due to raising the crop in combination with mung bean was reported by Palaniappan et al (1974), Anonymous (1973-74), Anonymous (1975-76), Bhalerao et al (1976) and Anonymous (1976-77). At Coimbatore and Parbhani centres of AICSIP, mung bean when intercropped with sorghum reduced the yield of sorghum considerably (Anonymous 1975-76).

In most of the cases when mung bean grown along with sorghum, the gross returns from the crop mixture was more than that when these were taken up solely in the same area (Anonymous, 1975-76; Krantz et al, 1976; Bhalerao et al, 1976; Hosmani, 1976-77 and Anonymous, 1976-77). Higher monetary returns from sorghum grown as a sole crop against those obtained from a crop-mixture of sorghum and mung bean have been reported by Reddy and Reddy (1976) and Anonymous (1975-76).

Gautam et al (1964) reported that mung bean could be grown successfully as an intercrop for green manure or green fodder along with the main crop of maize.

C. SORGHUM INTERCROPPED WITH PIGEONPEA:

Enyi (1973) reported that maize or sorghum with pigeonpeas, cowpeas or beans led to a reduction in leaf area, fresh weight yield at the time of anthesis, straw yield at harvest and grain yield of cereal crop. In sorghum, pigeonpea and cowpea had a greater adverse effect on grain yield than that of beans. Further he reported that the intercropping of sorghum with pigeonpeas increased the total grain yield per hectare; Bhalerao et al (1976) reported that the sorghum yield got lowered by intercropping with pigeonpea and the total grain yield of sorghum plus pigeonpea was also less than that of sole sorghum crop yield (Anonymous, 1973 74 and Anonymous, 1975-76). Yield of sorghum remaining unaffected due to intercropping with pigeonpea was reported by several workers (Hanagodimath, 1975; Anonymous, 1976,a; Krantz et al, 1976; Munde and Pawar, 1976 and Anonymous, 1975-76). Krantz et al (1976) reported an increase in the production of total dry matter in sorghum increased by intercropping with pigeonpea.

Reddy and Reddy (1976) and Anonymous (1975-76) observed that Sorghum plus pigeonpea gave less gross monetary returns than that from sorghum alone. Same monetary returns by growing sorghum alone and in combination with pigeonpea have been reported by Bhalerao et al (1976), Krantz et al (1976) and Mane and Ramshe (1976-77). Higher monetary returns by growing sorghum with pigeonpea against those obtained from sorghum as sole crop have been reported by Anonymous (1975-76), Munde and Pawar (1976), and Krantz et al (1976).

Effects of nitrogen fertilization on plant characters

A. PLANT HEIGHT

In a study conducted by Reddy (1965) at Rajendranagar in two sorghum varieties, it was observed that the plant height increased with increase in nitrogen level from 0 to 100 kg N/ha. Similar observations on plant height increase due to increasing level of nitrogen were made by several workers (Rai, 1965; Gupta and Singh, 1967; Bains and Milton, 1968; Anonymous, 1969-70; Premsingh and Choubey, 1972; and Reddy, 1974). Studies have also indicated that plant height was not significantly influenced by nitrogen fertilization (Raheja and Krantz, 1958; Reddy, 1968; Roy and Wright, 1973 and Balaiah, 1975).

B. NUMBER OF GREEN LEAVES PER PLANT:

Studies made by Reddy (1965), Reddy (1968), Reddy (1970) and Reddy (1974) in sorghum grown as a sole crop the number of green leaves per plant were maximum at heading stage and decrease in the number was recorded with advancement in age of the plants. Garg and Kayanda (1962), and Balaiah (1975) reported an increase in number of leaves with increase in level of nitrogen from 0 to 20 kg N/ha. Raghunath (1973) reported that the increase in nitrogen level from 60 to 120 kg N/ha increased the number of green leaves in sorghum from 6.5 to 7.5 percent.

C. LEAF AREA:

Rao (1970) recorded 40% increase in leaf area with increase in nitrogen level from 0 to 150 kg N/ha in sorghum sole crop. Krishnamurthy et al (1976) observed that higher level of nitrogen supply basically enlarged the photosynthetic source of sorghum (leaf area) even at earlier stages, thereby resulting in longer leaf area duration (LAD).

D. DRY MATTER PRODUCTION:

Raheja and Krantz (1958), Babu (1973) and Roy (1973) reported that sorghum plant weight continued to increase until harvest time. Warsi and Wright (1973a) reported an increase in dry matter production with increase in nitrogen level up to 60 kg N/ha. Rao and Reddy (1973) observed an increase in the level of nitrogen (except that at 150 kg N/ha level) increased the dry matter production in sorghum at all stages of plant growth. Similar observations were made by Rai (1965), Srivastava,(1969), Ramachandran (1971), Reddy (1974) and Balaiah (1975).

Narayanan and Sheldrake (1976) reported that the pigeonpea plants fertilised with 120 kg N/ha produced more dry matter than 22 kg N/ha fertilised plants.

E. EARHEAD LENGTH AND GIRTH:

Significant increase in earhead length and girth as a result of nitrogen fertilisation in sorghum was observed by some workers (Reddy, 1965; Reddy, 1969; Reddy, 1970; Premsingh and Choubey, 1972).

F. 1000 GRAIN WEIGHT:

Increase in 1000 grain weight as a result of nitrogen fertilisation to sorghum crop was reported by many workers (Porter et al, 1960; Garg and Kayande, 1962; Blum, 1967; Reddy, 1968; Krishnamurthy et al, 1975 and Balaiah, 1975). Tatwawadi and Choudhari (1976) reported that the increasing nitrogen level from 50 to 150 kg N/ha has no effect on 1000 grain weight in sorghum.

G. YIELD PER PLANT:

Tatwawadi and Choudhari (1976) reported that increase in nitrogen level from 50 to 150 kg N/ha resulted in increased grain weight per plant in CSH1 variety of sorghum.

H. GRAIN YIELD:

Several workers reported the positive response of sorghum to nitrogen fertilisation when it was grown as sole crop (Rahaja and Krantz, 1958; Herren et al, 1963; Bodade, 1964; Reddy, 1965; Welch et al, 1966; Reddy, 1969;

Shrotriya and Shekhawat, 1969; Srivastava and Ambikasingh, 1969; Rao, 1970; Bathkal et al, 1970; Reddy, 1970; Dubey and Lal, 1971 Shekawat and Chundewat, 1971; Deosthale et al, 1972; Premsingh and Choubey, 1972; Singh and Bains, 1973; Krishnamurthy et al, 1973; Warsi and Wright, 1973 Roy and Wright, 1973b, Naphadi and Choudery, 1974; Virenath et al, 1975; Singh and Mahvir Pershad, 1975; Shukla and Jagdish Seth, 1976; Bhattacharya, 1976 and Chari et al, 1976). Chari et al (1976) reported that with application of 80 kg N/ha, highest grain yield was obtained in sorghum, 45.5 q/ha and this was on par with that recorded at other levels up to 140 kg N/ha.

Krantz et al (1976) reported that sorghum responded well to nitrogen application at 120 kg/ha over 22 kg/ha level in intercropping, while pigeonpea as intercrop, was not significantly influenced by the fertilisation. The interaction between cropping system and nitrogen level was not significant on either of the red or black soil.

Venugopal and Marichan (1974) reported that N levels (0 to 30 kg/ha) had no affect on the seed yield of mung bean when the crop was grown singly.

I. STRAW YIELD:

Significant increase in straw yield with increase in nitrogen level was observed by many workers (Srivastava and Ambika Singh, 1969; Dubey and Lal, 1971; Roy and Wright, 1971; Balaiah, 1975; Babu, 1977).

J. NITROGEN UPTAKE:

Balaiah (1975) recorded that the N accumulation increased with increase in nitrogen level in sorghum plant. Similar observations were made by Herren et al (1963), Srivastava (1969), Warsi and Wright (1973) and Roy and Wright (1974).

K. PHOSPHORUS CONCENTRATION:

Srivastava (1971) , and Balaiah (1975) indicated that P content of sorghum and plant was not influenced by N levels.

L. POTASSIUM CONCENTRATION:

Ramachandran (1971) observed that N application did not influence the potassium content in leaves and stems of sorghum plant during early stages of crop growth. Roy and Wright (1974) reported that potassium uptake of sorghum plant significantly increased with nitrogen fertilization.

M. PROTEIN CONTENT:

The effect of nitrogen application to sorghum resulting in an increase in protein content of grain by increasing levels of applied nitrogen has been reported by many workers (Burlesun et al, 1956; Miller et al, 1964; Reddy, 1965; Rai,1965,a; Weggle et al, 1967; Reddy and Hussain, 1968; Roy and Wright, 1973; and Balaiah, 1975).

Reddy (1965) recorded that the grain protein of the bybrid sorghum 2930 from 6.3 at no nitrogen to 9.5, 9.6, 9.8, 10.0 and 11.4 (percent) by the application of 20, 40, 60, 80 and 100 kg N/ha respectively.

Influence of Spacings

A. SORGHUM:

Experiments conducted on sorghum spacing by AICSIP at several locations have recorded varying results (Anonymous, 1975-76). At Jalgaon, Navsari and Indore centers the yield of sorghum at 45 cm x 12 cm and 60 cm x 9 cm was on par. At coimbatore, Karad, Parbani, Akola and Udaipur centres 45 cm x 12 cm spaced sorghum crop has given much higher yields than that obtained at 60 cm x 9 cm spacing (Anonymous 1975-76).

Grain yield of sorghum was not influenced by space level. The yields were similar at 45 cm, 60 cm, 90 cm and 120 cm row spacings (Chandravanshi, 1976 and Bapat et al, 1976). Reddy and Reddy (1976) recorded higher yields of sorghum at 45 cm x 120 cm and 60 cm x 9 cm spacings over 90 cm x 6 cm and 120 cm x 4.5 cm. They further reported that the yields of sorghum recorded at 45 cm x 120 cm and 60 cm x 9 cm spacing were on par.

B. PIGEONPEA:

Singh (1971) reported that there was no significant difference in the yield of pigeonpea at row spacings of 75 cm and 100 cm. Bains and Chowdhury (1971) reported that a population of 50,000 to 60,000 plants/ha proved significantly better than that of 40,000 plants/ha. Venkata Swamy et al (1972) observed that the yields of rainfed pigeonpea was maximum at 90 x 30 cm space level. Krantz et al (1976) reported that the grain yields of four pigeonpea varieties with and without sorghum intercrop at two row spacings of 75 cm and 150 cm in black soil were on par. Variations in row spacings at 45, 90 and 135 cm with constant population did not influence the pigeonpea yield with HYB.2 variety (Anonymous, 1976,b).

MATERIAL AND METHODS

Experimental site: The present study was made in the Division of Agronomy, College of Agriculture, Andhra Pradesh Agricultural University, Rajendranagar. The field experiment was conducted simultaneously at the Farm, College of Agriculture, Rajendranagar; and at the plot-G Red Soil, Watershed-1 of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT-RW1-G) between July 1976 and January 1977. The college farm is located at an altitude of 542.6 m above sea level and with geographical bearing of 77.5°E on longitude and 18.59°N on latitude. ICRISAT-RW1-G is situated at an altitude of 545 m above sea level and with geographical kxxx bearing of 17°27'N on longitude and 78°28'E on latitude.

[For the remainder of the thesis the word "Site-1" is used to substitute Farm, College of Agriculture, Rajendranagar and "Site-2" for ICRISAT-RWI-G].

Soil: The fields at both the experimental sites were uniform in topography mechanical and chemical analyses of soil at the two sites are given below:

Soil mechanical analysis	Site-1	Site-2
Coarse sand	76.86%	78.18%
Fine sand	2.5%	2.5%
Silt	3.5%	3.5%
Clay	17.14%	15.82%

Soil chemical analysis	Site-1	Site-2
Soil pH	7.5 (slightly alkaline)	7.7 slightly alkaline
EC	0.1 mmhos/cm (normal)	0.09 mmhos/cm (normal)
Organic carbon	0.4% (low)	0.35% (low)
Available nitrogen	300 kg/ha (medium)	250 kg/ha
Available phosphorus	38.5 kg/ha (medium)	40.0 kg/ha (medium)
Exchangeable potassium	413 kg/ha (high)	389 kg/ha (high)

Season: The experiment was carried out between July, 1976 and January, 1977. Meteorological data were recorded during the period of crop growth at Site-1 and Site-2 and are represented in Appendix (1) and Figure 1. The season was normal.

Previous crop history: Crops grown during the previous year at both the sites were given below:

Site-1	Site-2
(1) Groundnut (weed control expt.) - kharif	Sorghum intercropping
(2) Wheat (commercial cultivation) - Rabi	trial (Kharif)
(3) Maize (seed production) - summer	

Experimental details:

A. EXPERIMENTAL MATERIAL:

Crop	Site-1	Site-2
Sorghum	CSH-6	CSH-6
Pigeonpea	ICRISAT-1	ICRISAT-1
Mungbean	PS-16	PS-10

B. EXPERIMENTAL DESIGN AND LAYOUT:

The experiment was laid out in split-plot design with nitrogen levels as main plot, spacing and cropping system as sub-plot treatments with three replications. The layout plans of the two sites are shown in Figure 2. The experiment was conducted under rainfed conditions at both the sites. Life saving irrigation was given at site-1 to pigeonpea crop after the harvest of sorghum.

Fig 10. METEOROLOGICAL DATA AT WEEKLY INTERVAL JUNE 2, 1976 - Jan 21, 1977

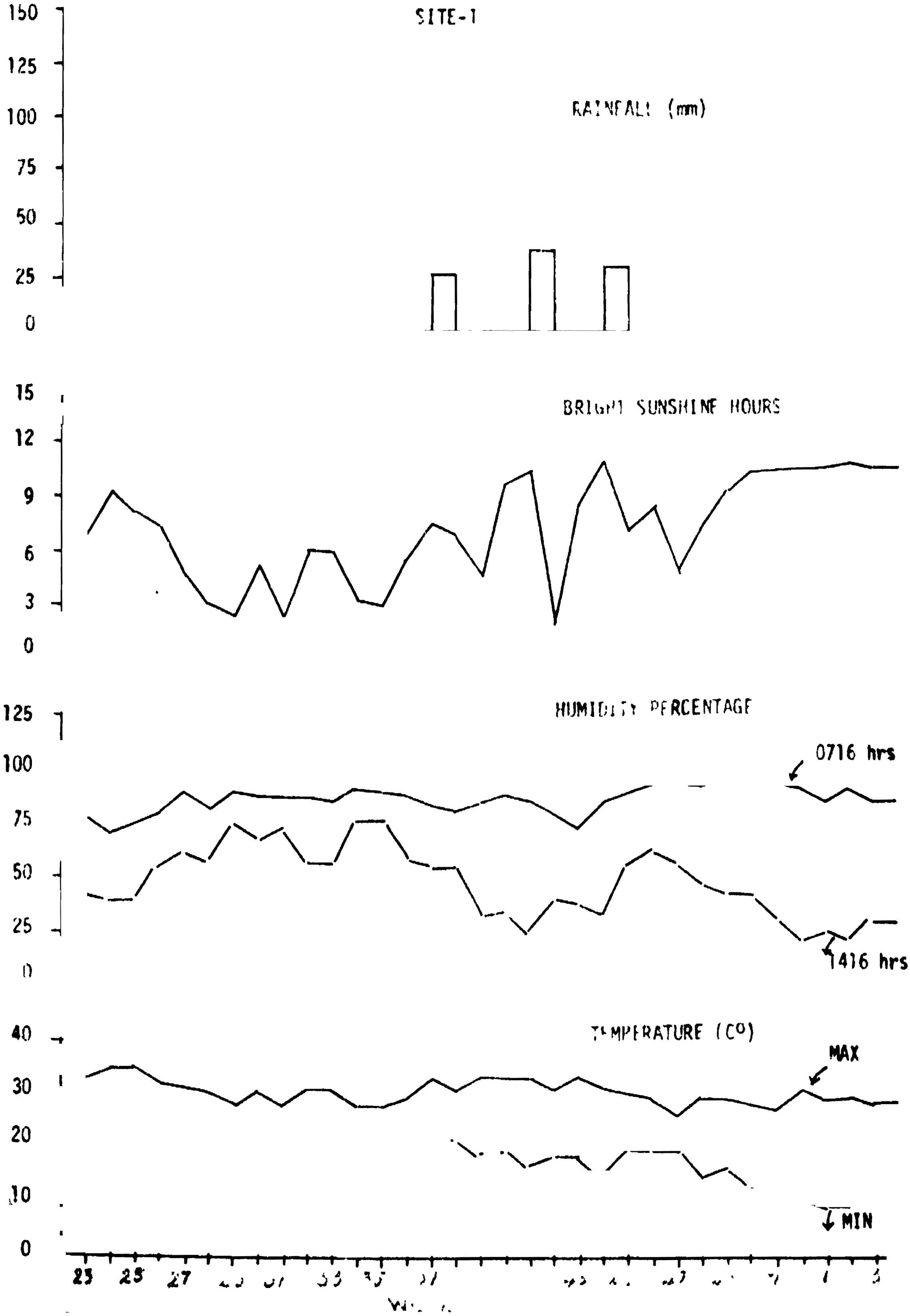


Fig. 1b METEOROLOGICAL DATA AT WEEKLY INTERVA (JUL - DEC , 1 76)

