

Diversification and Intensification of Rice Fallow with Pea and Potato in Sikkim

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ABSTRACT

Frontline demonstrations on garden pea (TSX-10) and potato (*Kufri Sindhuri*) was conducted by Krishi Vigyan Kendra, Namthang, South Sikkim, India. A total of 30 farmers were selected for both pea (20 farmers) and potato (10 farmers) demonstrations in NICRA adopted village Rabitar during the year 2025-26. The experimental results revealed that average yield of rice, pea and potato were 35.24 q/ha, 90.22 q/ha and 140.30 q/ha, respectively. Highest REY was recorded in rice-pea system (155.56 q/ha) followed by rice-potato (105.40 q/ha). However, the highest system production efficiency was recorded in rice-potato (66.24 kg/ha/day) than rice-pea system (58.35 kg/ha/day). The data regarding technology gap (9.46 q/ha), index (5.11 %) and LUE (72.60 %) was found better in rice-potato cropping system than rice-pea system. In regard to economics, rice-potato system had higher net returns (₹256300/ha) and system economic efficiency (₹754.71/ha/day). However, higher B:C ratio (3.73:1) was recorded in rice-pea cropping system. This demonstration indicated that inclusion of pea or potato is a feasible strategy for enhancing productivity, crop intensity and generation of significant income for farmer's livelihood in Sikkim.

Keywords: Frontline demonstration, Pea, Potato, Rice-fallow, Zero-tillage

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INTRODUCTION

Sikkim is recognized as India's first organic state nationally and internationally. The production of agricultural and horticultural crops is without the use of any chemical inputs. The state is situated in the eastern Himalayan region where it receives heavy rainfall during monsoon and seldom receives rain during *rabi* or winter season. Rice is principal agronomic crop after maize in the state with average annual production of 10271 tonnes from 10327 ha acreage. Due to the prevalence of mono-cropping among the farmers have rendered low cropping intensity of the state as 118% only (Kumar *et al.*, 2024). Usually, traditional rice are long duration varieties resulting in late harvesting and consequently late sowing of winter crops. Farmers often harvesting rice keep their land fallow with no following crop cultivation due to shortage of irrigation water, rapid soil moisture depletion and socio-economic factors (Kumar *et al.*, 2019). This sole rice-based system leads to low-income generation, low crop intensity and poor residual moisture management. Therefore, there is a great scope for crop diversification through inclusion of suitable resilient crop such as legumes and potato for crop intensification, soil fertility retention and additional income generation (Kumar *et al.*, 2025; Saurabh *et al.*, 2022). The production of *rabi* crop can be maximized with the implementation of soil moisture conservation techniques

such as zero tillage and timely sowing of winter crop. Sikkim records the lowest productivity of pea and potato when compared to national average. The state recorded a total pea production of 9.41 ('000 MT) from 2.44 ('000 ha) with productivity of 3.86 metric tonne/ha. Likewise, potato production recorded 44.62 ('000 MT) with lowest productivity of 7.24 tonne/ha (Banerjee *et al.*, 2024). Given the background of the issue, a frontline demonstration (FLD) was conducted by KVK, Namthang in NICRA village Rabitar, South Sikkim during *rabi* season in the year 2025-26. The FLD comprised the cultivation of garden pea variety TSX-10 under zero tillage in rice fallow for enhancement of farm income and cropping intensity of the village. The primary objective of this FLD was to utilize rice fallow with focus on increasing productivity by using high yielding and climate resilient crop varieties.

MATERIALS AND METHODS

A frontline demonstration was conducted on cultivation of garden pea var. TSX-10 and potato var. *Kufri Sinduri* in rice fallow areas in the farmer's field at Rabitar, a NICRA adopted village situated in Namchi district, South Sikkim during *rabi* season of the year 2025-26 (Figure 1). The total annual rainfall during the cropping period from June to March 2025-26 amounted to 1576.60 mm. The maximum annual temperature

