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Popularization of Toria Through Frontline Demonstration in Rice-Fallow Under Hill Region of North East India

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ABSTRACT

Low productivity and profitability are the major constraints of continuous rice - fallow practice in Sikkim Himalayas. Toria cultivation in rice-fallow may be an option for enhancing the productivity and profitability of the farmers and also for utilizing the residual soil moisture for increasing the cropping intensity. Therefore, frontline demonstration was carried out by the ICAR-KrishiVigyan Kendra, East Sikkim during 2021-2022 and 2022-23 for increasing productivity, profitability, and sustainability of the rice-fallow. Results indicated that rice yield was ranged from 20.8 – 21.3 q/ha during two years. The two-year mean of rice equivalent yield (REY) was recorded 41.54 q/ha and 21.05 q/ha under rice-toria and rice-fallow system, respectively. Higher system production efficiency (16.18 kg/ha/day), economic efficiency (139.10 Rs/ha/day), and land-use efficiency (72.47 %) were recorded in the rice-toria system compared to rice-fallow. The average net return, benefit-cost ratio were recorded Rs.35900/ha, Rs.14995/ha, and 1.70, 1.46 under rice-toria and rice-fallow, respectively. Higher output energy, net energy, and energy productivity were recorded in rice-toria as compared to rice-fallow. Energy input, energy output, output-input ratio, energy productivity, net energy return and energy productivity were recorded 6389.4 MJ/ha, 79318.5 MJ/ha, 12.41, Kg/MJ, MJ/ha and 11.41 and 8742.9 MJ/ha, 128102.0 MJ/ha, 14.65, 0.49, 119359 MJ/ha and 13.65 with rice-fallow and rice-toria respectively. Hence, it may be concluded that the inclusion of toria is an option for improving the productivity, profitability; cropping intensity and energy use efficiency also harvest the residual soil moisture.

Keywords: Economics, Energetics, Rice-Fallow, Toria, Yield

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INTRODUCTION

In India, about 11.7 m ha area of *Kharif* rice remains fallow in subsequent *rabi* season due to several biotic, abiotic, and socio-economic constraints (Kumar *et al.*, 2020). In Sikkim, Rice is the second most important crop after maize, which covered an area of 10481 ha with a productivity 1856 kg/ha. The cropping intensity of the Sikkim is very low (118%) due to the rice monocropping (Avasth e*et al.*,2019). Farmers' kept their field fallow after harvesting rice during the rabi season due to severe moisture scarcity. Hence, most of the area is remaining fallow in the state (Babu *et al.*, 2020). Cultivation of toria in rice-fallow may be an option to get the economic benefit of the farmers.

Oilseed crops are a significant part of the agricultural economy in India. India is the fourth largest oilseed economy in the world. Rapeseed and Mustard is the second most important edible oilseed after Ground nut sharing 27.8 per cent in India's oil seed economy. In terms of acreage, oilseeds occupy 14.1 per cent and rape seed mustard alone occupies 3 per cent of the total cropped area in the country (Shekhawat *et al.*,2013) and North eastern India having the area of 483300 ha with productivity 938.80 kg/ha, which is below the national level productivity of 1183 kg/ha (Agricultural Statistics of India, 2016-17). In the context of Sikkim, Oilseeds occupied an area of 6057 ha and production (5606tonnes) with productivity 925 kg/ha. Rapeseed and mustard area and production is 3115 ha and production 2734 tonnes. It is cultivating under East District of Sikkim which contributes 1475 ha area and production 1281 tonnes with productivity 868 kg/ha.Thus, there is potential for growth of toria in rice-fallow for increasing the cropping intensity, productivity, and profitability where the operational land holding is dominated by marginal (54%) and small (23%) farmers in the state (Avasthe *et al.*, 2019).

Among different indicators of crop performance, the energy analysis is one of the most important. The net output energy of a cropping system can be assessed for planning of sustainable cropping systems. Keeping the above point in view, KVK took the initiative and conducted frontline demonstration (FLD) on toriacultivation in rice-fallow under organic management during rabi season for improving the economic status of the farmers and increasing the cropping intensity.

