REPORT OF WORK

1980-1981

AGRONOMY AND WEED SCIENCE

FARMING SYSTEMS RESEARCH PROGRAM

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics
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NOTE TO THE READER

This is one of seven sub-program reports from the Farming Sys[illegible] Research Program designed mainly to stimulate thinking and comments from professional colleagues.

During 1980-81 the Agronomy and Weed Science subprogram involved in studies related to:

1. *On-Farm Research*
2. *Weed Management Research* and
3. *Operational Research on Farming Systems*

This report summarises the results of only on-farm and weed management research. Studies related to operational research are being reported by other subprograms of Farming Systems Research.

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AGRONOMY & WEED SCIENCE 1980-81

I. ICAR-ICRISAT COLLABORATIVE ON-FARM RESEARCH ON FARMING SYSTEMS (FS-4)

1. Introduction:

Improved and technically viable farming systems technologies for dry areas are available and the flow of alternate or modified technologies is continuous. However, there is a lack of information on the extent to which these improved technologies could be adopted by the farmers. Researchers are convinced that the impact of a new technology is measured not solely by its excellence in experimental plots but also by the extent to which it is or it could be transferred to farms. A close working relationship between researchers and farmers which permits farmers' agro-climatic and socio-economic environments to influence the technology design and performance is therefore considered as an important ingredient of farming systems research.

The ICAR and ICRISAT are involved since 1978 in a co-operative on-farm research on farming systems in three villages - Aurepalle, Kanzara and Shirapur - in three different agroclimatic and socio-economic subregions of central peninsular India. Initially by means of small scale experiments and surveys, preliminary information on suitable cropping systems and appropriate soil and water management methods has been obtained for these locatio in 1978 as part of ICRISAT Village Level Studies. Operational scale experiments on soil and water management and cropping system technologies were begun on small watersheds involving a group of farmers in 1979 in all the three villages.

2. Objectives and Scope:

It is envisaged that conducting cooperative research on farmers' fields will help to characterize, quantify and reduce the gap in crop productivity between experimental stations and farmers' fields in addition to help determine the important reasons for farmers' adoption or rejection of a new technology. The specific objectives of ICRISAT's present on-farm research include:

1. To test, adopt and measure the performance of the prospective farming systems technology on farmers' fields.
2. To involve farmers in the technology development process and to identify appropriate forms of group action among farmers for adoption of watershed-based system of resource development and management.
3. To assess the economic performance and farmer's acceptability of the "improved" systems compared to the "traditional" systems.
4. To monitor the rate of adoption and impact of new technology and to gather feed-back information on the research requirements for specific components of farming systems technology.

3. Technique and approach:

Some important agroclimatic and socio-economic characteristics of the three villages (fig. 1) are given in table 1.

Since natural resource development is an important phase of the research project, watersheds have been chosen for study and experimentation in each of the three villages. The two year period (1979/80 and 1980/81) is considered to have been a technology introduction and testing phase. The technology being tested involves several components including land shaping and cultivation, varieties and other agronomic inputs, cropping systems, tools and equipment, credit provisions, cost sharing and produce marketing etc. The experiments were discussed with and agreed to by the farmers cultivating land on the watershed. Selection of the crops and cropping systems is the farmers' prerogative. Major responsibility for improved agronomic recommendations is assigned to the representatives of the cooperating regional All India Coordinated Research Project for Dryland Agriculture Center and the Agricultural Universities.

Watersheds of 13.5 ha on Alfisols at Aurepalle in Andhra Pradesh involving five farmers, 12 ha on shallow to medium deep Vertisols at Kanzara in Maharashtra involving seven farmers and 13 ha on deep Vertisols at Shirapur in Maharashtra, involving seven farmers were developed during the dry season of 1979. The farmers were continuously involved in planning the work and participated in development and later crop management activities. Material and inputs were made available to farmers well prior to the monsoon.

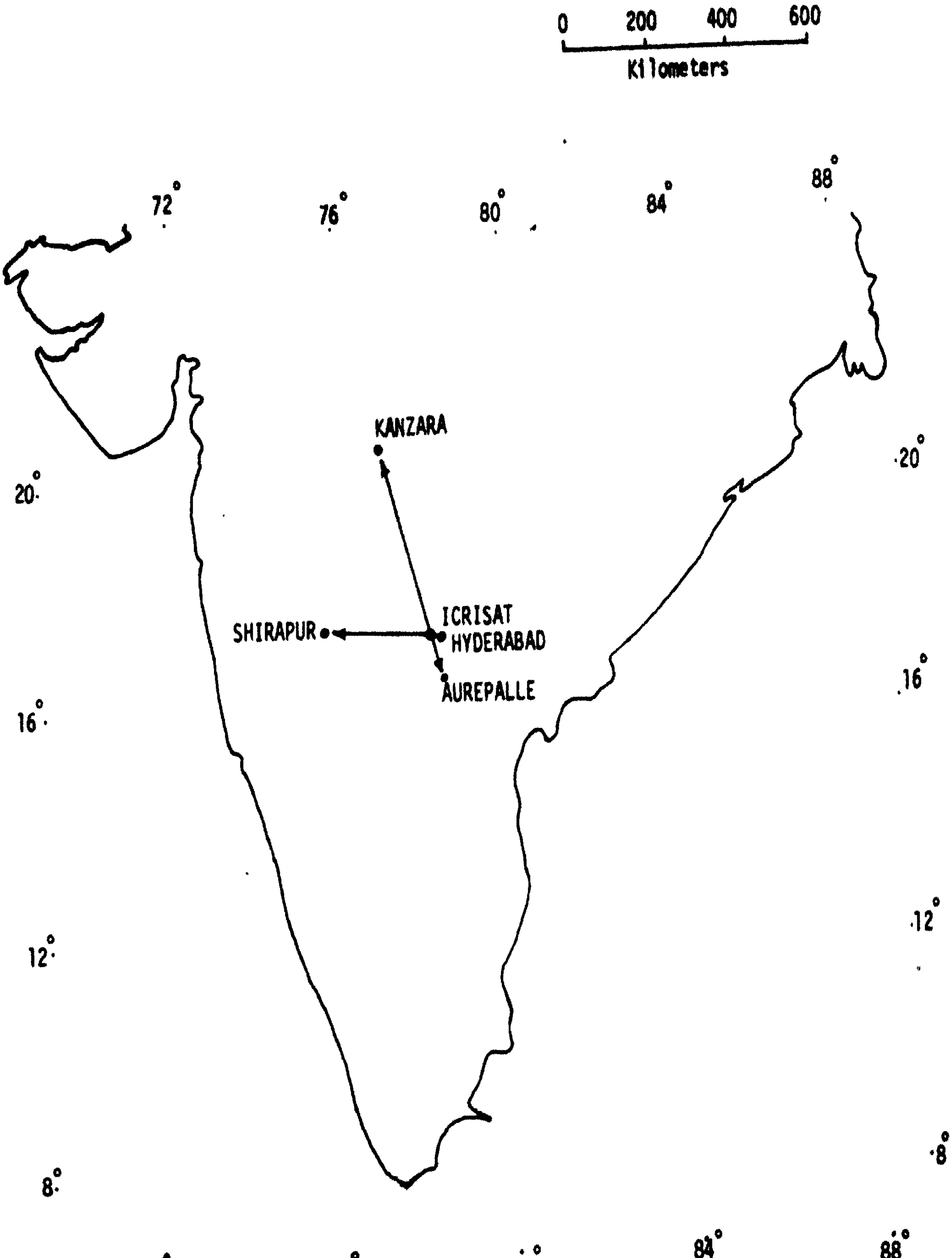

Fig. 1 . ICRISAT ON-FARM RESEARCH SITES.

Table 1: Some characteristics of the on-farm research sites, 1978-1981.

Sl. No.	Characteristics	State - / District- / Village -	Andhra Pradesh / Mahbubnagar / Aurepalle	Maharashtra / Sholapur / Shirapur	Maharashtra / Akola / Kanzara
1.	Distance from ICRISAT Center (Km)		100	300	500
2.	Average Annual Rainfall (mm)		681	635	818
3.	Soil type		Shallow Alfisols	Deep Vertisols	Shallow to medium deep Vertisols
4.	Important crops		Sorghum Castor Pearl-Millet Pigeonpea Paddy	Rainy season fallow and post-rainy season Sorghum Pigeonpea Chickpea Minor-Pulses	Cotton Sorghum Mungbean Groundnut Pigeonpea
5.	Households (No)		476	297	169
6.	Landless households (%)		28	23	32
7.	Average size of holding (ha)		3.5	6.5	6.1
8.	Rainfed area to total cropped area (%)		88	92	95
9.	Total area of the watershed where "Improved" systems are being tested (ha)		13.5	13	12
10.	No. of cooperating farmers hodling land on the watershed		5	7	7

The test criterion is productivity; the comparisons are made against the farmers' traditional system of farming in plots out side and adjacent to the watersheds. This is done by comparing agronomic performance and resource requirement data of "improved" systems with those of "traditional" systems involving similar crops on similar soils.

As originally agreed, material and input support by the Universities, AICRPDA and ICRISAT will continue only upto 1980-81 season. Thereafter any capital subsidies involved will be ceased. However, technical advice will be continued and whereever possible, will be provided through the participation of local extension services. The major focus of future analysis will become what use, if any, the farmers involved in the experiments will make of the new technology.

In addition to the above general techniques and methodologies, during 1980-81 on-farm research also included testing the performance of few individual components of new technology the details of which are presented in later sections.

4. Past experience:

Some salient observations and results from 1978-79 and 1979-80 crop seasons are given below:*

1. Results of the land and water development on a watershed base attempted during 1979 illustrated the utilization of under-employed labor and draft animals during the dry seasons. Watershed-based systems of resource development and management also revealed the relatively low capital cost involved and the increased employment potential for local labor and bullocks.
2. The yields obtained in Aurepalle and Kanzara with improved technology-varieties of high yield potential, the application of chemical fertilizers and better soil and crop management-were far greater than those of existing farming system.

*For more details see (a) ICRISAT Annual Report, 1978-79 and 1979-80 and (b) ICRISAT's involvement in cooperative on-farm research - a brief report prepared by J. Kampen for the meeting of ICRISAT's Research Program and Technology Transfer Committees, March, 1980.

3. Improved crop management technology is apparently related to the availability of precision equipment. Farmers in all villages appreciated the versatality of the multi-purpose tool carrier and the importance of precision and uniformity of seed and fertilizer placement.

4. Crop yields with the graded broadbed cultivation system with improved crop management in general exceeded those of the flat planted traditional system. The drainage function of the graded broadbed in Vertisols and its adaptability to several cropping systems were recognized.

5. Attempts to introduce double cropping in Shirapur were not successful.

6. It was confirmed that timeliness of all operations coupled with improved varieties and improved soil, water and crop management technology produce most spectacular effects.

7. The quantification of the gaps in productivity between experimental stations and farmers' fields showed the existence of large gaps and the potential of achieving much greater productivity under 'real-world' situations.

8. The need for continuous monitoring of the performance of improved technology to identify new problems is recognised. Examples are _Striga_ infestation associated with improved sorghum and millet cultivars in Aurepalle and Kanzara and perennial weed problems on broadbeds in Shirapur.

9. The need for adoptation of an improved technology suited to local situations and the value of 'feed-back' based on farmers' experience was recognised.

5. Cropping systems and methodology for 1980-81 growing season:

In addition to productivity comparison between improved and traditional farming systems additional informations were obtained during 1980-81 season by simulating additional treatments on the farmer fields. These treatments include beds vs flat cultivation, improved planting drill vs local planting drill, sole vs intercropping, local crop spacings vs standard row spacings, local vs improved cultivars, supplemental irrigation vs no irrigation etc. The physical, agronomic and socio-economic data were collected and the productivity was calculated as in previous seasons. However to obtain more accurate data crop yield samples were taken in consultation with the Statistician, and following procedure was adopted.*

*As per Mr. B. Gilliver's advice.

The sample size of 5 percent was used. 20 sample plots of 24 square meters (8m X 3m) were harvested per hectare. The same number of samples were taken from traditionally farmed fields outside the watershed. Using a grid system, with axes the number of beds and length of bed a 5% sample of pairs of random numbers were selected. In a field having the shape as shown in fig. 2 the chosen coordinates represent the plot area to be taken i.e. (3,2), (4,5), (6,4), (7,1), (9,3) - and are shown on the shaded area. The samples were harvested and the standard error was calculated. In some cases we had an opportunity to compare these sample yields with the actual threshing floor (or farmer reported) yields. This procedure of sampling was found useful and satisfactory.

Figs. 3,4 and 5 indicate the cropping systems on the farmer fields in Aurepalle, Kanzara and Shirapur watersheds.

The final seed bed preparation in all the research sites ted in May. The basal fertilizer application (18-46-0) was also completed before the onset of monsoon. Because of early onset of monsoon the planting in Aurepalle and Kanzara were done during the first and second week of June, 1980 utilising the first rains. However, Kharif planting in Shirapur was not attempted as the moisture was not sufficient to support a Kharif crop. Priority for planting was given to sorghum based cropping systems. Cultivations and hand weedings were carried out in time. Total nitrogen applied to cereals was on an average about 60 kg in Aurepalle, 70 kg in Kanzara and 25 kg/ha in Shirapur (along with 46 P_2O_5). Minimum plant protection measure were undertaken as the pest problems were not severe mainly due to early planting.

The total rainfall during 1980 was below normal in all the villages (fig. 6). Though the onset of monsoon was early the rains receded very early in the season and the crops suffered heavily due to late season drought. There was a brief drought spell during June/July in Aurepalle, but the overall rainfall distribution till the end of August was satisfactory. There were few heavy storms resulting in runoff and erosion in both Aurepalle and Kanzara watersheds.*

*The runoff and erosion however could not be quantified in these watersheds.

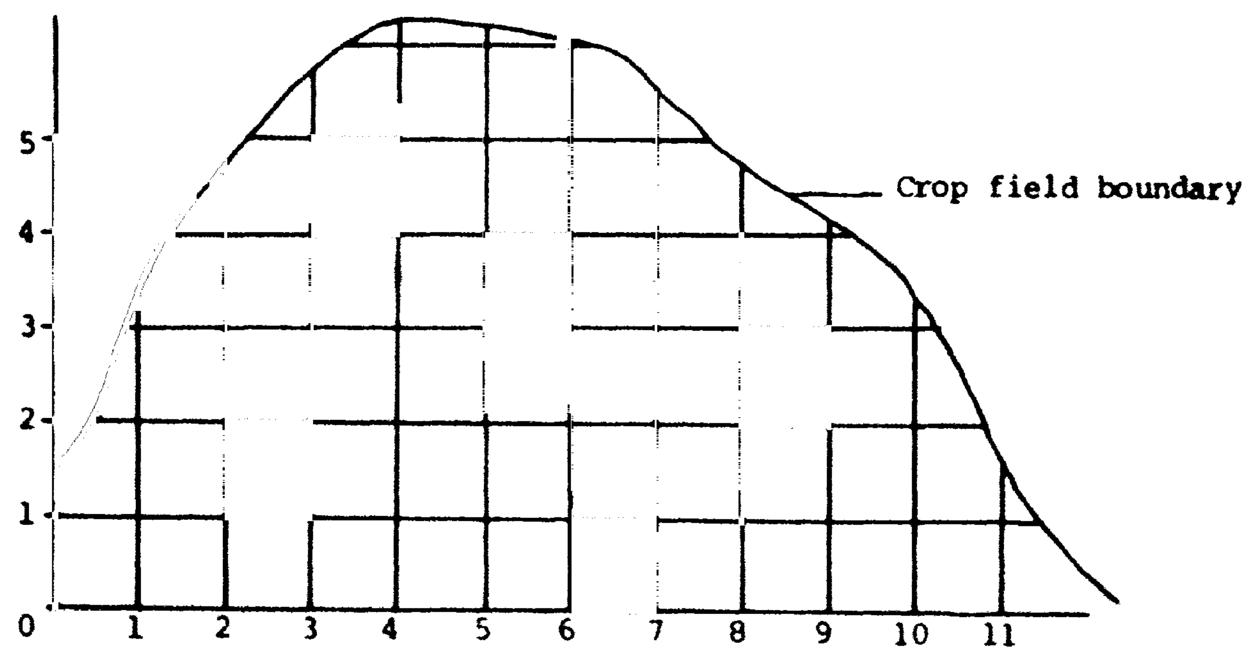

Fig. 2 . A DIAGRAMATIC PRESENTATION OF A FARMER FIELD SHOWING THE CROP YIELD SAMPLING PROCEDURE, 1980-81.

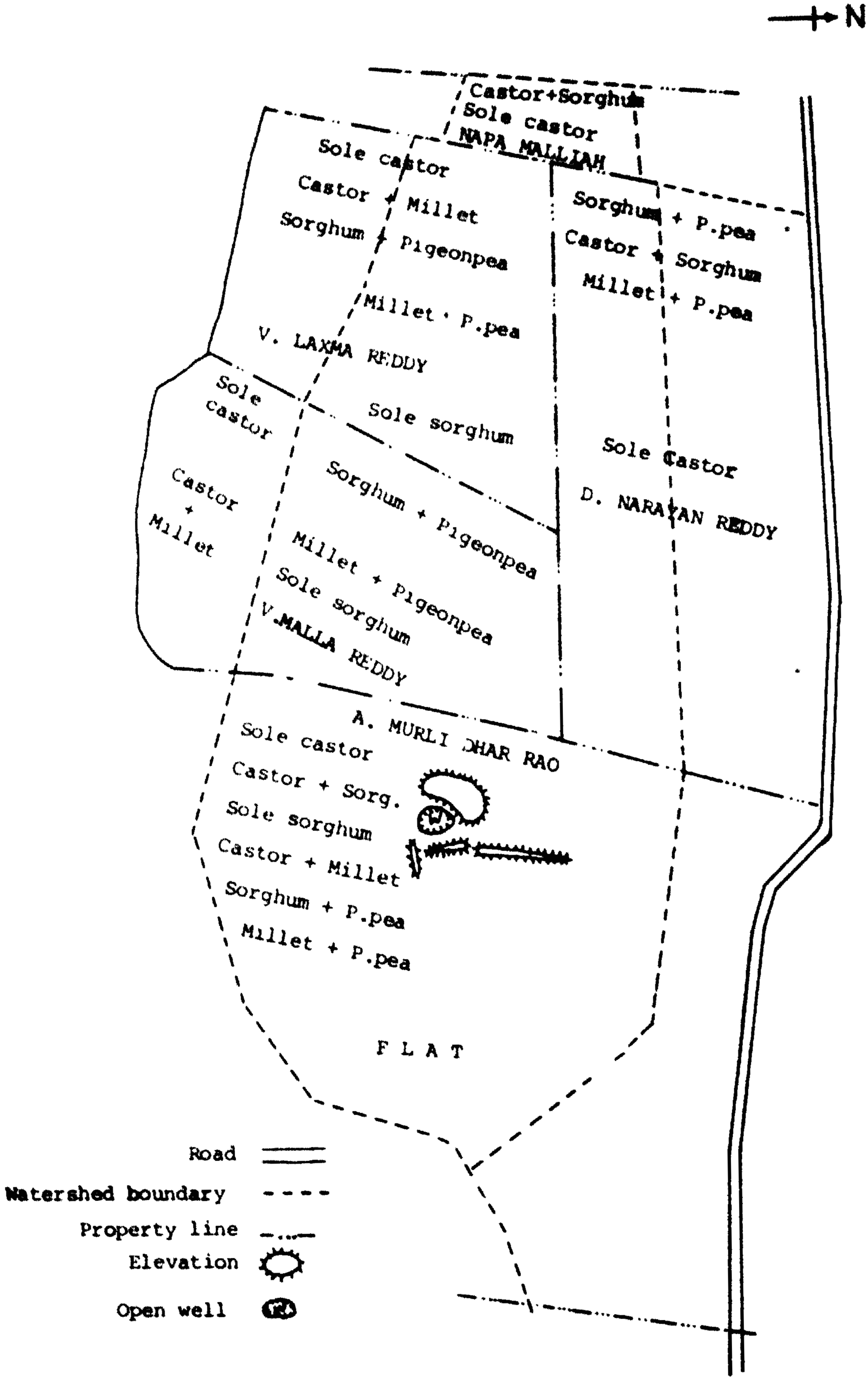

Fig. 3. AUREPALLE WATERSHED WITH FARMER BOUNDARIES AND IMPROVED CROPPING SYSTEMS, 1980-81.

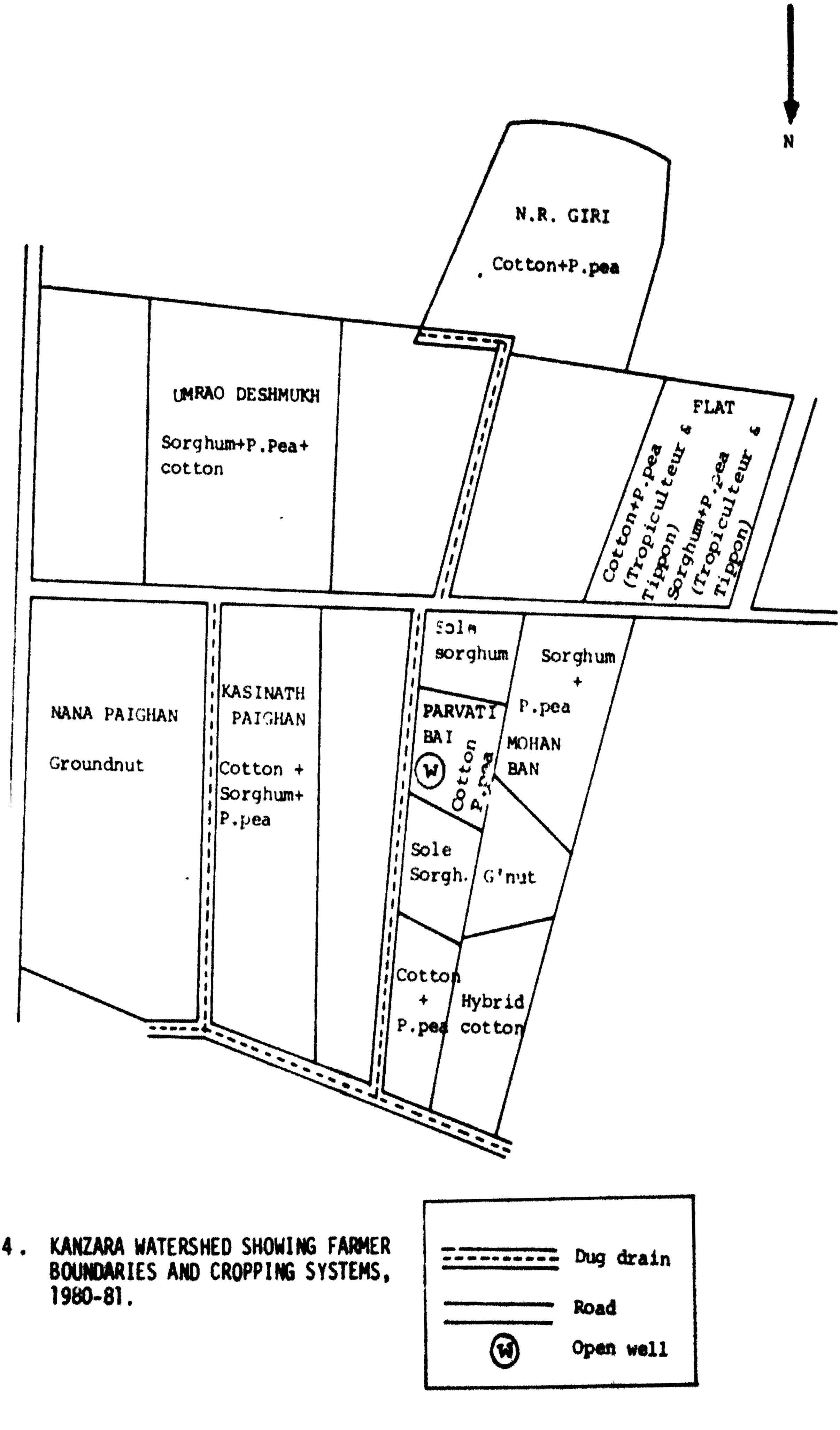

Fig. 4. KANZARA WATERSHED SHOWING FARMER BOUNDARIES AND CROPPING SYSTEMS, 1980-81.

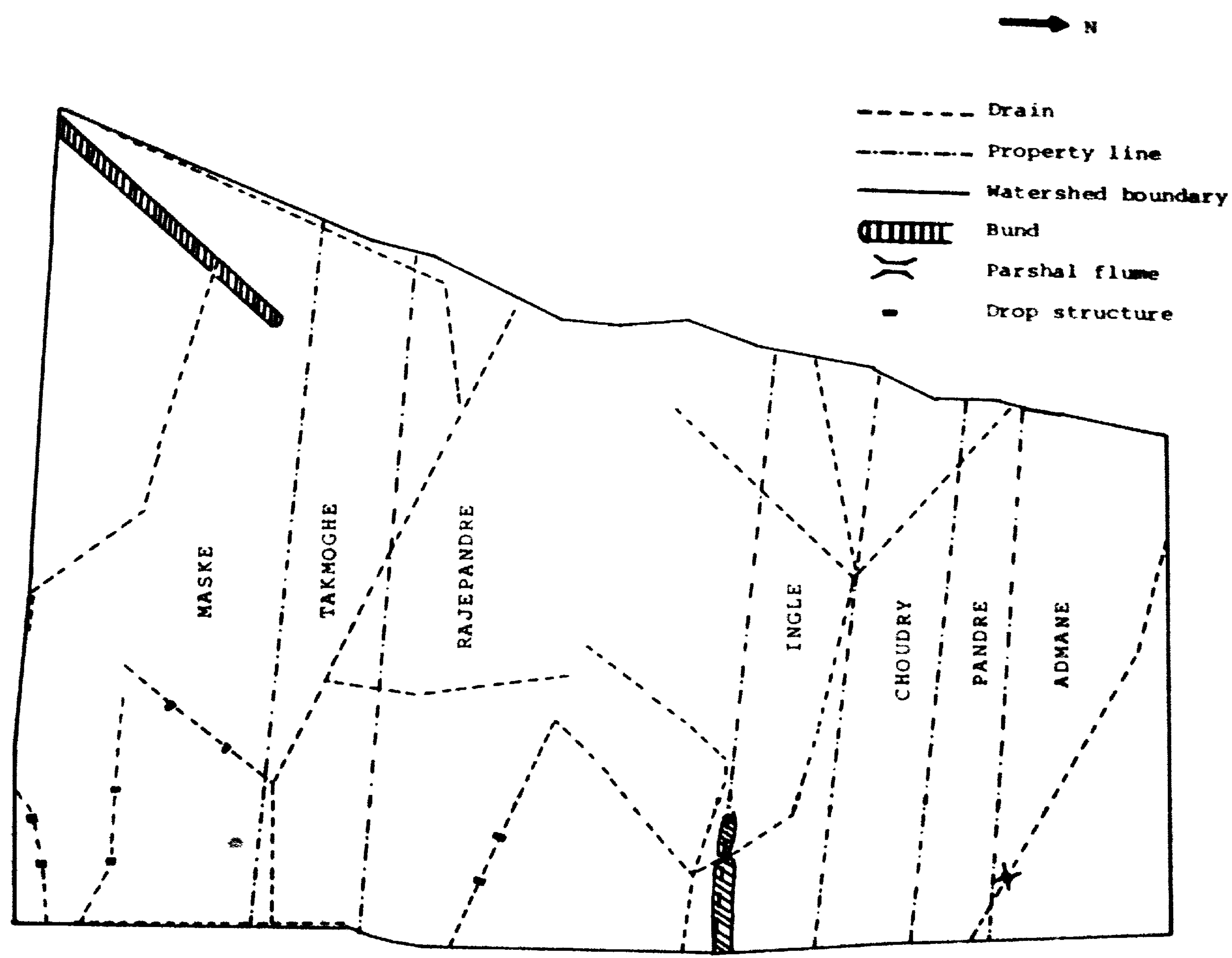

Fig. 5. SHIRAPUR WATERSHED SHOWING FARMER BOUNDARIES, 1980-81.

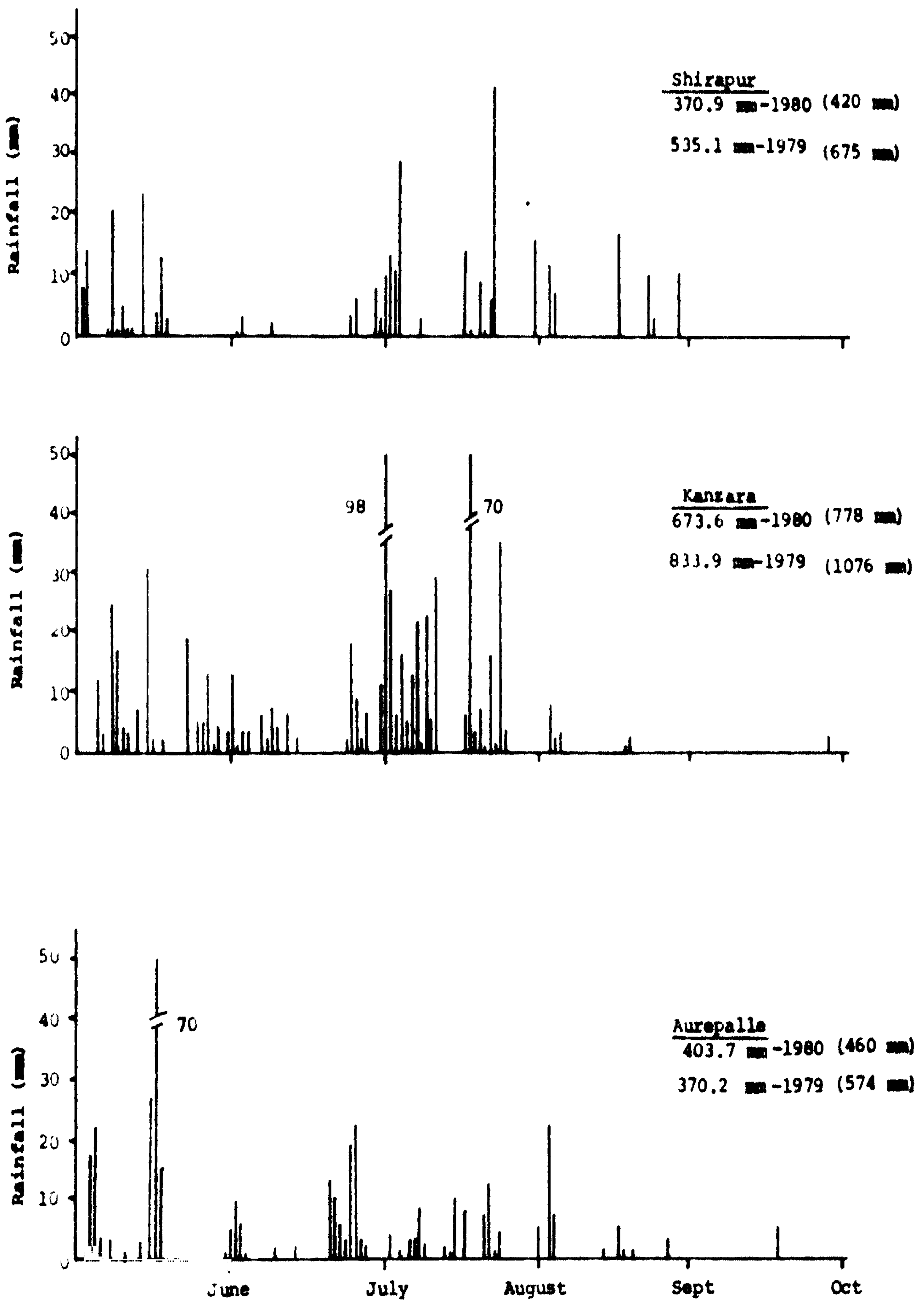

Fig. 6. RAINFALL DISTRIBUTION AT AUREPALLE, KANZARA AND SHIRAPUR - 1980.

Some of the common observations noticed in all the 3 villages are:

1) Wide variation in crop yields among different fields within a watershed.

2) Variation in the nature and extent of participation by farmers among and within villages and watersheds.

3) More priority for irrigated agriculture (and also for commercial crops) than to rainfed farming.

6. <u>Summary of results of 1980-81</u>:

Some of the salient results observed and the experience gained are summarised in the following pages.*

6.1. <u>Aurepalle</u>

1) The growth of cereals-sorghum and millet was excellent, but pigeonpea and castor suffered heavily due to early cessation of rains. The sorghum and millet in the watershed outyielded those under traditional system substantially (upto 7 times). Because of greater variations in moisture storage capacity (soil depth varying from 10 to 45 cm depth) the crop yield levels varied widely across farmers' fields within the watershed (tables 2 and 3).

2) Though sorghum suffered a mid-season drought, good yields were obtained because of timely rainfall later. Pearlmillet yields were not as good as sorghum mainly because of lack of moisture at the time of second top dressing of N and thus resulting in N deficiency. A heavy downpour of 70 mm once early in the season also caused the leaching of first dose of N applied. However, timely sowing and improved technology (fertilizer, cultivar, precision seed and fertilizer placement etc.) resulted in spectacular cereal yields when compared to traditional technology practised in rest of the villages (fig. 7).

3) The long duration crops - castor and pigeonpea suffered heavily because of early cessation of rains. However, castor in the watershed out yielded that in traditional plots.

4) The incidence of pests early in the season was negligible. But, weed problems were severe within the watershed where farmers had to handweed more than three times in addition to two interculturations. <u>Cyperus</u> was the major weed associated with improved technology. The blade attachments to tropiculteur were found better in controlling weeds than the duck

*The results are mainly based on crop yield samples taken as per the statistician's advice, though some attempt was made to calculate the net returns most of the observations are based on gross returns. The detailed economic analyses will be made by the Economics Program.

Table 2: Crop yields (q/ha) for several crops at Aurepalle village in 1980-81.*

Farm No.	Cropping system	Cereal grain	Standard error ±	Cereal fodder	P.pea grain	Castor
	On Broad beds					
1	Sole sorghum	28.4	1.5	54.9	-	-
1	Sorghum-pigeonpea	16.5	1.9	29.1	0.4	-
1	Millet-pigeonpea	15.8	1.0	17.5	0.2	-
1	Sole castor	-	-	-	-	4.9
1	Castor-millet (2:1)	9.3	1.0	10.4	-	1.3
1	Millet-castor (2:1)	13.5	1.8	13.5	-	0.7
2	Sole sorghum	23.8	1.1	41.1	-	-
2	Sorghum-pigeonpea	16.8	1.0	30.7	0.3	-
2	Millet-pigeonpea	14.7	.9	14.7	0.3	-
2	Castor-millet (2:1)	2.8	.6	4.5	-	2.6
2	Sole castor	-	-	-	-	4.0
3	Millet-pigeonpea	8.6	1.1	7.9	0.3	-
3	Sorghum-pigeonpea	10.6	1.0	21.5	0.2	-
3	Sorghum-castor (2:1)	9.4	1.9	23.6	-	0.1
3	Castor-sorghum (2:1)	5.0	1.0	11.2	-	1.1
3	Sole castor	-	-	-	-	2.9
4	Castor - Sorghum (2:1)	20.7	1.7	33.5	-	1.7
4	Sole castor	-	-	-	-	5.7
5	Sole sorghum	20.1	1.2	46.3	-	-
5	Sorghum-pigeonpea	10.9	2.3	30.9	0.4	-
5	Millet-pigeonpea	20.9	2.3	22.9	0.4	-
5	Sorghum-castor (2:1)	14.8	.5	37.5	-	0.7
5	Castor-sorghum (2:1)	13.7	1.8	33.3	-	0.6
5	Millet-castor (2:1)	12.1	2.2	17.5	-	0.1
5	Sole castor	-	-	-	-	3.2
	Flat cultivation**					
5	Millet-pigeonpea	8.5	.2	11.4	0.5	-
5	Sorghum-pigeonpea	17.2	2.6	34.9	0.3	-
5	Sole castor	-	-	-	-	2.2
5	Sorghum-castor (2:1)	17.4	2.6	34.2	-	0.2
5	Castor-sorghum (2:1)	11.2	1.9	21.5	-	0.4
	Local technology***					
	Sorghum-millet-p.pea	2.49 s	1.4			
		1.4 m	1.1			
		3.89		15.9	-	
	Sole castor					1.5

* The following farmers were involved in the experiment: (1) V. Malla Reddy (2) V. Laxma Reddy (3) D. Naravan Reddy (4) N. Malliah (5) A. Murlidhar Rao

** Data on flat cultivation presented here are from unreplicated small plots

Data collected from 8 farmers' fields - average of 72 samples

Table 3: Crop yields (q/ha) in Aurepalle watershed, 1980-81.

