

# PERFORMANCE OF CEREALS-PULSES-VEGETABLES BASED DIVERSIFIED CROPPING SYSTEM FOR SUSTAINABLE CROP PRODUCTION

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Crop diversification has been widely recognized as a key strategy for achieving sustainable agriculture while ensuring food and nutritional security (Barman *et al.*, 2022). The integration of cereals, pulses and vegetables within cropping systems provides multiple advantages. Crops such as paddy and millets safeguard household food security, while pulses enhance soil fertility and supply protein-rich diets. Vegetables including tomato, bhendi, brinjal, gourds and leafy greens etc., when grown under staggered sowings, not only enrich the dietary diversity but also generate regular and substantial cash flow through multiple harvests. Diversification with such high-value crops increases farm income by 20–30 percent compared to cereal monocropping (Bhargavi *et al.*, 2019). Beyond ensuring food and income security, crop diversification plays a vital role in maintaining ecological balance, optimizes resource use efficiency and generating year-round employment opportunities. Crop rotations, particularly with pulses, improve soil fertility through biological nitrogen fixation and lower dependence on chemical fertilizers and helps in breaking the life cycles of pests, diseases and weeds, which thrive under monocropping, thereby reducing the need for chemical pesticides. It also ensures efficient and sustainable use of water resources, since water-intensive crops like rice can be followed by low-water-demand crops such as pulses or millets. The vegetables based cropping system generates sustained

labour demand; provide consistent employment opportunities throughout the year for rural communities. Considering this, the present study was undertaken over two years to evaluate the cereal–pulse–vegetable based diversified cropping system, with a focus on its potential to enhance sustainability and ensuring year-round income security for farmers.

A non-replicative field study was carried out during two consecutive years, 2023–24 and 2024–25, at *J Farm, Agricultural Research Institute, PJTAU, Rajendranagar, Hyderabad*. The experimental site falls under the Southern Telangana agro-climatic zones, which is characterized by an average annual rainfall of about 950 mm, with mean maximum temperature of 38 °C and mean minimum temperature of 16 °C. The soil of the experimental site was clay loam in texture, with medium fertility status and moderate water-holding capacity.

The cropping system was designed to integrate cereals (paddy, finger millet, foxtail millet), pulses (redgram, greengram) and a wide range of vegetables (bhendi, brinjal, tomato, dolichus, carrot, cowpea, clusterbean, french bean, bottle gourd, ridge gourd, snake gourd, and leafy vegetables) under different crop seasons (*khari, rabi & summer*). Cropping system was planned according to seasonal suitability: i.e *khari* (June–September): paddy, millets, redgram, vegetables and marigold; ii.

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*rabi* (October–February): millets, greengram and vegetables; iii. *summer* (March–May): millets, greengram and vegetables (Table 1) allocated to specific portions of the land. The same cropping sequence was maintained in both years to ensure consistency in comparison.

The crops were grown on a gross cultivated area of 2.1 ha, with a net cropped area of 1.4 ha sown across three seasons (*kharif*, *rabi*, and *summer*), with cropping intensity of 150%, and were cultivated without following any formal statistical experimental design, as the study was primarily aimed at reflecting the farm production and profitability of small and marginal farmers under diversified cropping system.

Paddy was cultivated in low-lying fields, while vegetables were grown on upland areas under plastic mulch and drip irrigation systems. All the recommended package of practices was followed for raising the crops during the period of study, based on locally adopted methods. Only yield data was recorded from the respective crops sown area and productivity expressed in kg/ha (Table 2, 3 & 4). Cost of cultivation, gross and net returns were calculated based on the prevailing local market input and output prices and expressed in Rs/ha.

$$\text{Benefit - Cost Ratio (BCR)} = \frac{\text{net returns}}{\text{cost of cultivation}}$$

The economic performance of cereals, pulses and vegetables was analysed separately for comparative assessment of crop profitability and economic sustainability under diversified cropping system.