SITE-2

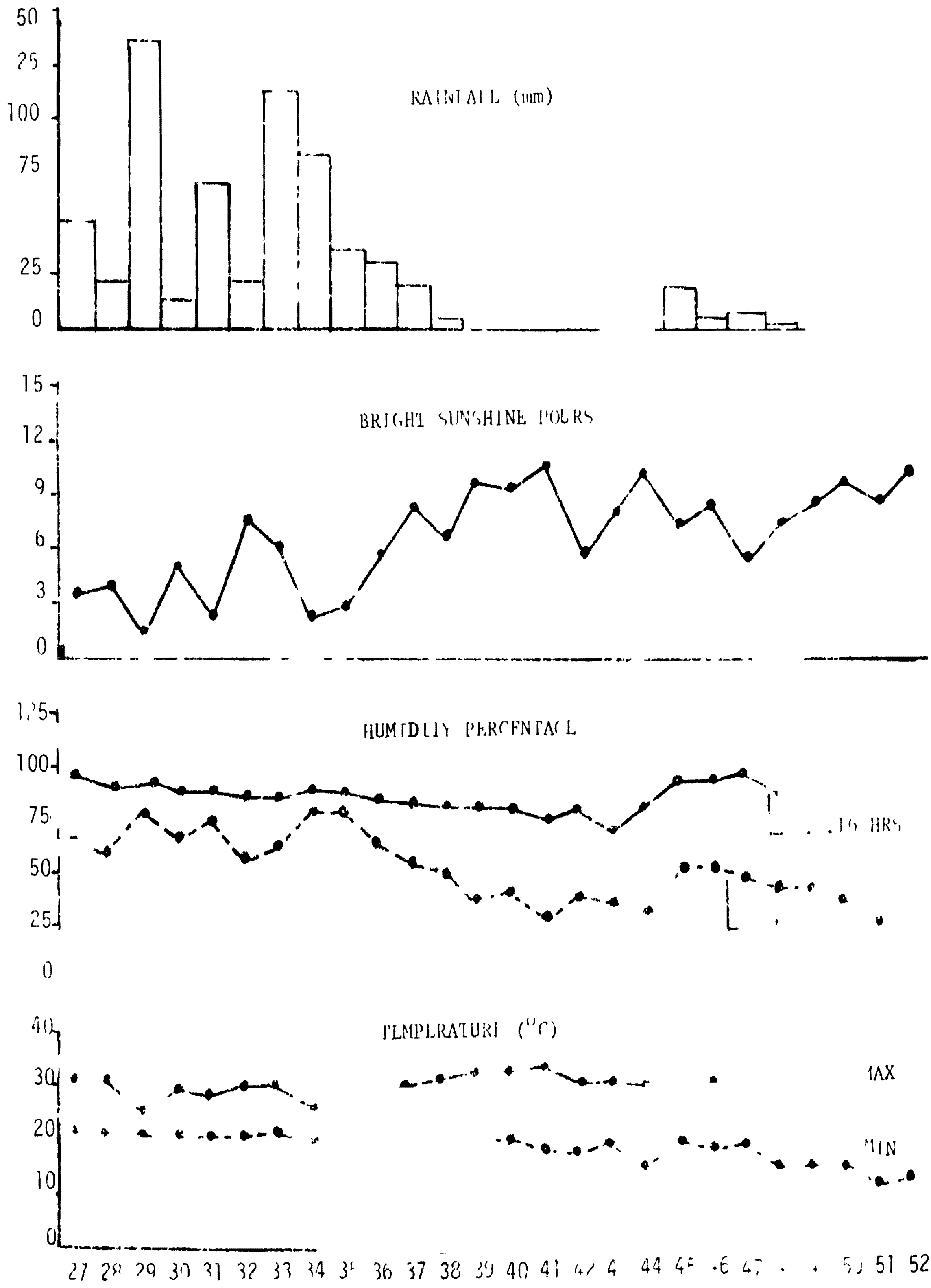


Fig. 2(a)

LAYOUT PLAN - SITE-1

Rep I

N2S2I[illegible]	[illegible]2S1I2	N2S1I1	N2S2I2	N2S3I2	N2S3I3	N2S3I1	N2S1I3	N2S2I1
N1S1I3	1S3I1	N1S2I3	N1S1I1	N1S1I2	N1S2I2	N1S2I1	N1S3I2	N1S3I3
NOS1I2	NOS2I1	NOS3I1	NOS1I3	NOS3I2	NOS2I2	NOS2I3	NOS1I1	NOS3I3

Rep II

N1S1I3	1S1I2	N1S1I1	N1S2I3	N1S2I1	N1S3I3	N1S2I2	N1S3I1	[illegible]S3I2
[illegible]OS2I1	NOS1I3	NOS2I2	NOS1I[illegible]	NOS1I3	NOS3I1	NOS3I2	NOS1I1	NOS3I3
N2S2I2	N2S1I1	N2S3I1	N2S3I2	N2S2I3	N2S1I3	N2S1I2	N2S2I1	[illegible]2S3I3

Rep III

NOS2I1	NOS3I1	NOS3I2	NOS1I3	NOS2I3	NOS1I3	NOS3I3	NOS1I1	NOS2I2
N2S1I2	[illegible]	[illegible]2S2I1	N2S1I1	[illegible]	N2S3I3	N2S2I3	[illegible]S3I2	N2S1I3
N1S1I3	[illegible]	[illegible]3I1	[illegible]	[illegible]1[illegible]3I1	N1S2I1	N1[illegible]I3	N1S2I2	N1S1I1

DESIGN [illegible] REPLICATIONS: 3 TREATMENTS: 27

REFERENCE : [illegible] 0, 40, 80, kg N/ha
S1S2S3 45 cm x 15 cm, 67.5 cm x 10 cm, 90 cm x 7.5 cm.
I1I2I3 - Sorghum monocrop, sorghum/mungbean, sorghum/pigeonpea.

LAYOUT PLAN - SITE-2

Rep I

NOS3I3	NOS3I1	NOS3I2	NOS2I2	NOS2I1	NOS2I3	NOS1I2	NOS1I1	NOS1I3
N1S3I2	N1S1I2	N1S1I3	N1S2I3	N1S2I2	N1S2I1	N1S1I1	N1S3I1	N1S3I3
N2S1I2	N2S1I3	N2S3I2	N2S2I3	N2S1I1	N2S2I1	N2S2I2	N2S3I3	N2S3I1

Rep II

N1S3I2	N1S2I1	N1S2I2	N1S1I1	N1S1I3	N1S3I3	N1S2I3	N1S3I1	1S1I2
NOS3I3	NOS1I2	NOS2I2	NOS3I1	NOS2I1	NOS1I3	NOS3I2	NOS2I3	NOS1I1
N2S3I1	N2S1I2	N2S1I1	N2S2I2	N2S1I3	N2S2I3	N2S2I1	N2S3I2	N2S3I3

Rep III

NOS1I3	NOS2I2	NOS3I3	NOS3I1	NOS1I1	NOS3I2	NOS1I2	[illegible]	NOS2I1
N2S2I2	N2S1I2	N2S1I3	N2S2I1	N2S3I2	N2S1I1	N2S3I1	N2S3I3	N2S2I3
N1S3I3	N1S3I1	N1S1I2	N1S2I2	N1S3I2	N1S2I1	N1S1I1	N1S2I3	N1S1I3

DESIGN : Split-Plot REPLICATIONS: 3 TREATMENTS: 27

REFERCNE : NON1N2 = 0, 40, 80, kg N/ha
S1S2S3 = 45 cm x 15 cm, 67.5 cm x 10 cm, 90 cm x 7.5 cm.
I1I2I3 = Sorghum monocrop, sorghum/mungbean, sorghum/pigeonpea.

Treatment details:

I. Main-plot treatments:

(1) No : Without nitrogen (control)

(2) N1 : 40 kg/ha of nitrogen

(3) N2 : 80 kg/ha of nitrogen

II. Sub-plot treatments: (Cropping Systems)

1. 45 cm x 15 cm - sorghum sole crop
2. 45 cm x 15 cm - sorghum + mungbean one row (15 cm apart in row)
3. 45 cm x 15 cm - sorghum + pigeonpea one row (60 cm apart in row)
4. 67.5 cm x 10 cm - sorghum sole crop
5. 67.5 cm x 10 cm - sorghum + mungbean two rows (15 cm apart in row)
6. 67.5 cm x 10 cm - sorghum + pigeonpea one row (40 cm apart in row)
7. 90 cm x 7.5 cm - sorghum sole crop
8. 90 cm x 7.5 cm - sorghum + mugnbean three rows (15 cm apart in row)
9. 90 cm x 7.5 cm - sorghum + pigeonpea one row (30 cm apart in row)

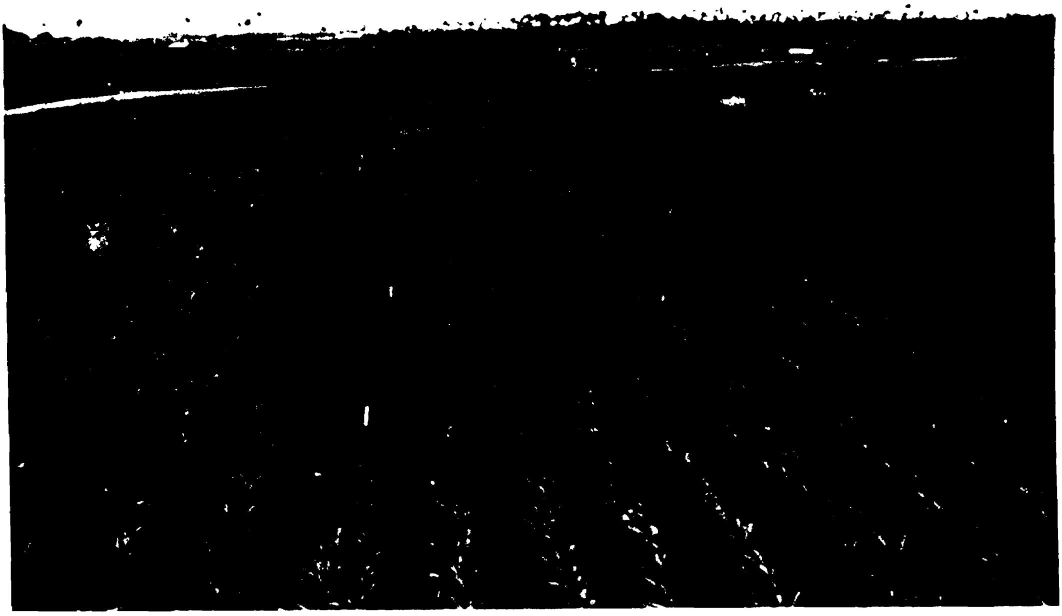
Sorghum and pigeonpea populations were constant in all treatments whereas mungbean population has increased with increase in interrow space level of main crop sorghum. (1.5 lakh at 45 cm, 2 lakhs at 67.5 cm and 2.25 lakhs at 90 cm). Sowing pattern of crops is represented in photos 1-5.

Plot size	Site-1	Site-2
Cross plot size	4.5 m x 5.5 m	3.6 m x 8 m
Net plot size	2.7 m x 4.9 m	2.7 m x 4.9 m

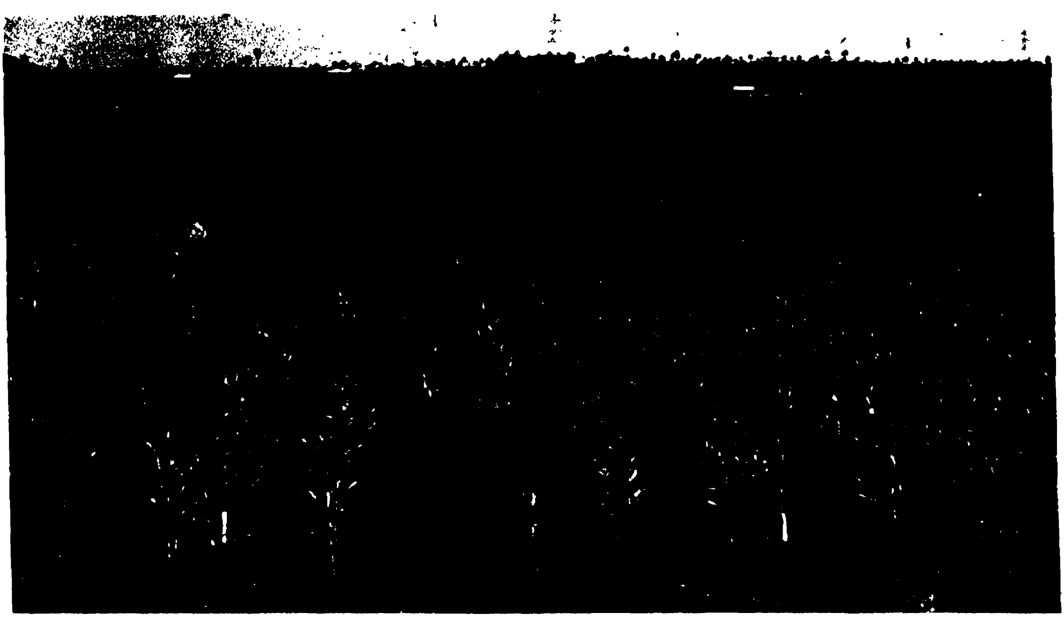
1) L to R: Single row mung intercrop and sole sorghum (45 cm x 15 cm)

(2) L to R: Sole sorghum (67.5 cm x 10 cm and two rows mung intercrop.

5) L to R: Three rows mung intercrop. and sole sorghum (90 cm x 7.5 cm).



4) Early stage general view.



5) Late stage general view.

Cultivation details:

(All the calendar of operations are given in Appendix 2).

Important field operations are given below:

A. **PREPARATORY CULTIVATION:** The field was plowed with tractor; after this cultivator was operated followed by levelling.

B. LAYOUT: Field was laid out as per the plan. In between main plots 0.75 m, and in between sub-plots 0.5 m space was provided.

C. SEEDS AND SOWING: Certified seeds were used. Seeds were hand dibbled.

D. FERTILISER APPLICATION: N was applied as urea in two split doses, 1/4th as basal and 3/4th as top dressing after 21 days of sowing by band placement to the main crop. N was not applied to the legume crops. P was applied in the form of super phosphate at the rate of 22 kg/ha of P_2O_5 as basal dose by broadcast method.

E. PLANT PROTECTION:

Sorghum seed was treated with Furadon chemical and after one week of sowing the same chemical was applied through soil as a precaution against shootfly infestation. Endrin was sprayed on 15th day after planting, granules of this chemical were applied on 22nd day after planting in whorls of sorghum. At site-1, Thiovit, a sulfur compound was sprayed on mungbean against the mild attack of powdery mildew. Periodical weedings were taken up, first weeding was done 12 days after planting and 2nd one after 25 days of planting.

F. HARVESTING: Harvesting of the crops was done with the human labour. No machinery was used.

Experimental observations:

Yield attributes and other plant characters were studied for the main-crop, at site-1. The observations made on the three crops at both the sites are represented in Appendix 3. As a sampling unit 5 plants were selected in each plot at random. Regular observations on plant characters were made at 30 days interval from the planting date.

A. PLANT HEIGHT:

The plant height was measured from the ground level to the uppermost leaf tip before earhead emergence and to the tip of the earhead thereafter.

B. NUMBER OF GREEN LEAVES PER PLANT:

Only fully opened green leaves were counted.

C. SHOOT DRY MATTER PRODUCTION:

Shoot dry matter production was recorded for all three crops at regular intervals of 30 days. Plants were cut at the base and dried in the oven for 24 hrs at 65°C and the weights were recorded.

D. LEAF AREA:

Leaf area for the five plants was taken directly by a photo electric planimeter from each plot. Leaf area index (LAI) was calculated by using the formula:

$$LAI = \frac{\text{Leaf area of the plant}}{\text{Land area occupied by the plant.}}$$

E. EARHEAD LENGTH AND GIRTH:

Earheads from five observational plants were harvested separately for recording length and girth of the earhead and also for the yield per plant.

The length of the earhead was measured from the base to the tip from five earheads and mean was calculated. The girth of the earhead was measured at three places (bottom, middle and top) and mean was calculated per ear.

F. 1000-GRAIN WEIGHT:

The 1000 grain weight was reocrded from the samples collected in the net plot.

G. GRAIN YIELD:

The grain harvested from the net plot was thoroughly cleared and sundried. The yield from each plot was recorded separately as kg/plot and then converted into q/ha (data were collected from both the sites).

H. STRAW YIELD:

Stalks from each net plot were harvested and dried separately. The straw yield from each plot was recorded separately as kg/plot and then converted into q/ha (data were collected from both the sites).

I. GROSS MONETARY RETURNS

Per ha yield of the three crops was converted into monetary returns. The following market values of the produce prevailed at harvest were used for calculations:

Jowar grain	:	Rs.120/quintal
Pigeonpea grain	:	Rs.260/quintal
Mungbean grain	:	Rs.200/quintal
Jowar fodder	:	Rs.10/quintal

(Data were collected from both the sites)

J. HARVEST INDEX:

Harvest indices were calculated for each crop separately and also for the respective combinations by adopting the following formula:

$$\text{Harvest index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where

Economic yield : Grain yield

Biological yield : Shoot dry matter + Grain yield (fallen leaves were excluded)

Chemical analysis:

A. NITROGEN UPTAKE BY GRAIN AND STRAW:

Nitrogen was estimated by Macro-Kjeldal method. Nitrogen concentration was estimated in the grain samples of the three crops, and in the straw of sorghum at maturity in all the plots. Nitrogen was estimated for composite samples collected in the early stages of crop growth. Uptake of nitrogen by grain and straw was calculated for main crop by using the formula:

Uptake of Nitrogen (in kg/ha) = 'N' percentage x grain straw yield (in q/ha)

B. PROTEIN CONTENT OF GRAIN:

The protein content was estimated by multiplying the nitrogen content with factor 6.25. Protein yield was also calculated for each crop individually and for the respective combinations by using the following formula:

Protein yield (kg/ha) : Protein percentage x Grain yield (q/ha)

C. PHOSPHORUS AND POTASH

P & K estimations were made from composite samples only. Phosphorus percentage in the main crop was estimated at 30 days interval in straw and also in grain at the time of harvest. P percentage was also worked out for intercrops at the time of harvest both in grain and straw. Phosphorus was estimated by Vandomolybdo Phosphoric acid yellow color method. Potash was estimated in the grain and straw of sorghum at the time of harvest. Potassium was estimated by Flame Photometer method.

Statistical analysis:

Fisher's analysis of variance method (Fisher, 1948) was used to test the significance of different treatments at 5% level. Standard error of mean and critical difference were calculated wherever required.

Correlation studies:

Simple and partial correlation coefficients between grain yield and other yield attributes were worked out.

RESULTS AND DISCUSSION

Results obtained from the study are presented and discussed hereunder.

Plant height in sorghum:

Data on plant height in sorghum collected at three growth stages 30th, 60th and 90th day of planting are given in Appendix 4. 30 and 60th day plant height trends were similar to 90th day.

Data on plant height recorded at 90 days of crop growth are presented in Table 1 & Figure 3. Statistical analysis of the data given in Table 1 revealed that the effect of nitrogen on plant height was highly significant at all the levels. At 90th day the mean plant height was maximum (162.8) with N 80 level and minimum (142.1 cm) with control. Application of 40 and 80 kg N/ha has resulted in increased plant height by 9.1 and 13.7 per cent respectively over control. The highest level of nitrogen (N 80) recorded taller plants i.e. by 5% against that observed in case of N 40 level. The rate of increase in plant height with increasing nitrogen level was in decreasing order. Increased plant height with increasing level of nitrogen was reported by Reddy (1965), Anonymous (1969-70) and Reddy (1974). All other treatments effect was non-significant for this attribute.

