Concluding project report
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ON-FARM TESTING OF IMPROVED VERTISOL MANAGEMENT TECHNOLOGY AT BEGUMGANJ IN RAISEN DISTRICT OF MADHYA PRADESH

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SYMBOLS AND ABBREVIATIONS

IVMT	Improved Vertisol Management Technology
BBF	Broadbed-and-Furrow
FOF	Furrow on Flat
FOG	Furrow on Grade
WTC	Wheeled Tool Carrier
DAP	Diammonium phosphate
M.P.	Madhya Pradesh
	Sequential cropping system
/	Intercropping system

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Mr. R.K. Nigam	Dy. Director, Bhopal	Initiation - April 1985
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ACKNOWLEDGEMENT

Our sincere thanks are due to Dr. S.M. Virmani for constant encouragement and solving the various administrative and technical problems encountered in the initiation of the project. We wish to thank Drs. M.S. Reddy, G.M. Heinrich and M/s. G.E. Thierstein, R.K. Bansal, K.L. Srivastava for their advice and guidance during initial stages of the project. We gratefully acknowledge the help and assistance from Dr. A.K.S. Huda for supplying the necessary agroclimatic information and its critical analysis; and Dr. Sardar Singh for providing the information on soil characteristics and properties. Also the help of Mr. K.G. Kshirsagar is greatly appreciated for economic analysis of the inputs and the profits under different systems. Mr. T.P. Ravindran, Secretary, deserves our special mention for his help and cooperation in the preparation of this report.

We wish to record our appreciation and thanks to the officials of the Department of Agriculture, Madhya Pradesh for their willing and able assistance to the project, both for carrying out the activities and for supplying necessary information and material.

The farmers of the village of course deserve our sincere thanks for their enthusiasm and willing participation without which it would have not been possible to implement the project.

R.D. Sangle
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November 1985

ON-FARM TESTING OF IMPROVED VERTISOL MANAGEMENT TECHNOLOGY AT HOSHANGABAD IN RAISEN DISTRICT OF MADHYA PRADESH

R.D. Sangle and D. Sharma

INTRODUCTION

Madhya Pradesh, the heartland of India, is endowed with 7 million hectares of deep Vertisols out of a total of 12 million hectares located in the dependable high rainfall (750 mm and above) region of the country (Fig. 1) (Ryan et al. 1982). The available soil moisture and the distribution of the evapotranspirational demands in this region in contrast with the Vertisol areas of the peninsular India (Fig. 2 and Table 1) indicate that it has the highest potential for increasing crop production under rainfed conditions.

Table 1. Rainfall (P), Potential Evapotranspiration (PE) and Moisture Availability Index (MAI) for the four locations representing Madhya Pradesh, Maharashtra, Karnataka, and Andhra Pradesh.

Location	State	Rainfall (mm)	Potential Evapo-transpiration (PE)	Moisture Availa-bility Index (MAI)
Bhopal	Madhya Pradesh	1282	1554	0.82
Akola	Maharashtra	876	1729	0.50
Gulbarga	Karnataka	753	1912	0.39
Hyderabad	Andhra Pradesh	764	1757	0.43

Source: Virmani, et al. 1982. Rainfall probability estimates for selected locations of semi-arid India. Research Bulletin No.1 2nd Ed. (enlarged).

However, the traditional practice of large scale rainy season fallowing to avoid excessive soil moisture conditions and the associated soil structural problems (very sticky and difficult to work when wet and hard when dry) utilizes only 39% of the available soil moisture (El-Swaify et al. 1985) as a crop is being raised on the residual soil moisture which is often limiting. Also in absence of a crop canopy the fallow lands are exposed to heavy runoff and soil loss during high intensity rainfall.

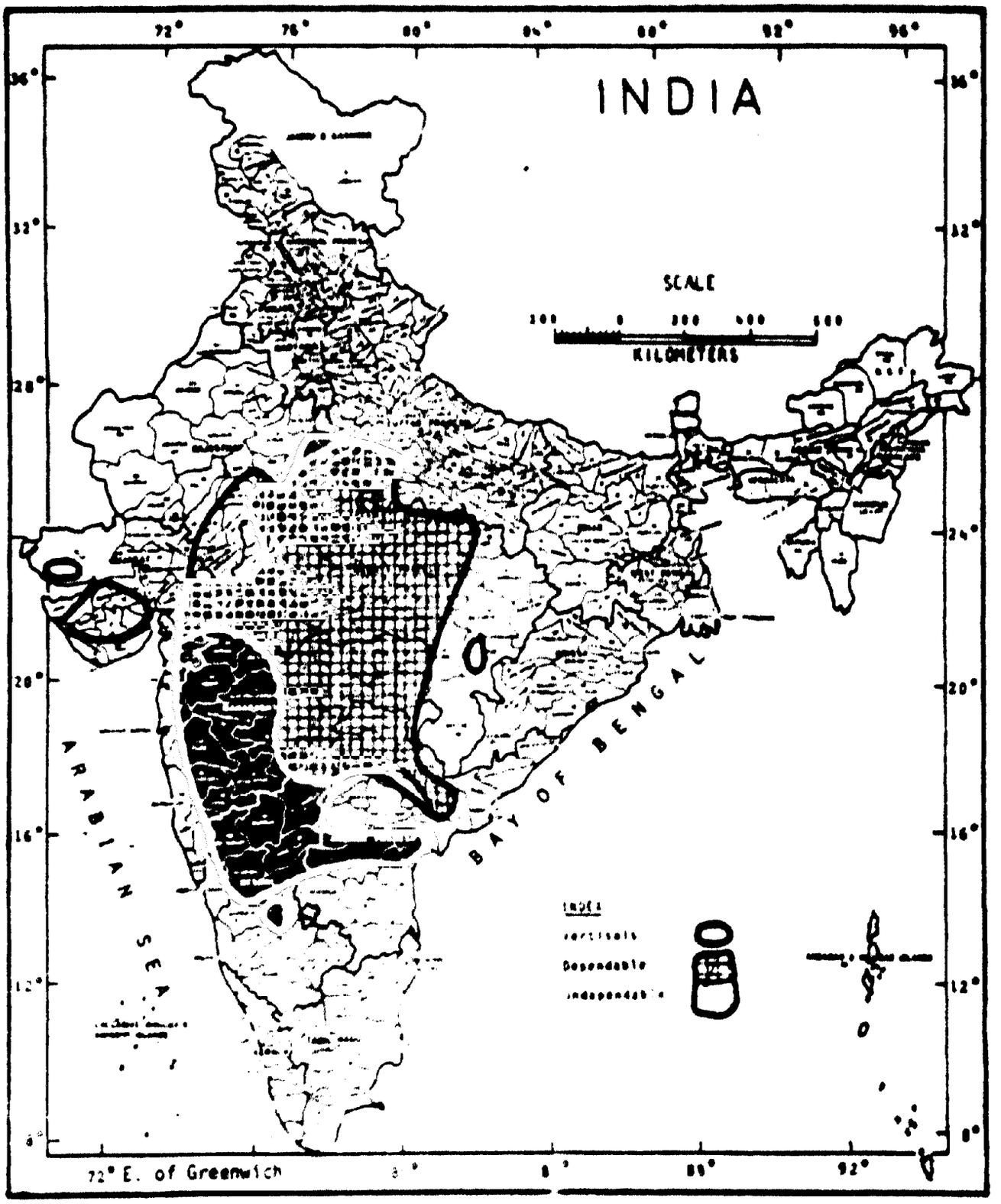


Figure 1 . The Vertisol areas of India where rainfall is dependable and undependable.

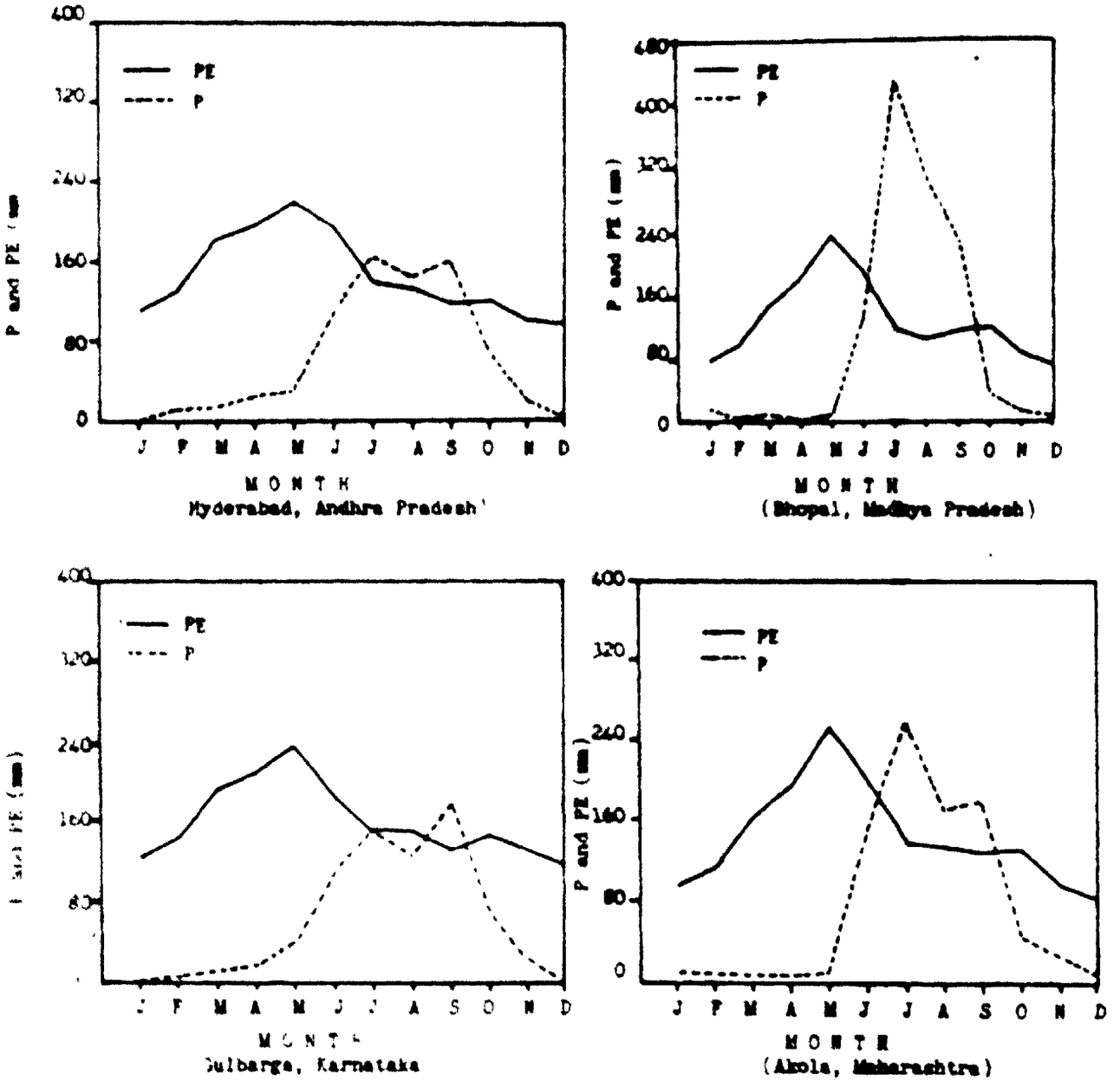


Fig. 2: Average monthly rainfall P' and Potential Evapotranspiration (PE) at four locations in Vertisol areas of the peninsular India.

The existing practices of raising a monsoon season crop in Vertisols based on local crops and crop varieties, bullock drawn traditional implements and cultivation practices, have area specific application as the extent of monsoon cropping in the different Vertisol districts ranges from 35-19 percent (Table 2). Moreover, it suffers from practical operational difficulties in covering the major portion of particularly large land holdings in a short time available at the beginning of the season and high risk due to waterlogging from excessive rains.

Table 2. Areas with high Potential for Improved Vertisol Management Technology in Madhya Pradesh.

Some dependable rainfall districts	Average area of rainy season fallow	Rainy season fallow as percentage of net sown area
1. Raisen	319 000	81
2. Vidisha	382 000	77
3. Sagar	355 000	70
4. Damoh	164 000	59
5. Jabalpur	299 000	50
6. Indore	114 000	45
7. Narsinghpur	173 000	64

Source: Ryan, J.G. and Sarin, R. ICRISAT. Improving the ıgement of India's Black Soil, May 1981.

ICRISAT Farming Systems Research Program has been working since 1975 to develop an improved Vertisol management technology based on land and water management practices ensuring optimum infiltration of rain water, adequate field surface drainage, utilization of available soil moisture through intercropping of a short duration and a long duration crop sequential double cropping and use of improved farm machinery.

The watershed based operational research at ICRISAT Centre that crops can be successfully grown both in rainy and postrainy season on deep Vertisols by undertaking the following operations.

- Cultivating the land immediately after harvesting of the postrainy season crop when the soil still contains some moisture and is not too hard.
- Improved drainage with the aid of field ity channels and the use of broadbed-and-furrows.
- Dry seeding of crops before monsoon rains commence.
- Use of improved seed and right level of fertiliser.
- Appropriate cropping system and row arrangement.
- Improved placement of seed and fertiliser for better crop-stand.
- Improved plant protection methods particularly for leguminous crops.

In 1981, this integrated package of technology was tried in an on-farm situation in Taddanpally village of Medak district in Andhra Pradesh. The first year's results showed that the yields of rainy season hybrid sorghum as an intercrop were about 2000 kg/ha; those of intercrop maize 1600 kg/ha and sole crop of maize yielded 2300 kg/ha. The traditional postrainy season sorghum yielded only 700 kg/ha after fallow. In general production and profits were markedly higher under the improved technology and an average marginal rate of return of 244% was obtained on an additional expenditure of Rs.580/ha (Ryan et al. 1982).

These highly encouraging results in the farmers fields at Taddanpally prompted that the improved Vertisol management technology should be tried in the farmers fields in Madhya Pradesh, where the potential for its use is maximum. Consequently in 1982 a collaborative project between the Department of Agriculture, Madhya Pradesh and ICRISAT was initiated at the village Begumganj in Raisen district with the following objectives:

1. To test the Vertisol management technology and try to adapt it to conditions in Madhya Pradesh.

2. To help in transferring system management capability to the Department of Agriculture, Madhya Pradesh.

3. To get feedback from farmers on their perception of the management system.

This report summarizes the results and observations obtained during the three years of the project.

BACKGROUND INFORMATION

Begumganj town is a Tehsil (sub-divisional headquarter) headquarter in District Raisen. It is located on Bhopal-Jabalpur highway at a distance of 125 kms from Bhopal, the capital city of Madhya Pradesh and 80 kms from Raisen. Begumganj has a population of 16036 and the town has the facilities of a Government hospital and a degree college.

Climate:

The maximum and minimum temperatures range between 45°C to 4°C with possibility of frosty conditions sometimes. The average rainfall is around 1393 mm which covers about 90% of potential evapotranspiration (PE) of 1542 mm and exhibits ustic soil moisture regime. The weekly rainfall distribution and the rainfall probabilities (Fig. 3) indicate that Begumganj has dependable rainfall distribution during rainy season. Figure 4 shows that at 100% probability Begumganj will have 743 or more rainfall in all the years. The P/PE value at Begumganj is >0.90 against the required minimum of 0.34 reported by Hargreaves (1975) to meet the water requirements of the dryland crops.