Farm No.	Cropping systems	Cereal grain	Cereal fodder	Pigeon-pea	Castor
1	Sole sorghum	28.4	54.9		
2		23.8	41.1		
5		20.1	46.3		
		24.1	47.1		
1	Sorghum-P.pea	16.5	29.1	0.4	
2		16.8	30.7	0.4	
3		10.6	21.4	0.3	
5		10.9	30.9	0.4	
		13.7	28.0	.37	
1	Millet-P.pea	15.8	17.5	0.2	
2		14.7	11.7	0.3	
3		8.6	7.9	0.3	
5		20.9	22.0	0.4	
		15	15.5	.3	
1	Sole castor				4.9
2					4.0
3					2.8
4					5.7
5					3.2
					4.1
3	Sorghum-castor (2:1)	9.4	23.6		0.1
5		14.8	37.5		0.7
		12.1	30.5		.4
3	Castor-sorghum (2:1)	5.0	11.2		1.0
4		20.7	33.5		1.7
5		13.6	33.3		0.6
		13.1	26.0		1.1
1	Millet-castor (2:1)	13.5	13.5		0.7
5		12.1	17.5		0.1
		13.1	26		.4
1	Castor-millet (2:1)	9.3	10.4		1.3
2		2.8	4.6		2.6
		6.0	7.5		1.9

*Farmers - 1. V. Malla Reddy, 2. V. Laxma Reddy, 3. D. Narayan Reddy, 4. N. Malliah, 5. A. Murlidhar Rao.

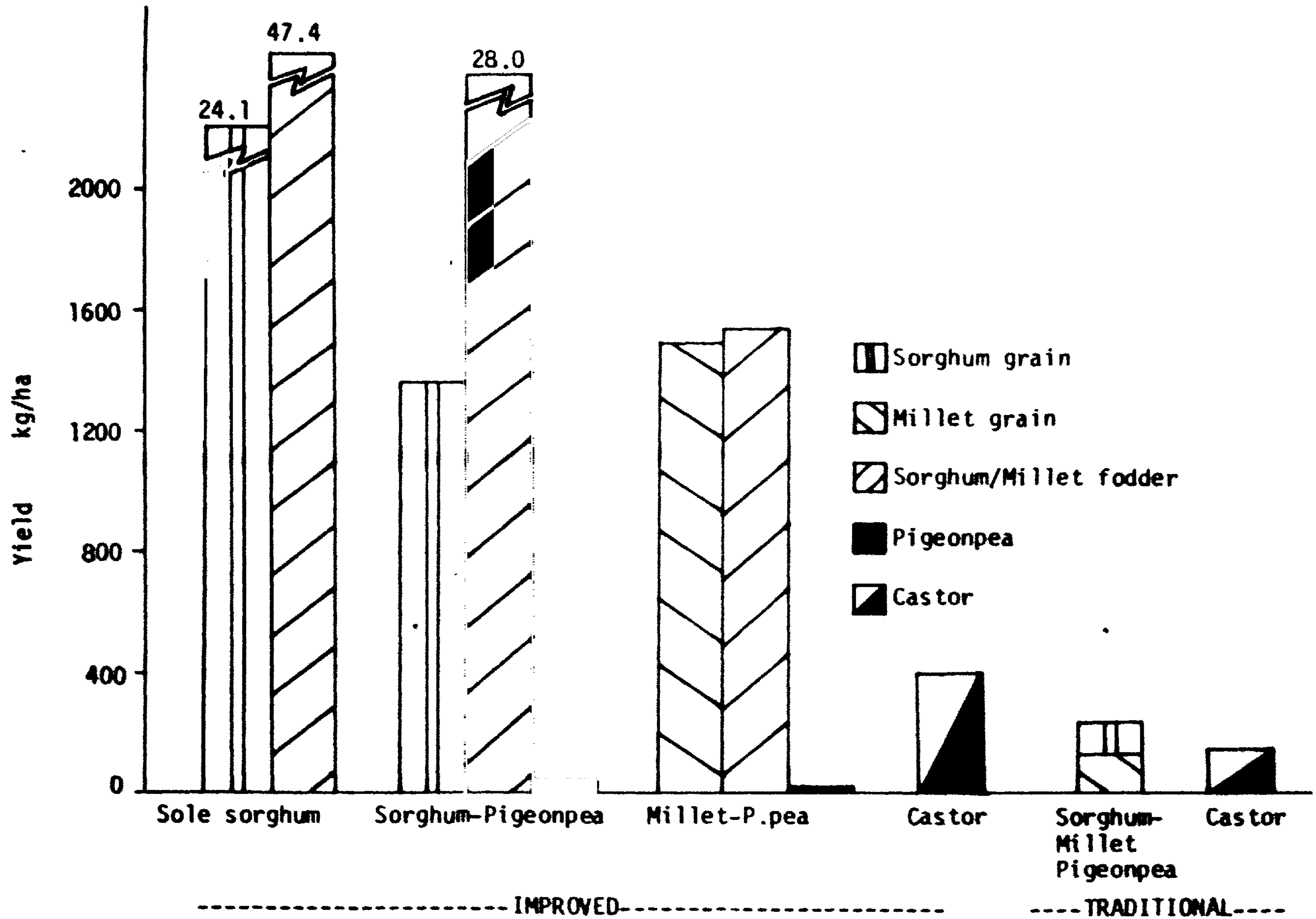

Fig. 7. CROP YIELDS FROM IMPROVED AND TRADITIONAL FARMING SYSTEMS AT AUREPALLE, 1980-81.

foot attachment. Severe infestation of <u>Striga</u> was also noted in patches associated with CSH-6 sorghum. Later in the season mites and earhead bugs were also noticed in sorghum.

5) The suitability of broad bed and furrows for Alfisols is still a question. Though it appeared that broad beds are necessary to obtain precision control in seeding and fertilizer application, there were no noticeable differences in yields between flat planted and broad bed and furrow planted crops (table 4 and fig. 8). A preliminary analysis* on net returns also supported this conclusion (fig. 9)

6) Preliminary trials to observe the potential of intercropping in castor indicated that weeding and interculti- vation are the major hurdles. Castor suffered adversely because of the early competition of sorghum or millet and their indirect effect on the lack of weed control later in the season. However, when compared to traditional sole castor, intercropping of castor with millet or sorghum seemed to have good potential particularly in the years of early cessation of rains (fig. 10).

   A preliminary economic analyses* of different castor based systems indicated that traditional castor resulted in net loss of Rs. 27/ha. In improved system on the watershed while sole castor resulted in Rs. 459 net profit all the castor based intercropping systems except castor-millet performed better than sole castor system. Castor-sorghum system resulted in highest profit of Rs. 688/ha. Though the gross returns were higher in all the intercrop system total inputs/ha were also higher in all the intercrop systems mainly because of additional costs involved in hand weeding.

7) Pigeonpea and castor suffered heavily because of early cessation of rians. While pigeonpea failed completely castor could yield only 1.5 q/ha in traditional systems. In general, the competitive effect of castor and pigeonpea on millet yields was same with no substantial change in millet yields. Sorghum suffered heavily because of intercropping with pigeonpea or castor as sole sorghum yielded substantially higher than intercropped sorghum. The competitive effect of castor and pigeonpea were however similar and there was no substantial difference in intercropped sorghum yields. As Aurepalle is primarily castor growing village intercropping of castor seems to have potential particularly to avoid rainfall vagaries. (fig. 11).

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*The economic analysis attempted by us is only very preliminary. The analysis incorporates only grain yields and only inputs like seed operation cost & fertilizer. For detailed economic analysis please refer to Economics Program.

Table 4: Crop yields (q/ha) for several crops at Aurepalle village watershed under flat cultivation.

Treat. No.	Geno-type	Plan-ting drill	Row spa-cing	Cropping systems		Cereal grain		Cereal fodder	P.pea	Castor
1	L	L	L	Sorg-Millet-P.pea	S M	5.2 .8	-	32.6	Nil	-
2	I	L	L	Millet-P.pea		5.8	± .5	9.6	.6	-
3	I	L	S	"		5.2	± .7	6.5	.4	-
4	I	I	S	"		8.6	± .2	11.5	.5	-
5	I	L	L	Sorg-P.pea		9.6	± 1.4	30.7	.4	-
6	I	L	S	"		12.5	± 1.0	27.1	.3	-
7	I	I	S	"		14.1	± 2.6	35.0	.4	-
8	I	I	S	Sole castor		-	-	-	-	2.0
9	I	L	S	"		-	-	-	-	3.5
10	I	L	S	Sorg-castor		15.1	± 2.7	29.0	-	.4
11	I	I	S	"		17.4	± 2.6	34.0	-	.2
12	I	I	S	Castor-sorg (2:1)		11.2	± 2.0	21.5	-	.4
13	I	L	S	"		9.1	± .6	17.3	-	.2

I = Improved

L = Local

S = Standard (45 cm)

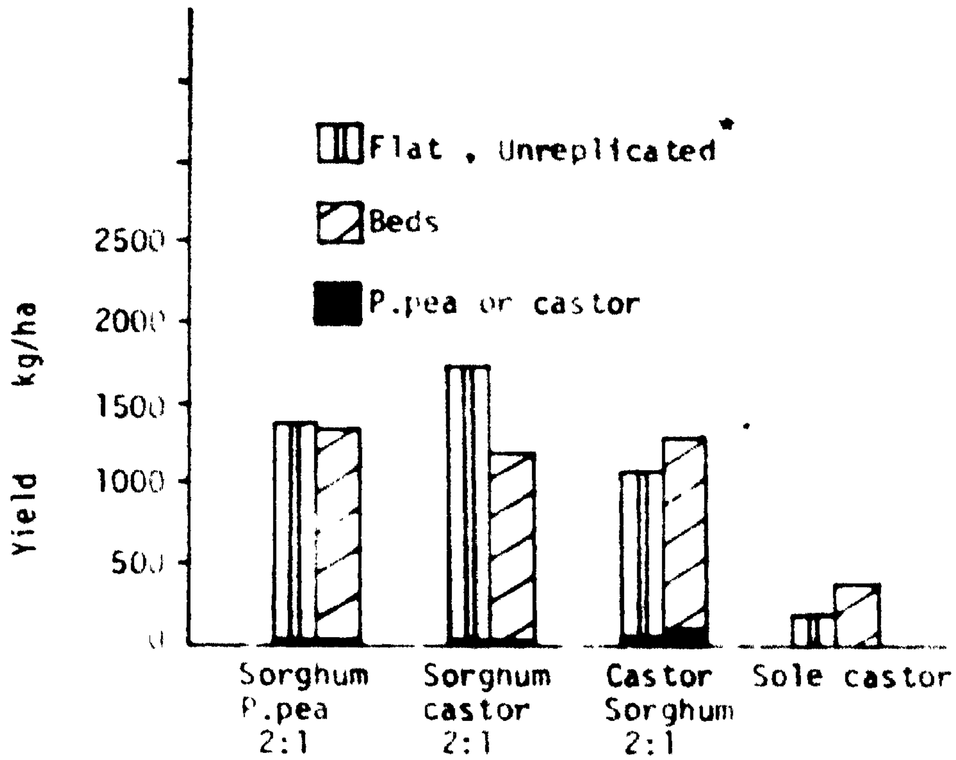

Fig. 8. YIELDS OF DIFFERENT CROPS AS AFFECTED BY FLAT* AND BROADBED SYSTEM OF CULTIVATION, AUREPALLE, 1980-81.

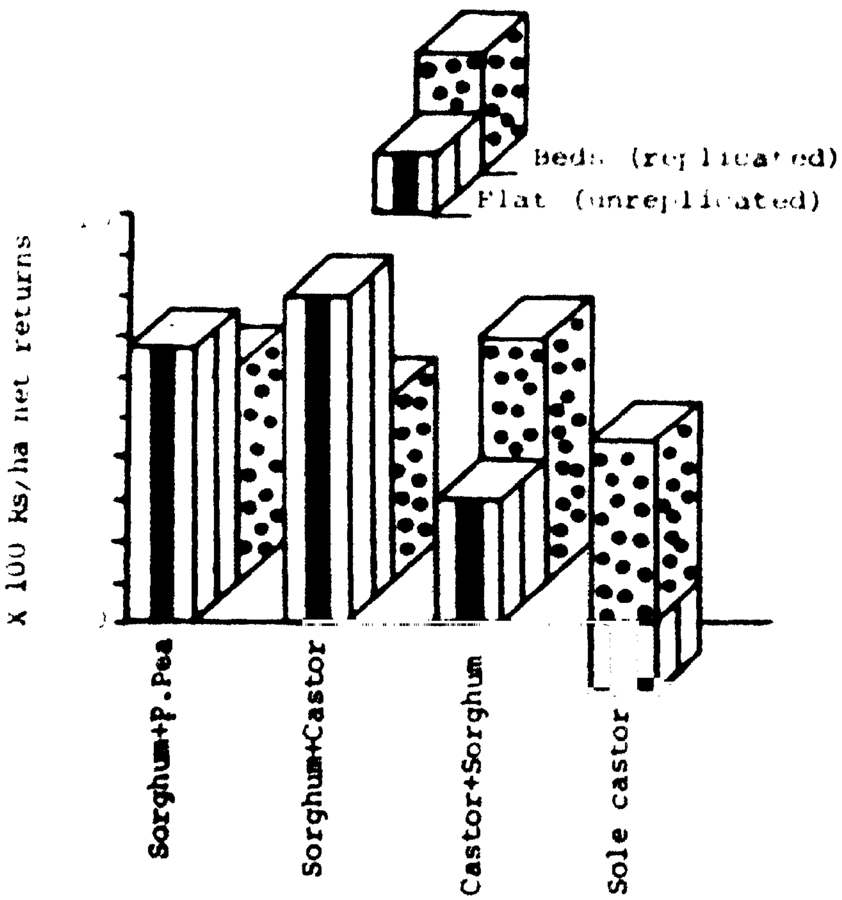

Fig. 9. EFFECT OF BED AND FLAT SYSTEMS OF CULTIVATION ON NET RETURNS FROM DIFFERENT CROPPING SYSTEMS IN AUREPALLE, 1980-81.

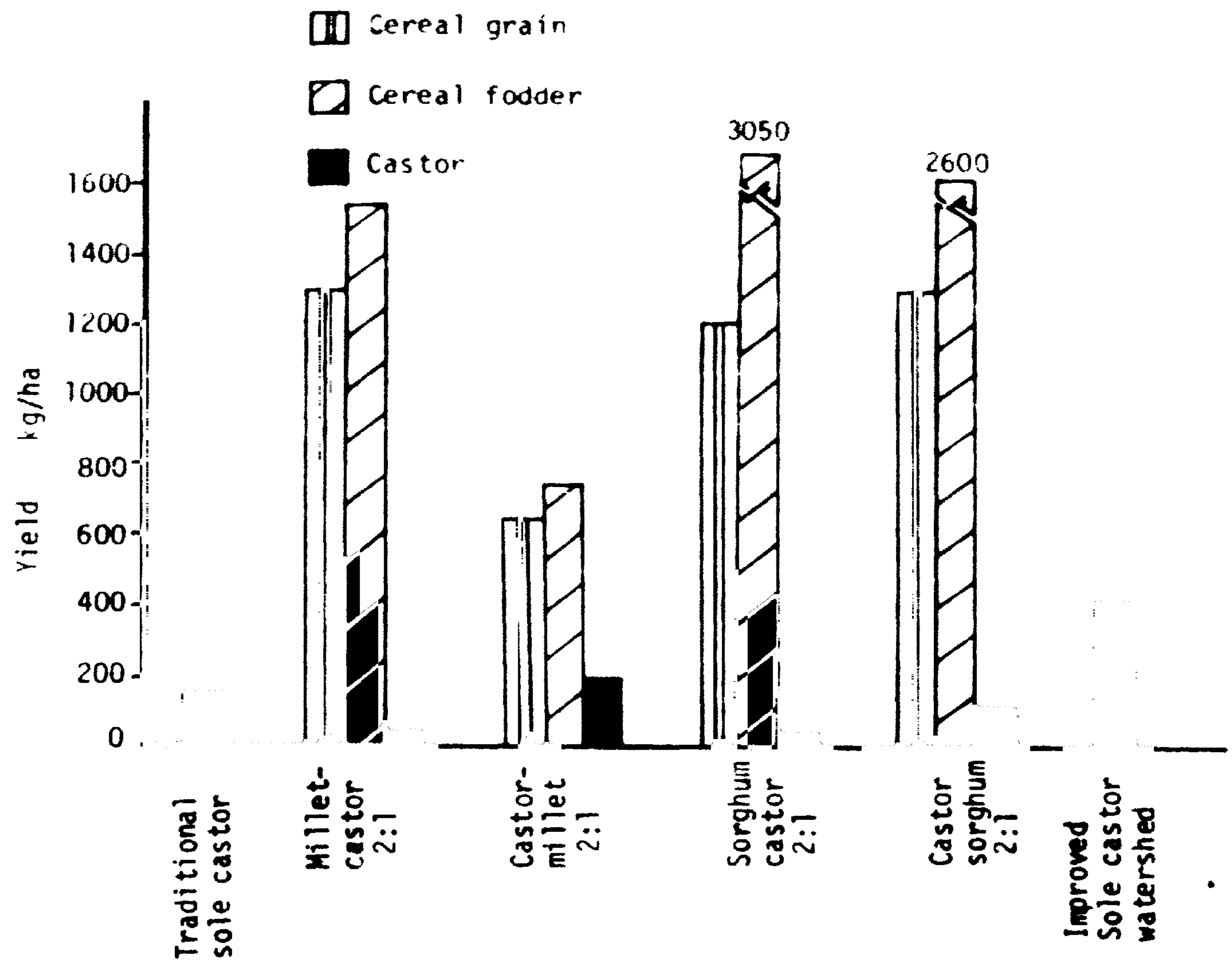

Fig. 10. CROP YIELDS OF CASTOR BASED CROPPING SYSTEMS, AUREPALLE, 1980-81.

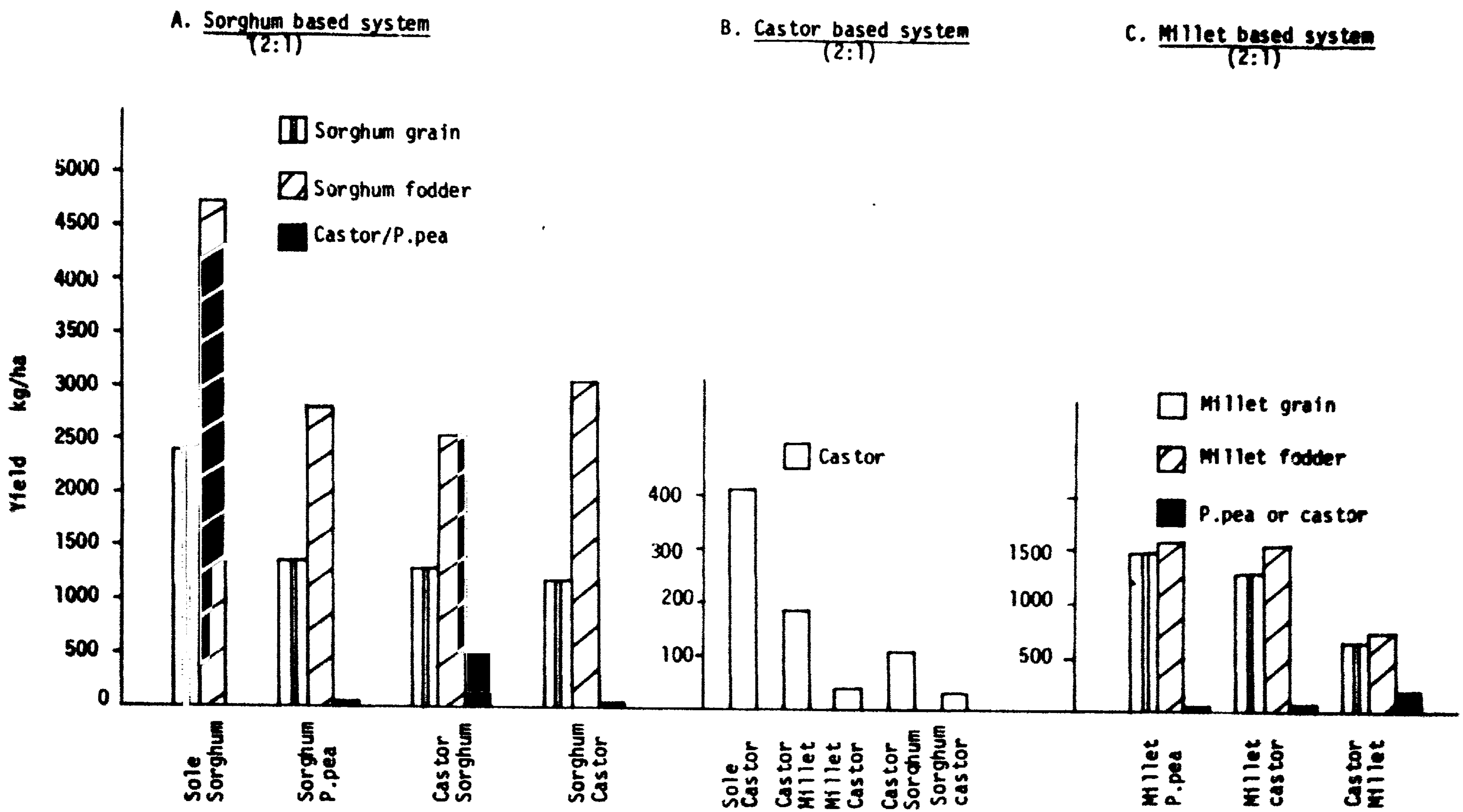

Fig. 11. EFFECT OF DIFFERENT CROPPING SYSTEMS ON THE YIELDS OF DIFFERENT COMPONENT CROPS, AUREPALLE, 1980-81.

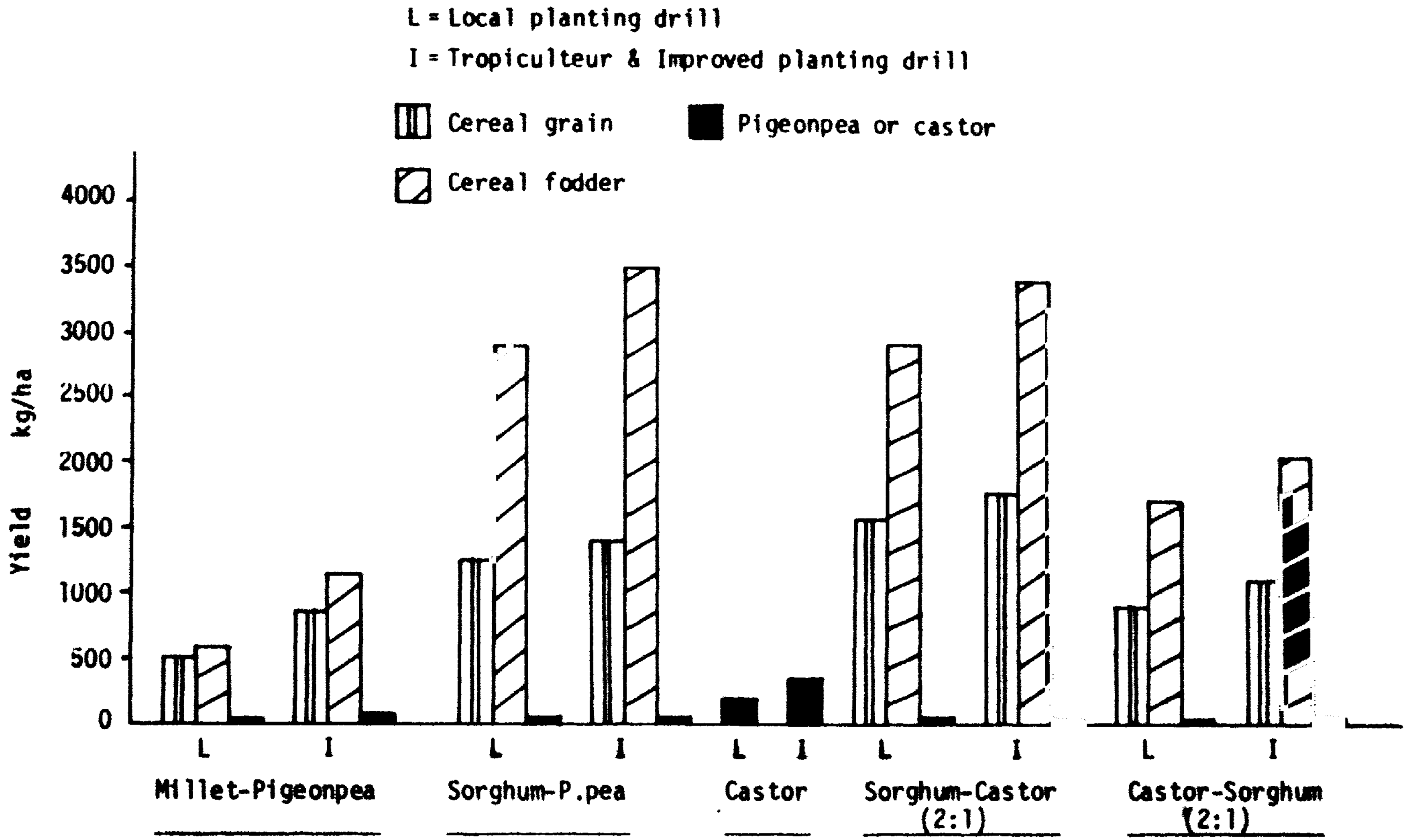

Fig. 12. YIELDS OF DIFFERENT CROPS AS AFFECTED BY TWO PLANTING DRILLS ON A FLAT SEED BED, AUREPALLE, 1980-81.

8) The utility of tropiculteur particularly in precision planting and fertilizer application was noticed. On flat seedbed, yields of all the crops were higher when planted with tropiculteur as compared to yields from local drill planted crops. (fig. 12). The combined effect of standard row spacings (2:1) and the use of tropiculteur resulted in higher crop yields than the yields of crops planted on a local spacings (7 to 10 lines of varying row widths of cereals and one or two rows of pigeonpea) by local drill.

9) If one considers two years data (1979 and 1980) of Aurepalle watershed, 1980 crop yields were far superior to 1979 yields though in terms of total rainfall 1979 was favourable. The reasons contributing to higher yields are manyfold -- major being early planting, better crop management and good rainfall distribution. The quantum jump in yields is more pronounced in improved technology treatments than in the traditional technology (fig. 13).

10) The yield gap analysis indicated the wide gaps that exist between research center (ICRISAT) and farmer fields. The performance of improved systems in ICRISAT center and farmers' fields and the performance of the traditional systems are compared in figs.14 & 15. It is striking to note the large gaps existing at both the levels in all the cropping systems when previous seasons research yields were taken into consideration (fig. 14). However, only gap II was noticed when 1980/81 research station data were considered (fig. 15). Future on-farm research should focus on the characterization and analysis of the factors responsible for these gaps and also on the development of technologies to bridge these gaps.

11) The sampling procedure adopted to gather yield data on the farmer fields for the first time this year provided useful information. The estimated produce by random sampling was almost at par with the actual produce from the threshing floor. After accomodating for the losses due to border effects, bulk harvest, bulk transport and bulk threshing etc. there does not seem to be much difference between estimated and actual yields (fig. 16). The sampling procedure thus can be adopted for future on-farm studies.

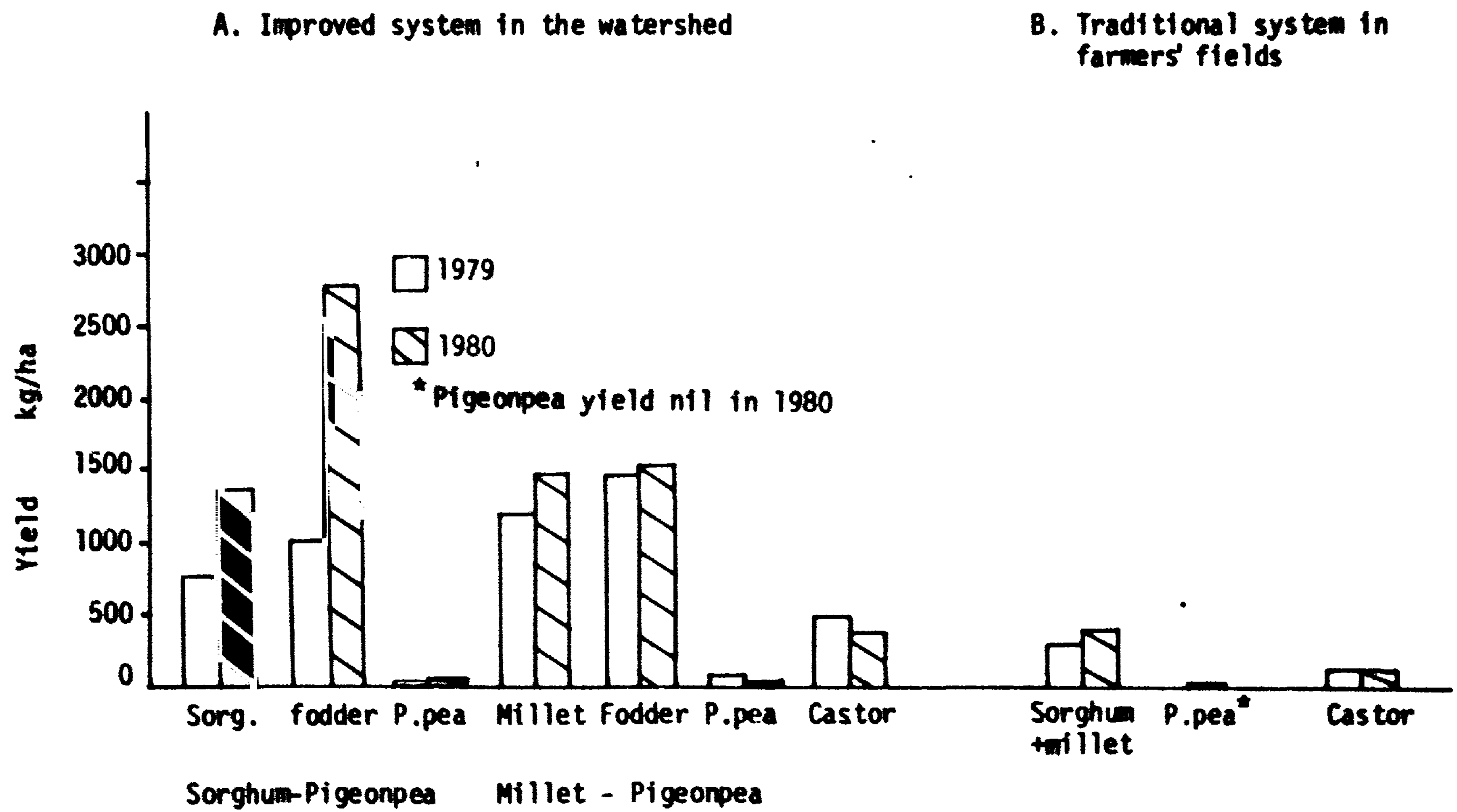

Fig. 13. CROP YIELDS AT AUREPALLE AS AFFECTED BY SEASONAL AND MANAGEMENT CHANGES, AUREPALLE, 1979-1980.

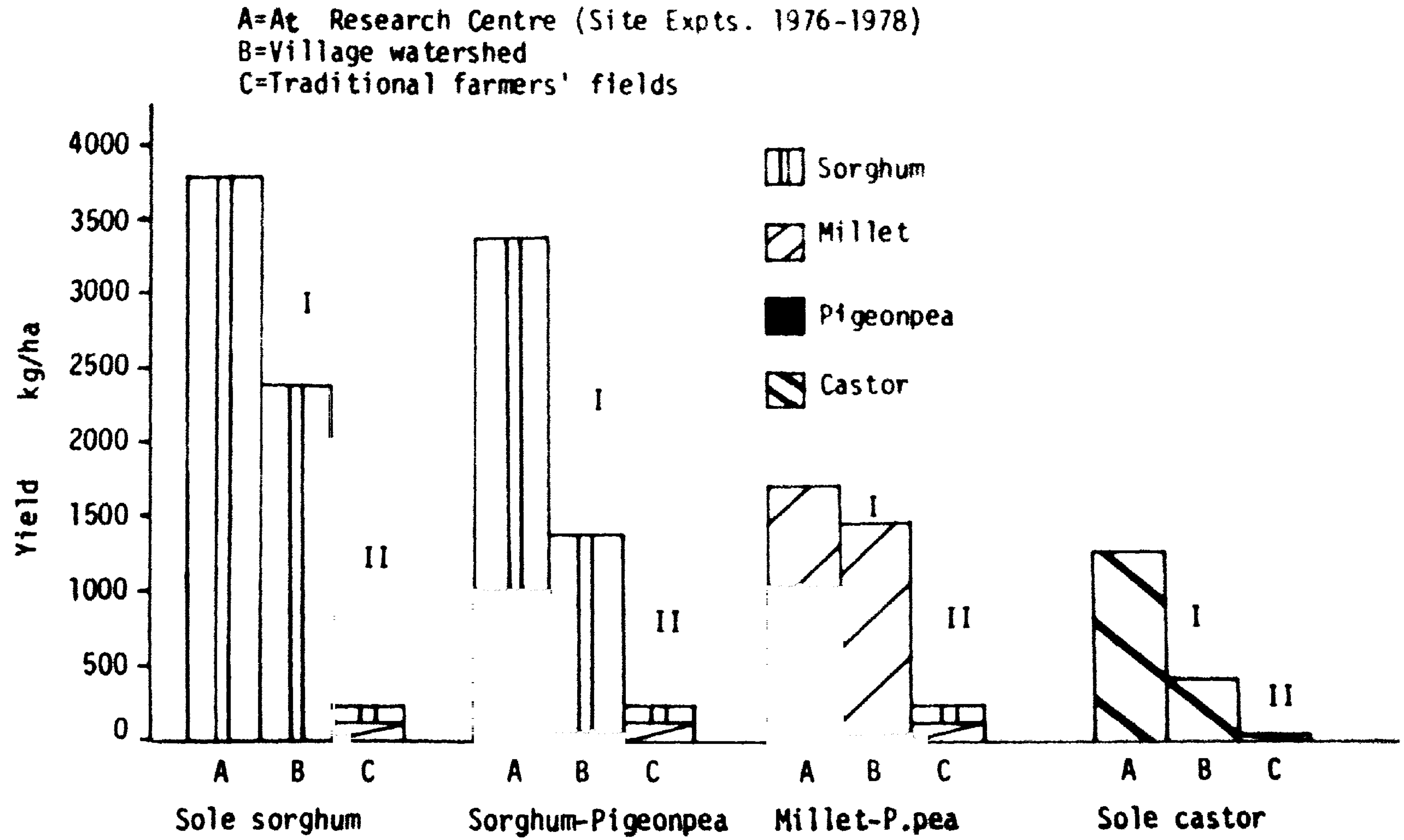

Fig. 14. CROP YIELDS AT AUREPALLE AS OPPOSED TO POTENTIAL YIELDS AT ICRISAT CENTER, AUREPALLE, 1980-81.

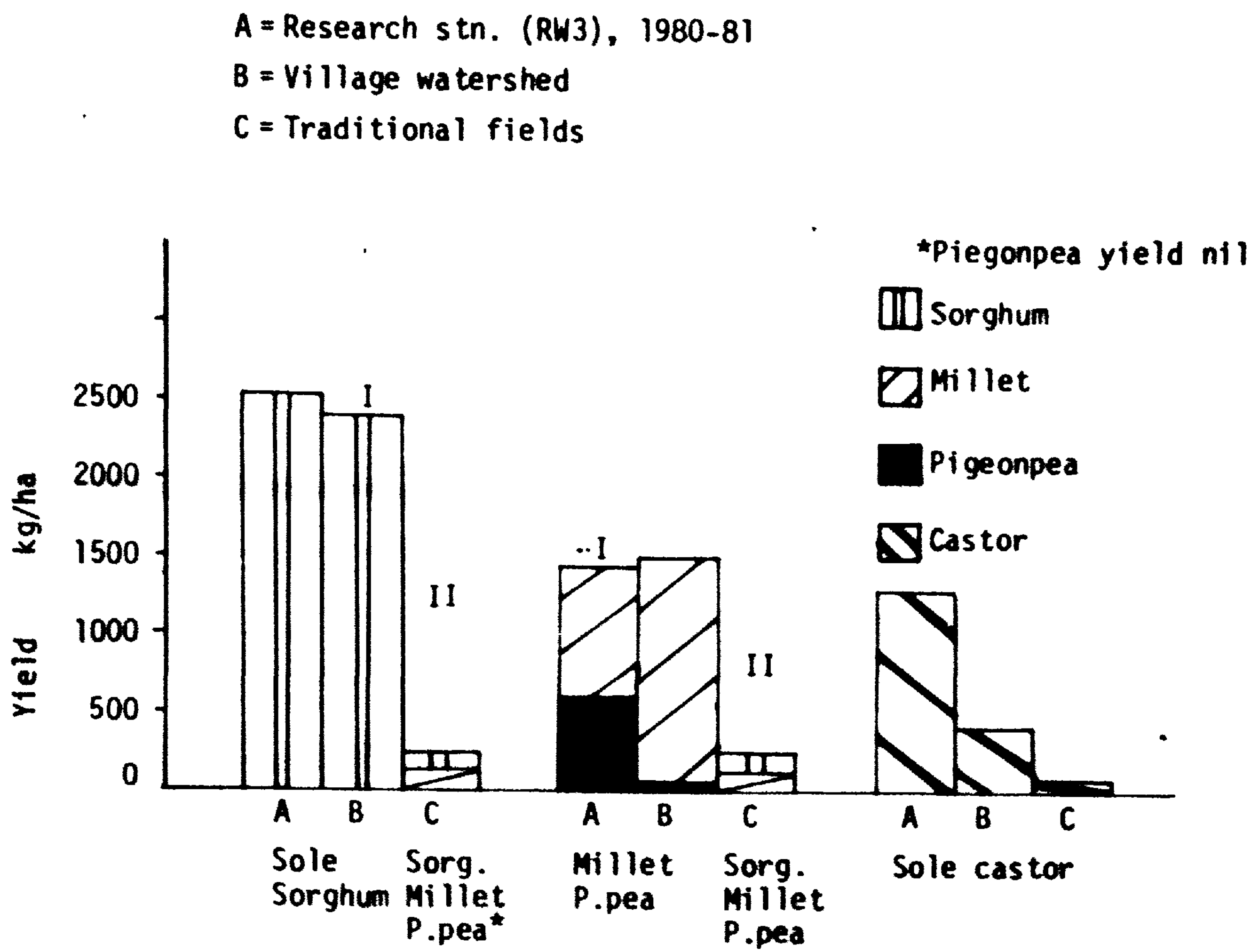

Fig. 15. CROP YIELDS AT ICRISAT AND AUREPALLE INDICATING THE YIELD GAPS BETWEEN POTENTIAL AND ACTUAL YIELDS, 1980-81.

