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By

C. A. Rama Rao,
M. Srinivasa Rao,
Y. S. Ramakrishna
K.P.R. Vittal
Y. V. R. Reddy

Assistance

Surendera Rao
Sridharachary
Sri Vani
Masood Khan

Published by

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Dr. H.P. SINGH
Former Director
CRIDA (ICAR)

Phone: 0522-2702656
Email: harishpsingh@rediffmail.com

Foreword

The Central Research Institute for Dryland Agriculture is mandated to develop and transfer technologies that enhance crop yields and conserve natural resources in the drylands of the country. The efforts of CRIDA through its network programmes of AICRPDA and AICRPAM have resulted in development of a number of yield-enhancing technologies. Among various traits of technology, economic viability is an important determinant for acceptance and adoption by the farmers. Adoption of technologies by farmers in turn is a prerequisite to enhance their incomes and to mobilize the resources for technology generation and transfer. It is therefore important to assess the economic viability of technologies under real farm situations. The information on the relative economic viability of dryland agricultural technologies is scanty and scattered. It is in this respect that this small bulletin assumes significance as it attempts to put together this much needed information on economics of a spectrum of dryland technologies which include methods of sowing, intercropping systems, integrated pest management, soil and water conservation measures, etc. The bulletin becomes handy while convincing the farmers for adopting these technologies. However, one should not lose sight of other constraints that hinder the adoption of technologies in a specific region. The authors and scientists of CRIDA deserve appreciation for their efforts in putting together such useful information.

(H.P. Singh)

Economics of Some Dryland Agricultural Technologies

1. Introduction

Enhancing the productivity of drylands is essential in order to achieve sustainable and more widely spread growth in Indian agriculture. The drylands are characterized by poor soil and water resource availability and shelter a majority of rural poor in India. Unlike with irrigated agriculture, achieving dramatic yield gains is difficult in dryland agriculture (Katyal *et al.,* 1996). Therefore, it is required to plan for gradual increases in crop yields by making a more efficient use of available resources. Development and transfer of technologies for enhancing crop yields under dryland conditions is the key mandate of the Central Research Institute for Dryland Agriculture.

Economics of a technology is one of the important determinants of technology adoption and as such economic viability is a necessary condition for a technology to be adopted. Technologies, which are strongly viable and profitable, will have the self-replicating ability. It is, therefore, important to assess the technologies for their economic viability before they are transferred to the farmers. The broad range of rainfed technologies includes development of an improved set of practices, appropriate intercropping system, integrated pest management, soil and water conservation measures. This bulletin intends to put together the information on the economics of some important dryland agricultural technologies.

2. Economics of Improved Production Practices

Use of poor quality seed, inadequate nutrient supply, high weed growth, and incidence of pests and diseases are the four important reasons for low productivity of rainfed crops. Keeping these problems in view, improved package of practices comprising use of good quality seed of improved varieties, application of moderate doses of chemical fertilizers, and appropriate weed and pest management practices were developed for various rainfed crops (Reddy and Rastogi, 1985). These technologies were evaluated for their viability at different locations in India (Table 1). Based on three-year (1985-88) data collected from on-farm experiments at different AICRPDA locations, the incremental benefit cost ratios (IBCRs) were computed to examine whether the additional investments required adopting these technologies would result in enough additional benefits. Thus IBCR indicates the economic viability of the technology under consideration.The results indicated that use of recommended practices improved the profitability of rainfed crops significantly. However, the increase in profitability is not uniform across crops and locations. The Incremental Benefit Cost Ratios (IBCRs) associated with recommended package of practices for *Kharif* (rainy season) sorghum varied between 1.08 in Kovilpatti to 2.98 in Hyderabad (Table 1). Thus, the additional costs involved in adopting the recommended technologies were just recovered in Kovilpati whereas in Hyderabad every rupee invested earned a net profit of Rs. 2/-. Similarly in case of *rabi* (post rainy season) sorghum, IBCR was 1.64 in Rahuri and 2.81 in Solapur. In pearl millet the profitability of recommended practices varied across locations. In three out of four locations, it was not profitable. In

Hyderabad, adoption of improved practices increased the returns by Rs. 913/- without involving any additional expenditure. Castor in Hyderabad recorded highest IBCR of 4.98, which explains the quick spread of castor in the southern Telengana region of Andhra Pradesh.