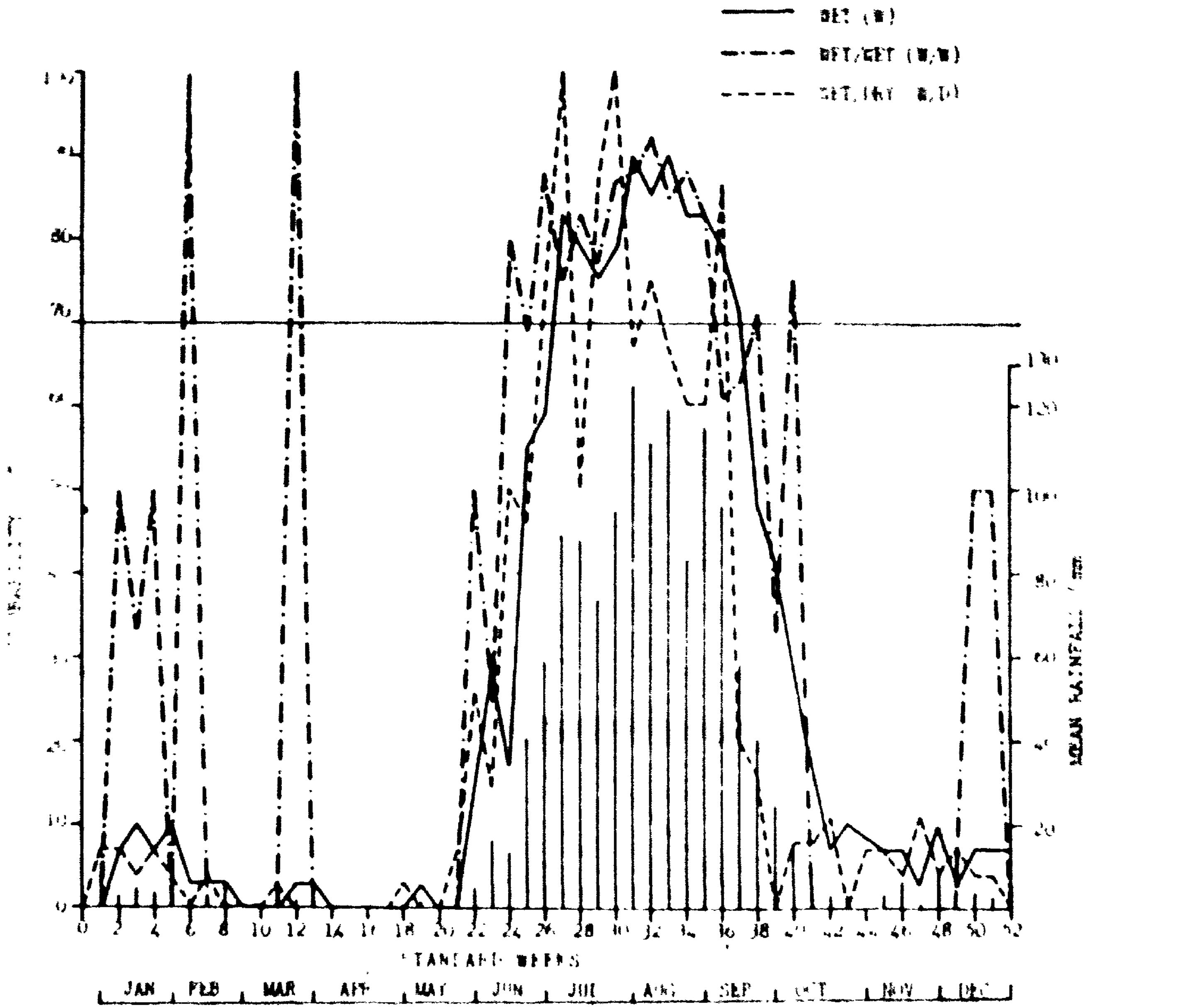


Fig. 3: Initial (W) and conditional probabilities ≥20mm of rainfall when preceded by wet week (W/W), a dry week (W/D) and mean weekly rainfall in [illegible], M.P. ([illegible] except [illegible])

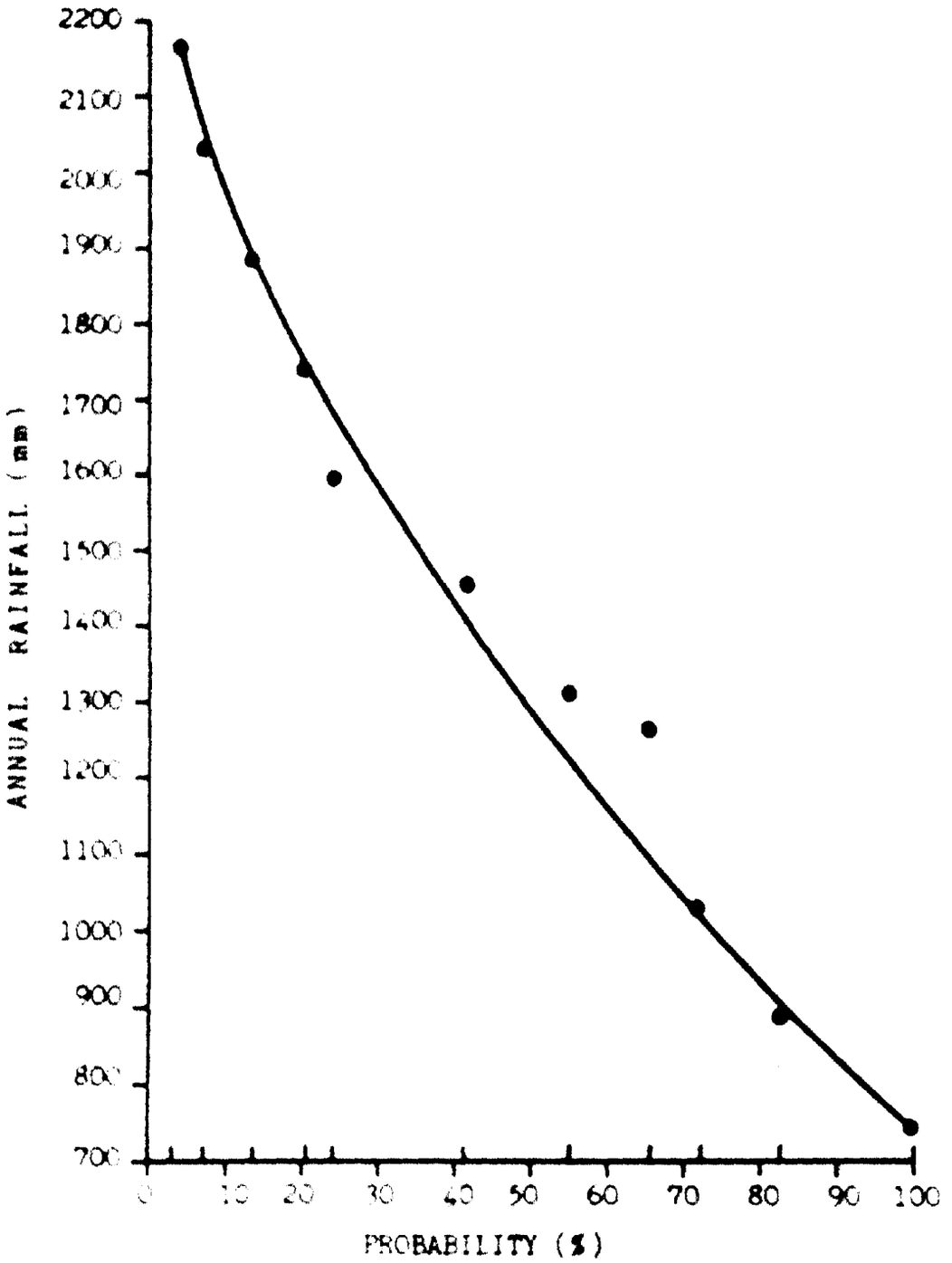


Fig. 4: Annual rainfall and probability curve (years 1953-82, except 1960) - Begumganj, Madhya Pradesh

Soils are deep Vertisols with level to very gentle sloping piedmont and moderately well drained characteristics. The detailed soil characteristics are given in Table 3. As such the soils are low in phosphorus and organic carbon and medium in potash and calcium and are mostly neutral to mildly alkaline in reaction (pH 7.4-8.00) throughout the profile. Clay content varies from 48.6 to 59.3% and has an increasing trend with depth. Bulk density varies from 1.81 to 1.99 with the depth, which indicates more compactness of soil in sub-surface horizon, relatively low saturated hydraulic conductivities in sub-soil layers, and poor root zone aeration*. The detailed analytical data of ganj soil is given in Table 4.

Table 3. Important morphological characteristics of the soil in Begumganj, M.P.

Soil Characteristics	
1. Physiography	Level to very gently sloping piedmont
2. Pedon characteristics	Very deep soils (120-150 cm) grayish brown to dark grayish brown clayey A horizon, underlain by dark grayish brown clayey substrata with coarse intersecting slickensides breaking to angular blocky pods with shiny pressure faces, grades to clayey C horizon.
3. Effective rooting depth	80-90 cm
4. Drainage	Moderately well drained
5. Permeability	Moderately slow
6. Major soil limitation	Wetness moderate deep subsoil alkalinity
7. Other features	Cracks upto 100 cm
8. Classification in India	Deep black soils
9. Classification U.S. Taxonomy	Fine, montmorillonitic hyperthermic family of Entic Chromustert

Source: Report on the detailed soil survey of village Begumganj, Raisen district, M.P. Agenda No. 1 (National Bureau of Soil Survey and Land Use Planning and ICRISAT Cooperative project, 1983)

* Report on the detailed soil survey of village Begumganj, Raisen district, M.P. Agenda No. 1 (National Bureau of Soil Survey and Land use Planning and ICRISAT Cooperative Project, 1983).

Table 4. Analytical characteristics of Begumganj soils.

Soil series typifying pedon of series abbr. & classification	Horizon	Depth (cm)	Mechanical separates			Organic carbon %	pH 1:2	E.C. mmhos/cm	Bulk density	Extractable bases				C.E.C.
			Sand (2-0.05)	Silt (0.05-0.002)	Clay (.002)					Ca	Mg	Na	K	
										------me/100 g soil--				
Begumganj	Ap	0-6	21.4	30.0	48.6	0.38	7.4	0.26	1.81	32.0	12.0	0.27	0.50	45.59
begumganj--clay	A12	6-31	17.6	30.5	51.9	0.36	8.0	<0.2	1.99	31.0	17.0	0.27	0.52	50.79
Entic	A13	31-62	15.5	33.6	50.9	0.32	8.0	<0.2	1.92	33.0	13 0	0.23	0.90	48.13
Chromustert	A14	86-112	17.6	27.8	54.6	0.33	8.0	<0.2	1.96	35.0	12.0	0.29	0.55	50.19
	Ac	112-145	15.7	25.0	59.3	0.34	8.0	<0.2	1.93	34.0	13.0	0.25	0.97	48.97

Source: Report on the detailed soil survey of village Begumganj, Raisen District, Madhya Pradesh. Agenda No. 1 (National Bureau of Soil Survey and Land Use Planning and ICRISAT cooperative project - 1983)

Agro-economic conditions of Begumganj village and Raisen district

The total cultivated area in Begumganj is 422 ha. In rainy season sorghum and pigeonpea have been the main crops in the past, but in recent years soybean is becoming popular (Table 5). In postrainy season wheat, chickpea, lentil and linseed are extensively grown. The present land use data (Table 6) for Begumganj reveals that Begumganj falls under wheat, chickpea, lentil and linseed crop zone. The cultivated area under different crops in Begumganj and the neighbouring villages is given in Appendix I. The yield levels of soybean, wheat and chickpea under rainfed conditions range from 7 to 10 quintals per hectare (Table 7).

Table 5. Area under rainy season crops in Raisen district, Madhya Pradesh (years 1978-79 to 1980-81).

Rainy season	1978-79	1979-80	1980-81
1. Paddy	58 000	57 000	58 000
2. Soybean	10 000	72 000	76 000
3. Sorghum	104 000	98 000	171 000
4. Maize	18 000	20 000	19 000
5. Pigeonpea	88 000	184 000	191 000

Source: Agricultural Statistics - 1981, Directorate of Agriculture, Madhya Pradesh, Bhopal.

Table 6. Present land use data in Begumganj, Madhya Pradesh.

Particulars	Area (ha)	Percentage of net geographic area
1. Total geogrpahic area	561	
2. Total cultivated area	422	75.2
3. Land put to non-agricultural use (Forest, wasteland and village situation)	139	24.8
4. Area under different crops		net sown area
Wheat	175	41.5
Gram	87	20.5
Lentil	52	12.0
Mustard	23	5.5
Paddy	20	4.5
Misc.	65	16.0

Source: Report on the detailed soil survey of village Begumganj, Raisen district, M.P., Agenda No. 1 (National Bureau of Soil Survey and Land Use Planning and ICRISAT Cooperative Project, 1983).

The average rainfall in Raisen district is around 1300 mm. The population density is around 76/sq.km, and 4 ha is the average land holding. Approximately 80% of the cropped area is left fallow during rainy season (Table 2). Bullock as well as tractor power is used for cultivation of land. On an average net cropped area per tractor and bullock pair is 307 and 2.5 ha respectively. Basic data of the district for 1982-83 is given in Appendix II.

Table 7. Yield levels (kg ha^{-1}) of principal Kharif and Rabi crops (unirrigated) in Begumganj Block.

Crop	Year		
	1982-83	1983-84	1984-85
Soybean	7.25	8.75	10.50
Wheat	7.30	7.80	8.10
Chickpea	7.60	8.40	9.25

Source: Department of Agriculture, Madhya Pradesh

The figures for fertilizer consumption during different seasons are given in Table 8, which show an increasing rate of fertilizer use during the rainy season. However, the fertilizer use during postrainy season is almost same for the three years surveyed. This is an indirect indication of a constant increase in rainy season cropping.

Table 8. Fertilizer (nutrients) (kg ha^{-1}) distribution in Raisen District, Madhya Pradesh.

Nutrient	Year		
	1980-81	1981-82	1982-83
I Rainy season			
Nitrogen (N)	179 000	310 000	540 000
Phosperous (P)	197 000	330 000	645 000
Potash (K)	30 000	60 000	73 000
II Postrainy season			
Nitrogen (N)	2 170 000	3 064 000	3 250 000
Phosperous (P)	1 420 000	2 257 000	2 731 000
Potash (K)	233 000	266 000	167 000

Source: Department of Agriculture, Madhya Pradesh

INITIATION OF IVMT EVALUATION AT BEGUMGANJ

The Minister of Agriculture along with high officials of the Department of Agriculture, Madhya Pradesh visited ICRISAT Center in latter half of 1981 to observe and discuss the various aspects of the watershed management and improved Vertisol technology. Their visit to ICRISAT triggered the necessary enthusiasm and interest in trying the technology under the agroclimatic conditions of Madhya Pradesh and evaluate its application to vast deep Vertisol areas with dependable high rainfall areas in the states. The initiative taken by the Minister of Agriculture culminated in establishment of a collaborative on-farm evaluation project involving the Department of Agriculture, M.P. and ICRISAT.