The sustainability of the cropping system was evaluated using the Sustainable Yield Index (SYI), which assesses the stability and consistency of yield over years. The SYI was calculated using yield data recorded during the years 2023-24 and 2024–25.

$$\text{Sustainability - Yield Index (SYI)} = \frac{\bar{Y} - Sd}{Y_{\max}}$$

Where,

$\bar{Y}$  (Mean yield): Average yield over the years (t/ha)

Sd (Standard deviation): Variation in yield over years

$Y_{\max}$ : Maximum yield recorded during the study period (t/ha)

The yield data were subjected to statistical analysis to compute mean and standard deviation, and subsequently SYI was derived.

#### **Yield performance under diversification of crops**

The yield data (Table 2, 3 & 4) indicated considerable variation in productivity across cereals, pulses and vegetables within the diversified cropping system. Among cereals, the highest grain yield was observed in paddy, primarily due to its nature as a high-input (110 N-60 P<sub>2</sub>O<sub>5</sub>- 40 K<sub>2</sub>O /ha), water-intensive crop supported by improved high-yielding varieties and better crop management practices. In comparison, millets, though known for their climate resilience and hardiness are generally grown as low-input crops (40 N-28 P<sub>2</sub>O<sub>5</sub>- 22 K<sub>2</sub>O /ha) exhibited relatively lower yields.

Among pulses, redgram outperformed greengram, owing to its long duration, deep root system and greater drought tolerance, which together enabled higher biomass production and grain yield. Conversely, greengram, with its short crop duration and quick maturity, produced relatively lower yields.

Vegetable crops such as bhendi, tomato and brinjal etc. performed well, benefitting from multiple harvests that ensured continuous production throughout the growing

season. Leafy vegetables, though yielding consistently, offered frequent harvests and contributed to both quick household consumption and steady market supply. Similarly, flowers like marigold produced moderate yields but added value during peak seasonal demand. Overall, cereals and pulses played a crucial role in ensuring household food security. Vegetables ensured regular and consistent production throughout the year, while flowers captured seasonal market demand, together enhancing overall farm productivity and profitability. This indicated that diversification reduces not only production risk but also stabilizes overall farm productivity and income. These results were aligned with Upadhaya *et al.*, (2022) and Narendra *et al.*, (2025).

### **Economic analysis**

The economic analysis showed that vegetables were the most profitable component of the diversified cropping system, contributing the highest share of net returns (67.3 percent) compared to cereals (24.78 percent) and pulses (6.79 percent). Within cereals, paddy generated the maximum net returns, due to its higher yield and assured market price; while millets, though less remunerative, but recorded the highest BCR of 2.04, reflecting their efficiency under low-input and resource-saving cultivation. This highlights that while paddy ensured income stability, millets performed well in terms of economic efficiency (Fig. 1).

Among pulses, higher net income and BCR (1.92) obtained in redgram compared to greengram (1.79), due to advantage of high market price and crop productivity, while greengram, being a short-duration crop, with low productivity and market price. However, vegetables clearly outperformed both cereals and pulses. Among the vegetables, bhendi (31.14 percent), tomato (16.76 percent),

dolichus (15.69 percent), and clusterbean (9.33 percent) achieved the highest net incomes, due to market demand and the advantage of multiple harvests across the seasons. In terms of benefit–cost ratio (BCR), leafy vegetables (3.9), bhendi (2.97), dolichus (2.63) and gourds (2.6) showed high profitability with relatively lower investment. Flowers such as marigold achieved the highest BCR (4.5), indicating their strong economic potential during seasonal peaks.

Most of the vegetable crops showed BCR values above 2.0, strengthening their role as high-value enterprises in the diversified cropping system. In contrast, cereals maintained moderate BCR values close to 2.0, providing economic stability rather than high profits, while pulses occupied an intermediate position with BCR values around 1.8. These results corroborate with earlier studies by Singh *et al.*, (2025) and Srinivasan (2025), who also reported that vegetable-based cropping systems considerably improve farm profitability when compared with cereal monocropping.