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MATERIALS AND METHODS

Frontline Demonstrations (FLDs) was conducted by the ICAR-Krishi Vigyan Kendra, East Sikkim, Ranipool on toria cultivation in rice-fallow under rice based system of Sikkim at farmers field during *rabi* fortwo consecutive year from 2021-22 to 2022-23 at different villages*viz*., Tanka,Timpyem, tuminshiley, Assam Linzey and Lingtam in East Sikkim. The total area covered 3.4 ha and 4.1 ha during the year 2021-22 and 2022-23 respectively. The total rainfall received during cropping period was 110.4 mm and 98.8 mm in 2021-22 and 2022-23, respectively.Maximum average temperature of both the year was 22.9^{0}Cwhile the minimum average (2 years) temperature was 6.8^{0}C.Toria(Cv.TS38)was sown in rice-fallow after harvesting of rice in the last week of October to 2nd week of November during both the year for increasing the cropping intensity, land use efficiency and income of the farmers. Two hand weeding was done at 15 and 35 days after sowing. The yield of rice and toria 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, B:C ratio and energetic 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.

Rice equivalent yield (REY) was calculated with formula:

REY=Yield of rice (first crop) + yield of second crop × price of second crop/price of rice.

Land use efficiency (LUE) was calculated with formula:

$$\text{Land use efficiency (LUE)} = \frac{\text{Total number of days occupied by different crop}}{365} \times 100$$

System productivity (kg/ha/day) was calculated by dividing production of sequence by total duration of crop sequences and system profitability in terms of Rs/ha/day was obtained by net returns of the sequence divided by total duration of crop sequences (Kumar *et al.*, 2017).

Energy input and output were calculated by converting the various inputs used viz. labour, farmyard manure and output *i.e*. grain and straw into energy units (MJ) as described by Yadav *et al.* (2017).

The energy parameters were calculated with the following formula:

Input energy: Total sum of Energy equivalents for all inputs was calculated as total energy input.

Output energy: Yields of grain and by-product (straw/leaves/stalk). Energy output from the product (grain) was calculated by multiplying yield and its corresponding energy equivalent. Energy outputs from by-product were calculated by multiplying yield of by-product and its corresponding energy equivalent.

Net energy return: It is the difference between gross output energy and the total input energy.

$$\text{Energy profitability(PE)} = \frac{\text{Net energy returnMJ/ha)}}{\text{Input energy (MJ/ha)}}$$

$$\text{Energy productivity(EP)} = \frac{\text{Crop economic yield(kg/ha)}}{\text{Energy input (MJ/ha)}}$$

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ/ha)}}{\text{Energy input (MJ/ha)}}$$

$$\text{Energy output efficiency} = \frac{\text{Energy output (MJ/ha}}{\text{Duration of the system(in days)}}$$

Economics and Rice Equivalent was calculated at prevailing wholesale market price during all the year for different commodities. Mean data of all the observations over three years were pooled and statistically analysed using F-test (Panse and Sukhatme, 1984). Test of significance of treatment was done on basis of t-test. Differences between treatments means, which were higher than respective least significant different (LSD) values were considered as significant difference at 5% level of probability (*p*=0.05).

RESULTS AND DISCUSSION

Production efficiency

Rice grain yield was ranged 20.8-21.3 q/ha under rice-toria and rice-fallow system. Mean toria seed yield of two years were recorded 8.9 q/ha and rice equivalent yield (REY) of toria was 20.5 q/ha during the demonstration. System REY of two years was recorded 41.54q/ha and 21.05 q/ha under rice-toriaand rice-fallow systemrespectively. Kumar *et al.* (2019a) reported that maximum productivity was found with rice-cabbage system. Maximum system production efficiency (SPE) was recorded16.18 kg/ha/day and 13.84 kg/ha/day in rice-toria system than rice-fallowrespectively. The inclusion of garden pea in rice-fallow might be the reason for higher productivity, profitability and production efficiency in rice-garden pea

Table 1: Rice yield, toria yield and rice equivalent yield of different system

Year	Cropping system	Area (ha)	Rice yield (q/ha)	Toria yield (q/ha)	*RE Toria yield (q/ha)	System *REY (q/ha)	System Production efficiency (kg/ha/day)
2021-22	Rice-fallow	4.80	20.8	-		20.80	13.77
	Rice-toria		20.8	9.2	20.35	41.16	16.10
2022-23	Rice-fallow	3.40	21.3	-		21.30	13.92
	Rice-toria		21.3	8.6	20.64	41.91	16.26
	Rice-fallow	4.10	21.05	-	-	21.05	13.84
Mean	Rice-toria		21.05	8.9	20.5	41.54	16.18

*REY: Rice equivalent yield,

system. Kumar *et al.* (2019) reported that rice-greem gram system enhanced the system profitability and production efficiency by 126 percent and 307 percent, respectively than rice fallow.

