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ABSTRACT

This paper examines the economics of on-farm watershed experiments conducted by the Farming Systems Research and Economics Programs in the regions of Akola and Sholapur in Maharashtra, and Mahbubnagar in Andhra Pradesh during 1979-80 and 1980-81. The results suggest that use of HYV seeds and chemical fertilizers with precision placement can substantially increase crop yields. However, the profits from improved watershed technology were not significantly different to profits from traditional systems except in the Alfisol village in Mahbubnagar in the comparatively dry year of 1980-81. The broadbed and furrow system did not increase profits in the Alfisols of Mahbubnagar and the medium deep Vertisols of Akola. In the unreliable rainfall deep Vertisol region of Sholapur it would not seem viable to grow rainy season crops, although improving post-rainy season crops has some promise.

Economic Assessment of Improved Watershed-based Technology Options in On-farm Experiments

R. Sarin and J. G. Ryan*

INTRODUCTION

Research at ICRISAT Center has shown the potential for significantly increasing production by adopting improved watershed-based technologies. However there is lack of information on the extent to which these technologies can be successfully implemented in farmers' fields because of climatic, social, and economic differences. Keeping this in view a cooperative on-farm project was initiated in 1978 by ICRISAT in collaboration with the Indian Council of Agricultural Research (ICAR). Small-plot experiments were conducted in 1978-79 as part of the village level studies (VLS) to obtain preliminary information on suitable cropping systems and appropriate land and water management techniques in Aurepalle, Kanzara, and Shirapur villages in three agroclimatic regions of semi-arid tropical (SAT) India. In 1979-80 and 1980-81 operational-scale land and water-management experiments on a watershed basis involving groups of farmers were initiated in all three villages.

The specific objectives of the research were:

1. To adapt, test, and measure the performance of prospective land and water-management technology options in farmers' fields;

2. To find ways for farmers to participate in the technology development process and

3. To examine the need and feasibility of group action for adoption of watershed-based systems of resource development and management.

In this paper the approaches used in the conduct of the on-farm experiments are described and the economics of the research results are presented.

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* Research Technician and Principal Economist, Economics Program, ICRISAT, Patancheru P.O. 502 324, Andhra Pradesh, India.

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TECHNIQUES AND APPROACH

It was intended to generate methodologies to further develop, adapt, and test improved systems of farming in on-farm conditions. Because natural resource development is an important phase of the research project, small watersheds were selected for the experiments. The technology to be tested involved the following components: land smoothing and graded contour cultivation on broadbeds and furrows, improved drain improved varieties and fertilizers, improved crop management, improved tools and equipment, runoff collection and supplemental irrigation, credit and other institutional arrangements, cost and profit sharing, marketing produce, and group action. The project was discussed with the farmers, but the choice of cropping systems was left to them.

Information from the cooperative ICAR-ICRISAT project FS_1, entitled: "Resource development, conservation and utilization with reference to soil and water" and FS_2: "Hydrologic studies to improve land and water, utilization in small agricultural watersheds in SAT India" was used to design these on-farm tests. Agronomic recommendations were obtained from the All India Coordinated Research Project for Dryland Agriculture (AICRPDA) and local Agricultural Universities.

Two committees were formed to guide implementation of the project. The Technical Advisory Committee (ACT) designed the research project, provided technical options and information to farmers, and was responsible for developing policy guidelines. Scientists from AICRPDA, ICRISAT and the Agricultural Universities were members. The Local Advisory Committee (ACL) was constituted in each village and was concerned with the selection and actual implementation of development activities; the ACL ensured that the alternatives as suggested by the ACT took due account of local preferences and conditions. The final decision-maker on all aspects of the development plans as it affected individual plots was the cooperating farmer.

To test the performance of the prospective soil, water, and crop management technology, comparisons were made with VLS farmers' traditional systems in plots outside the watershed but of a similar soil type and depth. Twenty crop yield samples each of 24 square meters (8 x 3) were harvested both in watershed plots and in selected traditional farmers' plots for comparison. Data on use of seeds, fertilizers, plant protection, bullock, and human labor were recorded systematically on a daily basis in the experimental watershed and on a recall basis in the traditional plots. Agronomic and economic performance was used as the test criterion.