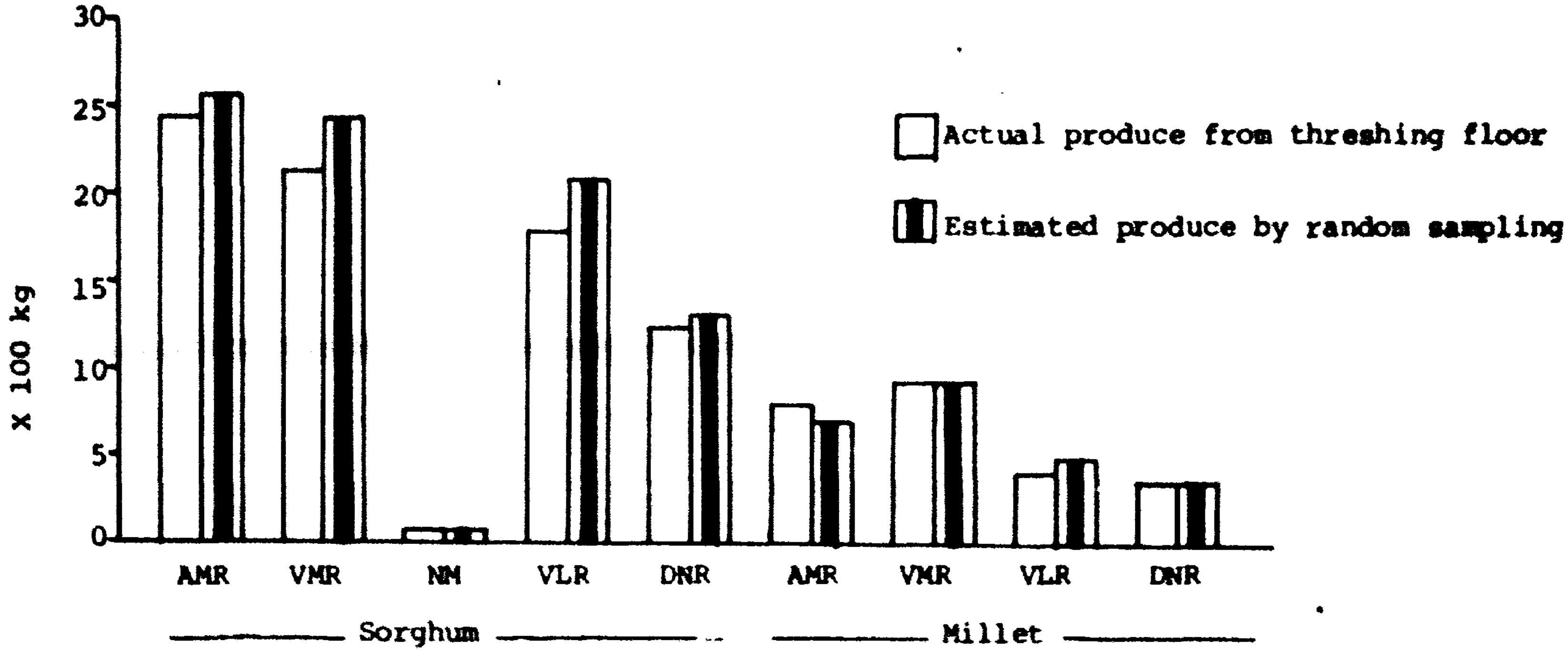

Fig. 16. A COMPARISON OF ESTIMATED AND THRESHING FLOOR YIELDS OF SORGHUM AND MILLET IN DIFFERENT FARMER FIELDS, AUREPALLE, 1980-81.

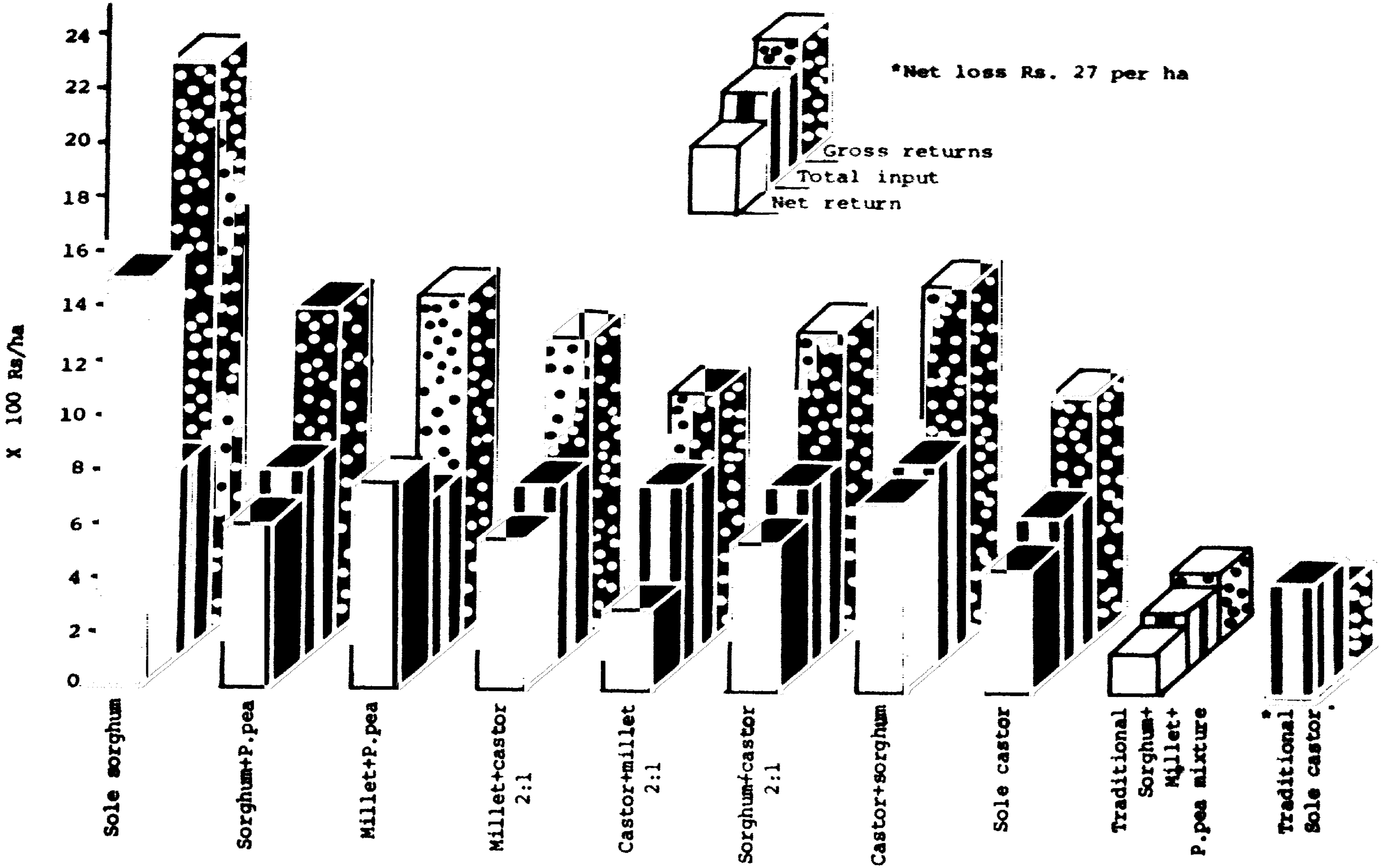

Fig. 17. ECONOMIC ANALYSES OF DIFFERENT CROPPING SYSTEMS IN AUREPALLE, 1980-81.

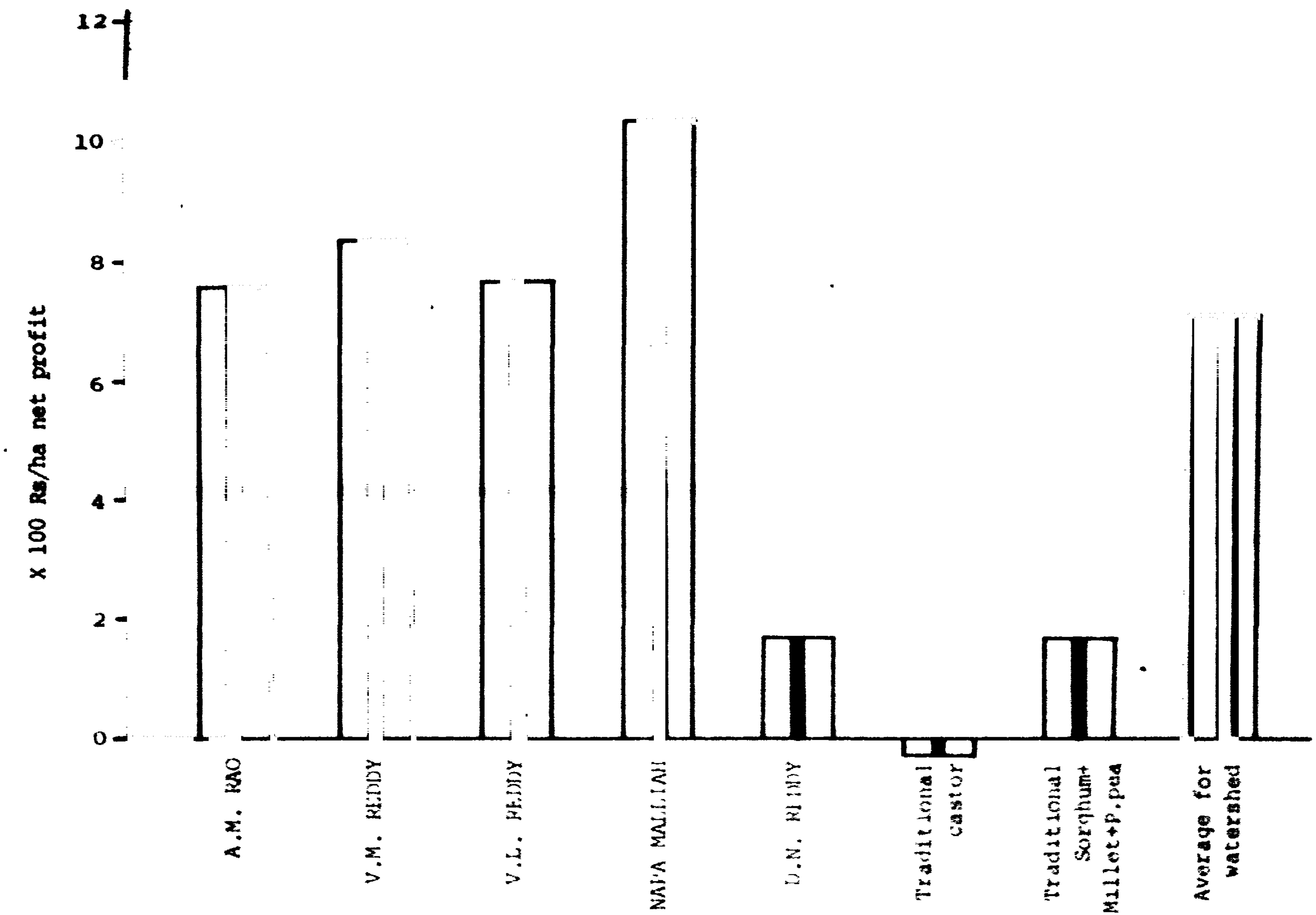

Fig. 18. AVERAGE NET RETURNS OBTAINED BY DIFFERENT COOPERATING FARMERS OF AUREPALLE, 1980-81.

12a)* A preliminary costs and returns analysis was also att pted and the results are presented in fig. 17. The net returns agree with the conclusion drawn earlier on gross returns. The net returns from the research managed systems on the watershed were about four to nine times greater than the traditional systems in the case of cereals or cereal based systems. In the castor based cropping systems while the crops failed in the traditional systems resulting in net loss, net profits varying from Rs. 343 to Rs. 688 were obtained from the watershed. In general castor based intercrop systems performed better than sole castor systems. The highest net returns of Rs. 1514/ha was obtained with sole sorghum system.

12b) Net returns for individual farmers along with the average returns from the watershed and from the traditional system are shown in fig. 18. The differences in net returns among farmers within watershed are mainly due to different cropping systems, different soil and other resource base and different managerial abilities of the farmers concerned. The test of significance (T-test) was highly significant when net returns from improved technology was compared with those from traditional technology.

6.2 Kanzara:

Kanzara received only 673 mm rainfall this year - when compared to 1979 rainfall of 1050 mm. In addition to total rainfall, the distribution of this year was also not favourable. Though the monsoon was set in early, the cessation of rains also occurred suddenly and very early during late August. The crops like pigeonpea and cotton suffered heavily during the critical period of thier growth. There were some very heavy showers during July and August resulting in some waterlogging and then later the crops suffered moisture stress during September and October. The crop growth in general was not very good because of both waterlogging and drought within a season. Erosion early in the season and moisture stress later were noticed in both flat and broad bed and furrow system of cultivation. It was also noticed that to maintain the shape of broadbeds sufficient crop canopy cover was necessary. Apparently sole cropping of cotton resulted in some splash erosion while groundnut helped in retaining broadbeds intact. Some of other major observations are:

*The detailed economic analyses will be reported by the Economics Program. Our economic analyses considered only grain yields and only major cash inputs like seed and fertilizer and operation cost.

1) The peformance of cotton in the village as a whole was poor because of early cessation of rains. However, all the crops in the watersheds performed better than those in the traditional systems of farming in the village (table 5).

2) Though the utility of broad bed and furrow system in facilitating drainage was observed on medium deep Vertisols (Watershed II), in general, there was no significant difference in yields between flat and broad bed planted crops (fig. 19 and 20).

3) Because of the use of high yielding cultivars, optimum fertility management, good weed control and optimum plant protection etc., the crop yields in the watersheds were far superior to the traditional system of farming (table 5). Though we could not measure the runoff and soil erosion, in general, there seemed no additional advantage by the broad beds to prevent runoff and erosion.

4) The use of tropicultour seemed to have considerable advantage in planting, fertilizer application and inter-cultivation which reflected in terms of higher crop yields.

5) When compared to the yields of traditional systems practised by surrounding farmers the yields obtained with the watershed management technology were substantially higher. Further, a preliminary yield gap analysis shown in fig. 21 indicates a wide gap existing between research center yields and the potential farm yields. Improved seed and agronomic management seemed to have contributed substantially towards the gaps in crop rpoductivity between research center and on-farm yields. Studies to analyse and quantify the factors responsible for these two gaps need to be initiated.

6) There was no substantial advantage of planting 4 rows of groundnut on a broad bed. Three rows of groundnut performed equally well (fig. 22). In the medium deep Vertisols SB11 seemed to have performed better when compared to Robut 33-1.

7) Though the season was not favourable to cotton, hybrid cotton (H_4) yielded twice as much as the local cultivars SRT-1. (fig. 22).

Table 5: Crop yields (q/ha) for several crops at Kanzara village in 1980-81.

Farm* No.	Cropping system	Sorghum	Sorghum fodder	Pigeon-pea	Cotton	Groundnut
1	Sorg-P.pea (bed)	8.3 ± .9	40.2	0.9	-	-
1	Sorg-P.pea (flat)	11.3 ± 1.2	45.8	0.9	-	-
1	Cotton-Sorg-P.pea (bed)**	1.8 ± .3	8.3	0.3	2.1 ± .1	-
1	Cotton-Sorg-P.pea (flat)	2.4 ± .9	8.3	0.2	2.1 ± .1	-
Broad beds						
2	Groundnut	-	-	-	-	6.0 ± .2
	Groundnut	-	-	-	-	7.3 ± .6
3	Sorg-P.pea	20.8 ± .9	53.3	0.7	-	-
3	Hybrid cotton	-	-	-	6.3 ± .4	-
4	Sole sorghum	18.0 ± 2.0	72.9	-	-	-
4	Cotton-P.pea (4:1)***	-	-	1.1	4.1 ± .3	-
5	Cotton-Sorg-P.pea	3.2 ± .3	10.8	0.2 ± .1	2.5 ± .1	-
6	Cotton-Sorg-P.pea	5.5 ± .7	15.8	0.2 ± .1	2.1 ± .2	-
7	Cotton-P.pea	-	-	0.2	2.4 ± .1	-
Flat cultivation with T.C.						
4	Sole sorghum	20.4 ± 1.3	81.2	-	-	-
4	Cotton-P.pea	-	-	1.1	4.0 ± .2	-
7	Cotton-P.pea	-	-	0.3	2.7 ± .1	-
7	Sorghum-P.pea	7.6	45.6	0.9	-	-
Flat cultivation with local drill						
7	Cotton-P.pea	-	-	0.2	1.8 ± .1	-
Traditional technology						
	Sorghum-P.pea	4.3	-	0.4	-	-
	Sorghum	1.5	-	-	-	-
	Cotton-P.pea-Sorg	0.6	-	0.3	1.3 ± .3	-

*Following farmers participated in the experiment: 1) M.G. Dhore 2) Nana Paighan 3) Mohan Ban 4) Parvati Bai 5) Umrao Deshmukh 6) Kashiram Paighan 7) N.R. Giri

**4 Beds Cotton; 1 Bed Sorghum - Pigeonpea ***4 Beds Cotton; 1 Bed Pigeonpea

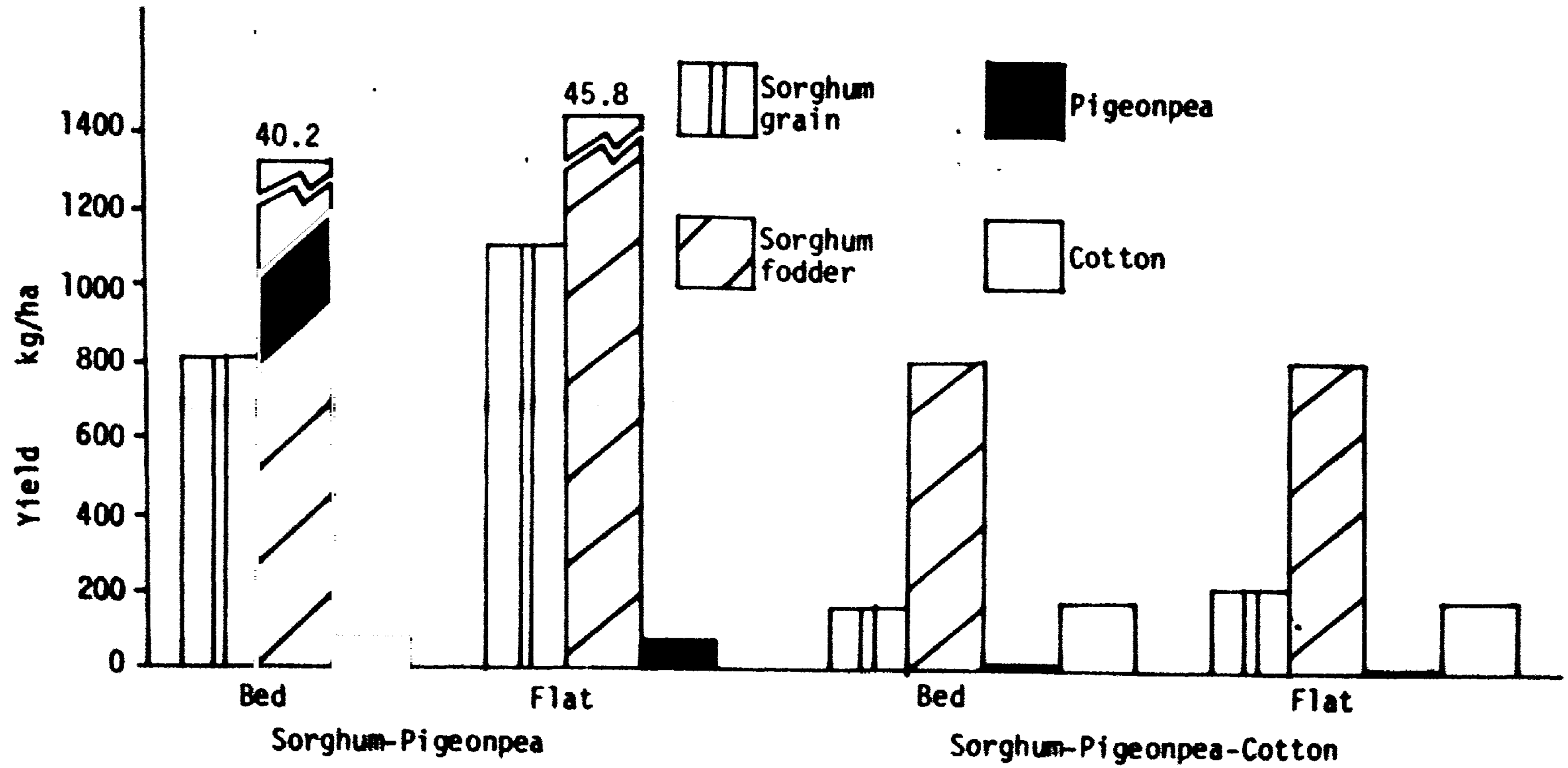

Fig. 19. CROP YIELDS IN KANZARA WATERSHED-I AS AFFECTED BY FLAT AND BROADBED AND FURROW SYSTEMS OF CULTIVATION, KANZARA, 1980-81.

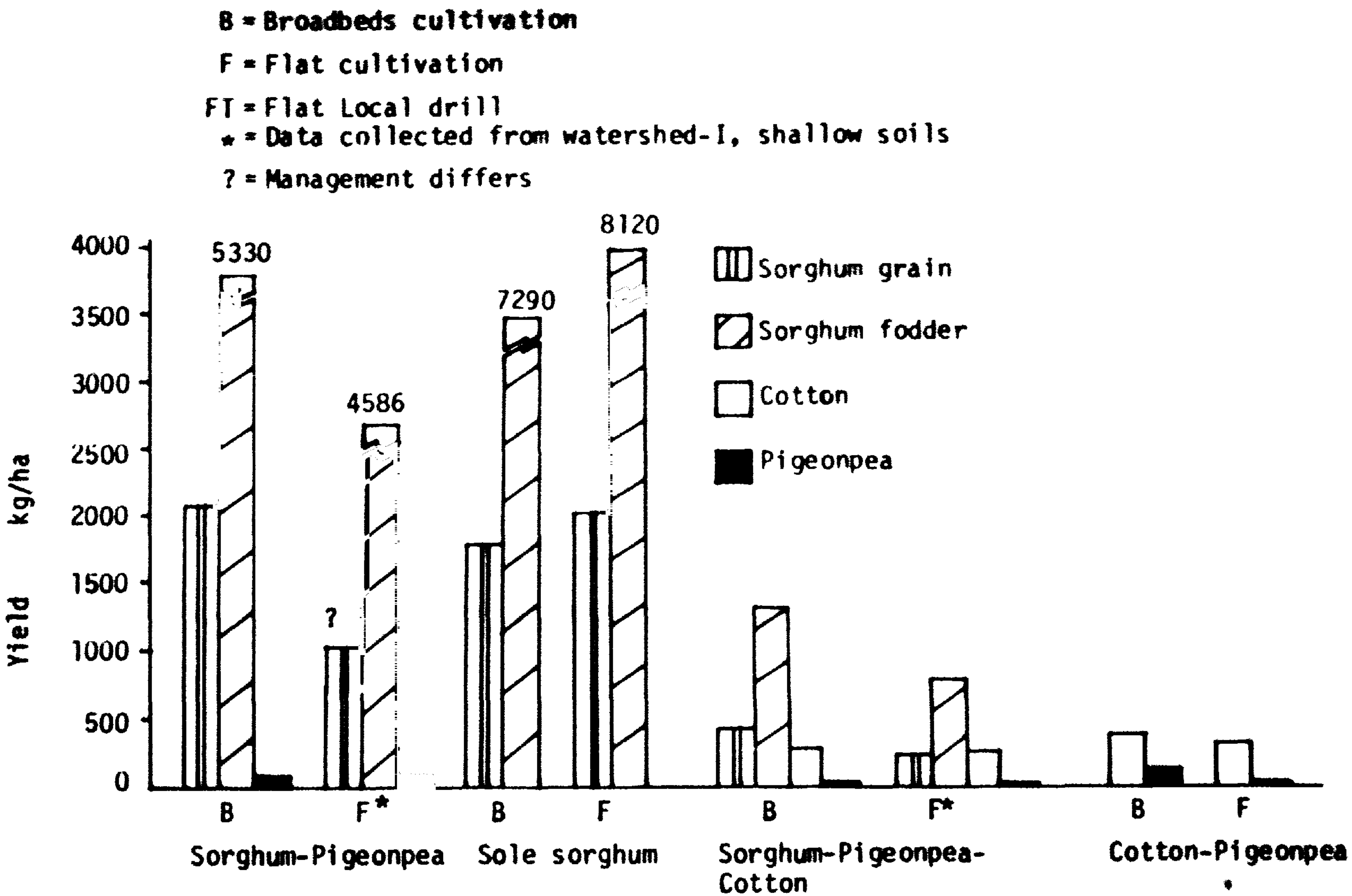

Fig. 20. CROP YIELDS IN KANZARA WATERSHED-II AS AFFECTED BY FLAT AND BROADBED AND FURROW SYSTEMS OF CULTIVATION, KANZARA, 1980-81.

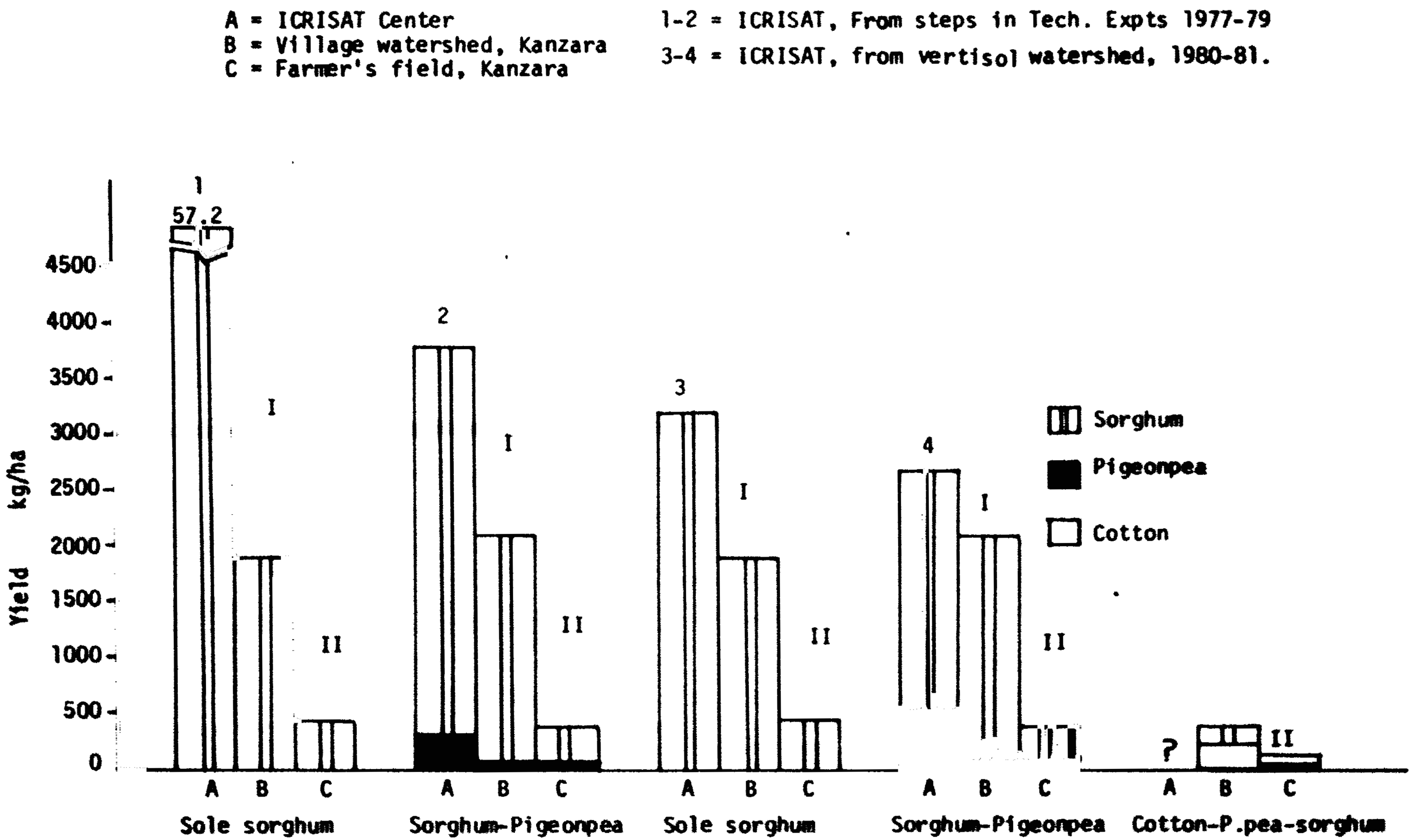

Fig. 21. CROP YIELDS AT ICRISAT CENTER AND KANZARA VILLAGE SHOWING THE GAPS IN CROP PRODUCTION, ICRISAT-KANZARA, 1980.

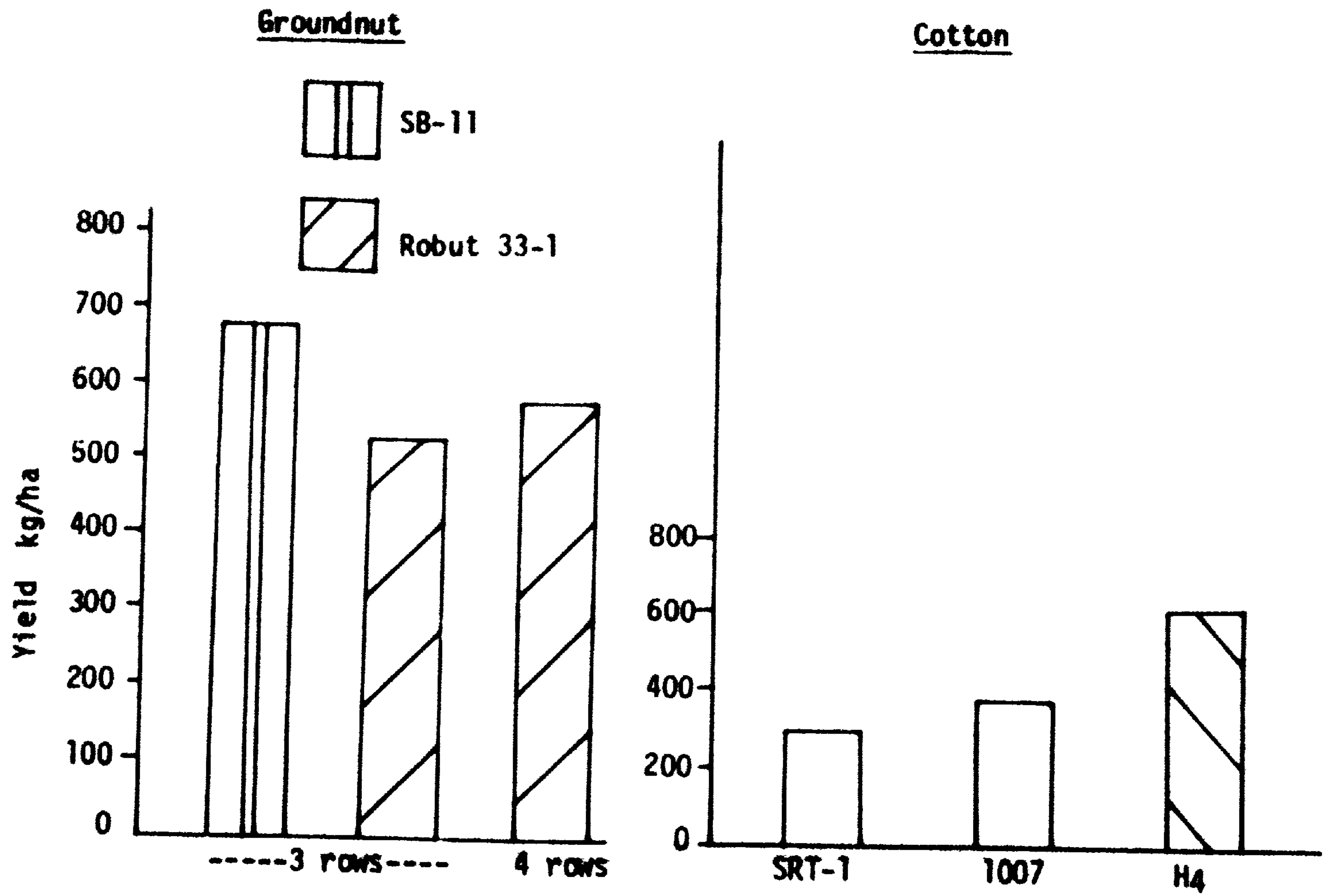

Fig. 22. YIELDS OF TWO CULTIVARS OF GROUNDNUT AND THREE CULTIVARS OF COTTON AT KANZARA WATERSHED, 1980-81.

8) There does not seem to be substantial grain yield loss in sorghum when intercropped with pigeonpea though fodder yield was reduced to some extent (fig. 23). In general since the season favoured cereals, the productivity of sole sorghum or sorghum/pigeonpea intercrop systems seemed higher than that of cotton based systems.

9) When compared to the yields obtained during 1979, in general, 1980 yields were poor (fig. 24). Rainfall-both total and distribution-contributed more to this effect. Though the crops escaped pests early in the season they suffered heavily because of pest attack later in the season. Stem borer on sorghum, pod borer on pigeonpea and bollworm complex on cotton were the major pests. Moisture stress and pests contributed more for yield reductions.

10) Figs. 25 and 26 show the comparison between threshing floor yields as reported by the farmers and the yields computed through sampling. The yields reported by the farmers are lower than the computed yields. The differences are greater than those observed in Aurepalle. Farmers tend to report lower yields and this tendency seemed more apparent in Kanzara.

11) A preliminary economic analyses on costs and benefits conducted indicate the higher net profits obtained through improved farming systems. When compared to net returns from traditional system the net profits obtained through improved systems were substantially greater in both watershed I and II. (fig. 27 and 28). In watershed I there was not much difference between beds and flat system. In general, returns from sorghum based systems were better than cotton based systems. Fig. 29 shows the net returns obtained by the individual farmer involved in our study. There is a clear trend of increasing net returns as the farmers resource base, managerial ability, and interest in farming and the type of cropping systems followed were better. The test of significance (T-test) was highly significant when net returns of watershed technology were compared with traditional technology.

