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Understanding Economics of Zero Tillage and Rice Straw Mulching in Potato Cultivation

Bijoy Sankar Goswami* and Pradip Kumar Baruah
University of Science and Technology Meghalaya (Meghalaya), India.

(Corresponding author: Bijoy Sankar Goswami)*
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ABSTRACT: Zero Tillage and Rice Straw Mulching (ZTRM) is such a technique which is widely used in wheat and other crops but has not been broadly used in potato. However, the ZTRM technique is becoming popular among small holders in Assam. The ZTRM technique does not require land preparation, and the mulch cover used in the technique retains high soil moisture. Whereas in Conventional Tillage (CT) there is requirement of land preparation, higher doses of fertilizer, and irrigation etc. Hence, both practices have different cost involvement. The current study provides an account of cost benefit analysis of ZTRM and CT in potato cultivation in Assam. This study was carried out in the district of Barpeta and Biswanath of state of Assam to have a better idea on variability on costs involved in different components in both the locations. It was found that the similar component had cost dynamics in both the places. This was a constraint to work out the cost of cultivation (CoC) to represent the benefit cost ratio for the same technique. The methods display various components to understand the cost involvement in both ZTRM, and CT using cost concept. The experiment was carried out in two different farmer's fields, one in each district. The obtained results were analyzed using ANOVA at 5% probability level.

The results demonstrated that the cost involvement in ZTRM is 22% and 28% lesser in Barpeta and Biswanath district respectively when it was compared with CT.

Keywords: Zero Tillage, Rice Straw Mulching, Conservation agriculture, Cost-benefit, Conventional Tillage.

INTRODUCTION

Potato is one of the most important semi-perishable and widely cultivated horticultural crops of Assam, a Northeastern state of India. Potato ranks fourth in terms of acreage under individual crops and occupies more than a lakh hectare of land which produced about 985400 tons of potatoes in 2020-21 (Borah *et al.,* 2016; Agriculture Statistics at a Glance, 2021). This shows the significance of potato in the economy of rural population in the state. It is well known that Assam is geographically suitable for potato cultivation particularly for Rabi season. Nationally, Assam is ranked 8th for potato production, and ranked 6th based on agricultural land used for potato production. The state has challenges of natural calamities hence, potato crop gets a very short window of 90-100 days after paddy harvest. It is primarily due to natural calamity like seasonal flood incidences which delays the sowing of Sali paddy (winter rice) (Kumar *et al.,* 2022). In addition, paddy varieties grown in Assam are mostly long duration varieties, that enhances the difficulty to have a suitable window for the optimal growth of potato crop. This is one of the reasons that farmers are failing to achieve required productivity from their crops. In addition, potato seed cost, availability, lack of scientific knowledge to cultivate potato, disease, and pest management are the other reasons that lowered the potato production of the State (Deka *et. al*., 2014). Moreover, farmers in the state generally use old age traditional practices for cultivating potato and they are quite reluctant to switch to new techniques and methods of agricultural practices. Generally, farmers wait for about a month after paddy harvest to prepare land for potato cultivation. This further shortens the available time window associated with potato crop in Assam. Ultimately, the crop faces delay in planting, harvesting, and there is loss in yield. During the month of February and March, temperature starts to rise, and it has an impact on yield and storage of the crop (Kumar *et al.,* 2022). Hence, the state needs early maturing variety of potato for timely harvest, and better yield (Khandai *et al.,* 2022). Additionally, infusion of new technology with the traditional one is a need to enhance farm productivity and profit by retaining environmental health (Behera and Sharma 2015). Extensive study has been carried out worldwide in Wheat and Maize under Conservation Agriculture (CA) based techniques. However, similar study in potato is yet to be done extensively. There are aspects of CA, which has been addressed by various studies in potato, but a comprehensive study to reveal cost benefit of CA based technique in potato is still a study of interest. Zero tillage technology is such a technology that helps

farmer minimize the use of inputs for crop production. Which eventually reduce the cost of cultivation (CoC). It also reduces the use of farm machinery for land preparation and thereby save considerable diesel costs. Study reveals that 44% diesel cost was saved per hectare after adoption of zero tillage technique in wheat (Singh, 2016). The mulch cover of Rice Straw can enhance moisture retention in soil. The mulch cover eventually compliments the traditional practice of farmers by providing required amount of water for the crop to grow without an effort being put by the farmers (Rautaray, 2010). As a result, irrigation cost is saved in mulching to accomplish lower CoC.CA techniques has the potential to protect soil degradation by reducing erosion, soilcompaction and enhances soil fertility thereby enhancing farm profitability (Muzari, 2016). Mulching on crop effortlessly improves irrigation requirement of potato crop with less investment, that contributes towards water conservation. This also improves soil quality by allowing the decomposition of the mulching material and utilizing this natural resource quite efficiently (Singh, *et al.,* 2018).

