

On-farm Evaluation of Rice-groundnut Sequence *vis-a-vis* Rice-rice Cropping System under Limited Irrigated Situations of Telangana, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author LP designed the study, wrote the protocol and the first draft of the manuscript. Author SS performed the statistical analysis and data interpretation of the study. Authors MG, GKR and MA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Crop diversification with resource efficient and remunerative cropping systems is a sustainable agricultural practice. On farm evaluation with an improved cropping system of rice-groundnut *vis-a-vis* farmers' practice of rice-rice was conducted in ten farmer's fields of Medak district of Telangana state. Crop diversification with Rice-groundnut realized 7.3% (881 kg ha⁻¹) higher mean rice grain equivalent yield (12969 kg ha⁻¹) over farmer's practice of cultivation of rice-rice (12,088 kg ha⁻¹). Mean technology and extension gaps were 2,231 kg ha⁻¹ and 881 kg ha⁻¹ respectively. Technology index ranged from 8.8 to 23.7% with an average value of 14.7%. The mean gross and net returns of improved cropping system were Rs 1,92,930 and 1,09,658 ha⁻¹, while that of farmers practice was

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Rs 1,81,320 and 83,955 ha⁻¹ respectively. On an average a B C ratio of 2.3 was earned in improved cropping system as against the 1.9 under farmers practice. The mean additional returns in improved cropping system were Rs 13,210 ha⁻¹ with a mean effective gain of Rs 27,303 ha⁻¹. Improved cropping system registered a mean total productivity per day of 35.5 kg ha⁻¹ day⁻¹ with a mean profitability of Rs 300 day⁻¹. Average Production Use Efficiency of improved cropping system was 56.4 kg ha⁻¹ day⁻¹, while that of farmer's practice was 49.3 kg ha⁻¹ day⁻¹. The edge in productive economic parameters in terms of Mean Relative Productive Use Efficiency and Relative Economic Efficiency were 7.3 and 30.6 respectively and were indicating the profitability of improved cropping system.

Keywords: Crop diversification; rice-groundnut; rice-rice; rice equivalent yield; technology gap; technology index; production efficiency; economic efficiency.

1. INTRODUCTION

In India, rice is cultivated over an area of 44 million hectares and rice-rice is the predominant crop sequence in a tropical climate with distinct dry and wet seasons such as in South India and in sub-tropical areas with mild cool winter climate such as in Eastern India [1] and the system is spreading over 6 million hectares. Occurrence of second generation problems, such as over-mining of soil nutrients, decline in factor productivity, reduction in profitability, lowering of ground water table and build up of pests including weeds, diseases and insects has been reported in continuous rice-rice cropping system [2]. To overcome these deleterious effects an alternate cropping system or crop diversification is the need of the hour. Crop diversification shows a lot of promises in alleviating problems viz., water scarcity, excess use of nitrogenous fertilizer, soil deterioration etc., besides, fulfilling basic needs for cereals, pulses, oilseeds, vegetables and also regulating farm income, withstanding weather aberrations, controlling price fluctuation, ensuring balanced food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, ensuring environmental safety and creating employment opportunity [2].

Similarly, rice-rice is the dominant mono cropping system under irrigated ecosystem of Telangana state of India. It is grown in 19.62 lakh ha area with a production of 62.63 lakh tonnes and productivity of 3192 kg ha⁻¹ during 2017-18 [3]. It is grown in an area of 10.47 l ha and 9.15 lakh ha during kharif and rabi respectively.

Further, in Telangana, oil seed crops are cultivated in an area of 2.03 Lakh ha with a production of 3.2 Lakh tonnes. Major oil seed crops are soybean, castor, groundnut, sesame and sunflower, which are grown mainly as

rainfed. Major irrigation sources in the state are bore/ tube wells and open wells followed by canal irrigation. Changing climate, decreasing water level and ever increasing electricity demand pose grave concerns for rice cultivation during rabi (dry season) and demand for inclusion of alternate crops. The ever increasing gap between the demand and supply of oilseeds at the state as well as country level opens up the scope to utilize the rice fallows for oilseeds. The National Mission on Oilseeds and Oil Palm (NMOOP) paved an opportunity for expansion of the area of oilseed crop by inclusion of oil seeds as intercrop and sequence crop in cereal crop.