The Soil Conservation staff from the Department of Agriculture selected and surveyed the Begumganj site in January 1982. It involved 24 ha. and 10 farmers to start with and expanded to 71 ha and 45 farmers in 1984. The detailed information about number of participating farmers, area covered with different cropping systems, land treatments, implements used and agronomic practices for the three years (1982-83 to 1984-85) are given in Table 9 and Figs. 5 and 6.

The Extension staff of the Department of Agriculture located at Begumganj helped in arranging bank loans for the participating farmers, provided input subsidies upto 50% on soybean seed and fertiliser (under demonstration program), while minor land shaping wherever required and the main drainage system were completed from departmental funds. Formation of broadbed and furrows was largely done by the Wheeled Tool Carrier provided by ICRISAT and at a later stage the Department of Agriculture hired a tractor for bed formation and sowing in some cases due to shortage of time.

ICRISAT provided necessary technical guidance and supervision by the scientists from the ICRISAT Center and a whole time staff member located at Begumganj.

Since, the soils and agroclimatic conditions of the area were substantially different than the ICRISAT Center it was thought essential that as an intermediary step exploratory trials on the aspects of cropping systems, depth of sowing, soil fertility and insects monitoring were conducted at the government farm in the area so that promising practices could then be recommended for application on the farmers fields.

Detailed economic data were collected on various farm operations, inputs and crop yields from the fields in the watershed and the adjacent fields of other farmers for comparing the economic profitability and viability of the improved technology.

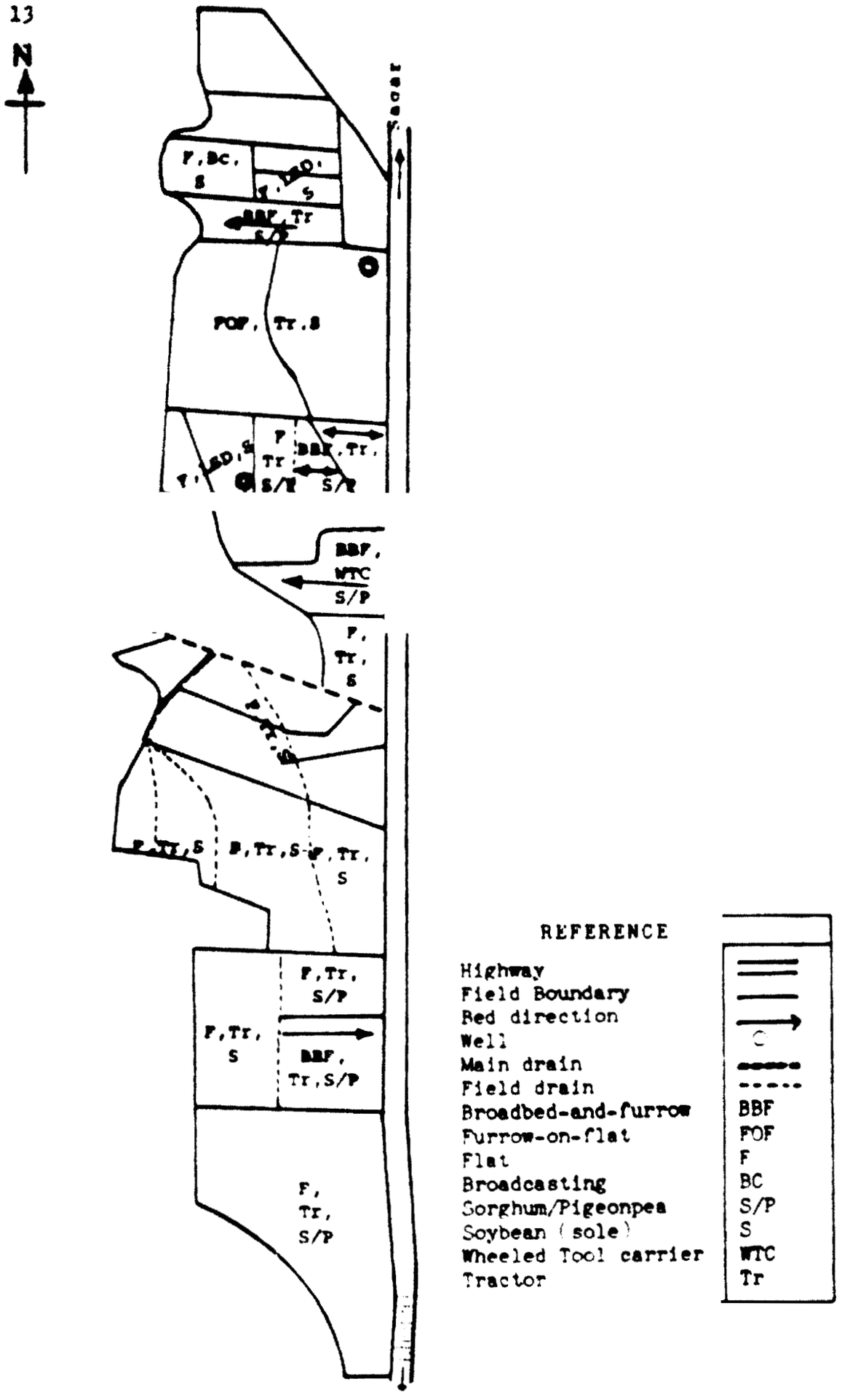


Fig Black soil ... management project - Berumganj, M.P. (Phase I)

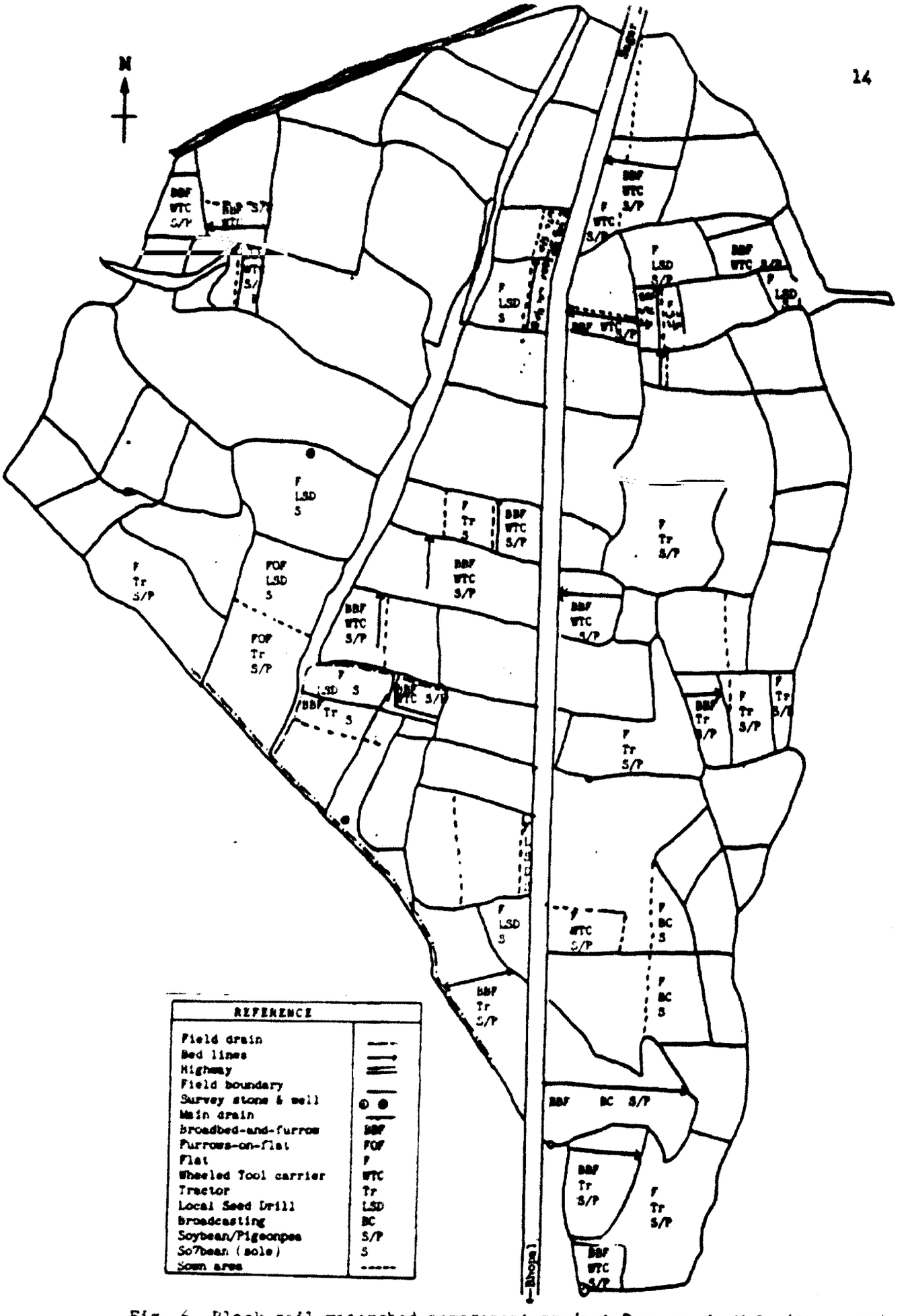


Fig. 6. Black soil watershed management project Begumganj, M.P. (Phase II)

Table 9. Participating farmers and area covered with different agronomic practices in the watershed project at Begumganj, Madhya Pradesh (1982-83 to 1984-85).

Particulars	Year 1982-83	1983-84	1984-85
Number of farmers	10	8	45
Area (ha)	24	16	71
Cropping pattern			
i) Intercrops	Sorghum/ Pigeonpea Soybean/ Pigeonpea	Soybean/ Pigeonpea	Soybean/ Pigeonpea
ii) Sequential crops	Soybean + wheat Chickpea Lentil Linseed	Soybean + Wheat Chickea Lentil Linseed	Soybean + Wheat Chickpea Lentil Linseed
Land treatments	BBF	BBF	BBF FOG and FOF
Implements used	WTC Tractor	WTC Tractor Local Implements	WTC Tractor Local Implements
Inputs:			
i) Seed - Sorghum	10 kg/ha	-	-
Soybean	100 "	100 kg/ha	100 kg/ha
Pigeonpea	20 "	20 "	20 "
Wheat	100 "	100 "	100 "
Chickpea	60 "	60 "	60 "
Lentil	50 "	50 "	50 "
Linseed	50 "	50 "	50 "
ii) Fertiliser			
DAP (8:46:0)	100 "	100 "	100 "
Samrudhi (8:32:8)	250 "	150 "	150 "
Gromor (28:28:0)	100 "	100 "	100 "
iii) Plant protection			
Endosulfan	1250 ml/ha	1250 ml/ha	1250 ml/ha

RESULTS AND DISCUSSIONS

Rainfall:

In 1982, the site received 130 mm of rain between June 13 and 19 followed by no rain during June 19 to July 9. This was the first time in 30 years that all those weeks had been consecutively dry. There was heavy and continuous rain during July 10 to September 4, which severely restricted kharif crop growth (Appendix IIIa). In October, 44 mm of rainfall was recorded which helped in establishing rabi crops (Fig. 8).

The year 1983 had good distribution of rains throughout the kharif crop growing season except that the last week of June was dry. The total rainfall during the year was 1688 mm with an all time record of 370 mm in 24 hrs (Appendix IIIb).

In 1984, the total rain received in Begumganj was 1308 mm which is slightly less than the annual average (1393 mm - Fig. 7). However, the uneven distribution and early cessation of rains in September affected germination and pod filling of Soybean and did not allow the seeding of the sequential crops after Soybean in the farmers fields (Appendix IIIc). The dry period between June 17 to 29 and July 6 to 31 had adverse effect on germination, while no rains after 14 September affected proper seed development. The heavy rains between August 1 and September 13 did not allow any time for interculture and weeding.

Rainfall Pattern:

The rainfall probability distribution in Figure 3 indicates that initial probabilities of a wet week (W) exceed 70 percent for all of July, August and part of September. There is no period during the kharif crop growing season when the threat of drought is serious. The average rainfall level is relatively high (1393 mm - Fig.7) and the distribution of rain across the growing season is such that it assures a good soil moisture condition for crop growth. However, the rainfall distribution during 1982 and 1984 given in Figure 8 indicates that these two seasons have been rather unusual. In 1982 the soil moisture situation early in the season affected the plant stand of the kharif crop but was favourable to the establishment of a sequential rabi crop, while in 1984 establishment of a sequential rabi crop was not possible.

Dry sowing:

In 1982, rainfall probability data was used to practice dry sowing on the 10th June (Heinrich and Sangle 1983). Since the monsoon was expected to begin around June 22, dry sowing started as per plan and covered about 5 ha. Between June 13 and 19, 130 mm of rain was received but following two weeks dry period resulted in poor crop stand.

In 1983, about 3.5 ha was dry seeded. A 20 mm rain was received on 23 June and then there was a dry spell (Fig. 8) which caused poor germination and plant stand.

