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Success story on zero-tillage garden pea cultivation in rice-fallow under East District of Sikkim

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ABSTRACT

The cropping intensity of the state is low (118%) due to monocropping of maize and rice. Rice is the second most important cereal grown in the state. In the state, farmers are kept their land fallow after rice harvest. Hence, most of the area is remaining fallow in the state. Garden pea may be an option if grown under zero-tillage condition in rice-fallow (farmers practice). As growing of vegetable crops provided almost four times higher income compared to food grain crops. Huge gap is being obseved in demand and supply of vegetables due to low production in the state. Thus there is potential for growing of garden pea in rice-fallow areas for increasing the cropping intensity, productivity and income of the farmers. Therefore, the Krishi Vigyan Kendra (KVK), East Sikkim, Ranipool took an initiative and conducted frontline demonstration (FLD) on garden (Cv. Avira 11) inthe rabi season during the year of 2016 -17 to 2019-20 in rice-fallow for additional income of the farmers. Results indicated that rice yield ranged 20.9 - 22.6 q/ha during three years. Three year mean of rice equivalent yield (REY) was recorded 107.23 q/ha and 21.6 q/ha under rice-garden pea and rice-fallow system, respectively. Higher economic efficiency (503.81 Rs/ha/day) and land use efficiency (73.51%) were recorded under rice-garden pea system compared to rice-fallow (137.44 Rs/ha/day and 39.45 % respectively).Soil organic carbon (SOC) was 7.20% higher under rice-garden pea system after 3 cropping cycles than initial value. Average net profit and benefit cost ratio was recorded Rs.135091.7/ha, Rs.19793.3/ha and 2.83, 1.83 under rice-garden pea and rice-fallow, respectively. Hence, it may be concluded that the inclusion of garden pea is an option for improving the productivity and profitability under Sikkim Himalayas.

1. Introduction

Sikkim a small hilly state in the Eastern Himalayas with altitude ranged from 300-8598 m above MSL. Which constitutes 0.22 percent of total geographical area with 0.05 percent population (6.11 lakh) of India. It has about 15.68 per cent of cultivable area of the total geographical area of 7,09,600 ha. Agriculture is the main occupation and 80 per cent population of the state is dependent on agriculture. Land distribution is skewed with 70% of small and marginal farmers holding 28% of the operational area and 30% of other farmers (semi medium, medium and large) holding 72% of the operational area. Total rainfall was received 2800-3200 mm annually in the state mainly during pre-kharif and kharif seasons. Most of the farmers practiced mono - cropping system of rice cultivation and their field remained fallow after harvesting of rice during rabi season resulting in low cropping intensity (118 percent) in the state. Generally, rainfall starts in the month of February and ends in the mid-October. However, after rice harvest plenty of soil moisture remains in the field which can be utilized by some suitable resource conservation techniques i.e., zero-tillage. Zero-tillage is an agricultural technique for growing crops or practice without disturbing the soil through tillage. It needs very negligible soil disturbance and the residues from previous crops remains largely undisturbed at the soil surface as mulch. Soil and water conservation is an additional benefit seen under zero tillage condition and also enabled farmers to increase returns and save crucial inputs cost. Hence, this promising technology to be an important alternative for generating higher farm income and saving of scarce

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resources in starved regions. Zero tillage helps in conserving in-situ residual moisture and timely sowing of crops immediately after rice harvest. Residue mulch retained under this practice helps in maintaining/conserving the soil moisture for longer period, thus, enhancing the crop productivity after harvest of rice crop by utilizing the residual soil moisture. This technology seems to be an appropriate strategy for adapting agricultural production systems to climate change by preserving water and soil resources that climate - change scenarios identify as being particularly threatened. Accumulation of organic matter in the top soil of crop lands because of permanent soil cover by mulch is a key mechanism for the observed soil and water conservation benefit. Soil carbon sequestration is most important aspect of conservation agriculture and zero - tillage is one of the components which promote climate resilient agriculture by enhancing the soil organic carbon content in the soil. Keeping the above point in view, KVK took the initiative and conducted frontline demonstration (FLD) on garden pea under zero tillage in rice-fallow under organic management practices during rabi season to enhance the farm income for livelihood improvement.

