

## Profitable and energy-efficient rice (*Oryza sativa*)-based cropping systems in Northern Telangana of Andhra Pradesh

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### ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station, Jagtial, during rainy (*kharif*) and winter (*rabi*) seasons of 1996–97 to 1998–99 on red sandy-loam soils, to find out profitable and energy-efficient rice (*Oryza sativa* L.)-based cropping sequences among different cropping sequences, viz., rice–maize (*Zea mays* L.), rice–sunflower (*Helianthus annuus* L.), rice–groundnut (*Arachis hypogaea* L.), rice–blackgram (*Phaseolus mungo* L.), rice–greengram (*Phaseolus radiatus* L.), rice–soybean [*Glycine max* (L.) Merr.], rice–Indian mustard [*Brassica juncea* (L.) Czernj. & Cossou] and rice–rice. Of the 8 cropping sequences, rice–rice, rice–maize and rice–sunflower cropping sequences gave significantly higher rice-equivalent yield (11,616, 11,553 and 10,868 kg/ha respectively) and gross returns (Rs 51,745, 51,464 and 48,291/ha respectively). Though field water supply was higher to rice–rice cropping sequence (2,800 mm), the water-use efficiency was lowest (4.15 kg/mm). Similarly, rice–rice cropping sequence also required higher energy input (75,036 MJ/ha) but the energy efficiency and energy productivity were lowest (4.2 and 155 g/MJ). However, net returns and benefit : cost ratio were higher with rice–maize (Rs 21,884/ha; 1.74) and rice–sunflower (Rs 21,321/ha; 1.79) cropping sequences. Similarly, these cropping sequences also recorded higher energy-use efficiency (6.4 and 5.1 respectively), energy productivity (227 and 238 g/MJ respectively) and water-use efficiency (7.22 and 7.50 kg/mm respectively) and were more sustainable than rice–rice and other rice-based cropping sequences.

**Key words :** Rice, Cropping system, Water-use efficiency, Energy-use efficiency, Economics

Rice is a main crop grown extensively during rainy season (*kharif*) and winter season (*rabi*) under tanks, wells and command of Sri Ram Sagar Project in Northern Telangana Zone of Andhra Pradesh. It requires huge quantity of water and energy for lifting and distribution of irrigation water. In this region, double cropping of rice is becoming difficult due to irregular supply of electricity and its increasing cost in addition to scarce resource of irrigation water. The *kharif* rice is harvested by the end of October first fortnight of November due to delayed release of water from the project during *kharif*. The prevalence of lower minimum temperature (>15°C) during winter (*rabi*) restricts the crop choice in Northern Telangana Zone. Hence the situation demands identification of alternate crops to rice during *rabi* to find out highly productive and profitable cropping systems with better energy-use efficiency. Since not much information is available on suitability of different winter crops to be grown after rice, an experiment was undertaken to select suitable rice-based

cropping sequence to increase production and net returns in this region.

### MATERIALS AND METHODS

The study was conducted at Regional Agricultural Research Station, Jagtial, Andhra Pradesh, during 3 rainy and winter seasons of 1996–97, 1997–98 and 1998–99 on same plot, in randomized block design with 3 replications. The soil was red sandy loam having pH 7.8; low in available nitrogen (259 kg/ha), medium in phosphorus (8.64 kg/ha) and high in potassium (475 kg/ha). Treatments comprised 8 cropping sequences after 'Kavya' rainy season rice, viz. 'IR 64' winter rice; 'Trishulatha' maize (*Zea mays* L.); 'MSFH 8' sunflower; 'JL 24' groundnut; 'LBG 17' blackgram; 'MGG 295' greengram 'MACS 330' soybean and 'GM 1' Indian mustard. The plot size was 5.4 m × 8.4 m. The rainy-season rice was sown under puddling during the first week of July and harvested during the last week of October in 1996 and the first week of November

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in 1997 and 1998. After harvest of rainy-season rice, field was ploughed thrice, then the above sequence winter crops were dibbled during the last week of November in 1996–97 and the first week of December in 1997–98 and 1998–99 and harvested as and when they were matured. The crops in sequence were raised as per recommended package of practices.