These results indicated that optimum nitrogen nutrition was essential for proper plant growth in sorghum. The increase in plant height with increasing nitrogen levels could be due to higher uptake of N at these levels (Table 10).

Number of green leaves per plant in sorghum:

Data on number of green leaves per plant in sorghum at three gorwth stages are presented in Appendix 4. Mean number of green leaves per-plant

Table: 1 - Plant height (cm) at harvest as influenced by varying levels of nitrogen, spacing and cropping system in sorghum.

LEVEL OF NITROGEN	Spacing S1			Spacing S2			Spacing S3		
	Cropping system I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	142.1	141.5	142.1	143.2	144.1	141.7	140.5	141.7	142.5
N1	155.1	155.2	153.8	152.4	154.8	155.7	154.8	153.0	154.9
N2	164.0	164.3	163.1	162.6	163.1	162.0	163.5	161.4	161.1

Means for Nitrogen N0: 142.14 N1:155.07 N2: 162.78
Means for cropping system I1: 153.1 I2: 153.9 I3: 153.00
Means for spacing S1: 153.5 S2: 153.3 S3: 153.3

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	NS	NS	NS	NS	NS
S. Em ±	0.90	0.67	0.67	1.17 1.31	1.17 1.31	1.17	2.0
C D at 0.05	2.50	-	-	-	-	-	-

Table: 2 Number of green leaves at 60 days crop age as influenced by varying levels of nitrogen, spacing and cropping system in sorghum.

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	7.93	7.60	8.26	8.06	8.06	7.8	.8	7.73	7.8
N1	7.89	8.6	7.67	7.93	8.2	8.2	7.87	8.07	8.33
N2	8.33	8.0	7.93	8.13	8.4	8.73	8.06	8.46	8.33

Means for Nitrogen N0: 7.92 N1: 8.08 N2: 8.27
Means for cropping system I1: 8.02 I2: 8.13 I3: 8.11
Means for spacing S1: 8.09 S2: 8.17 S3: 8.07

Source of variation	(N)	(S)	(I)	(NxS)	(Nxl)	(lxS)	(SxNxl)
'F' test	NS	NS	NS	NS	NS	NS	NS
S. Em ±	0.11	0.17	0.17	0.29	0.29	0.29	0.5
				0.26	0.26		
C D at 0.05	–	–	–	–	–	–	–

Fig 3 SORGHUM

(PLANT HEIGHT (Cm)

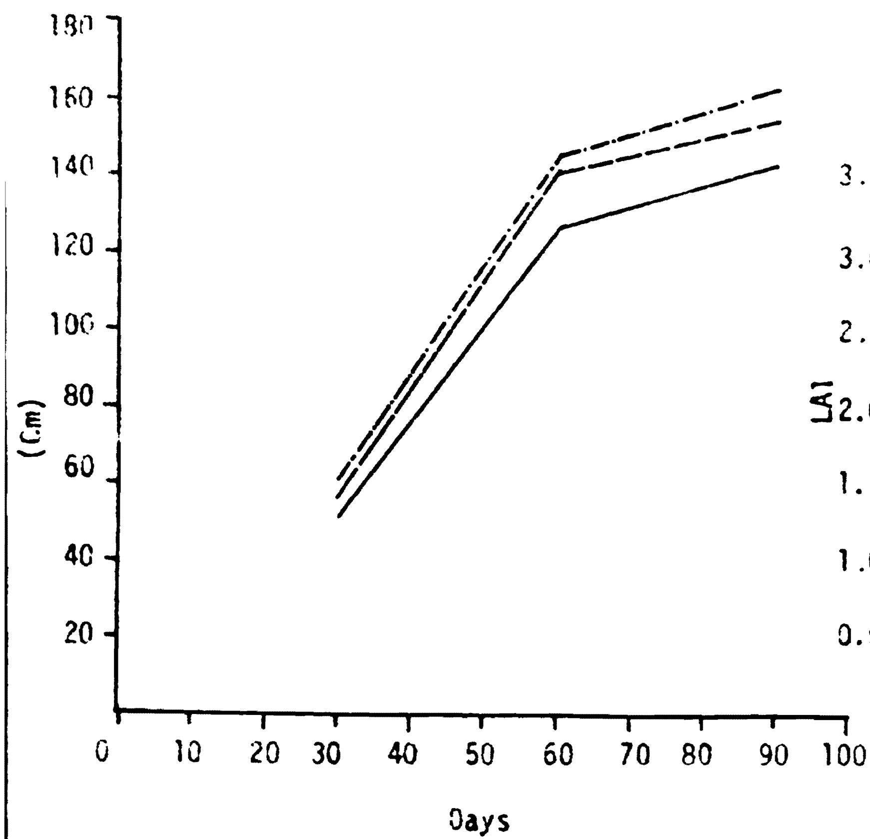
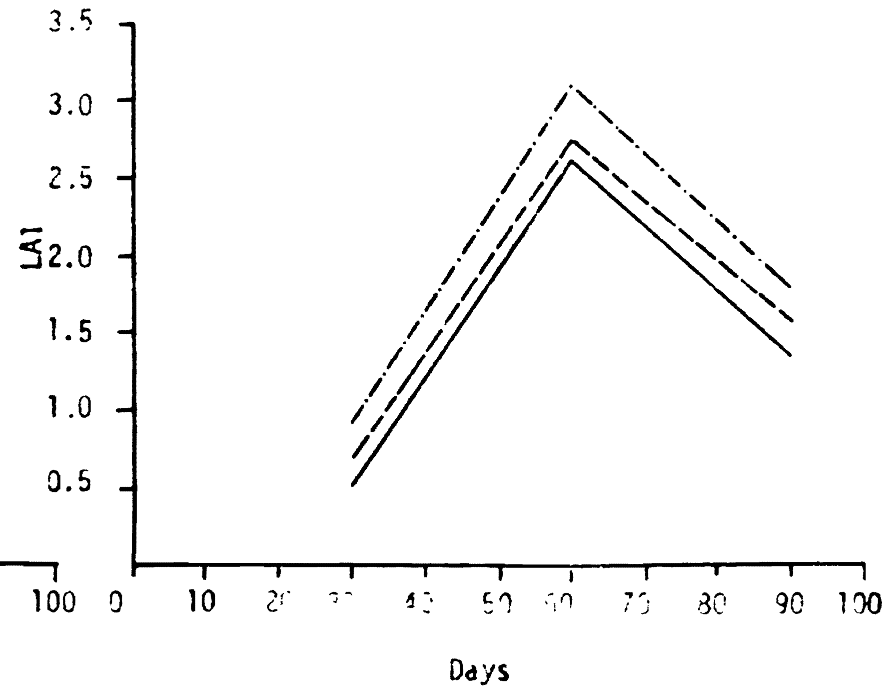


Fig 4 LAI



recorded was maximum on 60th day of crop growth in all the treatments; the number of leaves decreased after 60 days of crop growth due to senescence. Number of green leaves recorded at 60th day is given in Table 2. The treatments under study did not significantly influence the number of green leaves per plant; an increasing trend with increasing nitrogen levels was observed.

Leaf area index (LAI) in sorghum:

LAI was calculated at three growth stages and presented in Appendix 5 and Fig. 4. Maximum LAI was recoreded at 60th day of crop growth in all the treatments, thereafter it decreased due to reduction in number of green leaves Produced by the plants. Data on LAI at 60th day of crop growth was statistically analysed and presented in Table 3. Study of the data given in Table 3 revealed that the difference in LAI recorded at N 80 and No levels was significant whereas the differences between N 80 and N 40, and N 40 and No were not significant. Application of 80 and 40 kg N/ha resulted in increased LAI in sorghum by 11% and 6% respectively over control. Application of 80 kg N/ha increased the LAI by 4% over that recorded at 40 kg level.

These findings are in accordance with the observations made by Rao (1970) and Krishna murthy et al (1976) when increase in LAI of sorghum was recorded with increase in nitrogen level.

Further study of the data given in Table 3 and presented in Fig. 4 revealed that the LAI was high when sorghum was grown as sole crop than when grown along with the intercrops mungbean and pigeonpea.

Increase in LAI with increase in N levels could be due to increased N uptake at these levels (Table 10 and Fig. 10) which might have in turn contributed for good leaf area development.

LAI at 60 days of crop age as influenced by varying levels of nitrogen, spacing and cropping system in sorghum.

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	2.65	2.55	2.57	2.72	2.56	2.55	2.62	2.55	2.55
N1	2.83	2.77	2.74	2.88	2.78	2.76	2.82	2.75	2.76
N2	2.94	2.86	2.85	2.99	2.9	2.88	3.00	2.85	2.84

Means for Nitrogen N0: 2.6 N2: 2.78 N3: 2.90

Means for cropping system I1: 2.82 I2: 2.70 I3: 2.72

Means for spacing S1: 2.75 S2: 2.78 S3: 2.74

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	NS	NS	NS	NS	NS
S. Em ±	0.14	0.37	0.37	0.65	0.65	0.65	1.1
C D at 0.05	0.29	-	-	0.55 -	0.55 -	-	-

Drymatter production:

Information recorded on drymatter accumulation pattern of the experimental crops is shown in Appendix 5 & 6 and in Fig. 5. Data on drymatter production of the crops at maturity are given Table 4.

A. Sorghum

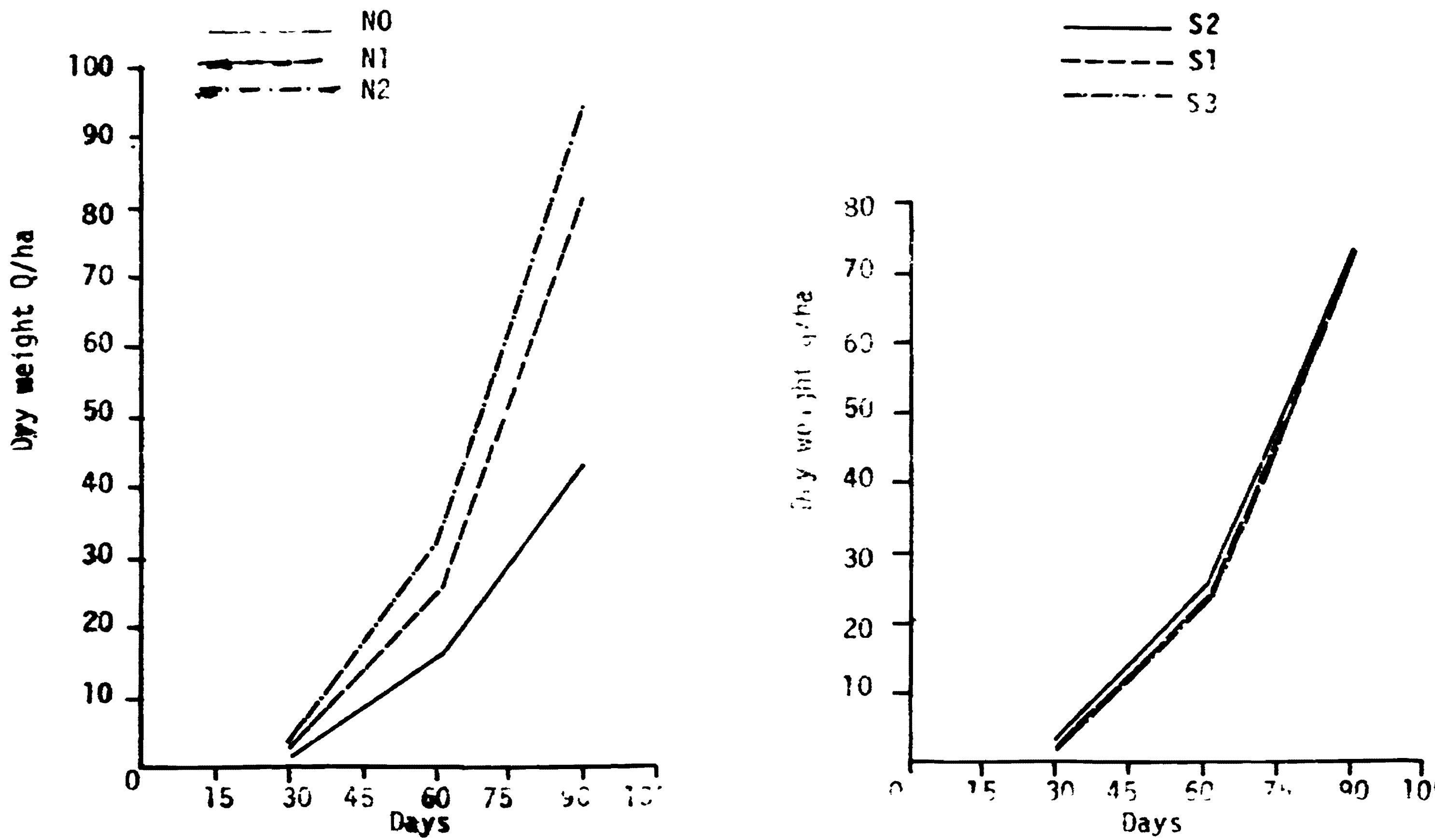
Influence of the main factors on drymatter production in sorghum was significant. Interaction between nitrogen and spacing was also significant for this attribute. The drymatter production with 40 and 80 kg N/ha was higher by 84 and 117 per cent than that for the control (N0) respectively.

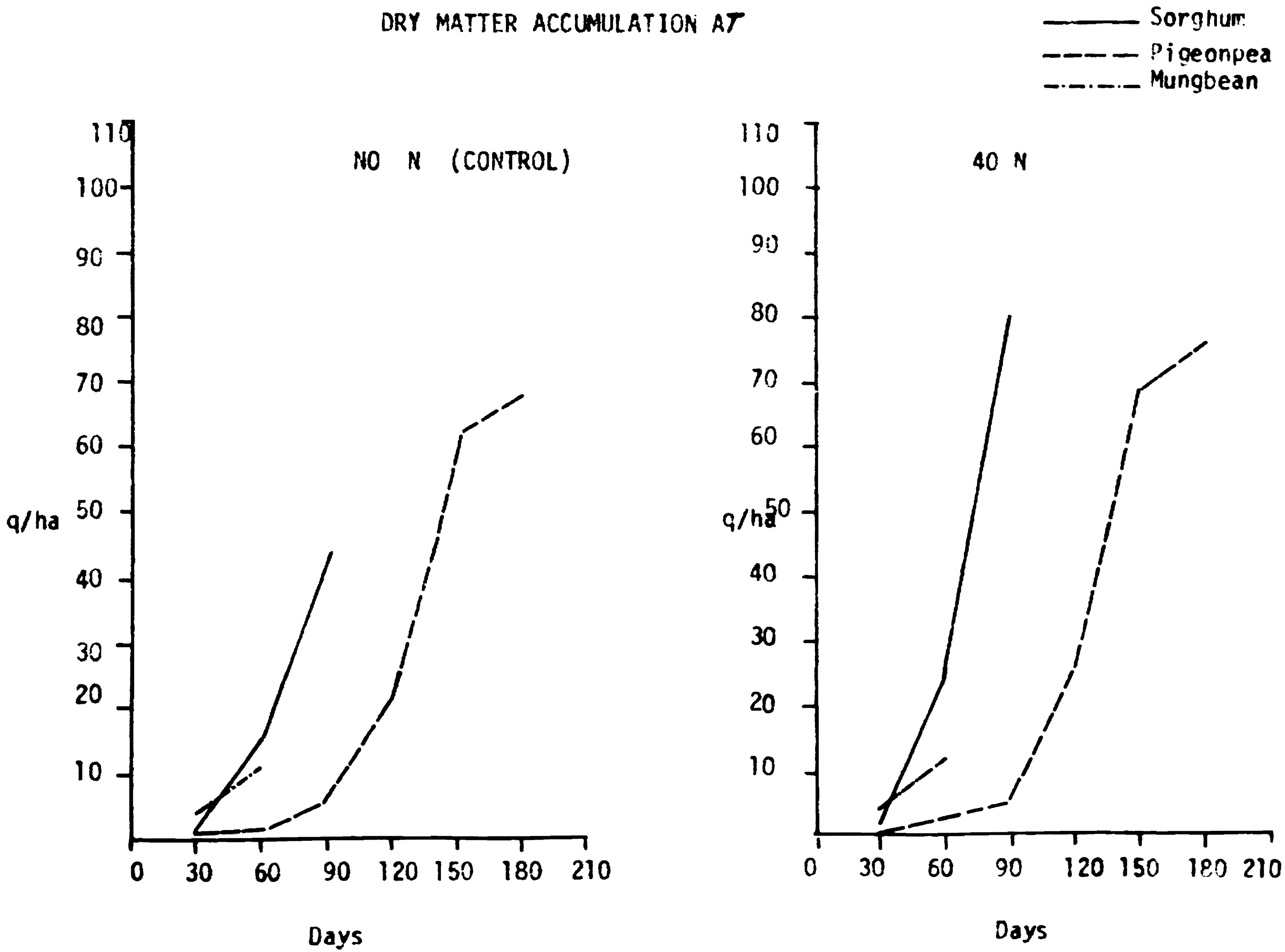
The spacing treatment 67.5 cm x 10 cm (S2) has given significantly higher drymatter yield than that of spacing treatment 45 cm x 15 cm (S1) and the treatment 90 cm x 7.5 cm (S3). The treatment S1 and S3 were on par with each other in drymatter production.

The treatment sole sorghum (I1) produced significantly higher drymatter in sorghum crop than that of sorghum/mungbean (I2) and sorghum/pigeonpea (I3). The difference between I2 and I3 was not significant.

The interaction between spacing and nitrogen levels was significant. Comparing the effects of spacing treatments under each N level, at 80 kg N/ha spacing treatment S2 produced significantly higher drymatter than that recorded against S1 and S3, which were on par with eachother. At 40 kg N/ha S1 was superior to S3 where as the difference between S1 and S2, and S2 and S3 were not significant. This trend was noticed in the control (NO) also.