2. Materials and Methods

Krishi Vigyan Kendra, East Sikkim, Ranipool conducted Frontline Demonstrations (FLDs) on zero -tillage garden pea cultivation in rice-fallow under rice based system of Sikkim at farmers field during winter (*rabi*) season for three consecutive year from 2016-17 to 2019-20 in different village *viz*., Nandok, Timpyem, Sajong, Saureni and Lingtam. The total rainfall received during cropping period was 17.42 mm, 98.60 mm and 108.8 mm in 2017-18 2018-19 and 2019-20, respectively (Fig. 1). Maximum temperature was 2017-18 (23.37^{0}C), 2018-19 (21.7^{0}C mm), 2019-20 (22.9^{0}C) while the minimum temperature was 2017-18 (9.68^{0}C), 2018-19 (6.4^{0}C) and 2019-20 (6.7^{0}C). Total area of 10.3 ha was covered in last three years covering 67 nos. of farmers from four number of villages. The area under each demonstration was ~0.10 ha. Recommended organic management practices (FYM @ 2.5 t/ha + vermicompost @ 1.0 t/ha + neem cake @ 0.5 t/ha + dolomite @ 0.5 t/ha) were applied before sowing of garden pea under no-till system. Rice was harvested from a height of 20 cm from the ground level in the month of November every year. Immediately after rice harvest garden pea was sown under zero -tillage .A narrow furrow open 30 cm apart on soil surface with spade or locally made wooden row marker, appllied all the organic nutrients. Seed was placed after manuring at a spacing of 15 cm plant to plant. The surface layer of soil should remain sufficiently moist to allow good germination. There are two critical stages such as pre flowering and pod formation stage where irrigation was applied to ensured good crop stands. Two hand weeding was done at 15 and 35 days after sowing. Regular monitoring of the demonstration site was made by Subject Matter Specialists through regular visits and provided them proper advisories. The yield of rice and vegetable pea were recorded at each demonstration and converted the yield into q/ha. The other parameter like rice equivalent yield (REY), production efficiency, economic efficiency, net returns and B:C ratio were calculated. The input and outputs prices of commodities prevailed during experiment for the three years of demonstration were taken for calculating cost of cultivation, gross return, net return, benefit cost ratio. The post harvest soil samples were collected from 0 to 15 cm depth for analyzing the available SOC and N, P & K status.

Rice equivalent yield (REY) was estimated using formula: REY=Yield of rice (first crop) + yield of second crop x price of second crop/price of rice. Land use efficiency (LUE) was obtained by dividing total number of days occupied by different crops by 365 days and multiplying with 100. System productivity (kg/ha/day) was calculated by dividing production of sequence by 365 days and system profitability in terms of kg/ha/day was obtained by net returns of the sequence divided by total duration of crop sequences (Kumar *et al.,* 2019a).

In economics, cost of cultivation was taken into account for calculating economics of treatments as work out net return per ha and benefit cost ration. The gross returns, were taken as total income receive from produce of grain and straw yield based on prevailing price. Net return and benefit cost ratio was calculated with the help of following formula (Kumar *et al.,* 2017):

Net return (ha^{-1}) = Gross return (ha^{-1}) - cost of cultivation (ha^{-1})

$$\text{Benefit : cost ratio} = \frac{\text{Grain yield}}{\text{Biological(Grain + Straw) yield}}$$

Production efficiency and economic efficiency (Kumaw at *et al.,* 2012) were calculated with the help of the formula.

$$\text{Economic efficiency(Rs/ha/day)} = \frac{\text{Net return (Rs/ha)}}{\text{Total duration of the crop (days)}}$$