The yield of winter crops was converted to rice-equivalent yield by converting the yield into economic value based on the prevailing prices at the local regulated market in different years. Net returns, benefit : cost ratio, production efficiency and land-use efficiency were worked out for all cropping sequences, and mean of 3 years was presented as per Reddy *et al.* (1996). The sustainable yield index and sustainable value index were calculated as per Singh *et al.* (1990). Energy-use efficiency was calculated (Panesar and Bhatnagar 1994) and energy productivity (g/MJ) was worked out by dividing the mean rice-equivalent yield with corresponding energy input. Similarly, field water-use efficiency (kg/mm) was calculated by dividing mean rice-equivalent yield with quantity of water supplied.

## RESULTS AND DISCUSSION

### Effect of previous crops on yield of rice

Pooled analysis of rice yield showed that the mean grain and straw yield ranged from 5,371 to 5,641 and 5,332 to 5,473 kg/ha, respectively, and there was no significant difference among different crop sequences. This indicated that none of the winter crops in sequence had adverse effect on yield of subsequent rice crop (Table 1). These results are in conformity with those of Nagalikar *et al.* (1999).

### Rice-equivalent yield

The mean rice-equivalent yield was higher with rice-rice cropping sequence, which was on a par with rice-maize and rice sunflower cropping sequences and was

significantly superior to rest to cropping sequences. Significantly lower mean rice-equivalent yield was obtained in rice-Indian mustard cropping sequence, mainly due to low yield of Indian mustard. However, the equivalent yield of rice-Indian mustard was comparable with rice-greengram and rice-soybean cropping sequences (Table 1).

### Monetary returns

Significantly higher gross returns were recorded with rice-rice cropping sequence, which was on a par with rice-maize and rice-sunflower cropping sequences. The higher gross returns were owing to higher yield of rice, maize and sunflower in sequence with rice than the other crops (Table 1). The net returns were significantly higher with rice-maize cropping sequence, being at par with rice-sunflower and rice-rice cropping sequences, was superior to the rest of the cropping sequences. Rice-blackgram cropping sequence was next in the order to these crop sequences in terms of net returns and was on par with rice-groundnut and rice-greengram cropping sequences. Similarly, benefit : cost ratio was also significantly higher with rice-sunflower and rice-maize cropping sequences, followed by rice-blackgram and rice-rice cropping sequences (Table 1).

### Land-use efficiency

Rice-groundnut cropping sequence used the land for more period in a year having land-use efficiency of 73% and was followed by rice-rice and rice-maize cropping sequences (Table 2). However, the other cropping sequences, viz. rice-greengram, rice-mustard, rice-soybean, rice-blackgram and rice-sunflower used the land for 62–66% period of the year. The variation in land-use efficiency was primarily due to the duration of winter crops in cropping sequence.

### Production and monetary efficiency

Rice-sunflower cropping sequence recorded higher

Table 1. Yield and economics of different rice-based crop sequences (pooled data of 3 years: 1996–99)

Crop sequence (rainy season- winter season)	Yield (kg/ha)				Rice-equivalent yield (kg/ha)			Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	Benefit : cost ratio
	Rainy season		Winter season		Rainy season	Winter season	Total				
	Grain	Straw	Seed	Stalk							
Rice-Indian mustard	5,543	5,402	463	1,199	5,793	1,198	6,991	31,347	22,460	8,887	1.40
Rice-greengram	5,641	5,417	546	867	5,887	1,821	7,708	34,535	23,290	11,245	1.48
Rice-soybean	5,538	5,473	656	914	5,786	1,637	7,423	33,260	23,200	10,060	1.43
Rice-blackgram	5,573	5,348	819	926	5,814	2,793	8,607	38,488	23,910	14,578	1.61
Rice-groundnut	5,510	5,348	1,172	1,689	5,753	3,739	9,492	42,368	29,890	12,478	1.42
Rice-sunflower	5,468	5,381	1,886	2,781	5,712	5,156	10,868	48,291	26,970	21,321	1.79
Rice-maize	5,589	5,332	4,644	6,072	5,830	5,723	11,553	51,464	29,580	21,884	1.74
Rice-rice	5,371	5,453	5,695	6,695	5,651	5,965	11,616	51,745	32,900	18,845	1.57
CD (P=0.05)	NS	NS			NS		814	3,598		3,598	0.04