Fig 5 SORGHUM DRY MATTER ACCUMULATION PATTERN UNDER DIFFERENT NITROGEN AND SPACINGS





DRY MATTER ACCUMULATION AT
Sorghum
Pigeonpea
Mungbean
NO N (CONTROL)
40 N
q/ha
Days
0 30 60 90 120 150 180 210
10 20 30 40 50 60 70 80 90 100 110

Table: 4a Drymatter yield (q/ha) at harvestas influenced by varying levels of nitrogen, spacing and cropping system in sorghum

LEVEL OF NITROGEN	Spacing S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I 2	I3	I1	I2	I3
NO	44.3	42.1	40.63	45.43	44.61	43.31	44.9	42.37	42.83
N1	81.48	80.17	80.00	82.0	78.5	77.83	81.67	79.33	79.67
N2	94.33	93.45	92.91	96.07	95.4	94.97	94.38	93.78	92.47

Means for Nitrogen No. 43.39 N1: 80.07 N2: 94.2
Means for cropping system I1: 73.84 I2: 72.19 I3: 71.63
Means for spacing S1: 72.15 S2: 73.13, S3: 72.38

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	Sig	Sig	Sig	NS	NS	NS
S. Em ±	0.44	0.29	0.29	0.5 0.6	0.5 0.6	0.6	0.85
C D at 0.05	1.21	0.57	0.57	1.00 1.44	-	-	-

Similarly comparing the effect of N under each spacing, application of 80 Kg N/ha produced significantly higher drymatter than 40 kg N/ha and control. At all spacings, in the same way, 40 kg N/ha under all spacings has recorded significatnly higher drymatter than that recorded with control.

The increase in drymatter production in sorghum at higher nitrogen levels was mostly through higher leaf area index (Table 3 and Fig. 4) and higher grain yield (Table 9 and Fig. 9). The higher leaf dry weight and grain could be due to higher uptake of nitrogen and better nutrition of the plant on account of increase in the level of nitrogen application (Table 10 Fig. 10). Sorghum in I1 has given higher drymatter than that recorded in I2 and I3. This could be due to inter-crop competition in I2 and I3 for nutrients and for other essential plant requirements. Reddy (1965) and Balaiah (1974) observed that N fertilization increased the drymatter yield.

B. Mungbean:

Nitrogen fertilization and spacing treatments significantly influenced the drymatter production in mungbean. Application of nitrogen to sorghum at 40 and 80 kg N/ha produced 13 and 20 per cent higher drymatter respectively over the control. The mungbean grown in 90 cm inter-row spacing of sorghum has given maximum drymatter production of 12.8 q/ha which was 16 percent higher than that recorded in 45 cm inter-row spacing of sorghum. The crop in 67.5 cm inter-row spacing of sorghum also recorded 11 per cent higher drymatter than that noticed in 45 cm inter-row spacing treatment. The differences between S1 and S2, and S2 and S3 were not significant for drymatter yield.

Table: 4b Drymatter yield (q/ha) at harvest stage as influenced by varying levels of nitrogen, spacing in mungbean

LEVEL OF NITROGEN	Spacing			Mean
	S1	S2	S3	
NO	9.22	11.31	12.06	10.9
N1	11.48	12.5	12.8	12.27
N2	12.5	13.16	13.5	13.05
Mean	11.07	12.32	12.8	

Source of variation	'F' test	S.Em ±	C D at 0.05
Nitrogen	Sig	0.44	1.22
Spacing	Sig	0.64	[illegible].39
Nitrogen x Space	NS		

Incr ase in drymatter yield in mungbean with increase in inter-row spacing of sorghum could be due to accomodation of more plants of mungbean in the wider inter-row spacings (67.5 cm and 90 cm) of sorghum than closer inter-row spacing of 45 cm. The magnitude of difference in drymatter production due to sorghum spacing treatments was not found corresponding to the difference in plant population in mungbean. This could be due to increased dropping of leaves at higher population level against that noticed in lower level of population.

C. Pigeonpea:

The effect of nitrogen fertilization to sorghum on the companion crop of pigeonpea was significant. Increase in drymatter by 10 per cent with 40 kg N/ha, and 19 per cent with 80 kg N/ha over control was observed.

Narayanan and Scheldrake (1976) reported that pigeonpea has produced higher drymatter at 120 kg N/ha over 22 kg N/ha. Though the intercrops were not fertilized with nitrogen their drymatter production substantially increased with increase in nitrogen level applied to the maincrop of sorghum. This could be due to higher availability of nitrogen as a result of increased application of the nutrient per unit area, and this might have enabled the plants to utilize higher amounts of nitrogen.

D. Total Drymatter:

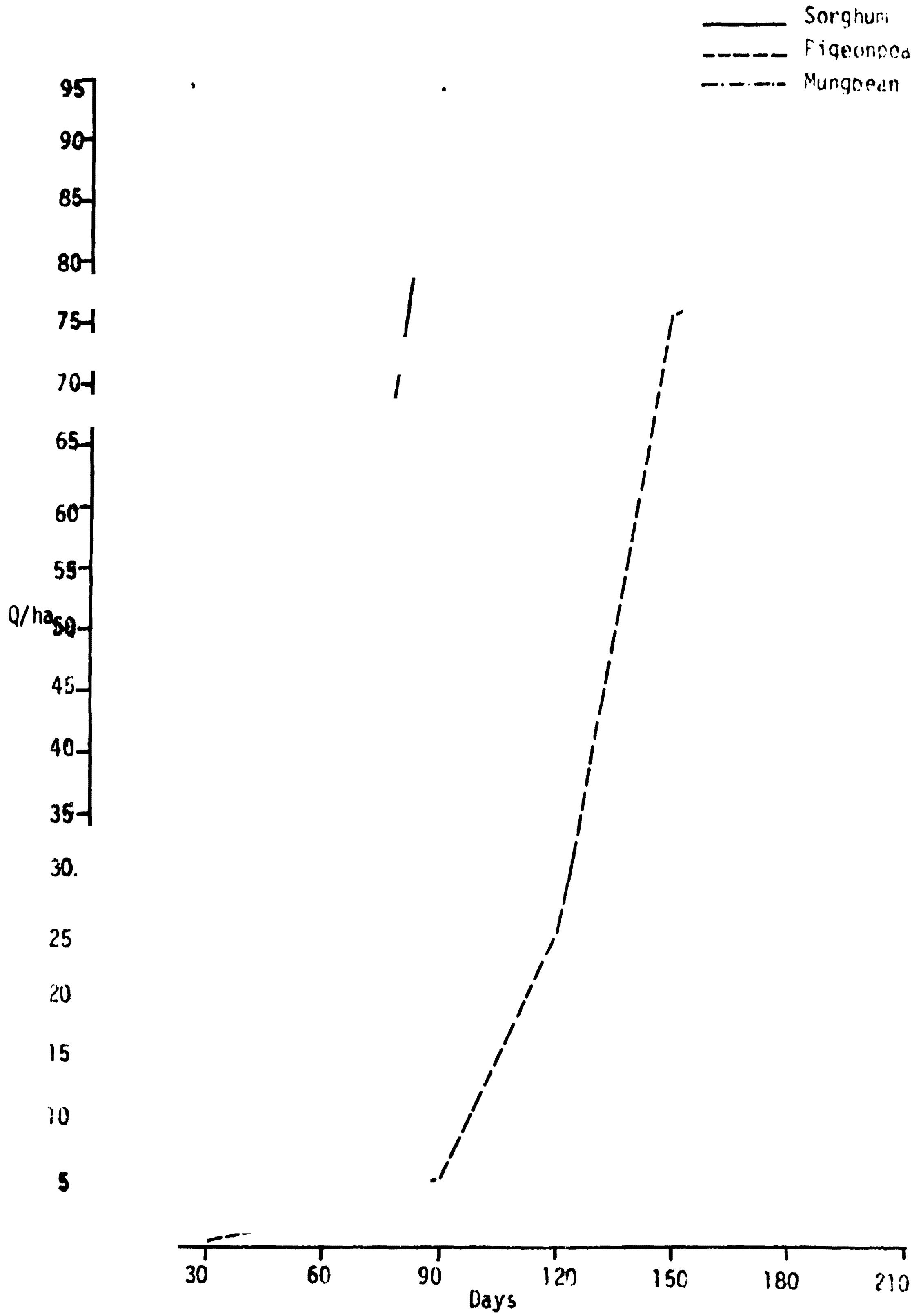
Data on total drymatter production of the crops studied under different cropping system treatments at harvest is given in Table 4. Statistical analysis of data on total drymatter production revealed that application of 80 and 40 kg N/ha produced 82 and 58 per cent higher figures respectively over control.

Table: 4c Drymatter yield (q/ha) as influenced by varying levels of nitrogen, spacing, in pigeonpea.

LEVEL OF NITROGEN	Spacing S1	S2	S3	Mean
N0	68.5	68.9	67.3	68.2
N1	75.0	75.3	76.06	75.4
N2	81.7	80.8	81.2	81.2
Mean	75.08	75.04	74.8	

Source of variation	'F' test	S.Em ±	CD at 0.05
Nitrogen	Sig	1.2	3.33
Spacing	NS	0.96	-
Nitrogen x Space	NS	1.66	-

Fig 5 DRY MATTER ACCUMULATION PATTERN OF THE THREE CROPS AT 80N LEVEL



Significantly higher drymatter was produced by S2 than that recorded against S1 and S3. S2 has given maximum total drymatter of 100 q/ha. The cropping systems I2 and I3 produced 5 and 98 per cent respectively higher drymatter than that observed, with cropping system I1.

The interaction between nitrogen and spacing was significant. At 80 kg N/ha, S2 recorded the highest amount of totaldrymatter; the difference between S2 and S3 was not significant. At 40 kg N/ha level the differences among the spacing treatments were not significant. In control (N0) the difference between S2 and S3,and S3 and S1 were not significant; the treatment S2 has given significantly higher drymatter yield compared to that at S1.

At all the spacings, 80 kg N/ha produced more total drymatter than that N 40 level and control. Treatment 40 kg N/ha produced significantly higher drymatter in all spacings than that at control (N0). Total drymatter produced by S2 at N80 level was recorded as the highest against the other treatment combinations.

At all the nitrogen levels, I3 produced significantly higher amount of drymatter than that recorded against I1 and I2; and I2 was superior in its effect over control. In all the cropping systems higher nitrogen level N80 produced greater quantities of total drymatter than the other two levels. Control recorded lower drymatter than N40 in all the cropping systems.

The interaction between I3 and N80 produced maximum total drymatter (Table 4). The higher drymatter production in I3 over I1 and I2 could be due to higher contribution of drymatter by the intercrop-pigeonpea against that observed in a combination of sorghum mungbean and sorghum alone. Drymatter production at N80 level was recorded as maximum in all the three cropping systems and this is attributed to increased uptake of nitrogen as a result of higher application of the nutrient.

Table: 4d. Total drymatter yield (q/ha) at harvest stage as influenced by varying levels of nitrogen, spacing and cropping system

LEVEL OF NITROGEN	Spacing S1			S2			S3		
	Cropping system I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	44.3	45.9	109.14	45.43	49.15	112.21	44.9	47.97	110.13
N1	81.48	84.39	155.04	82.0	84.16	153.13	81.07	85.6	155.07
N2	94.33	97.95	174.61	96.07	101.78	175.77	94.38	100.9	173.67

Means for Nitrogen N0: 67.68 N1: 106.95 N2: 123.27
Means for cropping system I1: 73.84 I2: 77.54 I3: 146.53
Means for spacing S1 98.57 S2:99.97 S3: 98.37

Source of vatiation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	Sig	Sig	Sig	Sig	NS	NS
S. Em ±	0.71	0.47	0.47	0.81 0.97	0.81 0.97	0.81	1.4
C D at 0.05	1.98	0.93	0.93	1.62 2.35	1.62 2.35	-	-

Length and girth of earhead in sorghum:

Length and girth of earhead in sorghum was statistically analysed and data were presented in table 5 & fig. 6.

A. EARHEAD LENGTH:

Earhead length in sorghum increased significantly with every increment in N level. Maximum length was recorded at N80 level (28.9 cm) and a minimum against control (21.6 cm). Application of 40 and 80 kg N/ha increased earhead length by 22.1 and 34.1 percent respectively over control.

The earhead length of sorghum grown in cropping system - 1, (26.3 cm) was significatnly higher than that when the crop was grown under cropping system-3 (25.1 cm). Cropping systems I1 and I2 and, I2 and I3 were on par for this attribute.

Correlation between grain yield and length of earhead (0.967) and, per plant yield and length of earhead (0.965) were highly significant.

B. EARHEAD GIRTH:

Earhead girth increased significantly with N40 and N80 levels over control(No.): N40 and N80 levels were on par. Maximum (9.46 cm) earhead girth was noticed at N80 and minimum (7.42 cm) at control. Increase in the girth due to application of 40 and 80 kg N/ha was 22.5 and 27.5 per cent respectively over control.

The earhead girth (9.2 cm) of sorghum grown in cropping system-1 was significantly superior over that (8.2 cm) recorded in the same crop against the cropping system-I3. Cropping systems 1 and 2, and also 2 and 3 were on par for the attribute under discussion. Correlations between grain yield and girth of the earhead (0.964) and, per plant yield and girth of the earhead (0.936) were highly significant.

Fig 6 EAR HEAD LENGTH OF SORGHUM (Cm)

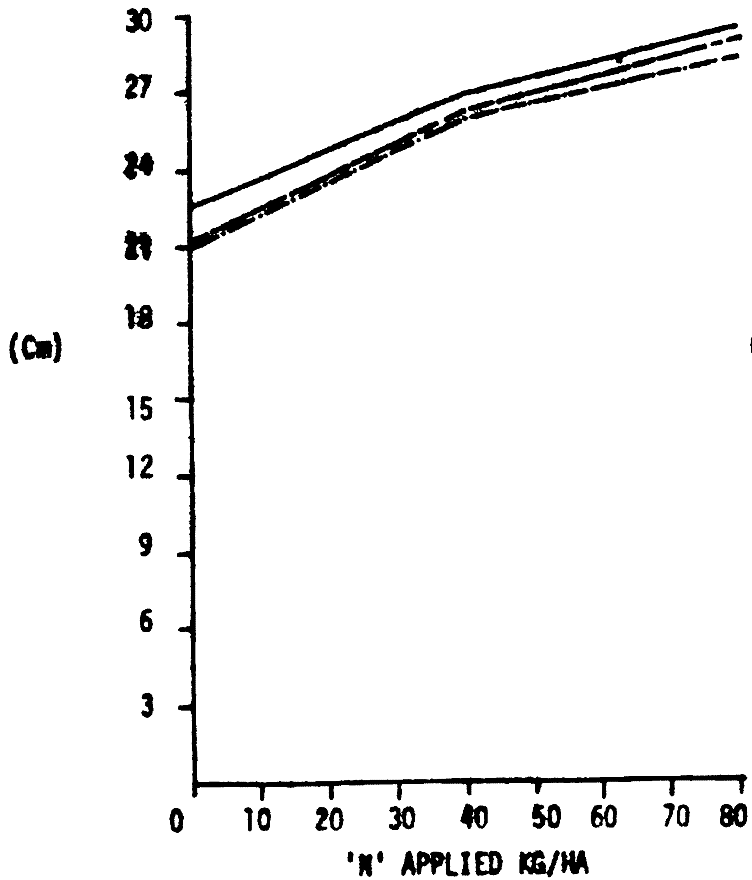


Fig.6 EARHEAD GIRTH (Cm) OF SORGHUM

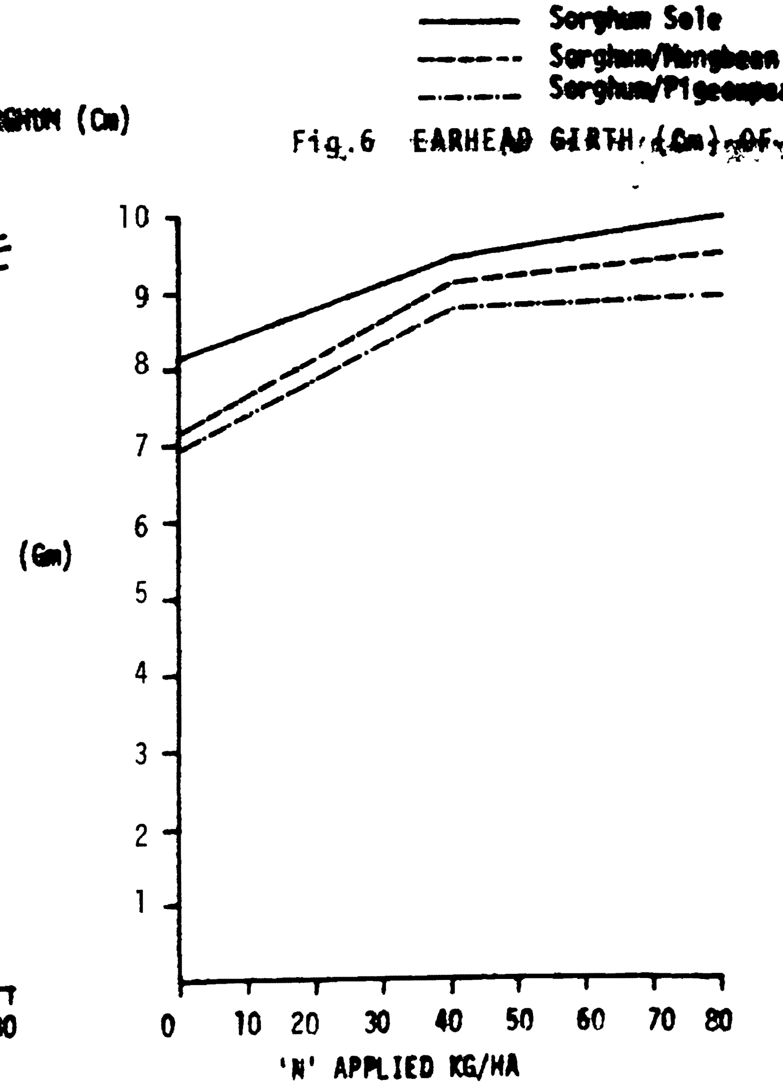


Table: 5a Earhead length (cm) as influenced by varying levels of nitrogen, spacing and cropping system in sorghum

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	22.47	21.17	21.13	22.57	21.57	20.93	22.33	20.9	20.97
N1	26.93	25.93	25.47	27.13	27.0	26.46	26.7	25.93	25.46
N2	30.17	29.17	28.33	27.47	28.57	28.37	30.4	29.2	28.43

Means for Nitrogen N0: 21.55 N1: 26.37 N2: 28.9
Means for cropping system I1: 26.24 I2: 25.5 I3: 25.06
Means for spacing S1: 25.64 S1: 25.56 S2: 25.59

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em ±	0.32	0.41	0.41	0.71	0.71	0.71	1.2
C D at 0.05	0.95	-	0.81	0.66 -	0.66 -	-	-

Table: 5b Earhead girth (cm) as influenced by varying levels of nitrogen, spacing and cropping system in sorghum

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	8.06	7.1	7.06	8.1	7.4	6.9	8.23	7.06	6.87
N1	9.53	9.03	9.06	9.5	9.13	8.9	9.27	9.07	8.3
N2	10.0	9.67	9.03	9.93	9.4	8.87	9.77	9.5	9.0

Means for Nitrogen N0: 7.42 N1: 9.09 N2: 9.46
Means for cropping system I1: 9.15 I2: 8.59 I3: 8.22
Means for spacing S1: 8.73 S2: 8.68 S3: 8.56

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em ±	0.68	0.77	0.67	0.13 0.12	0.13 0.12	0.13	2.3
C D at 0.05	1.18	-	0.92	-	-	-	-

The higher values for earhead length and earhead girth in sorghum at higher N levels of nitrogen could be a consequence of better growth components (plant height and LAI) expressed by sorghum crop at these levels. These in turn, have possibly resulted in increased photosynthetic efficiency and higher net assimilation rate (NAR) over control. Krishna Murthy et al, 1973 reported similar results. In addition to this, drymatter accumulation was also higher at high nitrogen levels (40 and 80 kg/ha) over control (Table 4 & Fig. 5). At these high N levels accumulation of nitrogen in grain was also high (Table 10 and Fig. 10).