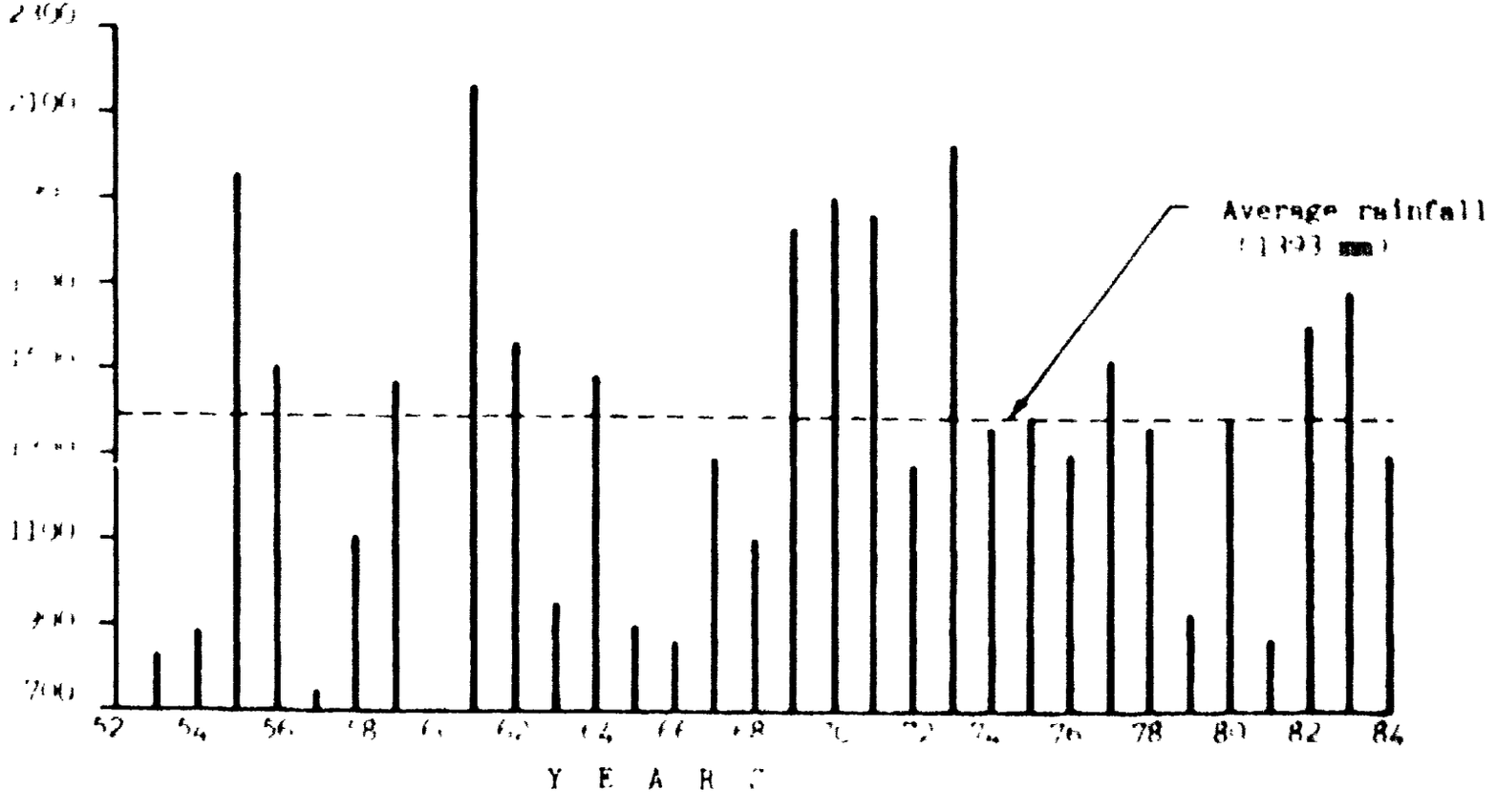


Fig. 7: Annual rainfall (1953-82, except 1960) - Begumganj, Madhya Pradesh

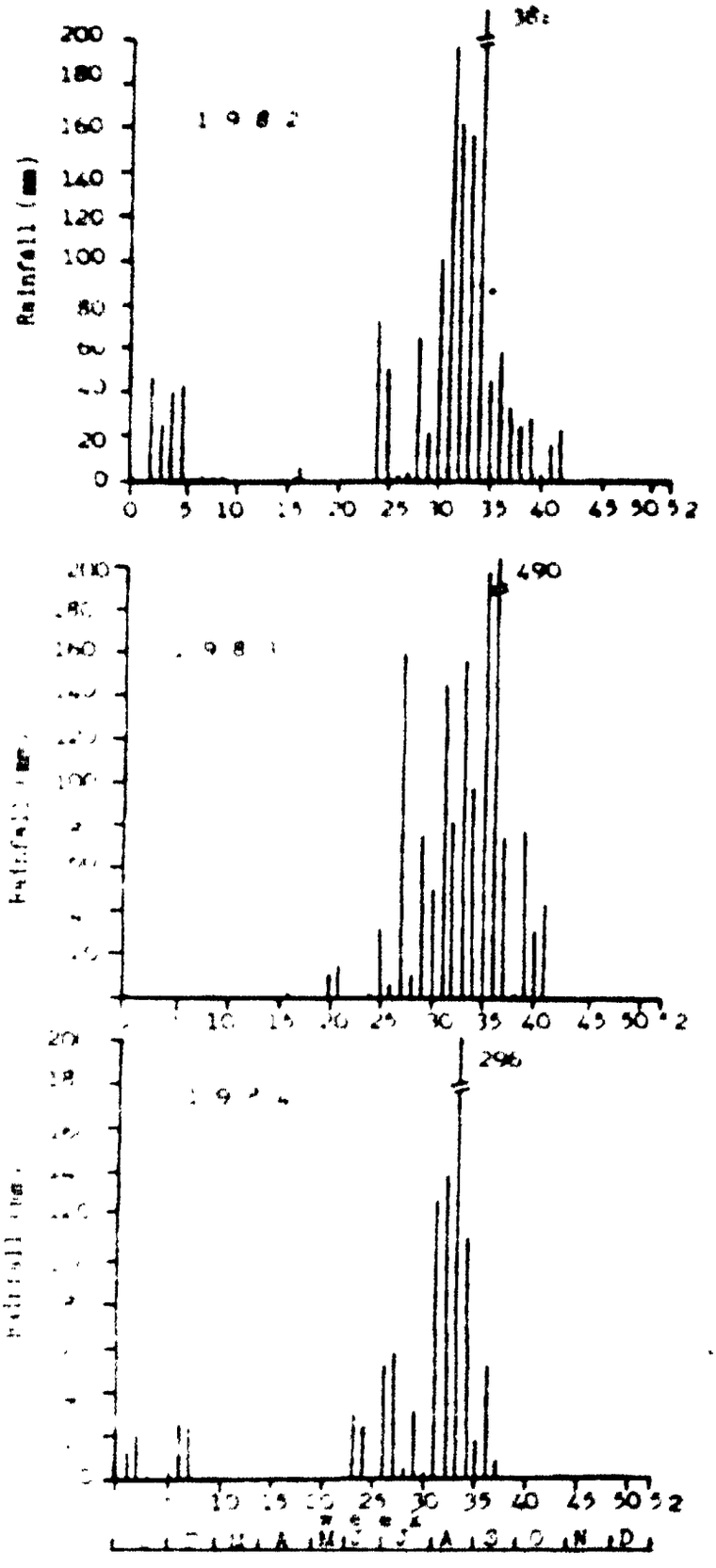


Fig. 3. Weekly rainfall (mm) 1982-84 - Begumganj, Madhya Pradesh

In 1984, the farmers discontinued dry sowing because of bad experience of poor germination and plant stand in 1982 and 1983.

Soil Moisture Availability:

Vertisols have a high moisture storage capacity (150 mm in a 0-100 cm profile) which can buffer prolonged dry spells once the crop, either kharif or rabi, is established. The moisture situation in general is more favourable for a kharif mono crop or an intercrop involving a short season kharif crop such as soybean and a long duration crop of pigeonpea, which can thrive on the residual soil moisture than a sequential double cropping. Figure 9 shows availability of soil moisture in the top 15 cm layer at the time of wheat sowing in different years, which clearly indicates that the moisture situation in 8 out of 29 years may be favourable to establish the sequential rabi crop. Also the soil moisture availability in the second 30 cm layer (Fig. 10) indicates that if a sequential rabi crop is established it can be easily sustained on the available soil moisture in 9 out of 29 years and in other years the success of the sequential crop will depend on winter rains.

Watershed development:

The watershed area was selected in 1982 and surveyed and laid out by the Department of Agriculture, Madhya Pradesh with advice from ICRISAT. The watershed fields were smoothened either by using bullock or tractor drawn leveller. Natural depressions in the fields were accommodated in waterways to remove excess water from fields to the community drain. Community drain was hand trimmed by labour hired by the Department of Agriculture and BBF were laid out with WTC and tractor to expedite the work.

The cost of land development and layout of BBF worked out to Rs.1035/ha. This high cost in comparison with the earlier experience in Taddanpally (Rs.254/ha) was probably due to hiring of tractors for extensive land smoothing and layout of BBF and digging of community drains for having an effective drainage system in a high rainfall area.

Broadbed-and-furrow, WTC:

The major land and water management component consisted of a BBF system laid on a gradual slope (0.4 to 0.8 percent). The beds were slightly raised and about 100 cm in top width to act as *in situ* bunds to prevent runoff and soil erosion. The furrows were opened at a distance of 150 cm, were about 50 cm wide and 15 cm deep to provide good surface drainage. The furrows were connected to waterways which channeled excess water to a community drain. BBF were laid out on individual fields without disturbing the field boundaries.

Wheeled Tool Carriers and tractors were used for preparing beds using same attachments. A three point linkage toolbar was used for the tractors to attach WTC implements (Design detail in Fig. 11). In 1982, about 61% of watershed area was sown by WTC and rest (39%) by the tractor. However, in the following two years the tractor sown area has been increased up to (47% and 56%). This was possibly due to high

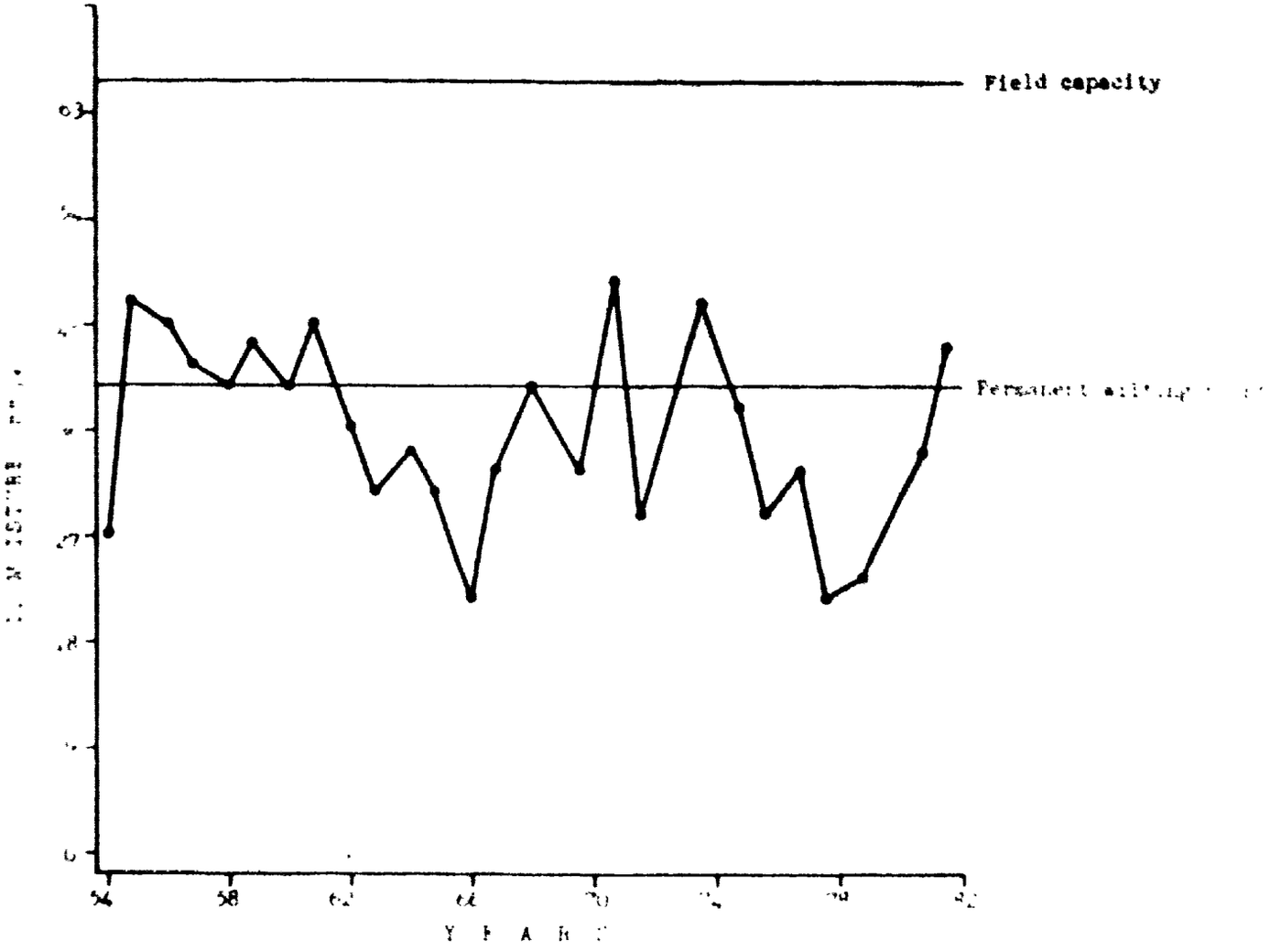
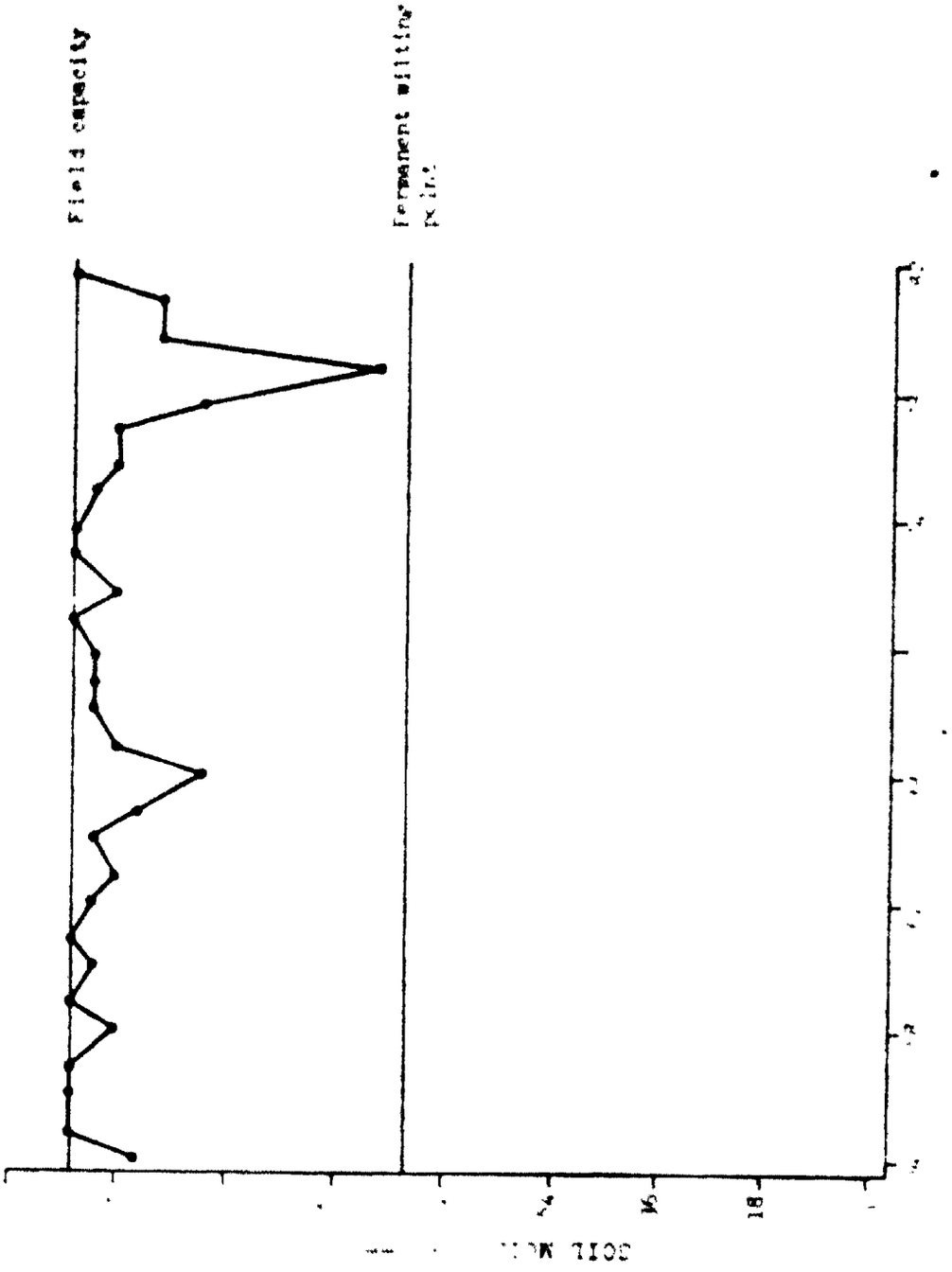