Table 1. Incremental benefit-cost ratio (IBCR) of improved package of practices for rainfed crops at different locations in India.

Crop	Location	IBCR
Sorghum (kharif)	Nagpur	1.40
	Hyderabad	2.98
	Rajkot	2.32
	Akola	1.36
	Kovilpatti	1.08
Sorghum (rabi)	Solapur	2.81
	Rahuri	1.64
Pearl millet	Nagaur	0.83
	Jodhpur	0.79
	Hissar	1.34
	Solapur	0.54
Finger millet	Bangalore	0.80
Groundnut	Rajkot	1.46
Castor	Hyderabad	4.98

3. Economics of Improved Planting Techniques

Planting method was considered as one of the crucial elements for improved productivity of rainfed crops. Various improved planting methods were evaluated for pearl millet and castor by the dryland research network in India. The changes in returns and costs from the traditional methods of planting were worked out and then IBCRs were computed to test their economic viability. These methods were evaluated at different locations of AICRPDA during 1988-90.

The results indicated that all these methods were economically viable as indicated by high IBCR (Table 2). Paired row method of planting pearl millet recorded the highest IBCR of 10.54 in Jodhpur. This method involves planting two rows of the crop at 30 cm inter-row spacing with a spacing of 60 cm between two pairs of rows. Similarly, square planting in castor was found to be more rewarding in Hyderabad recording an IBCR OF 7.65. Thus, improved methods of sowing contributed significantly to productivity and profitability gains. The observed high IBCR were because of the fact that these methods required very little additional investment compared to what the farmers were already following.

Table 2: Incremental benefit cost ratio (IBCR) of improved planting methods for rainfed crops at different locations in India.

Crop	Location	Planting method	IBCR
Castor	Hyderabad	Square planting	7.65
Pearl millet	Nagaur	Paired row	3.73
	Jodhpur	Paired row	10.54
	Hissar	Transplanting	3.57
	Hissar	Ridger seeder	5.98

4. Economics of Intercropping Systems

Rainfed farmers traditionally practice intercropping as a risk minimizing strategy. Farmers hope to harvest a good crop of at least one component of the intercropping system in years of unfavourable rainfall. Other benefits of intercropping system include improvement in soil fertility (with legumes as intercrops), better resource utilization, and increase in income. The performance of various intercropping systems vis-a vis sole crops was studied at different locations (Table 3).

Table 3. Incremental benefit-cost ratio (IBCR) and income equivalent ratio (IER) of various intercropping systems at different locations in India

Intercropping system	Locations	IBCR	IER
Sorghum + pigeonpea	Indore	2.8	1.5
	Jhansi	5.5	1.2
Soghum + black gram	Kovilpatti	5.0	1.3
Sorghum + cowpea	Kovilpatti	3.0	1.2
Pearl millet + pigeonpea	Rajkot	14.4	1.6
Groundnut + pigeonpea	Bijapur	6.0	1.3
Maize + blackgram	Dhiansar	3.3	1.2
Pigeonpea + maize	Bhubaneswar	2.9	1.9
Pigeonpea + rice	Bhubaneswar	3.5	1.1
Chickpea + safflower	Bijapur	3.9	1.4
Chickpea + mustard	Agra	3.7	1.1
Rice + Pigeonpea	Ranchi	1.5	1.4
Finger millet + soybean	Bangalore	1.4	1.1
Safflower + coriander	Bellary	6.4	2.1

Adoption of appropriate intercropping systems, though involves additional investment, is more profitable as indicated by high IBCRs. The IBCR varied from 1.4 for finger millet + soybean at Bangalore to 6.4 for pearl millet + pigeonpea at Rajkot (Table 3). Among all the intercropping systems tested, pearl millet + pigeonpea appeared to be more profitable with high IBCR. Income equivalent ratio (IER) is the extent of land required to realize the level of income from sole cropping that is possible with 1 ha of intercropping system. Thus, it is an appropriate measure to evaluate the performance of intercropping systems. The IER of all the intercropping systems was > 1. Intercropping systems with high IER can be considered as land saving systems.