The present findings are in confirmity with the observations made by Reddy (1965), Reddy (1969) and, Prem Singh and Choubey (1973).

Lower values of yield characters (length and girth of earhead) in sorghum, recorded with cropping systems I2 and I3 against those found with I1 (Table 5) could be attributed to reduction in quantities of nutrients available or account of competition of the crop with the companion crop (mungbeans or pigeonpea).

1000 grain weight in sorghum:

Statistical analysis of the data on 1000 grain weight (Table - 6) revealed significant increase in 1000-grain weight due to application of nitrogen at 40 (N1) and 80 (N2) kg/ha levels with a respective increase of 18.4 and 20.3 per cent against control. The treatment N2 recorded maximum 1000 grain weight (27.25 gm) and control the minimum (22.62 gm). The effects of treatments N1 and N2 were on par. The phenomenon of increase in the 1000 grain weight due to increase in the quantity of nitrogen applied could be attributed to higher translocation of the nutrients to developing grain favoured by increased application of the nutrient.

Table: 6 Test weight (gm) as influenced by varying levels of nitrogen, spacing and cropping system in sorghum

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	23.31	23.02	22.78	22.83	22.96	22.71	22.49	21.7	21.8
N1	26.20	25.79	25.5	26.14	26.41	25.57	25.57	25.26	25.67
N2	27.53	26.44	26.78	27.99	26.83	26.7	28.14	27.4	27.32

Means for Nitrogen N0: 22.62 N1: 26.79 N2: 27.25
Means for cropping system I1: 25.58 I2: 24.98 I3: 26.09
Means for spacing S1: 26.37 S2: 25.24 S3: 25.04

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	NS	NS	NS	NS	NS
S. Em $\pm$	1.02	0.9	0.9	1.5	1.5	1.5	2.7
C D at 0.05	2.84	-	-	1.6 -	1.6 -	-	-

Yield per plant in sorghum:

Data on yield per plant are presented in Table 7 and Fig. 7. Statistical analysis of the data given in Table 7 revealed an increase in the yield per plant with increased application of N. Mean per plant yield was at maximum (21.9 gm) in N80 and least (12.5 gm) was in control. Application of and 80 kg N/ha resulted in an increased per plant yield by 57.7 and 76.5 per cent over no nitrogen respectively.

The increase in per plant yield at higher N levels might be due to increase in earhead length, earhead girth and 1000 grain weight. (Table 5 & 6)

Tatwadi and Chowdhari (1976) reported that increase in N level from 50 to 150 kg N/ha increased the yield per plant in sorghum. Cropping system - 1 yield per plant of sorghum was significantly higher than that in cropping systems 2 and 3; the cropping systems 2 and 3 were on par. Cropping systems 2 and 3 recorded decrease in yield per plant by 7.5 and 9 per cent over cropping system-1 respectively.

This decrease in the yield per plant in cropping systems and 2 and 3 could be attributed to the lower values of earhead length and girth reocrded in these systems against that recorded in cropping system-1.

Simple correlations made between grain yield and yield per plant (0.982), nitrogen uptake by grain and yield per plant (0.958), leaf area index and yield per plant (0.818), shoot drymatter production and yield per plant (0.968), 1000 grain weight and yield per plant (0.949), length of the earhead and yield per plant (0.965) and, girth of the earhead and yield per plant (0.936) were significant.

Fig 8

PROTIEN YIELD

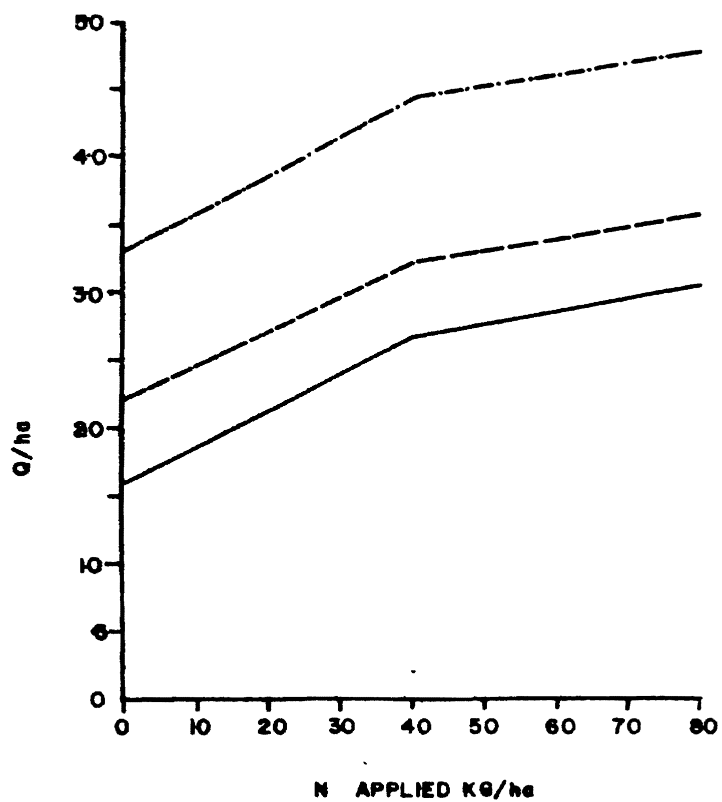


Fig. 7 PER PLANT YIELD (Gm) SORGHUM

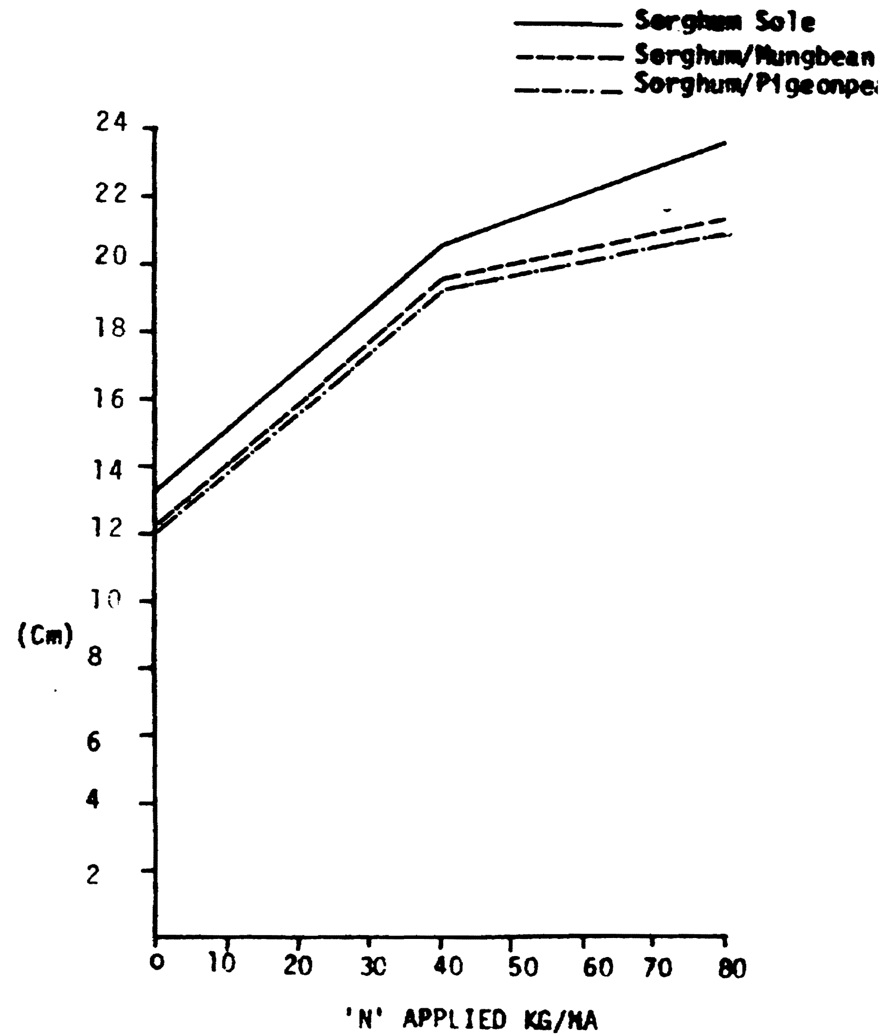


Table: 7 Yield plant (gm) as influenced by varying levels of nitrogen, spacing and cropping system in sorghum

LEVEL AT NITROGEN	Spacing S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	13.44	12.72	12.36	12.94	11.4	11.66	13.33	12.5	12.16
N1	20.33	19.36	19.0	20.33	19.66	19.5	20.93	19.33	19.16
N2	26.33	21.33	21.66	22.16	21.13	20.66	22.16	21.13	20.33

Means for Nitrogen No: 12.50 N1: 19.73 N2: 21.88
Means for cropping systems I1: 19.10 I2: 17.62 I3: 17.39
Means for spacing S1: 18.50 S2: 17.71 S3: 17.89

Source of variation	(N)	(S)	(I)	(NxS)	(Nxl)	(lxS)	(SxNxl)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em ±	0.39	0.34	0.34	0.59 0.62	0.59 0.62	0.59	1.0
C D at 0.05	1.09	-	0.68	-	-	-	-

Straw yield of sorghum:

Data collected on straw yield of sorghum at the two sites was statistically analysed and presented in Table - 8. The average yield of all the treatments were higher at site - 1, than at site - 2. Nitrogen fertilisation influenced the straw yield significatnly at both the sites, and application of 40 and 80 kg N/ha resulted in an increase of 50 and 93 per cent respectively over control at site - 1. Site - 2 data also followed similar trend.

The increase in the straw yield at high nitrogen levels could be due to increased plant height and leaf area index at these levels (Tables 1 & 3).

Similar observations were made by Roy and Wright (1971) and Balaiah (1975).

Grain yield:

Grain yield data of the experimental crops obtained from Site-1 and Site-2 were analysed statistically and presented in Table 9. Yield data from the two experimental sites (Table 9 and Fig. 9) revealed that the test crops at site-1 recorded higher yield than the same crops grown at site-2. The yield trends at both the sites were generally identical. Details are discussed hereunder.

A. SORGHUM (SITE-1)

The differences in grain yield of sorghum due to nitrogen levels were significant and maximum yield of 27.95 q/ha grain was realised at the highest level of nitrogen (80 kg N/ha) followed by 40 kg N/ha (25.39 q/ha) and the minimum yield of 16.7 q/ha was recorded in the control (NO) treatment. There was an increase 52 and 68 per cent over the control at the 40 and 80 kg N/ha levels, respectively.

Table: 8a Sundried fodder yield (q/ha) at site one as influenced by varying levels of nitrogen, spacing and cropping system in sorghum

LEVEL OF NITROGEN	Spacing S1			S2			S3		
	Cropping system I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	22.77	22.67	22.5	23.07	21.57	22.1	23.4	23.07	19.8
N1	35.43	33.13	32.97	32.43	32.37	36.07	34.1	32.93	32.97
N2	43.1	40.97	40.33	44.53	44.9	44.1	42.33	42.83	42.86

Means for Nitrogen N0: 22.33 N1: 33.6 N2: 43.0
Means for cropping system I1: 33.46 I2: 32.71 I3: 32.74
Means for spacing S1: 32.65 S2: 33.46 S3: 32.81

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	NS	NS	NS	NS	NS
S. Em ±	0.40	0.75	0.75	1.3 1.13	1.3 1.13	1.3 1.3	2.25
C D at 0.05	1.13	-	-	-	-	-	-

Table: 8b Sundried fodder yield (q/ha) at site two as influenced by varying levels of nitrogen, spacing and cropping system in sorghum

LEVEL OF NITROGEN	Spacing S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	21.1	22.67	21.5	21.07	20.2	21.03	21.63	19	19.7
N1	22.33	30.97	30.07	30.03	30.0	30.33	31.97	30.07	29.67
N2	43.4	40.23	39.33	43.53	42.23	42.87	41.0	41.47	40.53

Means for Nitrogen N0: 20.88 N1: 29.53 N2: 41.66
Means for cropping system I1: 30.67 I2: 30.63 I3: 30.56
Means for spacing S1: 30.18 S2: 31.32 S3: 30.56

Source of variation	(N)	(S)	(I)	(NxS)	(Nxl)	(lxS)	(SxNxl)
'F' test	Sig	NS	NS	NS	NS	NS	NS
S. Em ±	0.67	1.0	1.0	1.73 1.53	1.73 1.53	1.73	3.00
C D at 0.05	1.88	-	-	-	-	-	-

Intercropping with mungbean (I2) as well as pigeonpea (I3) resulted in slight but significant decrease in grain yield of sorghum in comparison with the sole sorghum (I1) grain yield. The decrease in sorghum grain yield was 8 and 11 per cent respectively when intercropped with mungbean and pigeonpea. These grain yield differences were not significant.

The grain yield differences in three spacings (45 cm x 15 cm), (67.5 cm x 10 cm) and (90 cm x 7.5 cm) were not significant. This indicated the ability of sorghum to adjust with changes in inter and intra-row spacings so long as the plant population per unit area was same.

The interactions between various factors were not significant.

B. Sorghum (Site-2):

Application of N (N40 and N80) increased the grain yiled of sorghum significantly over the control (N0) treatment while there was no significant difference between N40 and N80. The maximum grain yield of 26.85 q/ha was recorded at N80 level followed by that of 40 kg N/ha (23.91 q/ha) and the minimum grain yield of 13.29 q/ha was recorded against control (N0). This represented an increase in grain yield of 80 and 102 per cent over control with the application of 40 and 80 kg N/ha respectively.

Intercropping with pigeonpea (I3) reduced the sorghum yield significantly (7 per cent) compared to sole cropping of sorghum while its yield in mungbean intercropped treatment was on par with it. The grain yield differences due to spacing treatments were not significant as was observed in site-1. Similarly the interactions were also not significant in this respect.

g 9 SORGHUM GRAIN YIELD

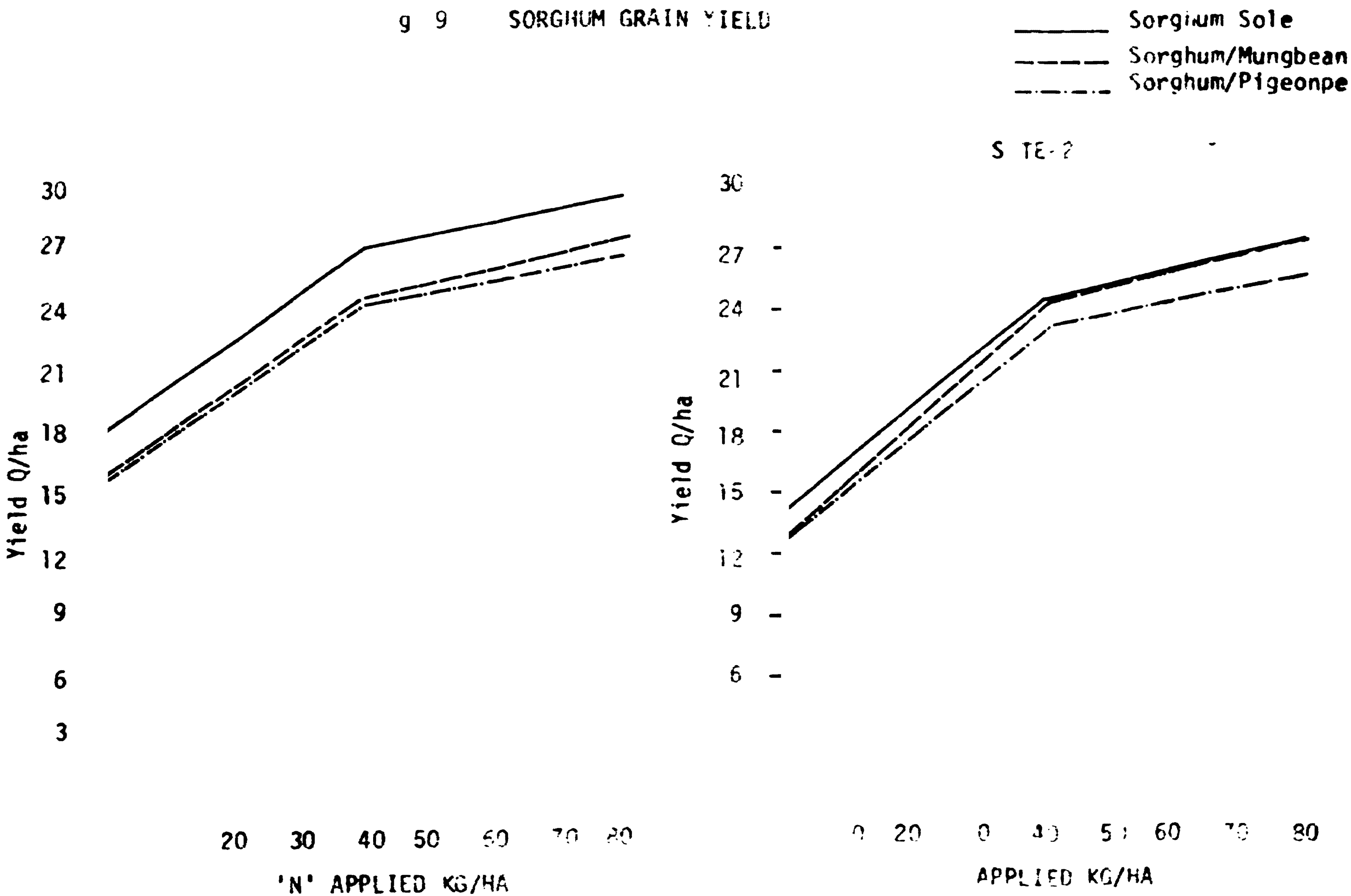


Table: 9a Grain yield (q/ha) as influenced by varyinglevels of nitrogen, spacing and cropping system at site-1 in sorghum

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
NO	18.44	16.5	16.16	18.49	15.5	15.14	17.68	16.41	15.7
N1	27.21	24.31	24.59	27.19	24.36	24.36	26.85	25.67	24.01
N2	30.11	27.26	26.4	29.57	28.17	26.6	28.92	27.77	26.85

Means for Nitrogen NO: 16.69 N1: 25.39 N2: 27.95
Means for cropping system I1: 24.94 I2: 22.88 I3: 22.2
Means for spacing S1: 23.44 S2: 23.26 S3: 23.31

Source of variation	(N)	(S)	(I)	(NxS)	(Nxl)	(lxS)	(SxNxl)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em $\pm$	0.83	0.87	0.87	1.52	1.52	1.52	2.63
C D at 0.05	2.3	-	1.7	-	-	-	-

Several workers reported the positive response of sorghum to nitrogen fertilisation when it was grown as sole crop (Raheja and Krantz, 1958; Krishna Murthy et al, 1973 and Chari et al, 1976). Krantz et al (1976) reported that sorghum responded well to nitrogen application at 120 kg/ha over 22 kg/ha level in intercropping.