6.3. Shirapur:

Because of previous years' experience of difficulties in establishing a Kharif crop in Shirapur, it was decided to attempt planting in Kharif with a precondition of at least 25 cm depth of moist soil. This occurred only during the beginning of August which was too late to plant

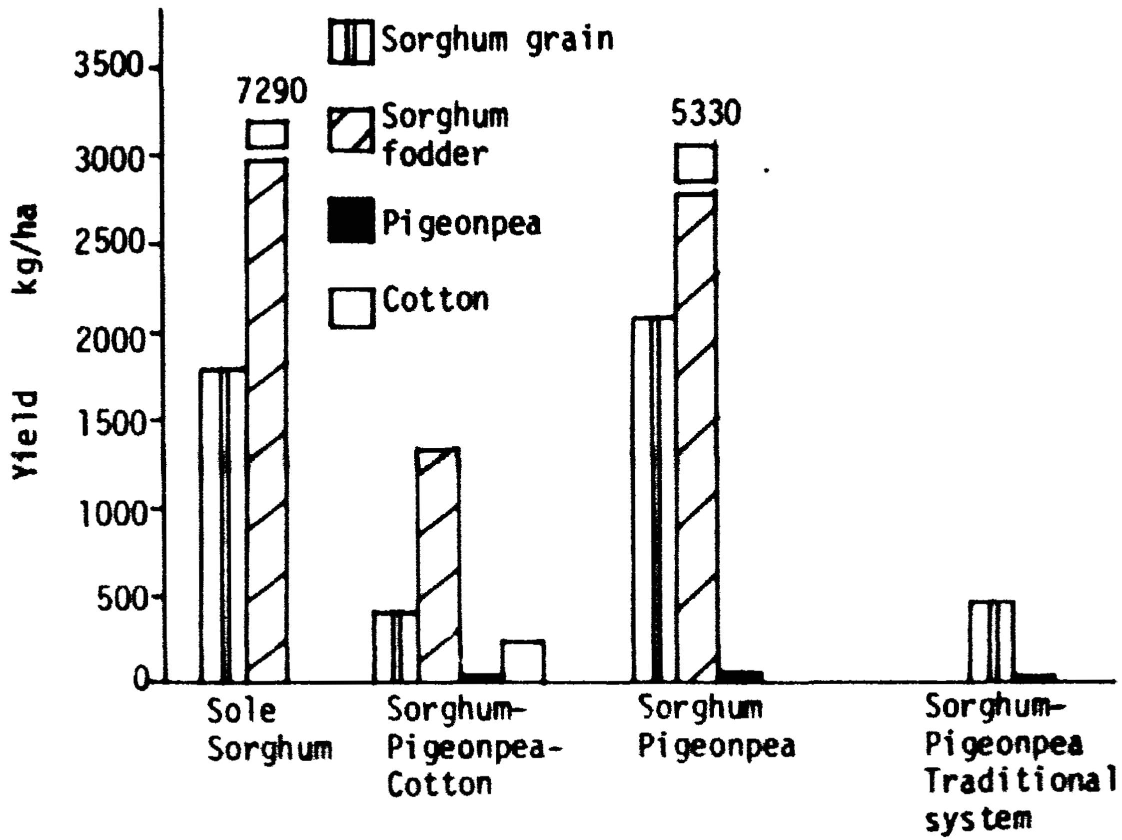

Fig. 23. CROP YIELDS OF SORGHUM BASED CROPPING SYSTEMS, KANZARA, 1980-81.

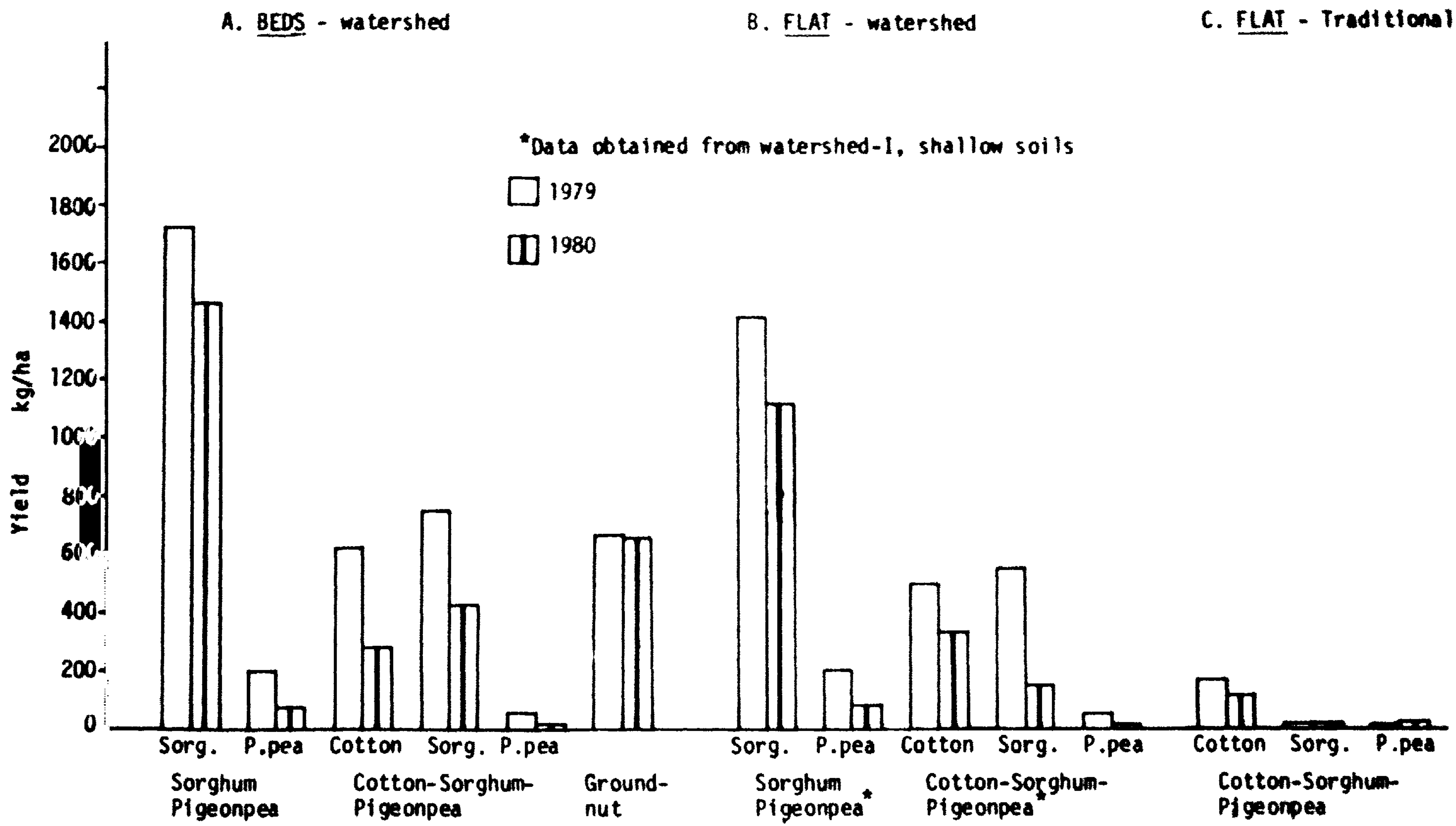

Fig. 24. CROP YIELDS IN KANZARA VILLAGE AS AFFECTED BY SEASONAL AND MANAGEMENT CHANGES, KANZARA, 1979-1980.

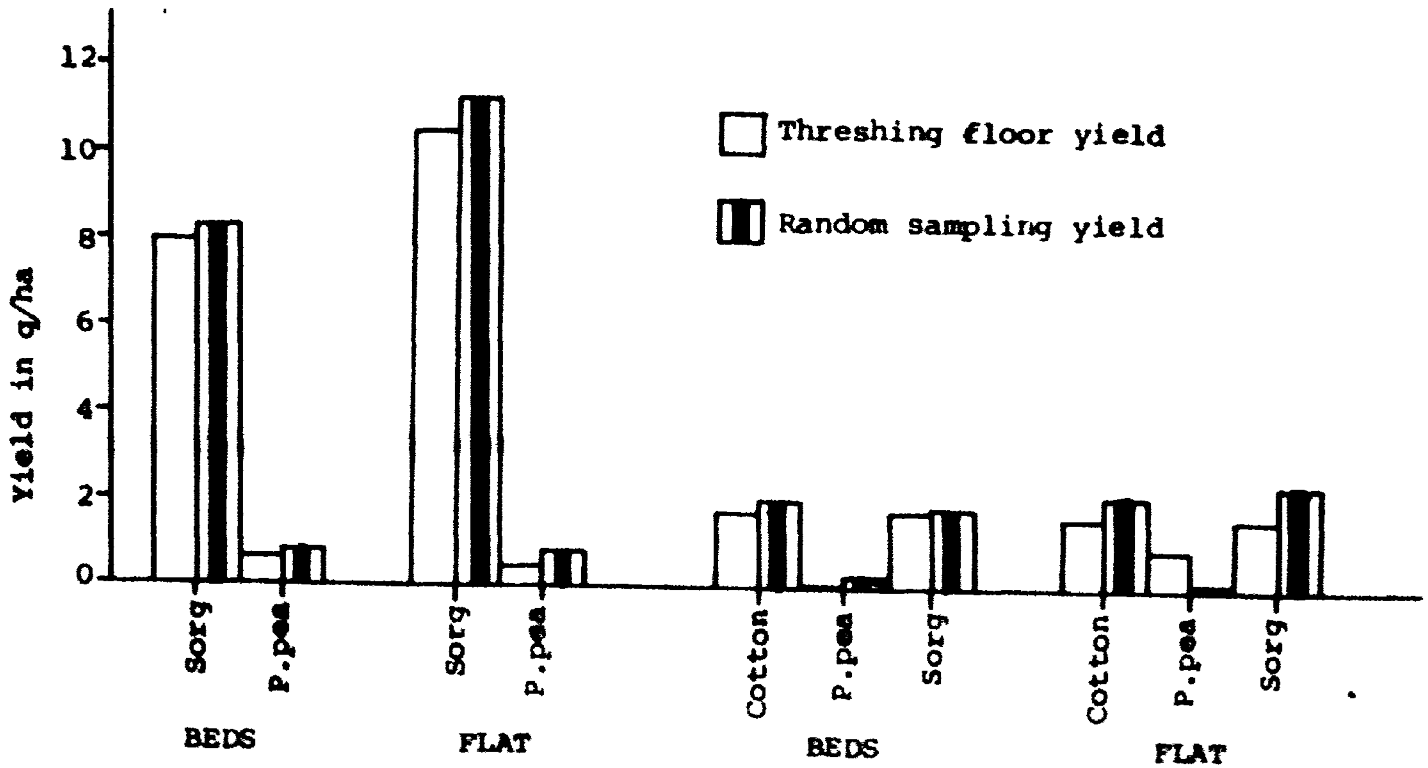

Fig. 25. A COMPARISON OF THRESHING FLOOR YIELDS AND RANDOM SAMPLING YIELDS FROM KANZARA WATERSHED-I, 1980-81.

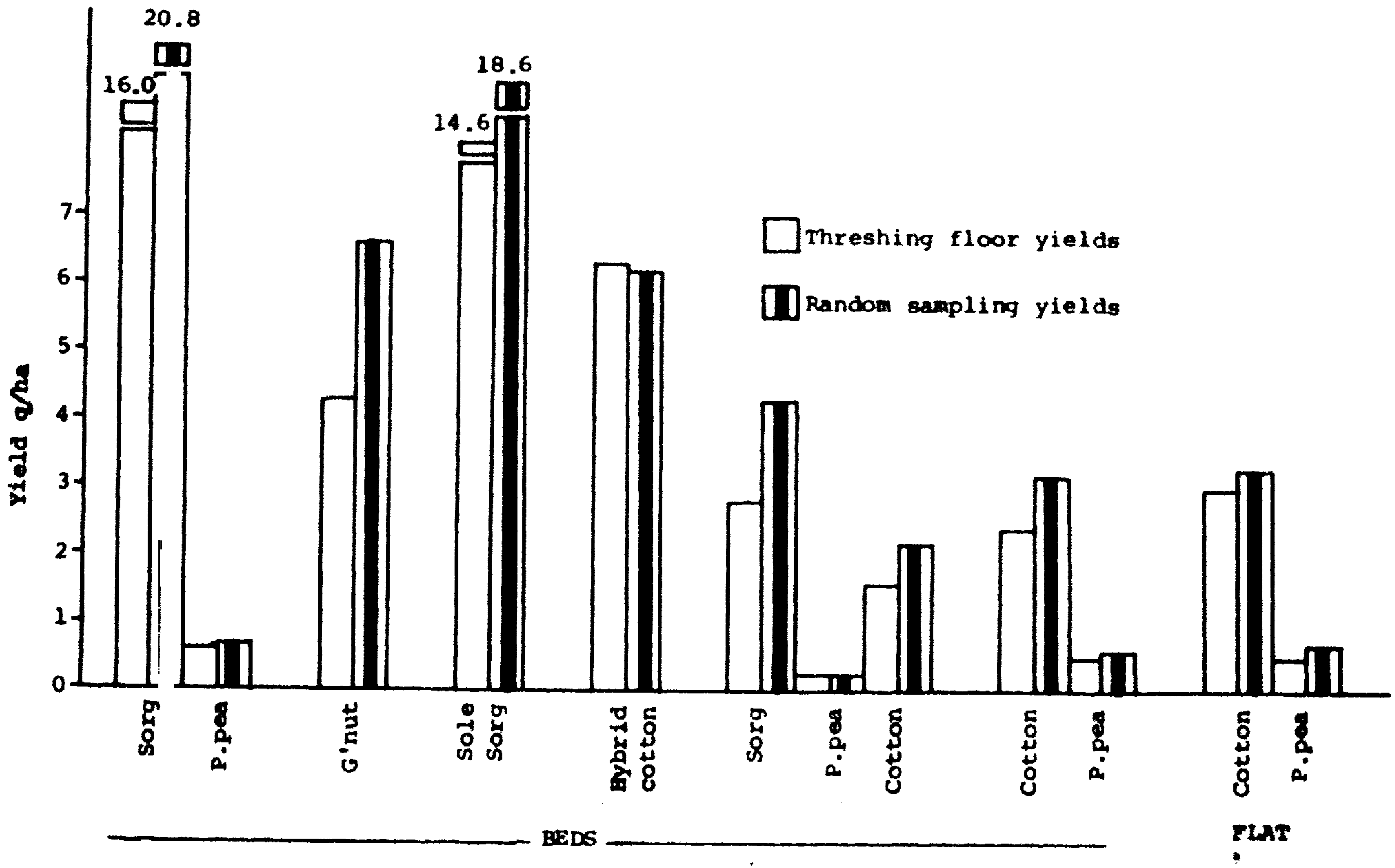

Fig. 26. A COMPARISON OF REPORTED THRESHING FLOOR YIELDS AND RANDOM SAMPLING YIELDS OF KANZARA WATERSHED-II, 1980-81.

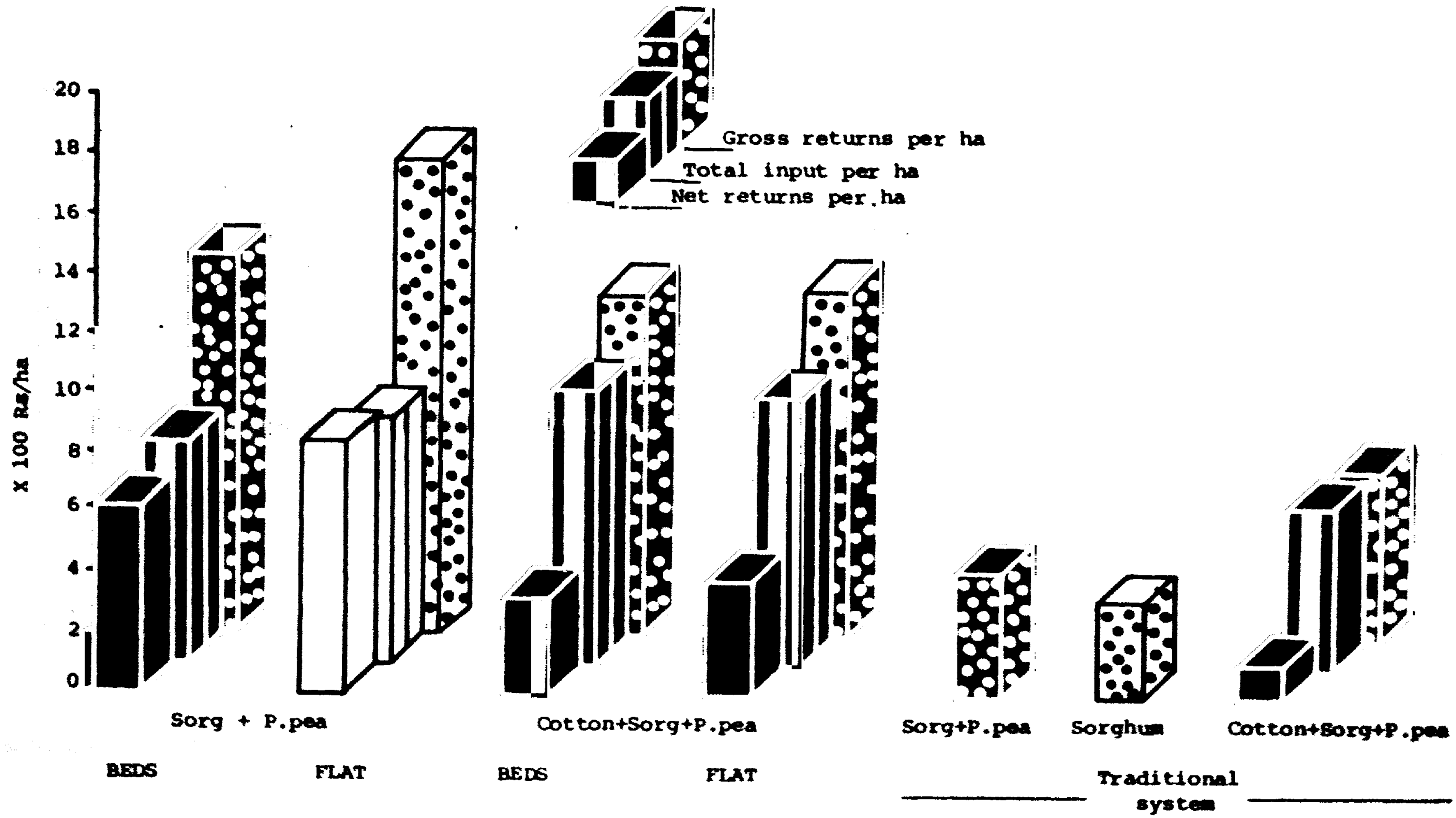

Fig. 27. AN ECONOMIC ANALYSIS OF FARMING SYSTEMS OF WATERSHED-I IN KANZARA, 1980-81.

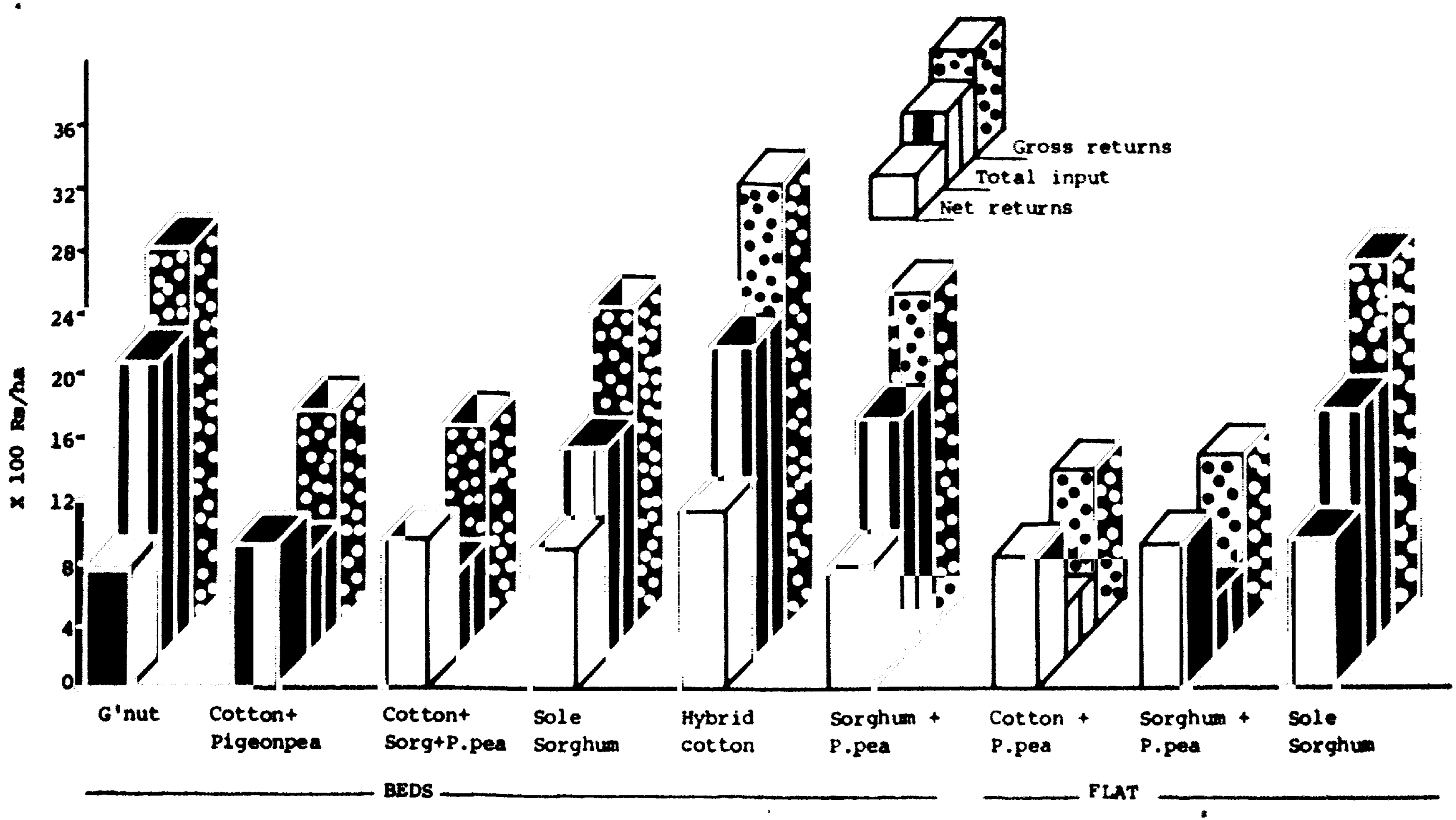

Fig. 28. AN ECONOMIC ANLAYSIS OF FARMING SYSTEMS OF WATERSHED-II IN KANZARA, 1980-81.

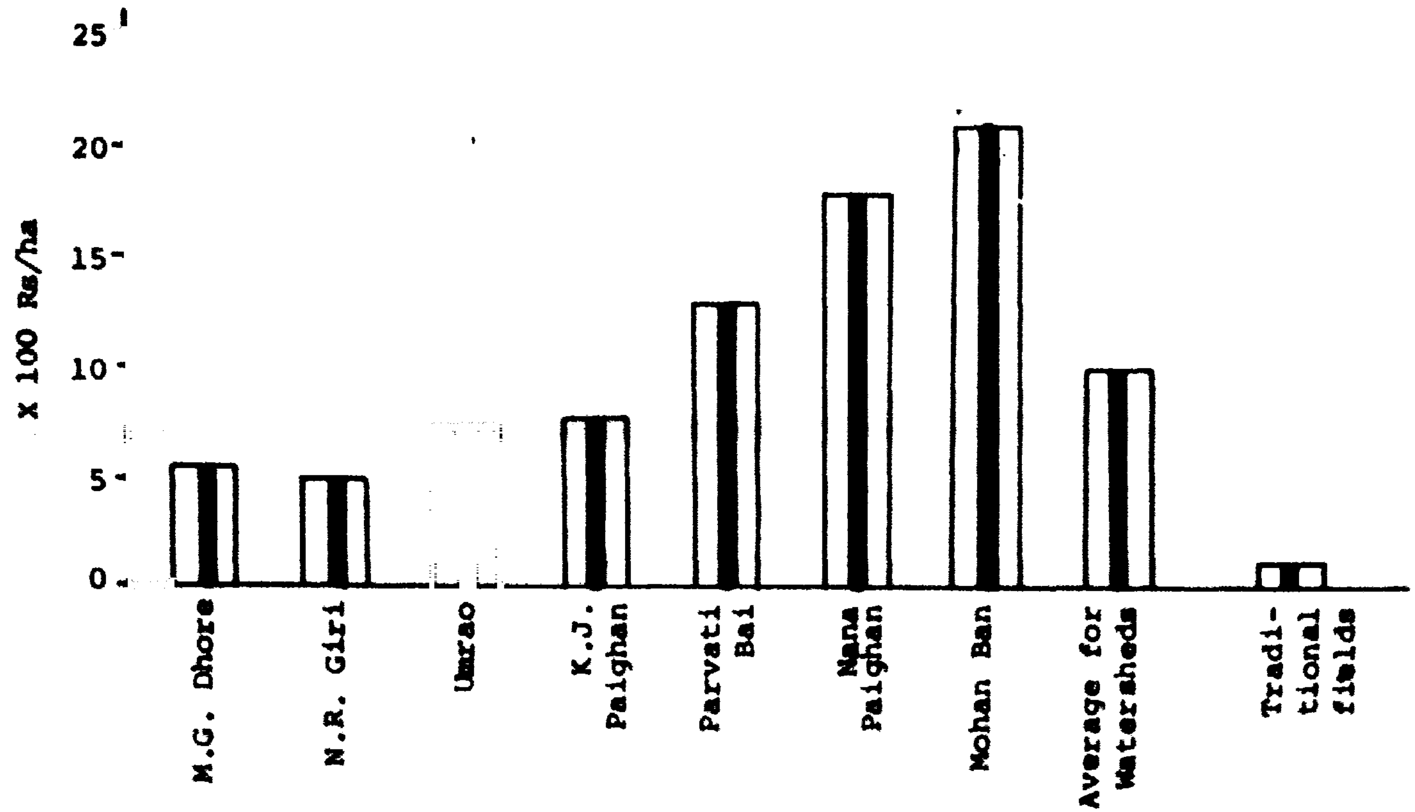

Fig. 29. NET RETURNS OBTAINED BY COOPERATING FARMERS OF KANZARA, 1980-81.

cereals. Farmers did not even subscribe to the suggestion of planting pigeonpeas in part of the watershed. Sorghum planting was completed during the last week of September.

Cultivations of the beds in the watershed were however done during the dry spells in kahrif. There was severe infestation of <u>Cynodon dactylon</u> in the watershed and the occasional cultivations with tropiculteur did not help to control this perennial weed. The traditional plots however were free of this weed because mainly of continuous harrowing in both the directions. The rainfall pattern in Sholapur area did not support a kharif crop at all and as the total rainfall (till October) was only 270 mm the growth of rabi crops was also poor. Some of the results obtained through this year study are as follows:

1) Table 6 indicates the sorghum yields obtained in the watershed when compared to yields from traditional fields. Under non-irrigated situation except GG 1483 all other cultivars performed better than the M-35-1 planted under traditional system

2) Among different cultivars tested on the watershed CSH-8R performed well followed closely by M-35-1. Four breeders' material did not perform as expected. Under irrigated system however these cultivars peformed well, GG 1465 yielding the highest (fig. 30). Moisture stress and poor fertility status (the watershed received only 20-46-0) were the main reasons for poor yields. Perennial weeds on the broad beds also caused severe yield reduction.

3) When we compared 1979-80 and 1980-81 crop yields, though the rainfall was considerably lower in later year the yield levels did not change much (fig. 31) indicating the stability of the 'improved' system.

4) A preliminary attempt of gap analysis is shown in fig. 32. There exists a wide gap even with rabi sorghum production technology both at Gap I and Gap II levels. Though it would be difficult to convince the farmers on double cropping technologies, there still exists considerable potential for improving rabi crop productivity on-farm level. The development of fertilizer responsive and drought tolerant rabi sorghum is therefore crucial to this region.

Table 6: Grain yields in kg/ha at Shirapur, Rabi, 1980-81.

Sorghum cultivar	Non irrigated	Irrigated
M 35-1	1060.3	1380
CSH-8R	1283	1976
GG 1483	252	1360
GG 1485	920	2420
Ind. Syn. 600-21	743	1139
Ind. Syn. 387-3-1	697	1578
Average yields for 6 cultivars in watershed	825	1642
Traditional system* (farmer's plots) M 35-1	582	

*Average of 336 samples around watershed.

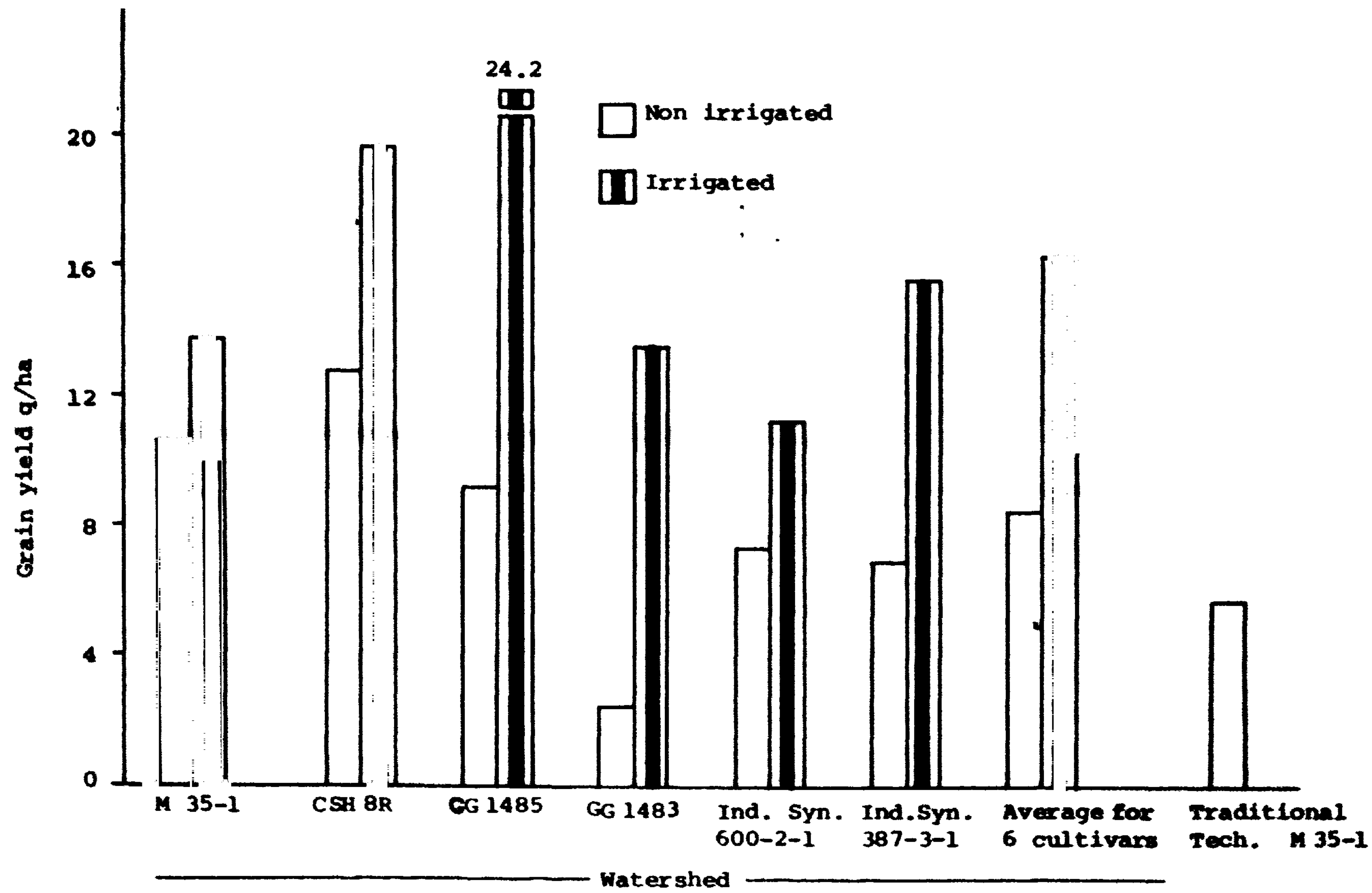

Fig. 30. GRAIN YIELDS OF DIFFERENT CULTIVARS OF SORGHUM IN SHIRAPUR WATERSHED, 1980-81.

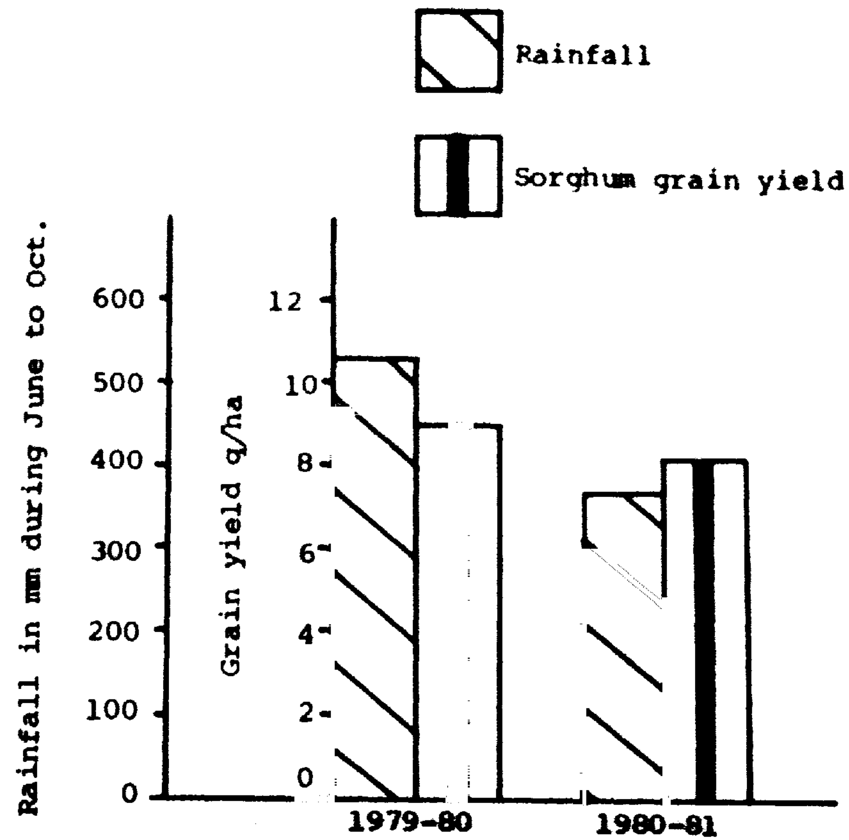

Fig. 31. SORGHUM YIELDS IN SHIRAPUR WATERSHED DURING 1979/80 AND 1980/81.

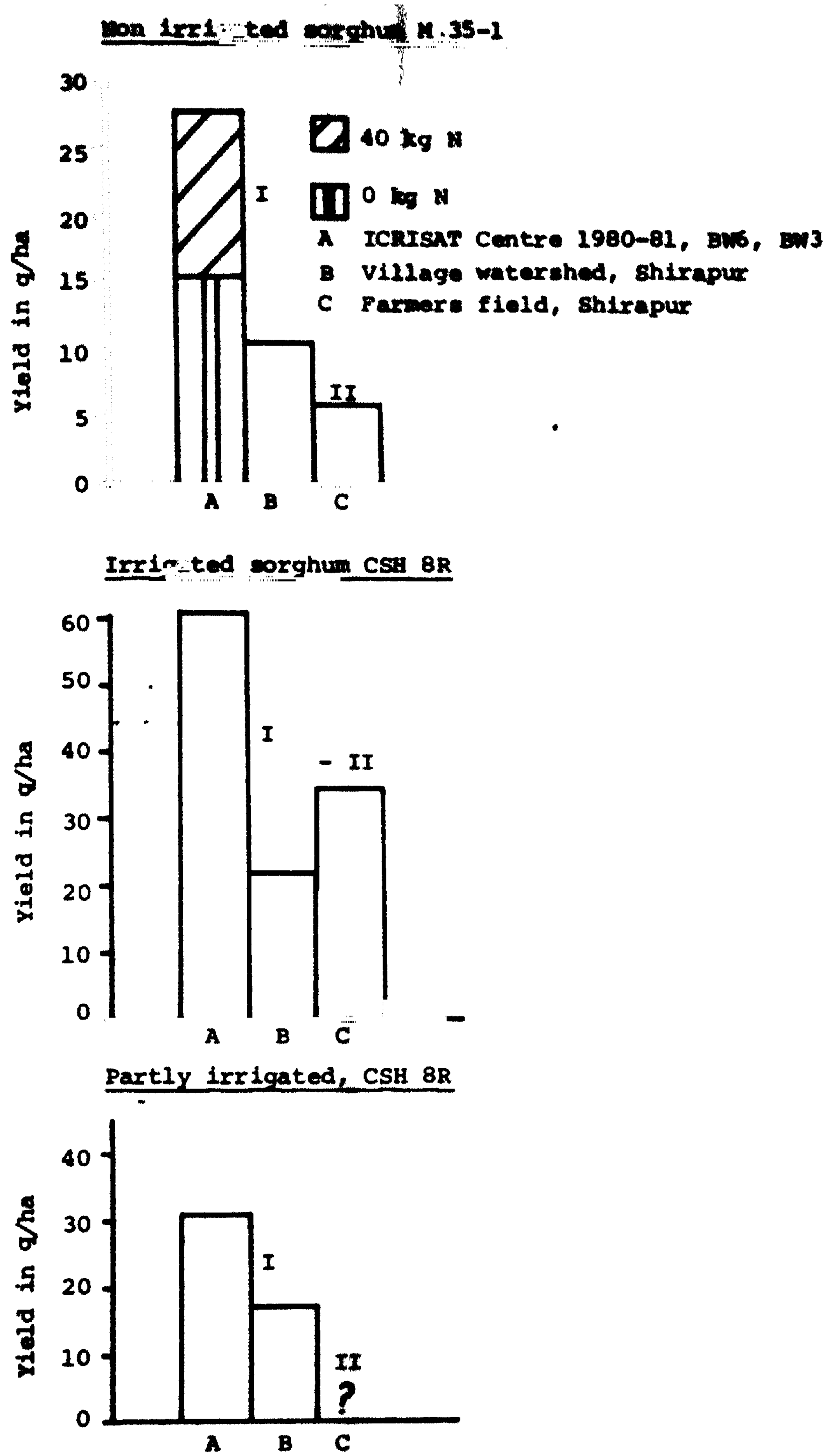

Fig. 32. SORGHUM GRAIN YIELDS AT ICRISAT CENTRE AND SHIRAPUR VILLAGE SHOWING THE GAPS IN CROP PRODUCTION, ICRISAT -SHIRAPUR, (RABI) 1980-81.