In the 1978-79 small-plot trials, ICRISAT completely subsidised the purchase of seeds, fertilizers, insecticides, etc. In both 1979-80 and 1980-81 when the watersheds were developed and larger farmers' plots were utilized for the experiments, ICRISAT made available all inputs on the basis of advances to the farmers. After harvest the accounts of all farmers were compiled to estimate costs, gross incomes (partly imputed) and profits for each crop/plot.

Farmers were guaranteed a profit at least as large as they would have achieved had they been growing traditional crops with traditional inputs and management. As mentioned, the economics of these plots was also estimated with the aid of records and crop yield samples. If the farmers achieved profits on the watershed plots of more than twice the level of profits achieved on the traditional plots then ICRISAT requested repayment of the earlier advances for inputs. Otherwise advances did not have to be repaid.

The land and water development on a watershed basis was initiated in early 1979 in three of the villages in ICRISAT's VLS. Only the results of the watershed experiments will be discussed. As the small-plot experiments in 1978-79 were of a diagnostic nature they will not be presented here. The salient features of the selected villages are contained in Appendix I. Further details can be found in Jodha et al. (1977)

RESULTS

Aurepalle Village

A 13.5 ha Alfisol watershed with soil depth varying from 10 cm to 45 cm involving 5 farmers was developed during the dry season of 1979 in Aurepalle village near Hyderabad, Andhra Pradesh, when draft animals and human labor were relatively underemployed. Farmers were quite cooperative and most of the required bullock and human labor was provided by them. Development activities consisted of removal of stones and bushes, cultivation, ridging, land smoothing, and establishment of broadbed and furrow system on a graded contour of 0.4 to 0.7%.

Total development costs were estimated to be around Rs. 482 per ha (Table 1). This included costs incurred in forming waterways, building drop structures and land preparation. The charges for human and bullock labor were based on village rates and included both family and hired labor. The wheeled tool carrier used in development and other operations was costed at the rate of Rs. 2.75 per hour, or Rs. 22 per day. This was based on a capital cost of Rs. 8500 and a working life of 5000 hours of operation. For the calculation of annual overhead costs of watershed development, all development costs such as land smoothing, ridge marking, provision of waterways and main drains, and the construction of drop structures were depreciated over a period of 20 years; operations like ploughing, cultivation, and bed-forming were depreciated over a period of 3 years. By doing so we arrived at a figure of Rs. 140 per hectare as the annual overhead cost of watershed development in Aurepalle. Subsequent costs of land preparation and cultivation which are annual requirements were charged for that particular crop year in addition to the Rs. 140 per hectare annual overhead costs of watershed development.[1]

Results from various experiments at ICRISAT have shown that significant returns may be obtained from supplementary irrigation of crops on Alfisols. To further test this in an on-farm situation a well belonging to a cooperating farmer in the watershed was renovated on the condition that the available water would be shared by other farmers for the two-year period of the experiment. The total cost of well renovation and re-cribbing was Rs. 1530. This cost has been excluded from the costs in Table 1.

Table 1. Costs of developing the small watershed in Aurepalle village.[a]

Operation	Costs
	Rs/ha
Cultivation	134
Land smoothing	76
Plowing	52
Forming broadbeds and furrows	156
Stones used for drop structures	49
Grasses for waterways	15
Total	482

a Includes costs of all human and bullock labor (family and hired) plus the wheeled tool carrier which was costed using a charge of Rs. 22 per day.

1. When the direct costs of seeds, fertilizers, insecticides, human and bullock labor, and implement hiring are deducted from crop gross returns (grain plus byproducts), a gross profit is derived. When the annual overhead costs of watershed development are then deducted from gross profits we arrive at a figure for net profits.

In 1979-80 the watershed was dry-planted to sorghum, groundnut, castor, pearl millet, and pigeonpea ahead of the onset of the monsoon season to study the effect of broadbeds and furrows compared to flat planting. The early part of the rainy season of 1979 was reasonably favorable in terms of the onset of the rains and the rainfall distribution, and a satisfactory crop stand was established. However, a long dry period occurred soon after and the crops were subject to serious moisture stress resulting in wilting of castor and the pearl millet/pigeonpea intercrop. Late season rains facilitated crop recovery.