The current study seeks to implement a Conservation Agriculture (CA) based technique for potato cultivation in Barpeta and Biswanath (Undivided Sonitpur district) districts in the State of Assam to demonstrate the cost efficiency of new technique when it is compared to the current practice of potato cultivation by giving a cost benefit analysis. It was carried out on the conservation agriculture- based technology Zero tillage and rice straw mulching (ZTRM) for potato cultivation on farmer's field.

MATERIALS AND METHOD

Study site: (Fig. 1)

The study was carried out in Sarukheti and Baghmara block of Barpeta (26°5' and 26°51' North latitude and 90°38' East longitude) and Biswanath district (Undivided Sonitpur) (26.28-27° North latitude and 91.19-93.47 East longitude) respectively in the state of Assam in the year 2021-22. Two experimental plots of ZTRM were used in an area of 100 Square meter (sqm) and a same plot was also implemented for CT in the same village to have a uniform understanding of cost involvement in the entire operation during the crop cycle in both the practices. The calculation of CoC and cost benefit was carried out for an area of 0.33 acre known as one *Bigha* in Assam (1333 sqm) area in both the cases for easy understanding by the farming communities. The entire operation was categorized according to the sequence of activities involved in the cultivation process. Cost involved in each activity were recorded using a field book for both ZTRM and CT. The CoC was worked out using standard cost concepts as defined and used in economies of farm management for estimating CoC (Singh *et al.*, 2019; Borah *et al*., 2016).

Cost concept

1. Variable cost= All cost incurred for material, inputs, hired labour, interest on working capital
2. Cost A_1= All variable costs + other miscellaneous charges
3. Cost A_2= Cost A_1 + Rental value of leased land
4. Cost B= Cost A_2 + Rental Value of own land
5. Cost C= Cost B+ Imputed value of family labour

The gross income and Net income were worked as below

Gross income = The gross income was computed by multiplied by the price of potato with the production quantity

Net Income= Gross Income – C (Cost of Cultivation)

The results achieved were analyzed using ANOVA at 5% probability.

RESULTS AND DISCUSSION

Potato is an important crop in Assam that improved economic status of the farmers. It gives maximum gain per unit area. However, practices are highly dependent on its productivity and good return on investments. From this study, it was found that the ZTRM is more rewarding than the CT if the cost benefit is seen and compared. The advantage of ZTRM comes with both higher yield in terms of marketable tubers, and the lesser CoC. The CoCof ZTRM is 22% and 28% less than the CoC of CT in Barpeta and Biswanath district respectively (Table 1). Although the other costs are somewhat similar, but the cost of land lease is quite high in Barpeta district compared to Biswanath. As a result, the overall CoC stands higher in Barpeta than in Biswanath. It is also evident from the Table 1, that the cost in component A1 is highest in both the practices (Fig. 2A). Moreover, the cost of seed is another big factor in deciding the total cost of cultivation. In the below scenario seed only constitute 30-35% of total CoC. It also determines the productivity of the crop which has a direct relation on the Return on Investment (RoI) (Kumar *et al*., 2021). Whereas in the CT, the cost of labour is highest that involved in the cropping operation (Fig. 2B). This is basically due to intensive activities involved in weeding, irrigation etc. Whereas in ZTRM, these costs are negligible. Similar study was carried out on onion in state of Rajasthan, reveals that a considerable cost is attributed towards labour which comprises 28% of the total operational cost in a normal cultivation practice (Meena *et. al.,* 2016).