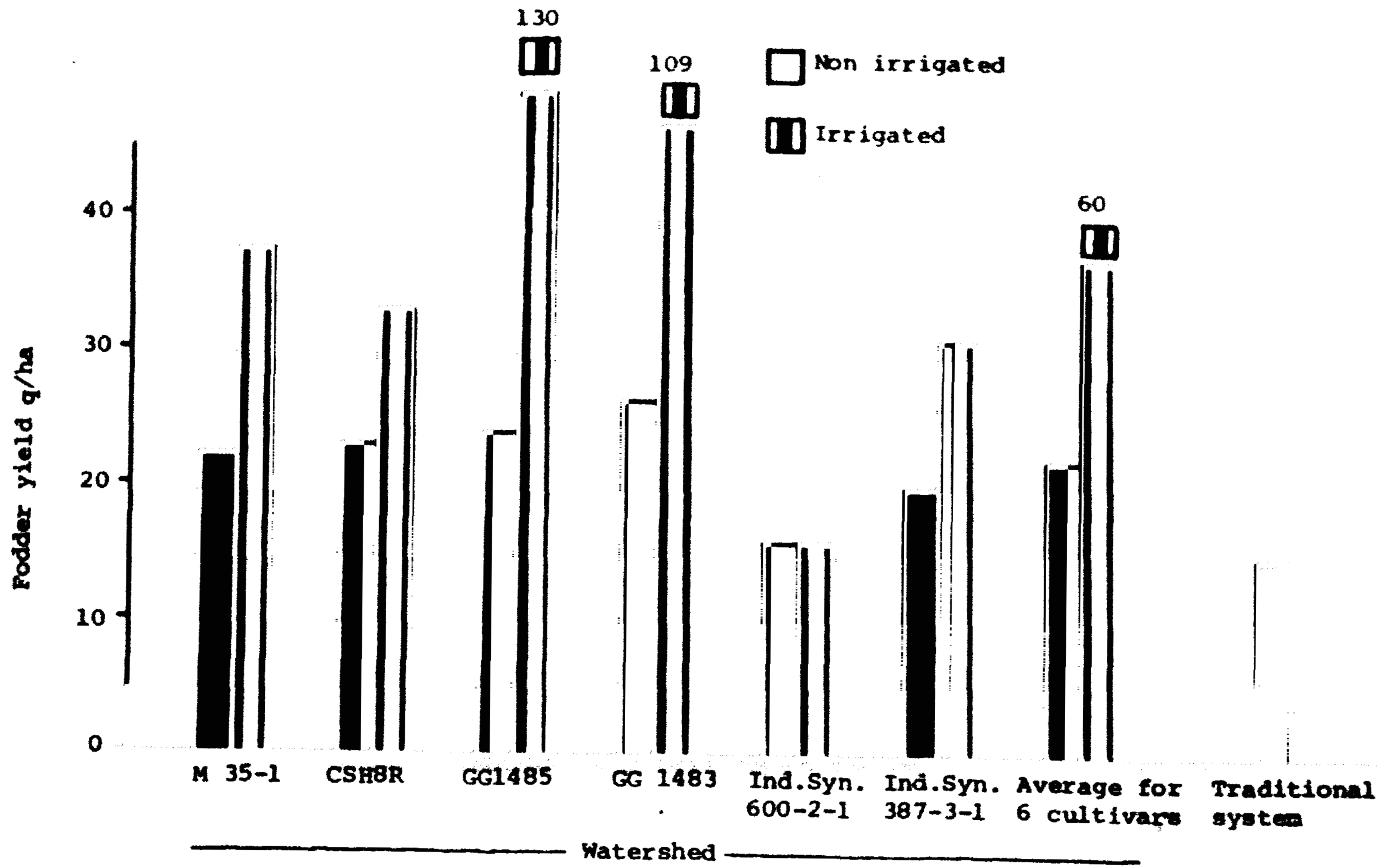

Fig. 33. FODDER YIELDS OF DIFFERENT SORGHUM CULTIVARS ON SHIRAPUR WATERSHED, 1980-81.

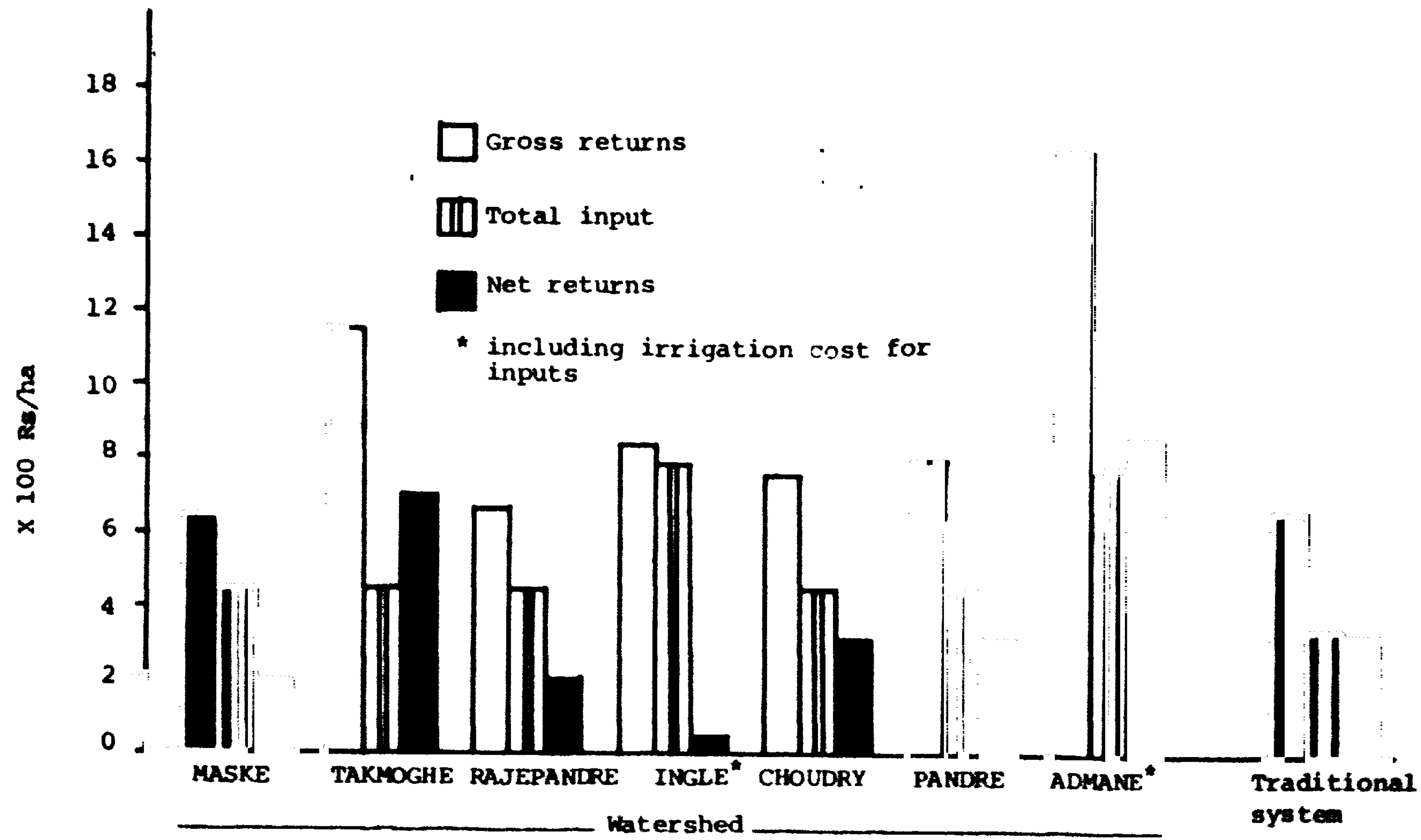

Fig. 34. AN ECONOMIC ANALYSIS OF "IMPROVED" AND TRADITIONAL SYSTEMS OF FARMING IN SHIRAPUR, 1980-81.

5) Fodder yields presented in fig. 33 also indicate that the sorghums in the watershed produced substantially better fodder yields when compared to sorghums in traditional fields. Though ICRISAT breeders' material performed poor terms of grain yields, they produced excellent fodder yields especially under irrigated conditions.

6) An attempt was made to compute net returns from improved and traditional systems. Fig. 34 shows that though the gross returns from watershed based technology were superior there does not seem to be much significant differences in net returns between these two systems.

7. Action plans for the future:

7.1. Adoption study:

The two year period (1979/80, 1980/81) is to be considered as a "technology introduction, testing and adaptation" phase. Until now ICRISAT has been incurring expenses on the development and management of the watersheds in these villages. It is hoped that the farmers have become acquainted with the merits (and demerits) of the improved farming systems. It is therefore proposed that the emphasis now should be on the last objective of the original proposal i.e., "to monitor the rate of adoption and the impact of new technology and to gather feed back information on the research requirements for specific components of farming systems technology".

The methodology from now-on will involve entrusting all operations to the farmers and confining our attention to mainly technical support (if farmers desire any). Capital subsidies provided earlier will cease, but material inputs will be made avaialble in the village for cash purchase. Similarly the improved equipments also will be available on hire. The focus of study will be to monitor what use, if any, the farmers involved in the experiments will make of the new technology and why. Such studies also help in gathering more information on the biological, physical and socio-economic factors affecting the rate of adoption of the new technology.

A small portion of the watershed (possibly one small plot in each of the farmers' fields) can be kept under researchers control to obtain information on the potential of the new technology for the particular season and to gather data for stability analysis. It is anticipated that the following treatments will be available for evaluation, analysis and comparisons.

1. Improved farming systems executed by researchers
2. Improved/modified farming systems executed by farmers
3. Traditional farming systems executed by farmers on the previously developed watersheds
4. Traditional farming systems in the rest of the village

It is proposed that the above study will be continued for 2 or 3 seasons in Aurepalle and Kanzara villages. However, the involvement in Shirapur will be reduced as the impact of new technology could not be demonstrated in this village. Further, farmers' involvement in the experiments during the past two years has fallen short of expectations. As irrigation facilities are now well developed the farmers have already disturbed the beds and are planning to grow irrigated crops.

7.2. Diagnostic or investigative research:

The improved farming systems technology seemed to have some advantage over the farmers existing technology in Kanzara and Aurepalle situations. It is therefore worthwhile to find out through experimentation the biological and socio-economic constraints responsible for the existence of low yields. Proposals to initiate field experiments (along with village surveys) to measure the size of the productivity gap by determining the potential and the actual farm yields are under consideration. Characterization and quantification of individual production factors ('test factors') responsible for the production gap need further on-farm experimentation. The exact methodology and plan of work need to be worked in detail.

Problems were encountered in attempts to transfer technologies from ICRISAT and AICRPDA Research Centers to the selected on-farm locations because of the dissimilarity of the agro-climatic environment on the farms compared to that at adjacent centers and ICRISAT. Neither of the three villages is similar to ICRISAT in terms of soils (particularly depth and moisture holding capacity) or with regard to rainfall quantities and distribution. Future selection of on-farm research sites should take these past experiences into consideration.

At present, the subject of 'on-farm' experimentation in relation to Farming Systems Research at ICRISAT is under review. The need and relevance of on-farm research have been recognised. It is agreed that without on-farm research the vision emanating from a farming systems research will be seriously impaired as scientists will have little assurance that identified research priorities address actual on-farm problems, that proposed solutions measure upto expectations under farmers' conditions, and that released technologies have potential for rapid adoption. Questions of research strategy and coordination among ICRISAT research programs and with national organisations are being considered. Successful on-farm research requires a close working relationship among farmers, national programs and ICRISAT.

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II. WEED MANAGEMENT RESEARCH

1. Introduction

During 1980-81 crop seasons weed management research was mainly confined to two broad areas:

a) Quantification of the effect of different physical, cultural and biological factors on crop-weed balance and

b) Operational scale evaluation of different weed management

Field trials were conducted to monitor the weed and crop growth to determine how the weed populations respond to different crops, management techniques and systems of cropping. Different factors studied during the year include soil management treatments, depth of weed seed incorporation, shading, weed density, time and duration of weed removal, crop cultivars and crop row arrangements. In the area development and evaluation of alternate weed management systems emphasis was to examine the operational feasibility of improved weed management systems on an operational scale along with other production factors on an "year-round" basis. These trials were aimed at developing information and understanding of crop, soil, climatic and social situations in which improved weed management could have a greater impact.

In addition to these agronomic studies in the field, laboratory studies were also continued to understand biology of major weeds of ICRISAT center. Weed surveys were also continued on both Alfisols and Vertisols to document the new weed species, if any, and these collections were added to our Herbarium.

2. Effect of different factors on Crop-Weed balance

2.1. Effect of different soil management practices on the intensity and composition of weed seeds in the soil:

Different management systems affect weed seed germination and weed seedling establishment. A long term experiment was initiated in April 1978 to monitor the trends in weed emergence and weed seed depletion from the soil under different soil and crop management systems in comparison with traditional systems. The objective also included the quantification of potential weediness as influenced by different management systems.

Soil samples were collected from two depths (0-15 cm and 15-30 cm) of experimental plots of Vertisols where soil management treatments - broad beds and furrows (150 cm), narrow ridges (75 cm) and flat beds - are being evaluated. Soils from same depth of a plot were bulked together and placed in earthern pots. The pots were watered regularly to stimulate weed seeds to germinate. As and when seedlings appeared, they were identified, counted and removed from the pots.

Fig. 35 shows the third year results of the study. As in 1978 and 1979, the first flush of weeds emerged during the month of June immediately after monsoon showers followed by subsequent emergences of weeds later in the season. But, the intensity of later weed emergence were less when compared to first flush. Maximum number of seedlings emerged from soil upto 15 cm depth in all the months. As the monsoon season progressed there was a declining trend in weed seed germination, but during November there was again an increase in weed germination due to emergence of post rainy season weeds.

Results of 1978 to 80 pooled together highlight the influence of management practices upon weed seed germination of the soil as seen in fig. 36 and 37.

Among land management treatments, soils collected from narrow ridges showed maximum number of weed seedlings followed by flat and broad beds. In kharif 1979 narrow ridge treatment was abandoned and only flat and broadbed systems were continued upto 1980. Three years data of total weed emergence (fig. 36) suggests that the number of weed seedlings declined gradually from year to year due to cultivation practices. But the rate of decrease depended upon type of seed bed formation also. It also suggested that most of the weed seeds emerged come from the soil collected upto 15 cm depth only. Seasonal emergence of weed seeds for three consecutive years indicated a peak period in June-July and a lesser peak in Nov-Dec. It should be noted that our observation in this study is limited to only annual weeds and not perennial weeds. Annual weeds however formed the bulk of the weed composition.

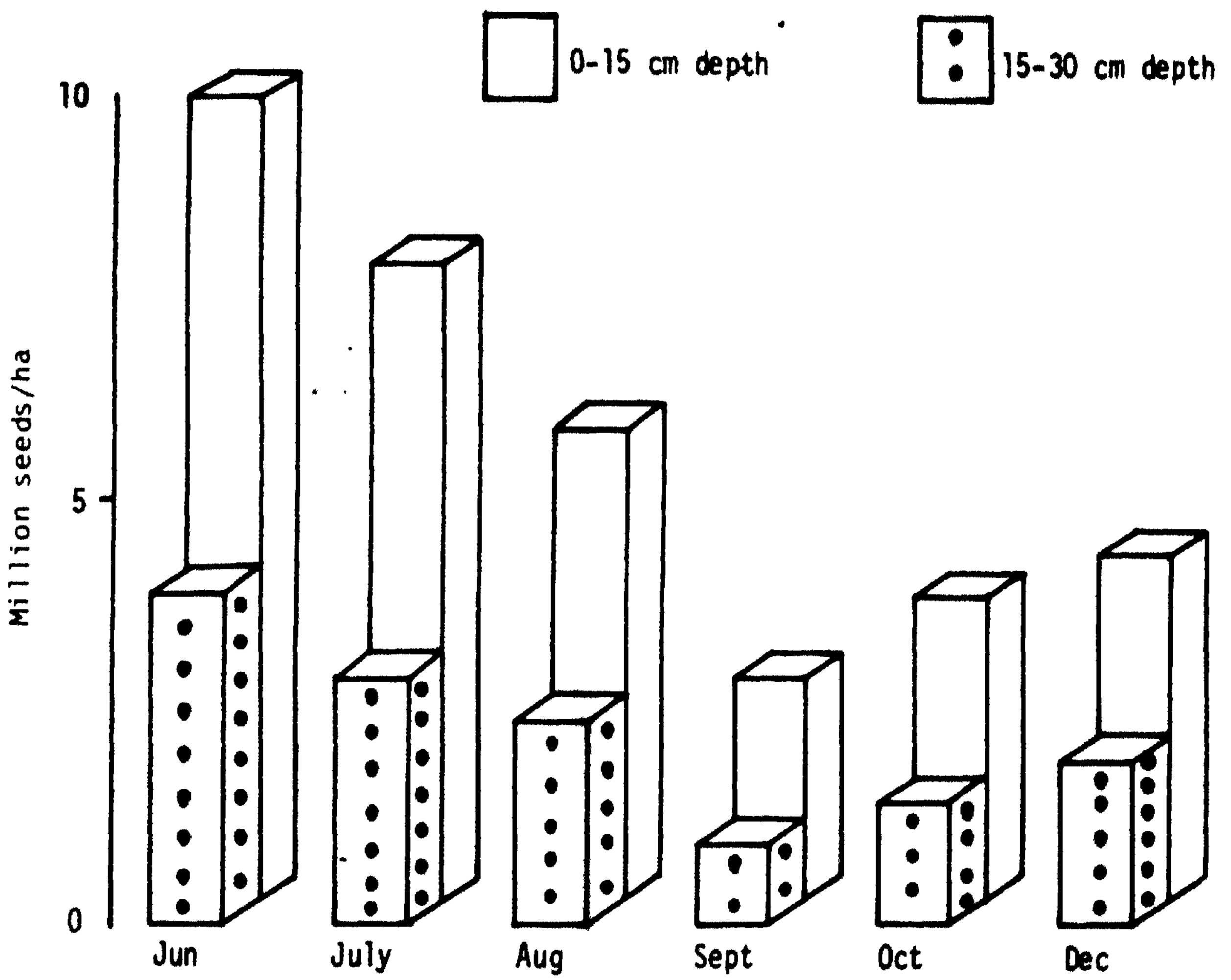

Fig. 35. TOTAL WEED EMERGENCE DURING DIFFERENT MONTHS IN DEEP VERTISOLS, 1980.

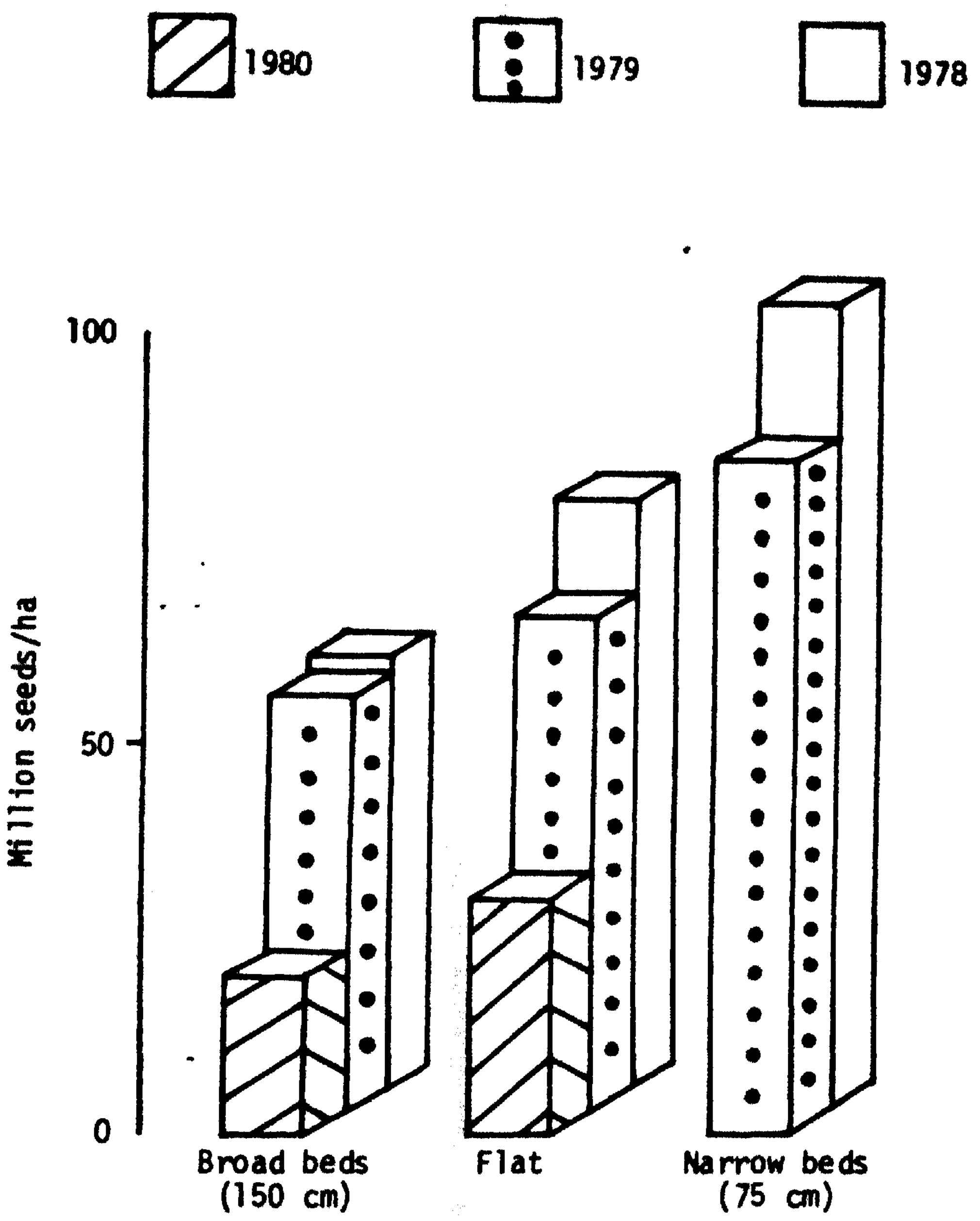

Fig. 36 . EFFECT OF THREE SOIL MANAGEMENT SYSTEMS ON TOTAL ANNUAL WEED EMERGENCE ON VERTISOLS, 1978-1980.

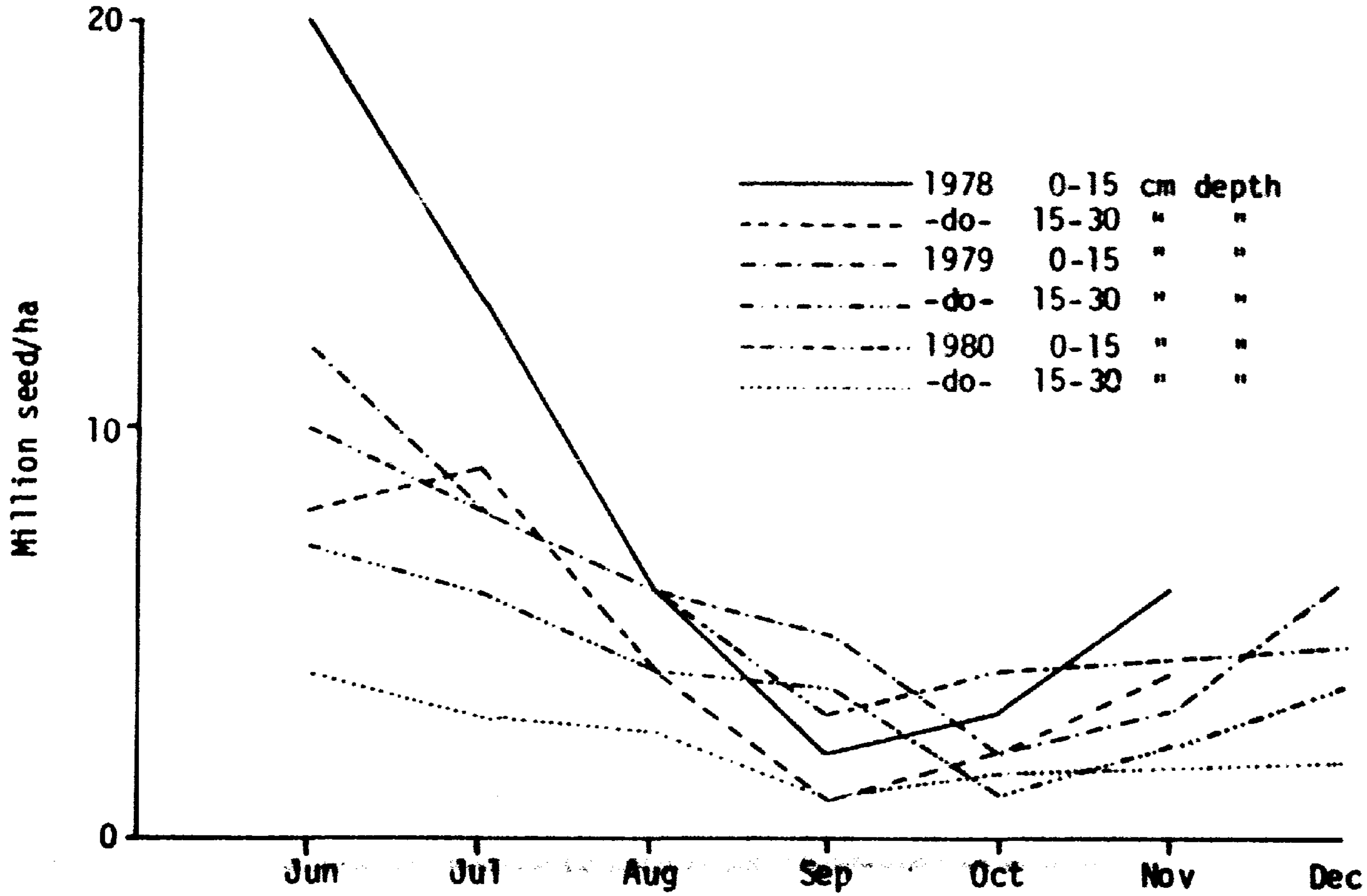

Fig. 37. TOTAL WEED EMERGENCE DURING DIFFERENT MONTHS IN DEEP VERTISOLS FOR THREE MONSOON SEASONS, 1978-1980.

2.2. Effect of depth of incorporation of seeds and cultivation on weed seed emergence:

In order to study the influence of depth of incorporation of seeds and disturbance (cultivation) on weed seed germination, a pot culture experiment was conducted during 1978. Freshly collected seeds of twenty major annual weeds of ICRISAT center were mixed in the pots of Vertisols upto different depths like 2.5, 7.5, 15 & 30 cm. In Alfisols 12 species of them were included and the depth of incorporation was 2.5, 7.5 and 15 cm only. The experiment was started in April 1978 and continued upto April 1979. 100 seeds of each weed species were incorporated to each depth in the pots. At the end of the experiment the total number of weeds emerged were expressed as percentage of added seeds. The pots were kept in open air and no water was given except that the pots received normal rainfall.

In Vertisols the total weed seedlings emerged from cultivated soils (disturbed pots) amounted to 95, 50, 30 and 20 percents of seeds added for depths of 2.5, 7.5, 15 and 30 cm respectively. The corresponding values for undisturbed soil were 69, 28, 20 and 11 percents. Data for individual species are given in table 7 At 2.5 cm depth, Digitaria produced maximum seedlings (82%) followed by Cyanotis axillaris (78%). As the depth of incorporation was increased the emergence decreased. In undistrubed soils, except for Desmodium and Indigofera, emergence was always less when compared to cultivated soils.

In Alfisols, the total emergence from cultivated soil amounted upto 85, 44 and 23% of seeds incorporated to the depths of 2.5, 7.5 and 15 cm respectively. The corresponding values for undisturbed soil were 44, 18 and 6%. Data for individual species are given in table 8. In cultivated soils maximum emergence was recorded for Celosia argentea (73%) followed by Digitaria (66%). In undisturbed soils except Tridax, emergence was always less than that of cultivated soils.

Fig. 38 indicates that in both type of soils, cultivation resulted in emergence of more weed seeds irrespective of depth of incorporation. As the depth of incorporation increased the no. of seeds germinated decreased in both the soils.

Table 7: Percentage seedlign emergence of some annual weeds in cultivated and undisturbed soils, Vertisols, 1978-79.

Weeds	Cultivated				Undisturbed			
	2.5	7.5	15	30	2.5	7.5	15	30
1) *Acanthospermum hispidum*	30	16	12	8	13	8	6	3
2) *Achyranthes aspera*	-	-	22	10	-	-	11	9
3) *Alysicarpus rugosus*	50	30	14	10	40	10	10	4
4) *Cardiospermum halicacabum*	39	36	32	25	29	27	22	13
5) *Celosia argentea*	40	17	12	10	37	13	-	-
6) *Corchorus olitorius*	-	-	-	-	-	-	-	-
7) *Cyanotis axillaris*	78	64	57	36	49	47	36	15
8) *Dactyloctenium aegyptium*	14	13	11	4	10	5	2	-
9) *Desmodium dichotomum*	31	24	18	5	38	26	14	2
10) *Digera muricata*	13	11	10	-	-	-	-	-
11) *Digitaria ciliaris*	82	70	53	33	61	54	29	11
12) *Eclipta prostrata*								
13) *Flaveria australasica*	17	11						
14) *Goniocaulon glabrum*								
15) *Indigofera glandulosa*	35	16	10	6	35	12	9	5
16) *Lagascea mollis*	32	16	5	3	30	15	3	-
17) *Phyllanthus maderaspatensis*	57	28	19	14	33	15	13	2
18) *Trianthema portulacastrum*	40	22	15	7	38	18	11	3
19) *Trichodesma zeylanica*	33	32	24	16	25	21	17	9
20) *Tridax procumbens*	30	22	15	7	37	27	11	-

Table 8: Percentage seedling emergence of some annual weeds in cultivated and undisturbed soils, Alfisols, 1978-79.

Weeds	Cultivated soil Depth of burial (cm)			Undisturbed soil Depth of burial (cm)		
	2.5	7.5	15	2.5	7.5	15
1) *Alysicarpus rugosus*	32	17	12	29	11	8
2) *Celosia argetea*	73	51	31	65	41	21
3) *Cyanotis axillaris*	50	35	22	38	28	19
4) *Dactyloctenium aegyptium*	20	5	2	12	2	-
5) *Desmodium dichotomum*	-	-	-	-	-	-
6) *Digera muricata*	30	20	6	-	-	-
7) *Digitaria ciliaris*	66	45	38	53	36	25
8) *Flaveria australasica*	10	5	3	-	-	-
9) *Goniocaulon glabrum*	-	-	-	-	-	-
10) *Indigofera glandulosa*	25	21	12	18	15	8
11) *Phyllanthus maderaspatensis*	29	14	10	16	4	-
12) *Tridax procumbens*	41	25	12	44	26	11

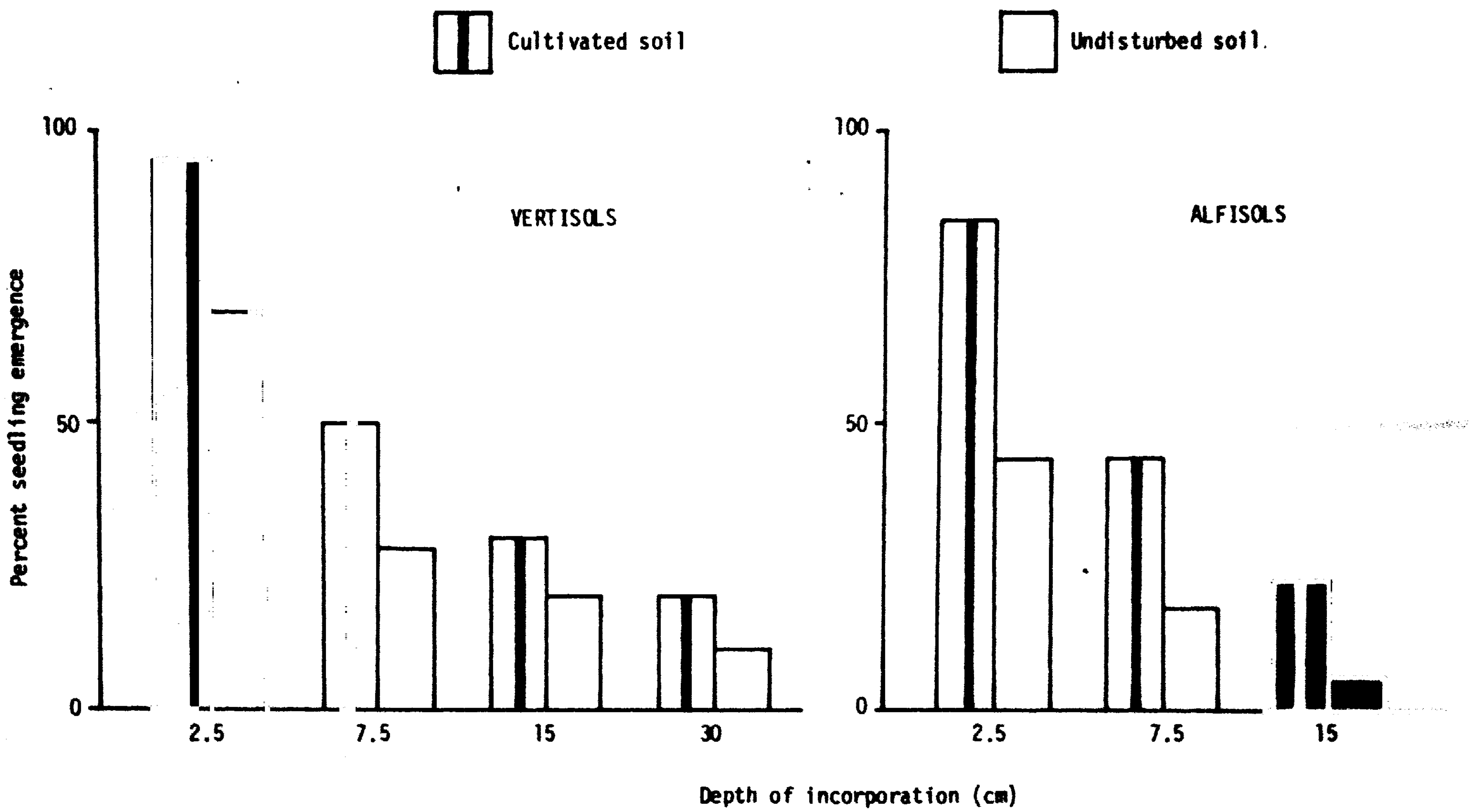

Fig. 38. EFFECT OF DEPTH OF INCORPORATION ON WEED SEEDLING EMERGENCE IN TWO SOILS, 1979.

Other significant observations from this study are:

1. Indigofera and Desmodium produced maximum seedlings when the soil was kept undisturbed.
2. Tridax produced more seedlings in undisturbed conditions than cultivated soils.
3. Goniocaulon, Corchorus & Eclipta did not germinate at all under these conditions. Most probably an enforced dormancy might have thrusted upon them and they needed special mechanism to break such a dormancy.

2.3. Effect of shading on weed growth:

Light is one of the important physical factors operating in crop-weed balance and for better management of weeds, manipulation of light would provide selective shading through crop canopies. Previous work by us have provided substantial evidence on the importance of light as a factor in crop-weed competition and its manipulation to suppress weeds. To examine the growth response of some selected rabi weeds to different levels of shading a trial was conducted in Alfisol during Rabi 1979. Different levels of shading were simulated through bamboo shade frames as done in 1978 and 1979 Kharifs. The test weed species were Cyperus rotundus and Xanthium strumarium. In collaboration with Agroclimatologists PPFD (Photosynthetic Photon Flux Density) was recorded by traversing photon sensors and other growth observations were recorded frequently. The results are presented in table 9 & 10 figs. 39-44.

Both the weed species selected, for this experiment exhibited light sensitivity. The drymatter production at the end of life cycle indicates that the normal growth of these weeds has been affected significantly. There was marked reduction in dry matter weights of tubers and shoots of Cyperus as shading level increased. As in 1978 and 1979, plant height was not much affected, but LAI closely followed the trends of dry matter production. This observation corroborates earlier findings that Cyperus is highly sensitive to shade.

Xanthium responded to shading as Cyperus did and the data on final dry matter production indicates that growth of this weed was significantly affected at 90% shading. The plants grown under shade were considerably shorter. Seed production of this weed was also affected by shading. At 60% shading seed production recorded was 50% of that of control (i.e. no shading).

Table 9: Effect of different levels of shading on the growth of <u>Xanthium strumarium</u>, post-rainy season. (Rabi) 1979.

Photosynthetically active radiation (Microeinsteins/cm^2/sec)	Plant height in cms	Biomass g/m^2	Seed production (%)	Leaf Area Index
10%	55.1	774.9	19	0.4
20%	83.1	974.9	33	1.3
25%	110.6	1241.6	39	1.9
40%	128.5	1841.6	53	2.8
100%	160.9	2150	100	3.8
C.D. at 5%	11.1	416.1	4.2	0.3
Correlation Coefficient (r)	0.996	0.982	0.923	0.996

Table 10: Effect of different levels of shading on the growth of <u>Cyperus rotundus</u>, post rainy season (Rabi) 1979.