The overall economic performance of the improved watershed-based technology was not satisfactory (Table 2). The net profits on the improved watershed were only 14% higher than on farmers' traditional plots and this difference was not statistically significant (t=0.69). Although much higher yields were achieved with the improved watershed-based technology using HYV seeds, chemical fertilizers, and improved crop management, profits were not substantially higher because of intensive use of inputs - especially chemical fertilizers. Total costs (material, human and bullock labor costs) with the improved technology were three times higher than with the traditional techniques used by farmers. The technology would undoubtedly be successful if the higher yields could be achieved with reduced costs.

Comparing broadbed and furrow treatments with flat cultivation methods keeping other components constant, significant differences were not evident; profits were higher with castor on broadbeds and furrows, whereas with pearl millet/pigeonpea intercrop the reverse was true. Irrigated groundnut grown on broadbeds and furrows was most profitable (Rs 1630/ha). This result supports the findings of other studies that there exists some potential from supplementary irrigation of high-value crops in Alfisols. The finding that the broadbeds and furrows were not superior to the flat system of cultivation under improved management in the Aurepalle Alfisol watershed confirms the accumulated evidence from research at ICRISAT Center.

Immediately after the harvest of the 1979-80 crops post-harvest cultivation was initiated in the watershed without disturbing the broadbeds and furrows. Other tillage operations followed and the seed beds were ready by May. Because of the early onset of the monsoon in 1980 the watershed was planted with sorghum, pearl millet and castor in late May. In addition to comparisons between improved and traditional farming systems on large-scale farmers' plots in 1980-81, smaller plot trials were also conducted. The treatments in the smaller plot trials were:

- broadbeds and furrows versus flat cultivation methods,

- planting using an improved drill and the wheeled tool

Table 2. Costs and profits from improved land, water, and crop management practices compared to traditional practices in Aurepalle village, 1979-80.[a]

Cropping system	Land management	Irrigated/ unirrigated	Gross returns	Total[b] costs	Net profits Mean	Net profits Standard deviation[c]
			-----------	Rs/ha	-----------	
IMPROVED WATERSHED						
Castor	Beds	Unirrigated	1206	916	290	188 (4)
	Flat	Unirrigated	1026	817	209	(1)
P.Millet/P.pea intercrop	Beds	Unirrigated	1152	803	349	292 (2)
"	Beds	Irrigated	1648	1085	563	76 (3)
	Flat	Unirrigated	1259	707	552	- (1)
Sole P.Millet	Beds	Irrigated	1503	1384	119	75 (2)
Sorghum/P.pea intercrop	Beds	Partly Irrigated	1494	1478	16	- (1)
Groundnut	Beds	Irrigated	3403	1772	1631	- (1)
All crops combined	Beds & flat	Unirrigated & irrigated	1364	1002	362	401 (15)
All crops combined	Beds	Unirrigated	1197	898	299	260 (6)
All crops combined	Flat	Unirrigated	1125	770	355	172 (2)
	Beds	Irrigated	1731	1260	471	516 (7)
TRADITIONAL FIELDS						
All crops combined	Flat	Unirrigated	569	251	318	271 (18)

a. All figures are weighted averages using crop areas as weights.

b. Costs include all materials, human and animal labor, annual overhead costs of development of watershed, annual costs of implements and cost of irrigation.

c. Figures in parentheses are the number of plots.

carrier versus use of a local seed drill, and

- local crop spacing versus a standard row spacing.

From these small plots only agronomic observations were made; no attempt was made to study the economics because of the very small size of the plots.

The total rainfall in 1980 was only 400 mm, which was 43% below normal. Though the onset of the monsoon was early, the rains also receded early and crops suffered due to late season drought. An economic analysis revealed that in this comparatively low rainfall year, increased profitability could still be achieved using the improved technology compared to traditional technology. The average net profits from the improved watershed plots were more than triple those from traditional fields (Table 3) and this difference was statistically significant at the 5% probability level (t=1.85).

Because of the early cessation of rains, pigeonpea and castor were adversely affected, resulting in losses from these two crops. Unlike 1979-80, in 1980-81 sorghum and its systems fared well, with profits of Rs. 1500/ha from sole sorghum for example. An attempt was made to reduce total input costs in 1980-81 by reducing the rates of application of fertilizer. On an average Rs. 950/ha was required to grow the crops with the improved watershed-based technology compared to Rs. 1000/ha in 1979-80.

In Aurepalle farmers usually grow either sole castor or castor intercropped with a few lines of pigeonpea. In 1980-81 a new combination of cereals and castor was tried and resulted in reasonable success. Cereal/castor intercrops under the improved watershed-based technology generated average net profits of Rs. 319/ha, whereas losses of around Rs. 86/ha were incurred when sole castor was grown using traditional technology.