Land use efficiency *(LUE):*LUE was recorded 73.15 %, and 71.78 % higher under rice-toria during 2021-22 and 2022-23, respectively as compared to rice-fallow (Table 1). Mean LUE of two years was recorded 72.47 % in rice-toria as compared to 41.10 % in rice-fallow. This might be due to inclusion of toria after rice harvest and utilised land efficiently, which enhanced the profitability with more employment generation 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 46.7-78.31%.

The economic indicator clearly showed that net returns from the rice-toria were substantially higher than the rice-fallow. Net return was ranged Rs.12440/ha – Rs.17550/ha in rice-fallow, whereas it was Rs.29500/ha - Rs.42300/ha with rice-toria system during the two years of demonstration (Table 2). The benefit cost (B:C) ratio was recorded 1.43, 1.49 in rice-fallow and 1.72, 1.68 in rice-toria system during 2021-22 and 2022-23 respectively. This might be due to that recommended practices produced higher yield than farmers practice. Similar result had been reported earlier by Singh *et al.* (2012). Economic efficiency was recorded 115.23 and 163.96Rs/ha/day under rice-toria system and 82.38 and 114.70 Rs/ha/day in rice-fallow during 2021-22 and 2022-23, respectively. Higher mean economic efficiency was also recorded 139.59Rs/ha/day with rice-toria than rice-fallow (98.54 Rs/ha/day). Higher efficiency under rice-toria might be due to inclusion of second crop (toria) in rice-fallow, which enhanced the productivity as well as income. Kalita *et al.*(2018) reported that the higher economic efficiency was obtained in rice - cabbage and rice-tomato than rice-fallow in Assam.

Table 2: Economics and land use efficiency of different system

Cropping system	Year	Net income (Rs/ha)	B:C ratio	**EE (Rs/ha/day)	***LUE (%)
2021-22	Rice-fallow	12440	1.43	82.38	41.37
	Rice-toria	29500	1.72	115.23	73.15
2022-23	Rice-fallow	17550	1.49	114.70	40.82
	Rice-toria	42300	1.68	163.96	71.78
Mean	Rice-fallow	14995	1.46	98.54	41.10
	Rice-toria	35900	1.7	139.595	72.47

**EE: Economic efficiency, ***LUE: Land use efficiency

Energetics : Energy analysis is recent tools to know the efficiency of the different treatment and respective treatment is considered more efficient when it produces higher output energy and requires less input energy. The mean (2 years) highest input energy was 8742.96 MJ/ha with rice-toria system than rice-fallow (6389.44 MJ/ha). The output energy was recorded 128102 MJ/ha and 79318.5 MJ/ha with rice-toria and rice-fallow respectively (Table 3). Higher net energy return, output/input ratio, energy productivity and energy profitability were recorded 119359 MJ/ha,14.65, 0.49 kg/MJ and 13.65 with rice-toria and 72929.09 MJ/ha,12.41, 0.33 and 11.41 under rice-fallow. While highest amount of product produced per unit of energy invested in rice-vegetable system (Kumar *et al*., 2019).

Table 3: Energetics of different system

Cropping system	Year	Energy input (MJ/ha)	Energy output (MJ/ha)	Output/input energy	Energy productivity (Kg/MJ)	Net energy Return(MJ/ha)	energy profitability
2021-22	Rice-fallow	6412.96	78951	12.31	0.33	72538.04	11.31
	Rice-toria	8782.16	128852	14.67	0.49	120069.8	13.67
2022-23	Rice-fallow	6365.92	79686	12.52	0.33	73320.08	11.52
	Rice-toria	8703.76	127352	14.63	0.50	118648.24	13.63
Mean	Rice-fallow	6389.44	79318.5	12.415	0.33	72929.06	11.415
	Rice-toria	8742.96	128102	14.65	0.495	119359	13.65

CONCLUSION

It may be concluded that the cultivation of toria in rice-fallow system not only increase the productivity, profitability but also enhanced the cropping intensity. Cultivation of toria in rice-fallow also harvest the residual soil moisture for higher profit.

CONFLICT OF INTEREST

All the author both individually and collectively, affirms that they do not possess any conflicts of interest either directly or indirectly related to the research being reported in the publication.

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