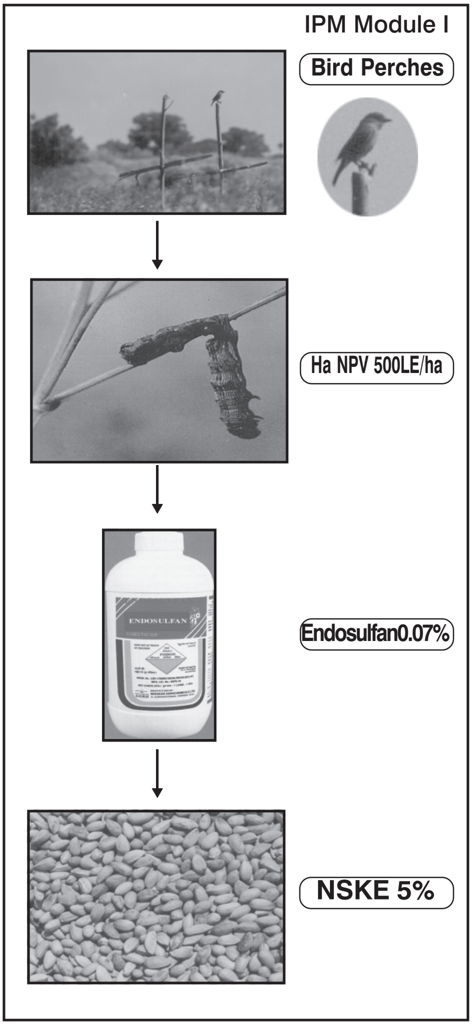
5. Economics of Alternate Land Use Systems

Cultivation of coarse cereals, pulses and oilseeds predominate rainfed regions. These crops, especially, coarse cereals and millets are mostly consumed by low-income groups and as a result the income elasticity of demand is relatively low. The consumption of oilseeds is also responsive to relative prices and any increase in the prices tends to reduce the demand. These factors make it difficult to ensure remunerative prices to the rainfed farmers. On the other hand, soil erosion and degradation are the major problems threatening the sustainability of rainfed agriculture. Various alternate land use systems that help conserve soil resources and meet multiple needs of the farmer were developed. These systems were examined for their economic viability vis-à-vis arable crops using the data collected from farmers' fields. Agri-horticulture and agri-silvi culture are the two important alternate land use systems developed by CRIDA. Most of these systems were found to be more profitable than arable cropping.

Agri-horticulture, growing arable crops and horticultural crops together, was found to be most remunerative with a beneft-cost ratio of about 5.00 as against 2.00 from agri-silviculture 1.2 to 1.7 in case of arable crops. Dryland horticultural crops without any arable crops grown during the initial period gave favourable benefit-cost ration of 3.21 in mango, 2.18 in guava, 3.04 in acid lime and 2.89 in sweet lime. However, it should be noted that the favourable benefit-cost ratio alone would not ensure the adoption of these systems. Adoption of these systems by farmers require high initial investments and adequate marketing facilities (Reddy and Sudha, 1989) on one hand and access to the necessary information, skills and inputs. Also, it may not be possible for small and marginal farmers to take up these systems in heir small and fragmented holdings, which place them in a disadvantageous position. Mechanisms such as cooperative farming and marketing that help impart economies of scale need to be evolved if the benefits from these systems were to be shared to the small and marginal farmers.

6. Economics of Integrated Pest Management

Insect pests are one of the major factors carrying heavy yield losses in rainfed crops, especially pigeonpea and cotton. In order to develop means for achieving pest management in a manner that does not harm environment and is cost-effective, efforts were made to develop integrated pest management (IPM) modules. The effectiveness and economics of such IPM modules in pest management in case of pigeonpea are described here.