Mungbean and pigeonpea reduced the sorghum yield when intercropped with it (Anonymous, 1975-76).

Grain yield of sorghum was not influenced by changes in spacing. The yields were similar at 45 cm, 60 cm, 90 cm and 120 cm row spacings (Chandravanshi, 1976 and Bapat et al, 1976).

Higher nitrogen application resulted in better N uptake (Table 10) by the plant. It also recorded higher LAI and more drymatter which were responsible for better synthesis of photosynthesis. Nitrogen application also improved the 1000 grain weight of the grain, earhead length and girth, and per plant yield. The cumulative effect of all these yield attributes contributed to higher grain yield for sorghum with higher nitrogen levels.

The competition between the main sorghum crop and the intercrops for nutrietns in cropping systems 2 & 3 appear to be little individually since non-significant reduction in LAI, drymatter, length and girth of the earhead, test weight and per plant yield were noticed but the combined effect of all these attributes might have contributed to reduction in grain yield of the main crop.

Correlations made between grain yield and other plant characters were significant.

Table: 9b Grain yield (q/ha) as influenced by varying levels of nitrogen, spacing and cropping system at site-2 in sorghum

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	13.66	13.02	12.52	15.62	13.00	12.98	13.2	12.6	12.77
N1	24.62	24.39	23.08	24.39	24.24	22.8	24.12	24.14	23.41
N2	27.66	27.51	25.62	27.64	27.06	25.74	27.21	27.31	25.85

Means for Nitrogen N0: 13.29 N1: 23.91 N2: 26.85
Means for cropping system I1: 22.03 I2: 21.47 I3: 20.53
Means for spacing S1: 21.36 S2: 21.5 S3: 21.18

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em $\pm$	2.49	0.4	0.4	0.7	0.7	0.7	1.22
C D at 0.05	6.91	-	0.78	-	-	-	-

Grain yield of sorghum and nitrogen uptake by grain	: 0.97
Grain yield of sorghum and leaf area index	: 0.83
Grain yield of sorghum and shoot drymatter production	: 0.97
Grain yield of sorghum and test weight	: 0.96
Grain yield of sorghum and earhead girth	: 0.96
Grain yield of sorghum and per plant yield	: 0.96

C MUNGBEAN (SITE-1)

In higher sorghum inter-row spacing of 90 cm, significantly increased the grain yield of mungbean was recorded compared to that against 45 cm spacing treatment. However, the yields of mungbean between S2 and S1, and also between S2 and S3 were on par. This indicated two wider inter-row spacings (67.5 cm and 90 cm) of sorghum resulted in an increased grain yield of mungbean by 22 and 39 per cent respectively over the closer inter-row spacing of sorghum (45 cm).

D MUNGBEAN (SITE-2)

Spacing treatment S2 and S3 significantly increased grain yield of mungbean over that S1 treatment. The differences between S2 & S3 was also significant. Higher grain yield of 4.5 q/ha was noticed in the widest inter-row spacing of sorghum while the lower grain yield (3.26 q/ha) of mungbean was observed in the closest inter-row spacing.

Increase in grain yield of mungbean with the increase in inter-row spacing of sorghum could be due to accomodation of more number of mungbean plants in available space on account of wider sapcing in sorghum.

Table: 9c Grain yield (q/ha) as influenced by varying levels of nitrogen and spacing at site-1 in mungbean

LEVEL OF NITROGEN	Spacing S1	S2	S3	Mean
N0	3.6	4.13	4.91	4.21
N1	3.52	4.38	4.89	4.26
N2	3.05	3.92	4.36	3.78
Mean	3.38	4.14	4.72	

Source of variation:	'F'test	S. Em ±	C D at 0.05
Nitrogen	NS	0.23	-
Spacing	Sig	0.48	1.045
Nitrogen x Space	NS	0.84	-

Table: 9d Grain yield (q/ha) as influenced by varying levels of nitrogen and spacing at site-2 in mungbean

LEVEL OF NITROGEN	Spacing S1	S2	S3	Mean
N0	3.46	4.01	4.82	4.1
N1	3.36	4.02	4.71	4.03
N2	2.97	3.75	3.97	3.56
Mean	3.26	3.93	4.5	

Source of variation	'F' test	S. Em ±	C D at 0.05
Nitrogen	NS	0.183	-
Spacing	Sig	0.137	0.298
Nitrogen x Space	NS	0.234	-

E PIGEONPEA:

The yield of pigeonpea was not affected by the treatments at both the sites. Krantz et al (1976) reported that the grain yields of four pigeonpea varieties with and without intercrop at two row spacing 75 cm and 150 cm in black soil were on par. Variations in row spacings as 45, 90 and 135 cm with constant population did not influence the pigeonpea yield with Hybrid-2 variety (Anonymous 1976b). This might be due to the maintenance of constant population in all the treatments. The yield of pigeonpea at site-1 was higher than that recorded at site-2; the difference in yield could be due to life saving irrigation given to the crop at Site-1 whereas at site 2 did not receive any irrigation.

Chemical analysis:

The chemical analysis data pertaining to nitrogen, phosphorus and potash carried out on different crops and at different growth stages are presented in Appendix 7 & 8.

A. NITROGEN:

Concentration of nitrogen decreased with advancement of crop age in all the crops (sorghum, mungbean and pigeonpea).

B. NITROGEN UPTAKE BY SORGHUM CROP:

Nitrogen uptake in the grain, and straw of 90th day in the main sorghum crop was analysed statistically and presented in Table 10 & Fig. 10. The differences between the N levels for N uptake in grain and straw were significant. The N uptake increased significantly with increased nitrogen levels. In sorghum grain, maximum uptake of 43.95 kg N was recorded at N_{80} level and the minimum uptake of 21.22 kg N was recorded in the control.

Table: 9e Grain yield (q/ha) as influenced by varying levels of nitrogen and spacing at site-1 in pigeonpea

LEVEL OF NITROGEN	Spacing			
	S1	S2	S3	Mean
N0	10.58	11.33	11.64	11.18
N1	10.93	11.71	12.25	11.63
N2	11.74	10.81	10.86	11.13
Mean	11.08	11.28	11.58	

Source of variation	'F' test	S.Em ±	C D at 0.05
Nitrogen	NS	0.55	-
Spacing	NS	0.76	-
Nitrogen x Space	NS	1.32	-

Table: 9f Grain yield (q/ha) as influenced by varying levels of nitrogen and spacing at site-2 in pigeonpea

LEVEL OF NITROGEN	Spacing S1	S2	S3	Mean
N0	5.12	4.98	5.19	5.09
N1	4.96	4.88	5.17	5.00
N2	4.76	4.69	5.02	4.82
Mean	4.94	4.85	5.12	

Source of variation	'F' test	S.Em ±	C D at 0.05
Nitrogen	NS	0.2	-
Spacing	NS	0.216	-
Nitrogen x Space	NS	0.38	-

Application of 40 and 80 kg N/ha increased N uptake in grain by 75 and 107 per cent respectively compared with the control. In sorghum straw also maximum 23 kg uptake of N was recorded at N80 level and the minimum 5.18 kg uptake of N was noticed in the control, Nitrogen levels 40 and 80 kg N/ha increased N uptake in straw by 112 and 343 per cent respectively over control. The recovery of nitrogen as evidenced by the uptake of N in grain and straw of sorghum was 55 and 50 per cent respectively in N 40 and N 80 levels.

Cropping systems also significantly influenced the uptake of N in sorghum crop. In cropping system-1 uptake of N both in grain and straw was superior over the uptake of N by the same crop in other cropping systems 2 and 3, cropping systems 2 and 3 were on par with each other for this attribute. This might be due to intercrop competition in cropping systems 2 and 3 which was evidenced by the higher drymatter production of intercrops at higher nitrogen levels (Table 4).

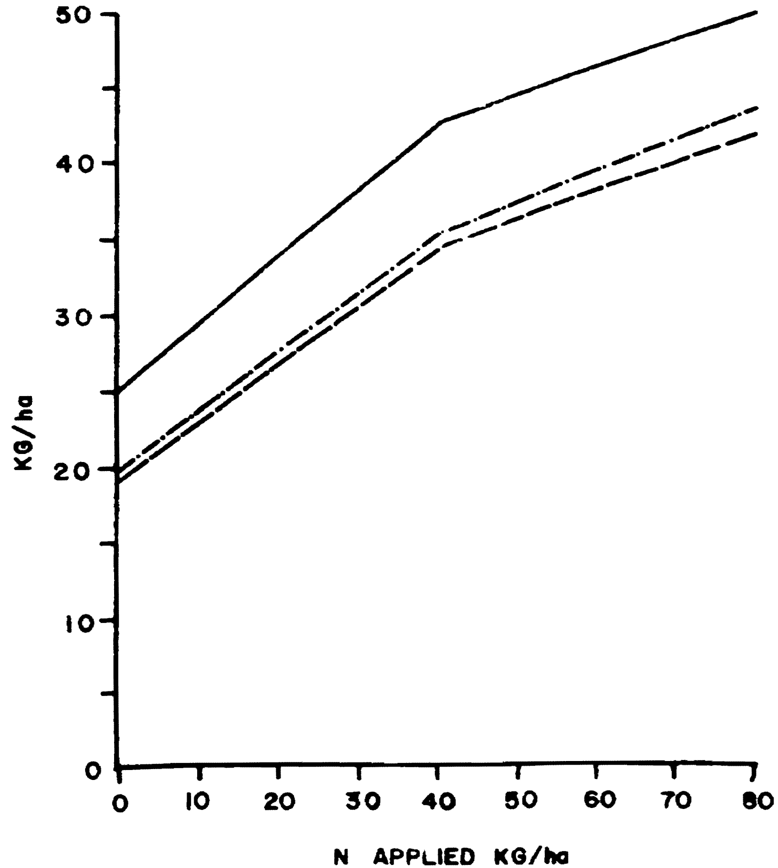
Nitrogen uptake by grain of sorghum was highly correlating with other plant characters.

Nitrogen uptake by grain and grain yield	: 0.98
Nitrogen uptake by grain and leaf area index	: 0.84
Nitrogen uptake by grain and shoot drymatter production	: 0.94
Nitrogen uptake by grain and test weight	: 0.93
Nitrogen uptake by grain and length of the earhead	: 0.93
Nitrogen uptake by grain and girth of the earhead	: 0.93
Nitrogen uptake by grain and per plant	: 0.95

g 10

— Sorghum Sole
– – – – Sorghum/Mungbean
–·–·– Sorghum/Pigeonpea

UPTAKE B N KG/HA



UP AKE BY STRAW KG/ha

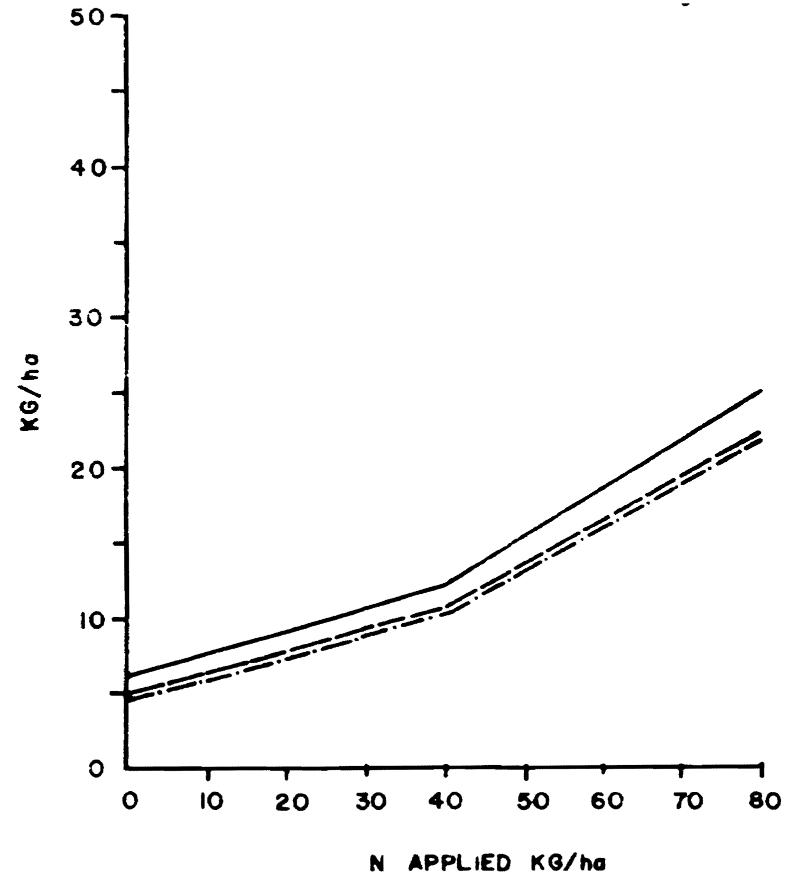


Table:10a N uptake (kg/ha) by grain as influenced by varying levels of nitrogen, spacing and cropping system in sorghum.

LEVEL OF NITROGEN	S1			S2			S3		
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	25.08	18.76	21.05	25.44	18.8	18.96	24.26	19.32	19.28
N1	39.7	31.86	35.2	42.66	30.6	32.6	45.63	39.56	37.38
N2	51.06	41.91	41.35	49.03	41.96	42.22	47.45	41.45	39.41

Spacing: S1, S2, S3; Cropping system: I1, I2, I3

Means for Nitrogen N0: 21.22 N1: 37.24 N2: 43.95
Means for cropping system I1: 38.92 I2: 31.55 I3: 31.94
Means for spacing S1: 34.00 S2: 33.58 S3: 34.83

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em ±	1.15	1.79	1.79	3.1 2.8	3.1 2.8	3.1	5.4
C D at 0.05	3.2	-	3.5	-	-	-	-

Table: 10b N uptake (kg/ha) by straw of sorghum as influenced by varying levels of nitrogen, spacing and cropping system

LEVEL OF NITROGEN	Spacing S1			S2			S3		
	Cropping system I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	6.31	5.2	4.48	6.18	4.81	5.04	5.7	4.93	4.03
N1	13.11	10.47	10.67	11.17	11.04	10.3	11.85	10.05	10.06
N2	24.83	21.95	20.88	25.6	22.51	21.74	25.15	21.71	22.53

Means for Nitrogen N0: 5.18 N1: 10.97 N2: 22.99
Means for cropping system I1: 14.43 I2: 12.52 I3: 12.19
Means for spacing S1: 13.1 S2: 13.15 S3: 12.9

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em ±	0.48	0.47	0.47	0.82	0.82	0.82	1.4
C D at 0.05	1.34	-	1.86	-	-	-	-

C <u>PHOSPHORUS CONCENTRATION</u>:

P concentration is presented in Appendix 7 & 8. At 30 days growth stage of the main crop 40 and 80 N applied treatments recorded more concentration of P (around 0.7) than control treatment (NO) (around 0.5). At 60 days growth stage the trend differed largely from 30 days stage. Control treatments (NO) recorded maximum P concentration (around .48), followed by 80N (0.4) and minimum concentration was recorded in 40N levels (around 0.28). This trend of 60 days continued at 90 days stage and even in grain of sorghum. Thus the P concentration has not followed a specific pattern in various stages sorghum plant growth and with various treatments. It's concentration in grain of pigeonpea and mungbean was almost same and not at all influenced by various treatments under study.

D <u>POTASSIUM CONCENTRATION</u>:

Potash concentration of grain (harvest) and straw (90 days) of sorghum is presented in Appendix VII. The potassium concentration in straw was almost double to grain. The various treatments under straw have not influenced the concentration of potash either in grain or straw much.

Gross monetary returns:

Gross monetary returns calculated from the experimental data are presented in Table 11. Application of nitrogen influenced gross monetary returns at both the experimental sites. At site 1, there was an increase in gross returns to the extent of Rs 1178 and Rs 1521/ha with the application of 40 and 80 kg N/ha, respectively, while the corresponding increase at site-2 was Rs 1365 and Rs 1760/ha with 40 and 80 N level respectively over control. The gross monetary returns at site 1 were more than that site-2, when the average of all treatments is considered. Response to applied nitrogen in terms of monetary returns was more at site-2 than that at site-1. This could be due to poor fertility status of the soils at site-2 in comparision with that at site-1. With increasing nitrogen level, the increase in gross monetary returns was in decreasing order at both the sites; this trend in gross monetary returns has followed the trends in grain yield in sorghum.

Cropping systems also influenced the gross monetary returns significantly at both the sites. Cropping system I 3 had given an increase of Rs 2610 and Rs 1112/ha respectively at site-1 and site-2 over cropping systems I1. The higher gross monetary returns at site-1 was due to the higher grain yield of pigeonpea at that location.

