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Opportunities and econometrics for rice (*Oryza sativa*) fallow pulses in north coastal Andhra Pradesh

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Pulses occupy a unique place in India as they are one of the less expensive sources of protein and consumed equally by India's rich and poor (Mohanty and Satyasai 2015). India has a great demand and market value for the pulses but still grown only on 283.4 lakh ha area and produces only 23.2 M T with an average productivity of 817 kg/ha for the year 2019–20. Among states, Madhya Pradesh, Maharashtra, Uttar Pradesh, Andhra Pradesh, Karnataka and Rajasthan are the major pulse growing states in India (75% area and production) (Ministry of Agriculture and Cooperation 2015–16). The recommended dietary allowances (RDA) for protein of an adult male and female are 1 g/kg body weight/ day. As a result of stagnant pulse production and continuous increase in population, the per capita availability of pulses has decreased considerably i.e. 60.7 g in 1951 to 35.4 g in 2010 (Tiwari and Shivhare 2016).

Rice (*Oryza sativa* L.)–Pulse cropping system is not only an opportunity for meeting the demand of pulses but also improves the soil quality in terms of nutrient dynamics, soil organic carbon and biological activities. Rice is a predominant crop during rainy (*kharif)* season in most parts of the country and about 44 M ha of land is under its cultivation of which rice fallow pulse is in around 12.0 M ha. Twenty percent of rice fallow pulse area has been occupied in southern states of Andhra Pradesh, Tamil Nadu and Karnataka (Subbarao *et al.* 2001) and on an average 11.7 M ha of this area remains fallow during winter (*rabi)* season. The rice area under *kharif* in the north coastal districts comprises 4.31 lakh ha of which only 28% area is being utilized for growing fallow pulses. Hence there is ample scope to expand the area of rice fallow pulses in north coastal districts, viz. Srikakulam, Vizianagaram and Visakhapatnam and considered as main objective by the University under Biotech KISAN Project of Department of Biotechnology, Ministry of Science and Technology, Government of India.

Baseline survey was conducted in the project areas Srikakulum and Visakhapatnam districts of Andhra Pradesh during 2018–19 and 2019–20 with a sample size of 60 farmers from each district in the selected villages and mandals by Krishi Vigyan Kendra and District Agricultural Advisory and Transfer of Technology Centre respectively, to know the present status of the pulses and technological constraints of the farmers. Ex-post facto design was followed for the study. A pre-tested interview schedule was used to collect data from the respondents. Selected characteristics of the respondents,' viz. knowledge and adoption were considered as independent variables of the study. The adoption indexes were assessed based on the scores on all the recommended practices of pulse production as adopted and not adopted, and the respondents were further categorized into 3 groups based on their adoption levels separately for each district as low, medium and high. Further based on the baseline data production constraints were identified, strategies were framed and 89 on-farm demonstrations were laid out in both the districts (49 in Srikakulam and 43 in Visakhapatnam) during rainy (*kharif*) and winter (*rabi*) seasons of 2018–19 and 2019–20. Yield data were recorded and cost economics were computed. Farmer's feedback and post evaluation was attempted to assess the improvement in knowledge and adoption levels.

The farmer profile characters revealed that 95.01% and 88.35% of the farmers are small farmers respectively in Srikakulam and Visakhapatnam districts. The adoption of sustainable cultivation practices by the farmers from different districts indicated that the knowledge and adoption rate for seed treatment, intercrops and IPM is low in both the districts (Srikakulam and Visakhapatnam) (Table 1). Even though the knowledge on improved varieties, recommended fertilizers, recommended chemicals for pest and disease management, INM, IPM is medium to high but adoption is

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Table 1 Knowledge and adoption of sustainable cultivation practices by the farmers

Adoption index	Knowledge		Adoption	
	Srikakulam	Visakhapatanam	Srikakulam	Visakhapatanam
Low (up to 33.33)	4,11,14	4,9,11,14	1,4,8,9,11,12,13,14	1,4,8,9,11,12,13,14
Medium (33.34 to 66.66)	1,3,5,6,7,8,9,14	1,3,5,6,7,8	2,3,5,6,7,10	2,3,4,5,6,7
High (Above 66.66)	2,10,12	2,10,12,13,14	-	10

1, Improved varieties; 2, Sowing time; 3, Suitable soils; 4, Seed treatment; 5, Sowing methods; 6, Spacing; 7, Seed rate; 8, Recommended fertilizers and their dosage; 9, Recommended herbicides and their dosage; 10, Inter cultivation; 11, Intercrops; 12, Recommended chemicals for insect and disease management; 13, INM practices; 14, IPM practices.

low in both the districts which clearly show that, the farmers should be demonstrated about the sustainable cultivation practices. The knowledge and adoption of sustainable practices like suitable soils, sowing method, spacing and seed rate is medium in both the districts. The district wise distribution of farmers on adoption of sustainable cultivation practices also shows that adoption rate is low to medium in north coastal districts Srikakulum (66.7% low and 26.7% medium) and Visakhapatnam (65.0% low and 30.0% medium).