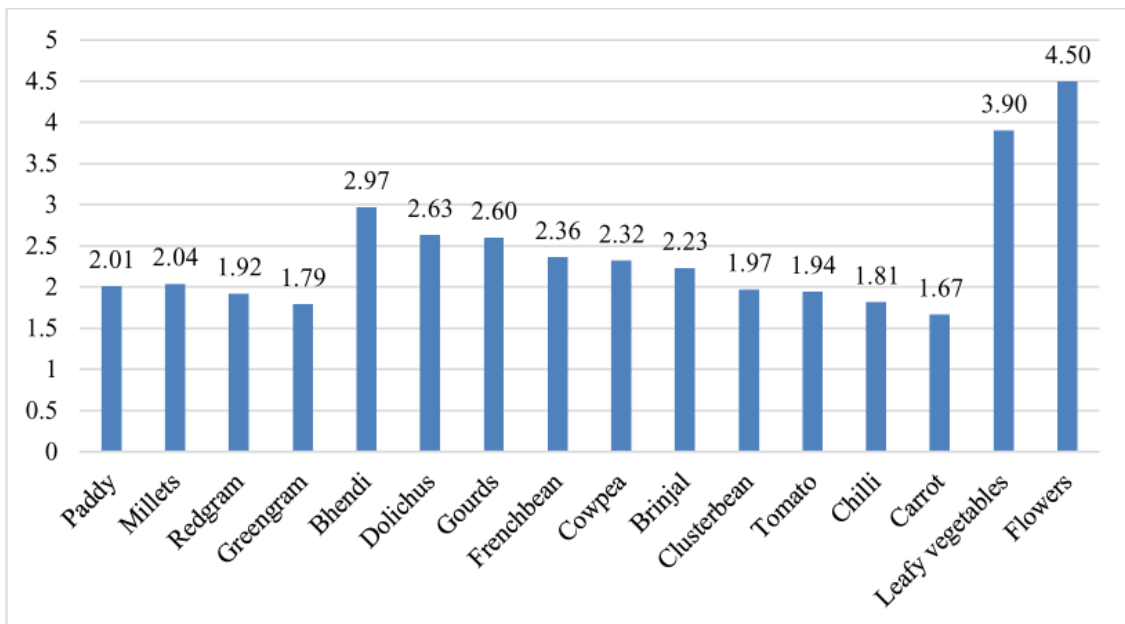
### **Sustainability and livelihood implications**

The cropping system recorded yields of 12.04 t/ha in 2023-24 and 9.82 t/ha in 2024–25, with a mean yield of 10.93 t/ha. The calculated Sustainable Yield Index (SYI) was 0.82, indicating high sustainability of the system. The higher SYI value (>0.75) suggests that the cropping system maintained stable and consistent productivity across years despite variation in yield. This reflects the resilience and reliability of the system under varying conditions.

Diversified cropping systems not only enhanced farm profitability but also considerably contributed to sustainability by improving resource-use efficiency, soil health, and pliability to climate and market variability.

**Table 1. Cropping sequence and area distribution of different crops across *kharif*, *rabi* and *summer* seasons during two-year study (2023-24 & 2024-25)**

Category/ Season	<i>Kharif</i>		<i>Rabi</i>		<i>Summer</i>		
	Crop	area (ha)	Crop	area (ha)	Crop	area (ha)	
Cereals & Pulses	Paddy	0.48	Paddy	0.16			
	-		Greengram	0.10	Foxtail millet	0.10	
	Finger millet	0.10	Finger millet	0.06	Greengram	0.10	
	-		Foxtail millet	0.04	-		
	Foxtail millet	0.08	-		-		
	Redgram	0.14	-		-		
Vegetables	Bhendi	0.10	Clusterbean	0.03	Clusterbean	0.08	
	-		Tomato	0.02	-		
	Brinjal	0.02	-		Cowpea	0.02	
	Tomato	0.02	Carrot	0.01	Brinjal	0.02	
	Dolichus	0.05	Bhendi	0.04	Dolichus	0.03	
	-		Frenchbean	0.01	Tomato	0.02	
	Clusterbean	0.04	Dolichus	0.04	Bhendi	0.06	
	Cowpea	0.02	Brinjal	0.01			
	Chilli	0.004	-		-		
	Frenchbean	0.01	Cowpea	0.01	-		
	Gourds	0.02	Gourds	0.01	Gourds	0.01	
	Leafy vegetables	0.02	Leafy vegetables	0.02	Leafy vegetables	0.02	
	Flowers	Marigold	0.01	-		-	
		<b>Total</b>	<b>1.10</b>		<b>0.55</b>		<b>0.45</b>