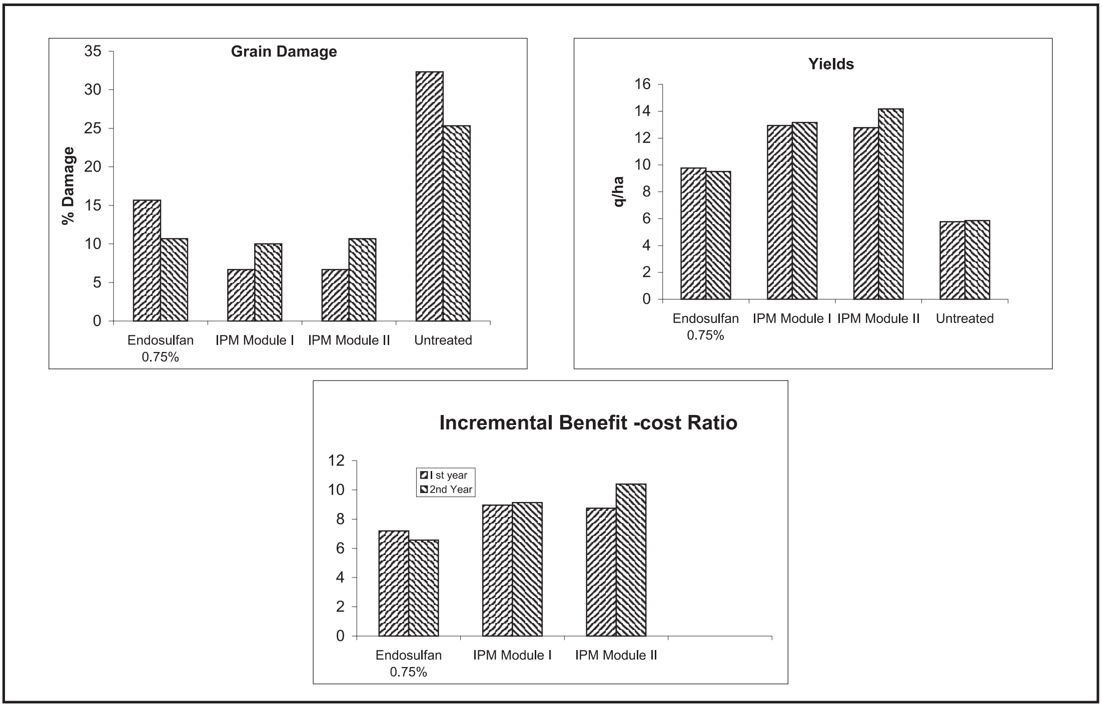
Different components of IPM were evaluated individually and in combination in order to identify most effective module for managing the major pests in pigeonpea at HRF, CRIDA. Application of NPV, NSKE, HaPV, mechanical collection, erection of bird perches and chemical sprays are the components that were included in the IPM. Two different IPM modules were specifically tested wth the sequential application of effective treatments (Giraddi *et al.,* 1994) and compared with chemical control of pests.

IPM-1 module included sequential sprays of NPV @ 500 LE ha^{-1}, endosulfan 0.07 per cent followed by NSKE 5 per cent (Plate1). IPM-2 module comprised two rounds of NPV @250 LE ha^{-1}+ NSKE 2.5 per cent with one spray of endosulfan 0.07per cent in between. Both the modules included erection of bird perches. These practices were evaluated for the grain damage, grain yield and economics in a two-year study. The findings indicated that the grain damage by lepidopteran borers was significantly less in both the IPM modules (6.67%) .The damage did not vary significantly among the rest of the treatments viz., endosulfan (15.67%), HaNPV (15.67%), NSKE (17.00%) and mechanical collection (18.67%). The untreated check recorded significantly highest per cent of grain damage (32.33). The grain damage by pod fly was significantly less in IPM module I (9.67%) and was on par with chemical control using endosulfan (10.67%). IPM module II (13.33%) was the next best.

The grain yields of pigeonpea were also more in IPM modules in both the years (12.94 -14.17 q ha^{-1} in IPM II). The endosulfan spray increased the grain yields (9.77 and 9.51 q ha^{-1} in first and second years) and was on par with HaNPV (9.55 and

9.27q ha^{-1}).The NSKE(7.14 and 7.83 q ha $^{-1}$ in first and second years) was on par with the rest of the treatments which did not record significant higher yields over untreated check excepting NSKE in second year (Fig 1).

