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Integrated crop management enhances productivity and profitability of redgram (*Cajanus cajan* L.) under rainfed alfisols

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Abstract

Front Line Demonstrations (FLDs) on Integrated Crop Management (ICM) in redgram were conducted during 2022–23, 2023–24 and 2024–25 under rainfed Alfisol conditions of Mahabubnagar district, Telangana, to evaluate the effect of improved crop management technologies on productivity and profitability of redgram. A total of 14 demonstrations were conducted in farmers' fields and compared with the prevailing farmers' practice. The results revealed that Integrated Crop Management practices significantly improved grain yield, net returns and benefit-cost ratio over farmers' practice. The pooled analysis of three years data indicated that demonstration plots recorded an average yield of 1819 kg ha⁻¹ compared to 1563 kg ha⁻¹ under farmers' practice, resulting in 16.38 per cent yield enhancement. The average B:C ratio under demonstration plots was 2.47 compared to 2.06 under farmers' practice. Paired t-test analysis showed significant differences in grain yield during 2023–24 and 2024–25. The study demonstrated that adoption of Integrated Crop Management practices can effectively enhance redgram productivity and profitability under rainfed Alfisol conditions.

Keywords: Redgram, integrated crop management, front line demonstration, rainfed alfisols, t-test, productivity, profitability

1. Introduction

Redgram (*Cajanus cajan* L.) is one of the important pulse crops cultivated in semi-arid and rainfed regions of India and plays a significant role in food security and soil fertility improvement through biological nitrogen fixation. However, the productivity of redgram in farmers' fields remains low due to cultivation of local varieties, imbalanced nutrient management and inadequate pest and disease management practices.

Integrated Crop Management (ICM) is a holistic approach integrating improved varieties, nutrient management, biofertilizers, agronomic practices and plant protection measures for sustainable crop production. Adoption of integrated crop management technologies has been reported to improve productivity and profitability of pulse crops under rainfed conditions (Harish *et al.*, 2020) [3]. Bharathi *et al.* (2015) [1] also reported that integrated nutrient management practices significantly improved growth, yield and economics of pigeonpea under rainfed conditions.

The use of improved varieties such as PRG-176 in combination with integrated nutrient and pest management practices enhances yield potential and adaptability of redgram under dryland ecosystems (Reddy *et al.*, 2018; Indian Institute of Pulses Research, 2020) [9, 4]. Improved crop management practices including seed treatment with Rhizobium, phosphate-solubilizing bacteria (PSB) and Trichoderma viride improve nutrient uptake, root growth and disease resistance in pulse crops. Patel *et al.* (2015) [7] reported that biofertilizer application along with integrated nutrient management enhanced growth and yield of pigeonpea under semi-arid ecosystems.

Front Line Demonstrations (FLDs) are effective extension interventions for bridging the gap between research recommendations and farmers' practice. Samui *et al.* (2000) [10] reported that FLDs significantly improved productivity and profitability of pulse crops. Similar findings on the effectiveness of Front Line Demonstrations in pulse crops were also reported by Choudhary *et al.*, 2017 [2] and Verma *et al.*, 2018 [13]. Therefore, the present study was undertaken to evaluate the

effect of Integrated Crop Management practices on redgram productivity and profitability under rainfed Alfisol conditions and to statistically validate the yield differences using paired t-test analysis.

Therefore, the present study was conducted to

1. Evaluate the effect of Integrated Crop Management practices on redgram productivity.
2. Compare yield and economic returns between farmers' practice and demonstration plots.
3. Validate the yield differences statistically using paired t-test analysis.

2. Materials and Methods

2.1 Study area

Front Line Demonstrations on Integrated Crop Management in redgram were conducted by Telangana Rythu Vignyan Kendra (formerly District Agricultural Advisory and Transfer of Technology Centre), Mahabubnagar district under Professor Jayashankar Telangana Agricultural University during 2022–23, 2023–24 and 2024–25 under rainfed Alfisol conditions. Five farmer locations were selected each year and an area of 0.4 ha per location was covered under demonstration.

The demonstrations were conducted to study the production potential and economic feasibility of improved crop management technologies in redgram. The test variety used was PRG-176. Seed treatment was carried out with Rhizobium for nitrogen fixation, phosphate-solubilizing bacteria (PSB) for phosphorus availability and Trichoderma viride for wilt disease management. The crop was sown at a spacing of 90 × 20 cm and nipping was carried out at 45 DAS. Nutrients were applied at 8 kg N acre⁻¹ and 20 kg P₂O₅ acre⁻¹. Timely weed, pest and disease management practices were followed as per PJTAU recommendations.

The region receives seasonal monsoon rainfall and is characterized by nutrient-deficient Alfisol soils typical of dryland agriculture.

