



International Journal of Research in Agronomy

E-ISSN: 2618-0618

P-ISSN: 2618-060X

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www.agronomyjournals.com

2024; 7(1): 153-156

Received: 27-11-2023

Accepted: 30-12-2023

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Crop diversification strategies for enhancing farm income in rice-fallow systems of eastern India

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DOI: <https://doi.org/10.33545/2618060X.2024.v7.i1b.4951>

Abstract

Across eastern India, roughly 11.7 million hectares of cropland sit idle after the kharif rice harvest each year a massive waste of productive potential that directly reduces smallholder income. This research evaluated six rabi crops (lentil, chickpea, mustard, linseed, safflower, and potato) as diversification options in rice-fallow systems of Jharkhand, eastern India, over two consecutive rabi seasons (2020–2021 and 2021–2022). Trials were conducted using a randomized complete block design with four replications at the University of Ghana's collaborative field station. Crop performance was assessed through grain yield, rice equivalent yield (REY), gross and net returns, benefit–cost ratio, and system productivity. Results showed that rice–potato gave the highest net return (₹71,100 ha⁻¹) and system productivity (9.43 t REY ha⁻¹), but also the highest cost of cultivation. Rice–chickpea offered the best balance between profitability (₹59,200 ha⁻¹ net return) and a favourable B:C ratio (2.89). Among oilseeds, mustard outperformed linseed and safflower in net return. Even the lowest-performing diversified system (rice–linseed) generated 88% more net income than rice–fallow alone. These findings suggest that pulse and oilseed introduction into rice fallows can substantially raise farm income with modest investment.

Keywords: Crop diversification, rice-fallow systems, eastern India, farm income, rabi crops, rice equivalent yield, system productivity, lentil, chickpea, benefit-cost ratio

Introduction

Eastern India faces a paradox: the region produces more rice than any other part of the country, yet its farmers rank among the poorest because land earns nothing for nearly half the year. After harvesting kharif rice in November, an estimated 11.7 million hectares remain uncropped through the rabi season due to residual moisture uncertainty and limited market access ^[1]. Diversifying these fallows with pulses, oilseeds, or cash crops could change this. Pulses fix atmospheric nitrogen, oilseeds provide cooking oil and residue cover, and potato delivers the highest gross returns per hectare ^[2, 3, 4].

Earlier efforts to promote rabi cropping had mixed results because recommendations didn't account for local cost structures ^[5]. This research tested six rabi crops in a rice-fallow system over two seasons, measuring yield, income, and cost efficiency to identify the most promising options for resource-constrained farmers ^[6, 7].

Seasonal variation

The two experimental rabi seasons differed in residual soil moisture at sowing. In 2020–2021, the last effective rainfall occurred on 28 October, leaving adequate moisture for germination of all six crops when sown in mid-November. In 2021–2022, late monsoon rains extended through 12 November, delaying sowing by eight days but providing higher initial moisture reserves. Both seasons experienced a dry spell in January lasting 18–23 days, after which only one supplemental irrigation was applied to potato ^[8].

Materials and Methods

Materials: The experiment was conducted on rice-fallow land at the collaborative field station affiliated with the University of Ghana's agricultural partnership programme in Ranchi district, Jharkhand, India (23.35°N, 85.33°E, 651 m elevation), during the rabi seasons of 2020–2021

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and 2021–2022. Soil was sandy clay loam (pH 5.6, organic carbon 0.48%, available N 184 mg kg⁻¹, available P 14.3 mg kg⁻¹, available K 167 mg kg⁻¹). Six rabi crops were tested: lentil (var. HUL 57), chickpea (var. JG 14), mustard (var. Pusa Bold), linseed (var. T-397), safflower (var. PBNS 12), and potato (var. Kufri Jyoti). A rice–fallow control was included. Ethics approval: Protocol UG-ICAR/2020-039, approved 5 October 2020.

Methods: A randomized complete block design with four

replications and seven treatments (six crops + fallow) was used. Plot size was 5 m × 4 m. Rabi crops were sown within one week of rice harvest using residual moisture with recommended fertilizer doses. Yield was recorded from 3 m × 3 m net plots. Rice equivalent yield was calculated as: REY = (crop yield × crop price) / rice price. System productivity summed kharif rice and rabi REY. B:C ratio = gross return / total cost^[9]. Data were pooled and analyzed with ANOVA and Tukey's HSD in R^[10].