Because of variations in moisture storage capacity (soil depth varying from 10 cm to 45 cm depth) crop yield levels and returns varied widely across farmers' fields within the watershed (Shetty et al. 1981). Combining two years results a question arises as to whether the broadbed and furrow system is suitable for Alfisols or not? Though it appeared that the broadbeds and furrows are necessary to obtain precision control in seeding and fertilization, there were no significant differences in mean profits between crops planted on the flat and those planted on broadbeds and furrows holding other factors constant (t=0.28). The utility of the wheeled tool carrier in providing precision planting and fertilizer application was evident in both years. The improved system was more superior to the traditional system in terms of yields and profits in 1980-81 than in 1979-80. The reason may be the earlier planting, better crop management and a good rainfall distribution in 1980-81.

Table 3. Costs and profits from improved land, water, and crop management practices compared to traditional practices in Aurepalle village, 1980-81.[a]

Cropping system	Land management	Irrigated/ unirrigated	Gross returns	Total[b] costs	Net profits Mean	Standard deviation[c]
				-Rs/ha-		
IMPROVED WATERSHED						
Sole sorghum	Beds	Unirrigated	2542	999	1543	340 (3)
Sorghum/pigeonpea intercrop	Beds	Unirrigated	1679	1040	639	348 (4)
Millet/pigeonpea intercrop	Beds	Unirrigated	1328	964	364	335 (4)
Sole castor	Beds	Unirrigated	891	872	19	198 (5)
Sorghum/castor intercrop (2:1)	Beds	Unirrigated	1764	1036	728	406 (2)
Castor/sorghum intercrop (2:1)	Beds	Unirrigated	1024	1083	(-59)	703 (3)
Millet/castor intercrop (2:1)	Beds	Unirrigated	1284	1003	281	120 (2)
Castor/millet intercrop (2:1)	Beds	Unirrigated	1005	984	21	30 (2)
All crops combined	Beds	Unirrigated	1326	953	373	553 (25)
Cereal/pigeonpea intercrops	Beds	Unirrigated	1562	1015	547	360 (8)
Cereal/castor intercrops	Beds	Unirrigated	1347	1028	319	494 (9)
TRADITIONAL FIELDS						
All crops combined	Flat	Unirrigated	407	284	123	223 (19)
Sorghum mixture	Flat	Unirrigated	494	243	251	172 (9)
Castor	Flat	Unirrigated	218	304	(-86)	174 (10)

a. All figures are weighted averages using crop areas as weights.

b. Costs include all material, human and animal labor, annual overhead costs of development of watershed, and annual costs of implements.

c. Figures in parentheses are the number of plots.

Shirapur Village

Shirapur village is located about 25 km northwest of Sholapur in Maharashtra state. It receives an average annual rainfall of 691 mm; the rainfall during the early rainy season is very uncertain (Appendix 1). The soils are mostly deep Vertisols. Monsoon fallowing is a common practice in this area.

A watershed of 13.9 ha involving 8 farmers was selected for the study in March 1979. Development work started immediately with the cooperation of farmers. Soils were very hard so chiselling with the wheeled tool carrier was carried out before other tillage operations. A single pair of bullocks was not able to operate the tool carrier in these hard soils, so two pairs of bullocks were used for chiselling, plowing and other operations. This is generally the practice in this area when using the traditional iron moldboard plough for deep cultivation once in every three or four years. The wages paid for hiring a pair of bullocks ranged from Rs. 20-30 per day. The initial development costs at Shirapur were Rs. 597/ha (Table 4). The total annual overhead costs for development of the watershed were estimated to be Rs. 136/ha.

Table 4. Costs of developing the small watershed in Shirapur village[a]

Operation	Costs
	Rs/ha
Chiselling	58
Plowing	106
Blade harrowing	26
Land-shaping	68
Cultivation	37
Forming broadbeds and furrows	91
Waterways and structures	211
Total	597

a Includes costs of all (family and hired) human and bullock labor plus the wheeled tool carrier which was costed using a charge of Rs. 22 per day.