Fig 1. Impact of IPM in Pigeonpea



The incremental benefit-cost ratios computed for these practices also indicated that the IPM modules were more profitable. IPM module I and II recorded IBCR s 8.96 and 8.75 followed by endosulfan (7.19) and NSKE (5.19) and mechanical collection (3.04) in first year. In second year also, IPM modules II (10.39) and I(9.13) registered higher CBR than the rest of treatments. NSKE application and endosulfan with incremental benefit-cost ratios of 7.46 and 6.56 were found to be next best. The erection of bird perches showed better IBCR (5.71) than the rest of treatments.

Apart from economic viability, IPM has also led to other ecological advantages in terms of enhancing the natural enemies of pests. For example, the predator population varied significantly across treatments at three and seven days after each application. Untreated check had higher number of over all mean predator population (7.28) followed by IPM module II (6.33) and I (6.06).The endosulfan sprayed plots had 4.94 population.

7. Economics of Water Conservation Technologies

Simple conservation technologies were evaluated for their impact on crop yield and economics at AICRPDA centers at Bijapur and Solapur during 2002-03. The findings from the on-farm experiments are presented hereunder.

Bijapur

The study region received about 600 mm of rainfall (normal rainfall 594 mm) in 18 rainy days during the year 2002-03. Two major treatments – conservation furrow (T1) and deep ploughing, conservation furrow and residue incorporation (T2) were evaluated in the groundnut and pigeonpea inter croppind system. These practices require additional labour inputs. These two technologies were compared with the existing farmers' practice for their impact. These technologies were evaluated at ten on-farm trials. The additional costs involved and yields obtained are given Table 7 and the economic impact in Table 8.

Table 4. Additional Costs Incurred and Yields Obtained with various Conservation Measures, Bijapur 2002-03

Technology	Additional Costs (Rs ha^{-1})	Yield (kg ha^{-1})		Difference from Farmers' Practice (kg ha^{-1})	
		Groundnut	Pigeonpea	Groundnut	Pigeonpea
Farmers' Practice		543	440		
T1	413	626	500	83	60
T2	3793	661	555	118	115

Table 5. Impact of Conservation Practices on the yield and profitability in Groundnut + Pigeonpea, Bijapur, 2002-03

Particulars	With T1	With T2	Farmers' Practice	Difference over farmers' practice	
				T1	T2
Cost of cultivation (Rs ha^{-1})	11974	15354	11561	413 (4%)	3793** (33%)
Yield@ (kg groundnut ha^{-1})	1161	1255	1012	149*(15%)	243**(24%)
Net Returns$ (Rs ha^{-1})	4854	2840	3122	1732*(55%)	-282 (-9%)
Cost of production (Rs.kg groundnut^{-1})	10.3	12.2	11.4	-1.1*(-10%)	0.8 (7%)

*** and * indicate that the differences are statistically significant at 1 and 5 per cent, respectively.*
@ Yields were expressed in groundnut equivalents.

It is observed from the tables 4 and 5 that both the treatments resulted in higher yields compared to the farmers' practice. However, the yield effect was more when all the three conservation treatments were followed in combination (T2). Such an impact on yield was probably due to the synergistic effects of the three practices. However, adoption of all these practices resulted in higher cost of cultivation, which was 33 per cent more than the farmers' practice. Thus, in spite of the superior yield effect, the net returns from T2 fell by 9 per cent (though not statistically significant). On the other hand, the practice of opening conservation furrows increased the yields by 15 percent and net returns by 55 per cent with very little additional expenditure (4%). The cost of production was also observed to decrease by 10 per cent with T1 as opposed to a 7 per cent rise with T2. The marginal rate of return from T1 was found to be 4.

Solapur

The study region received about 644 mm of rainfall, which was less than the normal rainfall (722 mm) by 11 per cent. There was a long dry spell during late June and early July because of which crops suffered. The target crop was sunflower intercropped with pigeonpea. The technology assessed was adoption of deep ploughing and conservation furrow in conjunction. This requires additional inputs of human and bullock labour. These technologies were evaluated at ten on-farm trials. The additional costs involved and yields obtained are given Table 6 and the economic impact in Table 7.