2. MATERIALS AND METHODS

To demonstrate the production potential and economic advantage of improved cropping system of rice-groundnut in comparison with farmer's practice of rice-rice, front line demonstrations were conducted during the year 2017-18 in 10 locations (irrigated and light soils) of Medak district by On Farm Research Centre, All India Coordinated Research Project on Integrated Farming Systems. An area of 0.4 ha per each location was chosen for study. The variety MTU 1010 of rice and K-6 for groundnut were used in the study. MTU 1010 variety of rice is a cross between Krishnaveni /IR 64, grain type is long slender Semi- dwarf (108 cm), resistant to blast and tolerant to BPH has yield potential of 6.25 - 7 t ha⁻¹ and comes to maturity in 120 days. Kadiri-6 (K-6) of groundnut is a Spanish bunch type with 100-110 days duration and yield potential of 3-3.5 t ha⁻¹ were selected. The cultivation of rice-rice (farmer's practice) was considered as control. Sowing of crops in both the treatments during kharif season was done during the June 2nd week to June 4th week 2017 and same was transplanted after attaining the age of 25-30 days. Whereas rabi crops groundnut and rice were sown during the

November 1st week to November 4th week and rabi rice of 25 day nursery was transplanted. Recommended spacing of 15 X 15 cm and 22.5 X 10 cm was adopted for rice and groundnut respectively. A seed rate of 50 kg ha⁻¹ and 200 kg ha⁻¹ was adopted for rice and groundnut respectively. In rice, seed was treated with carbendazim @ 1 g/kg seed while the groundnut seed was treated with mancozeb @ 3 g /kg of seed followed by 7 ml of imidacloprid /kg of seed to protect from pest and diseases. All

management practices for weed, nutrient, pest and diseases were adopted as per the recommendations of PJTSAU. A rainfall of 678 mm was received in 40 rainy days and the irrigations were given as per the need. The data on grain yield was collected by random crop cutting method and the yield of both the crop was presented as rice equivalent yield. It was calculated by converting the pod yield of groundnut into rice equivalent yield on the basis of the sale price of groundnut

$$\text{Rice Equivalent Yield} = \frac{(\text{Groundnut pod yield (kg ha}^{-1}) \times \text{Price of groundnut (Rs kg}^{-1}))}{\text{Price of rice grain (Rs kg}^{-1})}$$

Benefit Cost ratio, gross and net returns were calculated based on grain and pod yield and prevailing market price. Per day net returns were worked out by dividing total net returns with the duration of the crop.

The extension gap, technology gap and technology index were calculated as per the following formula drawn by Samui et al. [4]

$$\text{Extension gap} = \text{Yield in improved practice} - \text{Yield in farmers practice}$$

$$\text{Technology gap} = \text{Potential Yield} - \text{Yield in improved}$$

$$\text{Technology Index} = \left(\frac{\text{Technology gap}}{\text{Potential yield}} \right) \times 100$$

Production and Economic indices are calculated based on following formulae.

$$\text{Additional Returns} = \text{Extension gap} \times \text{Sale price}$$

$$\text{Effective Gain} = \text{Additional returns} - \text{Additional cost}$$

$$\text{Returns per rupee investment (Rs Re}^{-1}) = \frac{\text{Net returns}}{\text{Cost of cultivation}}$$

$$\text{Per day Productivity (kg ha day}^{-1}) = \frac{\text{Total Productivity}}{365}$$

$$\text{Per day Profitability (Rs ha day}^{-1}) = \frac{\text{Total Profitability}}{365}$$

As Production Use Efficiency is efficiency measured in terms of yield/day

$$\text{Production Use Efficiency (kg ha day}^{-1}) = \frac{\text{Total Grain Yield of the System}}{\text{Period in days consumed to produce yield}}$$

$$\text{Relative Production Use Efficiency (\%)} = \left(\frac{\text{Total productivity of diversified system} - \text{Total productivity of the existing system}}{\text{Total Productivity in the existing sequence}} \right) \times 100$$

$$\text{Relative Economic Efficiency (\%)} = \left(\frac{\text{Net returns from diversified Sequence} - \text{Net returns of the existing sequence}}{\text{Net returns of the existing sequence}} \right) \times 100$$