Fig. 9: Soil moisture content in the top 1'cm layer at . with the f wheat at Begumganj, M.P. (decimal figures rounded-off)

(Source: Mr. . Lal Pandey's unpublished thesis)


Field capacity
Permanent wilting point
SOIL MOI
18

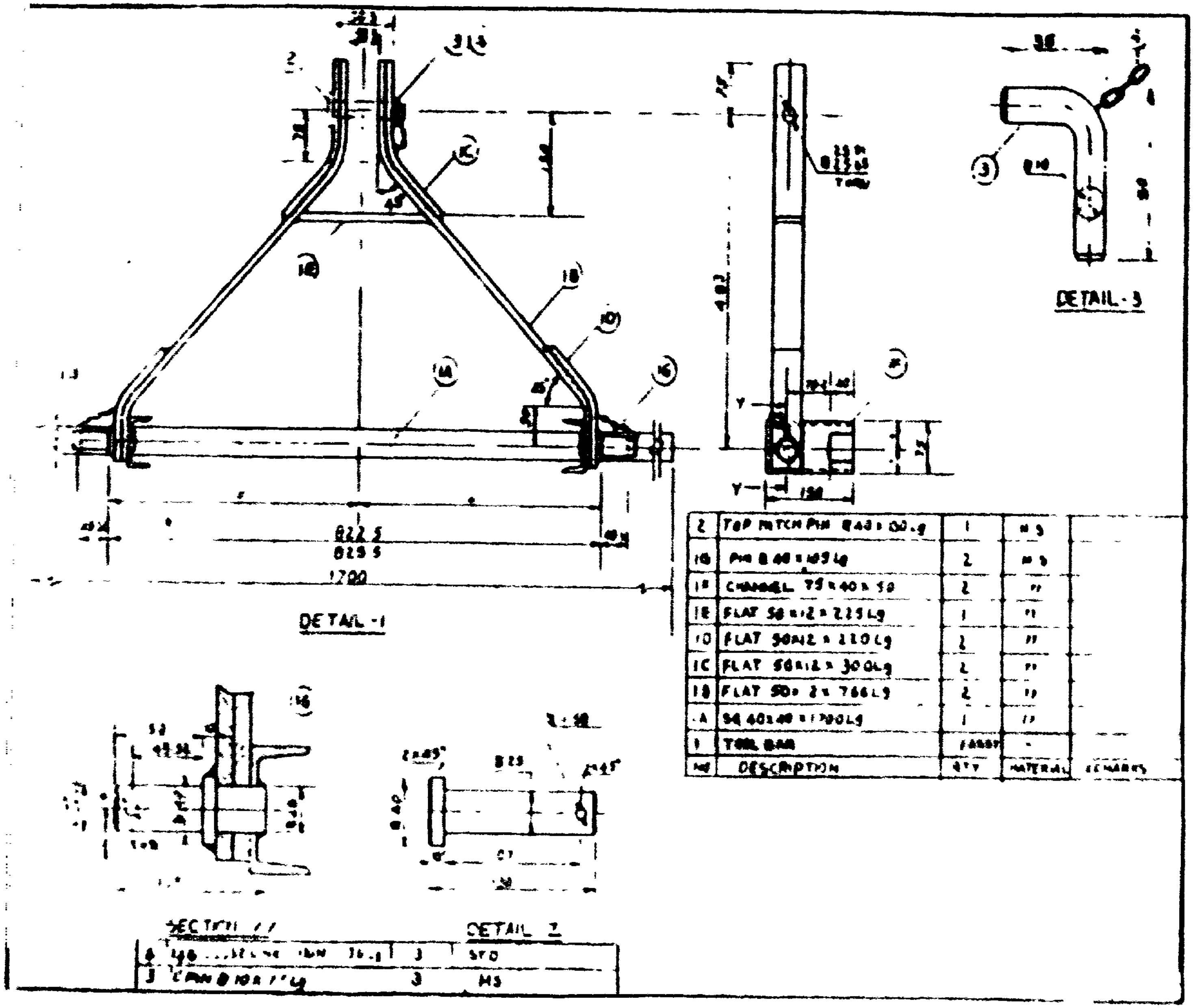


Fig. 11: Details of three-point linkage toolbar for tractor

efficiency of tractor in covering more area in a given time during the critical period and due to the availability of tractors in the village on custom hiring.

Wheeled Tool Carrier mounted planter gave better distribution of seed and fertilizer and germination was generally good. However, the planter mechanism gave some problems during operations, which an average farmer had difficulty in solving. Tractor drawn seed drill was modified and adjusted to sow the Kharif crop on the beds.

Cropping Systems:

Different cropping systems tested in the watershed are listed in Table 9. The plot-wise data for all material inputs, implements used, labour, bullocks and tractor employed were recorded. Yield was calculated from crop samples (16 samples/ha) collected from 12 square metre area from each treatment and individual farmers field (sample crop cutting method in Appendix IV). Economic evaluation was based upon actual material and labour costs, bullocks and tractor rental costs. Family labour and farmer owned bullocks and tractors were considered the same as for hired. The use of WTC was charged according to the machinery hiring rate in the village (see foot note in Appendix Va and Vb). Gross returns were calculated from prevailing local market prices of produce approximately half month after harvest.

Data were also collected from traditional fields (managed by the farmers) around the watershed having cropping systems similar to those in the watershed. Traditional fields were stratified as poor, medium and good according to the inputs applied, plant stand, crop growth and soil type and sample crop cutting for yield was done as described in case of the watershed. Often a cropping system in the watershed project was not available in traditional fields for comparison, hence, it was difficult to have sufficient sampling of traditional fields.

Results:

Data for crop yields for individual plots and a s ry for each cropping system are given in Appendix VI a-c.

Intercropping:

Sorghum/Pigeonpea: In 1982, a short duration hybrid sorghum (CSH-5) was intercropped with a long duration pigeonpea (local variety recommended by the Department of Agriculture, M.P). The intercrop was sown on the beds with a 2:1 cereal/pulse ratio, advised on the basis of ICRISAT research results. About 40% area was covered under sorghum/pigeonpea intercrop and 100 kg DAP/ha was applied during sowing. Sorghum yielded only 0-338 kg/ha, it was due to continuous rains during July 10 to September 4, which did not allow any time for interculture, weeding and top dressing. However, pigeonpea yields were better (602 to 1276 kg/ha) (Appendix VIa), which resulted in a gross profit of Rs.1739/ha from intercropping (Appendix VIIa). Because of poor yields the farmers discontinued sorghum sowing ih the subsequent years.

Soybean/Pigeonpea: Soybean/Pigeonpea intercrop was sown 4:1 ratio in 12% area using WTC and tractor drawn seed drills. About 250 kg/ha Samrudhi (8:32:8) fertiliser was applied as suggested by the Department of Agriculture. Poor plant stand of soybean crop sown by tractor drawn seed drill in some places resulted in a wide variation of crop yields (245 to 1303 kg/ha). In spite of this variation in the yields the farmers could get a gross profit around Rs.3000 for the three years (Appendix VII a-c).

These results confirmed the profitability of soybean pigeonpea intercropping on deep Vertisols under high rainfall conditions of Madhya Pradesh recommended by Sharma et al. (1973, 1975). The enhanced returns popularised soybean/pigeonpea intercrop and the intercrop area increased from 12% in 1982-83 to 65% in 1983-84. A very wide plot-to-plot variation in soybean and pigeonpea yield and profits was observed in both 1983-84 and 1984-85 seasons. There is a need to determine the causes of this variation so that agronomic practices could be developed and recommended to stabilise the yield of the crop at an optimum level.

Sequential cropping:

Soybean-wheat: Soybean-wheat sequential cropping was undertaken in 31% of the area during 1982-83. The loss incurred in the soybean-wheat sequential cropping may be due to (i) poor plant stand in tractor sown soybean crop area, (ii) dry spell during June 19 to July 9, which resulted in poor crop yields (277 to 552 kg/ha) (Appendix VIa), and (iii) high input costs. However, in 1983-84 the farmers were benefited with a gross returns of Rs.3117/ha but there was a reduction in soybean-wheat sequential crop area from 31% in 1982-83 to 22% in 1983-84 (Appendix VIIb). The reduction in the area was due to wide acceptance of soybean/pigeonpea intercropping system by the farmers. The farmers' acceptance of soybean/pigeonpea intercropping in preference to soybean-wheat sequential cropping is easily understood by the fact that CV of gross profits was 345% in case of soybean-wheat sequential crop as against 35% for soybean/pigeonpea intercrop (Walker et al. 1983). Nevertheless, intercropping with a long duration pigeonpea suffers from the risk of frost damage and therefore, sequential cropping after soybean will be tried at a substantial scale as a catch crop strategy. During 1984 majority of the pure crop soybean fields in the watershed could not be sown to a subsequent rabi crop due to lack of available soil moisture or the crop sown failed, while in 1983 all the soybean pure crop fields were double cropped either by planting wheat or chickpea.

Three years observations on cropping systems, irrespective of the land treatment (Table 10) show that:

1. Soybean/pigeonpea intercropping gives maximum profits.

2. Kharif cropping of soybean even as a monocrop is more profitable than traditional cropping of fallow wheat.

3. As sequential crops lentil and linseed in rabi after soybean have more assured returns than wheat as a sequential crop.

4. In case of fallow rabi monocrop system lentil and linseed may equal in profits to monocrop soybean cropping in kharif, and are better alternatives than fallow-wheat, however, are likely to be more risky than kharif cropping.

Table 10. Inputs and profits (Rs ha^{-1}) for the different systems in three years of IWMT in the Begumganj watershed.

Cropping System	Land treatment	1982-83		1983-84		1984-85	
		Inputs	Gross profits	Inputs	Gross profits	Inputs	Gross profits
IMPROVED WATERSHED							
Sorghum/Pigeonpea	BBF	1450	1876	--	--	--	--
Soybean/Pigeonpea	BBF	4099	3318	2310	2726	1294	2983
Soybean/Pigeonpea	FOG	--	--	2172	2335	1090	2818
Soybean/Pigeonpea	FOF	--	--	--	--	1267	2976
Soybean-wheat	BBF-FOG	2677	-333	2261	3117	1733	1035
Soybean-chickpea	BBF-FOG	3303	295	2532	2345	--	--
Soybean-lentil	BBF-FOG	3410	3215	--	--	1519	687
Soybean-linseed	BBF-FOG	2476	696	--	--	--	--
Soybean-fallow	BBF	--	--	--	--	1056	808
Soybean-fallow	FOG	--	--	--	--	791	802
Soybean-fallow	FOF	--	--	--	--	980	1345
Fallow-wheat	FOG	--	--	--	--	490	463
Fallow-wheat+ chickpea	FOG	--	--	--	--	622	344
Fallow-lentil	FOG	--	--	--	--	488	682
Fallow-linseed	FOG	--	--	--	--	501	1294
TRADITIONAL FARMERS FIELD							
Soybean/Pigeonpea	Trad.	--	--	1497	3087	1285	3000
Soybean-wheat	Trad.	--	--	1488	2400	--	--
Soybean-chickpea	Trad.	--	--	1781	2909	--	--
Soybean-fallow	Trad.	963	534	--	--	894	655
Fallow-wheat	Trad.	962	370	914	401	465	306
Fallow-chickpea	Trad.	920	344	937	728	--	--
Fallow-lentil	Trad.	741	1680	--	--	419	755
Fallow-linseed	Trad.	664	796	--	--	313	868
Pigeonpea (sole)	Trad.	474	1708	--	--	--	--

CONCLUSIONS

The state department of Agriculture initiated an improved Vertisol management project at Begumganj, district Raisen in collaboration with ICRISAT in 1982 in a microwatershed of 24 ha involving 10 farmers, which expanded to 71 ha and 45 farmers in 1984.

The average rainfall in Begumganj is 1393 mm, which covers about 90% of potential evapotranspiration (PE) of 1542 mm and exhibits ustic soil moisture regime. The maximum and minimum temperatures range between 45°C to 4°C with possibility of frosty conditions sometimes. The weekly rainfall distribution and the rainfall probabilities indicate that Begumganj has dependable rainfall distribution during the rainy season.

area. Soybean yields are not improved by BBF land-and-water management system and planting of wheat as a sequential crop on the broadbeds is not able to compensate for the loss of land in furrows. Consequently wheat yields in BBF system are less than in flat continuous planting.

Soybean and soybean/pigeonpea intercropping systems during kharif are going to predominate the cropping system in the area. However, since intercropping system with long duration pigeonpea suffers from frost sequential cropping after soybean will be tried at a substantial scale, though its success varies from year to year. The probability is that 8 out of 29 years sequential double cropping will be a success.

Soybean yields vary widely (1506-1300 kg/ha) from one farmer's field to another. There is a need to study and standardise the agronomy of the crop so that the yield levels in the farmers fields could be stabilised.

Three years observations on cropping systems, irrespective of the land treatments, showed that:

1. Soybean/pigeonpea intercropping gives maximum profits.

2. Kharif cropping of soybean even as a monocrop is more profitable than traditional cropping of fallow wheat.

3. As sequential crops linseed and lentil in rabi after soybean have more assured returns than wheat as a sequential crop.

4. In case of fallow-rabi monocrop system lentil and linseed may equal in profits to monocrop soybean cropping in kharif and are better alternatives than fallow-wheat. However, it is likely to be more risky than kharif cropping.

Comparison of individual cropping systems showed that higher economic profitability of the improved watershed technology was mainly due to the absence of fallowing and practice of inter- or double cropping in the watershed.

Dependability and profitability of the sequential rabi crop can be assured by recycling the excess runoff for one or two irrigations through farm ponds or wells. Wells are becoming popular in the area.

Tropicultor suffered from lack of plasticity in operating time (can operate only under dry conditions), high cost, and heavy draft for medium and small size bullocks of the farmers. Farmers are interested in having low cost implements capable of covering more area in a given time, particularly seed and fertilizer placement equipment.

Maintenance of field to field grassed waterways has not been possible since farmers are not interested to lose the land involved and are in the habit of cultivating and planting a crop in the marked waterways. A practical solution is to plant the waterways with rice by broadcasting soon after the seeding of the general crop.

Soils are deep Vertisols with level to very gentle sloping piedmont and moderately well drained characteristics. Clay content varies from 48.6 to 59.3% and has an increasing trend with depth. Bulk density varies from 1.81 to 1.99 with depth, which indicates more compactness of soil in the subsurface horizon, resulting in relatively low saturated hydrolic conductivity in subsoil layers and poor root zone aeration.

In rainy season sorghum and pigeonpea have been the main crops in the past, but in recent years soybean is becoming popular. The present land use in Begumganj reveals that traditionally Begumganj falls under wheat, chickpea, lentil and linseed crop zone and approximately 80% of the cropped area is left fallow during the rainy season.