production and monetary efficiencies and was comparable with rice–maize and rice–rice either because of higher yield of price of economic produce. Lower production and monetary efficiencies were recorded with rice–mustard due to lower yield and gross returns/ha. Though rice–groundnut sequence took longer duration, the production and monetary efficiencies were lower compared to these crop sequences (Table 2).

### Sustainability

The sustainable yield and value indices were higher with rice–maize cropping sequence irrespective of variation in weather and price (Table 2). This was followed by rice–sunflower and rice–rice cropping sequences. Hence these 3 cropping sequences were more stable than the other cropping sequences.

### Water-use efficiency

The field water supply was lowest with rice–soybean or blackgram cropping sequence and the highest with rice–rice cropping sequence (Table 2). The highest field water supply was perhaps due to substantially high water requirement of *rabi* rice. The field water supply was almost double with rice–rice compared with the other crop

ping sequences. Similar results were reported by Parihar *et al.*, (1999). However, the water-use efficiency was higher with rice–sunflower cropping sequence, followed by rice–maize because of higher production with less water use. Though field water supply was higher to rice–rice cropping sequence, the water-use efficiency was lowest compared with rest of cropping sequences.

### Energetics

The total energy input in different cropping sequences was highest with rice–rice followed by rice–maize and rice–groundnut cropping sequences and it was lowest with rice–greengram cropping sequence. Among different sources of input energy, electricity followed by fertilizers accounted for the highest percentage of input energy in different cropping sequences. The energy input through electricity was higher in rice–rice cropping sequence which was almost double compared with the other cropping sequences because of higher water requirement. The results are in agreement with those of Parihar *et al.* (1999). However, the energy input through electricity was lower with rice–mustard or greengram or blackgram or soybean cropping sequence because of lower water requirement for these cropping sequences. Higher energy

Table 2. Sustainability and efficiency of different rice-based crop sequences (pooled data of 3 years: 1996–99)

Crop sequence (Rainy season– winter season)	Duration of crop sequence (days)	Land-use efficiency (%)	Production efficiency (kg/ha/day)	Monetary efficiency (Rs/ha/day)	Sustainable yield index	Sustainable value index	Field water supply (mm)	Water use (kg/mm)
Rice–mustard (93)	231	63	30.3	135.7	0.39	0.33	1,400	4.99
Rice–greengram (88)	226	62	34.1	152.8	0.43	0.37	1,400	5.51
Rice–soybean (92)	230	63	32.3	144.6	0.42	0.36	1,360	5.46
Rice–blackgram (94)	232	64	37.1	165.9	0.49	0.42	1,360	6.33
Rice–groundnut (130)	268	73	35.4	158.1	0.57	0.50	1,550	6.12
Rice–sunflower (104)	242	66	44.9	199.6	0.70	0.61	1,450	7.50
Rice–maize (122)	260	71	44.4	197.9	0.71	0.62	1,600	7.22
Rice (138)–Rice (126)	264	72	44.0	196.0	0.68	0.60	2,800	4.15

Figures in parentheses are actual duration of the crop

Table 3. Energy-use efficiency of different rice-based crop sequences (pooled data of 3 years: 1996–99)