Photosynthetically active radiation (Microeinsteins/cm^2/sec)	Plant height in cms	Increase in No. of tubers/m^2	Tuber biomass m^2	Increase in No. of shoots/m^2	Shoots biomass m^2
10%	20.8	55	9.8	84	17.5
20%	34.8	147	22.3	183	23.9
25%	41.2	168	46.1	201	51.4
40%	45.0	228	61.2	297	61.3
100	37.1	768	181.9	687	143.4
C.D. at 5%	6.1	184.9	20.6	57.7	18.9
Correlation Coefficient (r)	0.354	0.994	0.996	0.998	0.989

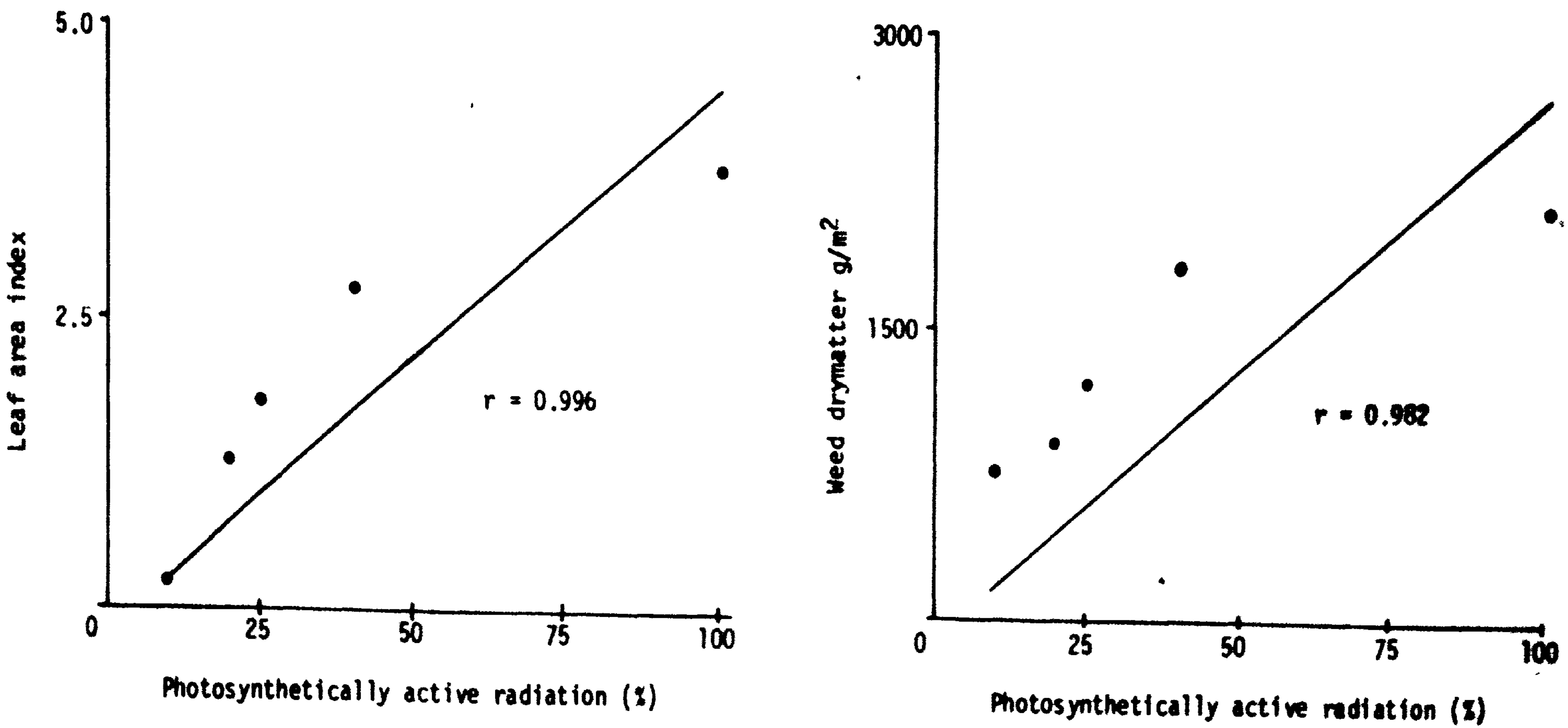

Fig. 39. EFFECT OF DIFFERENT LEVELS OF LIGHT TRANSMISSION ON (a) LEAF AREA INDEX AND (b) WEED DRYMATTER OF *Xanthium strumarium* ON ALFISOLS, (RABI) 1979.

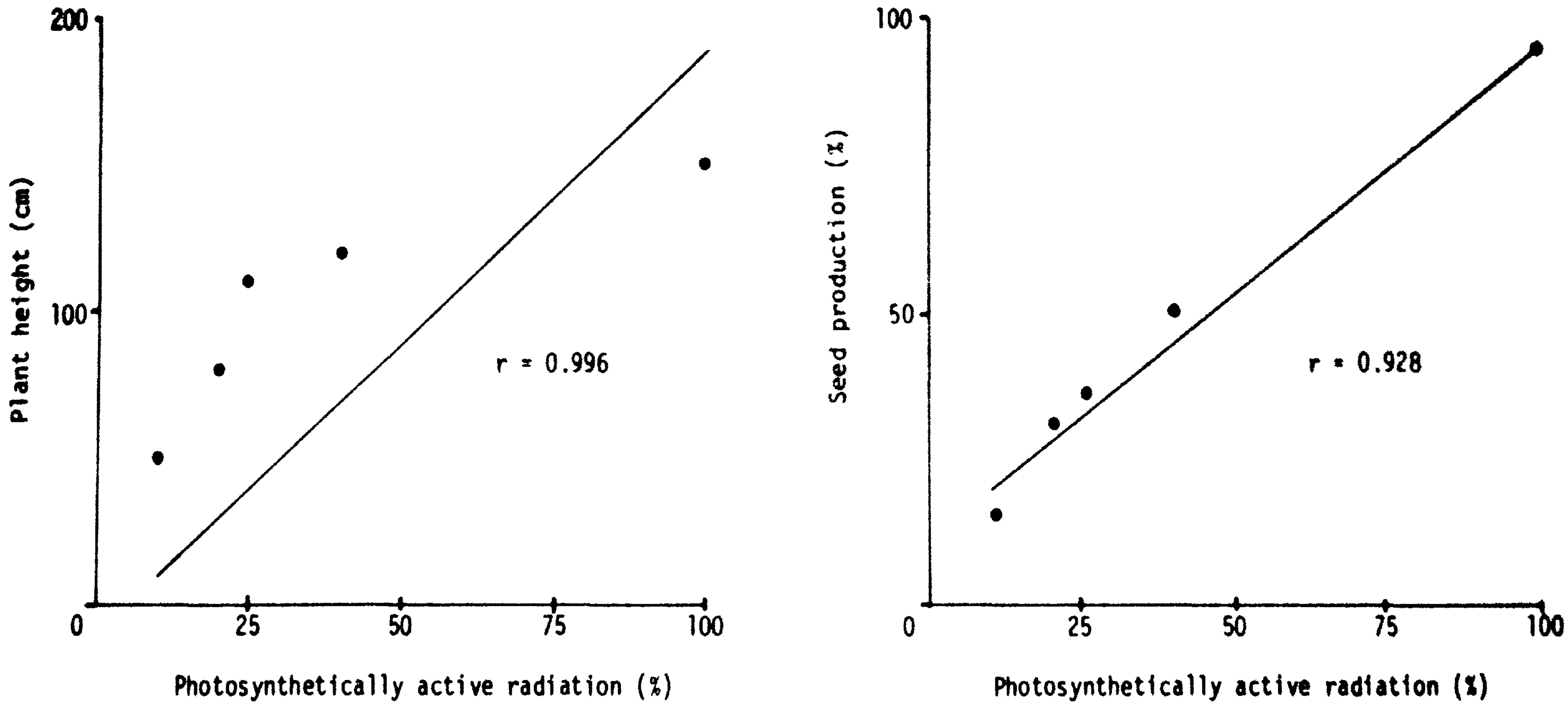

Fig. 40. EFFECT OF DIFFERENT LEVELS OF LIGHT TRANSMISSION UPON (a) PLANT HEIGHT AND (b) PERCENT SEED PRODUCTION OF *Xanthium strumarium* ON ALFISOLS (RABI) 1979.

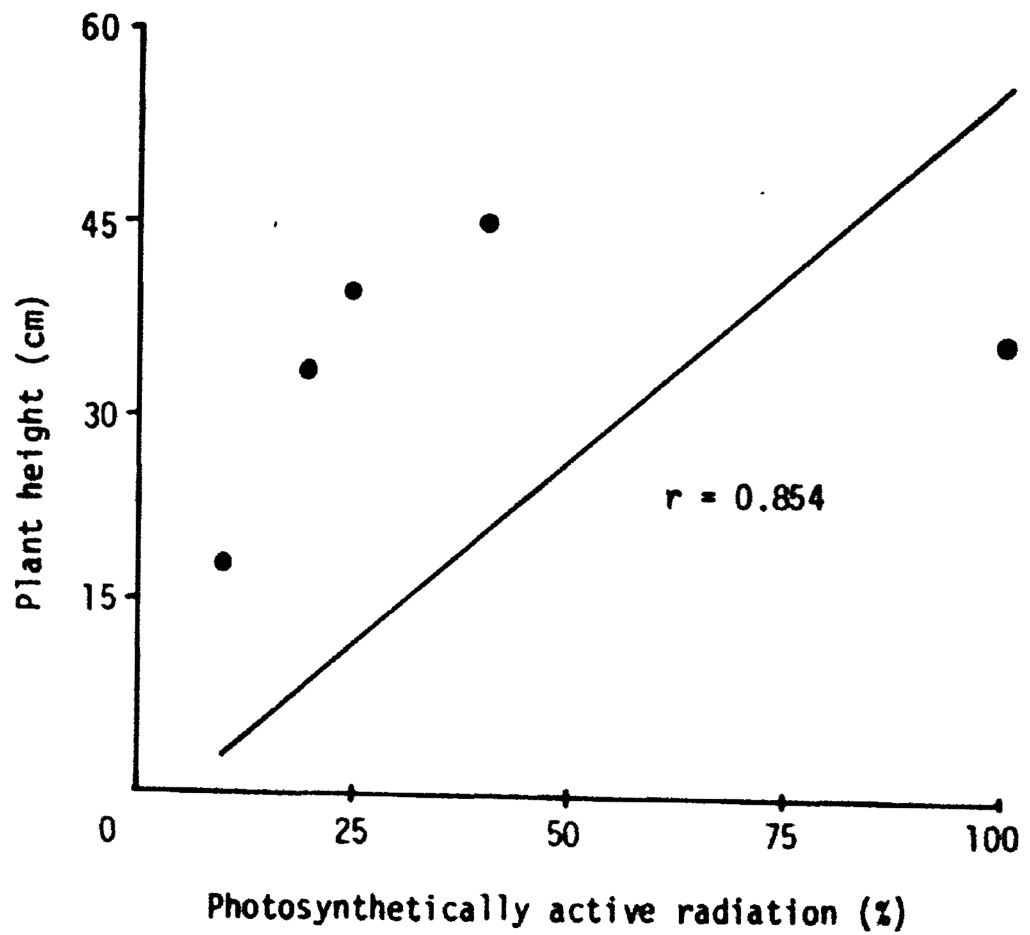

Fig. 41. EFFECT OF DIFFERENT LEVELS OF LIGHT TRANSMISSION UPON PLANT HEIGHT OF *Cyperus rotundus* ON ALFISOLS (RABI), 1979.

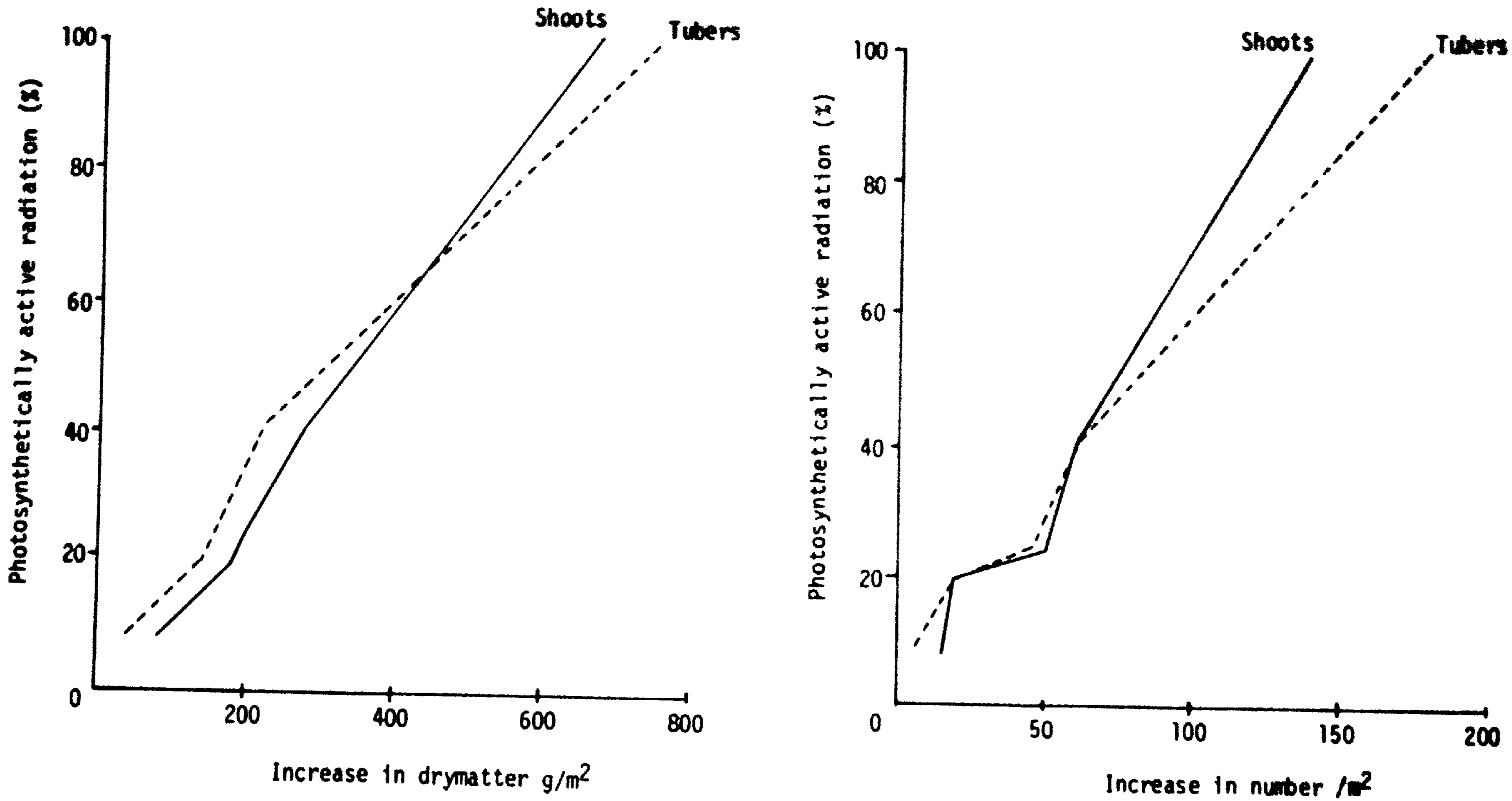

Fig. 42. EFFECT OF DIFFERENT LEVELS OF SHADING UPON (a) INCREASE IN DRYMATTER AND (b) INCREASE IN NUMBER OF *Cyperus rotundus* ON ALFISOLS, (RABI), 1979.

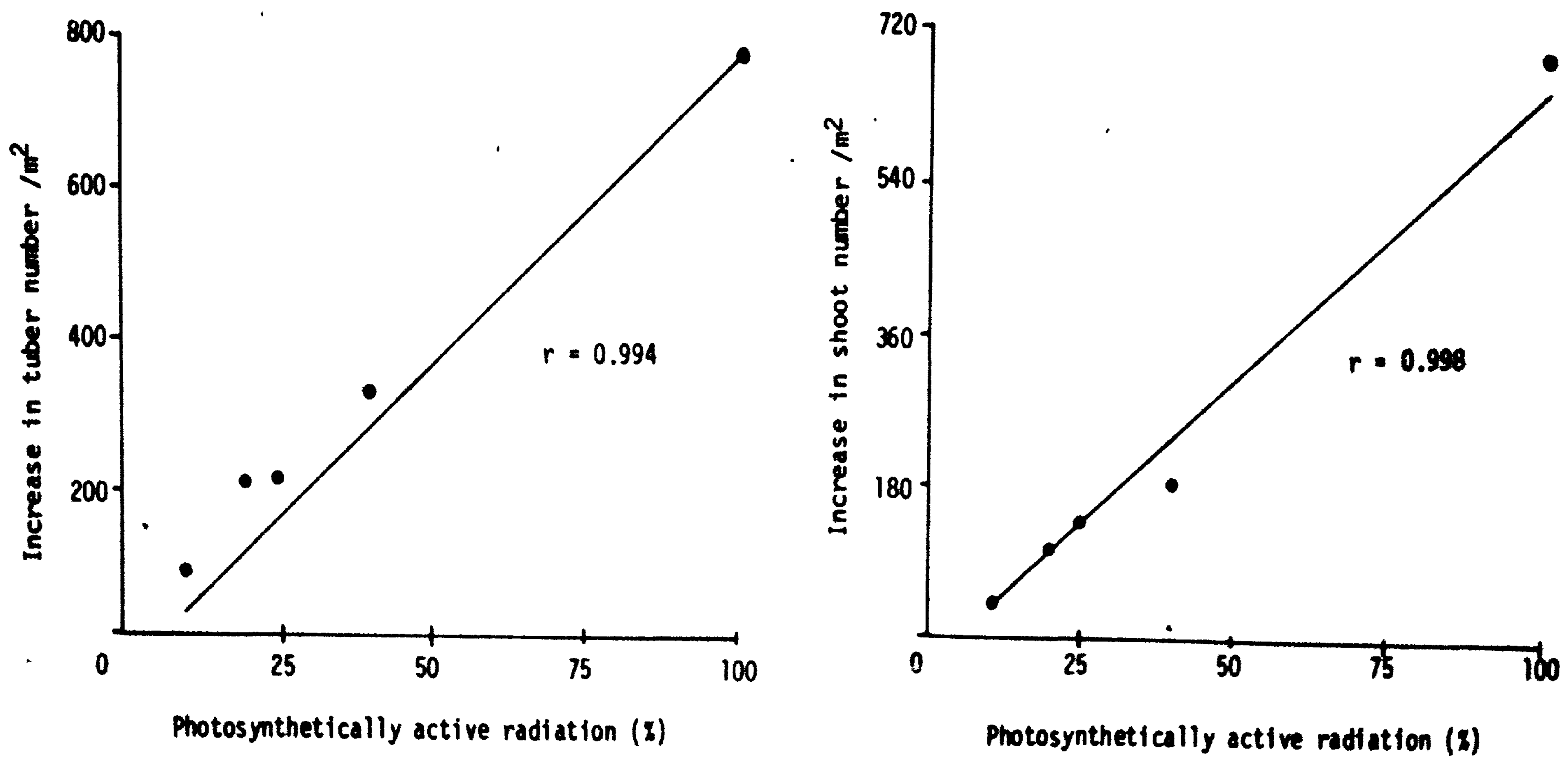

Fig. 43. EFFECT OF DIFFERENT LEVELS OF LIGHT TRANSMISSION UPON (a) INCREASE IN TUBER NUMBER AND (b) INCREASE IN SHOOT NUMBER OF *Cyperus rotundus* ON ALFISOLS, (RABI) 1979.

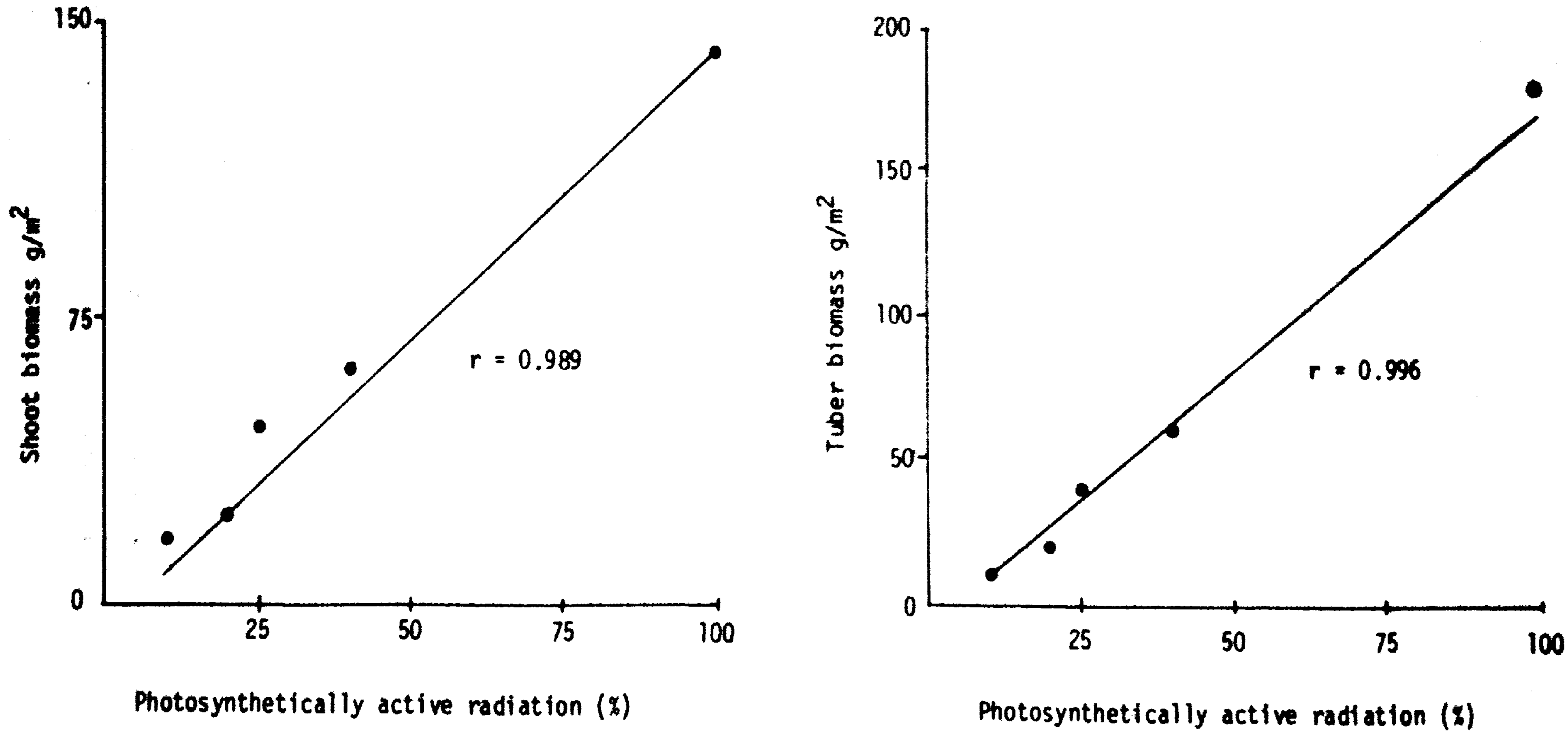

Fig. 44: EFFECT OF DIFFERENT LEVELS OF LIGHT TRANSMISSION ON (a) SHOOT BIOMASS AND (b) TUBER BIOMASS OF *Cyperus rotundus* ON ALFISOLS, (RABI) 1979.

2.4. Weed density:

A field trial first initiated three years ago was continued in deep Vertisols to examine the competitive effect of individual weeds in different densities on the growth and yield of sorghum. Two weeds Digitaria ciliaris, a grass and Corchorus olitorius, a dicot, were planted along with sorghum on the same row as well as across the crop row in different densities. The crop and weed growth observations were taken frequently to determine the competitive effect of these two weeds on sorghum. The detailed treatments and the results are presented in the table 11 and figs.45-47.

It was observed that the increase in weed density adversely affected crop yields in case of both the weeds. But the effect was more pronounced with Corchorus than Digitaria. Digitaria was more competitive to sorghum especially at lower density, perhaps due to its similar growth habit as that of sorghum. The same trend was appeared in previous years' studies also. Besides weeds on the crop were more competitive than weeds on crop row. Even along the crop row Corchorus was more competitive than Digitaria, at higher density levels while Digitaria was more competitive at lower density.

Three consecutive years' data indicate that after a weed density of about $200/m^2$ the reduction was not significant in sorghum yields. Further, the distribution of weeds along the crop row has more adversly affected sorghum yields than weeds across crop rows. This has practical significance in that the control of row weeds is as important as interrow weed control and the traditional system of only interrow cultivations are not sufficient to prevent yield losses due to weeds.

2.5. Time of weed removal:

Under semi-arid conditions, where major method of weed management is hand weeding, the critical period of crop-weed competition is an important aspect of research. But hitherto, most of the studies of crop-weed competition are related to only sole crops, and such competition studies are scanty on cropping systems. A series of long term experiments were intiated in 1978 at ICRISAT center mainly to study crop-weed competition as affected by different times of hand weeding in the major intercropping systems.

Table 11: Effect of different weed densities on growth and yield of sorghum on Vertisols, 1980.

Treatments Weed density plants/m^2	*Corchorus olitorius* Sorghum yield kg/ha	Fodder weight kg/ha	Weed drymatter g/m^2	*Digitaria ciliaris* Sorghum yield kg/ha	Fodder weight kg/ha	Weed drymatter g/m^2
1) 200 (crop row)	2796	5241	141	3190	4745	144
2) " (across)	3109	5545	316	3483	5671	264
3) 100 (crop row)	3326	5708	136	3712	6018	117
4) " (across)	3485	6527	170	3914	6597	150
5) 50 (crop row)	3896	7236	96	4045	6712	62
6) " (across)	4686	8060	132	4552	7523	95
7) Weed free	5157	9838	-	5157	9838	-
C.V. %	3.7	3.9	12.2	3.7	3.9	12.2
C.D. at 5%	242	431	28.9	242	431	28.9

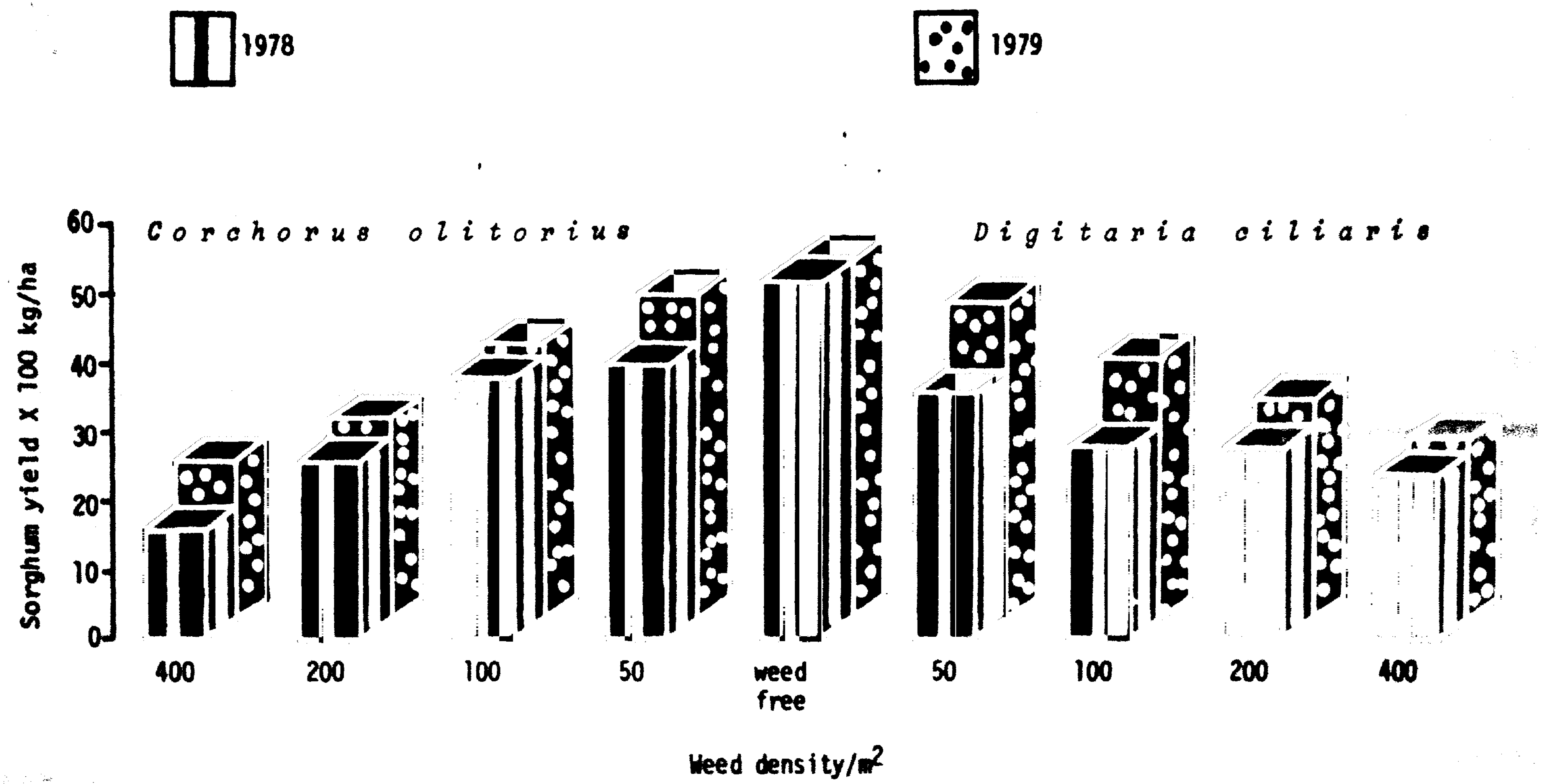

Fig. 45. EFFECT OF DIFFERENT DENSITIES OF TWO WEEDS ON SORGHUM YIELDS, VERTISOLS, 1978 - 79.

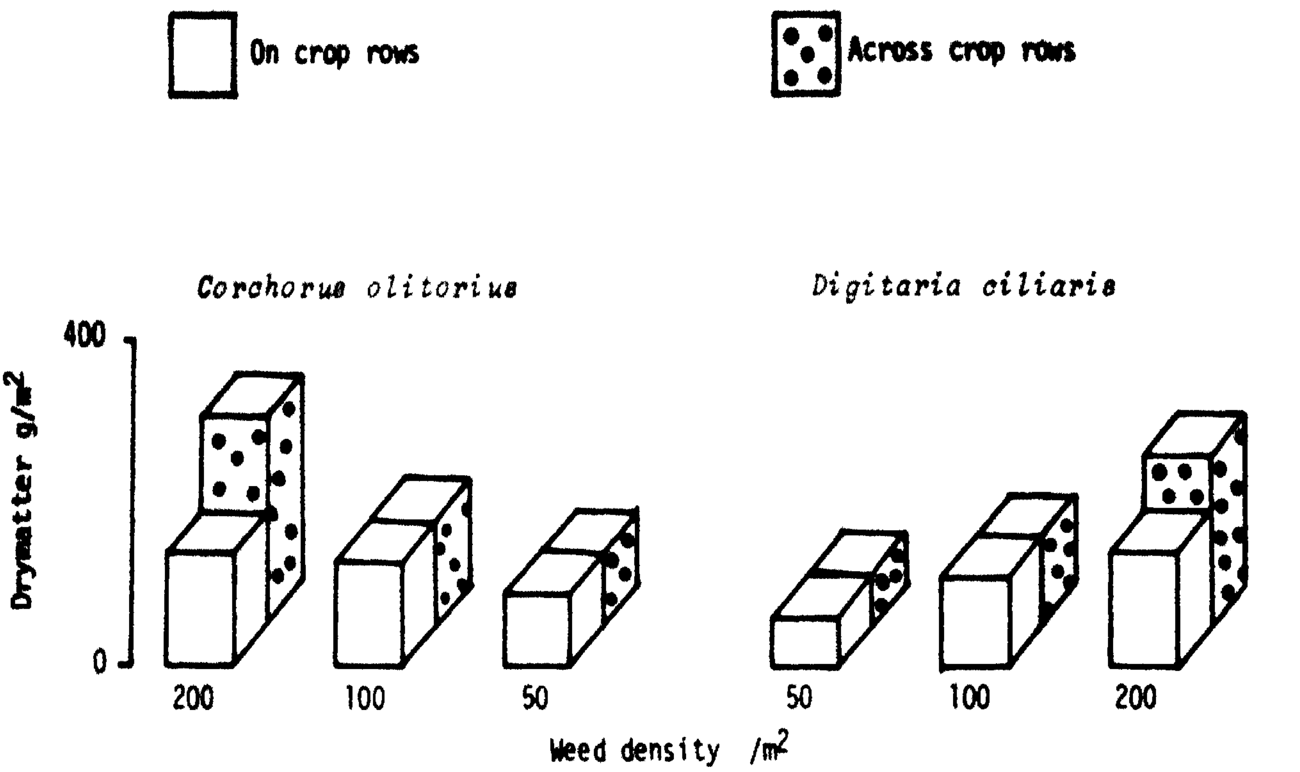

Fig. 46. EFFECT OF DIFFERENT DENSITIES OF TWO WEEDS ON WEED DRYMATTER, VERTISOLS, 19

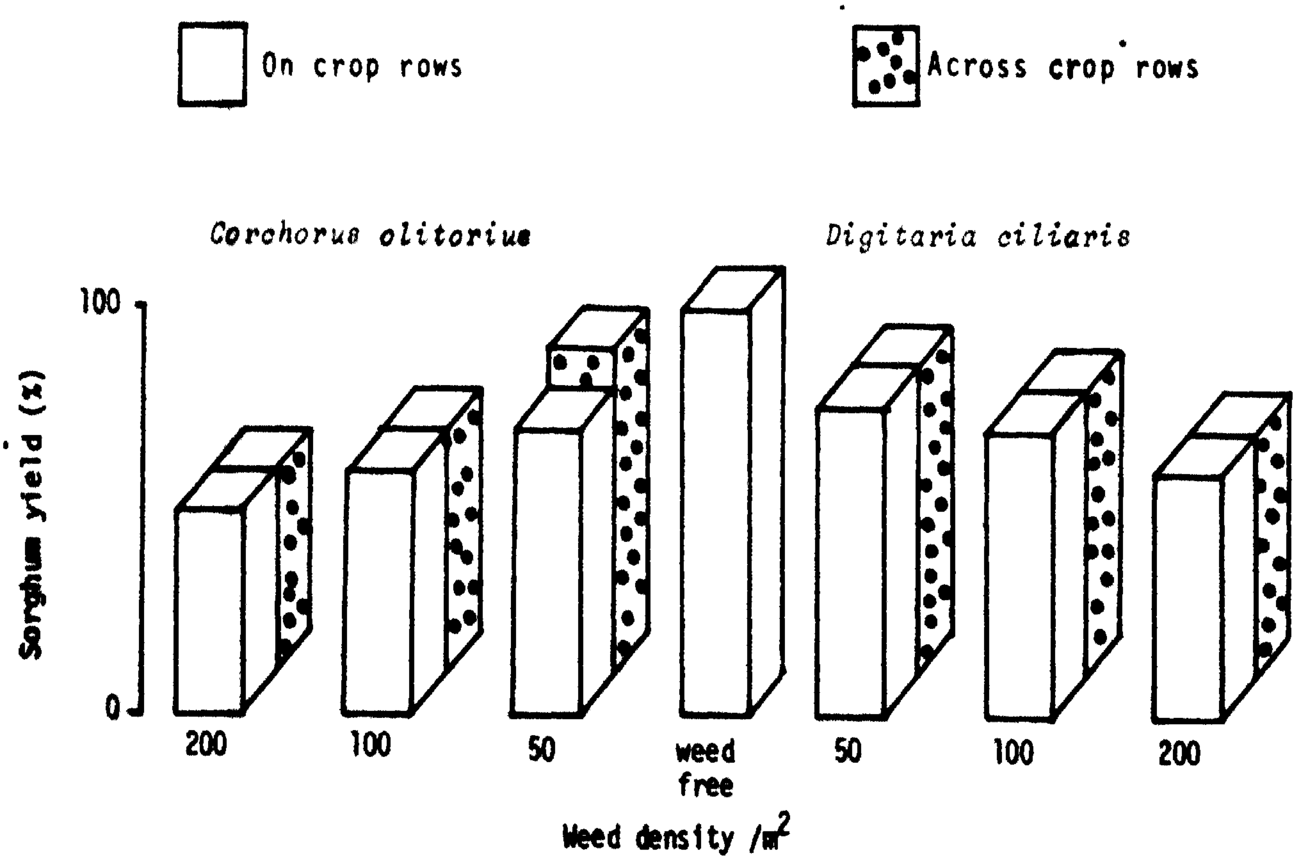

Fig. 47. EFFECT OF DIFFERENT DENSITIES OF TWO WEEDS ON SORGHUM YIELDS, VERTISOLS, 19

2.5.1. Sorghum/pigeonpea intercrop:

To evaluate the effect of different times of weed removal on the crop yields of sorghum/pigeonpea intercrop, a trial was conducted in the Vertisols during monsoon of 1980. Hand weedings were given at different intervals during the crop season. The detailed treatments and the results of 1980 are presented in table 12. Results of three consecutive years (1978-1980) are pooled and are illustrated in fig 48 and 49. As seen in the fig. 50 the optimum sorghum yield was obtained at 4 weeks after planting. Hand weedings given earlier to 4th week resulted in some yield reduction of sorghum. The same trend was observed in pigeonpea yield also. Two hand weedings at 3 and 5 weeks after planting performed better than weedings given at 4 or 6 weeks after planting. The results indicate that one hand weeding at about 4 weeks after planting or 2 hand weedings at 3 and 5 weeks after planting is essential to obtain optimum yields of sorghum/pigeonpea intercropping systems.