Considering the soil and the rainfall characteristics of the location saturated soil moisture regimes for considerable period and surface waterlogging in pockets; and socioeconomic factors such as low population density (76/sq. km in Raisen district), relatively large holdings (average holding 4 ha) and proximity to extensive forest land are some of the factors, that have been responsible for limited rainy season cropping as compared to the districts of Damoh, Jabalpur, and Narsingpur, which have similar agroclimatic and soil characteristics, but have over 50% kharif cropping.

The ICRISAT's improved Vertisol management technology was evaluated with the following objectives:

1. Avoid waterlogging conditions for the standing rainy season crop and quickly dispose off the excess water from the soil surface.

2. Increase cropping intensity by introducing an effective rainy season intercrop or a sole crop followed by an appropriate sequential crop.

Farmers and the Department of Agriculture officers appreciated the need and utility of landshaping, construction of field channels, grassed waterways and main drains for draining the excess water, which is often a problem in high rainfall areas. However, development of waterways and community drains, which has to be done by the Department of Agriculture needs to be properly implemented. It is not possible for the individual farmers to look after these aspects.

BBF system is difficult to maintain through the rainy season by intermittent interculture and bed shaping due to heavy rains and prolonged wet days and as such does not effectively contribute towards increased productivity and profits in a soybean system. Once landshaping, waterways, channels, and main drains are established simple treatments such as sowing along keylines on flat-on-grade and opening a furrow-on-grade after an interval of 3m should serve the purpose of improved drainage.

Cropping systems are location and area specific and land-and-water management treatments need to be determined according to the soil and land characteristics, and the rainfall pattern, and the crops to be grown. Sorghum/pigeonpea and maize/pigeonpea systems which gave high profits at ICRISAT Center could not be popular at Begumganj. Choice of crops less susceptible to excessive soil moisture or waterlogging to some extent such as soybean and rice were the natural preferences of the farmers to cope up with the excessive soil moisture conditions in the

Problems encountered

1. Cultivation of land soon after harvesting the wheat crop which extends up to April is not possible because of hard soil during hot dry period after wheat threshing, which has precedence over any other operation.

2. Interculture by tropicultor has not been possible in wet land while local implements are effective.

3. Since dry seeding of soybean is not very dependable, sowing in wet soil by tropicultor poses problems.

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APPENDICES

Appendix :

Cultivated area (ha) of Begumganj and the neighbouring villages year 1982-83 to 84-85)

Sl. No.	Particulars	Begumganj block			Begumganj village			Umer village			Bhareru village			Chandoria village			Unmarsed village		
		82-83	83-84	84-85	82-83	83-84	84-85	82-83	83-84	84-85	82-83	83-84	84-85	82-83	83-84	84-85	82-83	83-84	84-85
1.	Total cultivated area	[illegible]	5279	[illegible]	498	[illegible]	[illegible]	497	[illegible]	543	[illegible]	[illegible]	488	561	567	588	398	403	495
2.	Area under single crop	4458	[illegible]	[illegible]	471	441	386	393	391	403	358	[illegible]	305	375	389	409	379	381	399
3.	Area under double crops	2200	2300	[illegible]	27	31	[illegible]	24	[illegible]	[illegible]	[illegible]	[illegible]	183	31	38	50	19	22	37
4.	Area under soybean (Irrigated)	[illegible]	1200	[illegible]	19	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26	[illegible]	56	60	64	55	[illegible]	[illegible]
5.	Area under soybean (Unirrigated)	[illegible]	[illegible]	[illegible]	[illegible]	64	[illegible]	[illegible]	92	[illegible]	[illegible]	[illegible]	28	68	76	80	19	[illegible]	[illegible]
6.	Area under Rabi crops (Irrigated)	900	[illegible]	[illegible]	28	32	[illegible]	[illegible]	38	[illegible]	[illegible]	[illegible]	32	31	34	36	21	23	26
7.	Area under Rabi crops (Unirrigated)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200	[illegible]	418	[illegible]	309	303	409
8.	Area under Kharif crops other than soybean	[illegible]	3518	[illegible]	[illegible]	[illegible]	[illegible]	63	[illegible]	[illegible]	22	[illegible]	12	NA	NA	NA	NA	NA	NA

Source: Department of Agriculture, Madhya Pradesh

NA - Not available

BASIC DATA OF RAISEN DISTRICT - 1982-83

Particulars		
Geographical area	848 [illegible]	ha
Total cultivated land	408 [illegible]	"
Forest land	336 [illegible]	"
Land not used for agriculture	38 [illegible]	"
Area under grazing	27 [illegible]	"
Fallow land	8 [illegible]	"
Area under Kharif crop	100 [illegible]	"
Area under Rabi crop	[illegible]	"
Irrigated area	[illegible]	"
Average holding per cultivator	[illegible]	"
Diesel pumpsets installed	[illegible]	nos.
Electric pumpsets installed	[illegible]	"
Tube wells	[illegible]	"
Tractor	[illegible]	"
Number of electrified villages	[illegible]	"
No. of farmer family	[illegible]	"
No. of wells	[illegible]	"
Total villages	[illegible]	"
Fertilizer storage centres	9	"
Fertilizer distribution centres	[illegible]	"

Rainfall data (mm) for the year 1982 - Begumganj, M.P.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	An. Total
1	-	0.8	-	-	-	-	-	21.6	11.6	-	-	-	
2	-	-	-	-	-	-	-	43.8	1.2	2.6	-	-	
3	-	7.2	-	-	-	-	-	61.0	39.0	-	-	-	
4	-	1.4	-	-	-	-	-	11.8	10.6	-	-	-	
5	-	-	-	-	-	-	1.6	10.4	8.4	-	-	-	
6	-	-	-	-	-	-	1.0	-	-	-	-	-	
7	-	-	-	-	-	-	-	10.0	-	-	-	-	
8	-	-	-	-	4.4	-	-	-	-	-	-	-	
9	-	-	-	-	-	-	-	12.2	-	5.0	-	-	
10	10.4	-	-	-	-	-	37.0	4.4	9.2	12.6	-	-	
11	5.0	-	-	-	-	-	5.8	146.4	19.2	-	-	-	
12	-	-	-	-	-	-	-	-	4.4	-	-	-	
13	-	-	-	-	2.4	-	44.4	2.6	-	-	-	-	
14	34.8	-	-	-	-	35.	-	46.2	0.6	-	-	-	
15	24.6	-	-	-	-	33.4	-	62.2	-	-	-	-	
16	-	-	-	-	-	3.2	2.2	21.0	-	-	-	-	
17	-	-	-	-	2.3	0.8	-	14.8	-	-	-	-	
18	-	-	-	-	-	-	-	9.4	-	-	-	-	
19	-	-	-	-	-	17.6	5.6	1.0	-	3.2	-	-	
20	-	-	-	-	-	-	-	-	-	20.2	-	-	
21	-	-	-	-	-	-	-	98.4	-	-	-	-	
22	-	-	-	-	-	-	14.6	223.4	-	-	-	-	
23	-	-	-	-	-	-	8.6	31.2	24.4	-	-	-	
24	-	-	-	-	-	4.8	38.6	22.0	25.2	-	-	-	
25	2.2	-	-	-	-	1.0	5.4	7.4	3.0	-	-	-	
26	22.2	-	-	-	-	0.6	9.6	10.8	-	-	-	-	
27	15.4	-	-	-	5.8	-	-	4.4	-	-	-	-	
28	-	0.8	-	-	-	-	-	0.6	-	-	-	-	
29	1.4	-	-	-	-	-	39.6	-	-	-	-	-	
30	-	-	-	-	-	-	12.0	-	-	-	-	-	
31	12.0	-	-	-	-	-	32.0	27.0	-	-	-	-	
Total	148.0	10.2	-	-	18.6	124.8	236.6	885.8	156.0	43.4	-	-	1606

☐ Dry spell

Rainfall data (mm) for the year 1983 - Begumganj, M.P.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	An. Total
1	-	-	-	-	-	-	4.2	96.2	55.6	30.0	-	-	
2	-	-	-	-	-	-	42.2	-	27.6	-	-	-	
3	-	-	-	-	-	-	79.4	-	22.0	-	-	-	
4	-	-	-	-	-	-	21.2	17.0	19.0	-	-	-	
5	-	-	-	-	-	-	13.0	-	12.0	-	-	-	
6	-	-	-	-	-	-	-	-	1.6	-	-	-	
7	-	-	-	-	-	-	4.8	77.4	36.6	-	-	-	
8	-	-	-	-	-	-	-	2.0	29.8	-	-	-	
9	-	-	-	-	-	-	-	-	369.6	30.8	-	-	
10	-	-	-	-	-	-	-	-	54.4	-	-	-	
11	-	-	-	-	-	2.2	-	-	2.4	1..6	-	-	
12	-	-	-	-	-	1.0	8.8	2.0	-	-	-	-	
13	-	-	-	-	-	0.6	1.4	28.0	-	-	-	-	
14	-	-	-	-	-	-	-	28.4	-	-	-	-	
15	-	-	-	-	-	-	-	2.8	17.6	-	-	-	
16	-	-	-	-	-	-	-	-	-	-	-	-	
17	-	-	-	-	-	5.0	22.6	1.8	-	-	-	-	
18	-	-	-	-	8.4	2.0	3.0	14.0	-	-	-	-	
19	-	-	-	-	2.6	3.4	44.4	1.0	-	-	-	-	
20	-	-	-	-	-	6.4	4.4	74.2	-	-	-	-	
21	-	-	-	1.2	13.2	-	1.4	7.2	-	-	-	-	
22	-	-	-	-	-	-	-	16.0	2.6	-	-	-	
23	-	-	-	-	-	-	-	1.0	-	-	-	-	
24	-	-	-	-	1.8	19.4	-	-	-	-	-	-	
25	-	-	-	-	-	-	33.4	-	24.8	-	-	-	
26	-	-	-	-	-	1.6	7.8	-	25.8	-	-	-	
27	-	-	-	-	-	-	6.4	1.0	6.2	-	-	-	
28	-	-	-	-	-	-	2.0	2.2	-	-	-	-	
29	-	-	-	-	0.4	-	-	11.6	-	-	-	-	
30	-	-	-	-	-	-	19.8	76.6	19.0	-	-	-	
31	-	-	-	-	-	-	12.0	24.0	-	-	-	-	
Total	-	-	-	1.2	26.4	42.4	332.2	369.0	728.4	73.4	-	-	1688

☐ Dry spell

Appendix IIIb

Rainfall data (mm) for the year 1984 - Begumganj, M.P.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	An. Total
1	-	1.0	-	-	-	-	33.8	-	-	-	-	-	
2	12.2	-	-	-	-	-	-	18.4	9.8	-	-	-	
3	-	2.2	-	-	-	-	34.4	51.6	3.0	-	-	-	
4	-	-	-	-	-	-	-	21.2	0.6	-	-	-	
5	-	-	-	-	-	8.8	15.6	3.8	2.6	-	-	-	
6	-	-	-	-	-	5.6	4.0	-	17.2	-	-	-	
7	-	-	-	-	-	-	2.0	-	13.2	-	-	-	
8	-	25.0	-	-	-	1.0	3.0	53.2	-	-	-	-	
9	12.4	-	-	-	-	-	5.0	9.8	15.4	-	-	-	
10	5.8	-	-	-	-	10.0	-	71.6	-	-	-	-	
11	3.0	-	-	-	-	2.6	-	4.3	-	-	-	-	
12	-	-	-	-	-	-	-	-	8.0	-	-	-	
13	-	-	-	-	-	-	-	-	0.8	-	-	-	
14	-	-	-	-	-	-	-	6.6	-	-	-	-	
15	-	-	-	-	-	15.6	-	49.0	-	-	-	-	
16	0.6	-	-	-	-	6.2	-	38.0	-	0.8	-	-	
17	-	23.0	-	-	-	-	0.8	76.0	-	-	-	-	
18	-	-	-	-	-	-	11.6	69.8	-	-	-	-	
19	-	-	-	-	-	-	4.0	56.6	-	-	-	-	
20	-	-	-	-	-	-	14.2	4.2	-	-	-	-	
21	-	-	-	-	-	-	1.4	3.8	-	-	-	-	
22	-	-	-	-	-	-	-	1.8	-	-	-	-	
23	-	-	-	-	-	-	-	62.4	-	-	-	-	
24	-	-	-	-	-	-	-	33.4	-	-	-	-	
25	-	-	-	-	-	-	1.2	4.0	-	-	-	-	
26	-	-	-	-	-	-	2.6	1.4	-	-	-	-	
27	-	-	-	-	-	-	-	0.6	-	-	-	-	
28	-	-	-	-	-	-	-	1.0	-	-	-	-	
29	-	-	-	-	-	-	-	-	-	-	-	-	
30	-	-	-	-	-	19.0	-	8.0	-	-	-	-	
31	-	-	-	-	-	-	-	-	-	-	-	-	
Total	34.0	51.2	-	-	-	78.8	211.4	861.8	70.6	0.8	-	-	1308

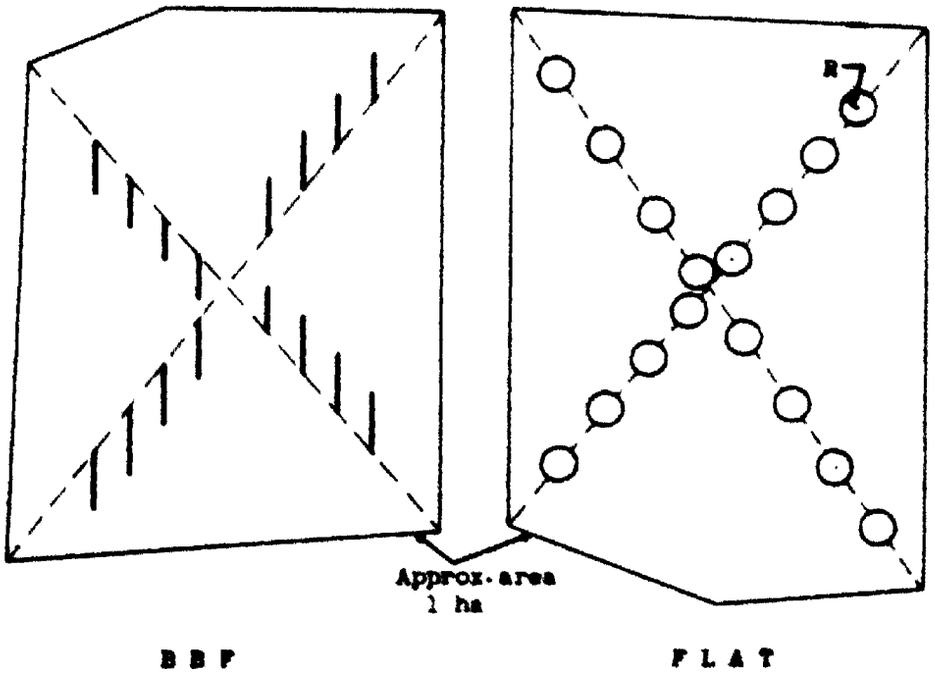
☐ Dry spell

Sample crop cutting method for determining yield

Crop yields were determined from crop samples taken from the fields in the watershed and in the traditional farmers' fields. The sampling method followed was:

1. Fixed two diagonal lines between two opposite corners of the field.
2. Left 10m on both the corners and divided rest of the length of the diagonal into equal parts to fix the sites for eight samples on each of the diagonals.
3. The sample area for each of the samples was 12 square meter.
4. The sample area in case of flat and BBF were circular (π 1.96m^2) and rectangular (8m x 1.5m) respectively. For making the circular sample-area a wooden 'A' frame was used.
5. Samples were taken for each of the treatments and the individual farmers fields.