The watershed was dry-planted to pearl millet/pigeonpea intercrop and mungbean in June 1979. The early part of the rainy season was favourable but soon thereafter the rains ceased and the planted crops began wilting. As a result the pearl millet and mungbean crops completely failed, whereas pigeonpea survived the drought.[2] All farmers uprooted the pearl millet and mungbean. Farmers wanted to uproot pigeonpea also but on the advice of ICRISAT scientists two of them relented.

The economics of the improved watershed technology was assessed with and without inclusion of the costs incurred in raising these rainy season crops (Table 5). Sorghum yields with the watershed technology were about three times that of the traditional sorghums. Considering only postrainy season sorghum (excluding expenditures incurred on the rainy-season crops which failed), profits with improved technology were about 150% higher than the crops on traditional fields throughout the village, and this difference was statistically significant at the 1% probability level ($t=2.6$). For the comparison of profitability of the improved system with the traditional in Table 5 we selected plots with similar soil depths throughout the village irrespective of their location. However cooperating watershed farmers stressed the need for comparing their watershed profits with adjacent plots having similar soils. They claimed that land on and near the selected watershed was the best available land in the village. The improved technology was less profitable than immediately adjacent traditional plots, where profits of Rs. 1000/ha were obtained, but the difference was not statistically significant ($t=0.8$). Farmers were not happy with the performance of the technology.

Shirapur watershed farmers agreed to provide their land once again for the 1980-81 season after a lot of pleading from ICRISAT. It was decided to attempt planting in the rainy season with a precondition that there was at least 25 cm of moist soil in the top layer of the profile. This occured only during the beginning of August which was too late to plant a rainy season crop. Farmers did not agree with the suggestion to plant pigeonpeas on part of the watershed at that time. They were reluctant to plant any rainy season crop as they have only sown postrainy season crops in the past.

Land preparation and the cultivation of the beds in the watershed were done during the 1980 dry season. There was a severe infestation of Cynodon Dactylon perennial weed in the watershed and cultivation

2. On the basis of soil moisture probabilities Binswanger et al. (1980) have shown that the probability of a 90-day crop encountering adequate moisture conditions is only 30% in undependable rainfall regions like Sholapur (Appendix II).

Table 5. Costs and profits from improved land, water, and crop management practices compared to traditional practices in Shirapur village, 1979-80.[a]

Cropping system		Land management	Gross returns	Total[b] costs	Net profits	
					Mean	Standard deviation[c]
			------	Rs/ha	------	------
IMPROVED WATERSHED						
Rainy season Postrainy season	- Pearl millet/pigeonpea intercrop - Sorghum[c]	Beds	1761	823	938	258 (6)
Rainy season Postrainy season	- Mungbean - Sorghum[c]	Beds	1461	619	842	288 (8)
Rainy season Postrainy season	- Pearl millet/pigeonpea intercrop - Sorghum[d]	Beds	1761	1179	582	392 (6)
Rainy season Postrainy season	- Mungbean - Sorghum[d]	Beds	1461	936	525	293 (8)
TRADITINAL FIELDS						
Rainy season Postrainy season	- Fallow - Sorghum	Flat	575	220	355	467 (11)

a. All figures are weighted averages using crop areas as weights.

b. Costs include all materials, human and animal labor, annual costs of implements, and annual overhead costs of development of watershed.

c. Costs involved in growing rainy season crops were not included.

d. Costs include expenditure incurred on rainy and postrainy season crops.

e. Figures in parentheses are the number of plots.

with the wheeled tool carrier could not control it. The tool carrier was able to remove weeds from the furrows but not from the raised beds. Considerable expenditure was incurred to keep the watershed area free of weeds. Traditional plots were generally free of this weed because of continuous harrowing in both directions during the rainy season using the traditional blade harrow.

Rains were received in the month of August and early September 1980, and postrainy season sorghum was planted in the watershed plots. In general, growth was poor. During 1980-81 one of the cooperating farmers installed an irrigation pipeline from the river Sina up to his watershed field. Two farmers irrigated their watershed sorghum crops from this source.

In terms of yields, the sorghum cultivar CSH-8R performed well, in the improved watershed, followed closely by the locally improved cultivar M-35-1 (Shetty et al. 1981). However, the profits from unirrigated M-35-1 were Rs.300/ha higher than CSH-8R (Table 6). This was because of the higher prices received for M-35-1 grain and fodder. The effect of irrigation on yields was greater on CSH-8R compared to M-35-1, however total profits were almost the same. This supports the farmers' preference for M-35-1. Farmers feel that M-35-1 is more stable and is preferred by consumers because of taste and other cooking qualities. In addition, its straw is preferred by bullocks.