3. Results and Discussion

Productivity

Rice yield was ranged 20.9-22.6 q/ha under rice-fallow and rice vegetable pea cropping system. Maximum vegetable pea yield was recorded 59.40 q/ha in the year 2016-17 followed by 49.70 q/ha (2019-20) and minimum 48.30 q/ha during the year 2018-19 (Table 1) with average (three years) vegetable pea yield of 52.16 q/ha. System rice equivalent yield (REY)was recorded 117.43, 101.93 and 102.33 q/ha during the year 2017-18, 2018-19 and 2019-20 respectively under rice-vegetable pea cropping system. Whereas, 20.8, 22.6, 21.4 q/ha during the year 2017-18, 2018-19 and 2019-20 respectively in rice-fallow system (table 1). Maximum mean (3 years) REY was recorded 107.23 q/ha in rice-garden pea system than rice-fallow (21.6 q/ha) and which was 397.6 percent higher than rice-fallow. Kumar *et al.,(*2019b) reported that rice-greem gram system enhanced the system profitability by 126 percent than rice-fallow.

Land use efficiency (LUE):

The land use efficiency (LUE) was recorded 72.88%, 73.70% and 73.97 % higher under rice-garden pea during 2017-18, 2018-19 and 2019-20, respectively as compared to rice-fallow. Mean LUE of three years was recorded 73.51% in rice-vegetable pea system as 39.45% in rice-fallow system. This might be due to inclusion of garden pea in rice-fallow and utilised land efficiently, which enhanced the profitability with more employment during the system. Kumar *et. al.* (2015) reported that intensification through short duration vegetables/ pulses in system increases LUE. This was also supported with the results of Kumar *et al.,*(2019a). Sharma *et al.* (2004) has also reported that intensification of vegetables and legumes crops increase the LUE by 78.31- 46.7 %.

Soil properties

Soil organic carbon (SOC) was recorded 1.354 % and 1.279 % in rice-garden pea and rice-fallow respectively after three cropping cycle in zero-tillage condition after rice harvest which was 7.20 % higher than the conventional farmers practice (rice-fallow). Higher available N, P and K was found 334.49, 16.10, 348.42 kg/ha with rice-garden pea respectively than rice-fallow (311.09, 15.02, 336.82 kg/ha respectively) and also higher than the initial value. This might be due to inclusion of garden pea in rice-fallow and which might have enhanced microbial activities due to symbiotic N-fixation, addition of N-rich leaf litter and biomass to soil (Das *et al.,* 2010)

Economics:

The input and outputs prices of commodities prevailed during experiment for the three years of demonstration were taken for calculating cost of cultivation, gross return, net return, benefit cost ratio (table 1) the economic indicator clearly showed that net returns from the rice-vegetable pea was substantially higher than the rice-fallow.Net return was ranged Rs.18250/ha- Rs.21450/ha in rice-fallow, whereas Rs.123375/ha – Rs.156050/ha with rice-vegetable pea system during the three years of demonstration. The benefit cost (B:C) ratio was recorded 1.79, 1.90, 1.80 and 2.98, 2.57, 2.60 in rice-fallow and rice-vegetable pea system during the year 2017-18, 2018-19 and 2019-20 respectively. Similar result had been reported earlier by Singh *et al*. (2012).Economic efficiency was recorded 586.7, 458.65 and 466.07 Rs/ha/day under rice-garden pea system and 130.85, 148.96 and 132.53 Rs/ha/day in rice-fallow during the year 2017-18, 2018-19 and 2019-20 respectively. Kalita *et al.,* (2018) reported that the higher economic efficiency was recorded in rice – vegetables system than rice-fallow in Assam.

4. Conclusion:

Farmers was happy with the cultivation of garden pea in zero-tillage by the principles of “learning by doing” and “seeing is believing”. By adopting zero-tillage, the farmers may increase the productivity, reduce cost of cultivation, increase the cropping intensity and enhanced the additional income and also improve the status of soil fertility.After successful implementation of the technology, farmers were highly impressed and motivated by the zero-tillage cultivation practice due to its cost effectiveness, less labour requirement, high energy saving and higher net income with efficient utilization of locally available resources.