Cropping system I2 has given an increase of Rs 566 and Rs 697 per ha at site one and two respectively over cropping systems one.

At site 1 the maximum gross return of Rs 6657/ha was obtained with the treatment of N 80, I3 and S1. The minimum gross return of Rs 2356 was obtained with the treatment N0 - I1 and S3. At site two, the treatment N80 I3 and S3 has given maximum gross returns,of Rs 4831/ha and minimum gross return of Rs 1800/ha were obtained in treatments combination of N0 I1 and S3.

Fig 11 GROSS MONETARY RETURNS

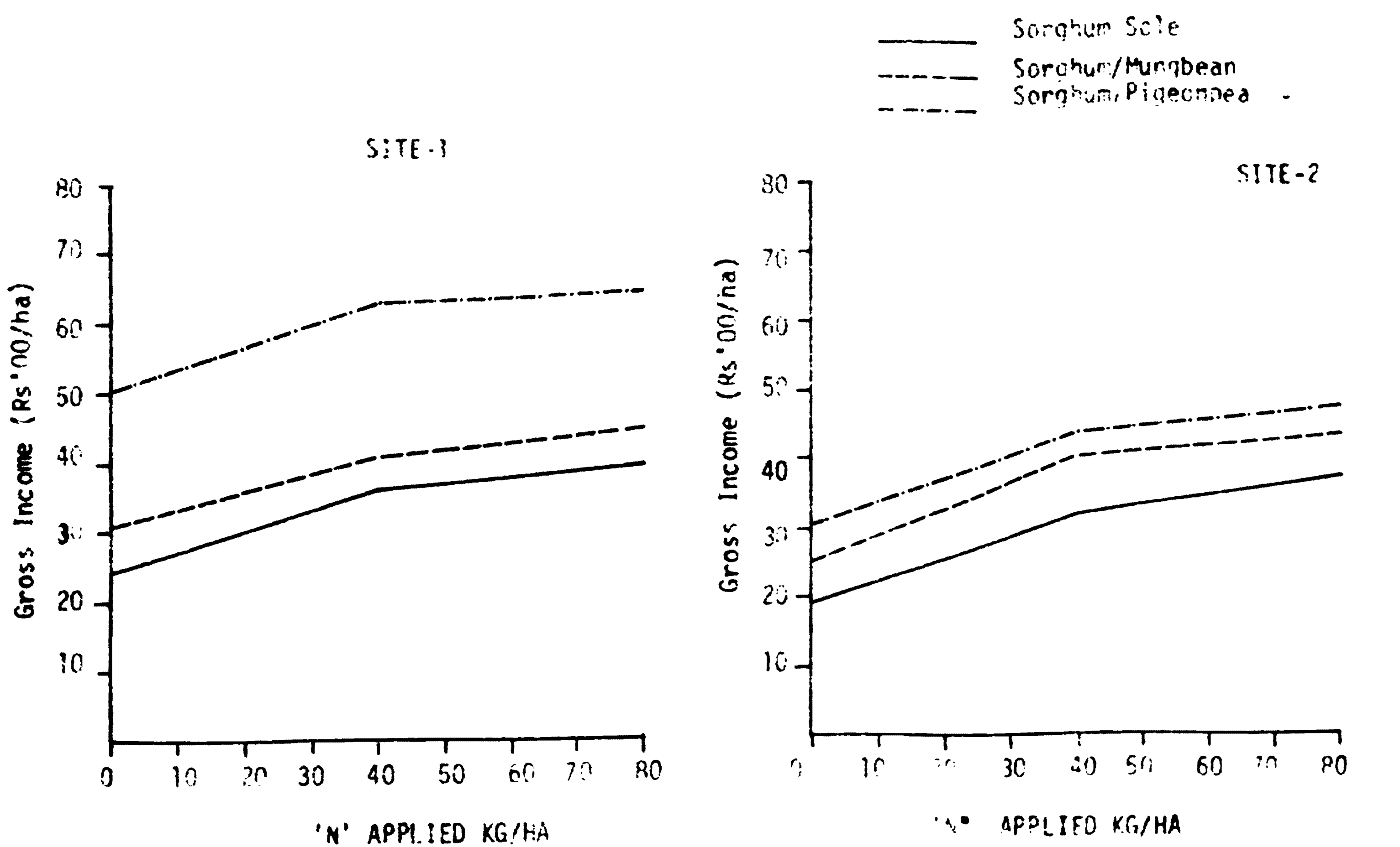


Table: 11a Gross monetary returns (Rs'00) as influenced by varying levelsof nitrogen, spacing and cropping system (site-1)

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	24.39	29.27	49.13	24.49	30.15	49.83	23.56	31.84	51.07
N1	36.19	38.57	61.22	35.86	41.23	63.29	35.29	43.87	63.93
N2	40.43	43.1	66.57	39.94	46.15	64.43	38.94	46.25	64.84

Means for Nitrogen N0: 34.86 N1: 46.64 N2: 50.07
Means for cropping system I1: 33.27 I2: 38.93 I3: 59.37
Means for spacing S1: 43.21 S2: 43.93 S3: 44.43

Source of variation	(N)	(S)	(I)	(NxS)	(Nxl)	(lxS)	SxNxl)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em ±	0.74	1.28	1.28	2.22 1.96	2.22 1.96	2.22	3.8
C D at 0.05	2.06	-	2.55	-	-	-	-

Table: 11b Gross monetary returns (Rs '00) as influenced by varying levels of nitrogen, spacing and cropping system (site-2)

LEVEL OF NITROGEN	Spacing S1			Spacing S2			Spacing S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	18.49	24.66	30.67	20.84	25.7	30.62	18.0	26.7	30.78
N1	32.77	39.08	43.58	31.89	40.87	43.08	32.12	41.38	44.5
N2	37.53	42.98	47.07	37.51	42.4	47.3[illegible]	36.75	44.88	48.31

Means for Nitrogen N0: 25.16 N1: 38.8[illegible] N2: 42.76
Means for cropping system I1: 29.54 I2: 36.51 I3: 40.66
Means for spacing S1: 35.2 S2: 35.59 S3: 35.93

Source of variation	(N)	(S)	(I)	(NxS)	(Nxl)	(lxS)	(SxNxl)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em ±	1.26	0.96	0.96	1.66 1.85	1.66 1.85	1.66	2.9
C D at 0.05	3.5	-	1.9	-	-	-	-

From the two sites data it is seen that spacing factor had no influence on the gross monetary retu ns the cropping system and nitrogen factors influenced the gross returns substantially.

The N80 and I3 combination had given highest gross monetary returns at both the sites; this was due to responsiveness of sorghum to added nitrogen (80 kg N/ha) and to the high gross return from the intercrop of pigeonpea. The cropping system I1 (sole sorghum) produced the lowest gross returns at all nitrogen levels and spacings at both sites.

Protein yield:

The trend of protein accumulation in sorghum was similar to that of nitrogen accumulation. The total protein yield from the cropping systems was calculated and analysed statistically and presented in Fig. 8 & Table 12. The nitrogen level N80 recorded significantly higher protein yield than the NO treatment. The N40 and N80, and N40 and control, were on par. The treatments with 40 and 80 kg N/ha increased total protein yield by 45 and 60 percent respectively over control. This increase in protein yield could be attributed to increased sorghum grain yield with increase in the level of nitrogen.

The total protein yield of cropping systems 2 and 3 were significantly higher than system 1. The maximum total protein yield of 4.18 q/ha was obtained from cropping system 3 and the minimum total protein yield of 2.44 q/ha was obtained from cropping system 1. Cropping systems 2 and 3 produced 23 and 71 percent more total protein yield than cropping system 1.

Table: 12 Total protein yield (q/ha) as influenced by varying levels of nitrogen, spacing and cropping system

LEVEL OF NITROGEN	Spacing								
	S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	1.65	2.05	3.31	1.61	2.18	3.3	1.51	2.39	3.38
N1	2.48	2.9	4.37	2.66	3.05	4.3	2.85	3.7	4.66
N2	3.19	3.4	4.92	3.06	3.65	4.82	2.96	3.7	4.6

Means for Nitrogen N0: 2.38 N1: 3.44 N2: 3.81
Means for cropping system I1: 2.44 I2: 3.00 I3: 4.18
Means for spacing S1: 3.14 S2: 3.19 S3: 3.31

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S. Em $\pm$	0.84	0.12	0.12	0.22 0.19	0.22 0.19	0.22	0.36
C D at 0.05	1.23	-	0.25	-	-	-	-

This increase of total protein yield in cropping systems 2 and 3 against cropping system 1 was from the contribution of the respective inter-crops (mungbean and pigeonpea) involved in the systems. Cropping system 3 produced 39 percent total protein yield over cropping system 2. This was due to the greater quantity of pulse grain produced from the cropping system 3 (pigeonpea) over the mungbean in (cropping system 2). The protein content of both the legumes was almost the same.

Harvest Index:

Data on harvest index are presented in Table 13.

A. SORGHUM:

Higher value of harvest index (38.39) was recorded against control, the value was lowest (29.66) at N80 level; N40 and N80 levels were on par. The levels of nitrogen 40 and 80 kg N/ha resulted in decreased HI by 17 and 22 percent respectively over control in sorghum. The decrease in HI with increasing nitrogen level might be due to the excessive production of dry matter (vegetative) rather than grain yield at higher nitrogen levels. Narayanan and Sheldrake (1975-76) reported that the higher HI does not necessarily mean a higher yield.

B. COMBINED HI:

As mentioned earlier the combined HI was calculated for the cropping systems. The influence of nitrogen fertilisation on combined HI was similar to that of its effect on HI in sorghum as sole crop. Cropping systems also influenced the combined HI significantly. Cropping system I1 and I2 were on par. This could be due to the higher HI recorded by mungbean. Cropping systems I3 recorded lowest 26.1 HI whereas cropping system I2 recorded the highest 36.15 HI. Cropping system I2 resulted in an increase in HI by 3 percent, whereas cropping system I3 showed a decrease in HI by 25 percent over control.

Table: 13a HI of sorghum as influenced by varying levels of nitrogen, spacing and cropping system

LEVEL OF NITROGEN	Spacing S1			S2			S3		
	Cropping system I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	41.67	39.25	39.7	40.7	34.6	34.9	39.4	38.7	36.7
N1	33.4	30.3	30.7	33.2	31.0	31.3	32.9	32.3	30.2
N2	31.9	29.1	28.4	30.8	29.5	28.0	30.6	29.6	29.0

Means for Nitrogen N0: 38.4 N1: 31.7 N2: 29.7
Means for cropping system I1: 34.9 I2: 32.7 I3: 32.1
Means for spacing S1: 33.8 S2: 32.7 S3: 33.3

Source of variation	(N)	(S)	(I)	(NxS)	(Nx1)	(1xS)	(SxNx1)
'F' test	Sig	NS	NS	NS	NS	NS	NS
S. Em $\pm$	1.77	1.22	1.22	2.12 2.48	2.12 2.48	2.12	3.6
C D at 0.05	4.92	-	-	-	-	-	-

Table: 13b Total HI as influenced by varying levels of nitrogen, space and cropping system

LEVEL OF NITROGEN	Spacing S1			S2			S3		
	Cropping system								
	I1	I2	I3	I1	I2	I3	I1	I2	I3
N0	41.7	43.8	24.6	40.7	40.1	23.5	39.4	44.4	25.0
N1	33.4	33.0	20.4	33.2	34.1	23.6	32.9	35.7	23.4
N2	31.9	30.9	21.8	30.8	31.5	21.3	30.6	31.8	21.7

Means for Nitrogen N0: 34.9 N1: 29.9 N2: 28.0
Means for cropping system I1: 34.9 I2: 36.15 I3: 26.1
Means for spacing S1: 31.2 S2: 31.2 S3: 31.6

Source of variation	(N)	(S)	(I)	(NxS)	(Nxl)	(lxS)	(SxNxl)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
S.Em ±	1.48	1.2	1.2	2.08 2.25	2.08 2.25	2.08	3.6
C D at 0.05	4.11	-	2.39	-	-	-	-

GENERAL DISCUSSION

It has long bean recognised that intercropping is a traditional practice of widespread importance. Until very recently the research attention on this subject has been negligible. One of the main reasons for this was probably an inherent belief that intercropping was only advantageous in poorly developed 'peasant farmer' situations, thus offering little scope for improvement. In any case, it must be accepted that, whatever the evidence for or against it, intercropping will continue tobe a widespread practice for atleast the foreseeable future. Hence the need for detailed studies on this aspect exists.

With these basic objectives, sorghum monocrop system was compared with sorghum/mungbean and sorghum/pigeonpea intercropping systems under three nitrogen levels (0, 40 and 80 kg N/ha) and three spacings (45 cm x 15 cm, 67.5 cm x 10 cm and 90 cm x 7.5 cm).

This experiment conducted at site-1 and site-2 revealed similar trends. Cropping system 1 is sole sorghum was highly influenced by nitrogen application (40 and 80 kg N/ha) at both sites. (Similar observations were made by Raheja and Krantz, 1958 and Chari et al, 1976). Growth characters plant height (Table.1 and Fig.3) and LAI (Table.3 and Fig.4) were significantly higher at 40 and 80 kg N/ha than control treatment (N0) consequently resulted in higher earhead length (Table. 5 and Fig. 6), higher earhead girth (Table. 5 and Fig. 6), higher 1000 grain weight (Table.6) and higher per plant yield (Table. 7 and Fig. 7). All these factors have contributed for higher grain yield in N40 and N80 treatments over control; finally leading to additional gross returns to the extent of Rs 1178 /ha and Rs 1621 /ha at site-1; and Rs 1315/ha and Rs 1760 /ha at site-2 in these treatments compared to N0 nitrogen treatments (Table. 11).

The differences between spacings were not significant for grain yield, gross monetary returns and for other plant characters. This was probably due to the ability of this crop to adjust the changes in spatial arrangement as long as population remained constant. This suggested the safe use of 90 cm x 7.5 cm spacing to sorghum, whereby we could accomodate an intercrop easily. This also gave scope for further research to try the crop by doubling the population with 45 cm x 7.5 cm spacing as a sole crop.

Sorghum/mungbean intercropping system (I2) gave Rs 566/ha and Rs 697/ha more gross returns compared to sole sorghum at site-1 and site-2 respectively (Table. 11). Similar observations made by Krantz et al, (1976) and Bhale Rao et al, (1976).

With increasing nitrogen levels to sorghum mungbean drymatter yield increased significantly, whereas its grain yield statistically remained uneffected (Table. 9). At both the sites there was slight increasing trend in mungbean grain yield with 40 kg N/ha over control while slight decreasing trend was observed with 80 kg N/ha compared to N40 and N0 treatments(Table. 9). The levels of nitrogen N40 and N80 applied to sorghum resulted in similar effects on mungbean at different population levels. This trend in mungbean yield indicated that the nitrogen levels did not influence its yield probably being a legume crop.

Sorghum (the maincrop in cropping system 2) yield increased with applied nitrogen levels of 40 and 80 kg N/ha. However, compared to sole sorghum its yield was less (significantly less at site-1 and non-significantly less at site-2) at (N0) control, 40 kg N/ha and 80 kg N/ha.

In sorghum/mungbean intercropping system, the sorghum yield ranged from 16.3 q/ha under no nitrogen conditions to 28.12 q/ha with 80 kg N/ha as against the corresponding yield of 18.20 q/ha and 29.53 q/ha in sole sorghum crop. This indicated that intercrop of mungbean reduced the grain sorghum yield at all levels of nitrogen at site-1. At site-2 sorghum yield in intercropped system was almost similar to that of sole sorghum system under 40 and 80 kg N/ha level indicating that mungbean did not compete with sorghum under adequate fertility condition.

All the characters studied were statistically on par for sorghum of I1 and I2. However, from the data it could be seen that earhead length, earhead girth, 1000 grain weight of sorghum were substantially reduced by intercropping with mungbean compared to sole sorghum.

Spacing factor has influenced the mungbean yield significantly (Table. 9). Wider row-spacings to main crop of sorghum, more plants of mungbean accomodated and that resulted in higher grain yield of mungbean at these spacings (90 cm and 67.5 cm) than the closer 45 cm spacing (Table. 9). However total gross monetary returns were not influenced to the extent of increasing the gross monetary returns to a significant level.

Sorghum/pigeonpea intercropping system has given higher gross returns than sole sorghum (Table. 11). Mane and Ramshe (1976-77) also reported similar results. At site-1 it was Rs 2610/ha, at site-2 it was Rs 1112/ha more than sole sorghum.

However pigeonpea had significantly reduced the main crop (sorghum) grain yield at site-1 and 2 compared to sole sorghum. Bhalerao et al (1976) also reported similar results. The reduction in grain yield by pigeonpea at spacing 1 (45 cm) was more than at spacing 2 & 3. This indicated the competition of pigeonpea in closer spacing with the main crop sorghum. This reduction was caused through significant reduction in earhead length, earhead girth and drymatter yield of sorghum in I3 compared to sole sorghum by pigeonpea (intercrop).

Spacing factor did not show influence on the grain yield of pigeonpea statistically (Table. 9). However 90 cm x 30 cm spacing gave better grain yield than the other two spacings (45 cm x 60 cm and 67.5 cm x 40 cm) of pigeonpea. Application of nitrogen (N40 and N80) to sorghum, the maincrop did not influence the pigeonpea' grain yield whereas it could influence only the drymatter yield significantly.

Thus from the experiment conducted at both the sites it could be seen that intercropping systems were giving better gross returns than the sole crop system. Application of 80 kg N/ha gave better results in intercrop and sole crop systems. Spacing factor did not influence the yield of either sorghum or pigeonpea and it could only influence mungbean yield.

Outof the two intercrop systems sorghum/pigeonpea system had given much better returns than sorghum/mungbean system. However, the selection of better intercropping system between these two depends on the factors like soils, rainfall pattern etc. For example with black soils and later season rainfall possibility sorghum/pigeonpea system may be useful whereas in red soils and with limited rainfall sorghum/mungbean system may prove advantageous.

SUMMARY AND CONCLUSIONS

An experiment entitled "Studies on the effect of intercropping of sorghum with grain legumes under semi-arid conditions" was conducted during the period from July 1976 to January 1977 at two sites namely Farm, College of Agriculture, Rajendranagar, and International Crops Research Institute for Semi-Arid Tropics, Hyderabad. The experiment involved three levels of nitrogen (0, 40 and 80 kg N/ha) as main-plot treatments, three spacings (45 cm x 15 cm, 67.5 cm x 10 cm and 90 cm x 7.5 cm) and three cropping systems (sorghum sole, sorghum/mungbean and sorghum/pigeonpea) as a sub-plot treatments. The experiment was laid out in split plot design with three replications.