In ZTRM, the cost of land preparation is completely absent. This technique does not require tillage for cultivation of potatoes. The potatoes are planted on the surface and mulched with rice straw. Moreover, the ZTRM practice requires less irrigation and water for the crop. The mulch cover used in the crop conserve good amount of moisture and keeps the plot water sufficient. The retention of moisture in ZTRM practice enhances the crop yield for a better return for the farmers. Hence, the practice has an advantage of cost benefit on irrigation as well as more gain through enhanced yield (Jat *et. al.,* 2009). Eventually this practice reduces overall cost of labor in particular operation of land preparation, irrigation, and weeding. However, all these processes were necessary in CT. Hence, the labour requirement in CT is more compared to the ZTRM. The

total cost of cultivation in both ZTRM and CT practiced as per our experiment showed in Table 2 (Fig.3).

Although some costs were similar like seed cost, won labour yet the cost of CT is more due to higher variable costs involved in land preparation and irrigation, thereby increase in number of labours required for the CT operation.

From this study, it was seen that the gross income is higher in the ZTRM compared to the CT (Table 3). Hence, overall cost benefit is better in ZTRM because the CoC in ZTRM is less compared to CT. It is quite evident that ZTRM can provide more RoI (Table 3).

The Net income and cost benefit ration in ZTRM practice had increased compared to CT (Fig. 4). The benefit cost ratio is 1.52 and 1.69 times compared to 1.11 and 1.21times in case of CT in Barpeta and Biswanath districts (Table 4). Although the net income has moderate increase in ZTRM practice (Fig. 4A) but has significant increase in cost benefit ratio to CT (Fig. 4B). Higher benefit cost ratio has also been achieved in Zero Tillage Wheat cultivation over CT cultivation in Haryana. Where a ratio of 1.43 was achieved in ZT against 1.31 in CT (Aryal *et al.,* 2014). The higher benefit cost ratio in ZTRM is basically due to lower CoC and at the same time higher yield quality. The ZTRM has the advantage of less weed growth on the crop field, low requirement of irrigation, easy harvesting to realize better RoI (Sarangi *et al.,* 2018).

Table 1: Cost involvement in various component of the techniques of ZTRM and CT in Barpeta and Biswanath 2021-22.

Cost category	Zero Tillage and Rice Straw Mulching		Conventional Tillage	
	Barpeta	Biswanath	Barpeta	Biswanath
Cost A1				
Land preparation	0	0	2000	2500
Inputs	1800	2200	2700	3300
Seed	6250	6250	6250	6250
Hired labour	5250	4500	7000	6000
Cost A2				
Land lease	4000	2000	4000	2000
Cost B				
Rental value of own land	1000	1000	1000	1000
Cost C				
Family labour	2000	2000	2000	2000
Total	**20300**	**17950**	**24950**	**23050**

Table 2: The total cost of cultivation in ZTRM and CT 2021-22.

Category of expenses	Zero Tillage and Rice Straw Mulching (in Rs.)		Conventional Tillage (in Rs.)	
	Barpeta	Biswanath	Barpeta	Biswanath
Cost A1	13300	12950	17950	18050
Cost A2	17300	14950	21950	20050
Cost B	18300	15950	22950	21050
Cost C	20300	17950	24950	23050

Table 3: Gross income in ZTRM and CT.

	Production (Kg)		Price/Kg		Gross Income	
Practice Type	Barpeta	Biswanath	Barpeta	Biswanath	Barpeta	Biswanath
Conventional Tillage	2968	2984	10	10	29680	29840
Zero Tillage and Rice Straw Mulching	3005	3039	10	10	30050	30390

Table 4: Net income and cost benefit ratio in ZTRM and CT.

Income and Benefit: Cost Ratio	Zero Tillage and Rice Straw Mulching (Rs)		Conventional Tillage (Rs)	
	Barpeta	Biswanath	Barpeta	Biswanath
Net Income= Gross income - C	30050-20300= 9750	30390-17950= 12440	29680-24950=4730	29840-23050=6790
Cost Benefit Ratio (Gross income/C)	1.52:1	1.69:1	1.11:1	1.21:1