**Fig 1. Benefit cost ratio of different crops in diversified cropping system**

**Table 2. Yield performance and economics of different crops under diversified farming system in the kharif season (pooled data of two years)**

S.No	Category	Crop	Area (m <sup>2</sup> )	Yield (kg)	Productivity (kg ha <sup>-1</sup> )	Cost of Cultivation (Rs ha <sup>-1</sup> )	Gross returns (Rs ha <sup>-1</sup> )	Net returns (Rs ha <sup>-1</sup> )	BCR
1		Paddy	4800	2267	4723	41250	122769	81519	1.98
2	Cereals	Finger millet	1000	155	1545	35000	108150	73150	2.09
3		Foxtail millet	800	81	1013	25000	60750	35750	1.43
4	Pulses	Redgram	1400	185	1313	45500	132143	87143	1.92
5		Bhendi	950	1202	12651	125000	506053	381053	3.05
6		Brinjal	160	370	23125	137500	462500	325000	2.36
7		Tomato	180	370	20047	141000	453403	290903	2.06
8		Dolichus	520	351	6750	112500	405000	292500	2.60
9		Cluster bean	420	304	7240	70000	216964	146964	2.1
10		Cowpea	150	112	7500	87000	298667	211167	2.43
11	Vegetables	Chilli	40	49	12313	175000	492500	317500	1.81
12		French bean	130	120	9259	106500	368462	260962	2.45
13		Gourds	180	403	22389	125000	447778	322778	2.58
14		Leafy vegetables	180	182	10106	100000	504167	404167	4.05
15	Flowers	Marigold	60	60	9813	126500	694167	569167	4.50

**Table 3. Yield performance and economics of different crops under diversified farming system in the rabi season (pooled data of two years)**

S.No	Category	Crop	Area (m <sup>2</sup> )	Yield (kg)	Productivity (kg ha <sup>-1</sup> )	Cost of Cultivation (Rs ha <sup>-1</sup> )	Gross returns (Rs ha <sup>-1</sup> )	Net returns (Rs ha <sup>-1</sup> )	BCR
1		Paddy	1600	771	4819	41875	127481	85606	2.04
2	Cereals	Finger millet	600	96	1596	36667	111708	75042	2.05
3		Foxtail millet	400	42	1056	25000	65750	38250	1.53
4	Pulses	Greengram	1000	119	1185	25000	71100	46100	1.84
5		Bhendi	375	450	11989	125000	480267	355267	2.84
6		Brinjal	140	307	22167	135500	438214	300714	2.22
7		Tomato	180	430	23597	166000	478194	315694	1.90
8		Dolichus	360	252	6986	112500	420000	307500	2.73
9		Carrot	140	277	20000	147000	395714	245714	1.67
10	Vegetables	Clusterbean	260	168	6475	70000	194135	124135	1.77
11		Cowpea	80	53	6563	87500	262500	175000	2.00
12		Frenchbean	160	141	8797	107500	351875	244375	2.27
13		Gourds	70	154	21854	125500	438571	313571	2.50
14		Leafy vegetables	190	182	9571	100000	477932	377932	3.79

**Table 4. Yield performance and economics of different crops under diversified farming system in the summer season (pooled data of two years)**

S.No	Category	Crop	Area (m <sup>2</sup> )	Yield (kg)	Productivity (kg ha <sup>-1</sup> )	Cost of Cultivation (Rs ha <sup>-1</sup> )	Gross returns (Rs ha <sup>-1</sup> )	Net returns (Rs ha <sup>-1</sup> )	BCR
1	Cereals	Foxtail millet	1000	151	1510	26000	105700	80700	3.10
2	Pulses	Greengram	1000	114	1140	25000	68400	43400	1.74
3		Bhendi	550	689	12548	125000	501364	376364	3.02
4		Brinjal	180	386	21297	138700	429167	291667	2.10
5		Tomato	200	465	23128	163000	464625	302125	1.85
6		Dolichus	320	212	6617	112500	397031	284531	2.53
7		Clusterbean	820	579	7065	70000	211829	141829	2.03
8	Vegetables	Cowpea	150	116	7743	87500	310000	222500	2.54
9		Gourds	70	162	23208	124000	461429	336429	2.71
10		Leafy vegetables	165	161	9706	100000	486364	386364	3.86

By the integration of different crops, pulses enriched soil fertility through biological nitrogen fixation and reducing the need for chemical fertilizers. Crop rotations involving cereals and pulses disrupted pest, disease and weed cycles, while vegetables ensured efficient utilization of land, labour, irrigation and other farm resources, thus strengthen the farm resilience.