Crop sequence (Rainy season– winter season)	Input energy (MJ/ha)						Total input energy (MJ/ha)	Total output energy (MJ/ha)	Energy- use efficiency	Energy produc- tivity (g/MJ)
	Human labour	Animal	Electricity	Seed	Fertilizers	Chemicals				
Rice–Indian mustard	3,267	2,424	20,997	860	13,204	667	41,419	182,164	4.4	169
Rice–greengram	3,575	2,586	20,997	956	8,761	848	37,723	169,499	4.5	204
Rice–soybean	3,389	2,424	20,997	2,485	9,390	770	39,455	177,646	4.5	188
Rice–blackgram	3,691	2,505	20,997	1,000	8,761	980	37,934	172,387	4.6	227
Rice–groundnut	4,177	2,424	24,814	3,235	14,679	930	50,259	207,549	4.1	189
Rice–sunflower	4,262	2,586	23,860	860	13,271	792	45,631	229,555	5.0	238
Rice–maize	4,482	2,666	26,723	1,029	15,133	788	50,821	326,371	6.4	227
Rice–rice	6,320	3,474	47,720	1,470	15,200	852	75,036	314,520	4.2	155

through fertilizer was required for rice-rice cropping system and it was lowest for rice-greengram or blackgram cropping sequences. However, the energy input through seed was highest with rice-groundnut followed by rice-soybean because of higher seed requirement per unit area than the other cropping sequences. The total output energy was higher with rice-maize, which was closely followed by rice-rice cropping system. However, rice-rice required 50% higher energy input for same output as that of rice-maize cropping systems. Though total output energy was higher with rice-rice than with all other cropping systems except rice-maize cropping system, the energy-use efficiency was lowest next to rice-groundnut cropping system. The energy use efficiency was higher with rice-maize followed by rice-sunflower cropping system. Energy productivity was also lowest with rice-rice cropping system because of higher input energy. Similar findings were reported by Pal *et al.* (1985). However, rice-sunflower and rice-maize or blackgram recorded higher energy-use efficiency of 238 and 227 g/MJ, respectively, because of higher energy output and lower energy input than the other cropping systems.

The results indicate that in red sandy loam soils of Northern Telangana, rice-maize and rice-sunflower cropping systems are sustainable cropping sequences and give higher production efficiency, water-use efficiency, energy

efficiency, net returns and benefit : cost ratio with lower energy input than the other cropping sequences particularly rice-rice.

#### REFERENCES

- Nagalikar, U.P., Setty, R.A. and Channabasavanna, A.S. 1999. Economic analysis of rice (*Oryza sativa*) based cropping systems for Tungabhadra Project area. *Indian Journal of Agronomy* 44(3) : 456-458.
- Pal, M., Singh, K.A., Saxena, J.P. and Singh, H.K. 1985. Energetics of cropping systems. *Indian Journal of Agronomy* 30(2) : I-Lxi.
- Panesar, B.S. and Bhatnagar, A.P. 1994. Energy norms for inputs and outputs of agricultural sector. (in) *Energy Management and Conservation in Agricultural Production and Food Processing*, pp. 5-16. Verma, S.R., Mittal, J.P. and Singh, Surendra (Eds). USG Publishers & Distributors, Ludhiana.
- Parihar, S.S., Pandey, D., Shukla, R.K., Verma, V.K., Chaure, N.K., Choudhary, K.K. and Pandya, K.S. 1999. Energetics, yield, water use and economics of rice-based cropping systems. *Indian Journal of Agronomy* 44(2) : 205-209.
- Reddy, M.D., Kumar, K.A. and Rao, K.V. 1996. Production efficiency of rainy season maize (*Zea mays*)-based cropping systems under Sri Ram Sagar Project command area of Andhra Pradesh. *Indian Journal of Agricultural Sciences* 66(5) : 276-279.
- Singh, R.P., Das, S.K., Bhaskar Rao, V.M. and Narayan Reddy, M. 1990. *Towards Sustainable Dry Land Agricultural Practices*. Central Research Institute for Dryland Agriculture, Hyderabad, Andhra Pradesh.