Table 6. Additional Costs Incurred and Yields Obtained with various Conservation Measures

Technology	Additional Costs (Rs ha^{-1})	Yield (kg ha^{-1})		Difference from Farmers' Practice (kg ha^{-1})	
		Sunflower	Pigeonpea	Sunflower	Pigeonpea
Farmers' Practice		1045	253		
With Technology	413	1435	320	390	67

Table 7. Impact of Conservation Practices on the yield and profitability in Sunflower + Pigeonpea, 2002-03

Particulars	With Technology	Without Technology	Difference*
Cost of cultivation (Rs ha^{-1})	15366	13589	1777(13%)
Yield@ (kg sunflower ha^{-1})	1900	1412	488(35%)
Net Returns$ (Rs ha^{-1})	5538	1946	3582(185%)
Cost of production (Rs.kg snflower^{-1})	8.1	9.6	-1.5(-16%)

** The differences are statistically significant at 5 per cent.*

@ The pigeonpea yield was converted into sunflower equivalent yield using the prices farmers received. Sunflower: Rs 11 kg^{-1} Pigeonpea: Rs.16 kg^{-1}

It can be observed from tables 6 and 7 that the adoption of technology influenced the yield and profitability of the crop significantly. By incurring an additional expenditure of Rs.1777 ha^{-1}, it increased the yield by 35 per cent and net returns by 185 per cent. As a result, the cost of production of sunflower fell from nearly Rs.10 kg^{-1} to Rs.8 kg^{-1}. Thus, at the farm level, adoption of deep ploughing and conservation furrows was observed to be highly remunerative. It is noted that these experiments need to be repeated for some more duration. However, since the rainfall conditions are normal during the year the findings are indicative of possible benefits.

8. Economics of Farm Pond

Soil and water conservation is the most important aspect of sustainable rainfed agriculture. Among various soil and water conservation practices, farm pond is the most remunerative technology to harvest and utilize rainwater. An *ex-ante* economic evaluation was done for a typical farm pond of 500m^3 capacity in an Alfisol at Hayathnagar Research Farm of the Central Research Institute for Dryland Agriculture (CRIDA). An examination of historic data indicated occurrence of 8-10 runoff events during a normal rainfall year. This particular farm pond gets filled twice a year. The water so stored can be utilized to give one life saving irrigation to 1 ha of sorghum and to grow 0.1 ha of vegetables such as tomato and *okra*. The returns were calculated by considering the above and the various viability measures given below were computed by generating cost and income flow for 20 years(Mishra *et al.,* 1998). The economic analysis was conducted by assuming that the current yield levels will be maintained and using a discounting rate of 12 per cent, which is the normal lending rate for agricultural loans.

Table 8 Indicators of Economic Viability of a Farm Pond

Net present value	Rs. 29,850/-
Benefit-cost ratio	1.57
Internal rate of returns (%)	18.57
Payback period	9 years
Initial investment	Rs. 50,000/-