ranged from 22 to 27°C, while the minimum varied between 2 and 10°C. A total of 30 farmers were selected to implement the demonstrations *viz.*, 20 farmers for pea and 10 farmers for potato. Each farmer's demonstration covered an area of approximately 0.2 ha resulting in a total demonstration area of 6 ha. Usually, rice is harvested with the help of sickle leaving the stub of about 20 cm on the ground during the month of November. Garden pea was then immediately sown under zero tillage system. A narrow furrow was made with the help of garden trowel at 25-30 cm distance apart. Before planting seeds in a zero-till system, farmyard manure @ 3/ha + vermicompost @ 0.5 t/ha were incorporated into the soil. Subsequently, pea seeds were treated with *Rhizobium* inoculum and planted in furrows with a spacing of 15 cm between each plant. Seed rate for pea was 80 kg/ha. Manual irrigation was applied during two critical stages, namely the pre-flowering and pod formation stages to ensure robust crop establishment and development. Hand weeding was done at 35 days after sowing (DAS). Simultaneously, selected whole potato tubers (approx. 50 g) were planted on ridge and furrow at a distance of 60 cm × 20 cm with conventional deep ploughing or ridge formation after rice harvest and FYM @ 12-15 t/ha were incorporated into the soil. A seed rate of about 20 t/ha was followed for potato. Two hand weedings were administered at 30 DAS and 60 DAS, respectively. The yields of rice and garden pea were recorded at each demonstration site and subsequently converted into quintals per hectare (q/ha). Parameters such as crop equivalent yield, land use efficiency (LUE), system production efficiency were calculated using the following formulas (Kumar *et al.*, 2019):

Rice equivalent yield (REY) was estimated using formula:
 $REY = \text{yield of rice (first crop)} + \text{yield of second crop} \times \text{price of second crop/price of rice.}$

$LUE (\%) = \text{Total duration of crops in a year (days)} / 365 \times 100$

$\text{System production efficiency (kg/ha/day)} = \text{Total system productivity (kg/ha)} / 365$

$\text{System economic efficiency (₹/ha/day)} = \text{Net returns of the cropping sequence} / \text{Total duration of crop sequence}$

Yield data from both demonstration plots and farmers' conventional practices were recorded to assess performance indicators, including technology gap, extension gap, and technology index, using the formula described by Kumar *et al.* (2014).

$\text{Technology gap} = \text{Potential yield} - \text{demonstration yield}$

$\text{Technology Index} = (\text{Potential yield} - \text{demonstration yield}) / \text{potential yield}$

For economic analysis, the cost of cultivation was considered to estimate treatment economics, including net returns per hectare and the benefit-cost ratio. Gross returns were calculated based on the total income generated from tuber yield using the prevailing market price. Therefore, net return and benefit to cost ratio was calculated with the help of following formula described by Kumar *et al.* (2021).

$\text{Net return (Rs/ha)} = \text{Gross return (Rs./ha)} - \text{Cost of cultivation}$

$\text{Benefit: cost ratio} = \text{Gross return (Rs/ha)} / \text{Cost of cultivation}$

RESULTS AND DISCUSSION

System productivity

The data pertaining to system productivity and rice equivalent yield is presented in Table 1. The yield of rice ranged from 32.6 to 36.55 q/ha to in all cropping system *viz.*, rice-fallow, rice-pea, rice-potato with an average yield of about 35.24 q/ha. The average yield of both pea and potato was recorded as 90.22 q/ha and 140.30 q/ha, respectively. However, the highest REY was recorded in rice-pea system (155.56 q/ha) followed by rice-potato (105.40 q/ha). The lowest system REY was found in rice-fallow (35.24 q/ha). This increase in system REY in both the cropping system was observed due to the inclusion of additional suitable crop resulting in the overall system profitability and farmer's income. Similar results were also reported by Kumar *et al.* (2019) and Das *et al.* (2010) where rice-green gram system increased profitability by 126% than rice-fallow. However, the highest system production efficiency was recorded in rice-potato (66.24 kg/ha/day) due to the greater accumulation of economic yield than rice-pea system (58.35 kg/ha/day). This result is in line with Kumar *et al.* (2021) in which enhanced SPE was recorded in rice-potato than rice-fallow.