Diagonal method for crop sampling



Cropping system-wise total operating cost, gross returns and gross profits from IVMT, Begumganj, Madhya Pradesh - 1982-83

(Rs/ha)

Cropping system/ Land treatment	Area ha.	Seed	Fertiliser	Pesticide	Human labour	Bullocks	Tropicultor, tractor & other cost	Total operating cost	Gross returns	Gross profits
Intercropping										
Sorghum-Pigeonpea (BBF)	7.7	165	563	106	417	32	122	1405	3144	1739
Sorghum-Pigeonpea-Chickpea (BBF)	1.8	463	966	190	464	67	60	2210	4712	2502
Soybean-Pigeonpea-Chickpea (BBF)	2.4	715	1312	124	739	133	227	3250	6785	3535
Soybean-Pigeonpea-Lentil (BBF)	0.4	560	1374	115	743	253	302	3347	5579	2232
Sequential cropping										
Soybean-wheat (BBF-POG)	5.7	660	886	-	303	30	571	2450	2257	- 193
Soybean-wheat-C.pea (BBF-POG)	1.6	1072	1434	-	531	314	106	3457	2644	- 813
Soybean-C.Pea-Mustard (BBF-POG)	2.0	625	1167	100	692	2	717	3303	3598	295
Soybean-Linseed (BBF-POG)	2.0	519	970	-	256	-	731	2476	3172	696
Soybean-lentil (BBF-POG)	0.4	838	1435	-	631	394	112	3410	4625	1215

Prices as per market rate

Sorghum	Grain	Rs.100/qunt.	Fodder	Rs.10/qunt.	Lentil	Grain	Rs.250	Fodder	Rs.20
Soybean	"	Rs.250 "	"	Rs.20 "	Chickpea	"	Rs.210	"	Rs.15
Pigeonpea	"	Rs.350/ "	"	Rs.12.5"	Mustard	"	Rs.375	"	-
Wheat	"	Rs.180/ "	"	Rs.20 "	Linseed	"	Rs.475	"	-

Hiring charges:

Bullock pair Rs.20/per day
WTC Rs.15; Tractor Rs.60/p.d
Thresher Rs.8 p.quint.
Hand winnower Rs.10 p.day
Sprayer Rs.5 p.day

Appendix VI

Cropping system-wise total operating cost, gross returns and gross profits from IVMT, Begumganj, Madhya Pradesh - 1983-84

(Rs/ha)

Cropping system/ Land treatment	Area ha.	Seed	Fertilizer	Pesticide	Human labour	Bullocks	Tropicultor, tractor & other cost	Total operating cost	Gross returns	Gross profits
Intercropping:										
Soybean-Pigeonpea (BBF)	8.8	561	286	43	783	94	543	2310	5036	2726
Soybean-Pigeonpea (FOG)	0.7	549	372	237	579	63	372	2172	4507	2335
Sequential cropping:										
Soybean-wheat (BBF-FOG)	3.2	630	171	-	513	-	947	2261	5378	3117
Soybean-Chickpea (FOG)	2.0	568	596	-	379	-	989	2532	4877	2345

Prices as per market rate:

Crop	Grain/fodder	
Soybean	300	20 (Rs/ quintal)
Pigeonpea	350	12.5 "
Wheat	180	20 "
Chickpea	300	15 "

Hiring charges:

Bullock pair	Rs.20/per day
WTC	Rs.15/per day
Tractor	Rs.60/per day
Thresher	Rs. 8/per quintal
Hand winnower	Rs.10/per day
Sprayer	Rs.5/per day

Appendix VIa

IWST watershed and traditional fields crop yield data
Begumganj, Madhya Pradesh - 1982-83

Farmer	Total area (ha)	Cropped area (ha)	Cropping system	Crop yield (kg/ha)		Land Treatment
				Rainy	Post-rainy	
Improved watershed						
1. Amarchand	4.400	2.000	Soy+C.pea	594	633	BBF
			Mustard		150	
		2.400	Sorghum/Pigeonpea	338	718	"
2. Gulabchand	4.000	2.000	Soybean+Linseed	541	351	"
		2.000	Sorghum/Pigeonpea	254	696	"
3. Bhavani	4.500	1.600	Soybean+wheat	359	746	"
		0.400	Soybean+Lantil	1320	1089	"
		2.500	Sorghum/Pigeonpea	207	602	"
4. Sheik Rafiq	1.200	1.200	Soybean/Pigeonpea	1303	824	"
5. Krishna Murari	3.000	2.200	Soybean+wheat	346	527**	"
		0.800	Sorghum/Pigeonpea	0	1090	"
6. Mukesh Kumar	3.000	2.200	Soybean+wheat	552	615**	"
		0.800	Sorghum/Pigeonpea	221	1276	"
7. Pooran Singh	0.800	0.800	Soybean/Pigeonpea	245	1432	"
8. Balkishan	0.400	0.400	Soybean/Pigeonpea	597	1477	"
9. Omrao	0.400	0.400	Soybean/Pigeonpea	542	1047	"
10. Ramcharan	2.100	1.200	Soybean+wheat	277	592	"
		0.900	Sorghum/Pigeonpea	0	626	
Traditional fields						
1. Sayyad Jaffar	1.500	1.500	Soybean+wheat	417	-**	Flat
2. Amarchand	1.200	1.200	Soybean+chickpea	962	500	"
3. Abdul Safi	1.00	0.500	Soybean+wheat	180	-**	"
4. Ramcharan	1.200	0.800	Soybean+Lentil	379	855	"
5. Ratan Ghosi	0.500	0.500	Soybean/Pigeonpea	750	572	"
6. G. Amerchand	1.500	1.500	Fallow+wheat	-	654	"
7. Gulabchand	1.000	0.800	Fallow+wheat	-	356	"
8. Manmohan	1.000	0.400	Fallow+wheat	-	612	"
9. Jitmaljl	1.000	0.800	Fallow+chickpea	-	619	"
10. Bhavarlal	1.500	0.900	Fallow+chickpea	-	628	"
11. Yasin Miya	0.400	0.400	Fallow+lentil	-	900	"
12. Ram Kumar	1.000	0.900	Fallow+lentil	-	692	"
13. Habib Mohd.	2.000	0.800	Fallow+linseed	-	295	"
14. Haji Abdul	1.500	0.800	Fallow+Linseed	-	376	"
15. Ram Kumar	1.000	0.500	Fallow+linseed	-	278	"

** Wheat crop was irrigated

Appendix VIb

IVMT watershed and traditional fields crop yield data
Begumganj, Madhya Pradesh - 1983-84

Farmer	Total area (ha)	Cropped area (ha)	Cropping system	Crop yield (kg/ha)		Land Treatment
				Rainy	Post-rainy	
Improved watershed						
1. Amarchand	5.600	3.200	Soybean+wheat	1078	967	BBF-POG
		2.400	Soybean/Pigeonpea*	1250	625	BBF
2. Gulabchand	4.000	2.000	Soybean+chickpea*	850	708	POG
		2.000	Soybean/Pigeonpea*	1200	313	BBF
3. Bhavani	2.000	0.800	Soybean/Pigeonpea*	811	558	BBF
4. Sheik Rafiq	1.200	1.200	Soybean/Pigeonpea*	547	275	BBF
5. Mukesh Kumar	3.000	0.700	Soybean+wheat	980	787	POG
		1.500	Soybean/Pigeonpea*	830	476	
		0.800	Soybean/Pigeonpea*	121*	1056	BBF
6. Poonan Singh	0.800	0.800	Soybean/Pigeonpea*	833	280	BBF
7. Balkishan	0.400	0.400	Soybean/Pigeonpea*	750	308	BBF
8. Omkar	0.400	0.400	Soybean/Pigeonpea*	642	275	BBF
Traditional fields						
1. Sheik Nasib	1.000	1.000	Soybean+wheat	750	580	Flat
2. Babulal	1.600	1.600	Soybean+wheat	700	987	"
3. Shivkant	1.600	1.600	Soybean+wheat	764	800	"
4. Babulal	0.400	0.400	Fallow+wheat	-	933	"
5. Bhavani	0.800	0.800	Fallow+wheat	-	840	"
6. Mohd. Aliyas	0.400	0.400	Fallow+wheat	-	875	"
7. Rajaram	1.000	1.000	Soybean+chickpea*	550	980	"
8. Tulsiram Solanki	0.800	0.800	Fallow+chickpea	-	750	"
9. Devendra Singh	0.800	0.800	Fallow+chickpea	-	430	"
10. Ramnath Singh	1.000	0.800	Fallow+chickpea	-	480	"
11. Govind Singh	1.600	0.800	Soybean+Pigeonpea*	625	708	"
12. Ramnath Singh	1.000	0.400	Soybean+Pigeonpea*	750	745	"
13. Shivkant	1.600	1.600	Soybean+Pigeonpea*	815	705	"

* Pigeonpea and chickpea crops were damaged by frost, hence yields varies with the percentage of crop damaged.

Appendix VIc

IWMP watershed and traditional fields crop yield data
Begumganj, Madhya Pradesh - 1984-85

Farmer	Total area (ha)	Cropped area (ha)	Cropping system	Crop yield (kg/ha)		Land Treatment
				Rainy	Post-rainy	
Improved watershed						
1. Sher Singh	1.000	1.000	Soybean/Pigeonpea	813	430	FOC
2. Shivkant	1.700	0.900	Soybean+Fallow	1000	-	FOF
		0.800	Soybean/Pigeonpea	1500	761	BBF
3. Amarchand	5.600	5.600	Soybean+Lentil	762	*	FOC
4. Gulabchand	4.400	4.400	Soybean+Wheat	925	*	FOC
5. Bhavani	5.000	1.000	Soybean/Pigeonpea	500	470	BBF
		2.000	Fallow+wheat	-	620**	-
		2.000	Fallow+Lentil	-	210	-
6. Shaik Hafiq	1.200	1.200	Soybean+Lentil	600	*	FOC
7. Sumitrabai	2.200	1.000	Soybean+Wheat (.2) +Fallow(.8)	515	1000** -	FOC
		0.800	Soybean/Pigeonpea	675	480	BBF
		0.400	Soybean/Pigeonpea	467	420	FOF
8. Mukesh Kumar	3.800	1.200	Soybean+Chickpea	500	520**	FOF
		2.200	Soybean+wheat & C.pea +Fallow(1.8)	380	1210** -	FOC
		0.400	Soybean/Pigeonpea	850	640**	FOC
9. Pooran Singh	0.800	0.800	Soybean+Chickpea	600	*	BBF
10. Balkishan	0.400	0.200	Soybean+Fallow	766	-	FOC
11. Omrao	0.400	0.400	Soybean+Fallow	433	-	FOC
12. Harbai	3.330	2.400	Soybean/Pigeonpea	312	990	BBF
		0.930	Fallow+Wheat	-	480	-
13. Ramcharan	1.200	1.200	Soybean/Pigeonpea	562	700	BBF
14. Bhagirath	1.200	0.400	Soybean/Pigeonpea	667	805	BBF
		0.700	Fallow+Wheat	-	346	-
		0.100	Fallow+Lentil	-	230	-
15. Ramvatibai	2.400	0.500	Soybean/Pigeonpea	424	496	BBF
		1.900	Fallow+Lentil	-	230	Flat
16. Shaukat Ali	1.610	0.500	Soybean+Fallow	375	-	FOC
		0.500	Soybean/Pigeonpea	400	540	BBF
		0.610	Fallow+Wheat	-	480	Flat
17. Pannalal Chamar	0.320	0.320	Soybean/Pigeonpea	320	458	BBF
18. Vali Mohd.	1.720	1.200	Soybean/Pigeonpea	637	565	BBF
		0.520	Fallow+Lentil	-	330	Flat
19. Laxmi Narayan	2.020	1.000	Soybean+ Chickpea	650	670**	FOC
		0.200	Fallow+ Wheat	-	1050**	
20. Ramcharan	2.030	1.200	Soybean+Chickpea	812	553**	BBF
		0.400	Fallow+Wheat	-	1240**	Flat
		0.430	Fallow-Chickpea	-	553**	Flat

* Crop failed due to lack of moisture
** Irrigated wheat crop

Appendix VIc (contd.)

ICRISAT watershed and traditional fields crop yield data Begumganj, Madhya Pradesh - 1984-85 (contd..)

Farmer	Total area (ha)	Cropped area (ha)	Cropping system	Crop yield (kg/ha)		Land Treatment
				Rainy	Post-rainy	
21. Khatoon Bee	2.420	2.420	Soybean/Pigeonpea	687	563	BBF
22. Shafique	1.070	0.870	Soybean+Wheat	825	1010**	FOG
		0.200	Soybean+Wheat	430		BBF
23. Akram	3.940	1.500	Soybean/Pigeonpea	475	330	BBF
		2.440	Fallow+Wheat	-	370	Flat
24. Sayeed	2.950	0.500	Soybean/Pigeonpea	972	500	FOG
		2.450	Fallow+Wheat	-	360	Flat
25. Mujjaffar Hussain	4.030	2.030	Soybean/Pigeonpea	587	600	FOF
		2.000	Soybean/Pigeonpea	657	525	FOF.
26. Khalid	4.450	3.000	Soybean/Fallow	656	-	FOG
			Soybean+Wheat(0.2)	656	1174**	
			Soybean+Chickpea(0.2)	656	629**	
27. Israr	4.450	2.000	Soybean+Wheat	512	1500**	FOG
		2.450	Fallow+Wheat	-	880**	Flat
28. Halimunnisa	1.550	1.000	Soybean+Fallow	587	-	FOG
29. Ram Narayan	2.420	1.000	Fallow +Linseed (0.5)		386	FOG
		0.420	Soybean-P.Pea	476	530	Flat
		0.500	Fallow+Wheat	-	410	Flat
30. Bhayelal	0.530	0.530	Soybean/Pigeonpea	325	567	BBF
31. Kashiram	0.800	0.800	Soybean/Pigeonpea	575	616	BBF
32. Ramvati	5.090	0.800	Soybean/Pigeonpea	641	520	BBF
		0.200	Soybean/Pigeonpea	466	367	FOG
		1.000	Fallow+Lentil	-	340	Flat
		1.090	Fallow+Linseed	-	350	Flat
		1.000	Fallow+Wheat & Chickpea	-	575	Flat
		1.000	Fallow+Wheat	-	640	Flat
33. Ramprasad	0.900	0.500	Soybean/Pigeonpea	250	520	BBF
		0.400	Soybean/Pigeonpea (0.2)	370	440	FOG
			Soybean+Wheat (0.2)	370	580**	FOG
34. Pyarelal	11.000	0.500	Soybean/Pigeonpea	750	575	FOG
		3.000	Soybean+Fallow	500	-	FOG
		2.000	Fallow+Lentil	-	315	Flat
		5.500	Fallow+Linseed	-	380	Flat
35. Sheikh Bahaddur	1.000	1.000	Soybean/Pigeonpea	325	610	FOG

IWMP watershed and traditional fields crop yield data
Begumganj, Madhya Pradesh - 1984-85 (contd...)