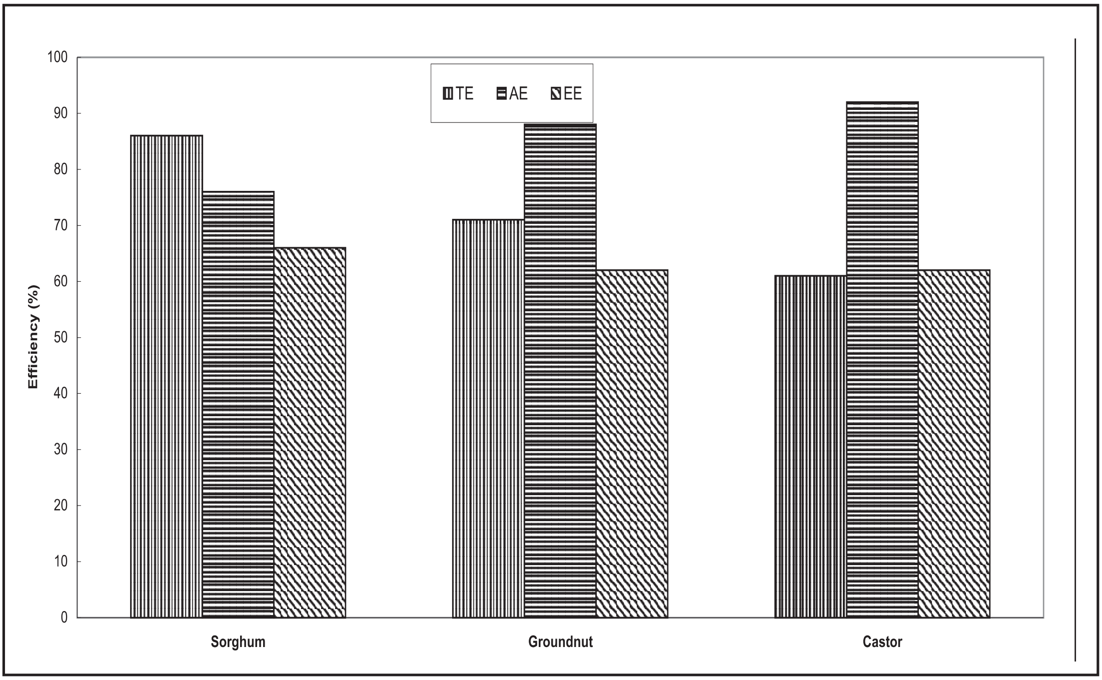
The results establish the economic viability of the farm pond as can be seen from the high benefit-cost ratio and net present value. However, the high initial investment required is a major impediment to its adoption. A larger part of this investment is to prevent the caving in of loose Alfisols, which can be avoided in black soils. If this initial investment can be reduced, farmers may be willing to adopt such a technology. As long as the initial investment is high, investment in ground water exploitation may be more attractive. However, such technologies can be promoted in regions with low ground water potential.

9. Economic Efficiency in Production of Rainfed Crops

It is as important to use the available resources and technologies efficiently as it is to develop appropriate technologies (Kalirajan *et al.*, 1996). It was further observed that improving the economic efficiency is one important source of achieving further productivity growth in Indian agriculture (Kalirajan and Shand, 1997). Economic efficiency is comprised of technical efficiency and allocative efficiency. A farmer is said to be technically efficient if he or she produces maximum possible output with the given level of resources and technology. The farmer is allocatively efficient when he or she maximizes profit by choosing those levels of inputs given the relative prices of inputs and outputs (Datta and Joshi, 1992). The economic efficiency in production of three major rainfed crops, viz., sorghum, groundnut and castor, was computed by fiiting a deterministic frontier production function to farm level data (Rama Rao *et al*., 1996).

At average levels of input use, the technical efficiency is relatively low in groundnut and castor compared to that in sorghum. The allocative efficiency is however comparatively high in groundnut (88%) and castor (92%) as against 76 per cent in sorghum (Fig 2). This indicates that farmers invest relatively more on inputs in commercial crops such as groundnut and castor than in fod crops such as sorghum (Katyal *et al*., 1993). A relatively high degree of technical efficiency (86%) in sorghum indicates that there is not much difference between the technically efficient farmer and average farmer. It should be noted here that improving technical efficiency

Fig 2. Technical, Allocative and Economic Efficiency in Production of Rainfed Crops



requires little monetary inputs to the farmer. Better management in terms of timeliness of operations such as sowing and fertilizer application, methods of operations help enhance technical efficiency. On the other hand, expanding the inputs use to the allocatively optimum levels involves additional investment. It was further found that if the inputs use is expanded to the optimum levels in a technically efficient way, productivity can be increase by 34 per cent in sorghum and 38 per cent in groundnut and castor.

10. Conclusion

The foregoing analysis makes it clear that adoption of various production and conservation technologies results in significant increase in crop yields and profits. Efforts are however needed to identify the factors that constrain the adoption of these technologies and initiate measures that promote adoption. Availability of adequate and relevant information, access to the required inputs, and availability of implements are some of the important constraints that need to be addressed. Further, farmers should be given access to information and inputs so that they can adopt appropriate technologies and use them efficiently and maximize their profits. Only then will the gains from investments in technology generation and transfer be realized.

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