Technology gap and index

The highest technology gap was observed in rice-pea (14.54 q/ha) followed by rice-potato system (9.46 q/ha) indicating the possibility of improvements in biological and economical yield of the system (Table 1). Similar findings were also reported by Kumar *et al.* (2021) and they found higher technology gap in rice-potato system than rice fallow. However, the feasibility of the demonstrated technology measured by technology index showed the higher feasibility in rice-potato (5.11%) and followed by rice-pea system (10.38%), aligned with the results of Kumar *et al.* (2014).

Land use efficiency

The data regarding land use efficiency showed that highest LUE was recorded in rice-potato (72.60 %) followed by rice-pea system (58.90 %). Table 2 shows sharp increase in land use efficiency from 36.98 % (rice fallow) to almost double in rice-potato (72.60 %). This sharp increase in LUE is due to the inclusion of potato and pea after rice harvest. The subsequent inclusion of crops led to the efficient utilization of land which in turn boosted the income remuneration of farmers. Similar results were also reported by Kumar *et al.* (2017).

Economics of the cropping system

Table 2 shows the economics of the cropping system such as system net return, system economic efficiency and benefit: cost ratio. All the calculation was done based on the prevailing market rate of all the input and output commodities during the demonstration year. Rice-potato system recorded highest system net return (₹256300/ha) and system economic efficiency (₹754.71/ha/day), respectively however the benefit:

cost ratio was recorded higher in rice-pea (3.73) cropping system. Nevertheless, it is noticed that economic profitability in both the demonstrated cropping system had significantly

increased by 5.5-fold when compared to rice fallow. Similar result of higher economic efficiency and benefit cost ratio were also reported by Kalita *et al.* (2018) in rice-vegetable system in Assam. ram crop and (Martinez-Pacheco *et al.*, 2009) on bean

Table 1: Rice equivalent yield and system productivity parameters of different cropping systems

Cropping system	Technology demonstrated	Area (ha)	Yield (q/ha)			REY (q/ha)	SPE (kg/ha/day)	TG (q/ha)	TI (%)
			Rice	Pea	Potato				
Rice-pea	Paddy var. Sikkim Dhan-1, Garden pea var. TSX-10	4.0	35.24	90.22	-	155.56	58.35	14.54	10.38
Rice-potato	Paddy var. Sikkim Dhan-1, Potato var. Kufri Sinduri	2.0	35.24	-	140.30	105.40	66.24	9.46	5.11
Rice fallow	Paddy monocropping	1.0	35.24	-	-	35.24	16.15	4.76	11.90

Note: REY=Rice equivalent yield; SPE=System production efficiency; TG= Technology gap; TI=Technology index

Table 2: Economics and land use efficiency of different cropping systems

Cropping system	Technology demonstrated	System net returns (₹/ha)	SEE (₹/ha/day)	B:C ratio	LUE (%)
Rice-pea	Paddy var. Sikkim Dhan-1, Garden pea var. TSX-10	251360	704.00	3.73	58.90
Rice-potato	Paddy var. Sikkim Dhan-1, Potato var. Kufri Sinduri	256300	754.71	2.43	72.60
Rice fallow	Paddy monocropping	45700	246.20	1.76	36.98

Note: SEE= System economic efficiency; B:C= Benefit: cost; LUE= Land use efficiency



Fig. 1: Cultivation and crop cutting of rice var. Sikkim Dhan-1 (a-d); cultivation of pea var. TSX-10 in rice fallow (e-j); Distribution and cultivation of potato var. Kufri Sinduri in rice fallow (k-l)

CONCLUSION

Crop diversification and intensification prove to be significant strategies for increasing farmers annual income and also to enhance agricultural productivity and profitability. Due to the realization of greater economic return with the implementation of these cropping systems in demonstration field, the farmers are motivated and encouraged to follow such profitable technology in future. Considering all the data regarding productivity and system economics, rice-pea was the best suited cropping system because of its higher economic return, cost effectiveness, low maintenance and minimal labor along with less water requirement accompanied with deeper root system. The adoption of zero tillage in case of rice-pea system had greater advantage over rice-potato leading to the better residual moisture utilization and waste management along with enhanced soil fertility due to the nitrogen fixation feature of pea plants in the soil.

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