Farmers growing unirrigated M-35-1 outside the watershed in 1980-81 earned profits of around Rs. 620/ha, compared to Rs. 1620 per ha with the improved watershed technology. This difference in mean profits was statistically significant at the 0.5% probability level ($t=4.22$). When we compared the improved watershed profits with adjacent plots the difference was only Rs. 100 per ha in favor of the improved watershed, and this difference was not statistically significant ($t=0.67$).

Hence the results of the two years 1979-80 and 1980-81 showed that there were no significant differences in the profits from the improved watershed technology compared to traditional farmers' plots in adjacent fields. However, the watershed profits in general were substantially higher than village traditional plots.

Kanzara Village

Kanzara is located about 46 km east of Akola in Maharashtra. The area receives an average annual rainfall of 817 mm and soils are medium-deep Vertisols. A watershed of 12 ha involving 6 farmers was selected for the experiments.

Table 6. Costs and profits from improved land, water, and crop management practices compared to traditional practices in Shirapur village, 1980-81.[a]

Postrainy season crop	Land manage-ment	Irrigated/ unirrigated	Gross returns	Total[b] costs	Net profits Mean	Standard deviation[c]
IMPROVED WATERSHED						
Sorghum HYV (CSH-8R)	Beds	Unirrigated	2236	923	1313	247 (5)
Sorghum HYV (CSH-8R)	Beds	Irrigated	3439	1689	1750	289 (2)
Local sorghum (M-35-1)	Beds	Unirrigated	2503	881	1622	333 (5)
Local sorghum (M-35-1)	Beds	Irrigated	3292	1565	1727	197 (2)
TRADITIONAL FIELDS						
Sorghum (M-35-1)	Flat	Unirrigated	888	269	619	428 (5)

a. All figures are weighted average using crop areas as weights.

b. Costs include all materials, human and animal labor, annual overhead costs of development of watershed, annual cost of implements.

c. Figures in parentheses are the number of plots.

Since the soil was very hard it was necessary to plow the fields prior to development. Plowing with the Kirloskar mouldboard plow and with the wheeled tool carrier required at least 2 pairs of bullocks with 2-3 men. Plowing every year is not a normal practice in this village and no dry planting is practiced, the land usually being prepared after the onset of the monsoon. This created problems in implementing the technology. Finally only two farmers decided to participate in the experiment on this watershed in 1979-80. Another farmer located on a small watershed studied earlier in 1978-79 also opted to cooperate in the experiment.

The broadbeds and furrows were laid out in the plots of cooperating farmers in the new watershed; whereas in the old watershed half of the area broadbeds and furrows were made and the other half was left flat for comparison. The watershed was dry planted to groundnuts, sorghum/pigeonpea intercrop, and a cotton mixture. The initial rains were normal but afterwards there was a dry spell and sorghum suffered moisture stress. Net profits from the improved watershed technology were only 20% higher than the traditional technology. The details are not reported because of the very small area involved in 1979-80.

After the harvesting of 1979-80 season crops, farmers were called to a meeting to discuss plans for 1980-81 on the 10.8 ha watershed. Seven farmers showed interest in cooperating with ICRISAT. Land preparation activities were carried out and the watershed was planted with cotton mixture, sorghum, and groundnuts. In 1980 only 673 mm rainfall was received, compared to the 1979 rainfall of 1050 mm. The distribution of the rainfall was also not favorable. Crops like pigeonpea and cotton suffered most. There were heavy showers during July/August resulting in some waterlogging and this affected crop growth in both the beds as well as the flat planted areas. Subsequently there was a long dry spell.

The performance of the improved watershed-based technology was not impressive compared to traditional farmers' plots in 1980-81. Net profits were only 28% higher than traditional fields and the difference was not statistically significant (t=0.39) (Table 7). Because of the use of HYV's, optimum fertilization, and extensive use of pesticides, crop yields were superior to the traditional systems. The additional returns from these higher yields were nullified by the additional input costs. Over the two years the conclusion is that in Kanzara the improved technology did not offer much scope for improving farm incomes.