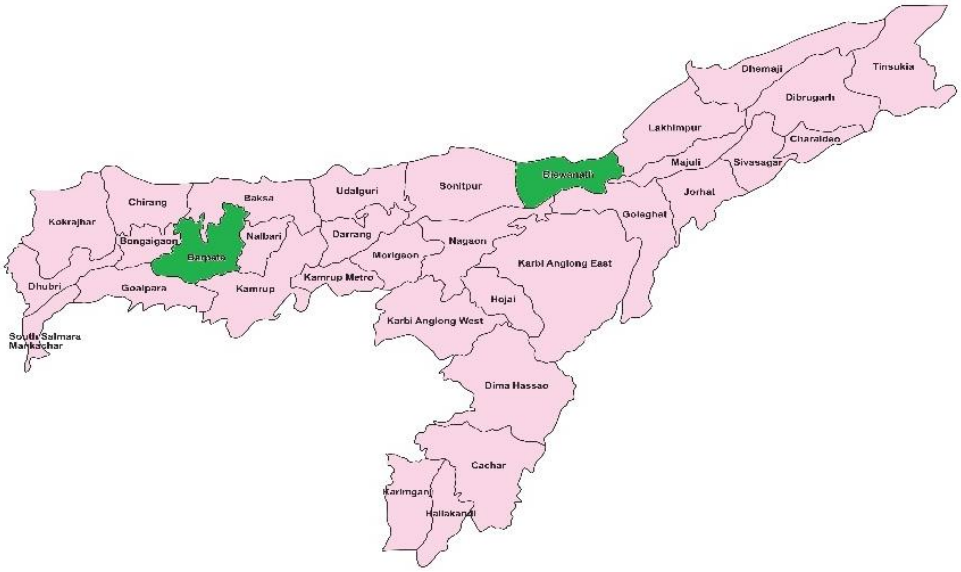

Fig. 1. Map of the Assam State. Study conducted at Barpeta and Biswanath districts (Showed in green color).

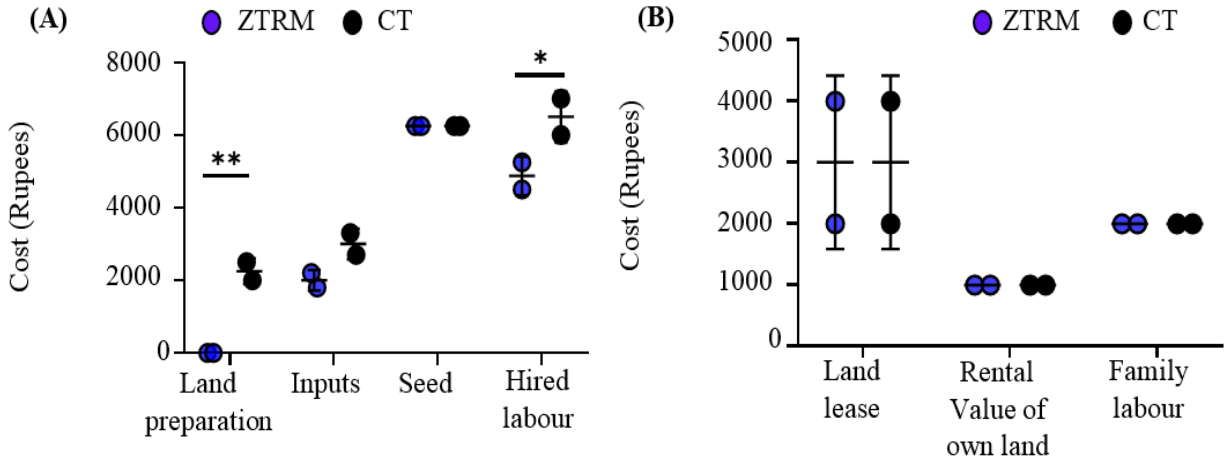

Fig. 2. Cost involvement in various component of the techniques of ZTRM and CT. **(A)** Comparison of cost A1, (B) Cost A2, B, and C between ZTRM and CT in Barpeta and Biswanath district. Data analyzed using two-way ANOVA, *p<0.05, **p<0.01. Test examined in two different locations.