2.2 Experimental treatments

Two treatments were compared:

Farmers' Practice (FP)

- Local redgram variety
- No seed treatment
- No nipping
- Imbalanced fertilizer application
- Untimely pest and disease management

Integrated Crop Management Demonstration Plot (ICM)

- Variety: PRG-176
- Seed treatment: Rhizobium + PSB + Trichoderma viride
- Spacing: 90 × 20 cm
- Nipping at 45 DAS
- Nutrient management: 8:20:0 kg NPK acre⁻¹
- Timely pest and disease management

2.3 Data collection

Data were collected from farmers' fields on:

- Input cost (Rs ha⁻¹)
- Grain yield (kg ha⁻¹)
- Gross returns (Rs ha⁻¹)
- Net returns (Rs ha⁻¹)

- Benefit-cost ratio

2.4 Statistical analysis

Yield data recorded from demonstration plots and farmers' practice plots were subjected to paired t-test analysis to determine the significance of yield differences between the treatments.

The t-test statistic was computed using the formula:

$$t = \frac{\bar{d}}{s_d/\sqrt{n}}$$

Where

- $\bar{d}$ = Mean difference between paired observations
- s_d = Standard deviation of differences
- n = Number of paired observations

The significance of treatment differences was tested at 5 per cent probability level.

3. Results and Discussion

3.1. Productivity and Yield Performance

The pooled data across three consecutive years (2022–23 to 2024–25) demonstrated a substantial enhancement in redgram grain yield due to the implementation of Integrated Crop Management (ICM) practices compared to traditional Farmers' Practice (FP). The demonstration plots (Demo) achieved a mean grain yield of 1819 kg ha⁻¹ whereas the Farmers' Practice plots recorded a lower mean grain yield of 1563 kg ha⁻¹ (Table 1). Adoption of ICM interventions led to a yield increase of 256 kg ha⁻¹ (16.38%) over traditional practices.

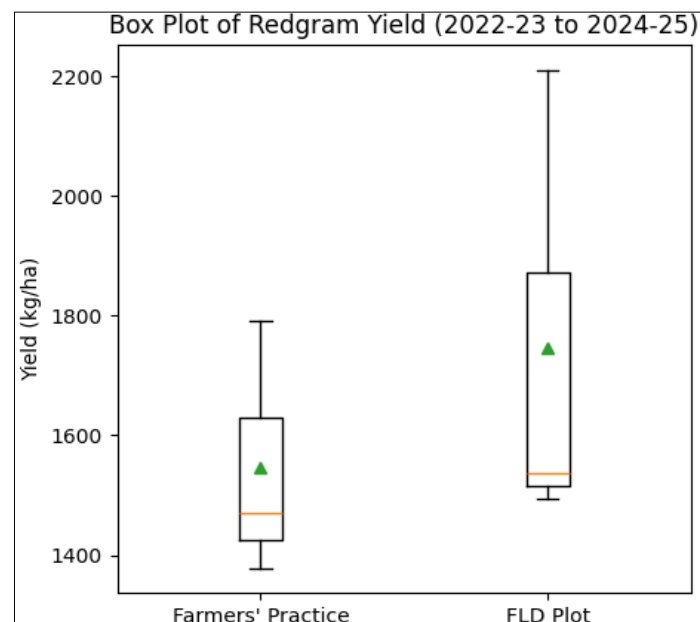
To assess statistical significance across the 14 paired frontline demonstrations ($n = 14$), a paired t-test was conducted. The test revealed a statistically significant difference between the demonstration and farmer practice plots ($t = 4.85$, $df = 13$, $p = 0.0003$) at a 1% level of significance ($p < 0.001$) (Table 1). This highly significant t-value confirms that the productivity gains were directly driven by the recommended ICM management package rather than random variability.

The superior performance under ICM can be attributed to the synergistic effect of balanced fertilization, improved seed treatment, optimum planting geometry, and timely integrated pest and weed management strategies. These findings are in close agreement with Indian Institute of Pulses Research (2020) [4], who emphasized that integrated production technologies enhance canopy development, photosynthetic efficiency, and source-to-sink translocation in pulse crops. Similar significant yield enhancements in pigeonpea under frontline demonstrations in rainfed dryland conditions were reported by Choudhary *et al.* (2017) [2], Singh *et al.* (2018) [12], and Verma *et al.* (2018) [13].

The variability and yield spread between treatments are illustrated in the box plot distribution (Figure 1). The median yield level in ICM plots was higher than in FP plots, with the upper whisker extending beyond 2200 kg ha⁻¹ in high-performing demonstration fields. Furthermore, the higher upper quartile (Q_3) observed in the ICM plots demonstrates that improved technologies offer greater potential for yield maximization under favorable growing seasons compared to non-standardized traditional farmer methods. Comparable yield variability and stability trends in rainfed redgram systems have been observed by Harish *et al.* (2020) [3] and Kumar *et al.* (2022) [5].

Table 1: Demonstration of Integrated Crop Management on Red gram yield (Pooled data of three years)

Parameters	Farmers Practice (F.P)	Demonstration (Demo)
Mean yield (kg ha ⁻¹)	1563	1819
SD	206.8	339.3
SEm	55.3	90.7
n	14	14
df	13	
t-value	4.85	
p-value	0.0003	

**Fig 1:** Distribution of Redgram Grain Yield under Integrated Crop Management and Farmers' Practice (Pooled Data of Three Years)**Fig 1:** Distribution of Redgram Grain Yield under Integrated Crop Management and Farmers' Practice (Pooled Data of Three Years)

3.2. Economic Returns and Profitability

The monetary returns and economic viability of redgram cultivation under ICM practices and Farmers' Practice are detailed in Table 2 and depicted in Figure 2.

