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System economics of rice based farming systems under rice-fallow lands

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Abstract
Producing food in sustainable manner by utilizing natural resources in eco-friendly manner through application of agro-techniques which are very adoptable by farming community because of their less reliability as per the farmer's needs as well as improving the soil health. The eco-friendly approach was applied under this experiment by utilizing the locally available natural resources and non-monetary input under rice-fallows to increase in the cropping intensity of the region as well as increasing the productivity and production of potato. The system economics was calculated to see their economic suitability under rice-fallows. The significantly higher beneficial outcomes were recorded during experimentation of rice-potato system economics where potato crop sown under S_1 (5th November) sowing date and cost of cultivation under M_1 (rice straw) mulch.

Keywords: rice-potato system, rice-fallows, sowing and mulching, system economics

1. Introduction
Potato is the fourth one of the most nutrient rich crops of the world (FAOSTAT, 2016) [4]. While third most important crop in India, after rice and wheat (Haq and Matin, 2006) [7]. Potato will be the crop which will be addressing and bring the food security in developing countries (Scott *et al.*, 2000) [14]. It is growing across the world specially in Asia and Europe. Potato is typically a temperature crop growing across the world. It is mainly growing as the winter crop in India as well as in the hilly regions. The crop grows very well in cool and frost-free seasons, but not suitable to grow under high temperature conditions. Because under high temperature conditions, the tuber formation is affected and does not perform very well which leads to poor yield. Potato and rice both crops are the major staple food in North East India. Rice is the most widely consumed staple food for a large part of world's human population, especially in Asia (Rao *et al.*, 2007; Kumar and Ladha, 2011) [12, 8]. Rice is the most important cereal crop of the world, which is contributing 90% producing and consuming in Asian continent only.it occupied an area of 45 m ha in the country (FAI, 2011) [3] and can be grown under wide range of climatic condition across the planet earth. Potato is also the most important food crop which famous for its nutritional quality and its higher industrial demands. Potato can be grown in wide range of climatic conditions too, but it's the most sensitive crop to temperature and moisture stress. The producing crops under climate change specially the potato crop under rice fallows is very challenging to farming community. The application of various organic mulch and sowing dates found very reliable to take crop production under limited natural resources in sustainable manner with eco-friendly approaches (Scott, 2007) [15] (Gurjar *et al.*, 2018) [5] of valley land of Meghalaya. These new techniques are like changing in the research. The critical research on agricultural crops related to impacts of high temperature and carbon dioxide concentration. These are some important sectors of research which are sustainability of crop production, water supply, input supply, food safety, plant varieties etc. all the above sectors of research require a new research technique of experiment to suit accordingly changing climate. Those all sectors need a new experiment to maintain our sustainable food production to supply food for increasing global population especially for Asian countries under changing climatic (Gurjar *et al.*, 2018) [5].

2. Materials and Methods
2.1 experimental site
The rice potato crop was grown under rice-fallow lands of valley region of Ri-Bhoi district of

Meghalaya for the two consecutive years during 2018-19 and 2019-20. Which is situated at 24.41^0 N latitude and 91.54^0 E longitudes at an elevation of 950 m above mean sea level (MSL). This region comes under sub-tropical climatic conditions.

2.2 Economic parameters

Cost of cultivation (₹ ha^{-1})

The cost of cultivation was calculated on per hectare basis for every treatment by taking into account the inputs, labours and operational cost.

Gross monetary returns (₹ ha^{-1})

The total monetary value of the grain and straw of rice, and tuber yield of potato as economic produce obtained from the crop and it was calculated on the basis of prevailing local market price of the produce and expressed on unit area (ha^{-1}). Using the following formula:

Gross income (Rs. ha^{-1}) = cost of grain, straw and potato tubers

Net monetary returns (₹ ha^{-1})

The cost of cultivation for each treatment was subtracted from the gross income to get net income in rupees per hectare (Rs. ha^{-1}). Using the following formula:

Net income (Rs. ha^{-1}) = gross income-total cost of cultivation

B:C ratio (%)

The benefit to cost (B:C) ratio of rice-potato cropping system was worked out using the following formula:

$$\text{Benefit cost ratio} = \frac{\text{Net income (Rs. ha}-1)}{\text{cost of cultivation (Rs.ha}-1)}$$

2.3 Statistical analysis

A standard method of analysis of variance was used for analysing data. The 'F' test of significance was used for testing the standard error of mean ($SE_{(m)\pm}$) for each treatment and where the treatment effects was significant, the critical difference (C.D.) at 5 % probability level worked out for testing the significance of treatment difference. The interpretation was based on the method given by Gomez and Gomez (1984).