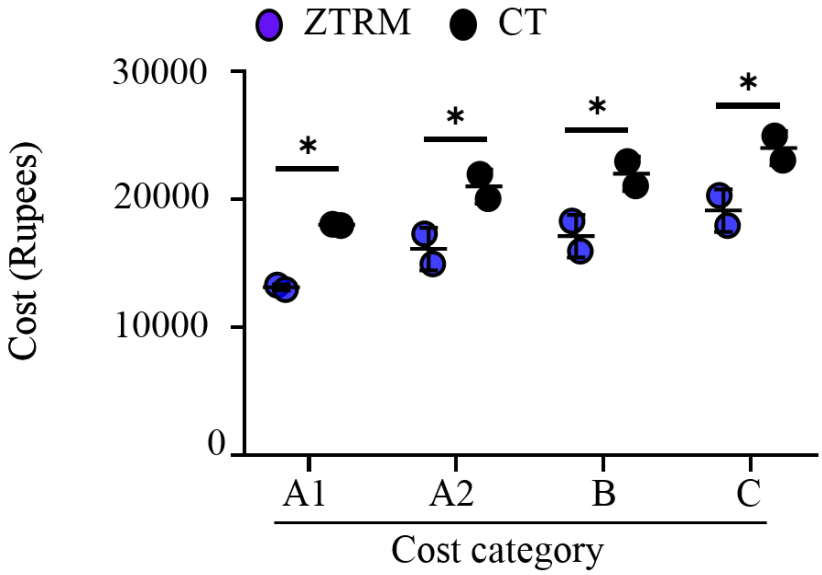

Fig. 3. The total cultivation cost involved between ZTRM and CT performed at Barpeta and Biswanath district. Data analyzed using two-way ANOVA, *p<0.05. Test examined in two different locations.

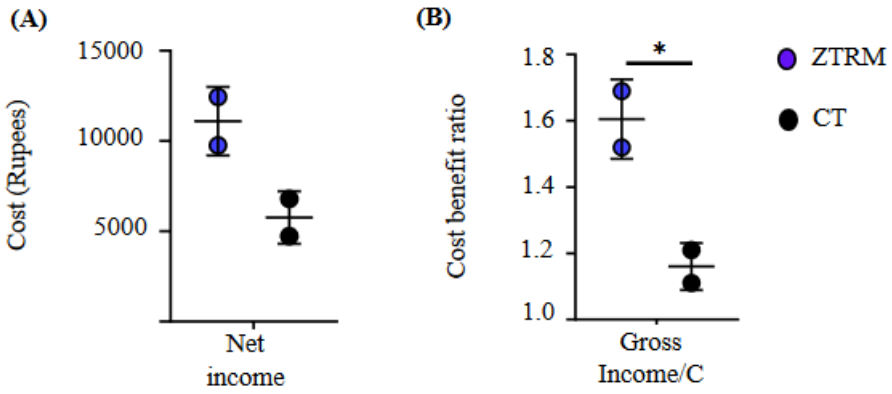

Fig. 4. Net income and cost benefit ration in ZTRM and CT performed at Barpeta and Biswanath District. Data analyzed using unpaired, non-parametric t-test, *p<0.05. Test examined in two different locations.

CONCLUSIONS

This study constitutes a basis for creating more awareness among farmers for practicing new methods such as ZTRM of potato cultivation. However, more in-depth and multilocation study would require knowing commercial and operational implications on a large-scale cultivation. The current study was performed on a smaller plot to understand the cost involvement. From the study, it is quite evident that small scale cultivation using ZTRM in the agricultural ecosystem of Assam can help small scale farmers. Because the ZTRM technology brings advantage of advancing the cropping cycle, it does not require land preparation, and no or very miniscule irrigation is required. This directly resonate with the current practice of farmers in Assam where irrigation in potato crop is hardly seen by farmers. In such situation ZTRM can complement the crop with conservation of moisture due to its mulch cover. As a result, farmers can get more benefit by realizing more yield.

FUTURE SCOPE

The findings presented in this paper are limited to two locations in Assam. However, there are dynamics in market in terms of input price and other Agricultural operations time to time and place to place. This study provides an insight to a technique and its financial implications on its entire operation. The area considered for this study is limited for ease of carrying out activities to understand the differences minutely. This might appear quite different considering a larger operation. Hence, the future scope lies in carrying out such analysis at a commercial level. Moreover, this would be helpful to apply such application in areas with flood incidences, drought etc. to understand its viability and feasibility. At large this needs to be beneficial for farmers to adopt it and gain more from it.

Author Contributions. The first author performed the experiments, collected the data, analyzed the data and wrote of the manuscript whereas the second author helped in conceiving the design and analysis of the findings, and editing the manuscript.

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Conflict of Interest. None.

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