The production constraints include growing of rice during rainy (*kharif*) season in the month of August with medium to long-duration varieties there by delay in pulse seeding, inappropriate seed rate, early thrips and viral disease infection due to non-adoption of seed treatment, failure in pest and disease management, and drought as a key variables affecting output levels and is in agreement with the results of Kumar *et al*. (2018). Based on the constraints, strategies were framed, viz. timely sowing of the *kharif* rice crop with medium and short-duration varieties, viz. MTU1121, MTU1010, MTU1210, MTU1075, MTU1156 etc, direct sowing with drum seeder, soil test based fertilizer application, use of biofertilizers and Integrated pest and disease management followed by *rabi* relay crop of blackgram with varieties like LBG 752, 787, PU31, TBG104, GBG 1 and greengram with varieties like LGG407, TM96-2, WGG42, LGG460, IPM2-14, usage of correct recommended seed rate 16-18 kg/ac, seed treatment with imidachloprid 600 FS @5 ml or thiomethoxam 70 WS @5 g + mancozeb 75 WP @3 g/kg seed, 24–48 h before sowing. No need of fertilizer application, if weed Management- Sodium aceflorfen 16.5 + clodinafop-propargyl 8% (Iris) - 400 ml/acre, giving two irrigations @ bud initiation stage and grain filling stage, foliar application of 19:19:19 1.0 kg/acre 30-35 DAS and 13:0:45 @1.0 kg/acre at 55–60 DAS and following Integrated pest and disease management practices.

The results of the demonstrations conducted during 2018–19 and 2019–20 are presented in Table 2. Direct sowing rice with gorru and drum seeder resulted in a saving of ₹3800/ha on cost of cultivation and harvested 6–7 days earlier. An additional benefit of ₹2.19 and ₹1.35 was recorded with relay crop of rice fallow greengram and

Table 2 Performance of technology demonstrations during winter (*rabi)* season, 2018–19 and 2019–20 and economics of different cropping systems

Crop	No. of Mandals (n)	Yield (kg/ha)		Mean differ-ence	't'-cal. Value	Average yields (kg/ha)	Yield increase over check (%)	Yield increase over mandal average (%)	Gain in Benefit (₹) over control	B:C ratio comparison in different cropping system
		Demo	Control							
Visakhapatnam										
Rice – *kharif*	20	4780.0	4230.0	550.0	7.52**	2528.0	13.0	89.0	0.30	1.58
Greengram – Relay crop in rice fallows	29	702.0	492.5	209.5	6.87**	550.0	42.5	27.6	2.19	2.52
Blackgram – Relay crop in rice fallows	30	619.2	440.9	178.4	6.23**	436.9	40.5	41.7	1.35	2.24
Srikakulam										
Rice – *kharif*	20	5373.0	5167.0	206.0	5.69**	4088.0	4.0	31.4	0.09	1.78
Blackgram–Relay crop in rice fallows (sown after November 15)	29	422.1	369.8	52.3	2.44*	350.0	14.2	20.6	0.46	2.10
Blackgram–Relay crop in rice fallows (sown before November 15)	20	718.8	575.0	143.75	4.68**	556.0	25.0	29.2	1.37	2.40