3. Experimental findings

3.1 Effect of sowing dates

Sowing dates found significant effects on cost of cultivation, gross monetary returns, net monetary returns and on benefit to cost ratio during both the years of rice-potato system.

The cost of cultivation was recorded non-significant under various sowing dates from S_1 (5th November) to S_5 (4th January). The cost of cultivation was recorded equal among the different sowing dates during both the years while the significantly higher cost of cultivation (131526 ₹) was recorded during first year in comparison to second year (124424 ₹) of rice potato system. The cost of cultivation during both the years under various sowing dates was found on par to each other. The pooled analysed data also showed the similar results of cost of cultivation (127975 ₹). Gross monetary return was significantly influenced by various sowing dates. The maximum gross monetary returns were recorded 328103, 349181 and 338642 ₹ under S_1 (5th November) sowing date during both the years of crop experimentation as well as in the pooled analysed data, respectively. However, the significantly lower gross monetary returns were recorded 149724, 148990 and 149366 ₹ under S_5 (4th January) sowing date during both the years and in pooled analysed data, respectively. Furthermore, the significantly higher gross monetary returns were recorded during second year (2019-20), while lower during first year (2018-19). Net monetary returns were significantly affected by various sowing dates during both the years of crop experimentation and in pooled analysed data too. The significantly higher net monetary return was recorded 196577, 224757 and 210667 ₹ under S_1 (5th November) sowing date in comparison to others during both the years and in the pooled analysed data, individually. Moreover, its lower net monetary returns were recorded 29105, 44554 and 36829 ₹ under S_4 (20th December) sowing date. Furthermore, the significantly higher and lower net monetary returns were recorded during second year in comparison to first year. The sowing dates were significantly influenced the benefit to cost ratio of rice-potato cropping system. The significantly higher benefit to cost ratio was recorded 2.47, 2.74 and 2.60 where potato crop was sown under S_1 (5th November) sowing date and lowest 1.14, 1.18 and 1.16 under S_3 (5th December) sowing date during both the years of crop experimentation and as per the pooled analysed data too. Moreover, the higher benefit to cost ratio was recorded during second year in comparison to first year of rice-potato cropping system.

3.2 Effect of mulching practices

Mulching practices were found significant effects on cost of cultivation, gross monetary returns, net monetary returns and on benefit to cost ratio during both the years of rice-potato crop experimentation. The significantly higher cost of cultivation (145235, 138133 and 141684 ₹), gross monetary returns (293808, 343685 and 318747 ₹), net monetary returns (148573, 205552 and 177063 ₹) and benefit cost ratio (2.02, 2.49 and 2.26) was recorded under M_1 (rice straw) mulch in comparison to others and lower cost of cultivation (116085, 108983 and 112534 ₹), gross monetary returns (173525, 148509 and 161017 ₹), net monetary returns (57440, 39526 and 48483 ₹) and benefit to cost ratio (1.49, 1.36 and 1.43) was recorded under M_0 (no mulch) during both the years of crop experimentation and in pooled analysed data too, respectively. Moreover, the higher cost of cultivation under various mulching was recorded during first year in comparison to second year of rice-potato crop experimentation, while higher gross monetary returns, net monetary returns and benefit to coat ratio was recorded during second year of rice-potato cropping system.