From the livelihood perspective, crop diversification reduced economic risks by spreading production across multiple crops and simultaneously increasing labour demand, which created year-round employment opportunities. This was particularly advantageous for small and marginal farmers as well as farm labour, thereby enhancing livelihood security and contributing to rural sustainability. These results were consistent with the findings of Goverdhan *et al.*, (2020) and Ravishankar *et al.*, (2023).

The integration of cereals–pulses–vegetables based diversified cropping systems provides a profitable and viable pathway. Most of the vegetable crops showed BCR values above 2.0, strengthening their role as high-value enterprises in the diversified cropping system. In contrast, cereals maintained moderate BCR values close to 2.0, providing economic stability rather than high profits, while pulses occupied an intermediate position with BCR values around 1.8. Such systems provide regular cash flow round the year through frequent harvests. The calculated Sustainable Yield Index (SYI) was 0.82, indicating high sustainability of the system. The higher SYI value (>0.75) suggests that the cropping system maintained stable and consistent productivity across years despite variation in yield. This reflects the resilience and reliability of the system under varying conditions. Overall, diversified cropping pattern emerges as a profitable, resilient and scalable model

that can enhance the adaptive capacity of small and marginal land holders, contributing to long-term food security and sustainability.

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## REFERENCES

- Barman, A., Saha, P., Patel, S and Bera, A. 2022. Crop diversification an effective strategy for sustainable agriculture development. Sustainable Crop Production. Intech Open publications, 1-18. DOI: 10.5772/intechopen.102635.
- Bhargavi, B., Behera, U. K., Rana, K. S., Singh, R., Prasad, S., Pandey, R. N. and Singh, G. 2019. Crop diversification with high-value crops for higher productivity and profitability under irrigated ecosystem. Indian Journal of Agronomy, 64(4):440-444.
- Goverdhan, M., Pragathi Kumari, C. H., Kiran, G. R., Sridevi, S., Alibaba, M. D., Chiranjeevi, K and Santhosh, M. K. 2020. Evaluation of integrated farming system model for resource recycling and livelihood security of small and marginal farmers of Telangana state, India. Current Journal of Applied Science and Technology, 39 (34): 17-26. DOI:10.9734/CJAST/2020/v39i3431033.
- Narendra, K., Mohammad, H, K., Hazra, K and Nath, C. P. 2025. Crop diversification options for enhancing sustainability in irrigated ecosystems. Indian Farming, 75(03): 66-70.
- Ravishankar, M., Devender, P. K., Anilkumar, V., Abhishek, R., Murray, U., William, B.,

- Ashok, K., Bapi, G and Ramakrishnan, M. N. 2023. Diversifying vegetable production systems for improving the livelihood of resource poor farmers on the east Indian plateau. *Frontiers in Sustainable Food systems*, 7: 966376. <https://doi.org/10.3389/fsufs.2023.966376>.
- Singh, S. K., Singh, N., Bhardwaj, D. R., Roy, S., Singh, Y and Singh, R. 2025. Diversification of cropping system through vegetable crops for higher productivity and profitability. *Indian Farming*, 74(10): 10-13.
- Srinivasan, R. 2025. Diversification of rice-based cropping systems with vegetables and legumes in Asia and Africa. *Crops*, 5: 43. <https://doi.org/10.3390/crops5040043>.
- Upadhaya, B., Kishor, K., Kumar, V., Kumar, N., Kumar, S., Yadav, V. K., Kumar, R., Gaber, A., Laing, A. M and Brestic, M. 2022. Diversification of rice-based cropping system for improving system productivity and soil health in eastern gangetic plains of India. *Agronomy*, 12(10): 2393. <https://doi.org/10.3390/agronomy12102393>.

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