2.5.2. Pearlmillet/groundnut intercrop:

To determine the critical period of weed crop competition in pearlmillet/groundnut intercrop (1:3 row proportion) a trial was initiated in 1979 rainy season and repeated during rainy season of 1980 on Alfisols. The plots were kept weedfree by hand weedings upto different duration after planting during the crop season. The detailed treatments and results are presented in the table 13. The data and results of two consecutive years (1979-1980) are illustrated together in figs. 51-51.

As seen in the figs. 51-52 the optimum pearlmillet yield was obtained when one hand weeding was given at 4 weeks after planting. The yields were almost similar to those obtained from the treatment of weed free till 4 weeks after planting. Hand weedings given to keep weed free till 3.5 and 7 weeks after planting did not perform better than the treatment of weeding at 4 weeks after planting. Groundnut yields followed the same trend as that of pearlmillet.

2.6. Cultivar effect:

A series of field experiments conducted during previous years indicated that the crop cultivars differ in their weed competitive ability. It was also concluded that in some crops there exists a differential herbicide tolerance among different cultivars. During 1980 an experiment first initiated two years ago was continued with different cultivars of pearlmillet on Alfisols.

Table 12: Effect of time of weed removal on weed growth and crop yields of sorghum/pigeonpea intercrop on Vertisols, 1980-81.

Treatments	Sorghum yield kg/ha	Fodder yield kg/ha	Pigeonpea yield kg/ha	Weed drymatter g/m²
1) Hand weeding after 2 weeks	2148	4016	266	1190
2) Hand weeding after 3 weeks	3023	4725	367	1132
3) Hand weeding after 4 weeks	3375	6023	668	135
4) Hand weeding after 6 weeks	3193	5891	498	160
5) Hand weeding after 8 weeks	2863	5391	498	179
6) Hand weeding after 3 + 5 weeks (2 hand weedings)	4591	6430	726	122
7) Hand weeding after 3 + 5 + 8 weeks (3 hand weedings)	4819	7016	903	110
8) 1 H.W.* (4 weeks) + 1 H.W. immediately after sorghum harvest	3396	6239	652	148
9) Weedy check	1510	3266	151	1257
C.D. at 5%	311	372	50	123

*Hand weeding

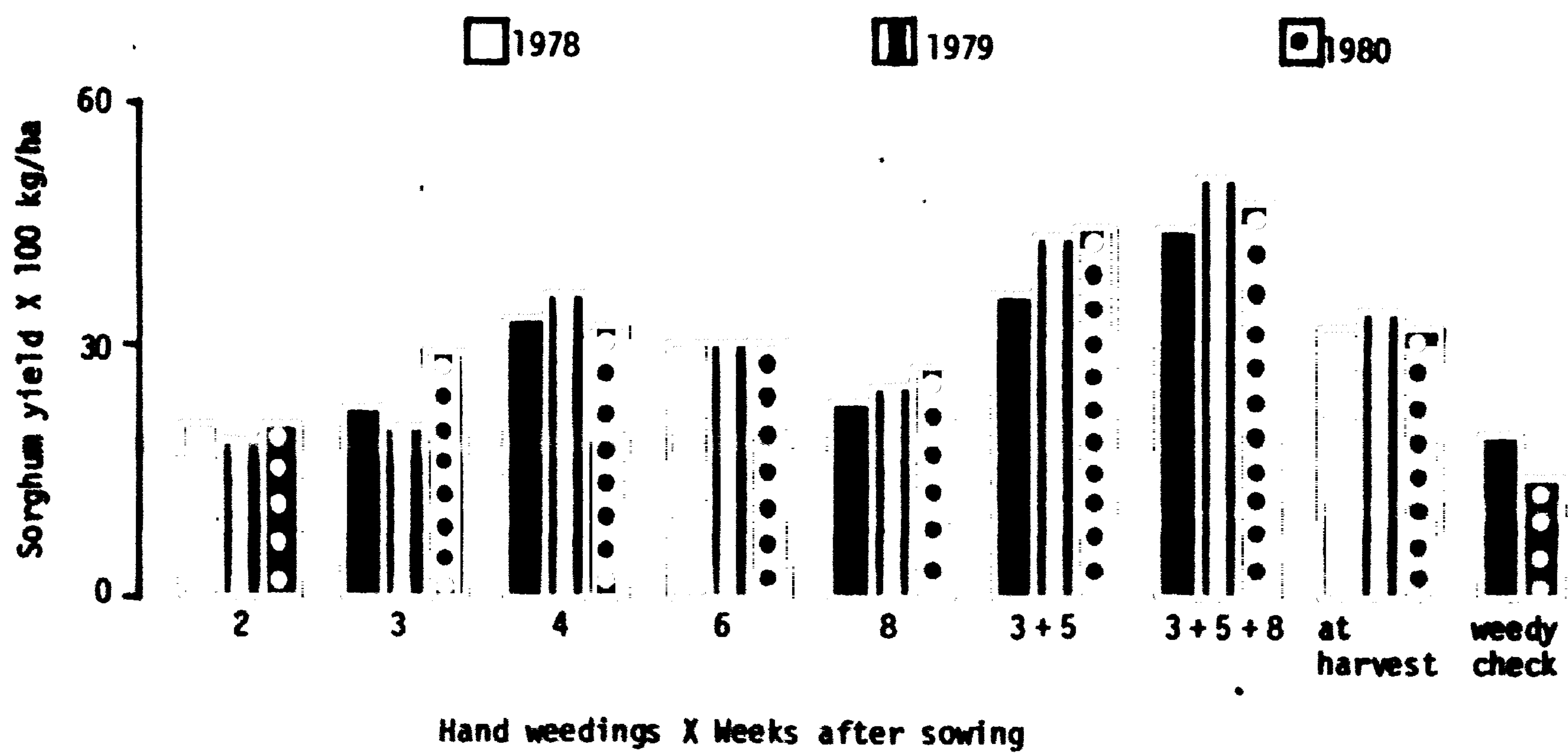

Fig. 48. EFFECT OF DIFFERENT TIME OF WEED REMOVAL ON SORGHUM YIELDS IN SORGHUM/PIGEONPEA INTERCROP ON VERTISOLS, 1978-80.

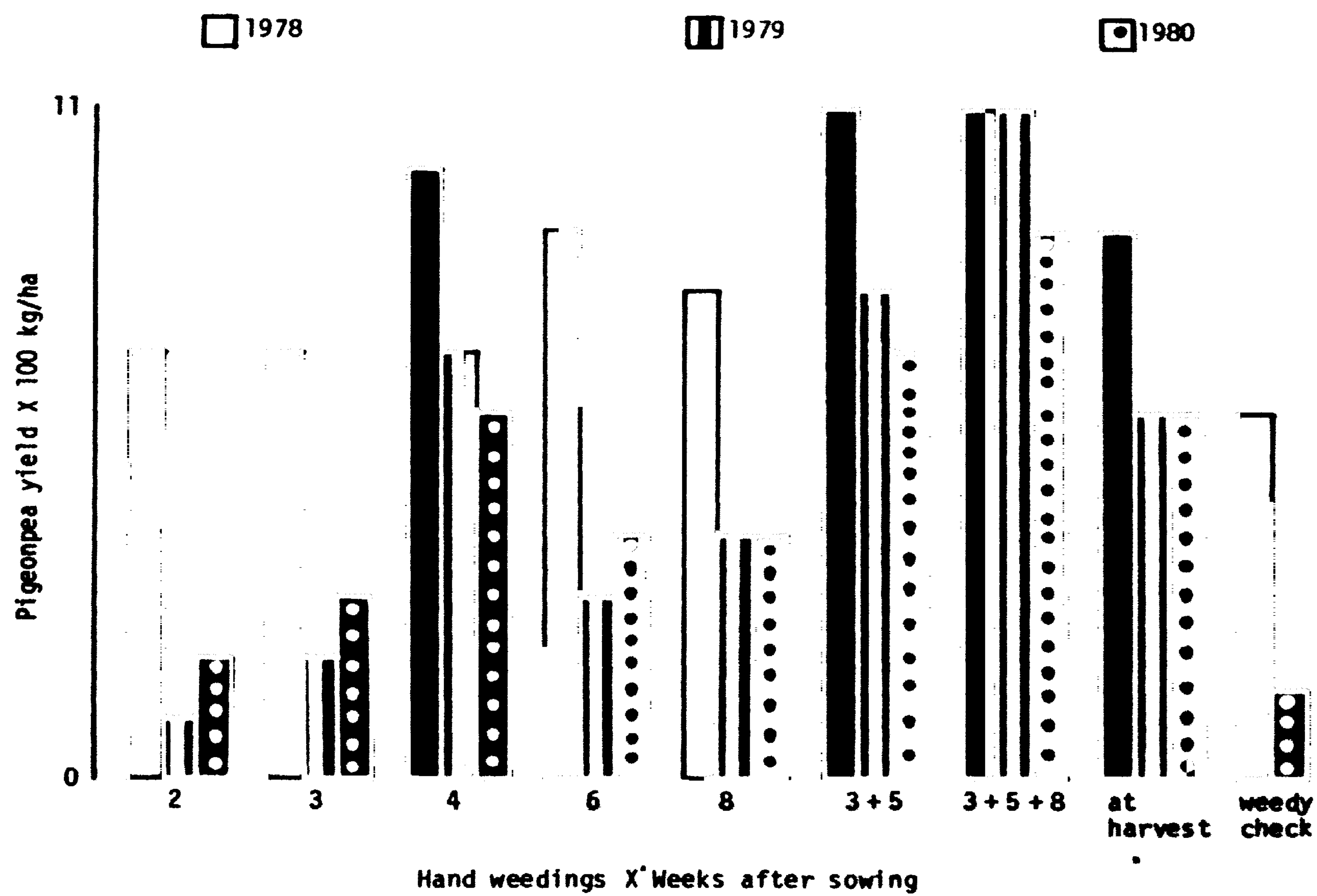

Fig. 49. EFFECT OF DIFFERENT TIME OF WEED REMOVAL ON PIGEONPEA YIELDS IN SORGHUM/PIGEONPEA INTERCROP ON VERTISOLS, 1978-80.

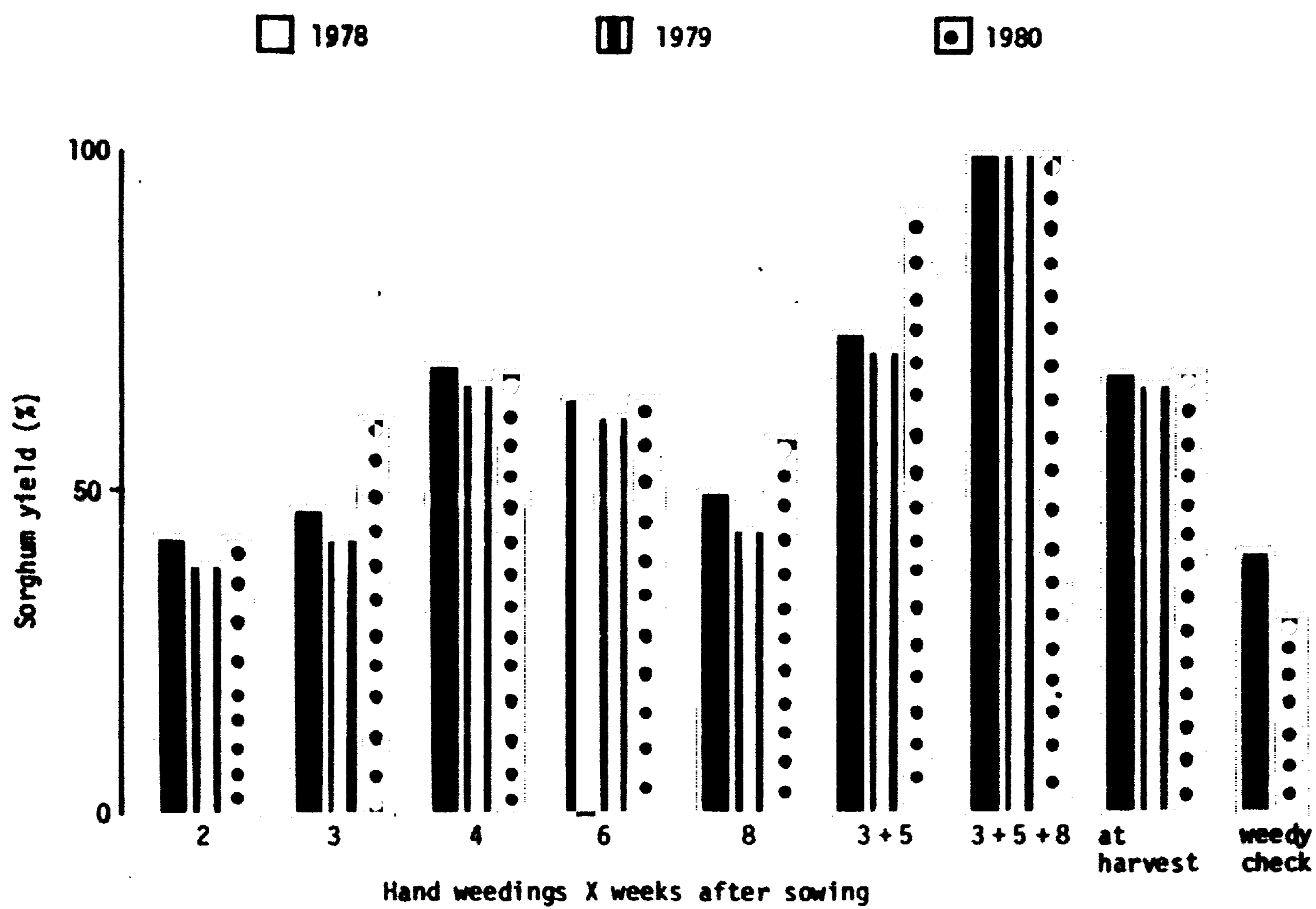

Fig. 50. EFFECT OF DIFFERENT TIME OF WEED REMOVAL ON SORGHUM YIELDS IN SORGHUM/PIGEONPEA INTERCROP FOR THREE YEARS, VERTISOLS

Table 13: Effect of time of weed removal on crop yields and weed growth in pearlmillet/groundnut intercrop on Alfisols, 1980.

	Pearlmillet yield kg/ha	Groundnut yield kg/ha	Weed drymatter at groundnut harvest g/m²
1) Weed free upto 2 WAS*	1171	669	251
2) Weed free upto 3 WAS	1354	746	177
3) Weed free upto 4 WAS	1951	1162	129
4) Weed free upto 5 WAS	1696	1060	37
5) Weed free upto 7 WAS	1547	972	20
6) Weed free upto 9 WAS	1887	1271	9
7) One HW** 4 WAS	1468	943	79
8) Two HW 3, 6 WAS	1407	8[illegible]	60
9) Weed free	1975	1345	-
10) Weedy check	1051	102	319
C.D. at 5%	93	41	18

*WAS = Weeks after sowing

**HW = Hand Weeding

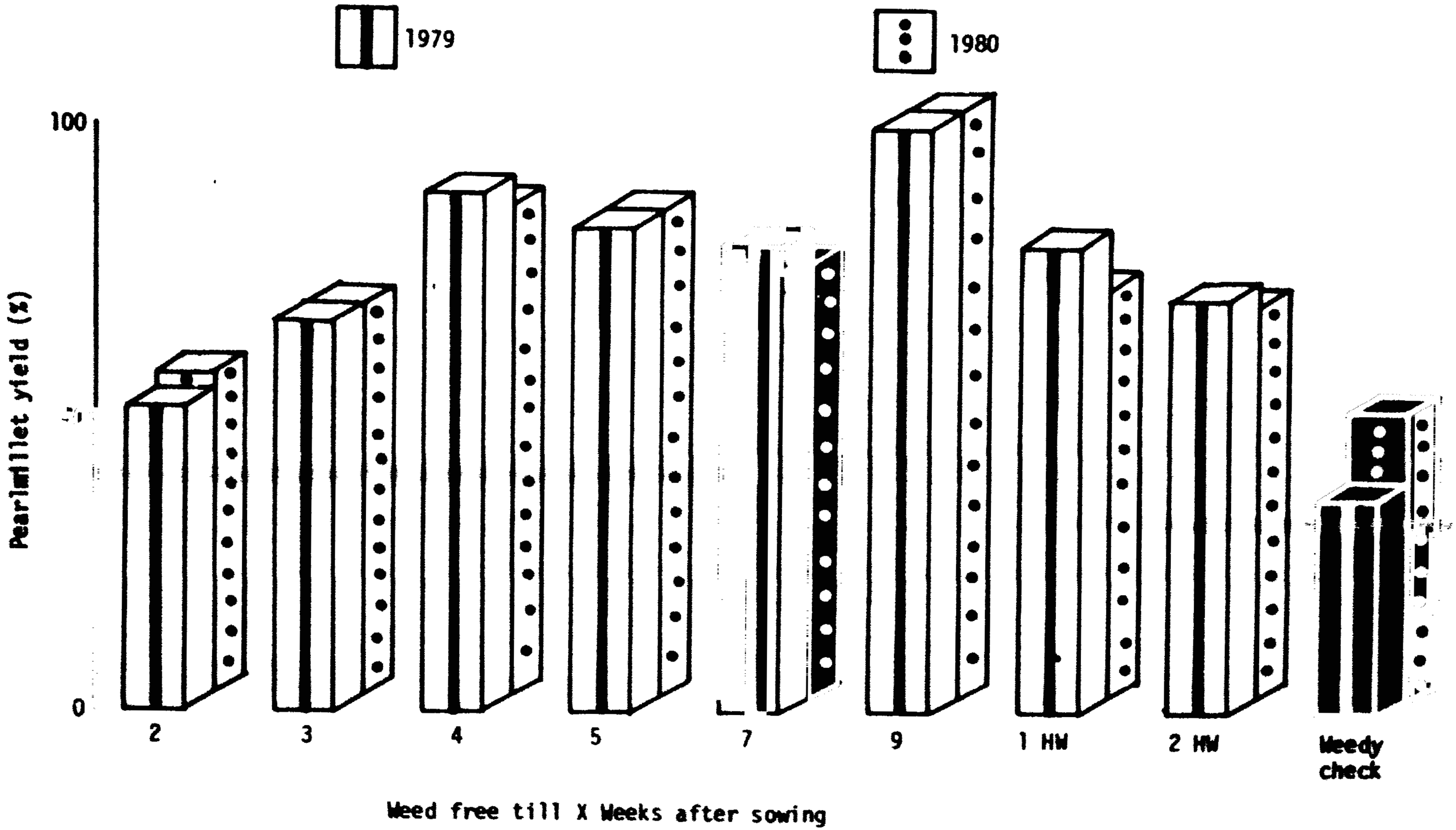

Fig. 51. EFFECT OF DIFFERENT TIME OF WEED REMOVAL AND DURATION OF WEED COMPETITION ON PEARLMILLET YIELDS IN PEARLMILLET/GROUNDNUT INTERCROP, ALFISOLS, 1979-80.

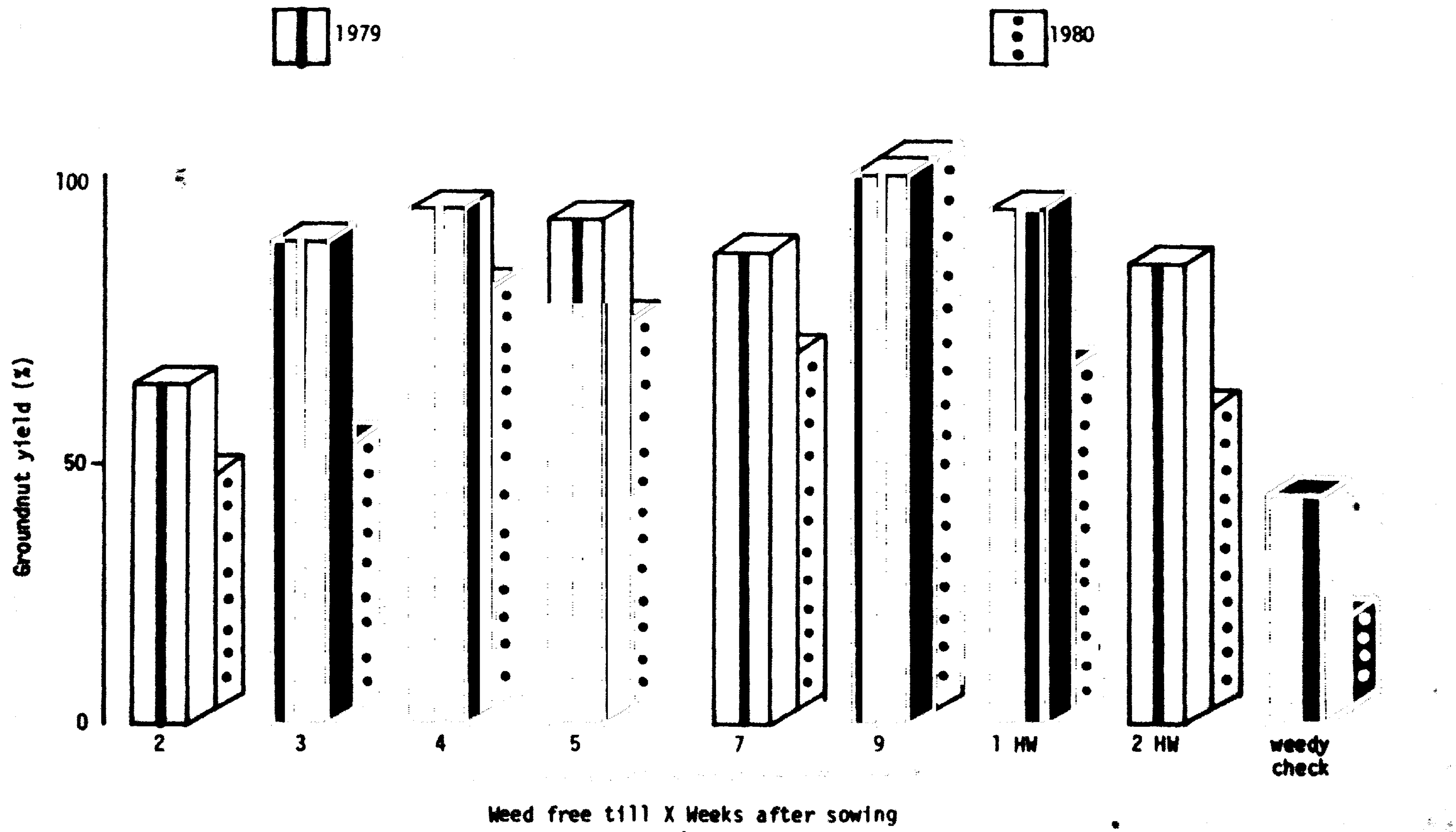

Fig. 52. EFFECT OF DIFFERENT TIME OF WEED REMOVAL AND DURATION OF WEED COMPETITION ON GROUNDNUT YIELDS IN PEARLMILLET/GROUNDNUT INTERCROP, ALFISOLS, 1979-80.

Table 14: Effect of different weeding treatments on the yields (kg/ha) of different cultivars of pearlmillet, Alfisols, 1980.

Cultivars	Atrazine 1 Kg ai/ha.	HW*	Weed free	Weedy check	Mean
Ex-Bornu	2355	1110	2959	251	1669
GK-77-3	2225	1043	2962	98	1582
BJ 104	2320	1152	3135	172	1695
IVS AX 75	2164	1085	3202	152	1651
Mean	2266	1098	3065	168	

LSD (0.05) for comparisons of weed management treatments	109
LSD (0.05) for comparisons of cultivars	214
LSD (0.05) for comparisons of means within the groups	428
LSD (0.05) for comparisons of means of different groups	387

*Hand weeding

The results of the experiments are presented in the table 14(over). Among the weed control treatments, herbicide in general performed very well. The cultivar BJ 104 out yielded other cultivars followed closely by Ex-Bornu. Under weedy condition BJ 104 performed well because of its good seedling vigour as well as good tillering habit. Among other cultivars the tall cultivar Ex-Bornu could withstand weed competition better than the dwarf type GK-77-3. Though the yield potential of IVS/A8-75 and GK-77-3 was better than Ex-Bornu under weed free situation Ex-Bornu seemed to perform better under weedy situations. There was no differential herbicide tolerance among cultivars and all the four cultivars tolerated the herbicides effectively.

The trial again highlighted the differential d competitive ability by different crop cultivars.

3. Evaluation of nt system:

The project on evaluation of weed management systems involved primarily operational scale evaluation in the watersheds as well as small plot scale evaluation on other experimental fields.

3.1. Operational scale evaluation:

During the past few years different small plot experiments were conducted to develop and evaluate weed control system on individual crops and also on different cropping systems. Since last year some of these potential weed control systems were also tested on ICRISAT watersheds on an operational scale and on "year-round" basis. These evaluation trials also included the incorporation of latest technology components developed by other subprograms. Such operational research was continued during the current season with the major objective of determining the productivity of each weed management system under different cropping systems and also to observe the operational feasibility of such an improved system. Economics and ecology were the integral parts of such operational research. Weed management system being evaluated on operational scale trials include 1) Hand weeding based system; 2) Herbicide based system and 3) Smother cropping system. These different treatments are being evaluated along with weed free and weedy check plots to determine their efficacy and feasibility. All other package of practices were kept to optimum as suggested by other FSRP subprograms. All the operations were carried out either by bullocks or human labor. Some brief results of second year studies on a few test cropping systems are presented below.

3.1.1. Maize-Chickpea sequential cropping system:

The treatments and the results are presented in table 15 and fig. 53 The herbicide used was pre-emergence application of atrazine at the rate of 1.5 kg/aiha. In general, this year maize yields were good because of favourable rainfall during early kharif, but chickpea yields were poor because of the early cessation of rains and the problems associated with crop establishment after maize harvest. The kharif weeding treatments did not significantly affect the post rainy season chickpeas though weedy check treatment performed very poorly when compared to weed free and herbicide treatments. There were me yield reductions in smother cropping system because of competitive effects of cowpea or mung. But the additional cowpea or mung yields compensated this loss to some extent. Herbicide system performed next to weed free system both in gross and net returns.

The results from this year study showed the same trend observed during earlier year. Herbicide system seemed to have good potential in maize based system in deep Vertisols particularly during good rain fall years. Further, smother cropping system seems to have less potential in maize based system as maize is perhaps susceptible for smother crop competition. The results further confirm our earlier hypothesis that herbicides can be an integral part of improved farming systems in high rainfall deep Vertisols areas. As far as operational feasibility is concerned again herbicides will be better placed because of difficulties associated with working on the wet Vertisols during hand weedings. The trial also indicated the feasibility of smother cropping system in that the additional crops, cowpea and mung can be planted on broadbeds with the tropiculteur without any extra attachments.

3.1.2. Sorghum/pigeonpea intercrop system:

The herbicide used on the sorghum/pigeonpea system was fluchloralin (at 1.5 Kg/aiha) commercially known as Basalin. The herbicide proved effective particularly on pigeonpea as there was substantial increase in pigeonpea

Table 15: Effect of different weed management systems on the net productivity of maize-chickpea sequential cropping system Vertisols, 1980-81.

Treatments	Kharif			Rabi		Total returns Rs/ha	Opera-tional cost Rs/ha	Net returns Rs/ha
	Maize yield	Smother crop yield kg/ha	Return Rs/ha	Chickpea kg/ha	Returns Rs/ha			
Hand weeding system	4142		4349	361	993	5342	320	5022
Herbicide system	4321		4537	415	1141	5678	560	5118
Smother system								
Mung	3411	132	3978	260	715	4693	360	4333
Cowpea	3583	156	4230	365	1004	5234	360	4874
Weed free	5307		5572	512	1408	6980	640	6340
Weedy check	2869		3012	245	674	3686	-	3686

Monetary values considered:

Maize	: Rs. 105/q	Hand weeding	: Rs. 160/ha
Chickpea	: Rs. 275/q	Herbicide	: Rs. 240/ha
Cowpea/Mung	: Rs. 300/q	Smother crop seed	: Rs. 40/ha

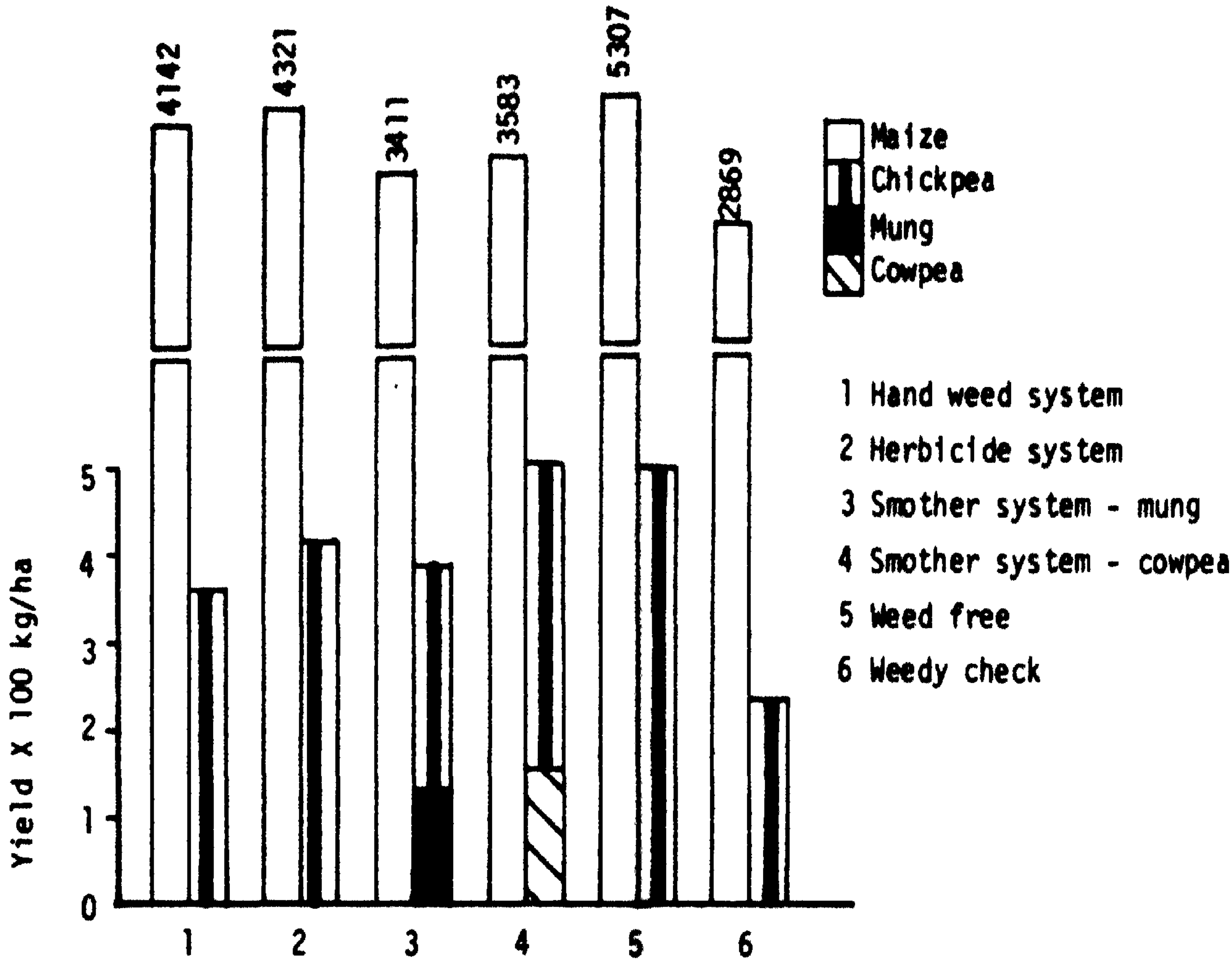

Fig. 53. EFFECT OF DIFFERENT WEED MANAGEMENT SYSTEMS ON THE PRODUCTIVITY OF MAIZE-CHICKPEA SEQUENTIAL CROPPING SYSTEMS, VERTISOLS, 1980-81.

yields with herbicide system when compared to other systems. The detailed results and economic analysis are given in table 16 and fig. 54. The net returns obtained with herbicide system was higher than other systems except weed free treatment. Smother cropping systems also performed better than hand-weeding system. The trials also demonstrated that 2 rows of smother crops can be accomodated on the broad bed along with 3 rows of main crops, sorghum and pigeonpea. There was also not much difficulty in using tropiculteur for planting all these three crops on the bed. It is also interesting to note the yield losses due to weeds in the weedy check treatment when compared to weed free treatment which amounts upto Rs. 2000/ha net loss. Another interesting information to note is the higher pigeonpea yields when compared to chickpea yields as observed in maize-chickpea sequential system.

3.1.3. Sorghum-chickpea sequential system:

Propazine at the rate of 1.5 Kg ai/ha was used as sorghum herbicide as atrazine caused some phytotoxicity during earlier years. Propazine performed very well on sorghum and the yields obtained were almost on par with those obtained through weed free treatment. However propazine just as any triazine herbicide, seemed to have some residual effect on chickpea planted after sorghum harvest (table 17 and fig. 55). Though chickpea yields were in general poor because of the failure of late rains, propazine probably caused some phytotoxicity thus resulting in very poor chickpea yields. Chickpea after sorghum in general is not a feasible system because of ratoonability of sorghum. The net returns shown in table 17 indicate overall smother cropping system with cowpea performed better than all other systems inspite of obtaining lesser chickpea yields. The net returns obtained with sorghum/pigeonpea system were however better than sorghum-chickpea system because mainly of poor chickpea yields. The trends in yield losses due to weeds however is almost similar to sorghum/pigeonpea system.

A similar type of operational trial was also conducted on sorghum on Alfisols. The results are presented in table 18 and fig. 56. Propazine seemed to have caused some phytotoxicity to sorghum on Alfisols. Though the sorghum yield levels on Alfisols resemble those on Vertisols the weed free and 2 hand weeding treatments yielded very high and one hand weeding system performed very poor. Among the smother crops cowpea yielded better because of disease problem on mung which ultimately yielded very low.

Table 16: Effect of different weed management systems on the net productivity of sorghum/pigeonpea intercropping system, Vertisols, 1980-81.

Treatment	Kharif			Rabi		Total returns Rs/ha	Opera-tional cost Rs/ha	Net returns Rs/ha
	Sorghum yield kg/ha	Smother	Return Rs/ha	Pigeonpea kg/ha	Return Rs/ha			
Hand weeding system	2995		2246	749	1947	4194	320	3874
Herbicide system	3080		231[illegible]	936	2434	4744	470	4274
Smother system								
Mung	2676	105	2322	886	2304	4626	360	4266
Cowpea	2934	171	2714	735	1911	4625	360	4265
Weed free	3841		2881	1143	2972	5853	640	5213
Weedy check	1699		1274	654	1700	2974	-	2974

Monetary values considered:

Sorghum	: Rs. 75/q	Hand weeding	: Rs. 160/ha
Pigeonpea	: Rs. 260/q	Herbicide	: Rs. 150/ha
Cowpea/Mung	: Rs. 300/q	Smother crop seed	: Rs. 40/ha

1 Hand weeding system
2 Herbicide system - Fluchloralin 1 kg ai/ha
3 Smother system-Mung
4 Smother system-Cowpea
5 Weed free
6 Weedy check

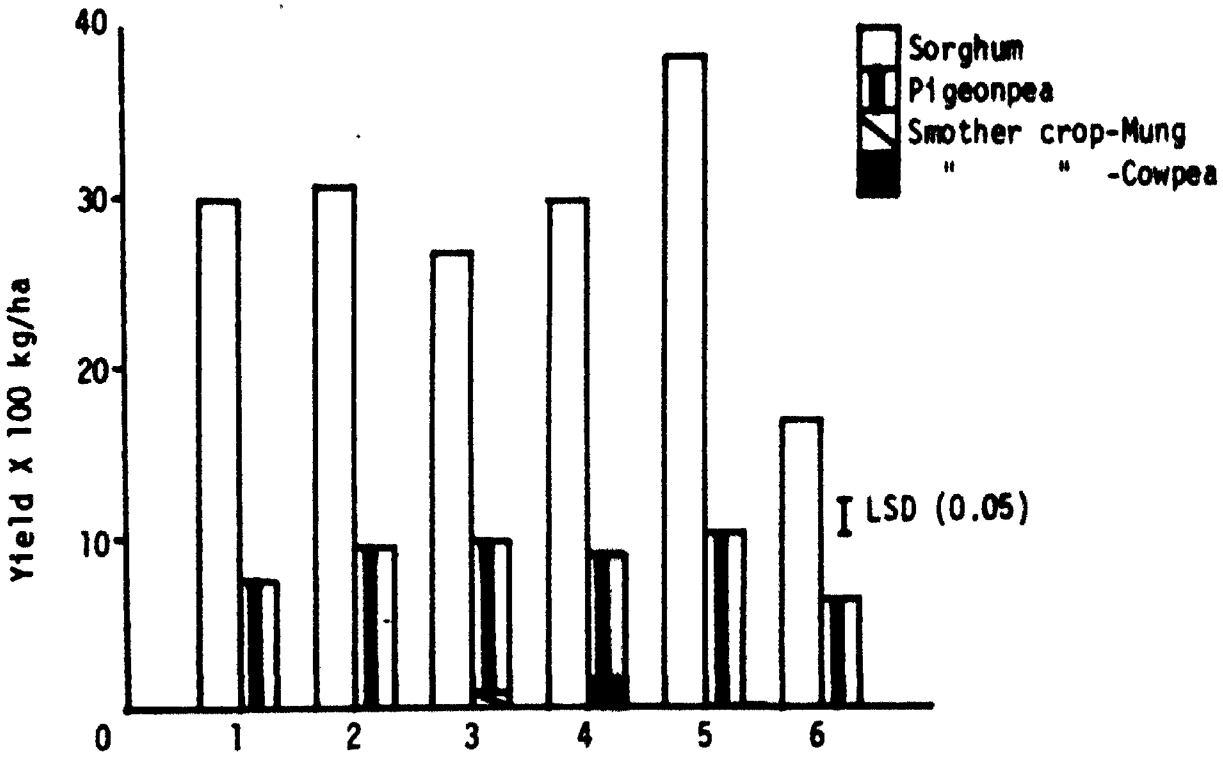

Fig. 54. EFFECT OF DIFFERENT WEED MANAGEMENT SYSTEMS ON THE PRODUCTIVITY OF SORGHUM/PIGEONPEA INTERCROP SYSTEMS, VERTISOLS, 1980-81.