Table 1. Grain yield, technology gap, extension gap and technology index of improved cropping system vis –a-vis farmers’ practice

Trial No	Grain yield (kg ha ⁻¹) in Improved cropping system (Rice-Groundnut)		Rice Grain Equivalent Yield (kg ha ⁻¹) in Improved system	Rice yield in farmers practice (rice-rice) (kg ha ⁻¹)			Rice Gain Equivalent Yield (kg ha ⁻¹)	Potential yield (kg ha ⁻¹) of Improved system	% increase in yield over farmers practice	Technology gap (kg ha ⁻¹)	Extension gap (kg ha ⁻¹)	Technology Index
	Rice (Kharif)	Groundnut (Rabi)		kharif	Rabi	Total						
1	6535	2665	13642	6535	6650	13185	457	15200	3.5	1558	457	10.3
2	5950	2625	12950	5950	6280	12230	720	15200	5.9	2250	720	14.8
3	6175	2810	13668	6175	6245	12420	1248	15200	10.1	1532	1248	10.1
4	5825	2410	12252	5825	6260	12085	167	15200	1.4	2948	167	19.4
5	6005	2665	13112	6005	6465	12470	642	15200	5.1	2088	642	13.7
6	6230	2865	13870	6230	6505	12735	1135	15200	8.9	1330	1135	8.8
7	5265	2375	11598	5265	5845	11110	488	15200	4.4	3602	488	23.7
8	5725	2800	13192	5725	6135	11860	1332	15200	11.2	2008	1332	13.2
9	5665	2775	13065	5665	5945	11610	1455	15200	12.5	2135	1455	14.0
10	5205	2675	12338	5205	5970	11175	1163	15200	10.4	2862	1163	18.8
Mean	5858	2667	12969	5858	6230	12088	881	15200	7.3	2231	881	14.7
Std. Dev							439.5					
t statistic							6.34					
Two-tail p-value							0.00014					
Confidence Level 95%							272.4					

Table 2. Economics of improved cropping system vis –a-vis farmers’ practice

Trial No	Cost of Cultivation (Rs ha ⁻¹)		Gross Returns (Rs ha ⁻¹)			Net Returns (Rs ha ⁻¹)		B: C ratio		Per day Net Returns (Rs ha ⁻¹)	
	Improved system	Farmers Practice	Improved system	Farmers Practice	Gain	Improved system	Farmers Practice	Improved system	Farmers Practice	Improved system	Farmers Practice
1	81900	98000	196625	197775	14950	114725	99775	2.4	2.0	499	407
2	80400	95400	194250	183450	25800	113850	88050	2.4	1.9	495	359
3	83800	94150	205025	186300	29075	121225	92150	2.4	2.0	527	376
4	86600	98780	175775	181275	6680	89175	82495	2.0	1.8	388	337
5	80675	97225	196675	187050	26175	116000	89825	2.4	1.9	504	367

Trial No	Cost of Cultivation (Rs ha ⁻¹)		Gross Returns (Rs ha ⁻¹)			Net Returns (Rs ha ⁻¹)		B: C ratio		Per day Net Returns (Rs ha ⁻¹)	
	Improved system	Farmers Practice	Improved system	Farmers Practice	Gain	Improved system	Farmers Practice	Improved system	Farmers Practice	Improved system	Farmers Practice
6	80300	96200	208050	191025	32925	127750	94825	2.6	2.0	555	387
7	85850	99650	173975	166650	21125	88125	67000	2.0	1.7	383	273
8	87650	100750	197875	177900	33075	110225	77150	2.3	1.8	479	315
9	82200	95600	195975	174150	35225	113775	78550	2.4	1.8	495	321
10	83350	97900	185075	167625	32000	101725	69725	2.2	1.7	442	285
Mean	83272.5	97365.5	192930	181320	25703	109658	83955	2.3	1.9	477	343
Std dev					9110						
t statistic					8.92						
Two-tail p-value					0.00001						
Confidence Level 95%					5646						

Table 3. Production and economic indices of improved cropping system vis –a-vis farmers’ practice