The data on various growth characters viz plant height, number of leaves, leaf area index and drymatter production, and yield attributes namely earhead length, earhead girth, test weight, per plant yield were recorded periodically for the main crop of sorghum. Nitrogen content of the plants at different growth stages and protein content in grain were estimated for the main and intercrops. Phosphorus was estimated in the main crop periodically and K was estimated only at harvest. Data on straw and grain yields were recorded to determine gross monetary returns and harvest indices. Results of the experiment are summarised below.

1) The levels of nitrogen 40 and 80 kg N/ha influenced all the growth characters of sorghum except number of green leaves per plant, the yield components and yield significantly. Protein yield, nitrogen uptake and monetary returns were also influenced favourably by these levels of nitrogen.

2) Spacing treatments did not influence the main crop of sorghum and the intercrop pigeonpea. Increase in inter-row spacing of sorghum resulted in increase in grain yield in mungbean.

3) Mungbean intercropping with sorghum resulted in decreasing the yield of main crop to different degrees. However, gross monetary returns were in favor of intercropping.

4) Pigeonpea intercropping with sorghum also reduced the yield of sorghum crop. However, by virtue of higher grain yield and monetary returns to pigeonpea the gross returns from sorghum/pigeonpea intercropping system were superior to the other two systems.

CONCLUSIONS: Sorghum/pigeonpea intercropping with 80 kg N/ha found to be more beneficial followed by sorghum/mungbean intercropping system compared to sorghum monocrop system on the light soils of Hyderabad region during the kharif season.

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APPENDIX

APPENDIX 1(a)

Meteorological data during crop growth period (site-1)
From 4th June, 1976 to 21st January, 1977

Std Wk.		Dates	Rain-fall (mm)	Average Temperature °C Max.	Min.	Average humidity 07.16	14.16	Average hrs of bright sunshine/day
23	Jun	4 - 10	23.6	33.3	22.9	77	44	6.9
24		11 - 17	19.1	34.8	23.6	70	40	9.2
25		18 - 24	77.3	35.3	22.9	76	40	8.0
26		25 - 1	0.0	32.2	23.3	79	55	7.0
27	Jul	2 - 8	88.4	31.2	22.5	88	62	4.6
28		9 - 15	39.3	30.3	22.6	83	58	3.2
29		16 - 22	108.8	27.6	21.9	89	75	2.6
30		23 - 29	13.2	29.8	22.9	86	67	5.2
31		30 - 5	70.8	27.7	22.1	86	73	2.4
32	Aug	6 - 12	2.4	30.8	22.1	86	56	5.9
33		13 - 19	10.4	30.8	22.6	84	56	5.7
34		20 - 26	59.0	28.0	22.2	90	75	3.4
35		27 - 2	26.8	28.1	22.1	89	75	3.1
36	Sep	3 - 9	38.6	28.9	21.3	88	58	5.5
37		10 - 16	3.2	32.8	22.1	83	54	7.6
38		17 - 23	27.8	31.4	21.8	81	54	7.0
39		24 - 30	0.0	33.2	19.9	83	33	4.6
40	Oct	1 - 7	0.0	33.3	20.6	87	35	9.7
41		8 - 14	0.0	33.6	17.3	84	25	10.1
42		15 - 21	38.7	30.9	19.5	78	41	.15
43		22 - 28	0.0	32.9	19.8	72	37	8.5
44		29 - 4	0.0	30.7	15.7	85	33	10.8
45	Nov	5 - 11	30.6	29.4	20.7	87	56	7.0
46		12 - 18	14.2	29.1	20.2	92	60	8.3
47		19 - 25	5.6	26.0	20.0	93	56	4.8
48		26 - 2	1.0	29.0	14.5	91	46	7.4
49	Dec	3 - 9	0.0	29.1	15.9	95	43	9.3
50		10 - 16	0.0	28.2	13.8	95	42	10.1
51		17 - 23	0.0	26.7	11.2	93	33	8.5
52		24 - 31	0.0	30.7	11.5	91	21	10.4
1	Jan	1 - 7	0.0	24.2	10.1	85	25	10.5
2		8 - 14	0.0	30.0	10.6	90	22	10.7
3		15 - 21	0.0	29.4	13.9	85	29	10.4

APPENDIX 1(b)

Meteorological data during crop growth period (site-2)
From 4th June, 1976 to 21st January, 1977

Std Wk.	Dates	Rain-fall (mm)	Average Temperature °C Max.	Min.	Average humidity 0717	1417	Average hrs of bright sunshine/day	Average daily evaporation (mm)
23	Jun 4 - 10	22.7	34.3	23.2	76	38	6.8	11.2
24	11 - 17	10.4	35.4	23.7	69	40	8.7	9.1
25	18 - 24	52.9	35.7	23.2	76	40	8.6	9.7
26	25 - 1	-	32.7	23.5	78	45	7.2	8.1
27	Jul J2 - 8	50.2	31.5	22.1	90	61	3.7	5.6
28	9 - 15	21.3	31.1	22.3	85	55	3.9	6.5
29	16 - 22	132.7	27.7	22.1	89	77	1.3	5.0
30	23 - 29	11.6	29.8	22.4	88	66	5.2	4.5
31	30 - 5	71.3	28.3	21.6	89	74	2.2	3.7
32	Aug 6 - 12	17.0	29.9	21.4	87	58	7.2	5.2
33	13 - 19	113.3	30.1	22.3	87	64	6.2	5.3
34	20 - 26	79.3	27.2	22.1	93	78	2.1	2.8
35	27 - 2	33.6	27.3	21.9	92	79	2.7	2.4
36	Sep 3 - 9	31.1	28.8	21.3	90	60	5.8	3.8
37	10 - 16	20.4	30.2	22.0	86	57	8.3	5.2
38	17 - 23	5.3	30.9	22.2	84	51	6.6	4.8
39	24 - 30	-	32.7	20.5	84	34	9.0	5.7
40	Oct 1 - 7	-	33.0	21.8	84	39	9.3	6.6
41	8 - 14	-	33.3	19.1	75	29	9.7	7.2
42	15 - 21	0.6	30.6	18.7	78	38	5.5	5.6
43	22 - 28	-	32.3	20.1	73	37	7.7	5.4
44	29 - 4	-	30.4	16.1	77	32	10.7	5.9
45	Nov 5 - 11	20.4	28.9	20.5	91	56	6.8	3.5
46	12 - 18	4.2	30.1	19.6	91	53	8.2	4.9
47	19 - 25	4.5	27.7	20.5	92	66	4.6	2.9
48	26 - 2	0.6	28.9	17.2	85	39	7.3	4.8
49	Dec 3 - 9	-	28.8	17.2	92	42	8.9	4.4
50	10 - 16	-	28.5	17.1	88	38	9.8	4.8
51	17 - 23	27.3	27.8	12.8	87	28	8.4	4.5
52	24 - 31	-	30.3	14.0	79	21	10.3	5.6
1	Jan 1 - 7	-	28.5	12.4	73	22	10.5	5.7
2	8 - 14	-	30.2	13.0	71	23	10.8	5.5
3	15 - 21	29.7	29.0	14.9	75	29	10.4	5.8

APPENDIX II

Calender of operations

Name of the operation	DATES Site-1	Site-2
Preparatory cultivation	20th June, 1976	15th June, 1976
Lay-out	5th July, 1976	11th July, 1976
Sowing	10th July, 1976	14th July, 1976
Fertilization.		
(a) Basal	10th July, 1976	14th July, 1976
(b) Top dress	1st August, '76	5th August, 1976
Weeding - 1st weeding	22nd July, 1976	26th July, 1976
2nd weeding	4th August, 1976	8th August, 1976
Irrigation	8th October, 1976	No irrigation was given.

APPENDIX III

Experimental observations made at site 1 and site 2

Name of the observation	Site 1 Sorghum	Site 1 Mungbean	Site 1 Pigeonpea	Site 2 Sorghum	Site 2 Mungbean	Site 2 Pigeonpea
Plant height	*	-	-	-	-	-
No. of leaves	*	-	-	-	-	-
Leaf area	*	-	-	-	-	-
Shoot drymatter production	*	*	*	-	-	-
Earhead length	*	-	-	-	-	-
Earhead girth	*	-	-	-	-	-
1000 grain height	*	-	-	-	-	-
Per plant yield	*	-	-	-	-	-
Nitrogen analysis	*	*	*	-	-	-
Phosphorus analysis	*	*	*	-	-	-
Potash analysis	*	-	-	-	-	-
Straw yield	*	-	-	*	-	-
Grain yield	*	*	*	*	*	*

Reference: * Observation was made

- Observation was not taken

APPENDIX - IV

Plant height and number of green leaves per plant in sorghum at different growth stages

Treatment	Plant height (cm) on			No. of green leaves/plant		
	30th day	60th day	90th day	30th day	60th day	90th day
NOS1I1	55.3	125.0	142.1	5.9	7.93	5.7
NOS1I2	54.3	120.0	141.5	5.7	7.66	5.7
NOS1I3	55.0	120.6	142.1	6.2	8.26	5.0
NOS2I1	52.6	131.0	143.2	6.0	8.06	5.7
NOS2I2	50.3	132.0	144.0	6.0	8.06	5.7
NOS2I3	51.3	131.3	141.7	5.8	7.8	5.3
NOS3I1	49.0	125.6	140.5	6.1	8.0	5.7
NOS3I2	48.0	125.1	141.7	5.4	7.73	5.7
NOS3I3	49.0	126.0	142.5	5.9	7.8	5.0
N1S1I1	57.0	142.3	151.1	5.9	7.89	6.0
N1S1I2	55.3	140.3	155.2	6.1	8.6	6.0
N1S1I3	55.3	141.3	153.8	6.5	7.67	5.0
N1S2I1	57.3	141.0	152.5	6.1	7.93	6.7
N1S2I2	50.3	137.6	154.8	6.1	8.2	5.7
N1S2I3	51.3	133.6	155.7	6.2	8.2	5.0
N1S3I1	59.3	143.3	154.8	6.2	7.87	5.7
N1S3I2	55.3	142.3	159.0	5.9	8.07	5.7
N1S3I3	55.6	144.0	154.9	6.1	8.33	6.0
N2S1I1	60.0	148.0	164.0	6.3	8.33	6.1
N2S1I2	59.6	146.3	164.3	6.3	8.0	6.1
N2S1I3	60.0	147.3	163.1	6.0	7.93	5.9
N2S2I1	58.0	145.0	162.6	6.0	8.13	5.9
N2S2I2	56.0	144.0	163.1	6.4	8.4	6.0
N2S2I3	56.3	144.6	162.0	6.7	8.73	6.2
N2S3I1	63.3	145.3	163.4	6.1	8.06	6.0
N2S3I2	60.3	144.2	161.4	6.4	8.46	6.2
N2S3I3	59.3	144.3	161.1	6.3	8.33	6.0

APPENDIX - V

LAI and Drymatter accumulation pattern insorghum at different growth stages

Treatment	L A I			Drymatter (q/ha)		
	30 days	60 days	90 days	30 days	60 days	90 days
N0S1I1	0.55	2.65	1.45	1.16	16.2	45.0
N0S1I2	0.51	2.55	1.35	1.06	15.05	43.15
N0S1I3	0.51	2.57	1.37	1.33	15.8	42.00
N0S2I1	0.58	2.72	1.42	1.21	16.85	46.00
N0S2I2	0.54	2.56	1.36	1.01	14.85	44.15
N0S2I3	0.56	2.55	1.36	1.15	14.35	43.85
N0S3I1	0.54	2.62	1.42	1.43	15.35	44.00
N0S3I2	0.5	2.55	1.35	1.13	14.72	43.00
N0S3I3	0.5	2.55	1.35	1.3	15.7	42.5
N1S1I1	0.75	2.83	1.63	2.3	25.9	81.75
N1S1I2	0.72	2.77	1.56	2.12	24.8	80.72
N1S1I3	0.71	2.74	1.53	2.20	25.0	80.00
N1S2I1	0.7	2.88	1.67	2.20	26.12	81.00
N1S2I2	0.68	2.78	1.51	2.15	25.11	79.00
N1S2I3	0.71	2.76	1.44	2.22	24.81	78.5
N1S3I1	0.72	2.82	1.63	2.25	24.00	82.00
N1S3I2	0.67	2.75	1.5	2.10	24.00	78.0
N1S3I3	0.7	2.76	1.52	2.10	23.8	79.00
N2S1I1	0.9	2.94	1.81	2.8	32.00	95.00
N2S1I2	0.85	2.86	1.72	2.66	30.3	94.35
N2S1I3	0.86	2.85	1.65	2.77	31.0	93.25
N2S2I1	0.95	2.99	1.81	3.00	33.05	96.00
N2S2I2	0.82	2.9	1.82	2.75	30.95	96.5
N2S2I3	0.85	2.88	1.73	2.53	31.00	94.8
N2S3I1	0.91	3.00	1.8	2.97	30.00	96.15
N2S3I2	0.90	2.85	1.65	2.56	31.00	95.85
N2S3I3	0.888	2.84	1.65	3.00	29.65	93.52

APPENDIX VI

Dry matter production of pigeonpea (q/ha) in various growth stages

Treatment	Days 30	60	90	120	150	180
NOS1	0.35	1.6	5.12	21.12	61.0	69.36
NOS2	0.36	1.7	5.4	21.0	62.5	68.26
N0S3	0.34	1.5	5.0	21.5	63.5	67.5
N1S1	0.54	2.24	5.76	25.28	64.0	75.47
N1S2	0.56	2.35	5.36	24.28	72.0	77.4
N1S3	0.55	2.13	6.0	26.0	69.5	73.0
N2S1	0.53	2.46	5.76	21.24	78.0	80.0
N2S2	0.54	2.56	6.0	27.0	74.0	82.1
N2S3	0.55	2.5	5.45	25.5	76.0	81.27

Dry matter production of mungbean (q/ha) in various growth stages

Treatment	30 days	60 days
NOS1	3.25	8.8
NOS2	3.75	10.7
NOS3	3.85	12.7
N1S1	3.7	10.2
N1S2	4.1	12.17
N1S3	4.2	13.27
N2S1	4.1	12.15
N2S2	4.35	13.7
N2S3	4.45	14.15

APPENDIX VII

Percentage of N, P and K in Sorghum at different stages of its growth

Treatments	N Straw 30 days	N Straw 60 days	P Straw 30 days	P Straw 60 days	P Straw 90 days	P Grain Harvest	K Grain Harvest	K Straw Harvest
N0S1I1	1.69	1.26	.52	.48	.12	.43	.53	1.15
N0S1I2	1.65	1.15	.47	.48	.12	.43	.53	1.12
N0S1I3	1.64	1.09	.47	.45	.13	.39	.48	1.12
N0S2I1	1.68	1.27	.52	.49	.15	.4	.48	1.14
N0S2I2	1.64	1.17	.52	.49	.12	.37	.47	1.12
N0S2I3	1.65	1.11	.49	.51	.13	.42	.54	1.1
N0S3I1	1.67	1.18	.54	.48	.14	.34	.46	1.11
N0S3I2	1.65	1.19	.46	.51	.14	.33	.5	1.10
N0S3I3	1.65	1.13	.49	.47	.15	.34	.5	1.2
N1S1I1	2.03	1.4	.71	.29	.08	.33	.48	1.0
N1S1I2	1.89	1.28	.71	.28	.08	.32	.47	1.1
N1S1I3	1.84	1.3	.73	.3	.1	.33	.45	1.0
N1S2I1	2.03	1.35	.74	.27	.09	.32	.45	1.05
N1S2I2	1.88	1.25	.7	.28	.09	.3	.44	1.15
N1S2I3	1.86	1.31	.68	.28	.07	.31	.49	1.01
N1S3I1	2.02	1.39	.72	.28	.08	.31	.48	1.05
N1S3I2	1.86	1.32	.72	.26	.05	.3	.47	1.05
N1S3I3	1.88	1.22	.74	.28	.06	.3	.5	1.1
N2S1I1	2.28	1.54	.68	.42	.12	.35	.5	1.25
N2S1I2	2.11	1.41	.67	.44	.13	.35	.42	1.15
N2S1I3	2.08	1.43	.69	.42	.13	.35	.46	1.1
N2S2I1	2.26	1.56	.7	.42	.13	.36	.47	1.25
N2S2I2	2.16	1.34	.7	.42	.14	.34	.48	1.2
N2S2I3	2.1	1.34	.7	.39	.13	.33	.51	1.2
N2S3I1	2.28	1.56	.68	.44	.14	.36	.51	1.25
N2S3I2	2.12	1.35	.69	.43	.13	.35	.51	1.3
N2S3I3	2.12	1.37	.66	.44	.13	.35	.55	1.0

APPENDIX - VIII

Percentage of N & P in pigeonpea at different growth stages under different treatments

Treatment	Concentration in straw N						Conc. in grain	
	30 days	60 days	90 days	120 days	150 days	Harvest	N in grain	P in grain
N0S1	3.39	2.44	2.45	2.27	1.44	1.14	3.03	0.36
N0S2	3.33	2.42	2.31	2.18	1.37	1.07	3.01	0.38
N0S3	3.24	2.4	2.27	2.09	1.4	1.1	2.98	0.37
N1S1	3.00	2.5	2.46	2.09	1.45	1.16	3.17	0.37
N1S2	2.98	2.5	2.41	2.09	1.4	1.13	3.1	0.36
N1S3	2.9	2.4	2.33	1.97	1.4	1.14	3.03	0.36
N2S1	2.9	2.62	2.54	2.15	1.5	1.22	3.24	0.36
N2S2	2.81	2.55	2.48	2.13	1.39	1.08	3.22	0.37
N2S3	2.88	2.52	2.54	2.05	1.45	1.2	3.15	0.36

Percentage of N & P in mungbean at different growth stages under different treatments

Treatment	30 days	60 days	'N' in grain	'P' in grain
N0S1	3.8	3.05	3.94	0.36
S2	3.77	3.08	3.9	0.34
S3	3.78	3.07	3.98	0.36
N1S1	3.38	3.15	4.13	0.35
S2	3.4	3.16	4.14	0.35
S3	3.42	3.11	4.05	0.36
N2S1	3.39	3.28	4.16	0.37
S2	3.39	3.25	4.14	0.33
S3	3.38	3.32	4.14	0.35