Adoption of ICM resulted in a lower overall cost of cultivation Rs. 49,068ha⁻¹ compared to Farmers' Practice Rs. 52,268 ha⁻¹, resulting in a direct input savings of Rs. 3,200 ha⁻¹ (Table 2). The reduced production cost under demonstration plots was primarily achieved through balanced nutrient management, avoidance of excessive or unnecessary pesticide spraying, and optimized seed usage. Similar reductions in cultivation costs due to systematic nutrient and pest management were reported by Bharathi *et al.* (2015) [1] and Sharma *et al.* (2016) [11].

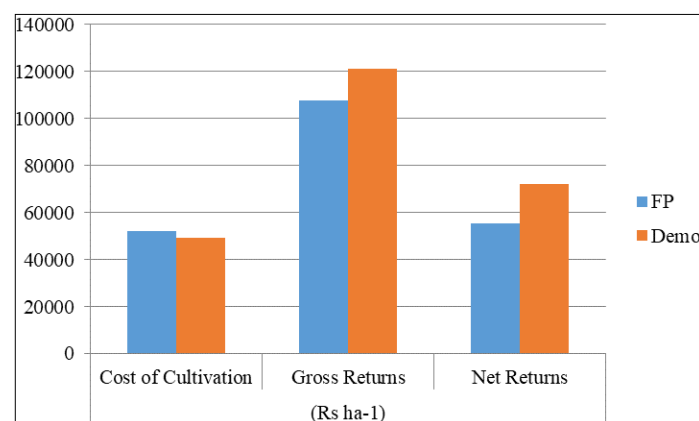
Owing to higher grain production and lower input expenditures, the demonstration plots registered higher gross returns Rs. 121,328 ha⁻¹ and net returns Rs. 72,260 ha⁻¹ compared to Farmers' Practice Rs. 107,653 ha⁻¹ gross returns and Rs. 55,385 ha⁻¹ net returns (Table 2, Figure 2). Demonstration plots generated an additional net profit of Rs. 16,875ha⁻¹, representing a 30.47% increase in net profit over conventional practices.

The Benefit-Cost (BC) ratio was substantially higher under ICM demonstrations (2.47) than under Farmers' Practice (2.06) (Table 2). The higher BC ratio highlights the enhanced capital efficiency and economic robustness of recommended technology packages for dryland redgram growers. These economic benefits are consistent with findings from Samui *et al.* (2000) [10], Patel *et al.* (2015) [7], Reddy *et al.* (2018) [9], Rao *et al.* (2019) [8], and Kumar *et al.* (2020) [6], who concluded that adopting integrated crop management interventions significantly boosts both farm

profitability and benefit-cost ratios in rainfed pulse production systems.

Table 2: Demonstration of Integrated Crop Management on Redgram Economics (Pooled data of three years)

Treatments	(Rs ha ⁻¹)			BC ratio
	Cost of Cultivation	Gross Returns	Net Returns	
FP	52268	107653	55385	2.06
Demo	49068	121328	72260	2.47

**(Pooled Data of Three Years)****Fig 2:** Effect of Integrated Crop Management on the Economics of Redgram Cultivation

4. Conclusion

The present study demonstrated that Integrated Crop Management (ICM) practices significantly enhanced the productivity and profitability of redgram under rainfed Alfisol conditions of Mahabubnagar district, Telangana. Adoption of improved variety PRG-176 along with seed treatment using Rhizobium, PSB and Trichoderma viride, balanced nutrient management, nipping and timely pest and disease management resulted in higher grain yield, net returns and benefit-cost ratio compared to farmers' practice. The pooled analysis of three years data indicated 16.38 per cent yield improvement under demonstration plots over farmers' practice. Paired t-test analysis further confirmed significant yield enhancement during 2023–24 and 2024–25, validating the effectiveness of Integrated Crop Management technologies. Thus, wider adoption of ICM practices through Front Line Demonstrations can play a vital role in improving pulse productivity, profitability and livelihood security of farmers under rainfed dryland ecosystems.

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Authors' contributions

K. Kalyani conducted the field demonstrations, collected and analyzed the data, performed statistical analysis and prepared the manuscript. Ch. Bharat Bhushan Rao provided technical guidance, supervised the study and critically reviewed the manuscript. P. Archana assisted in implementation of demonstrations, extension activities, data compilation and manuscript editing.

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Research content

The research work presented in this manuscript is original and has not been published elsewhere. The manuscript is not under consideration for publication in any other journal.

Ethical approval

This article does not involve experiments on humans or animals. Therefore, ethical approval was not required for this study.

Conflict of Interest

The authors declare that there is no conflict of interest regarding publication of this manuscript.

Data availability

All data generated or analyzed during the present investigation are included in this manuscript.

Consent to publish

All the authors have read and approved the final version of the manuscript and consented to its publication.

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