Trial No	Additional Returns (Rs ha ⁻¹)	Effective gain (Rs ha ⁻¹)	Per day productivity (kg ha ⁻¹ day ⁻¹)		Per day Profitability (Rs ha ⁻¹ day ⁻¹)	Production Use Efficiency (kg ha ⁻¹ day ⁻¹)		Relative Productive Use Efficiency (%)	Relative Economic Efficiency (%)
			Improved system	Farmers Practice		Improved system	Farmers Practice		
1	6850	22950	37.4	36.1	314	59.3	53.8	3.5	15.0
2	10800	25800	35.5	33.5	312	56.3	49.9	5.9	29.3
3	18725	29075	37.4	34.0	332	59.4	50.7	10.1	31.6
4	2500	14680	33.6	33.1	244	53.3	49.3	1.4	8.1
5	9625	26175	35.9	34.2	318	57.0	50.9	5.1	29.1
6	17025	32925	38.0	34.9	350	60.3	52.0	8.9	34.7
7	7325	21125	31.8	30.4	241	50.4	45.3	4.4	31.5
8	19975	33075	36.1	32.5	302	57.4	48.4	11.2	42.9
9	21825	35225	35.8	31.8	312	56.8	47.4	12.5	44.8
10	17450	32000	33.8	30.6	279	53.6	45.6	10.4	45.9
Mean	13210	27303	35.5	33.1	300	56.4	49.3	7.3	30.6

The paired T test was employed to test the efficiency of improved cropping system over farmers practice.

3. RESULTS AND DISCUSSION

3.1 Grain Yield

The Rice Equivalent Yield (REY) of improved cropping system of rice - ground nut ranged from 11,598 kg ha⁻¹ to 13870 kg ha⁻¹ across the locations and was 1.4 to 12.5% higher than the yield of rice-rice system (farmers' practice - 11110 kg ha⁻¹ to 13185 kg ha⁻¹). On an average REY of improved cropping system (Table 1) of rice - ground nut was 7.3% higher (12969 kg ha⁻¹) than grain yield in farmers practice of rice-rice system (12088 kg ha⁻¹). The gain in yield of the improved system (rice-groundnut) was statistically significant, with a two-tail *p* value greater than zero (Mean gain =881 kg ha⁻¹, SD =440, with a *t* stat value of 6.34 and two-tail *p* value of 0.00014), providing evidence that the improved cropping system is more efficient than farmers practice. Virdia and Mehata [5] also reported that paddy - groundnut as the biologically efficient as well as cash ensuring and profitable crop sequence and fetched more return per unit.

Repeated cultivation of rice leads to the formation of hard-pan below the plow layer, deteriorates the soil structure, inhibits the root elongation and delays the planting of a succeeding crop [6]. Continuous rice cultivation for longer periods with poor crop management practices has often resulted in loss of soil fertility and in turn leads to multiple nutrient deficiencies [7, 8]. Crop rotation with legumes improves soil properties [9,10,11,12]. Crop rotation also influences the N use efficiency and prompt changes in various N sources, affecting availability to the plant [13]. Though legume materials contribute only a small portion of the available N pool, their main value appears to be long term, i.e., in their capacity to maintain or increase concentrations of soil organic N to be decomposed at relatively slow rates in the following years [14].

3.2 Economics

Improved cropping system of rice-ground nut earned gross returns ranging from Rs. 1, 73,975 to Rs 2,08,050/- across the locations. While gross returns of rice-rice under farmer's practice ranged from Rs. 1, 66, 650 to Rs 1, 97, 775/-

(Table 2). The mean gross returns under improved cropping systems were Rs 1,92,930 vis-a-vis Rs 1,81,320/- in farmers' practice. The mean gain of net return was Rs 25703 with a standard deviation of 9110 and was significant over farmers' practice with a *t* stat value of 8.92 and two-tail *p* value of 0.00001, providing evidence that the improved cropping system is beneficial than farmers practice. Net returns in improved cropping system ranged from Rs. 88,125 to Rs 127, 750 with a mean value of Rs 1,09, 658 while net returns of farmers practice of rice-rice system varied from Rs 82, 495 to Rs 99,775 with an average net return of Rs 83,955/-. The returns earned on per rupee investment were ranging from Rs 2.0 to Rs 2.6 with a mean BC ratio of Rs 2.3 in improved cropping system, whereas in farmers practice the benefit was Rs 1.7-2.0 per rupee cost with a mean value of 1.9. Per day net returns ranged from Rs. 383 to Rs. 555 in improved cropping system with at an average of Rs 477. While rice-rice system resulted in Rs 273 to 407 per day returns with mean of Rs 343. Higher economics in improved cropping systems over farmers' practice can be attributed to higher rice equivalent yield, high gross and net returns and lower cost of cultivation. The results are in conformity with the findings of Latheef pasha et al. [15] stated that the mean gross and net returns of improved cropping system (Soybean-Maize) were Rs 141471 and 68941 ha⁻¹, while that of farmers practice (Maize-Maize) were Rs 132158 and 55693 ha⁻¹ respectively. On an average a B C ratio of 2.0 was earned in improved cropping system as against the 1.7 under farmers practice.