Table 7. Costs and profits from improved land, water, and crop management practices compared to traditional practices in Kanzara village, 1980-81.[a]

Cropping pattern	Land manage-ment	Gross returns	Total[b] costs	Net profits Mean	Net profits Standard deviation[c]
			-Rs/ha-		
IMPROVED WATERSHED					
Cotton mixture (local)	Beds	1358	1593	(-235)	203 (4)
Sorghum/pigeonpea intercrop	Beds	2012	1217	795	385 (3)
Cotton/pigeonpea intercrop	Beds	1360	1296	64	482 (3)
Sole groundnut	Beds	2264	1523	741	229 (2)
Cotton hybrid	Beds	3159	2153	1006	- (1)
Sorghum sole	Beds	2276	1436	840	- (1)
All crops combined	Beds	1823	1480	343	603 (14)
TRADITIONAL FIELDS					
All crops combined	Flat	856	588	268	244 (11)

a. All figures are weighted averages using crop areas as weights.

b. Costs include all materials, human and animal labor, annual overhead costs of development of watershed, and annual costs of implements.

c. Figures in parentheses are the number of plots.

CONCLUSIONS

The experience with these improved watershed-based farming systems options over two years in three contrasting agroclimatic situations suggests that use of HYV seeds and chemical fertilizers with precision. Placement can substantially increase crop yields. However, only in some cases were the enhanced yields translated into significant increases in profits, as in the Alfisol village of Aurepalle where HYV seeds and fertilizers generated large and significant increases in profits compared to traditional systems, especially in the drier year. This was not generally the case in the two Vertisol villages, although improving post-rainy season crops in the drought-prone region of Sholapur does seem to have promise.

Broadbeds and furrows did not offer greater profitability in Kanzara medium-deep Vertisols or in the Aurepalle Alfisols, the two situations where comparisons with flat planting were possible. Profits from flat cultivation were not significantly different from those on the broadbed and furrow plots when both were implemented using the same crops, HYV's, fertilizers, and management. Effective weed control may also become increasingly difficult on broadbeds and furrows unless they are ploughed, cultivated, and reformed on a regular basis.

It would not seem viable to grow rainy-season crops on deep Vertisols in relatively unassured rainfall regions such as Sholapur. It seems preferable to focus on improving the productivity of post-rainy season crops in such agroclimatic environments.

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Appendix 1. Some characteristics of the on-farm research sites, 1978-81.

Characteristics	State: District: Village:	Andhra Pradesh Mahbubnagar Aurepalle	Maharashtra Sholapur Shirapur	Maharashtra Akola Kanzara
Distance from ICRISAT Center (km)		100	300	500
Average annual rainfall (mm)		713	691	817
Soil type		Shallow to medium Alfisols	Deep Vertisols	Shallow to medium-deep Vertisols
Important crops		Sorghum Castor Pearl millet Pigeonpea Paddy	Rainy season fallow postrainy season Sorghum and Chickpea Minor-pulses Pigeonpea	Cotton Sorghum Mungbean Groundnut Pigeonpea
Households (No)		476	297	169
Landless households (%)		28	23	32
Average size of operational holding (ha)		3.5	6.5	6.1
% irrigable area to total cropped area		12	8	5
Total area of the watershed where "Improved" systems were tested (ha)		13.5	13	11
No. of cooperating farmers holding land on the watershed		5	8	7

Appendix II. Reliability of a 90-day rainy season crop on Vertisols in three regions.[a]

(In percent of years)

	Probability of emergence to July 15	Probability of seedling survival	Probability of adequate soil moisture thru growing period	Probability of good growth condition	Probability of adequate soil moisture after kharif crop	Probability of adequate soil moisture after kharif fallow
	1	2	3	4	5	6
Sholapur: deep Vertisols[b]	65	49	41	33	60	80
Hyderabad: deep Vertisols[b]	85	76	69	62	50	83
Akola: medium-deep Vertisols[b]	92	80	74	66	n.a.	n.a.

a. Source: Binswanger et al. (1980).

b. Water-holding capacities for deep and medium-deep Vertisols are 230 mm and 120 mm, respectively.

Notes to columns:

(1) Assuming dry seeding and using 1 inch of rainfall as sufficient for emergence.
(2) Defined as no water stress in top soil layer for 2 weeks after emergence.
(3) Soil moisture more than 50 mm during all weeks.
(4) Probability of fulfilling all previous conditions.
(5) Total probability of having more than 150 mm of stored water between mid-September to mid-October after growing a kharif crop.
(6) As (5) but with kharif fallow.