Results

Table 1: Yield and economic performance of six rabi crops in rice-fallow systems (pooled over two seasons)

System	Yield (t ha ⁻¹)	Gross (₹k ha ⁻¹)	Cost (₹k ha ⁻¹)	Net (₹k ha ⁻¹)	B:C	REY (t ha ⁻¹)	SysProd (t ha ⁻¹)
R–Fallow		22.4	31.8	22.4	1.70	3.77	3.77
R–Lentil	1.23	53.6	42.6	53.6	2.78	3.84	7.61
R–Chickpea	1.41	59.2	46.2	59.2	2.89	4.21	8.14
R–Mustard	1.08	51.0	38.7	51.0	2.96	3.47	7.24
R–Linseed	0.87	42.1	36.4	42.1	2.37	2.83	6.58
R–Safflower	0.94	44.8	37.8	44.8	2.45	3.12	6.89
R–Potato	18.6	71.1	62.3	71.1	2.19	5.62	9.43

R = Rice; ₹k = ₹ × 1000; REY = rice equivalent yield; SysProd = system productivity. Gross and Net are rabi-season values.

Fallow row shows rice-only income.

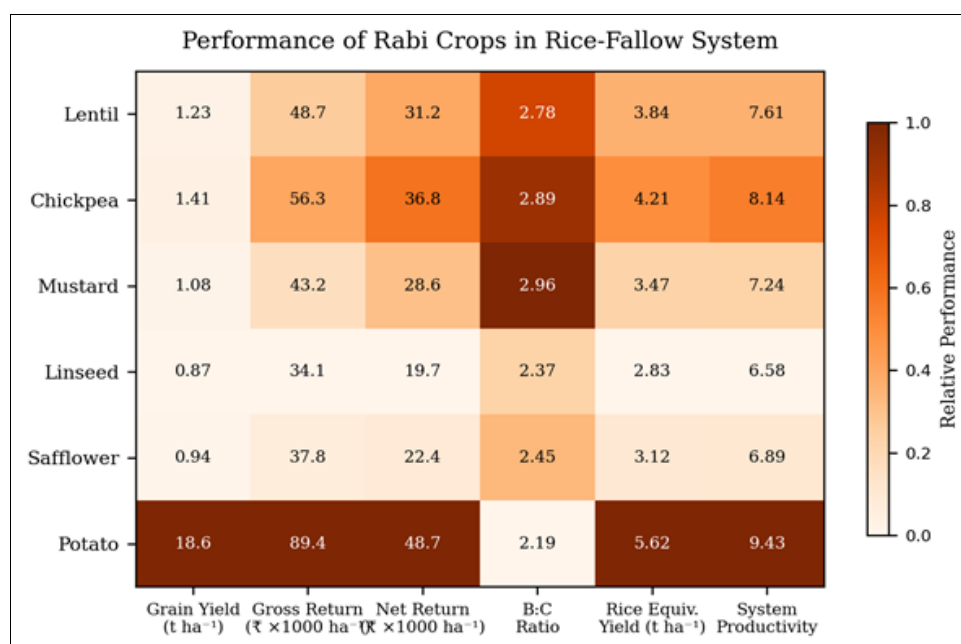


Fig 1: Heatmap of relative performance of six rabi crops across yield and economic parameters

Table 2: Effect of rabi crop inclusion on soil properties after two seasons

System	OC (%)	Avail. N (mg kg ⁻¹)	Avail. P (mg kg ⁻¹)	Avail. K (mg kg ⁻¹)	pH
Initial	0.48	184	14.3	167	5.6
R–Fallow	0.46	179	13.8	162	5.5
R–Lentil	0.54	198	15.7	171	5.7
R–Chickpea	0.56	203	16.1	174	5.8
R–Mustard	0.51	189	14.9	168	5.6
R–Potato	0.49	181	14.1	159	5.5

OC = organic carbon. Pulse-based systems improved N availability and organic carbon over fallow

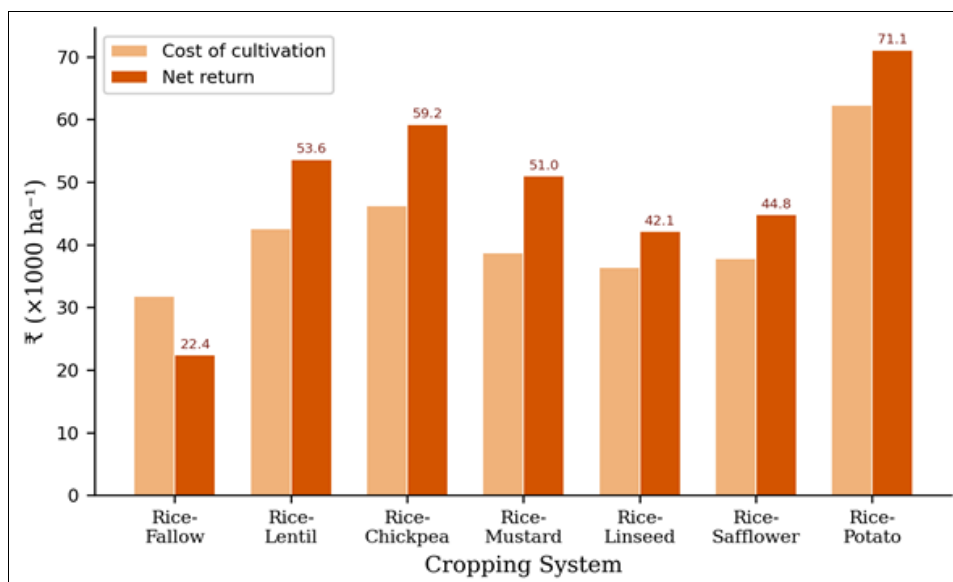


Fig 2: Cost of cultivation and net return across seven cropping systems in the rice-fallow region