3.3 Technology Gap, Extension Gap and Technology Index

Technology gap ranged from 1330 kg ha⁻¹ to 3602 kg ha⁻¹ with a mean of 2231 kg ha⁻¹. Whereas extension gap varied from 167 to 1455 kg ha⁻¹ with average value of 881 kg ha⁻¹ (Table 1). The technology index represents the feasible adaptability improved cropping systems from lab to land. Lower the technology index means more viability of innovative cropping system in farmer's field. Thus attaining higher yields almost close to potential yields will hasten up the adoption of improved cropping system interventions to increase the yield performance. The technology index in the current study ranged from 8.8 to 23.7% with an average value of 14.7%. Similar indices were observed by Latheef pasha et al [16] in the redgram + soybean cropping system

(diversified system) over sole redgram (farmers practice) that mean Technology gap was 594 kg ha⁻¹ and it ranged from 193 kg ha⁻¹ to 1036 kg ha⁻¹. Whereas extension gap varied from 497 to 1067 kg ha⁻¹ with an average value of 854 kg ha⁻¹. Technology index ranged from 4.5 to 24.1% with an average value of 13.8%.

3.4 Production and Economic Indices

Additional returns in the diversified cropping system ranged from Rs. 7325 to 21825 ha⁻¹ with mean additional returns of Rs 13210 ha⁻¹ (Table 3). The effective gain in improved cropping system ranged from Rs 14680 ha⁻¹ to Rs 35225 ha⁻¹ with an average of Rs 27303 ha⁻¹. Total per day productivity in improved cropping system varied from 31.8 kg to 38.0 kg ha⁻¹ day⁻¹ with a mean of 35.5 kg ha⁻¹ day⁻¹ as against 33.1 kg ha⁻¹ day⁻¹ in farmers practice which ranged from 30.4 to 36.1 kg ha⁻¹ day⁻¹. Mean per day profitability of improved cropping system was Rs 300 and was ranging from Rs 241 to Rs 350/-.

Production Use Efficiency of improved rice-groundnut system ranged from 50.4 to 59.4 kg ha⁻¹ day⁻¹ with an average of 56.4 kg ha⁻¹ day⁻¹, while it was 45.3 to 53.8 kg ha⁻¹ day⁻¹ with a mean of 49.3 in rice-rice system. Relative Productive Use Efficiency of the rice-groundnut system shoot up to 12.5% with an average of 7.3% whereas Mean Relative Economic Efficiency was 30.6% and it ranged from 8.1 to 45.9%. The results are in conformity with the findings of Samant [17] and Prasad et al. [18].

Rice-oilseeds cropping sequences are considered as a valuable cropping system for food and nutritional security. In eastern India, rice-groundnut, rice-rapeseed/mustard are predominant cropping systems. The finding by Lal et al. [19] at NRRI, Cuttack demonstrated that early sowing of dry season toria after rice is profitable and it ensures profitability of rainfed rice based cropping system. Inclusion of pulses, oilseeds and vegetables in the cropping system is more beneficial than rice-rice cropping system [20].

An intensification of cropping sequence is essential in the existing farming situation. Non-rice crops like oilseeds, pulses and vegetables are receiving more attention owing to higher price due to increased demand. Inclusion of these crops in a sequence changes the economics of the cropping sequences [21].

4. CONCLUSION

Results obtained from the computation of indices, yield and returns showed a significant advantage of diversifying the system with rice – groundnut sequence crop rather than mono-cropping of rice-rice system in limited irrigated situations of Telangana state.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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