3.3 Interaction effect

The effects of sowing dates and mulching practices on economics of rice-potato cropping system was recorded significant except cost of cultivation during both the years and in pooled analysed data. The significantly higher gross monetary returns (413342, 513617 and 463429 ₹), net monetary returns (268007, 375484 and 321745 ₹) and benefit to cost ratio (2.85, 3.72 and 3.30) was recorded under S_1M_1 (5th November sowing date and rice straw mulch) during both the years as well as in pooled analysed data. Likewise, lower gross monetary returns (130408, 98015 and 117879 ₹) were recorded under S_4M_0 (20th December sowing date and no mulch), net monetary returns were recorded significant (14323 and 5345 ₹) during first year, and in pooled analysed data under S_5M_0 (4th January sowing date and no mulch), while it was recorded negative during second year (-3052 and

-10967) under S_4M_0 (20th December sowing date and no mulch) and S_5M_0 (4th January sowing date and no mulch), and benefit to cost ratio (1.07) under S_5M_1 (4th January sowing date and rice straw mulch) during first year and 0.90 and 1.04 under S_5M_0 (4th January sowing date and no mulch) during second year and in pooled analysed data, respectively. The significantly higher economic parameters were recorded during second year in comparison to first year except cost of cultivation during experimentation.

Table 1: Effect of different sowing dates and mulching practices on system economics of rice-potato system during experimentation

Treatments	Cost of cultivation (₹ ha^{-1})			Gross monetary returns (₹ ha^{-1})			Net monetary returns (₹ ha^{-1})			Benefit to cost ratio		
Sowing dates	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**	**2018-19**	**2019-20**	**Pooled**
S_1	131526	124424	127975	328103	349181	338642	196577	224757	210667	2.47	2.74	2.60
S_2	131526	124424	127975	264797	262248	263522	133272	137824	135548	1.98	2.07	2.02
S_3	131526	124424	127975	257936	273734	265835	126411	149311	137861	1.93	2.14	2.03
S_4	131526	124424	127975	160631	168977	164804	29105	44554	36829	1.21	1.33	1.27
S_5	131526	124424	127975	149742	148990	149366	18216	24566	21391	1.14	1.18	1.16
S.E(m)±	*	*	*	7820	7748	4494	7820	7748	4494	0.063	0.058	0.035
CD (p=0.05)	*	*	*	25499	25265	13472	25499	25265	13472	0.205	0.188	0.104
Mulching practices												
M_0	116085	108983	112534	173525	148509	161017	57440	39526	48483	1.49	1.36	1.43
M_1	145235	138133	141684	293808	343685	318747	148573	205552	177063	2.02	2.49	2.26
M_2	133257	126155	129706	229392	229684	229538	96135	103530	99832	1.72	1.82	1.77
S.E(m)±	*	*	*	5446	6136	3745	5446	6136	3745	0.041	0.046	0.028
CD (p=0.05)	*	*	*	16063	18098	10702	16063	18098	10702	0.121	0.137	0.081
Interaction	*	*	*	S	S	S	S	S	S	S	S	S

*Non-significance

4. Discussion

Total cost of cultivation of rice potato system under M1 was found significant (145235 ₹). The significance of higher cost of cultivation among various practices is due to higher cost of rice straw mulch in comparison to other mulch, while in case of sowing dates it was not recorded significant. Gross monetary income (349181₹), net monetary income (224757₹) and benefit to cost ratio (2.74) of rice potato system under S1 was calculated significantly higher. The results were in accordance with the findings of Mandal *et al*., (2020) [9], who reported the higher gross income and net income as well as productivity of potato crop under potato system and rice-based systems. The higher monetary returns from various practices are due to variability in the yield of rice and potato crop with respect to sowing and mulching practices. The similar findings are supported by Pastukhov *et al*., (2020) [11]; Ali *et al*., (2019) [1]; Brar *et al*., (2019) [2]; Sarangi *et al*., (2010) [13]; Pandiaraj *et al*., (2017) [10].

5. Conclusion

The system economics of rice-potato cropping was recorded significantly higher gross income, net income and benefit to cost ratio was recorded under S_1 sowing date in comparison to others and higher cost of cultivation of the rice-potato system was recorded under M_1 in comparison to other practices.

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