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Photographs

General view of rice field

View of Garden pea cultivation under zero-tillage in rice -fallow at farmers field

Table 1. Rice yield, vegetable yield and rice equivalent yield under rice-fallow

Year	Area (ha)	Cropping system	Rice yield (q/ha)	Pea yield (q/ha)	System *REY (q/ha)	Net income (Rs/ha)	B:C ratio	**EE (Rs/ha/day)	***LUE (%)
2017-18	2.6	Rice-fallow	20.9	-	20.9	18250	1.79	130.85	38.90
		Rice-garden pea	20.9	59.4	117.4	156050	2.98	586.7	72.88
2018-19	4.5	Rice-fallow	22.6	-	22.6	21450	1.90	148.96	39.45
		Rice-garden pea	22.6	48.3	101.9	123375	2.57	458.65	73.70
2019-20	3.2	Rice-fallow	21.4	-	21.4	19054	1.80	132.53	40.0
		Rice-garden pea	21.4	49.7	102.3	125850	2.60	466.07	73.97
Mean		Rice-fallow	**21.6**	**-**	**21.6**	**19793.3**	**1.83**	**137.44**	**39.45**
		Rice-garden pea	**21.6**	**52.16**	**107.23**	**135091.7**	**2.72**	**503.81**	**73.52**

*REY: Rice equivalent yield, **EE: Economic efficiency, ***LUE: Land use efficiency

Table 2. Soil properties after 3 cropping cycles

	Initial				**Final**			
	SOC (%)	**Avail. N Kg/ha**	**Avail. P Kg/ha**	**Avail. K Kg/ha**	**SOC (%)**	**Avail. N Kg/ha**	**Avail. P Kg/ha**	**Avail. K Kg/ha**
Rice-fallow	1.263	305.58	13.87	332.54	1.279	311.09	15.02	336.82
Rice-gardenpea					1.354	334.49	16.10	348.42

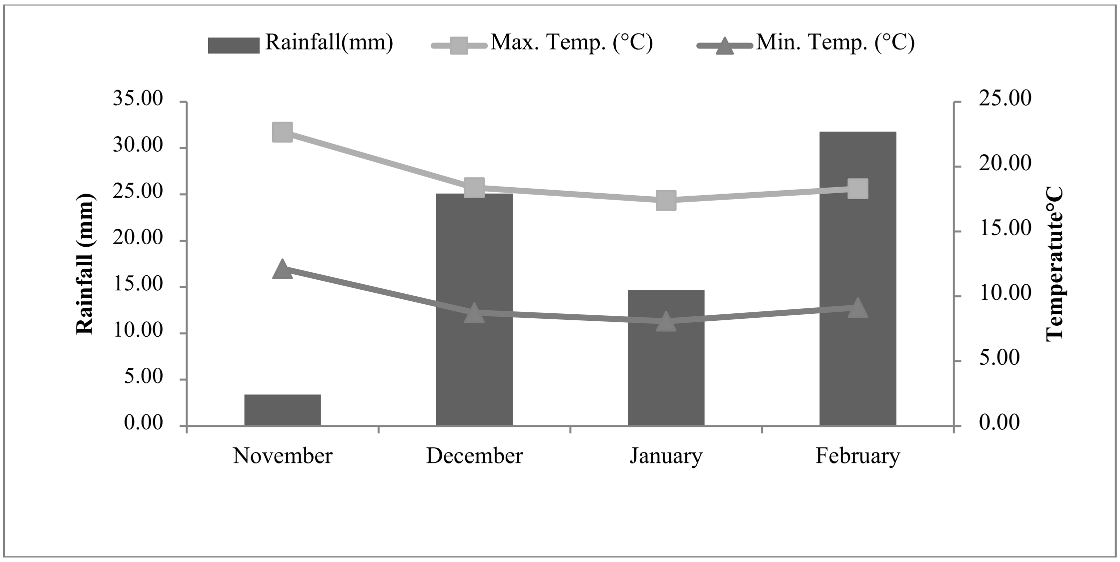

Figure 1. Mean monthly weather parameter during the experimental period (mean 3 years)