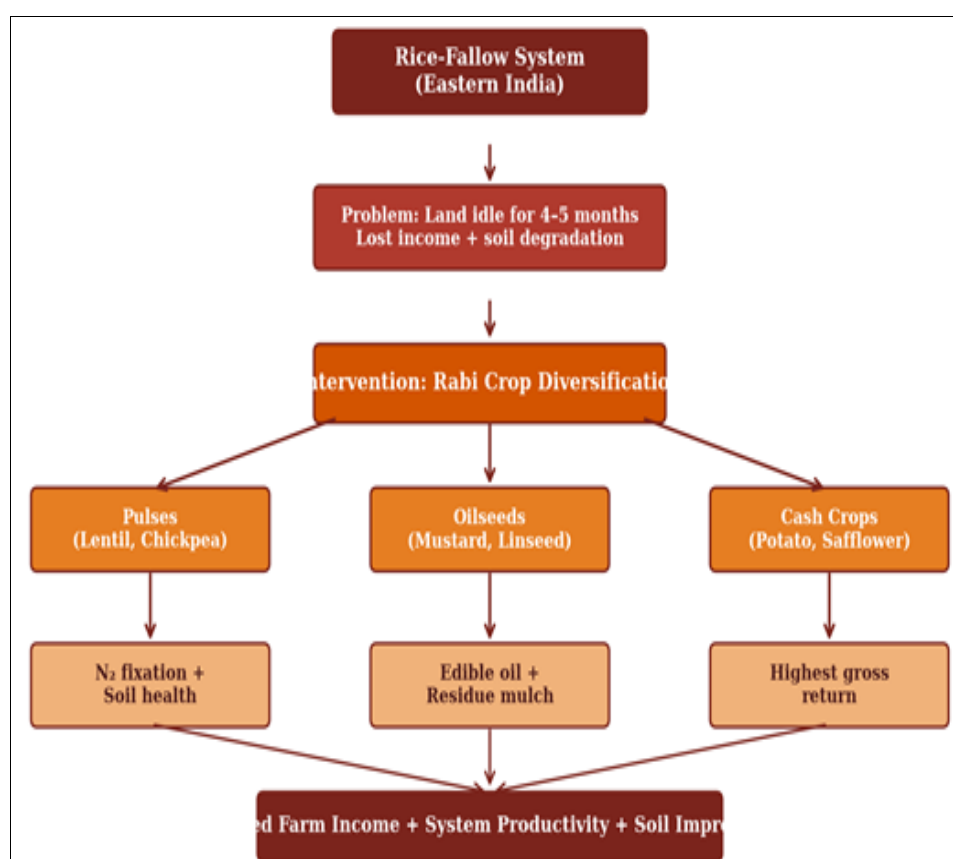


Fig 3: Process diagram showing crop diversification pathways and their outcomes in rice-fallow systems

Comprehensive interpretation

Every diversified system outperformed rice-fallow in net return and system productivity (Table 1, Figure 2). Rice-potato topped all metrics for gross and net return but required the highest investment (₹62,300 ha⁻¹). Rice-chickpea offered the strongest balance: second-highest net return (₹59,200 ha⁻¹) with a competitive B:C ratio (2.89). Among oilseeds, mustard stood out with the best B:C ratio (2.96) despite moderate absolute returns. Pulse-based systems improved soil organic carbon and available nitrogen after two seasons (Table 2), whereas potato and fallow showed slight declines. The heatmap (Figure 1) confirmed that no single crop dominated all parameters chickpea and potato

each excelled in different metrics, supporting the need for location-specific recommendations (Figure 3).

Discussion

The 88% income increase from rice-linseed over rice-fallow matches ICAR network trial estimates where pulse introduction raised income by 60–120% [1]. Rice-chickpea's strong performance reflects its market price advantage and ability to yield well on residual moisture [3]. Mustard's B:C ratio of 2.96 the highest among all options means farmers earn nearly three rupees per rupee invested [4]. Soil health benefits from pulse rotations align with evidence that legume residues add 30–60 kg

N ha⁻¹ through fixation ^[11]. Potato's high return came with higher risk, as its cost was nearly double that of pulses and price volatility can erode margins ^[15, 12].