Farmer		Total area (ha)	Cropped area (ha)	Cropping system	Crop yield (kg/ha)		Land Treatment
					Rainy	Post-rainy	
36.	Rahim Karim	5.170	0.500	Soybean+Fallow	150	-	BBF
			1.175	Fallow+Lentil	-	420	Flat
			3.495	Fallow+Wheat	-	920	Flat
37.	Shafiq	1.700	0.300	Soybean+Chickpea	450	980**	BBF
			0.700	Fallow+Lentil	-	300	Flat
			0.700	Fallow+Wheat	-	515	Flat
38.	Khatoom Bee	2.640	2.640	Soybean/Pigeonpea	562	740	BBF
39.	Habib Mohd.	1.990	1.990	Soybean/Pigeonpea	562	770	BBF
40.	Iqbal (Jee Miya)	0.870	0.870	Soybean/Pigeonpea	697	427	BBF
41.	Gopal Singh	5.050	1.700	Soybean/Pigeonpea	631	966	FOO
			0.800	Soybean/Pigeonpea	567	540	BBF
			1.500	Fallow+Lentil	-	300	Flat
			1.000	Fallow+Wheat	-	530	Flat
42.	Shahjahan Bee	2.280	2.280	Soybean/Pigeonpea	245	560	FOO
43.	Tulsi Ram	1.990	1.990	Soybean/Pigeonpea	568	640	FOO
44.	Dwaraka Prasad	5.750	2.000	Soybean/Pigeonpea	556	550	FOO
			0.750	Fallow+Linseed	-	355	Flat
			1.500	Fallow+Lentil	-	295	Flat
			1.500	Fallow+Wheat	-	420	Flat
45.	Nasama	0.220	0.220	Soybean+Fallow	664	-	FOO
Traditional Fields:							
1.	Amarchand	3.000	3.000	Soybean/Pigeonpea	975	580	Flat
2.	Sher Singh	2.000	2.000	Soybean/Pigeonpea	725	375	"
3.	Sukar Ali	1.300	1.300	"	480	418	"
4.	Keertiya	1.300	1.300	"	800	390	"
5.	Halkai Sahu	0.350	0.350	"	800	196	"
6.	Mula Chaudhary	0.500	0.500	"	550	255	"
7.	Rishi Kumar	1.000	1.000	"	1030	640	"
8.	Shiv Dhan Singh	3.600	3.600	Soybean+Fallow	150	-	"
9.	Shankar Lal	0.920	0.920	"	177	-	"
10.	Ramprasad	0.500	0.500	"	1062	-	"
11.	Ram Shankar Jain	1.600	1.600	"	1119	-	"

IWMT watershed and traditional fields crop yield data
Begumganj, Madhya Pradesh - 1984-85 (contd..)

Farmer		Total area (ha)	Cropped area (ha)	Cropping system	Crop yield (kg/ha)		Land Treatment
					Rainy	Post-rainy	
12.	Abdul Wahid	0.600	0.600	Soybean+Fallow	1024	-	Flat
13.	Bhagwan Singh	0.950	0.950	"	663	-	"
14.	Bala Ram	0.550	0.550	"	1090	-	"
15.	Ganpat	1.600	1.600	"	390	-	"
16.	Motilal Sharma	1.700	1.700	"	706	-	"
17.	Sultan Singh	4.000	4.000	"	375	-	"
18.	Rahim Karim	1.260	1.260	Fallow+Wheat	-	540	"
19.	Mohan Lal	4.000	2.800	"	-	410	"
			1.200	Fallow+Linseed	-	280	"
20.	Dayachand	1.320	1.320	Fallow+Wheat	-	260	"
21.	Panmalal Sahu	3.710	1.700	"	-	370	"
			1.100	Fallow+Lentil	-	220	"
			0.910	Fallow+Linseed	-	340	"
22.	Tej Singh	1.260	1.260	Fallow+Wheat	-	320	Flat
23.	Mohd. Ishaq	3.220	3.220	Fallow+Lentil	-	370	"
24.	Kunwarbai	1.720	1.720	"	-	330	"
25.	Khuman Singh	1.520	1.520	"	-	190	"
26.	Pooran Singh	0.550	0.550	"	-	280	"
27.	Hussain Khan	1.610	1.610	Fallow+Linseed	-	220	"
28.	Munwar Ali	1.610	1.610	"	-	180	"
29.	Jamna Prasad	1.590	1.590	"	-	260	"

Appendix VIIa

Economics of the Improved Integrated-based Technology Options on Rice Varietals in the Rajnandgaon District, Madhya Pradesh.

Cropping systems	Proportions grown	Gross returns[a]	Operational costs	Gross profits	YIELDS			No.of plots
						Grain	Fodder	
	%	Rs/ha				kgs/ha	Qtls/ha	
DEMONSTRATIONS[b]								
Sorghum-pigeonpea intercrop	32	3144	1405	1739	Sorghum Pigeonpea	283 673	20 20	4
Sorghum-pigeonpea-chickpea[c]	7	4712	2210	2502	Sorghum Pigeonpea	100 1173	16 20	2
Soybean-pigeonpea-chickpea	18	6705	3250	3535	Soybean Pigeonpea Chickpea	811 1135 42	14 24 -	3
Soybean-pigeonpea-lentil	2	5579	3347	2232	Soybean Pigeonpea Lentil	543 1045 -	9 20 -	1
Soybean-wheat-sequence	24	7257	2450	+193	Soybean Wheat	695 568	6 6	3
Soybean-wheat-Chickpea	7	3644	3457	+813	Soybean Wheat Chickpea	389 779 -	9 8 -	1
Soybean-Chickpea-Mustard	8	3898	3303	295	Soybean Chickpea Mustard	995 633 150	7 5 -	1
Soybean-linseed-	8	3172	2476	696	Soybean Linseed	940 354	7 -	1
Soybean-lentil	2	6625	3410	3215	Soybean Lentil	1320 1090	10 20	1
Weighted averages	100	3520	2348	1172				
TRADITIONAL FARMERS' FIELDS[b]								
Pigeonpea sole	2	2182	474	1708	Pigeonpea	572	9	1
Soybean sole	4	1497	963	534	Soybean	514	11	5
Wheat sole	7	1332	962	370	Wheat	667	7	3
Wheat-chickpea intercrop	34	1452	954	498	Wheat Chickpea	582 125	7 -	3
Chickpea sole	22	1264	920	344	Chickpea	572	4	3
Lentil sole	24	2421	741	1680	Lentil	787	23	3
Linseed sole	7	1468	664	796	Linseed	307	-	3
Weighted Averages	100	1652	866	786				

a. Prices in Rs. per quintal are:

Grain	Rs/qtl.	Fodder	Rs/qtl.
Sorghum	180	Sorghum	10
Soybean	250	Soybean	20
Pigeonpea	200	Pigeonpea stalks	12.5
Wheat	180	Wheat	20
Lentil	250	Lentil	20
Chickpea	210	Chickpea	15
Mustard	375		
Linseed	475		

b. Data refer to 24 ha of watershed and 19.86 ha. of traditional farmers' fields.

c. In these two plots, chickpea gave no production.

Appendix VIIb

Economic evaluation of the improved watershed-based technology options on deep vertisols in the Bogumgunj watershed, Madhya Pradesh, 1983-84.

Cropping systems	Land and water management	Proportions grown	Gross returns	Operational costs	Gross profits[a]	Crops	Yields: Grain	Yields: Fodder	No. of plots
			---- Rs/ha ----				kg/ha	Qts/ha	
IMPROVED WATERSHED[b]									
Soyabean-pigeonpea intercrop	BBF	80	5036	2310	2726	Soyabean Pigeonpea	1013 478	10 13	8
Soyabean-pigeonpea intercrop	Flat on grade	5	4507	2172	2335	Soyabean Pigeonpea	830 476	8 15	1
Soyabean-wheat	BBF, Flat on grade	20	5378	2261	3117	Soyabean Wheat	1078 969	11 9	1
Soyabean-chickpea	Flat on grade	13	4877	2532	2345	Soyabean Chickpea	850 709	10 -	1
Weighted averages		100	5064	2321	2743				11
TRADITIONAL FARMERS' FIELDS[b]									
Soyabean-pigeonpea intercrop	Traditional	10	4584	1497	3087	Soyabean Pigeonpea	654 679	6 10	3
Soyabean-wheat sequence	Traditional	25	3888	1488	2400	Soyabean Wheat	739 773	7 7	3
Soyabean-chickpea sequence	Traditional	15	4690	1781	2909	Soyabean Chickpea	550 980	5 -	1
Fallow-wheat	Traditional	30	1315	914	401	Wheat	664	6	3
Fallow-chickpea	Traditional	20	1685	957	728	Chickpea	555	-	3
Weighted averages		100	2861	1250	1611				13

a. Prices in rupees per quintal are:

Grain	Rs/100 kg	Fodder	Rs/100 kg
Soyabean	300	Soyabean	20
Pigeonpea	350	Pigeonpea	12.5
Wheat	180	Wheat	20
Chickpea	300		

b. Data refer to 14.7 ha of watershed and 9.8 ha of traditional farmer's fields.

Appendix VIIc

Economic evaluation of the improved watershed-based technology options on deep Vertisols in the Begumganj watershed, Madhya Pradesh, 1984-85.

Cropping systems	Land and water management	Proportions grown	Gross returns	Operational costs	Gross profits[a]	Yields: Crops	Yields: Grain	Yields: Fodder	No. of plots
			..... Rs/ha				kg/ha	qts/ha	
IMPROVED WATERSHED[b]									
Soybean-pigeonpea intercrop	Broadbeds & Furrows	22	4277	1294	2983	Soybean pigeonpea	866 629	12 29	21
Soybean-pigeonpea intercrop	Furrows on flat	5	4243	1267	2976	Soybean Pigeonpea	628 557	13 32	4
Soybean-pigeonpea intercrop	Flat on grade	11	3908	1090	2818	Soybean Pigeonpea	531 559	11 28	11
Soybean-wheat	Flat on grade	4	2768	1733	1035	Soybean Wheat	901 25	19 -	2
Soybean-lentil	Flat on grade	7	2206	1519	687	Soybean Lentil	733 c	15 c	2
Soybean-fallow	Broadbeds & Furrows	2	1861	1056	808	Soybean	617	13	2
Soybean-fallow	Furrows on flat	2	2325	980	1345	Soybean	771	16	2
Soybean-fallow	Flat on grade	9	1593	791	802	Soybean	528	11	8
Fallow-wheat	Flat on grade	17	953	490	463	Wheat	474	5	11
Fallow-wheat + chickpea	Flat on grade	2	966	622	344	Wheat Chickpea	481 c	5 c	2
Fallow-linseed	Flat on grade	7	1795	501	1294	Linseed	374	-	4
Fallow-lentil	Flat on grade	12	1170	488	682	Lentil	300	6	10
Weighted averages			2523	945	1578				
TRADITIONAL FARMERS' FIELDS[b]									
Soybean-pigeonpea intercrop	Traditional	19	4285	1285	3000	Soybean Pigeonpea	806 463	16 20	7
Soybean-fallow	Traditional	11	1549	894	655	Soybean	511	11	10
Fallow-wheat	Traditional	42	771	465	306	Wheat	384	4	5
Fallow-linseed	Traditional	18	1181	313	868	Linseed	246	-	5
Fallow-lentil	Traditional	10	1174	419	755	Lentil	301	6	5
Weighted averages			1638	636	1002				

a. Prices used were based on actual realized or market prices. They were as follows:

Grain	Rs/100 kg	Fodder	Rs/100 kg
Soybean	260	Soybean	20
Pigeonpea	350	Pigeonpea	12.50
Wheat	180	Wheat	20
Lentil	350	Lentil	20
Linseed	480		

b. Data refer to 102.60 ha of watershed, and 48.84 ha of traditional farmers' fields.

c. Crop failed. No yields.

Input cost and returns from different treatments in the Bagumpanj watershed 1984-85

Cropping pattern	Plot		Yield* kg/ha		Physical input cost		Total operational cost		Gross Profits		Remarks
	No.	Area ha	Rainy season	Postrainy season	Average	Range	Average	Range	Average	Range	
Soybean:Pigeonpea BBF	21	22.4	566 (250-1500)	629 (330-950)	679	580-852	1294	1143-1648	2983	1346-6053	
Soybean:Pigeonpea FOF	4	4.83	628 (468-850)	557 (420-660)	668	490-705	1267	948-1551	2976	2220-3634	
Soybean:Pigeonpea FOG	11	11.37	480 (245-1065)	575 (365-640)	487	268-816	1090	732-1935	2818	952-4318	
Soybean:Wheat FOG	2	4.6	901 (370-925)	25 (0 - 50)	948	860-952	1733	1728-1830	1035	451-1056	Failure of wheat crop in one plot
Soybean:Lentil FOG	2	6.8	733 (600-762)		892	827-906	1519	1221-1504	687	1811-2290	Failure of lentil crop
Soybean:Fallow BBF	2	1.7	617 (150-812)	-	645	587-784	1056	1016-1151	888	- 681-1435	No postrainy season crop could be established
Soybean:Fallow FOF	2	1.7	771 (518-1000)	-	616	571-655	980	900-1052	1345	642-1984	Farmer could not sow the rabi crop due to lack of moisture. Few plots gave low yield
Soybean:Fallow FOG	8	9.72	528 (374-765)	-	422	206-651	791	540-1078	802	69-1560	Minimum operational cost. However, low yields, low output value; hence low profits
Fallow-Wheat FOG	17	17.63	-	474 (360-640)	224	167-346	490	395-621	463	141-829	Chickpea crop failed
Fallow-Wheat+C.Pea FOG	2	1.7		481 (346-576)	315	264-350	622	580-646	344	107-509	Low input and high crop value gave reasonably good return
Fallow-Linseed FOG	4	7.84		373 (350-386)	110	92-240	501	356-694	1294	1140-1324	Very low yield in one plot
Fallow-Lentil FOG	10	12.1		300 (210-419)	160	120-358	488	358-962	682	-97-1283	

(*) Yields are weighted with proportionate area of the plot; Figures in parenthesis represent range

Appendix VIIIa

Input cost and returns from traditional farmers fields in Begumganj 1984-85

Cropping System	No. of plots	Proportionate groun	Yields		Physical input cost		Total operational cost		Gross profits		Remarks
			Average	Range	Average	Range	Average	Range	Average	Range	
Soybean Pigeonpea intercrop	7	19	806	480-975	571	414-665	1285	1153-1442	3000	1916-4298	Good soybean yield resulted in high gross profits
Soybean Fallow	10	11	511	150-1119	496	261-774	894	484-1342	655	-82-2408	
Fallow Wheat	5	42	384	260-540	227	198-258	465	425-485	306	60-659	
Fallow Linseed	5	18	246	180-339	82	67-93	313	258-342	868	606-1292	
Fallow Lentil	5	10	301	190-370	171	79-256	419	278-576	755	468-936	

Appendix VIII