**significant at 0.01 level of probability; *significant at 0.05 level of probability.

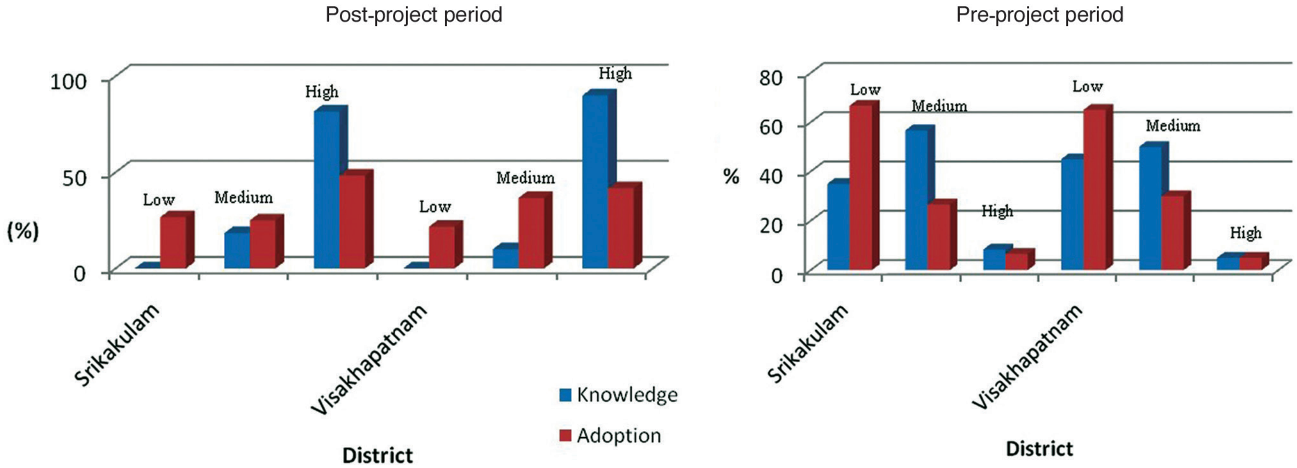

Fig 1 Knowledge and adoption levels of farmers during pre- and post-project period.
*Low (up to 33.33); Medium (33.34–66.66); High (Above 66.66).

blackgram respectively with technology demonstrations when compared with farmers practice in Visakhapatnam and ₹1.37 with relay crop of rice fallow blackgram sown before November 15 in Srikakulam. When t-test was conducted, the increased yields was significant at 0.01 level of probability both for greengram and blackgram. In Srikakulam, when blackgram crop sown before November 15 recorded 25.0% increased yield over farmers practice and 29.2% increased yield over mandal average yields. But yield increase was only 14.2% when sown after November 15. The average yields were low in all the crops due to the damage caused by '*Titlee*' and '*Phethai*' cyclones during 2018–19, however, yields recorded in technology demonstrations were higher when compared to farmers practice and district average yield.

The economics pertaining to the different cropping systems reveals that in Srikakulam district the rice-blackgram cropping system gave cost benefit ratio of 1:2.40 as against rice-rice cropping system with 1:1.78. Similarly in Visakhapatnam district, the rice–greengram system recorded a cost benefit ratio of 1:2.52 and rice-blackgram with a cost benefit ratio of 1:2.24 as against rice-rice cropping system 1:1.58. These results clearly indicate that in both the districts, sowing of greengram/blackgram in rice fallows as relay crop after *kharif* is highly beneficial as against rice-rice cropping system.

Rice fallow pulse crop (Rice-pulse) recorded 1356 man hours, 700 mm water and 251.94 kg of fertilizer consumption per hectare as against 1756 man hours, 1220 mm water and 410.02 kg fertilizer in rice-rice cropping system there by a saving 400 man hours, 520 mm water and 158.08 kg fertilizer which clearly demonstrates that rice-fallow pulse crop saves input costs and increases the net returns. Growing of greengram/blackgram in rice fallows as relay crop is an easy task for the farmer and produce assured returns at low investment (Behera *et al.* 2014). Moreover, this is a practice which protects environment due to reduction in release of GHG and soil ecology through water saving (200–400 mm), grow with residual fertilizer applied for rice crop during *kharif,* accumulates and adds soil nutrients (Ali *et al.* 2009).

The knowledge and adoption levels of the farmers on sustainable agricultural practices during pre- and post-project period has revealed that in both the districts, the knowledge level for the farmers falling under category of high has increased drastically during post project period. The adoption of the sustainable cultivation practices by the farmers falling under high category increased i.e. 48.33% and 41.67% respectively in both the districts with reduction in percentage of the farmers falling under low category (Fig 1)

SUMMARY

The present study was carried out during 2022 at the Biotech KISAN Hub unit, Krishi Vigyan Kendra, Banavasi. Constraints in production of fallow pulse crop along with the strategies to overcome them were discussed and addressed in north coastal districts (Srikakulam and Visakhapatnam), which have increased the pulse production and at the same time improved the net returns of the farmers. Majority of the farmers in these districts are small farmers (>85%) and low to medium in their knowledge and adoption levels on sustainable agricultural practices. This project also enhanced the knowledge levels of the farmers pertaining to the benefit and importance of rice fallow pulse cropping and the farmers are ready to adapt this cropping pattern. Rice fallow pulse cropping not only improves the socio-economic status of farmers but also plays a key role in meeting the high demands of pulses and overcoming the malnutrition which is need of the hour. Hence, the remaining rice area as mentioned above 72% under *kharif* in these districts if utilized for growing pulses in winter (*rabi*) season which is around 3.11 lakh ha, it can lead to increased pulse production of around 420.2 Mt and can generate an additional income of approximately ₹2941 crores at low input costs.

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