Table 17: Effect of different weed management systems on the net productivity of sorghum-chickpea sequential cropping system, Vertisols, 1980-81.

Treatments	Kharif			Rabi		Total Returns Rs/ha	Opera-tional cost Rs/ha	Net returns Rs/ha
	Sorghum yield kg/ha	Smother	Return Rs/ha	Chickpea kg/ha	Return Rs/ha			
Hand weeding system	3586		2690	236	649	3339	320	3019
Herbicide system	4208		3156	61	168	3324	450	2874
Smother system								
Mung	3088	121	2679	139	382	3061	360	2701
Cowpea	3785	144	3271	169	465	3736	360	3376
Weed free	4790		3593	364	1001	4594	640	3954
Weedy check	1789		1342	194	534	1976	-	1876

Monetary values considered:

Sorghum	: Rs. 75/q	Hand weeding	: Rs. 160/ha
Chickpea	: Rs. 260/q	Herbicide	: Rs. 130/ha
Cowpea/Mung	: Rs. 300/q	Smother crop seed	: Rs. 40/ha

1 Hand weeding system
2 Herbicide system + 1 HW
3 Smother system - mung + HW
4 Smother system - cowpea + HW
5 Weed free
6 Weedy check

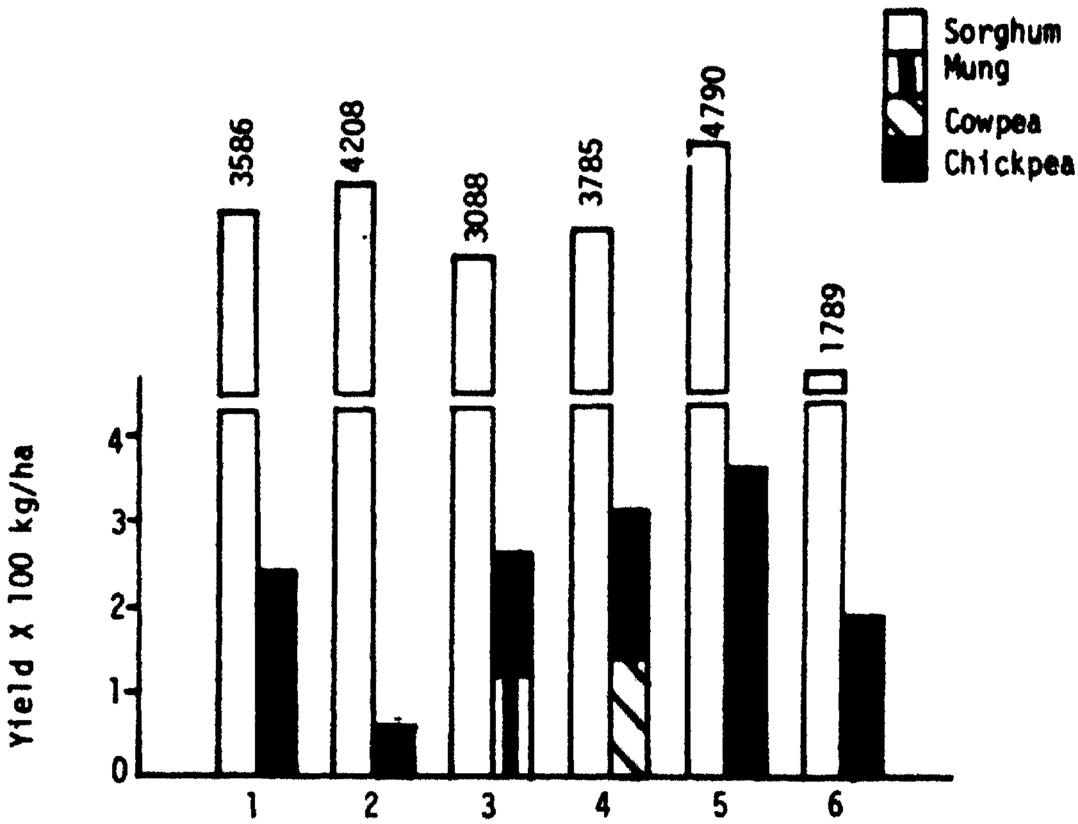

Fig. 55. EFFECT OF DIFFERENT WEED MANAGEMENT SYSTEMS ON THE YIELDS OF SORGHUM-CHICKPEA SEQUENTIAL CROPPING, VERTISOLS, 1908-81.

Table 18: Effect of different weed management systems on the productivity of sole sorghum system, Alfisols, 1980.

Treatments	Sorghum yield kg/ha	Smother crop yield, kg/ha	Weed biomass g/m^2
2 HW 3,6 WAS	5572		166
1 HW 4 WAS	2608		205.9
Smother, mung + 1 HW	3422	90	72.1
Smother, cowpea + 1 HW	3041	294	56.7
Propazine (1 kg a.i./ha)+1 HW + 1 HW	8502		85.4
Weed free	6075		
C.V. %	18.2		13.6
C.D. at 5%	1347		30.0

HW = Hand weeding

WAS = Weeks after sowing

1 2 HW 3,6 WAS
2 HW 4 WAS
3 Smother-Mung + HW
4 Smother-cowpea + HW
5 Propazine 1.0 kg/ha + HW
6 Weed free

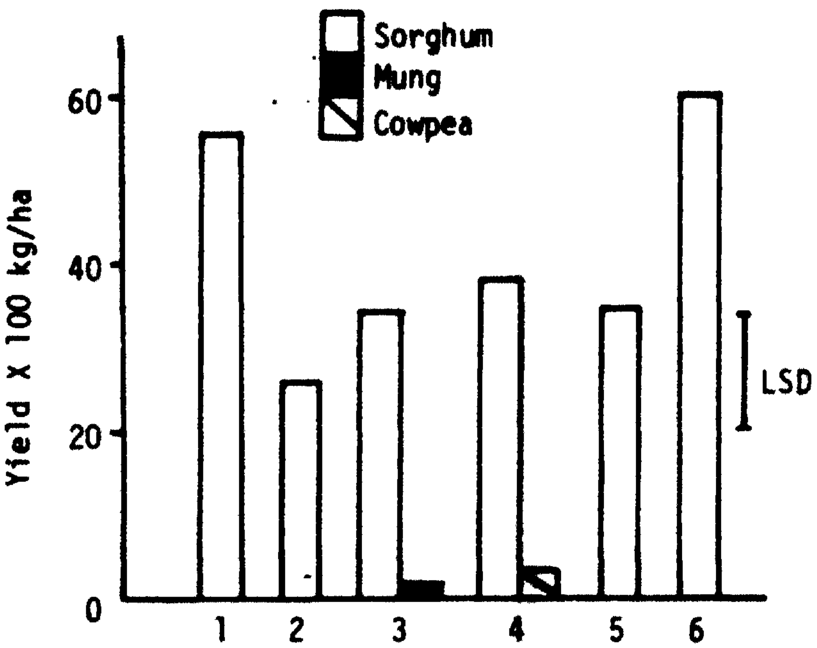

Fig. 56. EFFECT OF DIFFERENT WEED MANAGEMENT SYSTEMS ON THE YIELDS OF SORGHUM, ALFISOLS, 1980.

3.2. Weed management systems for ratoon:

An experiment was conducted in Vertisols to determine the effect of kharif and rabi weed management systems on main crop and ratoone sorghum. The objectives also include the optimum weeding systems for a successful ratoon sorghum. The detailed treatments and the results are presented in table 19 and 20. and fig. 57. Among the kharif treatments on sorghum none of the treatments performed as weed free treatment though 2 hand weedings performed better than propazine and one hand weeding.

The yields of ratoon sorghum varied depending on the kind of kharif weeding system. The weed free treatment resulted in about 24 q/ha of ratoon yield which is about 50% of the main crop yields. Hand weeding immediately after the harvest of main crop resulted as much as 2 hand weedings. One hand weeding after 3 weeks of ratooning did not perform well. No weeding in ratoon sorghum resulted in less than 50% of the weed free yields.

Among the effect of kharif treatments on post rainy ratoon sorghum propazine seemed to have some advantage over other treatments. There were not much differences between the ratoon yields obtained from kharif one hand weeding, 2 hand weeding treatments. Propazine might have helped in early establishment of main crop without much weed competition. There were no substantial interaction effects,as in general, all the individual rabi treatments behaved similarly on all the kharif treatments.

3.3. Effect of row widths and smother cropping:

Field trials were conducted in both Vertisols and Alfisols to evaluate the performance of different smother cropping systems. The treatments also included different sorghum row widths to facilitate the inclusion of additional rows of smother crops with the assumption that increasing row widths do not significantly affect the crop yeidls.

3.3.1. Vertisols:

The detailed treatments and the results are presented in table 21 and fig. 58. Increasing row widths from 45 cm to 90 cm did affect the sorghum yields significantly though the yield reduction were not significant in the case of 67.5 cm row width treatment. Increasing row widths also

Table 19: Effect of different weed management systems on sorghum main crop yields, Vertisols, Kharif 1980.

Treatments	Yield kg/ha	Weed biomass g/m^2
Propazine 1.5 kg a.i/ha	4565	25.3
HW* - 4 WAS**	4357	25.2
2 HW 3,6 WAS	5266	12.9
Weed free	5690	
C.V. %	5.5	16.5
C.D. at 5%	437	6.0

*HW = Hand weeding **WAS = Weeks after sowing

Table 20: The effect of Kharif and rabi weed management systems on the yield of ratoon sorghum (kg/ha), Vertisols, 1980-81.

Postrainy/ Rainy season treatments	Propazine 1.5Kg a.i./ha	HW* 4 WAS**	2 HW 3,6 WAS	Weed free	Mean
HW immediately after harvest	1936	1626	1955	2296	1953
2 HW 0,3 WAR***	2028	1945	1646	2222	1960
HW 3 WAR	1744	1724	1881	2042	1848
Weed free	2389	2329	2326	2546	2398
Weedy check	1030	928	998	1151	1027
Mean	1825	1710	1761	2051	

LSD (0.05) for comparison of weed management treatments - 260 - 260

LSD (0.05) for comparison of rabi weed management treatments means - 178

LSD (0.05) for comaprison of means within groups - 356

LSD (0.05) for comparisons of means cf different groups - 411

*HW = Hand weeding **WAS = Weeks after sowing ***WAR = Weeks after ratooning

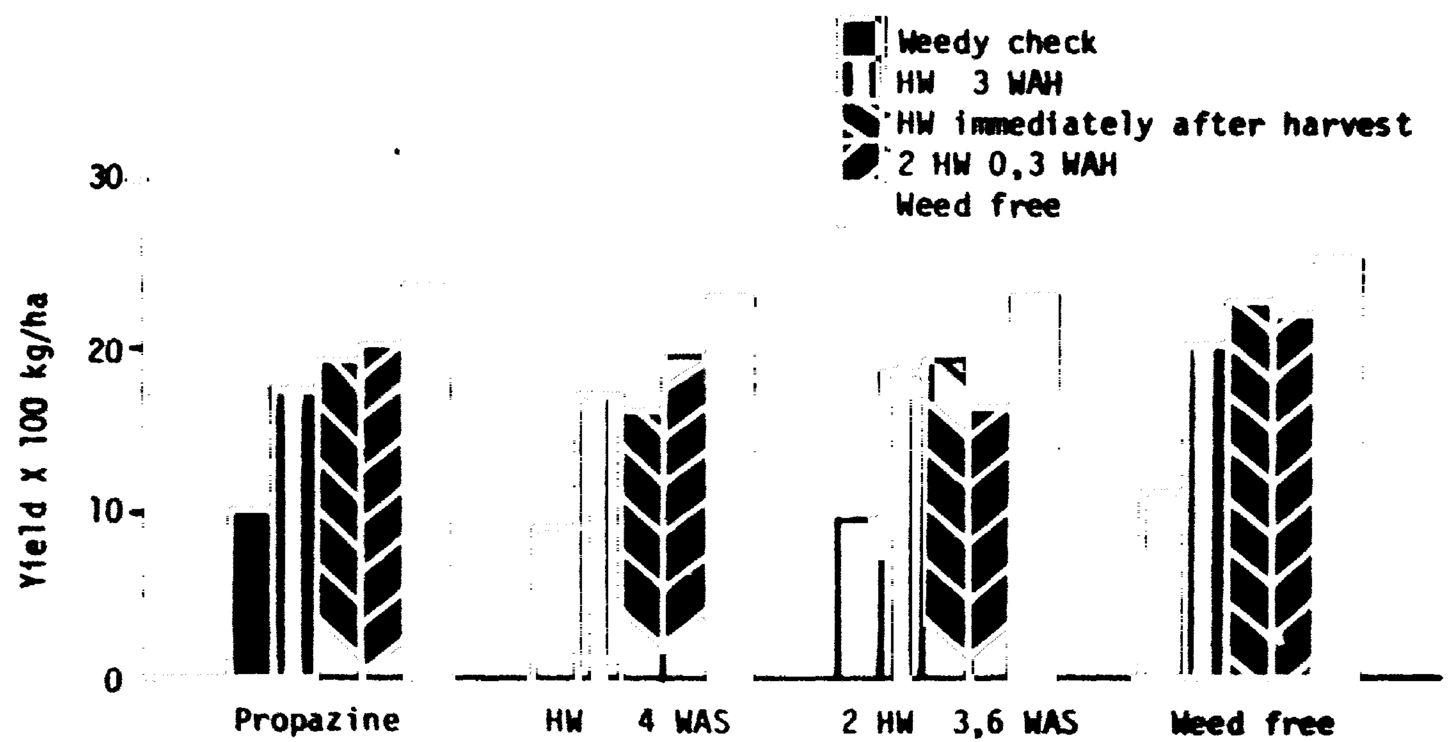

Fig. 57. EFFECT OF KHARIF AND RABI WEED MANAGEMENT SYSTEMS ON THE YIELD OF RATOON SORGHUM, VERTISOLS, 1980-81.

Table 21: Effect of different row widths and smother cropping on the crop yields and weed growth. Vertisols, 1980.

Row width and weed management sy	Sorghum yield kg/ha	Smother crop yield kg/ha (cowpea)	Weed biomass g/m^2
1) 45 cm 2 HW*	4827		162
2) 67.5 cm 2 HW	4519		203
3) 90 cm 2 HW	3473		253
4) 45 cm 1 HW, smother crop (1 row)	3749	525	155
5) 67.5 cm 1 HW, smother crop (1 row)	3306	608	175
6) 90 cm 1 HW, smother crop (2 rows)	2902	869	192
C.V. %	8.3		4.1
C.D. at 5%	478.8		16.1

*HW = Hand weeding

1 45 cm 2 hand weeding
2 67.5 cm 2 hand weeding
3 90 cm 2 hand weeding
4 45 cm smother crop-cowpea + hand weeding
5 67.5 cm smother crop-cowpea + hand weeding
6 90 cm smother crop-cowpea + hand weeding

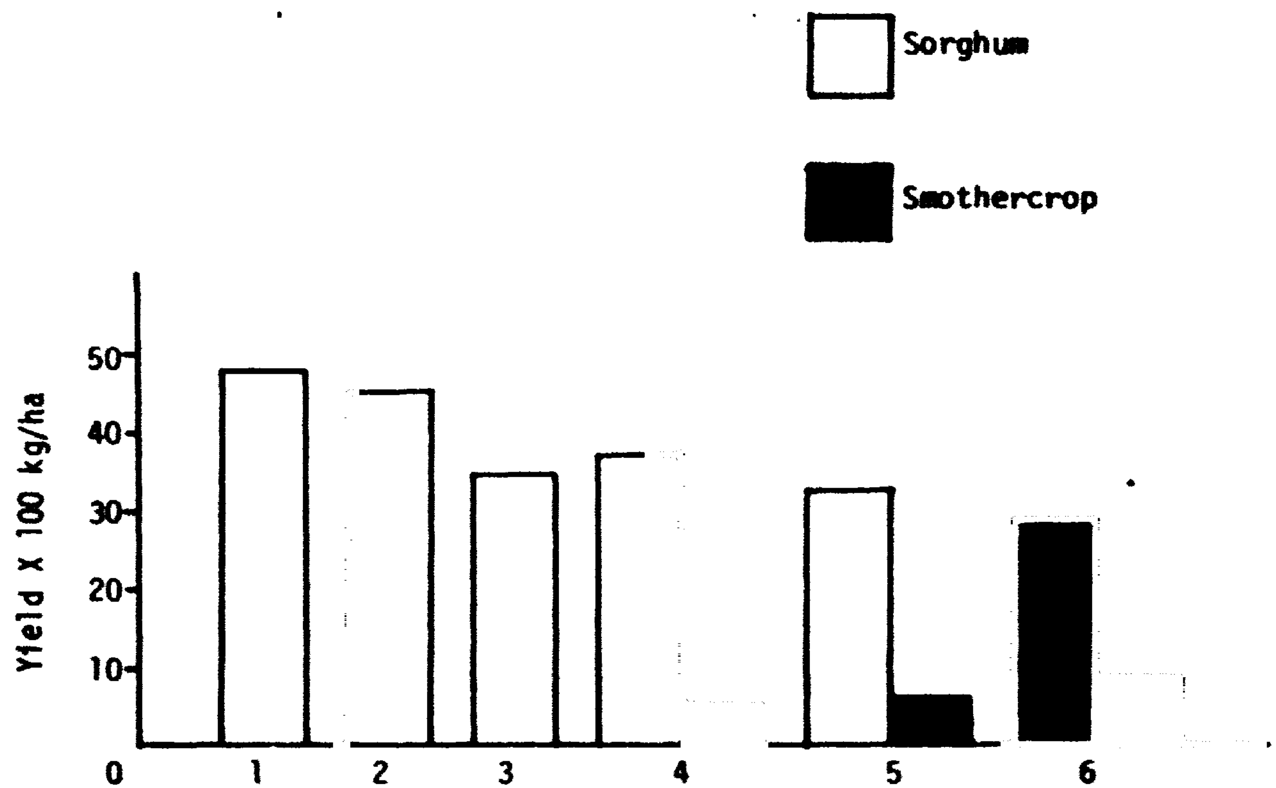

Fig. 58. EFFECT OF ROW WIDTH AND SMOTHER CROPPING ON THE YIELDS OF SORGHUM, VERTISOLS, 1980.

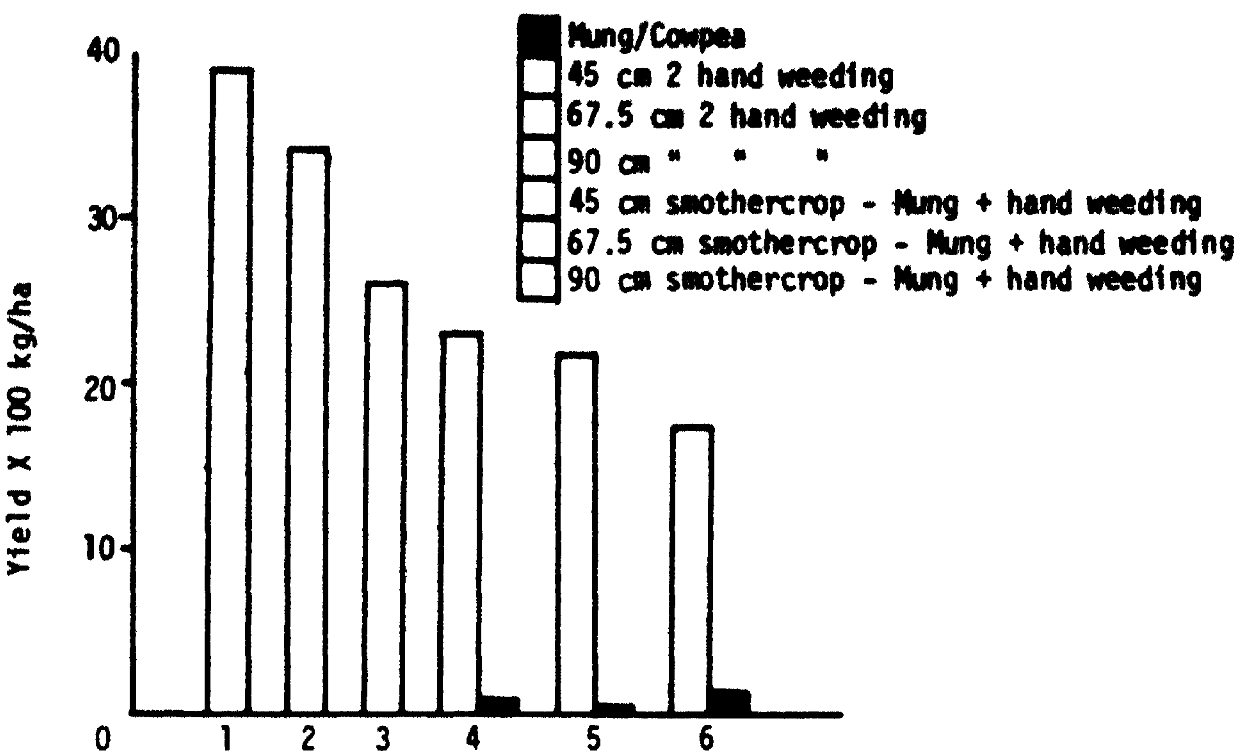

Fig. 59. EFFECT OF DIFFERENT ROW WIDTH AND SMOTHER CROPPING ON THE YIELDS OF SORGHUM, ALFISOLS, 1980.

increased weed growth in between the crop rows. When we introduced smother crops and at the same time reduced the 2 hand weedings to only one hand weeding, there were significant reduction in sorghum yields. However smother crop yields of 500 to 850 kg of high value cowpea grains have compensated this main crop yield loss. The yield loss was again significant when the row widths were increased to 90 cm. But the cowpea yields (869 kg) obtained with this treatment was also substantial. The results indicate that the row widths can be increased without significant yield losses only upto 67.5 cm and the additional smother crop yields can be obtained with only one hand weeding without losing the overall productivity even with 90 cm row spacings. Widening the crop rows did facilitate inclusion of additional smother crops and thus reducing the cost of hand weeding and increasing the overall productivity of the system.

3.3.2. Alfisols:

The yield levels in general were poor in Alfisols but the trends in yield reduction with wider sorghum rows was similar to that in Vertisols (table 22 and fig. 59). There was some difficulty in establishing good crop stands early in the season because of shoot fly incidence. There was significant yield loss when the crop rows were increased from 45 cm to 90 cm. This resulted in more weed reduction in hand weedings and introduction of additional crops resulted in substantial yield loss. The smother crop yields were very poor and did not help in productivity compensations. However the trial indicated the similar trend as far as yield reduction in wider rows are concerned.

3.4. Utilization of Weeds as fodder:

To evaluate the effect of sorghum row widths on the incidence of weeds and to explore the possibility of utilising weeds as forage two trials one each in Alfisols and Vertisols were conducted in the cropping season of 1980. The detailed treatments and results are presented in table 23 and 24.

As seen from the table 23 weed infestation was more severe in Vertisols. As the row width of sorghum was increased from 45 cm to 90 cm there were no significant yield loss of sorghum in weed free treatment. But sorghum yields were reduced as the row widths were increased in treatments of only intra row weed control and allowing the inter row weeds to

Table 22: Effect of different row widths and smother cropping on the crop yields and weed growth. Alfisols, 1989.

Row width and weed management system	Sorghum yield kg/ha	Smother crop yield kg/ha (mungbean)	Weed biomass g/m^2
1) 45 cm 2 HW*	3990		35.6
2) 67.5 cm 2 HW	3441		78.0
3) 90 cm 2 HW	2562		96.0
4) 45 cm 1 HW smother crop (1 row)	2322	79	88.2
5) 67.5 cm 1 HW smother crop (1 row)	2210	59	236.1
6) 90 cm 1 HW smother crop (2 rows)	1749	134	150.2
C.V. %	15.9		15.4
C.D. at 5%	649.8		26.5

*Hand Weeding

Table 23: Effect of inter and intra-row weeds on the yield of sorghum and forage production, Vertisols, 1980.

Treatments	Sorghum yield kg/ha	Forage kg/ha	Weed dry matter at sorghum harvest g/m^2
1) 45 cm weed free	5508	-	-
2) 45 cm, intra-row weed control	4150	9507	35.5
3) 67.5 cm, weed free	5025	-	-
4) 67.5 cm, intra-row weed control	3675	12550	71.25
5) 67.5 cm, inter-row weed control	4425	-	32.0
6) 90 cm, weed free	5425	-	-
7) 90 cm, intra row-weed control	335	22750	122.5
8) 90 cm, inter-row weed contsol	4275	-	88.7
C.V. %	18	13	19
C.D. at 5%	1040	3880	11.1

Table 24: Effect of inter and intra row weeds on the yield of sorghum and forage production, Alfisols, 1980.

Treatments	Sorghum yield kg/ha	Forage kg/ha	Weed dry matter g/m²
1) 45 cm, Weed free	3100		
2) 45 cm, intra-row weed control	1675	6325	25.2
3) 67.5 cm, weed free	3175		
4) 67.5 cm, intra-row weed control	1200	9200	46.5
5) 67.5 cm, inter-row weed control	1900		22.5
6) 90 cm, weed free	2825		
7) 90 cm, intra-row weed control	1300	12350	72.5
8) 90 cm, inter-row weed control	1925	-	25.5
C.V. %	10	11	17
C.D. at 5%	445	1933	10.6

grow as fodder. However, increasing the row widths facilitated more forage growth. Though we did not work out the total productivity of the system there seems to be some logic in farmer's practice of growing weeds as fodder. In inter row weed control treatments however there was no significant yield reduction as the row width of sorghum was increased up to 90 cm. In Vertisols, the major weed flora comprised of Brachiaria eruciformis, Dinebra retroflexa, Digitaria ciliaris the grasses, and Merremia emarginata, Tridax procumbens the dicots. Among these weeds cattle relish more of grasses like Brachiaria, Digitaria and Dinebra.

In Alfisols, in general the crop stand was poor and the plant population of sorghum could not be maintained due to variation in fertility levels and pest incidence. As shown in table 24 there was not significant yield reduction in weed free sorghum when planted in 45 to 67.5 cm row widths. However, as in Vertisols in intra row control treatments, there was yield reduction as row widths were increased. Forage yields were also increased as the row widths were increased. The total productivity of sorghum grain and forage yields however were not computed. In inter row weed control treatments there was no significant yield loss as row width was increased from 67.5 to 90 cm.

In Alfisols the major weed flora consisted of Celosia argentea, Digitaria ciliaris, Dactyloctenium aegyptium and Tridax procumbens. Among these weeds only Digitaria and Dactyloctenium have good forage value. But Celosia in early stages was acceptable to cattle.

These trials indicated possibility of utilizing weeds as fodder which of course is the traditional practice by the farmer. The exact nature of competition between these weeds (fodder) and the main crops needs to be quantified. It is also worth quantifying the total productivity of the crops and the fodder obtained.

4. Future plans on weed research:

During the past six years the emphasis in Weed Research has been on studying the major factors operating in crop-weed balance of the semi-arid tropics and the evaluation of different weed management systems on the major crops and cropping systems of the rainfed farming. The losses due to weeds in the semi-arid tropics were also documented. Future weed research will involve minimum studies on determining crop losses due to weeds.

ICRISAT weed science program has a responsibility to serve all the research programs at ICRISAT. There will be clear distinction between weed control methods appropriate to the needs of the small farmer of the semi-arid tropics and those appropriate to the needs of a crop improvement research programs. Close interaction with indvidual crop improvement programs to determine the problem and needs in weed control and to provide necessary back up information and research to solve those problems will be anticipated.

Weed research on farming systems will be designed to specifically determine effects on weeds or to study the ability to control weeds in a given farming system. In planning the operational research in the ICRISAT watersheds long term studies on the specific effect of the farming systems on the weeds will be considered. Collaborative studies with Farm Power and Equipment and Land and Water Management subprograms to develop appropriate tools and cultural operations vis-a-vis weed control will be intensified. Herbicide studies will be confined to improve the overall productivity of a farming systems and to control difficult to manage weeds - perennial weeds. Studies related to weed biology and ecology should be initiated particularly on perennial weeds.

Weed management studies on farmers' fields - both diagnostic and testing type of studies - will receive greater emphasis in the near future,

III. FARMING SYSTEMS OPERATIONAL RESEARCH:

The Production Agronomy-Agronomy and Weed Science subprogram actively participated in the Operational research activity of the Farming System Research Program. A considerable portion of the subprogram resources - including personnel was committed to providing operational research support services to other subprograms. The overall management of about 100 ha of oeprational research watersheds was also entrusted to the subprogram. Further, some of the staff members were involved in FS1 and FS2 ICAR-ICRISAT cooperative experiments at the ICRISAT Center. The detailed results on the FSRP operational research are being reported by other individual subprograms of FSRP and therefore not included in this report.

APPENDIX - I

REPORTS/PUBLICATIONS (1976 to 1980)

Agronomy and Weed Science. Report of Work. 1976, 1977, 1978, 1979, 1980. Farming Systems Research Program, ICRISAT, Hyderabad, India.

On-farm Research

Kampen, J. 1980. ICRISAT's involvement in cooperative on-farm research. A brief report prepared for a meeting of ICRISAT's research program and Technology Transfer Committees. March 1980. ICRISAT, Hyderabad, 13 p. (Mimeo)

Kampen, J. 1980. ICAR-ICRISAT cooperative research projects at ICRISAT and On-farms. An informal report, March 1980. ICRISAT, Hyderabad: 51-63. (Mimeo)

Shetty, S.V.R. 1980. ICAR - Ag. Univ. - ICRISAT collaborative on-farm research on Farming Systems - Project outline, 1980-81. A general document prepared for interested colleagues. Aug. 1980. ICRISAT, Hyderabad, 7 p. (mimeo)

Shetty, S.V.R. and Virmani, S.M. 1980. ICAR-ICRISAT collaborative on-farm research on Farming Systems. FS-4, A brief report prepared for the ICAR-ICRISAT Policy Committee meeting. ICAR, New Delhi. Oct, 1980, P. 5 (Mimeo)

Shetty, S.V.R. 1981. A report on the ICAR-ICRISAT collaborative on-farm research on Farming Systems. A preliminary report presented at working group meeting on the ICAR-ICRISAT collaborative projects on Farming Systems, AICRPDA, Hyderabad. March 17-19, 1981, 34 p. (Mimeo)

Weed Management Research

Binswanger, H.P. and S.V.R. Shetty, 1977. Economic aspects of Weed Control in semi-arid tropical areas of India. Proc. weed sci. conf. 1977. Ind. Soc. weed sci. APAU, Hyderabad, India, p. 75-91.

Davies, E.L.P. 1978. The potential for introducing improved weed control methods to small farmer of the Indian semi-arid tropics. A dissertation submitted for Master of Agricultural Science (Tropical Agricultural development) at Univ. of Reading. Reading, U.K., p. 86.

Kanwar, J.S. 1978. Weed research in India - Whither! Valedictory address delivered at the 1978. Ann. Conf. of Ind. Sco. Weed Sci. Coimbatore, Feb. 3-5, 15 p.

Krantz, B.A. 1978. Weed management research in the semi-arid tropics. Key note address delivered at the 1978 Ann. conf. of Ind. soc. weed sci. Coimbatore, Feb. 3-5, p. 10.

Moody, K. and S.V.R. Shetty, 1979. Weed management in intercropping systems. Paper presented at the international workshop on intercropping, ICRISAT, Hyderabad, India. Jan. 10-13, p. 30.

Rao, M.R. and S.V.R. Shetty, 1976. Some biological aspects of intercropping systems on crop-weed balance. Ind. J. Weed Sci. 8:32-34.

Shetty, S.V.R. 1976. Possible approaches to weed management in sorghum. Pesticides Information, 2(3):72-80.

Shetty, S.V.R. 1977. Multicrop herbicide screening - Preliminary evaluation on major semi-arid tropical crops, Proc. Weed Sci. Conf. 1977. Ind. Soc. Weed. Sci. APAU, Hyderabad, India. p. 240-241.

Shetty, S.V.R. 1978. Some observations on weed intensity and crop management systems, in Environ. Physiol. Ecol. Plants. p. 145-155. ed. D.N. Sen and R.P. Bansal, Dehradun, India.

Shetty, S.V.R. 1979. Weed control in sorghum in the tropics. Paper presented at the 10th Ann. Meeting. Weed Sci. Soc. Philip. Manila, May 3-6, p. 14.

Shetty, S.V.R. and B.A. Krantz. 1980. Weed research at ICRISAT. Weed Sci. 28(4):451-456.

Shetty, S.V.R. and A.N. Rao. 1979. Weed Management studies in sorghum/pigeonpea and pearlmillet/groundnut intercrop systems - some observations. Paper presented at the international workshop on intercropping. ICRISAT, Hyderabad, India, 10-13, Jan. 15 p.

Shetty, S.V.R. and M.R. Rao. 1977. Weed management studies in pigeonpea based intercropping. Paper presented at the 6th Asian Pacific Weed Science Society Conference, Jakarta, Indonesia, July 11-17, 25 p. In Proc: Pages 655-672.

Shetty, S.V.R., B.A. Krantz, and S.R. Obein. 1977. Weed research needs of the small farmers. Proc. of Weed Sci. Conf., Ind. Soc. Weed Sci., APAU, Hyderabad, India. p. 47-60.

Shetty, S.V.R. 1979. Approaches to integrated weed management in maize and sorghum in tropical and subtropical areas. In pages 87-93 of Proc. 7th Asian Pacific Weed Sci. Soc. Conf. 1979. Sydney, Australia.

Shetty, S.V.R. 1980. Some agro-economical aspects of improved weed management systems in Indian semi-arid tropics. In pages 899-909 of Proc. 1980. British Crop Protection Conference - Weeds, Brighton, U.K.

Shetty, S.V.R. and R.K. Maiti. 1978. Preliminary observations on the root system of some tropical dicotyledonous weeds. Ind. J. Weed Sci. 10 (1 & 2):41-49.

Shetty, S.V.R, 1976. Principles of weed management with particular reference to semi-arid tropical agriculture. Paper presented at DPAP Conference. ICRISAT, Hyderabad, 21 p. (Mimeo).

Shetty, S.V.R. 1980. Approaches to integrated weed management in sorghum and pearlmillet, Lecture delivered at training program for plant protection specialists, Aug, 1980, CPPTI, Hyderabad, 9 p. (Mimeo).

Shetty, S.V.R. and A.N. Rao. 1980. Weed research methodology in cropping systems research. Paper presented at the Annual conference of the Indian Society of Weed Science. July, 1980. Bhubaneshwar, Orissa. 12 p. (Mimeo).

Shetty, S.V.R. and Krantz, B.A. 1980. Approaches to weed management research for the semi-arid tropics. In I.O. Akobondu Ed. Weeds and their control in the humid and subhumid tropics. p. 115-125. IITA, Ibadan, Nigeria.

Shetty, S.V.R. 1980. Some aspects of weed management in pigeonpea. Paper presented at the International Workshop on Pigeonpeas. Dec. 15-19, 1980. ICRISAT, Hyderabad, 20 p. (Proceedings in press).

Shetty, S.V.R., M.V.K. Sivakumar and S.A. Ram. 1981. The effect of shading on the growth of some common weeds of the semi-arid tropics. Agron. J (In press).