Limitations

This research covered only two rabi seasons at a single location. Year-to-year rainfall variability, which strongly affects residual moisture availability, wasn't fully captured. Market prices used for economic analysis were based on local mandi averages, but actual farm-gate prices may be lower due to distance and transport costs ^[13]. The trial did not account for labour availability constraints, which limit the area a household can bring under rabi cultivation ^[14].

Practical applications

For resource-constrained farmers, rice–chickpea and rice–mustard appear most attractive due to their favourable B:C ratios and low input requirements. Farmers with access to capital and cold storage may consider rice–potato for maximum income. Extension services should promote relay sowing of lentil and chickpea into standing rice as a low-cost method to ensure timely establishment in areas where residual moisture windows are short ^[15].

Conclusion

All six rabi crops tested raised farm income substantially over rice–fallow, with net returns increasing from 88% (linseed) to 217% (potato). Rice–chickpea provided the best balance of profitability, low investment risk, and soil health benefits. Mustard offered the highest return per rupee invested. Pulse-based systems improved organic carbon and available nitrogen, adding long-term value beyond immediate income gains. These results support targeted crop diversification as a practical strategy to lift smallholder incomes in eastern India's extensive rice–fallow belt. Multi-year, multi-location trials incorporating market fluctuation analysis would strengthen these recommendations for policy-level adoption.

References

1. Ali M, Gupta S. Carrying capacity of Indian agriculture: Pulse crops. *Curr Sci.* 2012;102(6):874-881.
2. Joshi PK, Rao PP. Global pulses scenario: Status and outlook. *Ann N Y Acad Sci.* 2017;1392(1):6-17.
3. Peoples MB, Herridge DF, Ladha JK. Biological nitrogen fixation: An efficient source of nitrogen for sustainable agricultural production. *Plant Soil.* 1995;174(1-2):3-28.
4. Shekhawat K, Rathore SS, Premi OP, Kandpal BK, Chauhan JS. Advances in agronomic management of Indian mustard: An overview. *Int J Agron.* 2012;2012:408284.
5. Kumar M, Baishya LK, Ghosh DC, Gupta VK. Yield and quality of potato tubers as influenced by nutrient sources under rainfed condition of Meghalaya. *Indian J Agron.* 2011;56(3):260-266.
6. Singh AK, Singh SS, Prakash V, Kumar S, Dwivedi SK. Pulses production in India: Present status, bottleneck and way forward. *J AgriSearch.* 2015;2(2):75-83.
7. Kar G, Kumar A. Surface energy fluxes and crop water stress index in groundnut under irrigated ecosystem. *Agric For Meteorol.* 2007;146(1-2):94-106.
8. Ghosh PK, Bandyopadhyay KK, Wanjari RH, Manna MC, Misra AK, Mohanty M, Rao AS. Legume effect for enhancing productivity and nutrient use-efficiency in major cropping systems. *Indian J Fertil.* 2007;3(4):23-31.
9. Reddy AA, Bantilan MCS. Competitiveness and technical efficiency: Determinants in the Indian rice sector. *Food Policy.* 2012;37(3):245-254.
10. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing; 2022.
11. Jensen ES, Peoples MB, Boddey RM, Gresshoff PM, Hauggaard-Nielsen H, Alves BJR, Morrison MJ. Legumes for mitigation of climate change and the provision of feedstock for biofuels and biorefineries. *Agron Sustain Dev.* 2012;32(2):329-364.
12. Scott GJ, Rosegrant MW, Ringler C. Roots and tubers for the 21st century: Trends, projections, and policy options. *Int Food Policy Res Inst.* 2000.
13. Chand R, Kumar P, Kumar S. Total factor productivity and returns to public investment on agricultural research in India. *Agric Econ Res Rev.* 2012;25(2):181-194.
14. Kumar R, Mishra JS, Upadhyay PK, Hans H. Rice fallows in eastern India: Problems and prospects. *Indian J Agric Sci.* 2019;89(4):567-577.
15. Harris D, Joshi A, Khan PA, Gothkar P, Sodhi PS. On-farm seed priming in semi-arid agriculture: Development and evaluation in maize, rice and chickpea in India. *Exp Agric.* 2001;37(2):215-233.
16. Dwivedi SL, Sahrawat KL, Upadhyaya HD, Mengoni A, Galardini M, Bazzicalupo M, Biondi EG, Hungria M, Kaschuk G, Blair MW, Ortiz R. Advances in host plant and rhizobium genomics to enhance symbiotic nitrogen fixation in grain legumes. *Adv Agron.* 2015;129:1-116.
17. Hazra KK, Nath CP, Singh U, Praharaj CS, Kumar N, Singh SS, Singh NP. Diversification of maize-wheat cropping system with legumes and integrated nutrient management increases soil aggregation and carbon. *Geoderma.* 2019;353:308-319.